

# THE LUMINA PROJECT

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## Technical Report #6

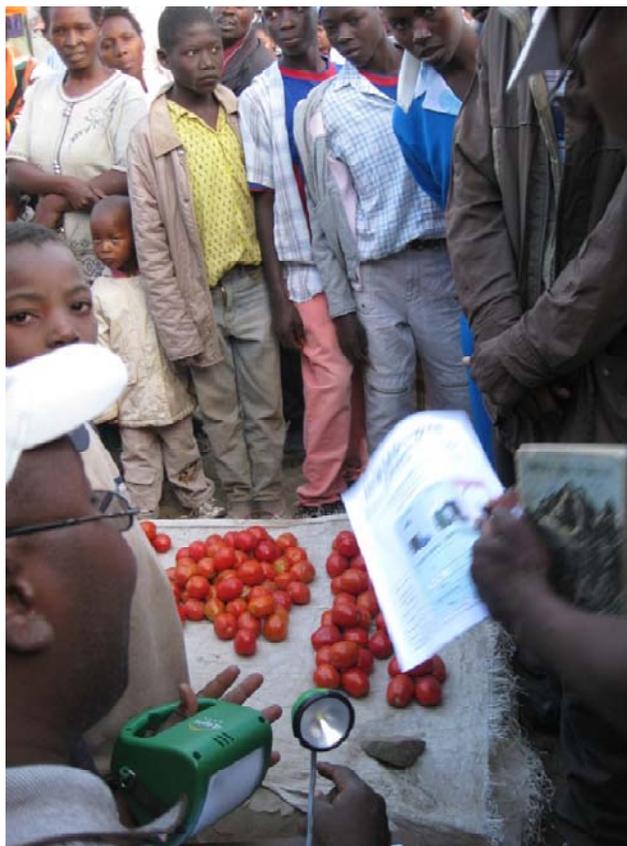
### Market Trial: Selling Off-Grid Lighting Products in Rural Kenya

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

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## Summary

In this study, we performed a market trial of off-grid LED lighting products in Maai Mahiu, a rural Kenyan town. Our goals were to assess consumer demand and consumer preferences with respect to off-grid lighting systems and to gain feedback from off-grid lighting users at the point of purchase and after they have used to products for some time. Key findings from this work include the following:

1. There was modest demand for the lamp products available through the Market Trial, with 23 systems sold to 164 shop visitors (14%) over a period of 9 months.
2. People preferred the performance and features of lamps designed to provide room lighting over those that were perceived primarily as task lights, despite the higher price of the former products.
3. One-quarter of the purchasers lived in electrified homes, two-thirds of whom retained the lamps in their home while the remaining used them in their non-electrified place of business. This suggests that people in electrified homes still see considerable value in off-grid lighting for use during power outages or other circumstances.
4. When given an option to purchase the grid-rechargeable LED lamp at a cheaper price without the solar charger option, 100% of the purchasers paid the higher cost to purchase the solar charger. This result contrasts with previous findings from prior work reported in Lumina Technical Report #3 (Radecsky, et al., 2008); it should be noted that the sample size in both cases was relatively small.
5. In follow up surveys completed a number of months after the initial purchase, 86% of buyers reported that the LED lamp fully replaced a pre-existing kerosene lamp. The remaining 14% reported that the LED lamp partially replaced a kerosene lamp.
6. Six-months after the start of the trial, the people who purchased LED lamps reported using the solar option to charge their lamp more than 90% of the time.
7. None of the purchasers of the LED lamp products reported significant levels of dissatisfaction with their lamps, and none elected to return their lamp for a full refund when presented with this option approximately six months after they had purchased the lamps.
8. Reasons for low sales appear to include a combination of contextual factors combined with suboptimal product marketing, including:
  - Product affordability; most potential buyers were not able to afford the products and relatively few had access to financing
  - Low purchasing power due to a persistently bad economy during the trial period
  - General suspicions about LED quality caused by prior experiences of potential customers with low-grade products

- Potentially ineffective marketing because the sales team was relatively inexperienced, the sales literature was printed only in English, and sales took place during the daytime when it was difficult to see how the lights performed
  - Potential reluctance to purchase due to a perception that the warranty period (six months) was too short and because some types of spare parts were not available
  - Possible suppression of demand that occurred when community members became aware of a broader set of attractive products that were not available through the sales trial; this awareness occurred late in the trial and did not affect the first seven months of the effort
  - Unavailability of products for sale; in one case a product supply ran out and additional pieces were not available for restocking
9. Market trial tests should include a diversity of product types; it is further important to anticipate and eliminate potential, and often unforeseen, impediments to sales.

## Methods

The market trial took place in the rural Kenyan town of Maai Mahiu from July 2009 through March 2010. Five different models of off-grid lighting products were made available for purchase out of a small shop in the town center. Our Kenya colleague, Maina Mumbi, owns the shop and two local residents were employed throughout the trial as the primary lamp sellers. A daily log was kept to document the customers that came into the shop to inquire about the lamp products. Those customers that purchased a lamp participated in a survey at the time of purchase and a six-month follow up survey.

**Maai Mahiu**, located in Kenya's Rift Valley, approximately 50 miles northwest of Nairobi (Figure 1), is a small truck stop town with a population of approximately 30,000 (Mumbi, 2009). Maai Mahiu residents are predominantly Kikuyu (one of Kenya's forty-two ethnic groups). Major sources of income for residents include agriculture, animal husbandry, *jua kali* labor (those who work with their hands, e.g., mechanics, seamstresses – generally known as the “informal sector”), quarry excavation, small business, and self-employment, including night watchmen. An average family in Maai Mahiu makes around 5,000 Kenya shillings (Ksh) per month, roughly \$65 (Mumbi, 2009). The town center is densely populated with small-businesses on either side of the main highway that passes through from Nairobi to Naivasha. Residential housing spans outward in all directions, encompassing an area of roughly ten square miles. Grid electricity was brought to the town in 1998; however, the majority of residents do not have electricity access in their homes; in some cases homes are not electrified because they are too far from the grid and in other cases because the homeowners cannot afford a connection despite being relatively close to a potential connection point. The electricity is used primarily in the town center, where most of the businesses are located. There is considerable intermittency in the service and blackouts are frequent.



**Figure 1. Map of study location. Yellow star indicates the approximate location of Maai Mahiu.** (map sourced from: <http://www.sandwatch.ca/images/Kenya/kenya%20Map.gif>)

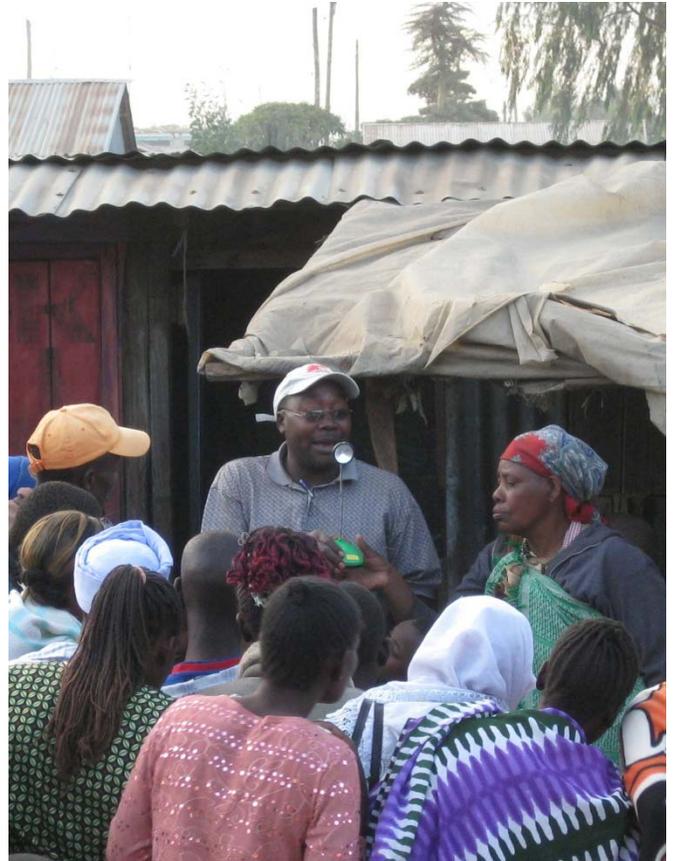
*The Shop* where the lamps were sold was located a couple of hundred meters west of the main road that links the town to Nairobi (Figure 2). The shop is owned by our colleague Maina Mumbi and had previously been solely a business that performed financial transactions through a service called M-Pesa.<sup>1</sup> The shop was divided into two rooms for the purpose of the market trial and the lamps were sold out of one side and the other remained operating as an M-Pesa shop. Six months after the initiation of the trial the shop location moved to another shop approximately ¼ mile north, positioned closer to the main road at only about 50 yards distance. The move took place because Maina Mumbi purchased another shop out of which he sold car batteries and he felt it was more appropriate to sell lighting products out of the battery shop instead of the M-Pesa shop. In regards to visibility, both shops could be easily accessed and seen from the main road. Mumbi oversaw the operation of the lamp business and purchased additional lamps as supplies diminished. As part of the trial he hired on a young man, Samuel Chege, a 2009 recent high

<sup>1</sup> Maina Mumbi has been selling solar products for over 10 years, and six months before setting up this study the M-Pesa shop was a battery charging and solar shop.

school graduate, to sell lamps out of the shop and to visit the Maai Mahiu daytime markets on a weekly basis to advertise and demonstrate the lamp products (Figure 3 and Figure 4). Six months after the trial began – the same time as the shop location changed – Chege left for college and a new lamp seller, Lucy Mungai, a high school graduate in 2007, was hired. Neither had significant prior retail experience.



**Figure 2. Inside the shop. Chege, the primary lamp seller, standing in the foreground with the lamps on display.**

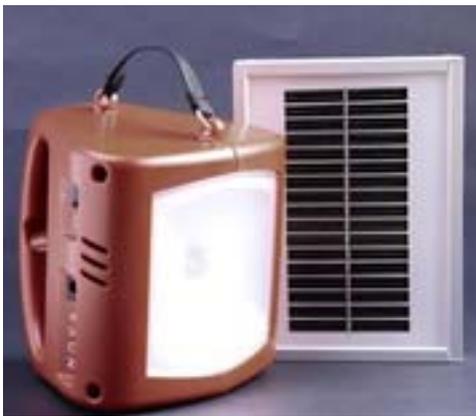


**Figure 3. Maina Mumbi demonstrating the lamp products at a day market.**



**Figure 4. A crowd of market shoppers gather around as Maina Mumbi talks about the lamp products.**

**The Lamp Products** included in the market trial were manufactured by two companies. D.Light Design made the Nova S201, the Nova S100 and the Solata, and Barefoot Power made the Firefly5 and the Firefly12 (Figure 5, Figure 6, Figure 7, Figure 8, and Figure 9). [See Appendix A for manufacturer’s product specification information sheets. See Appendix B for the flyer our research team created to advertise the products]. These five products were chosen based on satisfactory results from performance evaluations made at the Schatz Energy Research Center at Humboldt State University and because they were available for wholesale purchase in Kenya as of June, 2009. It was our initial intention to include other products in the trial, but they were not available for purchase in Kenya when the study began. Each of the five products had distinguishing characteristics from the others, including retail prices ranging from 1,000 to 3,500 Kenya Shillings (Ksh) (\$13-\$46). All products had a solar charge option and three of the products also had an AC grid charging option. Customers purchasing a lamp featuring both a grid charge and AC charge option were given a choice to not purchase the solar panel. Each of the products included in the study used LED technology, but the types of LEDs varied from power LEDs to low-power 5mm LEDs.



**Figure 5. Nova S100.**



**Figure 6. Nova S201.**



**Figure 7. Solata.**



**Figure 8. Firefly5.**



**Figure 9. Firefly12.**

The Nova S201 and Nova S100 are portable ambient lights for use in illuminating a room. At the time that the study began, they both had a retail price of 3,000 Ksh (\$39.50)<sup>2</sup> (w/out solar) or 3,500 Ksh (\$46) (w/solar). The main differences between the products were battery capacity and mobile phone charging capability. Both products used a sealed lead-acid battery, but the Nova S100 had a battery capacity twice that of the Nova S201. On a full battery the Nova S100 was advertised to last 12 hours on its highest light setting, where as the Nova S201 would last 6 hours on the highest setting. The Nova S201, however, came with a mobile phone charging feature. Both Nova lamps had a single highly efficient Power LED and four light level settings rated to last between 4 hours and 100 hours (depending on the light level) after a day of solar charge. The time required to charge the battery with the accompanying polycrystalline solar panel varied considerably between the two models (see Table 1 for product specifications).

The Solata and both Firefly lamps operate primarily as portable task lights for uses such as studying or reading. They were outfitted with a flexible gooseneck providing a 360-degree option for directing the light. At the start of the market trial the lamps had retail prices ranging from 1,000 Ksh to 1,400 Ksh (\$13 - \$18.40) depending on model and if purchased with the solar charging option (the latter being only relevant to the Solata). The battery capacities ranged from 400 to 900 milliamp hours (mAh) and used nickel cadmium (NiCd) batteries. The Solata had a single highly efficient Power LED and two light level settings, while both Firefly lamps had three light level settings and either five or twelve 5mm LEDs. The lamps were rated to last 4 to 50 hours on a charge, depending on the light level. The polycrystalline solar modules varied in size from 0.5 watts to 1.0 watts depending on model and required between five and six hours of full sunlight to fully charge the batteries (see Table 1 for product specifications).

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<sup>2</sup> Throughout this report, we use an exchange rate of 76 Kenya Shillings per US dollar.

**Table 1. Specifications for each of the five off-grid lighting products made available for purchase as part of the Market Trial.**

<b>Product</b>	<b>Nova S201</b>	<b>Nova S100</b>	<b>Solata</b>	<b>Firefly5</b>	<b>Firefly12</b>
<b>Primary Application/ Form Factor</b>	Ambient	Ambient	Task	Task	Task
<b>Retail Price (Ksh) w/ Solar<sup>3</sup></b>	3,500	3,500	1,400	1,000	1,400
<b>Retail Price (Ksh) w/out Solar</b>	3,000	3,000	1,100	NA	NA
<b># of LEDs</b>	1	1	1	5	12
<b>Type of LED</b>	Power	Power	Power	5mm	5mm
<b># of Light Level Settings</b>	4	4	2	2	3
<b>Battery Chemistry</b>	SLA	SLA	NiCd	NiCd	NiCd
<b>Battery Capacity (mAh)<sup>4</sup></b>	1,200	2,500	400	650	900
<b>Solar Panel Rating (watts)</b>	1.3	1.3	0.625	0.5	1.0
<b>Charge Time (hrs)<sup>5</sup></b>	8	19	6	6	5
<b>Run-Time (hrs) on Full Battery<sup>6</sup></b>	6 (H) 10 (M) 20 (L) 200 (B)	12 (H) 20 (M) 40 (L) 500 (B)	4 (H) 15 (L)	6 (H) 30 (L)	4 (H) 7 (M) 50 (L)
<b>Run-Time (hrs) after a Day of Solar Charge<sup>6</sup></b>	4 (H) 6 (M) 12 (L) 100 (B)	4 (H) 6 (M) 12 (L) 100 (B)	Not specified	Not specified	Not specified
<b>AC Charge option</b>	Yes	Yes	Yes	No	No
<b>Mobile Phone Charger</b>	Yes	No	No	No	No

<sup>3</sup> Products were given a retail price of about 15% higher than the wholesale cost.

<sup>4</sup> Manufacturers specified rating

<sup>5</sup> Manufacturers specified rating based on charging with the solar panel under full sun beginning with a battery discharged to 70% of its rated capacity.

<sup>6</sup> Manufacturers specified rating based on a full battery. Hours correspond to light level setting specified in the parentheses (H = high, M = medium, L = low, B = bed light).

*A Daily Log* was kept to document customer inquiries about the lamp products. The log recorded the customer's gender, approximate age, which lamp they preferred and why they preferred it. The log was filed out by the seller after the customer left the shop. After the initial six-month period, we made a few minor adjustments to the log and began asking, in addition to the previous questions, whether the customer was referred by another and if they had any major concerns or questions regarding product quality, warranty, spare parts availability, other issues. The later set of questions about product concerns were added after observing that many shop visitors inquired about these topics.

*A Terms of Sales Agreement* was signed by all those who purchased a lamp (Appendix C). The agreement stated their required participation in an initial survey at the point of purchase, as well as two follow up surveys to be administered within a year from the purchase date. The agreement also laid out the warranty terms which included six months of maintenance service free of charge from the date of purchase, where we agreed to repair, replace, or refund money for any lamp that failed due to a manufacturing defect. However, this was only valid if the owners took the lamp back to the point of sale for the repair work.

*Follow-up Surveys* were administered by the seller at the point of purchase and in January, six months after the trial began. Team members Maina Mumbi and Jennifer Tracy administered the surveys. The Point of Purchase survey consisted of questions about the lamp purchaser's current lighting use and their projected use of the lamp being purchased (Appendix D). The follow-up survey consisted of questions about the lamp purchaser's lighting use during the previous months while owning the new lamp and their actual uses and perceptions of the new lamp product (Appendix E).<sup>7</sup> Only five of the follow-up surveys were completed in full; the remaining follow-up surveys had to be carried out over the phone because the lamps were being used at locations that were far from Maai Mahiu. In these cases the survey was shortened for convenience and feasibility (Appendix F).

## **Results & Discussion**

Over the course of the Market Trial from early July to early March, 164 people came into the shop to inquire about the lighting products. The mean age was 30 years with a range from as young as 19 to as old as 65 years (Figure 10).<sup>8</sup> Men visited the shop significantly more often than women and were also the primary lamp purchasers (Figure 11). Among those purchasing lamps, the main sources of income included, farming, informal sector jobs, professional jobs (e.g., security guards, school teachers, and church personnel), and small-business ownership. The majority, by far, were farmers (Figure 12). Nearly three-fourths of purchasers did not have access to grid electricity in their homes and only a small portion of people had grid electricity at their place of business (Figure 13). The six people who purchased products that also had access to grid electricity in their home indicated that the lights were either going to be used as a backup when the electricity was down (n=4) or that the lamp was to be used at their place of business which had no electricity (n=2). The most commonly reported number of people per household

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<sup>7</sup> Six of the Nova S201 lamps were outfitted with dataloggers that recorded use patterns (i.e. when the lamp was on, off and charging) supplementing the reported values participants provided in the follow up survey. A detailed Lumina research note of these dataloggers by Alstone, et al. is forthcoming.

<sup>8</sup> Only 156 out of the total 164 visitors reported their age.

among those using the purchased lamps was five (the range was from one to eight), and on average had two school-aged children.

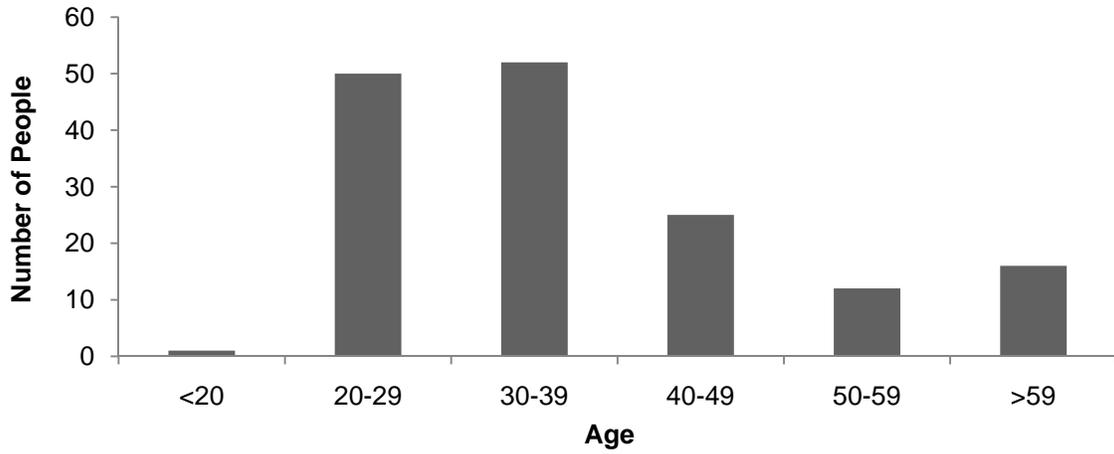


Figure 10. Ages and numbers of people visiting the shop to inquire about lighting products. N= 156.

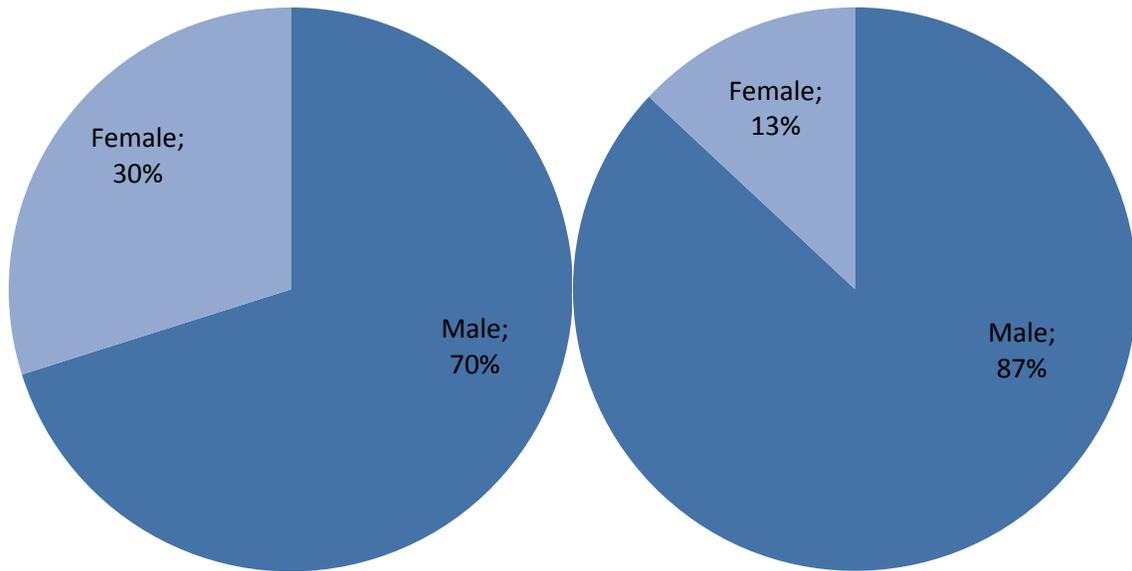
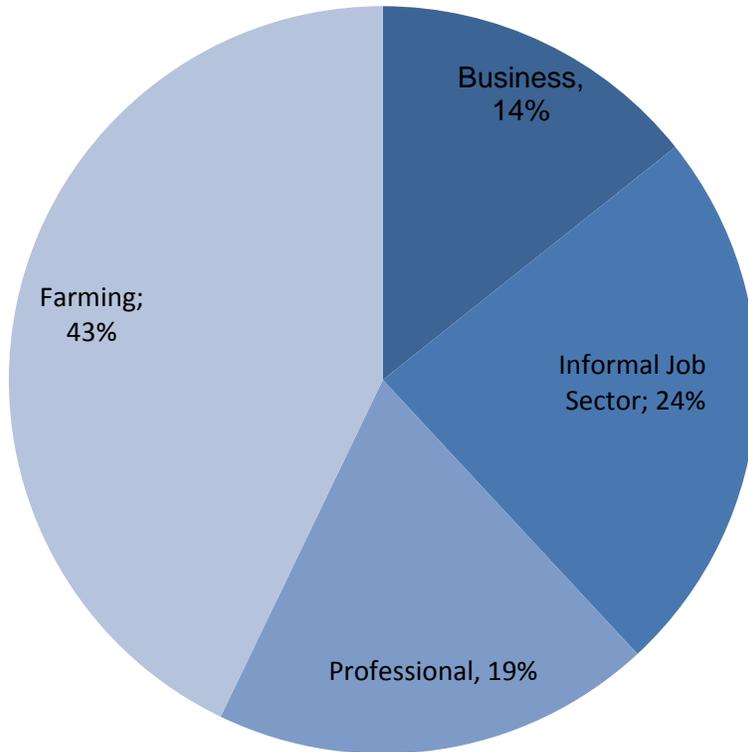
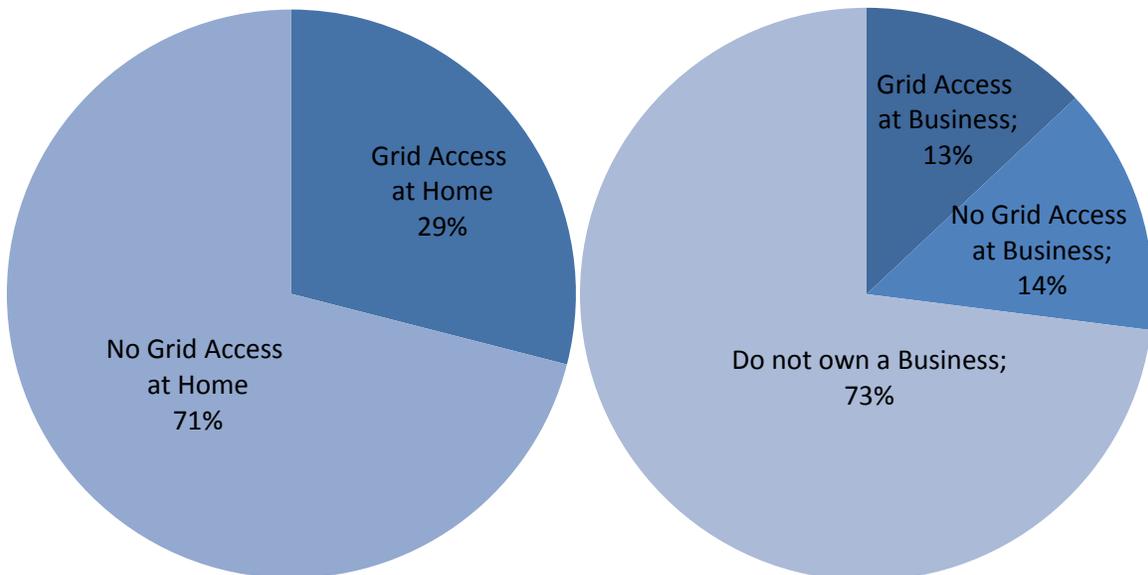


Figure 11. Gender of all shop visitors (left graph, N= 164) and gender of lamp purchasers (right graph, N=23).



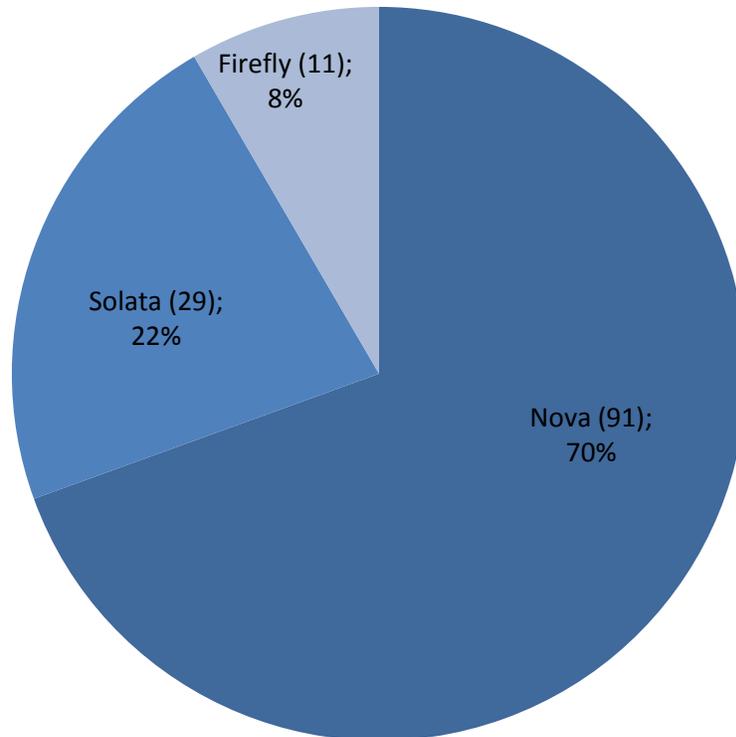
**Figure 12. Primary sources of income as reported by the lamp purchasers, N=23.**



**Figure 13. Percentage of lamp purchasers that have electricity at the home (left, N=21) or at their business place (right, N=22).**

When shop visitors were asked why they were interested in purchasing a lamp, 44 of the reporting 131 visitors communicated one main reason: because it was cheaper than owning and operating a kerosene lamp over the long-term. Safety was also mentioned, but by only a few

people, who referred to the elimination of risk of kerosene spillage if the lamp fell over. When visitors were further asked which of the lamps they preferred, the Nova lamps were by far rated the highest while the Firefly lamps were the least favorite (Figure 14). For simplicity on the part of the visitors, the Nova S100 and S201 models were categorized as the Nova and the Firefly5 and Firely12 were categorized together as the Firefly. The shop visitors in part directed this simplification, as they expressed not noticing much of a distinction between the Firefly lamps and there was almost no interest in the Nova S100 lamp.

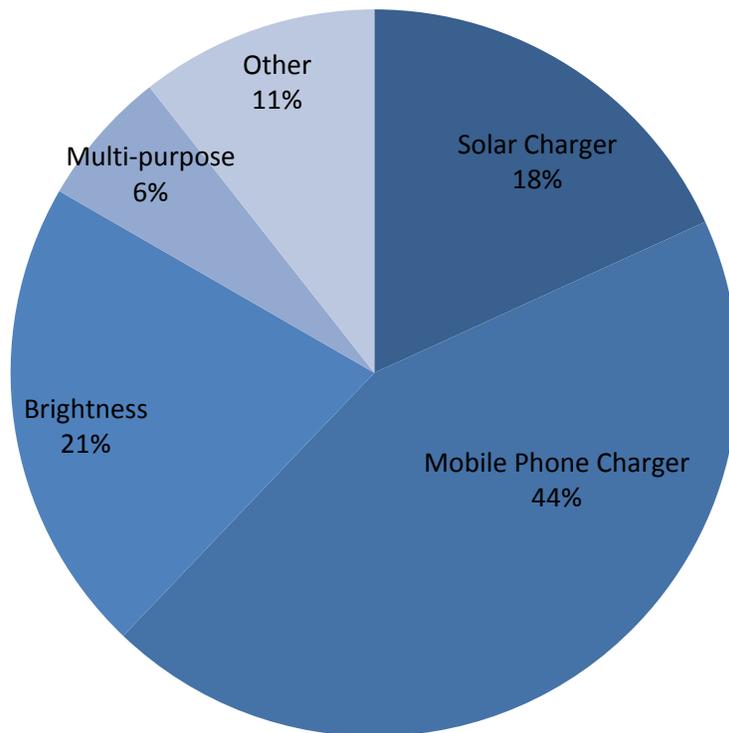


**Figure 14. Percentage of people visiting the shop by lamp preference. Number of people preferring the products is given in parentheses. The Nova S100 and S201 models were combined and referred to as the Nova and the Firefly5 and Firefly12 models were combined and referred to as the Firefly, N= 131.**

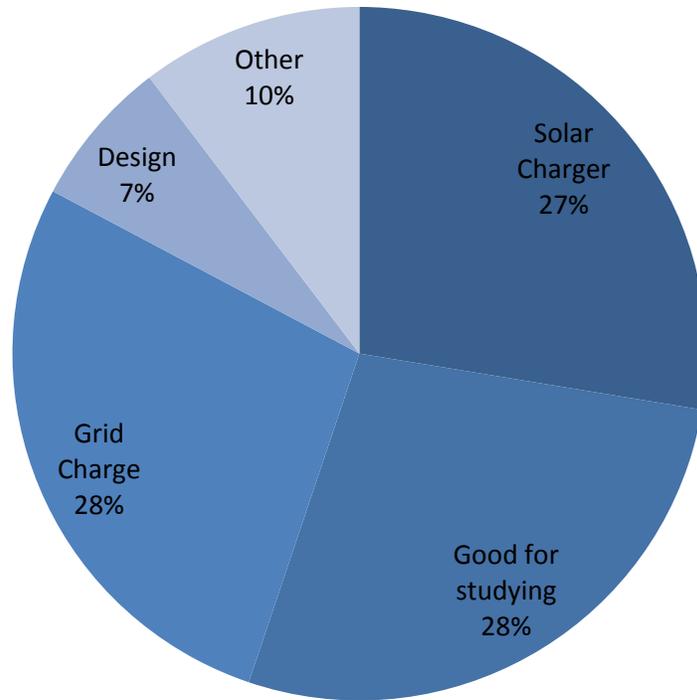
When asked why they preferred a particular lamp, 14 different features were reported amongst the three products (Nova, Solata, and Firefly):

- Solar charger option
- Grid charge option
- Mobile phone charger
- Portability
- Battery capacity
- Multiple light settings
- Brightness
- Easy to use
- Multipurpose
- Hanging option
- Swivel neck
- Stability
- Good for studying
- Design

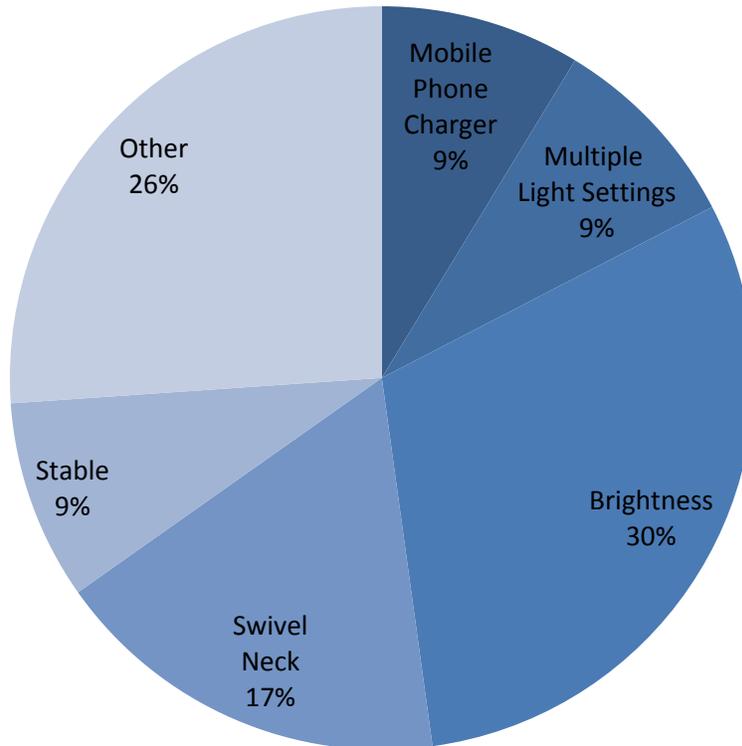
The Nova was favored primarily because of its ability to also charge a mobile phone. The Solata was favored primarily because of its option to be charged with solar and with the grid and because it would be good for studying (all three features ranked equally as important). The Firefly was favored primarily because of its brightness. [See Figure 15, Figure 16, and Figure 17 for a more complete breakdown of what features were reported by the customer preferring the Nova, Solata, or Firefly]. Having a mobile phone charging option, its brightness, and having a solar charging option were among the most preferred features (Figure 18). [In the graphs, the features reported as important in less than 5% of the responses were grouped together under the category “Other” and include all of the above features not specifically reported in the graph].



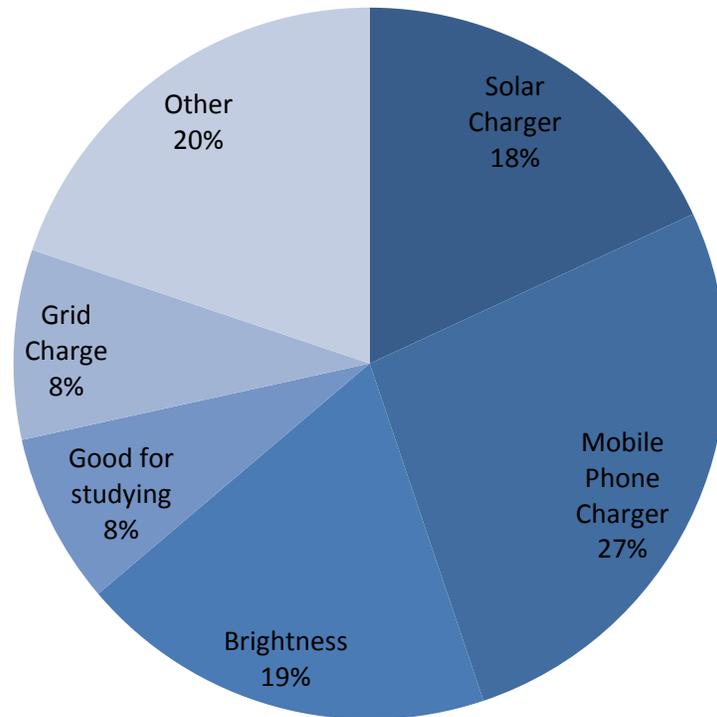
**Figure 15. Preferred features of the Nova lamp as reported by shop visitors, N=91.**



**Figure 16. Preferred features of the Solata lamp as reported by shop visitors, N=29.**



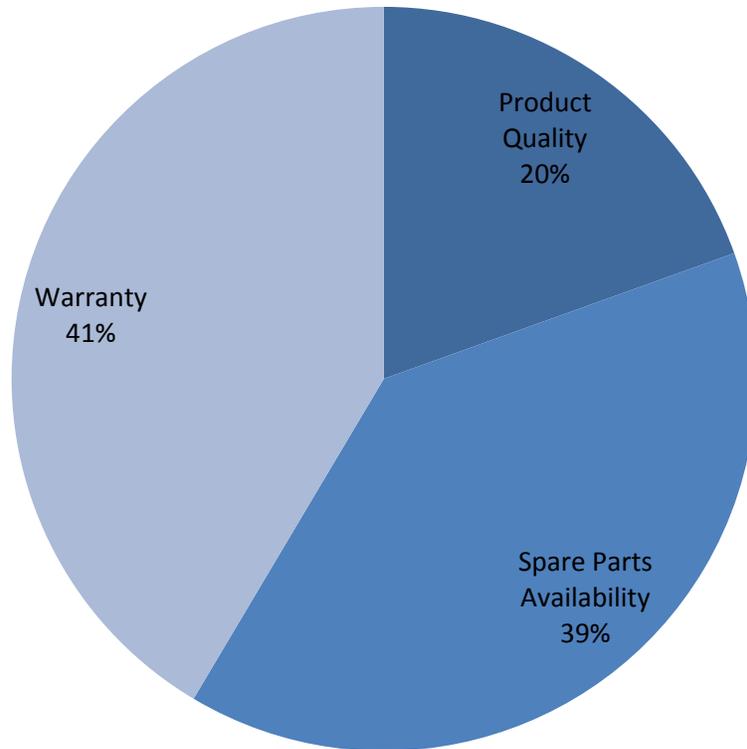
**Figure 17. Preferred features of the Firefly lamp as reported by shop visitors, N=11.**



**Figure 18. Features reported with the greatest frequency across the all lamps when the shop visitors were prompted about why they preferred one lamp over the others, N=131.**

It is important to note that beginning in January people in Maai Mahiu became aware of other attractive off-grid lighting products as a result of another lighting market research project, but that these products were not available in the shop. As a result, some people entering the shop appeared to delay their purchase of a light until these more attractive products became available. From mid January until the end of the Market Trial in early March, 19 people visited the shop to inquire about lights. Of those 19 visitors, four people favored the Nova S201, four others favored the Firefly12, and no visitor indicated the Solata as their favorite lamp during those months. The remaining 11 shop visitors however, favored five additional lighting products not part of our Market Trial, but part of the other study.

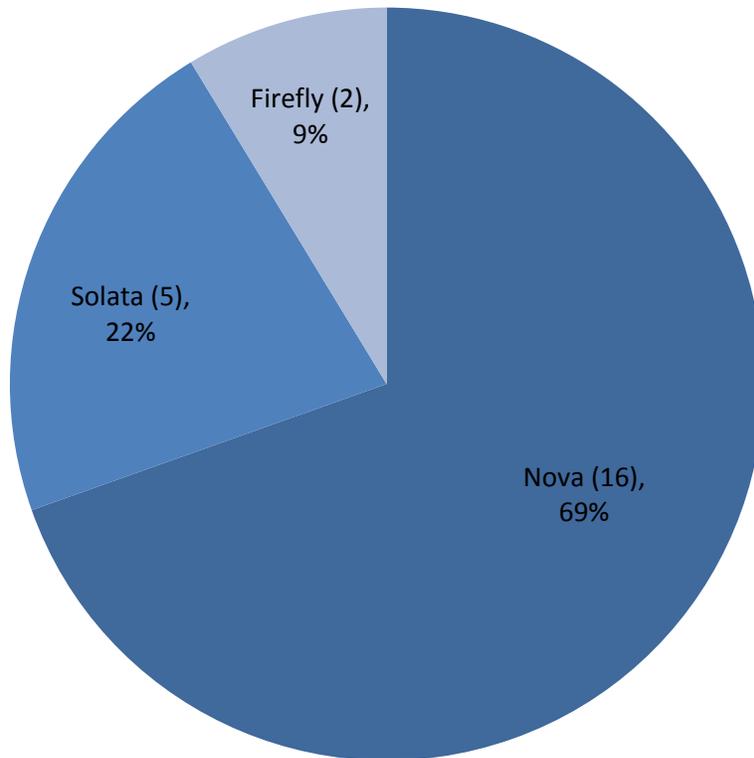
While inquiring about the lamp products, shop visitors repeatedly voiced several questions and concerns (n=42) (Figure 19). Of greatest importance was whether the product came with a warranty closely followed by concern regarding spare part availability. Product quality was also a significant concern.



**Figure 19. Percentage of concerns reported by shop visitors inquiring about lamp products. N= 42**

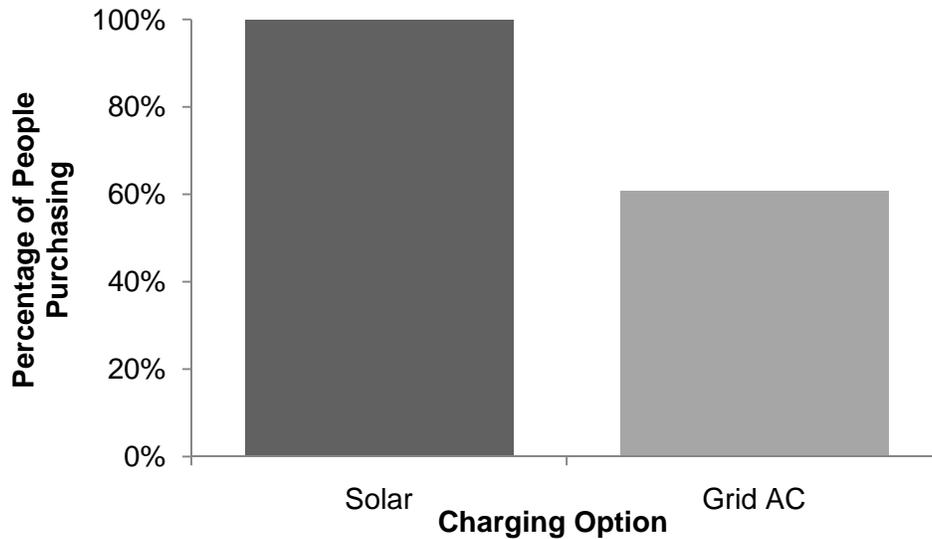
Of all the 164 visitors to the shop, 14% made a purchase (n = 23).<sup>9</sup> None of the Nova S100 lamps were sold, as were no Firefly5 models (only the Firefly12 was of interest to the visitors). The Nova S201, referred to as the Nova from here forward, had the highest sales rate while the Firefly saw the lowest number of sales (Figure 20). The percentages of sales nearly mirror the lamp preference percentages as depicted in Figure 14. Upon purchase the buyers reported choosing the lamp they did because of its performance (83%), the features of the lamp (52%), its ease-of-use (17%), economical price (9%), and its appearance (4%).

<sup>9</sup> All but three of the sales took place in the Shop. The shop owner sold three Nova lamps when he took a trip to Lodwar, in far north Kenya.



**Figure 20. Percentage of total sales of each of the three lamps products with number of products sold in parentheses. N=23**

All customers chose to purchase the accompanying solar panel as a charging option, while fewer opted for the additional AC grid charger (Figure 21).



**Figure 21. Percentages of lamp purchasing customers who bought a solar charger and an AC grid charger, N=23.**

## **Discussion: Possible Reasons for Low Sales**

Over the course of the Market Trial, our sales rate was approximately one lamp every 10 to 12 days, with 14% of visitors to the shop who inquired about the lamps actually purchasing.

Reasons for the relatively low sales appear to include a combination of contextual factors combined with suboptimal experimental design and execution, including:

- Product affordability; most potential buyers were not able to afford the products and relatively few had access to financing
- Low purchasing power due to a persistently bad economy during the trial period
- General suspicions about LED quality caused by prior experiences of potential customers with low-grade products
- Potentially ineffective marketing because the sales team was relatively inexperienced, the sales literature was printed only in English, and sales took place during the daytime when it was difficult to see how the lights performed
- Potential reluctance to purchase due to a perception that the warranty period (six months) was too short and because some types of spare parts were not available
- Possible suppression of demand that occurred when community members became aware of a broader set of attractive products that were not available through the sales trial; this awareness occurred late in the trial and did not affect the first seven months of the effort
- Unavailability of products for sale; in one case a product supply ran out and additional pieces were not available for restocking

It is useful to elaborate on a few of the most significant points.

LED flashlights present the first point of contact many people in Maai Mahiu have had with LED technology. These flashlights are very low in quality, lasting as little as a few days to a few months before malfunctioning (Tracy, et al., 2009). Because this has been their initial exposure to LEDs, it is likely that many people have serious reservations about the reliability of the technology. As a result, it may be difficult for people to rationalize purchasing a relatively costly LED lighting product. If market spoilage is, in fact, a contributor to low sales, this highlights the need for a quality seal or other mechanism that allows consumers to differentiate between low quality and higher quality LED lighting products. Another potential avenue for current market spoilage concerns the flexible gooseneck used in the Solata and Firefly lamps. A study performed by our research team in Maai Mahiu beginning in May 2008 involved the use of lamps that featured a gooseneck that was similar to the one used in the Solata and Firefly lamps. (Radecky, et al., 2008). In this study, night market vendors were given a chance to purchase an LED lamp with the goal of providing feedback on this alternative source of lighting. An outcome of that study was a high level of dissatisfaction with the durability of the gooseneck; it broke frequently (Alstone, et al., 2010). From this, it is possible that, through word of mouth, the gooseneck feature was associated with easy breakage and therefore avoided by potential lamp purchasers. In practice, the goosenecks on the Solata and Firefly lamps were an improved version that was not as prone to failure as the ones from the earlier study. However, many buyers may not have been aware of the difference between the older, failure-prone gooseneck

and the newer, more robust version. Our research team was not initially aware of the widespread negative perception of products with goosenecks in Maai Mahiu, and we therefore did not take steps to explain the difference between the older and newer versions.

Affordability presents another potential reason for low sales. The period from July-December 2009 was characterized by drought, which reduced the purchasing power of many people across Kenya. These conditions, in combination with a world economic recession that affected Kenya along with many other countries globally, reduced the purchasing power of potential buyers. In addition, there were seasonal effects that influenced purchasing power in Maai Mahiu during particular times of year. For example, harvest time generally occurs around January and May/June in the region around Maai Mahiu; those dependent on farm income generally have more cash just after the harvest. In addition, seasonally specific expenditures, such as payment of annual school fees, can influence access to funds for capital purchases. September was a period of particularly low sales at the shop, perhaps because school fees were due that month. Nonetheless, the trial spanned periods that involved both good and bad economic conditions for sales, but sales were never particularly strong at any time during the study.

It is likely that a contributing factor to the modest number of lamp sales was limited access to the money needed to cover the purchase price of the lamps. Although many kerosene users spend more money in a year owning and operating a kerosene lamp than they would owning and operating an LED lamp (Radecsky, et al., 2008), most people find it easier to access money in the small incremental amounts associated with purchasing kerosene fuel than to assemble the larger amount of money needed to make a one-time purchase such as an LED lamp.

Access to credit is often cited as a potential way to address this issue, and the low sales in the market trial can also be attributed to the lack of access to micro-credit loans. Banks and community groups serve as the main sources of credit in Maai Mahiu. The loans available through a bank, however, are directed toward larger purchases and are not applicable to lower cost purchases such as a LED lighting product. Furthermore, although the sales trial included efforts to reach out to community lending groups, no person who purchased a lamp indicated that they bought a lamp using money loaned from a community group. So, even though banks and community groups offer financing, this money did not appear to play a role in making the lamps more affordable to potential buyers. (See Appendix G. for a brief account of how community group money lending works as reported by a co-leader and member of several community groups in Maai Mahiu).<sup>10</sup>

Another potential reason for the low sales may have been the limited availability of spare parts. Of the people visiting the shop, 39% asked if replacement parts were available. Unfortunately, spare parts identical to those in the lamps were not available at the time of the study, and this was indicated to potential buyers. It is possible that without the option to purchase spare parts, people were hesitant to buy a lamp because they were concerned that it could not be repaired if it failed after the 6-month warranty period.

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<sup>10</sup> Three people who purchased lamps in the shop were allowed to pay a weekly amount until they had paid in full, at which time they were able to take the lamp home. This is another approach to assist those with limited incomes, although it can potentially be a problematic customer-business relationship. The shop owner offered this service to the three people because he had known them for many years and both parties trusted each other with the agreement.

### *Time of Purchase and Post Use*

Lamp purchasers participated in surveys at the time of purchase and approximately six months after the start of the trial. Questions were asked to gain a better understanding lighting use patterns before and after the purchase of the rechargeable LED lighting product. The follow up survey was conducted six months after the purchase in order to ensure that the collected data represented use patterns after considerable experience with the lamps. We also inquired about user satisfaction with the new products.

At the point of purchase, 22 of the 23 buyers reported using a kerosene lamp within their household. The kerosene lamps were typically used for four hours per day for a range of lighting applications. Eleven buyers reported using a LED dry cell flashlight for just over one hour per day, eight used an LED rechargeable flashlight for about three hours per day, and four people reported using an incandescent dry cell flashlight for just under an hour each day. One person reported using a generator for three hours per day (Table 2).

**Table 2 Average number of hours different lighting products owned were used for specified tasks, and the total number of use hours for each lighting product, as reported by lamp purchasers.**

Lamp Use	Type of Light				
	Hurricane	LED dry cell flashlight	LED rechargeable flashlight	Incandescent dry cell flashlight	Generator
<b>Number of people reporting use hours (N)</b>	<b>22</b>	<b>11</b>	<b>8</b>	<b>4</b>	<b>1</b>
General home lighting	3.5	1.7	0	0	3.0
In the kitchen	2.0	0	0	0	0
Morning preparations	0.9	0.5	0	0	0
Walking at night	1.0	0.8	3.0	0.8	0
Reading/Studying	1.9	0	0	0	0
At a business	4.0	0	0	0	0
<b>Total Average Use Hours</b>	<b>4.1</b>	<b>1.1</b>	<b>3.0</b>	<b>0.8</b>	<b>3.0</b>

Each product was used for a range of lighting applications including general lighting at home or at a business, kitchen activities, studying or reading, morning preparations, and walking outside at night. The costs associated with each lighting source varied considerably (Table 3). The average initial purchase cost for the kerosene lamps was 380 Ksh (\$5.00) and the average daily cost reported for purchasing kerosene was 20 Ksh (\$0.26), implying annual use of approximately 125 liters.<sup>11</sup> The average initial purchase cost for the LED dry cell, LED rechargeable, and incandescent dry cell flashlights were between 140 and 400 Ksh (\$1.84 and \$5.26). Average

<sup>11</sup> From January 2009 to January 2010, the cost for kerosene in Maai Mahiu was 58 Ksh per liter on average. Compared to previous research (Mills and Jacobson, 2007) an annual consumption rate of 125 liters is high for a single kerosene hurricane lamp burned for 4 hours per day. It is possible that this amount reported might correspond to more than one lamp being used, but which this study did not record.

reported monthly flashlight costs ranged from 70 to 110 Ksh (\$0.92 to \$1.45). For the single generator owned, the reported initial cost was 25,000 Ksh (\$330) and the reported daily fuel cost was 40 Ksh (\$0.53).

**Table 3. Average costs to own and operate different lighting products as reported by lamp purchasers and estimated total annual cost.**

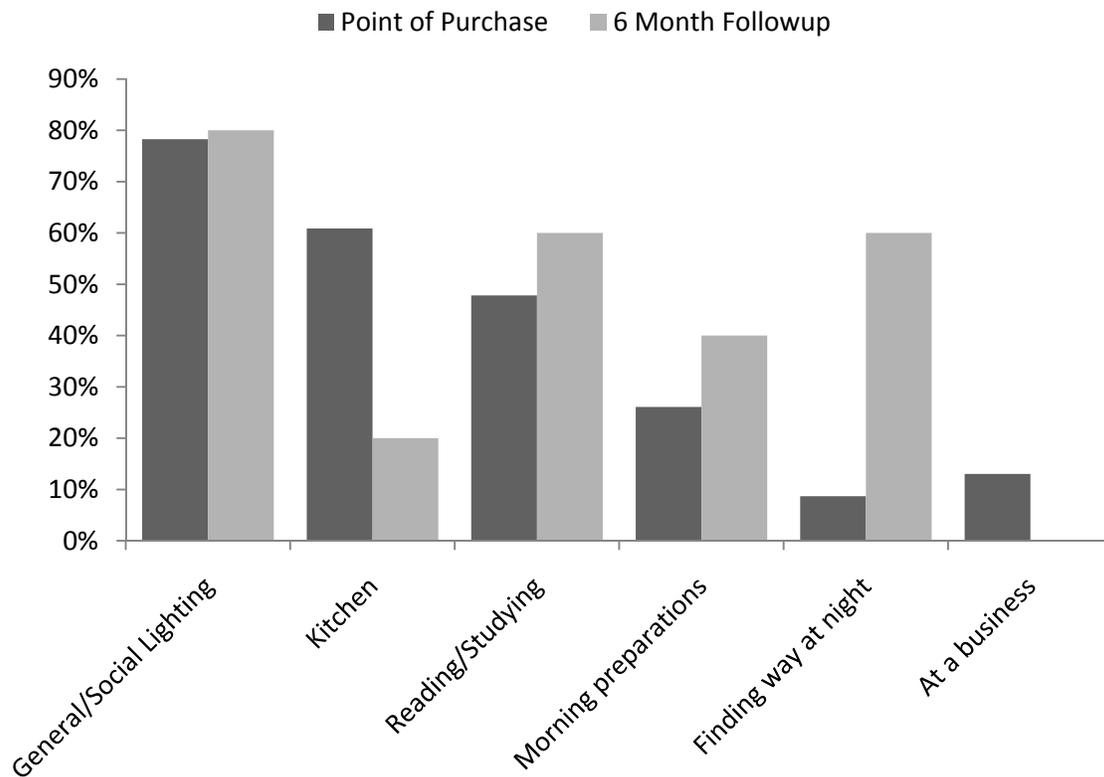
Cost of Ownership (Ksh)	Type of Light				
	Hurricane	LED dry cell flashlight	LED rechargeable flashlight	Incandescent dry cell flashlight	Generator
<b>Number of people reporting costs (N)</b>	<b>22</b>	<b>11</b>	<b>8</b>	<b>4</b>	<b>1</b>
Purchase Cost	380	180	400	140	25,000
Daily Operation Cost	20	NA	NA	NA	40
Monthly Operation Cost	NA	70	110	90	NA
Total Annual Cost <sup>12</sup>	7,680	1,920	3,720	1,920	39,600

Upon purchasing a lamp, each buyer was asked to predict their future use of the LED lamp; they were later asked the same questions during the six-month follow-up survey.

At the point of purchase buyers said the lamp would be mostly used for general household lighting, followed by use in the kitchen, reading and studying, morning preparations, at a business, and lastly, for finding their way at night. Of the five full-length follow up survey respondents, people said the light was actually used mostly for general household lighting, followed by finding their way at night, reading and studying, morning preparations, and for use in the kitchen (Figure 22).<sup>13</sup> General household lighting was the longest use, followed by use in the kitchen, reading and studying, morning preparations and for use outside at night. See Table 4 for average hours of use for specified task.

<sup>12</sup> This assumes flashlights have a lifespan of two months (Tracy, et al., 2009) and that the kerosene lantern and generator lasts longer than one year.

<sup>13</sup> The shorter phone interviews did not include this question, thus the reason for the small sample.

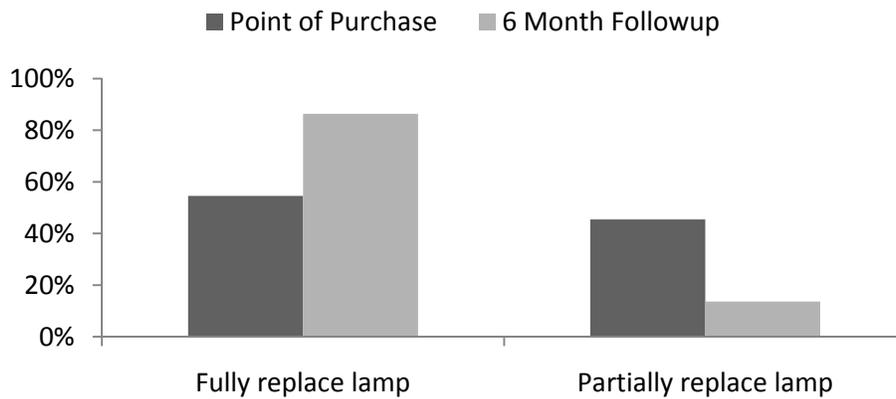


**Figure 22. Percentage of people reporting what they estimated their use would be at the point of purchase (dark grey, N=23) and what they actually used the light for as reported in the six month follow up survey (light grey, N=5).**

**Table 4. Number of hours lamp users reported using the lamp for specified tasks, N=5.**

Lamp Use	Follow up Survey Participant				
	1	2	3	4	5
General lighting at the home	4	3	0	3	2.5
In the kitchen	2	2	0	0	0
Morning preparations	1	0	0	0	0
Walking at night	0.5	0	0.5	0.5	0.5
Reading/Studying	2	0	0	2	0
At a business	0	0	0	0	0
<b>Total Use Hours per Day</b>	<b>4.0</b>	<b>3.0</b>	<b>0.5</b>	<b>3.0</b>	<b>3.0</b>

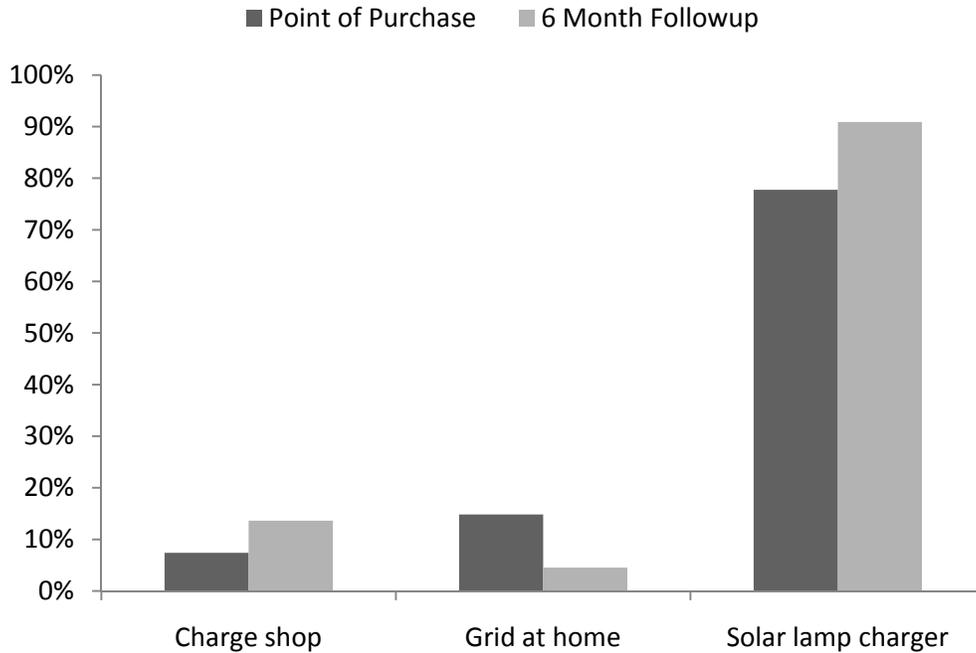
At the point of purchase 55% of the buyers reported that the lamp they were purchasing would serve as a replacement for their kerosene lamp, 45% reported it would be used in addition to it. No one assumed the lamp would replace their flashlight. Following up with the lamp owners after they had used the product for multiple months, 86% reported that it had fully replaced their use of a kerosene lamp (Figure 23), including 27% reporting that their lamp had replaced a flashlight. In the six cases where the flashlight was displaced, the displacement lamp was either a Solata (n = 2), Nova (n = 2), or the Firefly (n = 2).



**Figure 23. Percentage of lamp purchasers indicating whether the new lamp would fully replace or partially replace an existing lighting source (dark grey) as compared to what they reported actually happened (light grey), N=22.**

At the point of purchase 73% of the buyers reported that the whole household would be the primary lamp user, 14% reported that they (the purchaser) would be the primary user, and 14% said it would be used at their place of business. Because most of the follow-up interviews took place over the phone and were thus shortened, only four lamp purchasers responded to the lamp user question. Three people reported the whole household used the lamp, while one person said someone else outside of the home or place of business used it.

At the point of purchase, 78% said they would be using the solar panel to charge the lamp, 15% said they would use the grid electricity at their house, and 7% said they would take their lamp to a charge shop. In the follow-up, 91% reported using solar to charge the lamp, 5% reported using the grid electricity at their home, and 14% charged at a charge shop (Figure 24).



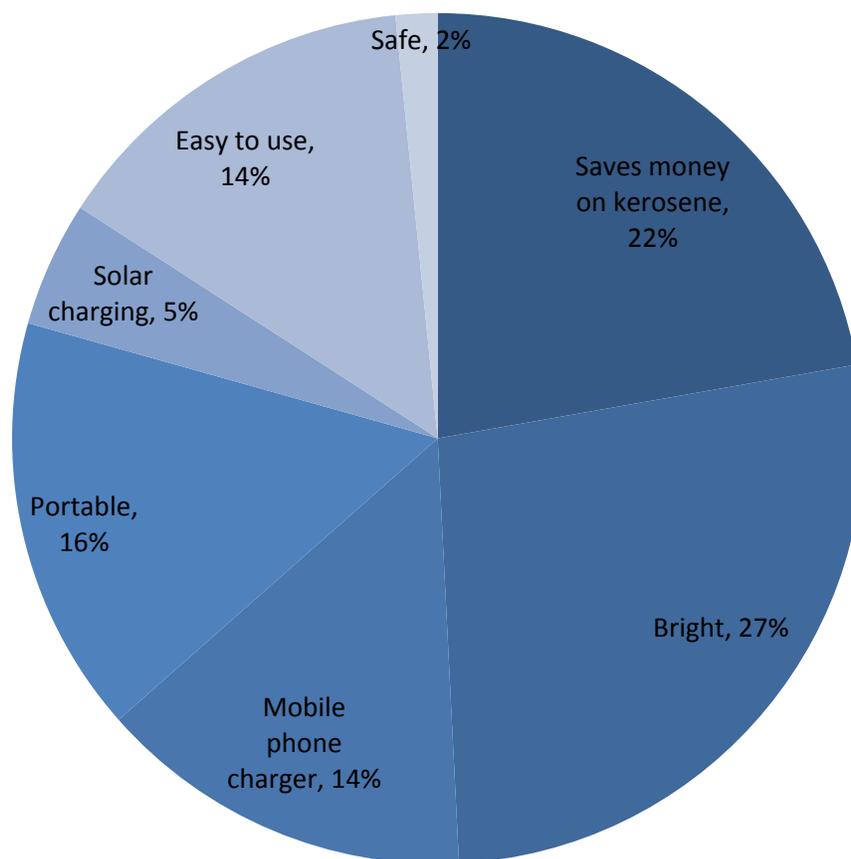
**Figure 24. Percentage of people indicating the type of charging method they will likely use (dark grey) as compared to what they actually used (light grey), N=23.**

In regards to how often the lamp was recharged, only five people responded; of these, 60% recharged daily and the other 40% recharged two times per week. Furthermore, the Nova mobile phone charger was used two times per week by three of the five reporting their use, three times per week by one respondent, and once per week by one respondent. The purchaser was reported to be the primary user of the mobile phone charger in 80% of the five follow up interviews, while the whole household used the charger in 20% of the cases. Of the fifteen people who purchased a Nova lamp with a mobile phone charger, nearly everyone was satisfied with the phone-charging feature (93%).

After using the lamp for multiple months, people were asked to evaluate their satisfaction with the product. When asked if they had the opportunity to return the lamp for a full refund, all lamp owners said that they would not return the lamp. Nearly everyone felt that the price they paid was fair (95%). Problems with the products arose for 5 of the 23 lamp owners; in all cases the specified problem was the lamp's battery not keeping a charge. The lamp owners reported noticing that the lamp would not last long if there was no sun or if they used it to charge their mobile phone.

This lamp owners reported several things they liked best about the lamp that they had purchased (Figure 25). The feature most appreciated was the product's brightness, closely followed by the money saved by not having to purchase kerosene. When asked specifically about brightness, battery performance and durability, in general lamp owners were very pleased. Everyone thought that their lamps were bright enough and that the lamps were durable. As for battery performance, 86% felt the battery lasted long enough after a single charge. The remaining 16%

that indicated that the battery did not last long enough all owned the Nova lamp and were using the mobile phone charger in addition to the light.



**Figure 25. Characteristics most liked about the lamp purchased, N=22.**

### **Lessons Learned for Market Research**

Based on our experience in the market trial, and user feedback that was provided, we can offer the following recommendations to others conducting similar experiments and more generally to those who are setting up retail outlets for off-grid lighting products in Sub-Saharan Africa:

- Time market trials to span seasons of the year that are both good (e.g. post harvest) and bad for sales.
- Offer an adequate range of quality products to prospective buyers
- Demonstrate products at night so that prospective buyers can obtain a true sense of the lighting quality
- Employ sales people with experience on a par with other sellers in the area
- Ensure that the prospective buyer population is large enough to yield sufficient data
- Effectively advertise to promote availability of new products
- Ensure availability of financing, lay-away, or other mechanisms to improve affordability
- Provide and honor an adequate warranty, and ensure that replacement parts are available

- Educate the consumers (e.g., informing buyers about health benefits)

## **Conclusion**

Of the 164 customers viewing the lamps at the point of sale, 23 lamps were sold during the Market Trial, a 14% purchase rate. A range of reasons for the low overall number of sales have been identified and further research exploring these hindrances would enable a more conclusive explanation.

Despite the relatively low sales numbers, much was gained from this study. We identified a potential market spoiling effect related to perceptions of LED lighting technology that appears to be undermining the rapid uptake of LED lighting systems. Two other potentially significant factors contributing to low product demand include the lack of access to consumer finance to cover the initial cost of the lamps and the limited availability of spare parts.

This study clearly showed that, of the lamps available, people preferred the ambient (i.e., room lighting) to the task lamp form factors, regardless of its higher cost. In addition, despite the option to reduce the price of the lamp by excluding the solar charger, everyone in the study preferred to purchase the product along with the solar charging option. Using the solar charger to recharge their lamp ended up being their primary mode of charging. Furthermore, the LED lamps were reported to have replaced a preexisting kerosene lamp for all but three of the 23 buyers; in the remaining cases the LED lamps were used as only a partial replacement. Lastly, no one was sufficiently dissatisfied with their product to return it for a full refund when they were offered the opportunity, indicating that sales were not low due to poor performance of the LED lamps for sale. Instead, the low sales numbers appear to have been related to the other reasons mentioned previously.

## **Work Cited**

Mills, E. and A. Jacobson (2007) "The Off-Grid Lighting Market in Western Kenya: LED Alternatives and Consumer Preferences in a Millennium Development Village," Lumina Project Technical Report #2. Lawrence Berkley National Laboratory.

Mumbi, M. Personal Communication. 20 November 2009.

Radecsky, K., P. Johnstone, A. Jacobson and E. Mills (2008) "Solid-State Lighting on a Shoestring Budget: The Economics of Off-Grid Lighting for Small Business in Kenya," Lumina Project Technical Report #3. Lawrence Berkley National Laboratory.

Tracy, J., A. Jacobson and E. Mills (2009) "Quality and Performance of LED Flashlights in Kenya: Common End-User Preferences and Complaints." Lumina Project Research Note #4. Available from: <http://light.lbl.gov/pubs/rn/lumina-rn4-torches.pdf>

**Appendix A. Manufacturer’s product specification information sheets**

**Nova S200 (the same as the S201)**



**Nova S200  
Mobile Charging  
Solar Lantern**



**Features**

- **Mobile Charging Nova: Plug into Nova and Get a Full Mobile Charge in 1 hr 45 min<sup>1</sup>**
- **30% Faster Charge than Nova S150**
- 12 Hours for Full Charge with Solar<sup>2</sup>
- AC Grid Compatible<sup>3</sup>
- Polycrystalline Solar Panel
- Easily Replaceable with 6V SLA Battery
- Smart Battery Indicator
- 4 Brightness Settings
- 8-10 times Brighter than Kerosene Lamp
- LED 30-50% more Efficient than CFL
- Weather/Impact Resistant
- Robust Circuitry for Long-Life Performance
- Patented Fast Charge AC Technology
- Easy Installation

**Hours of Light**

		Low	Med	High	Bed
<i>From 1 day's charge<sup>4</sup> in weather conditions:</i>		12	6	4	100
		8	4	2	64
		5	2	1	40
<b>On full charge:</b>	N/A	20	10	6	200

1. Based on 700mAh mobile phone battery
2. Charging under full sunlight in 25° C
3. 5-7 hours for full charge on AC
4. Solar charge from 9am – 5pm

- Unit Weight: 1.086 kg
- Units per Carton: 12 units per carton
- Carton Dimensions: 43.9 cm x 32.4 cm x 36.8 cm
- Total Carton Weight: 15 Kg
- 6,504 Units per 20' Container
- 12,281 Units per 40' Container

2000 Dec

## Nova S100



# The Nova S100

## All Purpose Solar LED Lantern (includes solar panel)

### About the Nova S100

The Nova S100 is a premium, all-purpose solar lantern charged by an 8.5V solar panel. The Nova is 8-10 times brighter than a kerosene lantern and 30-50% more efficient than fluorescent lights. The Nova is highly portable and can be used in the workplace, in the field, or for studying or other activities at home.

### Key Features

- Four brightness settings
- 8-10 times brighter than a kerosene lamp
- LED is 30-50% more efficient than CFL
- 8.5V 1.3W polycrystalline solar panel (included)
- Smart battery indicator LED
- Weather resistant
- Robust circuitry for long-life performance
- Deep discharge and overcharge protection
- No installation required
- Replaceable battery



### Additional Specifications

Color	Slate blue
Unit Weight	1.2 kg
Units Per Carton	12
Carton Size	43.7cm x 32.3cm x 36.8cm
Carton Total Weight	16.2 kg

### Hours of Light

Settings	Uses	Hours of Light on 1 Day of Charge (9am-5pm)	Hours of Light on Full Charge
Brightest	Studying / Precision Work	4	12
Very Bright	Working / Cooking	6	20
Bright	Walking / Socializing	12	40
Bed	Resting / Sleeping	100	500

### Charge Specifications

Solar Charge Time	Recommended 19-23 hours to fully charge (direct sunlight at 25° C)
Solar Panel	Aluminum framed 1.3W polycrystalline PV with 3m heavy duty outdoor cable with 2mm plug
Battery Type	6V, 2.5Ah SLA

## Solata



# Solata

**World's Most Affordable Solar Lamp**



### Features

- **Affordable LED Lamp**
- **Charge with Solar Panel (included)**
- **Or Charge with 6V DC Mobile Charger**
- 6 Hours for Full Charge on Solar<sup>1</sup>
- 4 Hours for Full Charge on AC
- Monocrystalline Solar Panel
- Easily Replaceable Battery
- Battery Indicator
- 2 Brightness Settings
- 5-6 times Brighter than Kerosene Lamp
- Flexible Gooseneck for 360-Degree Direction
- Weighs only 160g

### More Features

- Weather/Impact Resistant
- Robust Circuitry for Long-Life Performance
- Also charges with a Nokia mobile phone charger
- Easy Installation

### Hours of Light

	<i>Low</i>	<i>High</i>
<b>On full charge:</b>	15	4

- Unit Weight: 0.337 kg
- Units per Carton: 16 units per carton
- Carton Dimensions: 49.5 cm x 24.5 cm x 28.5 cm
- Total Carton Weight: 6.3 kg
- Units per 20' Container: 16,896
- Units per 40' Container: 32,944

1. Charging under full sunlight in 25° C

2008 Dec

# Firefly5



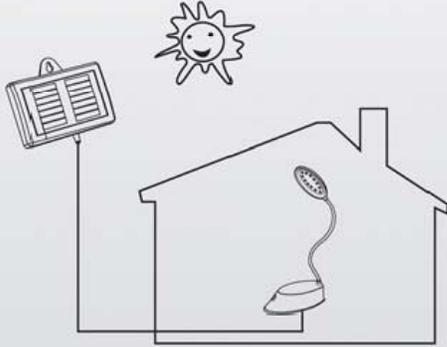
## Firefly 5

### Super Bright LED Lamp

Model: VLP09S005NC1



MADE IN GERMANY  
SOLAR CELLS



Note:  
Please keep the lamp  
inside when charging.

### Product Information

The Firefly "5" Solar Lamp is a new version of Barefoot Power's original Firefly solar lamp. The key innovation is improved design of LED angles to allow the reduction from 12 LEDs to 5 LEDs. A combination of wide and narrow beam LEDs have been used to ensure effective light output.

The narrow beam LEDs enable the lamp to provide similar light intensity as the original Firefly solar lamp, when measured 1-2 meters directly below the lamp. The area of lighting provided by the wide angled LEDs provides sufficient light to move around a room and undertake non-light intensive activities at the other side of a room. While the wide angle light output is not as intense as the original Firefly solar lamp, it is still much more than a kerosene lamp.

The reduction from 12 LEDs to 5 LEDs allows the use of the smaller 0.5W solar panel (1W on Firefly original). These innovations have resulted in a 25% price reduction for the new Firefly "5" Solar lamp over the original Firefly solar lamp.

Other improvements include: a new plastic encasement with a handy hook for hanging the lamp on a wall; LOW and HIGH power settings; and improved battery protection. The original Firefly Lamp is still available (12 LEDs and 1W Panel) with the above improvement.

### Kit Contents



5LED Lamp



0.5W Solar Panel



Colour Box

### Product Specifications

- Battery: 650mAh NiCd (2year\*), 1200mAh NiMH (4year\*\*)
- Solar Panel: 0.5W Polycrystalline
- Panel Wire: 4 meters
- Battery Protection: Overcharge and Overdischarge
- Runtime HIGH Setting: 6 hours
- Runtime LOW Setting: 30 hours
- Charging Time: 6hrs Solar or 3hrs AC
- AC Charging: an AC charger is also available

\*400-500cycles, 1 cycle = 1.5 nights @ 4hrs/night = 2 years (may vary depending on user behaviour)  
\*\*800-1000cycles, 1 cycle = 3 nights @ 4hrs/night = 4 years (may vary depending on user behaviour)

Contact details: Barefoot Power Pty Ltd., 79Morrisset St, NSW, 2795, Australia Ph. +86(0)769 85336728  
[www.barefootpower.com](http://www.barefootpower.com)

# Firefly12



## Firefly 12 Super Bright LED Lamp

Model: VLP09S010NC1

### Product Information

The Firefly "12" Solar Lamp is the original version of Barefoot Power's Firefly solar lamp. It utilises 12 super bright LEDs with a broad angle beam to provide an even spread of light right throughout a room, or if focused on a desk - a very bright reading light.

The Firefly 12 will provide around 4hrs bright light every night when on high setting. Alternatively, the lamp is fitted with a low setting, that can be used as a night light, for approximately 50hrs of use.

The lamp can be charged with a solar panel, or with an AC wall charger (which is sold separately). The rechargeable battery inside the lamp will last about 2 years depending on how the lamp is used. Replacement batteries are available at place of purchase.

The solar panels use German made solar cells, ensuring the highest quality to the end customer and long life time. Extensive work has been undertaken to ensure that the lamp meets similar standards, in particular in the selection of LEDs and batteries.

### Kit Contents



12LED Lamp



1W Solar Panel



Colour Box

### Product Specifications

Battery: 900mAh NiCd (2year\*), 1200mAh NiMH (4year\*)  
Solar Panel: 1.0W Polycrystalline  
Panel Wire: 4 meters  
Battery Protection: Overcharge and Overdischarge  
Runtime HIGH Setting: 4 hours  
Runtime MEDIUM Setting: 7 hours  
Runtime LOW Setting: 50 hours  
Charging Time: 5hrs Solar or 3hrs AC  
AC Charging: an AC charger is also available

\*400-500cycles, 1 cycle = 1.5 nights @ 4hrs/night = 2 years (may vary depending on user behaviour)  
\*800-1000cycles, 1 cycle = 3 nights @ 4hrs/night = 4 years (may vary depending on user behaviour)

Contact details: Barefoot Power Pty Ltd., 79Morrisset St, NSW, 2795, Australia Ph.+86(0)769 85336728

[www.barefootpower.com](http://www.barefootpower.com)

# New LED Lights

**Available NOW**

Brighter Light • No Kerosene • Safer

Come buy at **Broadnets M Pesa Shop** (WaMumbi) Maai

Mahiu

in the ZZ Building

Mobile: 0729074127

	Solata	Nova	FireFly
			
Price (Ksh)	<b>1100/1400</b>	<b>3000/3500</b>	<b>1000-1400</b>
Number of Light Level Settings	<b>2</b>	<b>4</b>	<b>2</b>
Light Hours**	<b>4-15</b>	<b>6-200</b>	<b>4-40</b>
Charge Time*	<b>4-6</b>	<b>5-8</b>	<b>4-8</b>
Charge Options	Grid/Solar	Grid/Solar	Solar
Phone Charge?	<b>No</b>	<b>Yes</b>	<b>No</b>

• Varies with light level setting. Based on a fully charged battery.

\* Based on manufacturer's rated specifications.

## Appendix C. LED Lamp Sales Agreement

### LED Lamp Sales Agreement Off-Grid Energy of Maai Mahiu Lumina Project Lighting Research in Rural Kenya

This paper outlines a sales agreement between you (the person buying the LED lamp) and Off-Grid Energy of Maai Mahiu. The agreement covers the terms of sale, a six-month service guarantee, and an agreement related to participation in research on off-grid lighting products. The research is being carried out by a team led by Dr. Arne Jacobson of Humboldt State University and Dr. Evan Mills of Lawrence Berkeley National Laboratories in the USA.

**Sales and Service Agreement:** Lamps that are purchased in conjunction with this signed sales agreement are covered by a six month service guarantee. The time period for the guarantee begins on the date that the agreement is signed as indicated below. Under the service guarantee, Off-Grid Energy agrees to repair, replace, or refund money for any lamp that fails due to a manufacturing defect. The choice of whether to repair, replace, or refund money is at the discretion of Off-Grid Energy (i.e., the business selling the products). Lamps that are damaged due to dropping or other impacts or due to short circuits not caused by manufacturing defects are not covered under the service agreement.

As the buyer, you agree to have the lamp serviced only by Maina Mumbi of Off-Grid Energy during the six month sales agreement period. If anyone other than Maina Mumbi or his appointed agent attempts to service or repair the lamp during the six month period then the service guarantee aspect of the sales agreement becomes null and void. Opening the lamp (e.g., removing any screws) for any reason by anyone other than Maina Mumbi or his appointed agent also voids the service agreement.

As the buyer, you also agree to participate in at least three survey interviews associated with the research described below. The first interview will take place at the point of sale. The other two interviews will take place within a year of the date that you purchase the lamp.

**Background information:** The team led by Arne Jacobson and Evan Mills is conducting research about the use of off-grid lighting products in Kenya. The purpose of the work is to evaluate the performance of off-grid lighting products and to determine the costs and benefits for users over time. The information will be used to assist in the development of better and more affordable lighting technologies for use in Kenya and other similar places.

The undersigned parties agree to the terms above for the sale and use of the lamp:

\_\_\_\_\_  
Maina Mumbi, Off-Grid Energy and Kenya Representative of Research Team

\_\_\_\_\_  
Lamp purchaser:

Date of Sale: \_\_\_\_\_

For inquiries, please contact Off-Grid Energy in Maai Mahiu, Kenya at 0729-074127

**Appendix D. Point of Purchase survey**

<p style="text-align: center;"><b>Survey Form Portable Lamps in Kenya June, 2009</b></p> <p style="text-align: center;"><b>Market Testing SURVEY – Point of Purchase</b></p> <p>Survey by: Arne Jacobson Humboldt State University Arcata, CA 95521, USA</p>
--

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

1.1 Name of person(s) administering survey: \_\_\_\_\_

1.2 Date & time of interview: \_\_\_\_\_

1.3 Town: \_\_\_\_\_ Location: \_\_\_\_\_

**1.4 Customer ID #** \_\_\_\_\_

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

Name: \_\_\_\_\_

1.6 **Gender:**  Female (1)  Male (2)

1.7 **Contact** information:

a) Mobile Phone # \_\_\_\_\_

b) Place to find \_\_\_\_\_

1.8 **Lamp** purchased: (check one)

Yage 3166 (1)  Barefoot Firefly (2)  d.Light Solata (3)  
 Thrive Accendo (4)  d.Light NOVA (5)  Other \_\_\_\_\_(6)

1.9 **Lamp ID #** \_\_\_\_\_

1.10 **What types of chargers were purchased?** (Mark all that apply)

Grid Charger (1)  Solar charger (2)

1.11 **Datalogger** included?

Yes, Has datalogger (1)  NO, plain lamp (2)

**Section 2: Current Lighting Access (Off Grid):**

**2.1 Regarding each Off-Grid lighting product you use at your home or business:**

- 2.1.1 What **types** of lights and how many of each are used?
- 2.1.2 How much did each **initially cost** you?
- 2.1.3 How many **hours** do you use each lamp **per night**?
- 2.1.4 How much do you **spend** to use the lamp **each night**?
- 2.1.5 How do you **use** each light?

Electric Lamps	Type	Code
Form Factor	Torch	T
	Lantern	L
	Array (or Strip)	A
	Gooseneck Lamp	G
Bulb	LED	LED
	Incandescent	INC
	Fluorescent	FLO
	CFL	CFL
Battery	Rechargeable	R
	Dry Cell (mawe)	D
<i>Ex: T-LED-D</i>		

Fuel Based Lamps	Code
Kerosene Wick	W
Kerosene Hurricane	H
Kerosene Pressure	P
Candles	C

Lamp #	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5						
	Lamp Type	Initial Cost (Ksh)	Total Hours used per night	Nightly Cost (Ksh)	Hours of Use for each type per day						
					General Lighting at Home	Lighting in the Kitchen	Morning Preparing	Lighting your way for walking	Reading/ Studying	At a Business	Other
1											
2											
3											
4											

Note 1: \_\_\_\_\_

Note 2: \_\_\_\_\_

Note 3: \_\_\_\_\_

Note 4: \_\_\_\_\_

### 3 Demographic Information

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

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

3.2 How many **people** are in your household? # \_\_\_\_\_

3.3 How many are **school-going children**? # \_\_\_\_\_

3.4 Do you have **grid** electricity at home?

- Yes (1)       No (2)

3.5 Do you have grid electricity at your business?

- Yes (1)       No (2)       Not Applicable (does not have small business) (3)

### 4 Lamp Purchase Information

4.1 Purchase: (*Check one*)

- Cash (paid full) (1)                       Credit (if credit, complete 4.1.1 below) (2)

4.1.1 (**Credit**) How did you access credit for this purchase?

- Sacco (1)                       Community Committee / group lending (2)
- Other lending organization: \_\_\_\_\_(3)

4.1.2 (**Credit**) What are the terms of credit? (Report all that are known)

Down Payment: Ksh\_\_\_\_\_ Monthly Payment: Ksh\_\_\_\_\_ # of Months\_\_\_\_\_

Fees: Ksh\_\_\_\_\_ Interest Rate: % \_\_\_\_\_

4.1.3 (**Credit**) What will be your total cost for the lamp, including all payments and any credit fees?

Ksh\_\_\_\_\_  Not Sure

### 5 Lamp Uses

5.1 What will be the **main uses** of this lamp? (Mark all that apply)

- General / Social Light (1)       Kitchen (2)
- Reading / Studying (3)       Preparing in the morning (4)
- Finding way at night (5)       For a Business (6)

I don't know (7)  Other\_\_\_\_\_ (8)

**5.2** Will this **replace** one of your current lighting sources, **or be in addition** to them?

Replace → *If replacing, which one (light # from Section 2)*\_\_\_\_\_ (1)

In addition to the current lamps (2)

**5.3** Who are the main **people who will use** the lamp?

Mostly Me (1)

Mostly someone else *Who?*\_\_\_\_\_ (2)

The whole household (3)

People working at the business (4)

**5.4** What is the main way that you will **recharge** the battery?

Charge Shop (1)  Grid at home (2)

Solar Lamp charger (3)  Other\_\_\_\_\_ (4)

**5.5** **Why did you choose** this one over the others? (Check all that apply)

Price - It is the one I can afford (1)

Performance – It is bright enough and will last a long time (2)

Looks – I like the color, shape, design, etc. (3)

Features – The lamp does things or has features the others don't (4)

Ease-of-use – This one looks easier to use (5)

Other\_\_\_\_\_ (6)

**Appendix E. Follow-up survey (full-length)**

<p style="text-align: center;"><b>Survey Form</b> <b>Portable Lamps in Kenya</b> <b>January 2010</b></p> <p style="text-align: center;"><b>Market Trial FOLLOW-UP Survey</b></p> <p>Survey by: Arne Jacobson Humboldt State University Arcata, CA 95521, USA</p>
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**Section 1: General Information (filled in prior to starting interview):**

1.1 Name of person(s) administering survey: \_\_\_\_\_

1.2 Date & time of interview (MM/DD/YYYY): \_\_\_\_\_

1.3 Town: \_\_\_\_\_ Location: \_\_\_\_\_

**1.12 Customer ID #** \_\_\_\_\_

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

Name: \_\_\_\_\_

1.14 **Lamp** purchased: (check all that apply)

d.Light NOVA (1)       Barefoot Firefly (2)     d.Light Solata (3)

1.15 **Lamp ID #**(s) \_\_\_\_\_

**2 Demographic Information**

**2.1** Do you have **grid** electricity at home?

Yes (1)       No (2)

**2.2** Do you have grid electricity at your workplace/business?

Yes (1)       No (2)       Not Applicable (3)

<b>Section 3: Current Lighting Access (Off Grid):</b> <b>3 Regarding each Off-Grid lighting product you use at your home or business:</b> <b>3.1.1</b> What <b>types</b> of lights and how many of each are used? <b>3.1.2</b> How much did each <b>initially cost</b> you? <b>3.1.3</b> How many <b>hours</b> do you use each lamp <b>per day</b> ? <b>3.1.4</b> How much do you <b>spend</b> to use the lamp <b>each day</b> ? <b>3.1.5</b> How do you <b>use</b> each light? (check all that apply)	<b>Fuel Based Lamps</b>	<b>Code</b>	<b>Electric Lamps</b>	<b>Type</b>	<b>Code</b>
	Kerosene Wick	W	Form Factor	Torch	T
	Kerosene Hurricane	H		Lantern	L
	Kerosene Pressure	P	Bulb	Array (or Strip)	A
	Candles	C		Gooseneck Lamp	G
			LED	LED	
			Incandescent	INC	
			Fluorescent	FLO	
			CFL	CFL	
			Rechargeable	R	
			Dry Cell (mawe)	D	
<i>Ex: T-LED-D</i>					

Lamp #	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5							
	Lamp Type	Initial Cost (Ksh)	Total Hours used per day	Daily Cost (Ksh)	Hours of Use for each type per day							
					General Lighting at Home	Lighting in the Kitchen	Morning Preparing	Lighting your way for walking	Reading/ Studying	At a Business	Other	
1												
2												
3												
4												

Note 1: \_\_\_\_\_

Note 2: \_\_\_\_\_

Note 3: \_\_\_\_\_

Note 4: \_\_\_\_\_

#### 4 **Lamp Uses**

4.1 Did the product you purchased fully or partially **replace** one of your lighting sources, **or is it used in addition** to them?

Fully Replace → *Specify lighting source(s) replaced* \_\_\_\_\_ (1)

Partially Replace → *Specify lighting source(s) partially replaced* \_\_\_\_\_  
→ How many hours less do you use the original lighting source specified previously \_\_\_\_\_ (2)

In addition to the lamps (3)

4.2 Who are the main **people who use** the lamp?

Mostly Me (1)

Mostly someone else *Who?* \_\_\_\_\_ (2)

The whole household (3)

People working at the business (4)

4.3 What is the main way that you **recharge** the battery?

Charge Shop (1)                       Grid at home (2)

Solar Lamp charger (3)  At work (4)

Other \_\_\_\_\_ (5)

Notes: \_\_\_\_\_

4.4 How often do you typically charge the lamp?

Daily (1)     Every other day (2)     Two-times per week (3)

Once per week (4)     Other (5), *specify* \_\_\_\_\_

Notes: \_\_\_\_\_

4.5 **Answer the following if a Nova lamp with mobile phone charger was purchased**

4.5.1 Are you **satisfied** with the mobile phone charger?

Yes (1)                       No (2), Why not? \_\_\_\_\_

4.5.2 **How often do you use** the mobile phone charger

Daily (1)     Every other day (2)     Two-times per week (3)

Once per week (4)       Other (5), *specify* \_\_\_\_\_

Notes: \_\_\_\_\_

4.5.3 **Who uses** the mobile phone charger?

Mostly Me (1)

Mostly someone else *Who?* \_\_\_\_\_ (2)

The whole household (3)

**5 Product Satisfaction**

**5.1** What was the thing(s) you **liked best** about the lamp?

**5.2** What did you **not like** about the lamp?

**5.3** Did you experience any **problems** with your lamp?

LEDs failed (1)       LEDs dim (2)       Solar Panel (3)

On/Off switch (4)       Dropped and broke (5)

Water leakage (6)       Battery no longer keeps the charge (7)

Rechargeable charging mechanism failed (8)

Other \_\_\_\_\_ (9)

Notes: \_\_\_\_\_

**5.4** Are you satisfied with the **price** you paid for the lamp?

Yes (1)  No, *what would be a fair price?* \_\_\_\_\_ (2)

**5.5** Are you interested in **purchasing other lamp** products sold at the shop?

Yes (1)  No (2)

**5.5.1** **If yes, which product and why?**

**Product:** \_\_\_\_\_

Why interested in purchasing: \_\_\_\_\_

5.5.2 **If no, why not?** (Mark all that apply)

- Don't have the money (1)  Prefer kerosene/other lamp (2)
- Not satisfied with lamp performance/quality (3)  No need for another lamp (4)
- Don't have financing (5)  Other (6), *specify* \_\_\_\_\_

5.6 If you had the opportunity to return the lamp you purchased for a **full refund**, would you return the lamp?

- Yes (1)  No (2)

5.6.1 If yes, explain why:

**6 Product Feedback**

6.1 Was the light **bright enough**?

- Yes, very happy with the brightness (1)  Just bright enough (2)
- Too dim (3)

6.2 Did the **battery last** long enough on a single charge?

- Yes, it lasted a long time (1)  It lasted just long enough (2)
- It did not last as long as I would have liked (3)

6.3 Is the lamp **durable**?

- Yes, very durable (1)  Somewhat durable (2)
- Not durable, easy to break (3)

6.4 **Additional Notes on Product Feedback**

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At work (4)                       Other \_\_\_\_\_(5)

**3 Product Satisfaction**

**3.1** What was the thing(s) you **liked best** about the lamp?

**3.2** What did you **not like** about the lamp?

**3.3** Did you experience any **problems** with your lamp?

LEDs failed (1)                       LEDs dim (2)                       Solar Panel (3)

On/Off switch (4)                       Dropped and broke (5)

Water leakage (6)                       Battery no longer keeps the charge (7)

Rechargeable charging mechanism failed (8)

Other \_\_\_\_\_(9)

Notes: \_\_\_\_\_  
\_\_\_\_\_

**3.4** Are you satisfied with the **price** you paid for the lamp?

Yes (1)  No, *what would be a fair price?* \_\_\_\_\_ (2)

**3.5** If you had the opportunity to return the lamp you purchased for a **full refund**, would you return the lamp?

Yes (1)  No (2)

**3.5.1** If yes, explain why:

**4 Product Feedback**

**4.1** Was the light **bright enough**?

Yes (1)       No (2)

**4.2** Did the **battery last** long enough on a single charge?

Yes (1)       No (2)

Other (3), Notes \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**4.3** Is the lamp **durable**?

Yes (1)       No (2)

**4.4 Answer the following if a Nova lamp with mobile phone charger was purchased**

4.4.1 Are you **satisfied** with the mobile phone charger?

Yes (1)       No (2), Why not? \_\_\_\_\_

**4.5 Additional Notes on Product Feedback**

\_\_\_\_\_

## **Appendix G. A brief account of how community group money loaning works.**

Community groups serve as support groups that focus on certain issues; a place where people can discuss their concerns about an issue and strategize their resolution. There are several types of community groups in Maai Mahiu, including women's groups, agricultural and water groups, forestry groups, church groups and more. Not all groups offer a loan service, though many do. Samuel Barbwega, a Pastor in Maai Mahiu, is a co-leader of two community groups and a member of a third. One of his groups does not offer loans, but the other two do. In an interview with Samuel he provided some basic information about how the loan process works in his groups. One group offers money-borrowing with an interest rate of 1% and the other at 10%. A group member can take out one loan at a time and there is no restriction on what the money can be used for. A loan under 15,000 Ksh (\$200) has a required payback period of three months, a loan between 15,000-30,000 (\$200 - \$400) must be repaid in six months, and a loan greater than 30,000 must be repaid in one year. In order to receive a loan, the group must first assess the assets of the group member requesting the loan. The borrower must have slightly more than the loan amount in assets in order to be able to borrow the money. The money available for lending comes from the dues members pay to the group each time they meet (one group meets every week and the other meets every other week). Dues are levied as a percentage of the member's income. This is just one example and not all community groups will have the same process, but Barbwega did indicate that many of the groups operate similarly when it comes to loaning money. Not everyone can take advantage of the community group loan offers; some people do not belong to a group and some people may not have the assets to cover a loan. Receiving money through a community group is not an option for everyone, but it can offer assistance to some.

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