LIGHTING AFRICA
Catalyzing Markets for Modern Lighting

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IFC International Finance Corporation
World Bank Group
THE WORLD BANK

The Off-Grid Lighting Market in Sub-Saharan Africa:

Market Research Synthesis Report

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About the Lighting Africa Program

Lighting Africa
Lighting Africa, a joint IFC and World Bank program, seeks to accelerate the development of commercial off-grid lighting markets in Sub-Saharan Africa as part of the World Bank Group's wider efforts to improve access to energy. Lighting Africa is helping mobilize the private sector to build sustainable markets to provide 2.5 million people with safe, affordable, and modern off-grid lighting by 2012. The longer-term goal is to eliminate market barriers for the private sector to reach 250 million people in Africa without electricity, and using fuel-based lighting, by 2030. Improved lighting provides significant socio-economic, health and environmental benefits such as new income generation opportunities for small businesses. Lighting Africa is a key element of the global Solar and LED Energy Access (SLED) program, an initiative of the Clean Energy Ministerial.
For more information, visit www.lightingafrica.org

Lighting Africa is implemented in partnership with: The Africa Renewable Energy and Access Grants Program (AFREA), the Asia Sustainable and Alternative Energy Program (ASTAE), the Energy Sector Management Assistance Program (ESMAP), the Global Environment Facility (GEF), Good Energies, Italy, Luxembourg, the Netherlands, Norway, the Public-Private Infrastructure Advisory Facility (PPIAF), the Renewable Energy and Energy Efficiency Partnership (REEEP), and the United States.

About the World Bank: The World Bank is a vital source of financial and technical assistance in developing countries worldwide, with a mission to help reduce global poverty and improve living standards. However, it is not a bank in the common understanding of the term. Rather, it is comprised of two unique development institutions owned by 185 member countries – the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA). Each institution plays a different but supportive role.

The IBRD focuses on middle income and creditworthy poor countries, while IDA focuses on the poorest countries in the world. Together, they provide low-interest loans, interest-free credit, and grants to developing countries for education, health, infrastructure, communications, and many other purposes. The World Bank concentrates on building the climate for investment, jobs, and sustainable growth to enable economies to grow, and investing in and empowering poor people to participate in development.
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About IFC: IFC, a member of the World Bank Group, is the largest development institution focused on the private sector in developing countries. IFC creates opportunity for people to escape poverty and improve their lives – by providing financing to help businesses employ more people and provide essential services, mobilizing capital from others, and delivering advisory and risk-management services to ensure sustainable development. In a time of global economic uncertainty, IFC's new investments climbed to a record US$18 billion in fiscal 2010.
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1 Executive Summary

The situation

Africa is home to one of the world's largest off-grid populations; approximately 590 million people live with no connection to their national electric grid.[1] As a result, large segments of the continent's population rely on hazardous forms of flame-based lighting, which produce very low levels of light output and require regular purchase of fossil-based fuels. This off-grid population presents a sizeable market opportunity for producers of low-cost alternative lighting products, such as those that are LED based and charged through solar or other means. The Lighting Africa initiative aims to address the lighting needs of off-grid populations by making safe, affordable, durable, and environmentally sustainable lighting available to the masses. Lighting Africa recognises that engaging in this emerging market is a challenge to manufacturers that require in-depth market research to design, develop, and deliver products and business models suited to local market needs.

A key barrier to lighting manufacturers, assemblers, and distributors in reaching these off-grid populations has been a lack of information on which to base their product and market development decisions. Lighting Africa has addressed this information deficit through conducting extensive consumer studies in a selection of test markets: Ethiopia, Ghana, Kenya, Tanzania, and Zambia. The studies included a selection of both consumer households and traders who use lighting products in their business. The insights in this report are based on approximately 10,000 interviews with potential off-grid consumers from four phases of market study in each country:

1. Qualitative Study to understand opportunities and to test modern lighting products
2. Quantitative Usage & Attitudes Study amongst two potential market groups, consumer households and traders
3. Quantitative test of target group responses to selected lighting product concepts
4. Qualitative product home trial study to understand target group interest in specific types of off-grid modern lighting products

The opportunity

The paraffin lamp with glass cover is the most commonly used lighting device in Kenya, Ghana and Tanzania, while in Ethiopia most consumers use paraffin lamps with a simple wick (no cover), and in Zambia 80% of the consumers use candles as their main source of light. Users' needs are not satisfied by the current lighting environment, which presents significant challenges. The main concerns are: light intensity, cost, health problems (from burns and due to emitted smoke) and safety. The fact that modern lighting devices do not negatively impact users' health is one of their key benefits and can be used in marketing.

[1] International Energy Agency, 2009. "World Energy Outlook 2009: Number of people without access to

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Most consumers consider their households to be under-lit. Almost two-thirds say that not all areas in the house that need light are lit. They indicate that lack of lighting restricts activities such as reading, doing homework and preparing food. In addition, approximately fifty percent also report that they are currently inhibited in performing certain outdoor activities due to lack of lighting such as visiting friends and family in the dark and looking after livestock. While most respondents indicate a desire for better lighting, their lack of available funds or the absence of better lighting alternatives available in the market leads to no alternatives being purchased. This widespread lack of appropriate and affordable choices in lighting devices is a strong indicator of a strong potential market.

Key insights from product testing

The following are the key insights from the in-depth four-phase study to inform product design:

1. **Affordability:** The price of the product is the greatest concern for most respondents; due to their typically low incomes, it is difficult to pay the full purchase price at once, and higher prices in general reduced people's willingness to purchase.

    - Consumers' willingness to pay[2] for lighting products depended strongly on their level of exposure to the lighting products. For those who only saw photos of products and heard about their benefits (i.e. similar to exposure to an advertisement), their willingness to pay or perceived value was only about 10-20% of the retail price for good quality off-grid lighting products. As consumers' exposure increased through an opportunity to handle products (i.e. similar to what might occur while shopping at a store) and then an opportunity to try products at home, their willingness to pay approached the recommended retail price.
    - Based on our findings, communicating features and benefits and directly demonstrating product quality and performance are very important aspects of marketing. Consumers are initially sceptical of new lighting product concepts but quickly recognize and respond to the value proposition they present once they have more information.
    - Availability of financing heightened interest in purchasing, especially for the more expensive products. In spite of consumers' perception that lighting products' value is close to their recommended retail price, many indicated that they would be unable to pay without some access to financing.

2. **Recharging methods**: Following users' preferences to minimise purchase costs, low operational cost was also considered an important motivating factor in the purchase decision. Solar recharging was very well received across all countries due to the lack of operating costs. Charging via electric grid power was deemed the fastest and most efficient way to recharge a lighting device where available and practically accessible, but was the least-liked charging option due to the ongoing operating costs associated with it.

[2] Throughout this report, willingness to pay indicates a *perception of value or acceptable price*. It was estimated through a variety of survey techniques. The estimates of willingness to pay do not necessarily indicate ability or intention to purchase because many of the respondents indicated that access to finance was a key barrier to them even if they agreed with the retail price of products.

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3. **Adequate light intensity**: Most respondents' preference was to have one lighting device capable of lighting the whole room instead of serving as only a task light.

4. **Multipurpose**: Many people have only one or two lighting devices throughout their buildings, but more places to light. Therefore lighting devices that are able to light two rooms simultaneously were positively rated. Devices able to light the household as a lamp and also serve as a torch to move from room to room are appreciated for being multi-functional.

5. **Portability**: In a related aspect, both traders and customers currently carry their lighting devices from one room to another and even outside due to bathing rooms, toilets, or kitchens often being detached from the main dwelling. This indicates that there is a need for portable lighting devices or systems capable of lighting multiple areas.

6. **Product placement**: It is important that a product is able to stand up on its own (e.g. the product includes a stand) and can be hung from the roof or the ceiling with a handle or strap.

7. **Long battery life**: Lighting products with a charge that lasts at least 5 hours are in demand, as the stated average period of light required per night is between 5 and 6 hours.

8. **Ease of use**: Products should be easy to use and have a user-friendly appearance. User guides are required at minimum, and user education or demonstrations on how to use the products are recommended.

9. **Safety**: The lighting devices should be safe no matter where they are placed, including when left switched on overnight – e.g. no possibility of burning users or starting a fire.

10. **Security**: Detachable solar panels with sufficiently long cords are preferred to prevent the risk of theft of the lighting device if it is charging outside. Preference was for the panel being placed on the roof of the house, while the device stays safely inside.

Market size estimation

Off-grid users of glass-covered paraffin lamps in the five countries studied spend an estimated total of US$910,000,000 every year, including both purchase and operating cost of the lamps. The three largest markets are Ethiopia, Kenya, and Tanzania.

Roughly 80% of the households in the countries included in our research are not connected to the electric grid. In total, we estimate this segment represents approximately 40,000,000 households in these five countries. We identified a total potential demand for modern lighting products greater than 50,000,000 units among off-grid people; it is split between several product types and price points. The annual potential demand would depend on the penetration into the potential market and product replacement rates.

Potential sales to households that are currently connected to the grid are also high due to the poor reliability of grid power in these countries.

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Challenges

Limited income is the single most pressing challenge for African consumers. Their priority is meeting their families' most basic needs on a day-to-day basis. This leaves very little room for savings and therefore affordability of lighting products is very important. The average monthly household income in the countries included in our research ranges from US$90 to US$154 (based on the averages from the surveys we conducted).

The overall optimum prices for each product among consumers and traders based on their initial reactions are, in general, below the recommended retail prices. However, it is important to note that after testing the products for five nights in their home or business, consumers' willingness to pay moved to near the recommended retail prices. This highlights that consumer awareness of solar and improved lighting products is low; as a result, they do not have a real appreciation of the value of these new innovations. Consumer education (with particular reference to direct marketing) and awareness is critical in demonstrating the value of good quality lighting to initially sceptical consumers.

Another challenge is the fact that, despite respondents being very enthusiastic about solar charged lighting products because they are free of operating costs, they are concerned about the ability to charge the battery in the rainy season. If they are not convinced that a product would be useful to them throughout the year, the probability they will buy this product is likely to be affected.

Recommendations

Manufacturers should focus on the needs of African consumers and traders regarding product design, pricing and marketing. As consumers and traders have low disposable incomes, it is important that they are sure that they can rely on the quality and usefulness of the product that they are buying.

In conclusion, Lighting Africa market intelligence indicates that:

- The design of successful off-grid lighting products should be durable, solar charged, easy to use and, preferably, multi-functional or allow use in two rooms simultaneously.
- The price should fall within the acceptable range indicated by the respondents. Even so, because it will be difficult for consumers to pay the full purchase price at once, financing alternatives are highly recommended. Options should include either consumer financing to offset part of the purchase and operating costs, or allowing purchases to be made in instalments. Modular systems that can be expanded over time and as income allows are another option. Furthermore, if financing is made available, it should be made very clear exactly what is involved, as the idea of financing for capital items is not familiar to many people in these markets.

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- The high initial purchase price of modern lighting products easily deters potential consumers if they are not explicitly aware of the benefits. A lack of trust in product quality and credibility of manufacturers claims for products the consumers have little experience with act as additional deterrents. In addition, people often do not realize how much they spend in total (purchase and operating costs) during the lifetime of their current lighting devices. Results from this study indicate that users spend approximately US$64 - US$310 over the product lifetime; the normalized average is US$158 over 1.4 - 3.2 years, which works out to an average of US$57 annually. It is important that these lifetime costs are communicated to put the purchase prices in perspective.
- Educating the consumer is very important. The marketing process must make buyers aware of the problems that they are facing and how the new lighting devices overcome these problems. The fact that solar-charged products have no operating costs is very appealing to consumers. Because lighting plays a key role in enabling study, and education is seen as key to escaping poverty, emphasising this emotionally potent benefit along with the lack of negative health effects are important marketing points.

Lighting Africa Market Research Data: Available for Public Use

We conducted thousands of interviews with potential end-users of off-grid lighting in Sub-Saharan Africa over four phases to inform this study. Lighting Africa is making these rich datasets available to researchers, manufacturers, and other stakeholders who are interested in analysing them for additional insights into the off-grid lighting market.

To access the data, visit the Lighting Africa website (www.lightingafrica.org). There, you will be asked to login or create an account to gain access.

We ask that those who use the data to create derivative, public works (e.g. journal articles or fact sheets) provide attribution to Lighting Africa for the raw data. Lighting Africa may also be interested in co-publishing or hosting derivative works on the Lighting Africa website. Contact us at qualityassurance@lightingafrica.org for more information.

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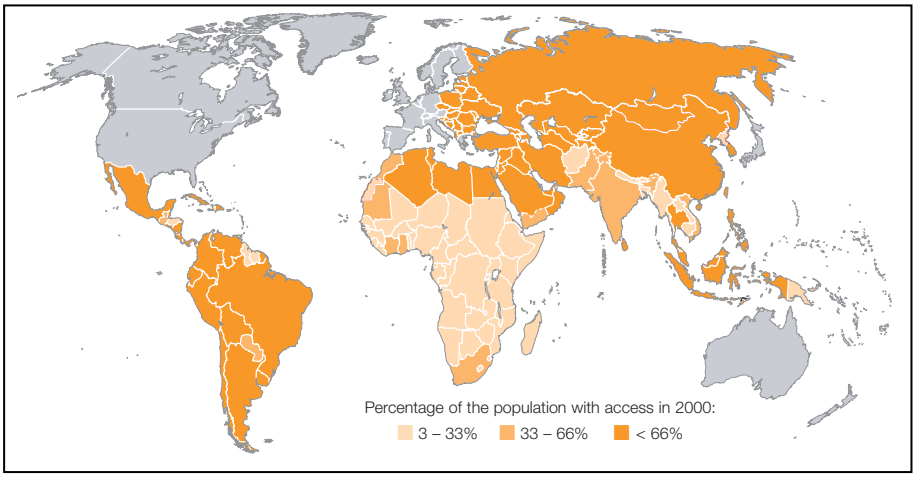
2 Introduction: A giant challenge and a giant opportunity

Africa is home to one of the world's largest off-grid populations; approximately 590 million people are not connected to the electricity grid.

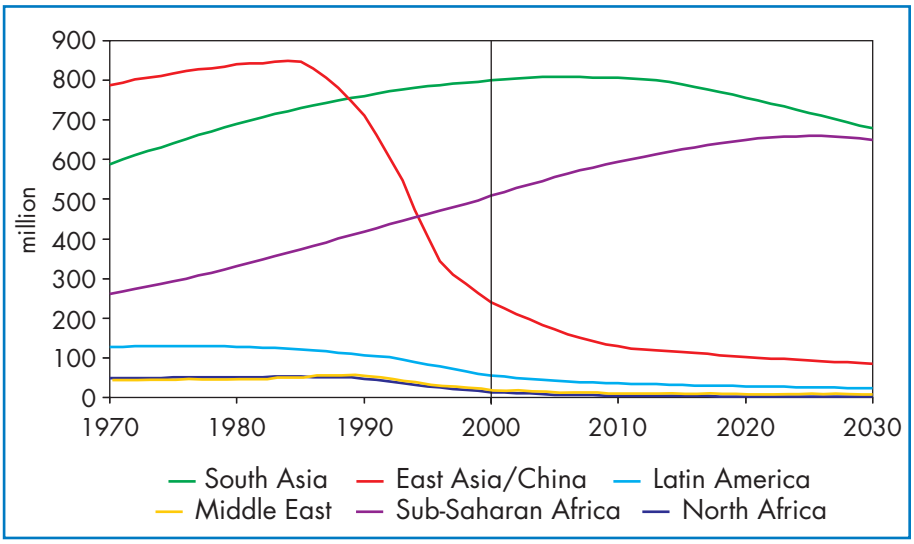
Percentage of the population with access to grid electricity in 2000



Source: UN-Energy: The Energy Challenge for Achieving the Millennium Development Goals, 2005

Furthermore, compared to other parts of the world, Africa's is the only off-grid population which is projected to expand significantly over the next 30 years, as illustrated by the graph below.

People without access to electricity (in millions)



Source: International Energy Agency World Energy Outlook Report 2002[3]

[3] International Energy Agency, 2002. "World Energy Outlook 2002: Figure 13.8: Number of People without Electricity, 1970-2030."

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Although African governments are making an effort to increase electricity coverage, it is mostly outstripped by population growth. Centralized grid electrification may not be a viable alternative in the near term for the majority of today's off-grid consumers, who live in rural areas – too far removed from the grid to justify incremental investments in grid infrastructure. Additionally, many Africans live within sight distance of the national grid but cannot afford the initial cost of a connection.

As a result, in Africa large segments of the poor rely on hazardous forms of flame-based lighting with very low levels of light output, or have no access to lighting at all. Worse, this "un-electrified" group of consumers pays the highest cost for electricity and energy access of all consumers in Africa. Amongst the poorest of the poor, lighting often represents the most expensive item among their energy uses, typically accounting for 10 to 15% of total household income.[4] In return for this disproportionate expenditure, they receive lighting of the lowest and dirtiest quality.

This status quo represents a sizeable market opportunity for producers of low cost alternative lighting products, such as those relying on Light Emitting Diode (LED) technology, who have the potential to offer consumers significant improvements. Preliminary results of an analysis conducted by Dalberg and Associates, commissioned by Lighting Africa, show that African consumers spend an estimated US$10 billion annually on fuel-based lighting. As of today, this potential is largely untapped by the international lighting industry.[5]

Getting engaged in this emerging market is a challenge, as manufacturers will have to provide products and develop business models that are suited to local market needs. The impact, however, promises to go beyond substantial sales volumes and revenue streams. It has the potential to trigger a disruptive change of African lighting standards, with fundamental improvements to life and livelihood at the bottom of the pyramid. Modern lighting can be a stop gap measure between the status quo (fuel-based lighting) and a widespread expansion in access to centrally generated or distributed electricity that will take decades to achieve.

The Lighting Africa program aims to address the lighting needs of African customers without electricity access – predominantly low-income households and businesses. The program's mission is to make affordable, environmentally sustainable, durable, and safe lighting available to the masses, which currently depend on lighting methods such as kerosene lanterns and candles. With these objectives, Lighting Africa is designed to contribute to the Millennium Development Goals by reducing poverty and enhancing quality of life.

While this is clearly an attractive market for lighting manufacturers, a key barrier has been a lack of information on which potential investors can base their decisions. This included a lack of comprehensive consumer data and insights. To address this deficit, extensive consumer studies were conducted between March 2008 and May 2009 in a selection of test markets: Kenya, Ghana, Ethiopia, Tanzania, and Zambia.

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[4] Lighting Africa, *Catalyzing Markets for Modern Lighting*

[5] IFC, *Lighting the Bottom of the Pyramid*; Evan Mills, International Association of Energy Efficient Lighting & Lawrence Berkley National Laboratory

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This report distils the key insights from the market research in these five countries. Its purpose is to provide a comprehensive, in-depth assessment of consumer behaviour in the market for lighting products to enable interested manufacturers to better evaluate and access the market. The synthesized insights into Africa's lighting consumers focus on the following:

- Current lighting needs of the populations studied
- Current lighting usage habits and attitudes
- Current spending on lighting and the expected willingness to spend on modern lighting devices
- Product acceptance with a focus on the desired functionality and design attributes of modern lighting products within several different product classes (i.e. Torch, Area Light, Task Light, Lantern, and Spot Light)
- The size of the opportunity and the likelihood of uptake for various types of lighting products

These insights were based on a sequence of four qualitative and quantitative market tests per country. Product testing was exclusively conducted with generic products to prevent brand- or manufacturer-related biases. Appendix 7.2 provides a detailed description of the research methodology applied, but the following chart is a summary.

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Phase 1: Qualitative Study (March/April 2008)

To define profile and behaviour as well as wants and needs regarding lighting

- Observation and in-depth interviews with respondents in their own environment. Respondents tested representative devices in familiar surroundings for three nights
- n=55 off-grid consumers and traders per country, urban and rural

Phase 2: Quantitative – Usage & Attitudes Study (June/July 2008)

To quantify usage, habits and attitudes as well as acceptable price ranges for modern lighting products

- Questionnaire specifically related to lighting wants & needs, lighting behaviour and expenditure on lighting
- n≈1000 consumers and n≈400 traders per country, urban and rural, of which a maximum of 10% was connected to the grid

Phase 3: Quantitative - Concept test Study (November/December 2008)

To quantify and identify which specific types and designs of lighting products were most acceptable

- Highlighting strengths and weaknesses of various lighting products
- A concept board was used which clearly depicted the modern lighting product to be evaluated and included a short description of its features, battery life and price
- n=300 consumers and traders per country, urban and rural

Phase 4: Qualitative Study (April/May 2009)

To test a selection of new modern lighting products & identify which designs were most acceptable

- Observing and interviewing respondents in their own environment. Respondents tested a selected group of devices in their own house for five nights
- n = 20 consumers per country, urban and rural

For an overview of concept descriptions and products tested in each phase, please refer to appendix 7.4.

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3 Consumer fundamentals

3.1 Understanding the profile of typical African households and traders

The views and habits of consumers and traders were explored separately in these studies. The rationale for this initial distinction was because it was felt that both consumers and small-scale businesses represented two important target market segments for lighting products. For both households and traders, the consumer research revealed **a set of relatively homogenous characteristics** across all five test markets. The resulting consumer profiles give aggregated insights into what informs the preferences, constraints, and decisions of African lighting consumers. We should remember when reading this section, that the sample was selected in such a way that a majority of these households and businesses are off-grid.

Here are five "enlightening" basics about African households:[6] [7]

1. A plurality of households (40%) consists of 4-5 people, including 1-3 children (<16 years old). Their average monthly income ranges from US$90 to US$154.[8] See appendix 7.5 for the exchange rates used.

Table 1. Average monthly income[9].

Income Structure	Unit	Ethiopia	Ghana	Kenya	Tanzania	Zambia
Monthly household income	US$ (Ø)	115.7	115.9	153.6	90.0	150.9

2. Limited income is the single most pressing challenge for African consumers in the lower LSMs (living standard measures; see Appendix 7.3 for details). Their priority is to meet their families' most basic needs on a day-to-day basis. This leaves very little room for savings. Purchases are mostly limited to basic commodities (e.g. staple foods, vegetables, wood fuels for cooking, paraffin for cooking and lighting), which claim the highest share of income among higher LSMs, too. This constrains the funds available to purchase new lighting devices. Purchasing decisions are made by the head of household or the spouse, while parents, siblings, and children have very little or no influence.

3. Improved education is the single most important aspiration among African consumers, across all LSMs and rural and urban populations. It is considered to be the most critical pre-requisite to sustainably improve their living standards. Access to improved power sources (e.g. grid

[6] Phase 1 Qualitative Study

[7] Phase 2 Quantitative Usage and Attitudes Study

[8] Phase 2 Quantitative Usage and Attitude Study

[9] Phase 2 Quantitative Usage and Attitude Study

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connection) is perceived to have a similar impact, notably via lighting and the usage of electrical home appliances. Further needs relate to improved water supply and better housing conditions.

4. One third of the consumers express an explicit desire for an improved lighting solution. Except in Ethiopia, every second consumer believes that improved lighting would significantly change their day-to-day life, and allow them to use their time more effectively. Consumers across all LSMs and countries typically get up before dawn (before 6 am) and go to bed after dark (10 pm). In these "dark" hours, they typically do household chores, prepare and cook food, socialize, or study for school, which are directly influenced by the available amount of light. In Ethiopia, only 25% believe that modern lighting devices would affect their day-to-day activities.

5. In one out of two households, the walls and roofs are dark-coloured due to the materials used. This results in significantly reduced indoor brightness, and raises the requirement of adequate light intensity. In addition, sanitation facilities are frequently shared and therefore lay outside the home, which indicates a need for portable lighting devices.

Some interesting facts about African traders:[10] [11]

1. These are extremely small businesses, with 90% being owner-operated, one-person businesses. In Kenya, Tanzania and Zambia roughly half of the businesses operate in premises 3 m^2 or less in area. The premises in Ghana and Ethiopia are slightly bigger: between 3-8 m^2. Those fortunate enough to have shops generally serve their customers and pile their stock in one room; in some cases, there is a back room for storage of stock. In other cases, the shop is a room in the house of the owner where one room is converted into the shop space and the back rooms are used as bedrooms and living space.

2. Many traders conduct their business outside on tables or in market stalls, where there may not be a place to easily hang a lantern at night.

3. Traders have small, dark premises. About half of those with permanent structures have bright-coloured walls, while the other half have dark walls.

Estate Shop
Slum Urban Nairobi

Roadside Shop
Urban Ethiopia

Makeshift stands / kiosk
Urban Ghana

[10] Phase 1 Qualitative Study

[11] Phase 2 Quantitative Usage and Attitudes Study

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4. Those working in business premises have to go elsewhere to use the toilet. Toilet facilities were found on the shop premises in very few cases. The journey to the toilet after dark could be very difficult without a torch or other portable lighting device.

5. Market traders open as early as 6:00 am and thus have a significant need for lighting products while they are setting up their stalls in the morning. Some food vendors work into the night until the food they are selling is sold; most finish trading before midnight. About half of the urban businesses close between six and 7 pm, at which time it's already dark thus lighting devices are already required. There is also indication of an opportunity in that a substantial proportion of both urban and rural retailers gave the lack of good lighting and the high cost of paraffin as reasons for not staying open late.

6. The average monthly revenue of traders is highest in Zambia (US$502) and lowest in Ethiopia (US$182). Most households of traders have someone earning income from another source, over and above their shop income.

7. Improved lighting is one of the top priorities for most business facilities, next to general improvements to the structure itself. About 25% of the respondents said the reason they wanted to have a grid power connection was to improve their access to lighting.[12]

8. Most retail businesses with permanent structures do not admit customers inside the store, instead serving them through a serving window or opening.

Detailed tables of data relevant to this section can be found in appendix 7.6.

3.2 Which devices and fuel types are currently used for lighting? For which activities and for how long?

3.2.1 Consumers

A paraffin lamp with a glass cover is the most commonly used lighting device in Kenya, Ghana and Tanzania while in Ethiopia most consumers use a paraffin lamp with a simple wick and no cover, and in Zambia, 80% of consumers use candles as their main source of light. This is shown in the table below. It should be noted, however, that the low usage of flashlights presented in the table reflects the fact that flashlights are mainly used to light the way to the toilet outside or as a backup light and not as a main device to light the living room.

[12] Phase 1 Qualitative Study

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Table 2. Types of lighting devices (in %) used by traders and consumers per country[13].
Question consumers (base: total sample): "What, if anything, was used to light the main room last night?"
Question traders (base: all who use lights in their business): "What, if anything, is used to light the business?"

		Ethiopia	Ghana	Kenya	Tanzania	Zambia
Paraffin lamp with glass cover	Consumers (%)	14	72	67	60	6
	Traders (%)	47	70	48	75	4
Paraffin lamp with simple wick (no cover)	Consumers (%)	69	5	30	30	8
	Traders (%)	43	8	4	7	4
Candles	Consumers (%)	4	18	5	19	79
	Traders (%)	20	18	10	25	77
Flash light	Consumers (%)	10	12	10	8	3
	Traders (%)	15	20	8	9	6
Light bulb in socket or lamp	Consumers (%)	8	6	8	10	6
	Traders (%)	7	11	10	12	14
Firelight	Consumers (%)	11	2	0	7	5
	Traders (%)	3	0	0	0	0

In more than half of households survey respondents said that they use paraffin and kerosene for cooking as well as lighting.

When consumers were asked if there was one thing they could do to improve their household or facilities, approximately 30% responded that they would like better lighting and about 12% that they would like to connect to the power grid or improve their power source. Of those desiring a grid connection, 40% say they would use the power to improve access to lighting, 30% mentioned that it would improve their overall standard of living and 30% said they would then be able to use household appliances whenever they want.

Early in the morning lighting is needed when preparing breakfast and doing household chores. Some, especially mothers with young children, do their laundry early in the morning when it is still dark, so that they have time for other household chores before leaving the house. Lighting is used for about 1 hour in the morning.

In the evening, various activities take place in the household. Typically, the woman will be in the kitchen preparing dinner, the children will be doing their homework in the living room, and the man will also be in the living room, relaxing or listening to the radio. Socializing is a very important aspect of the evening together; in some households, praying is as well. Children's rooms are sometimes lit, as they are sometimes afraid to sleep in the dark, and mothers with small children may keep a dimmed light on in case they need to breastfeed and change the baby at night. In rural areas,

[13] Phase 2 Quantitative Usage and Attitude Study

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there are insects that move around at night that can be harmful. Fuel-based lights are used to keep them away; the insects are repelled by the smoke.

Lighting products with a charge that lasts for at least 5 hours are required. In the evening, on average, it gets dark indoors between 6:00 pm and 7:30 pm and most people start switching on or lighting lights around half an hour later; some start using lighting devices after it is already dark, perhaps to save on fuel. It is likely that lighting devices without operating costs will increase the number of hours houses are lit. Lights are turned off between 9:30 pm and 11:00 pm by the majority of respondents, bringing the average number of hours a lighting device is used to about 5 hours: 1 hour in the morning and 4-5 hours in the evening.

On average, two rooms are lit in a household in the evening. This is usually the main room and the kitchen. Ethiopia is most likely to have only one room lit after dark. The time together in the main room of the house in the evening is the main activity for which light is required, and this room is the one used and lit longest. When it is time to go to bed, the same light is carried to the sleeping area.

Since education is seen as a key to escaping poverty, this is a very emotionally charged issue that can be used to market lighting. Lack of lighting restricts activities, particularly reading, doing homework, and preparing food. Respondents showed particular concern that the education of their children is hampered by a lack of light to do homework.

There is a need for torches as well as lamps, or combination products. A majority of toilets in off-grid households are outdoor pit latrines. This means that the family has to travel some distance in the dark to reach them and they can be very treacherous, especially for small children, since the toilet is an open gap. Bathing rooms are also outside the main house. Currently, lamps used inside are carried to the toilet and bathing room when required because these facilities are usually outside the main house, leaving those remaining in the main house in the dark.

About half of the respondents report that they are currently inhibited in performing certain outdoor activities due to lack of lighting. Apart from visiting the toilet and bathing room, these mainly consist of visiting neighbours or friends, and looking after livestock, especially in Ethiopia.

Survey respondents consider their households to be under-lit. Almost two-thirds say that not all areas in the house that need lighting are lit. This mostly concerns the toilet and bathing room as well as the patio or yard. As these areas are generally used only on an intermittent basis, lighting them continuously is not a high priority. In addition, more than 25% of the respondents answered that the cooking area was not lit adequately.

The view that households are under-lit indicates an opportunity for lighting manufacturers. It is important to know where respondents place their lights, to assist in product design. Generally, people place their lamp in the main room on a table or coffee table. Exceptions are Ghana, where half place their lamp on the floor, and Ethiopia, where half hang their lamp from the wall. A quarter of all households in the study say they move their lamp around as required.

Detailed graphs of data relevant to this section can be found in appendix 7.7.

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3.2.2 Traders

Half of traders operate their business regularly after dark, and a further 15% do so occasionally. Most use lights before daybreak or after dark; a small minority (5-15%) use them during the day as well. Most shops operate sufficiently on sunlight during daytime hours. In businesses, lights are used for about an hour in the morning, and for about one to three hours in the evening. Half of businesses not operating regularly after dark would do so if they had adequate lighting, as they would be able to attract more customers. Another 25% would open after dark occasionally if they had better lighting available.

This represents a significant opportunity for improved lighting. Light is used to both enable operation and attract customers. Traders in Ethiopia are least interested in operating after dark, with 70% indicating that they would never open their doors after dark, even if there would be adequate lighting.

A paraffin lamp with a glass cover is the most commonly used lighting device in Kenya, Ghana, Tanzania and Ethiopia, while in Zambia, 80% of traders use candles as their main source of light. Details are presented in table 2 in section 3.2.1. Lighting is used to attract customers, improve security, illuminate products on the shelves, light the faces of customers, and see money. Currently a single light normally serves all these purposes.

Lighting systems currently in use may not satisfy the multiple requirements of business lighting, and any new product has to consider this multiple-feature requirement. In premises with more than one room, lighting priority is given to the room that serves customers. When traders need to get something from the back rooms, they carry the portable light with them, leaving the customer room dark while they are gone.

Light design needs to be portable and, if possible, able to light two rooms at once. A majority of the traders prefer to position lighting devices at the till where money is collected or to light up the products they sell. A few traders keep another form of portable light that they use when going to the toilet outside the premises. Business lighting is a specific market in that a majority of traders use their lighting devices in their business premises only.

Open-air market traders who work after dark often rely on streetlights. When these are not working, they use a lamp or torch or they are forced to close due to lack of security.

The level of lighting outside the business is considered insufficient by 75-95% of traders, depending on the country. This results in concerns about security. Poor outside lighting also limits the visibility of the business it; customers may think the shop has closed or overlook it entirely.

Outside lighting is a potential area of opportunity for new products, although cost restricts traders' ability to buy more than one device as discussed in section 4.4. Despite the opportunities for improvement observed, the majority of traders say they are fairly or very satisfied with the current lighting of their business. The percentage of traders that is fairly or very dissatisfied is about 30% in Kenya, Ghana, and Zambia, and approximately 15% in Ethiopia and Tanzania. When asked, however, they do express a desire to have better lighting; most say they haven't done

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anything due to lack of available funds or because they have simply seen no better lighting devices available on the market.

Among those business people who are dissatisfied, the brightness of the light is the largest contributing factor. They state that it is difficult to read packaging, prices, and money in the dim light from a paraffin lamp, and, more importantly, that bright light attracts more customers. Another issue is that they do not own a sufficient number of lighting devices because they cannot afford it. Security is also a concern, albeit to a minority.

This prevailing lack of choice in lighting hints at a strong potential market. Marketing for new lighting devices must make buyers aware of the problems they are facing and how the new lighting devices overcome these problems.

Detailed graphs of data relevant to this section can be found in appendix 7.8.

3.2.3 Electric Grid Connection

While those not on the grid have a clear need for modern lighting products, both consumers and business people that are connected to the grid say that power outages are frequent and as such they also have a need for back-up lighting. Given that they have higher disposable income than those not on the grid, they may be some of the early adopters of LED lighting and could form an important target group.

Power outages in these countries occur at least once a week for large proportions of the population (40-70% of our survey respondents). Zambia has the most outages and Kenya is least affected. Even when power is available it is not necessarily adequate; a quarter of respondents connected to the grid gave the quality of the electricity a low rating. The number of hours electricity is available per day varies significantly amongst the countries, and can be as low as 4 hours per day (Tanzania).

Detailed graphs of data relevant to this section can be found in appendix 7.9.

3.3 How many lighting devices do consumers use, how much do consumers currently spend for lighting purposes, what are dominant purchasing criteria?

3.3.1 Number of lighting products per household

Based on the most commonly used lighting devices in the countries in the study, most households use in the range of 1.3 to 2.1 lighting devices at a time to light their homes. As noted above, this means that activities are often interrupted in order for the lighting product to be utilized in an alternative activity, such as going to the bathroom.

This indicates a market for a second lighting device, although the ability to afford a second device is constrained by price.

Detailed data relevant to this section can be found in appendix 7.10.

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3.3.2 *Purchasing criteria*

The most significant lighting-related challenge that consumers and traders face is cost. There has, in addition, recently been an inflationary period across Africa with increases in fuel and food prices. Pricing, therefore, is the most critical factor for manufacturers to address when launching modern lighting products

Within the lighting options available to respondents, based on their budget, the following factors are important in selecting a device: safety, light intensity, health (e.g. emission of smoke), familiarity, value for money, durability, convenience and ease of use.

The characteristics respondents gave when asked to describe an ideal lighting device are discussed in section 4.2.

3.3.3 *Durability of lighting devices*

The average lifespan of current lighting devices is short, at only 1.8 years. The paraffin lamp with glass cover and the pressure lamp are estimated to last an average of 2.5 years, while the tin paraffin lamp with no cover lasts for only 1.3 years, as the quality of the latter is much lower.

This means that there is a fairly frequent renewal cycle and potential sales opportunity as existing products need to be replaced.

3.3.4 *Current expenditure on grid electricity*

The sample for this study was selected in such a way that 10% of respondents are connected to the grid. Some of these cannot afford to use grid electricity continuously, so are also a potential target market for modern lighting devices.

The highest average monthly electricity bill expenditure is found in Zambia, the lowest in Ethiopia, as shown in the table below.

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Table 3. Monthly expenditure on electricity for those connected to the grid (median*)[14].

	Consumers	Traders
	US$	US$
Ethiopia	4.4	5.5
Ghana	9.4	10.6
Kenya	6.4	5.9
Tanzania	11.8	11.9
Zambia	28.5	31.5

* The median is the middle value in a set of ordered data and used in skewed distributions (i.e. not normally distributed data). For the mean values refer to appendix 7.11.

3.3.5 Purchase price and operating cost of existing lighting devices

The graphs below give an overview of the initial purchase price of various lighting devices as well as the operating costs for each (e.g. costs for batteries and kerosene). A complete overview of the exact purchase prices and operating costs per country can be found in appendix 7.12.[15]

As shown in the graph below, the prices of battery-powered torches are similar in the five countries, between US$1 and US$2. The prices of the other lighting devices vary from country to country. In most countries, the paraffin lamp with cover is most expensive and candles are least expensive. The average price for a paraffin lamp across all countries is US$4.90.

While the paraffin lamp with glass cover is most expensive, as noted previously it lasts longer than a tin lamp (or candles), and hence is cheaper in the long run. It also has additional features such as the ability to dim the light, which reduces paraffin consumption. It of course can be used by a number of people in the same room, unlike a torch, which is single-user only.

[14] Phase 2: Quantitative Usage and Attitude Study

[15] Phase 2 Quantitative Usage and Attitude Study

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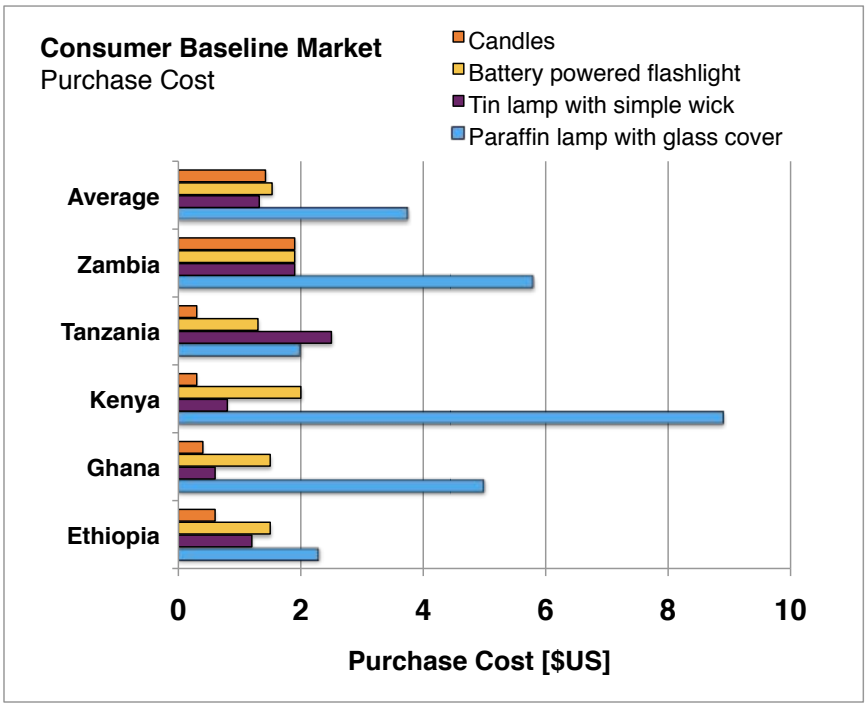
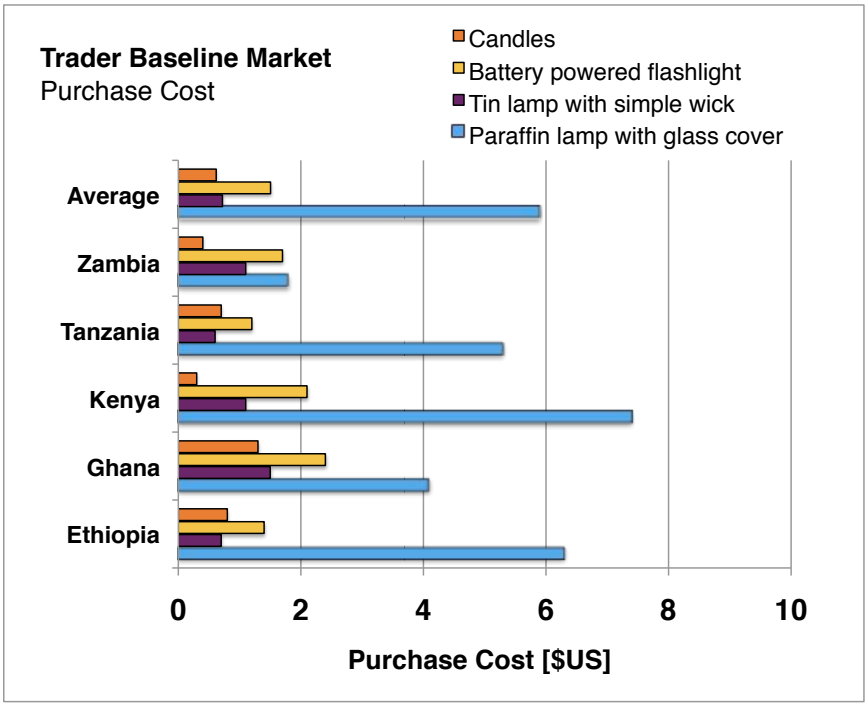


Graph 1. Consumers: Lighting device purchase cost.

Amongst traders, the paraffin lamp also has a relatively high purchase price compared to the other devices, as shown in graph 2.[16]



Graph 2. Traders: Lighting device purchase cost.

[16] Phase 2 Quantitative Usage and Attitude Study

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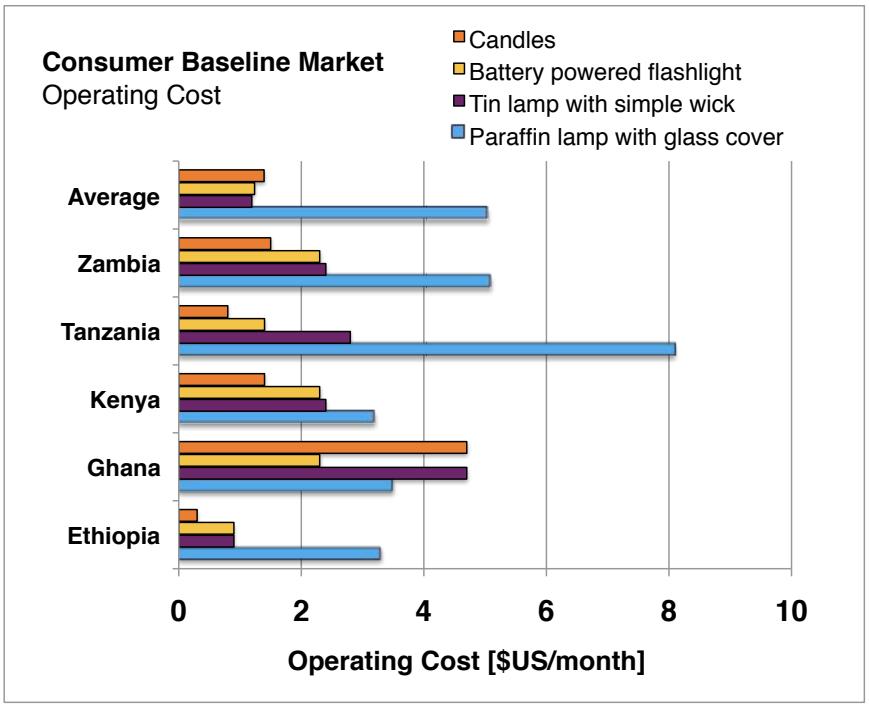
Because the survey data does not distinguish between the frequency of use of multiple types of lighting device within the same household, nor the number of hours that a device is used, the graphs here are not normalized to reflect operating cost per hour of use; they only show average operating cost for households or traders that use the device. The data is, therefore, significantly biased for infrequently used secondary devices in countries where that device is not in widespread use as a primary source of light. An occasionally-used secondary lighting device will have a relatively low average operating cost compared to more commonly-used devices, making the apparent operating cost of the device appear lower than the price of its fuel per hour would indicate were the data normalized based on use.

The operating costs for the paraffin lamp with glass cover are highest in most countries; since it is a commonly used device, this reflects the high cost of fuel. Zambia is an exception, as candles are the most regularly used lighting devices followed by the tin lamp with simple wick, so the operating cost of paraffin lamps with glass covers may reflect less frequent use of the devices. The monthly operating cost of the paraffin lamp with glass cover ranges from about US$3 to US$8, depending on country.



Graph 3. Consumers: Lighting device operating cost per month.

Lighting operating costs for traders vary considerably from country to country. The differences in costs vary from US$2 to US$4 per month in Ethiopia and Tanzania, and US$10 to US$12 in Kenya and Tanzania. Zambia is again an exception, with the tin lamp with simple wick having the most expensive operating cost, followed by candles. The discrepancy is in part because those who use candles, and to a lesser extent tin lamps, in other countries do not use them as their primary lighting device, but as an occasional supplemental device.

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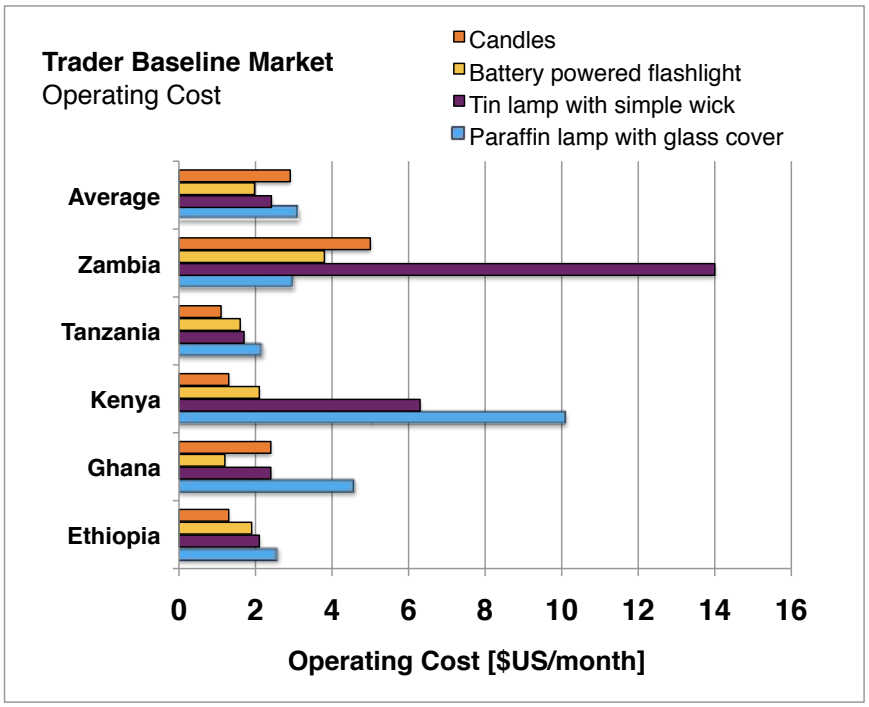

Graph 4. Traders: Lighting device operating cost per month.

Thus, if we take the average purchase price of a glass-shaded paraffin lamp paid by consumers, plus the monthly operating cost multiplied by the average lifetime of the product, we get a total cost ranging from US$64 to US$313, depending on country, over lifetimes ranging from 1.4 to 3.2 years. This gives an average lifetime cost of US$158 when normalized by population and fraction thereof using the lamps in question. Average annual cost, including purchase of the device, ranges from US$40 to US$98, with a similarly adjusted average of US$57 per year.

Manufacturers designing modern lighting products need to bear in mind this "competition" when considering pricing as well as marketing, especially for mass-market consumers. It is important to communicate and emphasize the zero or highly reduced operating cost of solar LED products, along with the length of time they last, as this will be a critical factor in encouraging consumer uptake. It would of course be possible to market more expensive lighting products to the higher LSM groups, and a dual variant approach could be considered to serve the two different markets.

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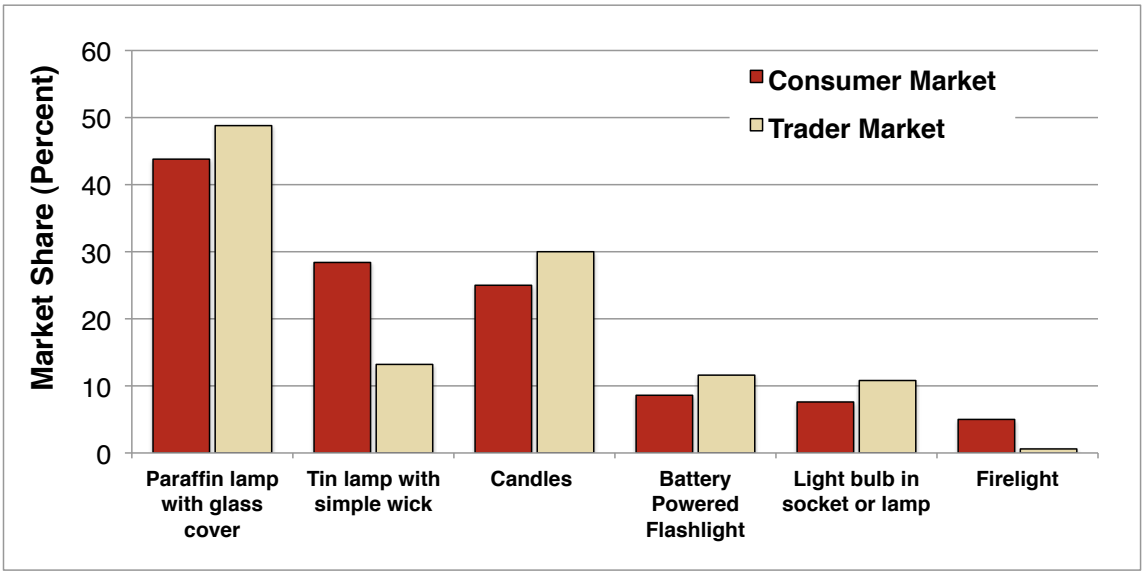
4 Ready for next generation devices: consumer feedback on lighting products

4.1 What are consumer perceptions of currently available lighting devices? Are consumers satisfied with their current lighting devices?

As mentioned in section 3.2 the paraffin lamp with glass cover is the most commonly used lighting device in three of the five countries included in our research. The graph below provides an overview of the use of the current lighting devices across all countries.



Graph 5. Types of lighting devices used, average across countries, consumers and traders (%).

The tables below show the advantages and disadvantages of each lighting device. Current fuel-based lighting devices present significant challenges to users, and do not satisfy their needs on a number of levels. When evaluating electrical lighting devices, the main positives are ease of use, safety, and portability, while the main negative is the expense. The lack of choice available to most people means that they are "trapped" in their current situation. The problems they face with currently available technologies should lead consumers to look for better options elsewhere. However, this would only be the case if these other options were available within the optimum price range that consumers are willing to pay, which is explored in the next section.

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Table 4. Advantages and disadvantages of current lighting devices.

Lighting device	Advantages	Disadvantages
Firelight from wood	• Cheap	• Risk of fire • Smoke deposits smell on clothes
Candles	• Easy to use • Cheap	• Dangerous: High risk of fire due to instability of candles • Easily blown out by the wind • Low light intensity • Messy (wax) • Bad smell
Tin lamp with simple wick	• Cheap • Widely available • Easily made at home • Portable	• Dangerous: Capable of causing a fire • Smokes a lot – irritates eyes and blackens ceiling • Bad smell • Easily blown out by the wind • Low light intensity
Paraffin lamp with cover	• Easy to use • Safer than open flame lamp • Portable • Gives enough light for usage by more than one person • Light can be controlled	• Paraffin is expensive • Bad smell • Smoke irritates eyes and causes health problems • Glass shades need to be cleaned regularly and can break • Filling the lamp with paraffin is messy • A lot of heat is emitted
Kerosene pressure lamp	• High light intensity	• Limited portability due to weight and delicate wick • Sometimes too bright, causes glare • Expensive: Initial purchase and fuel • Dangerous: Risk of explosion • Too much effort to use the lamp (pumping)
Torch	• Easy to use • Safe • Portable	• Batteries are expensive • Low light intensity • Short battery life
Light bulb connected to electric grid power or generator	• Bright • No smoke • Safe • Easy to use	• Frequent power blackouts so alternative lighting devices required • Expensive • If connected through neighbours, they often dictate the time of usage • Generators are hard to turn on (especially by women) • Refueling is expensive and dangerous
Rechargeable light	• High light intensity • Portability	• Unreliable • Short battery life • Expensive

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Respondents were also asked to rate each type of lighting device by ease of use. Paraffin lamps with glass covers, candles, and flashlights are considered the easiest to use. Their ratings on ease of operation are higher than solar powered lanterns, paraffin lamps without a cover, light bulbs in sockets, and lamps connected to gas bottles. The full results are included in appendix 7.13.

Negative health impacts are one of the issues reported by those using paraffin and kerosene. Levels of concern about negative health effects of using paraffin or kerosene vary from about half in Kenya and Zambia, one-fifth in Ghana and Tanzania, and only 4% in Ethiopia. Health problems mentioned are coughing, asthma, breathing difficulties, itchy eyes, headaches, the risk that children might drink the paraffin or kerosene, and soot in the nostrils. Eyestrain and poor eyesight caused by very bright pressure lamps are also mentioned.

The lack of negative health effects is one of the key benefits of the modern lighting devices, and can be used in marketing.

Most consumers did not report negative impact on the environment as an issue with the fuel-based lighting products they currently use; while they may be aware of the comparative environmental benefits of modern lighting, they are not a factor that many take into consideration when choosing lighting products.

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4.2 What are the characteristics of consumers' ideal lighting product?

Before seeing the modern lighting products that were tested, respondents describe the ideal lighting product as light bulbs connected to the grid or solar powered lighting. This indicates both a familiarity with as well the aspirational value of grid connections. Ease of operation, affordability, and adequate light intensity are the key features required. The ideal lighting product is also safe to use, generates little or no heat, does not produce smoke, and can be hung from the ceiling or a wall. Durability and portability (regarding weight and size) were also mentioned as important. The ideal lighting product should also be made by a reputable manufacturer in order to increase consumer confidence in the product, indicating the value of investing in and building up brand recognition.

The eleven most important aspects to consider when developing a new lighting device are listed below. This information was taken from a combination of insights from the quantitative study and findings from the qualitative.

Table 5. Characteristics of the ideal lighting device.

The ideal lighting device should be:	
Affordable	Most people live a hand to mouth existence and struggle to provide food for their family on a daily basis. The purchase price should not be too high; as most people do not save any money, they cannot spend much at once. Financing or payment in installments as well as modular systems would be a solution to overcome this problem. Ideally a lighting product is free from operating costs.
Portable	Many people often have only 1 or 2 lighting devices, but more places to light. Bathing rooms, toilets and kitchen are often detached from the main dwelling, which creates the need for a portable device that is not too heavy and has a good handle/strap. Portable lights can be used in the living room or kitchen during the evening and in the bedroom at night.
Sufficient light intensity	As most people have only 1 or 2 lighting devices, it is important that the light intensity and dispersion of at least one product be sufficient to light one whole room, e.g. the living room, so one light is sufficient for the activities of all family members in one room.
Able to control light intensity	As lighting devices are used for several activities, it is useful to be able to control the light intensity. During the evening the light should be bright enough to light the whole living room, while later at night dim light may be more useful.
Safe	A lighting device should be safe to use, especially for families with young children, e.g. no risk of electrocuting the user or setting the house on fire (i.e. no open flame).
Durable	The purchase of a modern lighting product represents a significant expense for most off-grid households. Therefore, durability, as well as credibility of manufacturer claims, are important factors that influence purchasing decisions.

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Table 5 continued.

Long run time	The light should be reliable once a device has been fully charged, because most people need the device for a minimum of 5 hours a day, and wish to use lighting products even longer. Solar charged products should provide enough light and allow for flexible operation (e.g. light intensity modes) to address different charging behaviours and available sunshine.
Easy to use and to maintain	An ideal lighting product is easy to use and maintain as people are intimidated by complex (looking) products that are difficult to operate. In addition, they don't have the time to deal with long processes to light or maintain a device.
Chargeable without the risk for theft	Detachable solar panels and sufficiently long cords are preferred, as people do not like to leave devices outside of their house unattended because of the risk of theft.
Familiar in design	People prefer product designs they are familiar with. Lighting devices that look too modern/different might alienate them.
Multi-purpose	As lights are often used for multiple purposes, it is convenient for people to be able to place them on a table, on the floor, hang them on a hook, or hold them in their hand.
Branding	Consumer confidence in products is automatically increased if a lighting device is endorsed by a known manufacturer. On the ideal lighting product the name of the reliable manufacturer is clearly mentioned.

4.3 How do consumers perceive potential new products?

The Lighting Africa program gave the research team a number of modern lighting devices to test. Various sets of products were tested in Phases 1, 3 and 4 of the research programme, and the insights from these tests are included below. Appendix 7.4 contains a table showing exactly which products were tested in which research phase.

There were four types of products tested: lanterns, torches, task lights, and area lights, which are lights that cover a large area and tend to be used outside. In the following section the pros and cons of the tested modern lighting devices are discussed by product type.

More information about the evaluation of the modern lighting devices in individual countries can be found in the individual reports of Phases 1, 3, and 4 available at www.lightingafrica.org.

4.3.1 Feedback on tested lighting devices

In the course of the qualitative study phases (one and four), we distributed a number of currently available products to typical end-users for trial periods in their homes (see Appendix 7.2.2 for details on the qualitative methods). The products included a range from low-cost torches to some of the most innovative products available at the time. After a three-day period of use, we interviewed the users about their initial impressions of the products and are including a compilation of their answers

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here. These results should not be interpreted as being comprehensive assessments of the individual products; they point to trends in consumer preferences and their initial reactions to the design of the products to which they were exposed. The products they evaluated were manufactured in 2007-2008 and many have been updated since then.

The key findings about what manufacturers must take into consideration in product design are summarized below:

1. **Affordability**: The price of the product is an important concern for most respondents; due to their low income, it is difficult to pay the full purchase price at once. Costs are further discussed in section 4.4 of this report.

2. **Recharging methods**: should be considered carefully as the operating cost and the efforts to charge a product are important factors in the purchase decision. Solar recharging was very well received across all countries due to the lack of operating costs. Charging via AC mains power was deemed the fastest and most efficient way to recharge a lighting device, but was the least-liked charging option due to the ongoing operating costs associated with it.

3. **Adequate light intensity**: is an important feature for each lighting device category. Most respondents prefer to have one lighting device that is capable of lighting the whole room, which avoids having to use more than one device in the same room. A bright white light is most preferred.

4. **Multipurpose**: Many people have only one or two lighting devices, but more places to light. Therefore, lighting devices that are able to light two rooms at once were positively rated. Devices that can be used both as a lamp to light the household and as a torch to move around the homestead are also appreciated for their multi-functionality.

5. **Portability**: Both consumers and traders currently carry their lighting devices from one room to another as well as outside, since toilets, bathing rooms and kitchen are often detached from the main dwelling. This indicates that there is a need for portable lighting devices. The lighting device should not be too big or heavy, and it should have a good handle or strap to carry it around easily. For torches, respondents prefer a size that fits in their pocket easily.

6. **Product placement** (hanging and standing): It is important that a product is able to stand on its own (e.g. includes a lamp stand) and can also be hung from the ceiling with a handle or strap.

7. **Long battery life**: Lighting products with a charge that lasts at least 5 hours are required as most respondents use lighting devices for a few hours in the morning and evening.

8. **Ease of use and maintenance**: The products should be easy to use and not look too complex. If required, provide education or demonstrations on how to use the products. Controls, knobs, and the connection of the battery to the device should be easy to understand and use.

9. **Safety**: The lighting devices should be safe no matter where they are placed, including when left on overnight – i.e. no possibility of starting a fire or electrocution.

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10. **Security**: For products that are recharged using solar panels, the respondents avoid putting devices outside their house unattended due to the risk of theft. Detachable solar panels are thus preferred

The tables below provide an overview of the commonly perceived advantages and disadvantages of the tested lighting devices.

Table 6. Commonly perceived advantages and disadvantages of the lighting devices people tested. These are aggregated responses for the products in each form factor category.

Product Category	Positive Impressions	Negative Impressions
Torches (Flashlights) 	• Easy to use and maintain; these are familiar products • Reliable • Affordable • Durable • Environmentally friendly (for solar products) • Familiar design • Portable • Economical: No operating cost (for solar products)	• Little product security when charging outside (for products with integrated solar modules) • Not practical to light a room as one would have to hold it when using it • Fragility, quality concerns (for low cost products) • Not functional without sunlight (for solar products) • Must pay to recharge (for grid-rechargeable products) • Concern about the availability of replacement batteries for both rechargeable and dry cell torches

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Table 6 continued.

Product Category	Positive Impressions	Negative Impressions
Task Lights    	• Portability • Easy to handle and use • Brightness for tasks • Economical: No operating cost (for solar products) • The solar panel is not an added expense (if it comes with the product) • Convenience of charging options (for those with multiply options) • Environmentally friendly (for solar) • Can be easily placed on any surface or hung on the wall (for many that have these options)	• Unfamiliar design • Heavy (for some of the larger products) • Fragile • Insecure when charging outside (for products with integrated solar modules) • Not functional during the rainy season (for solar-only products) • Short battery life • Light emitted is directional, cannot illuminate the whole room. • In some cases, not enough light.
Lanterns    	• Easy to use, familiar design • Bright, adequate light for whole room. • Portable • Attractive and easy to handle • Strong • Convenient • Multiple charging options provides flexibility, security • Easily rechargeable • Economical: No operating cost • Easy to hang by the handle	• Inadequate light intensity for large areas in some cases • Tiring and cumbersome charging method, prone to breakage (for hand cranks) • Battery life • No indication of battery life left or full charge indication • Some solar products have too short of a cable

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Table 6 continued.

Product Category	Positive Impressions	Negative Impressions
Area Lights     	• Adequate light intensity • Can act as security light • Ease of use • Cost effective: No operating cost (for solar) • Bright and reliable light • Design perceived as the type of high-end product one aspires to own • Safe • Modern • Attractive • People like multi-room lighting	• Bulky: Not portable • Expensive • Mounting problems • Hard to maintain • Cables too short • Can be easily stolen if not fixed to the wall / when charging outside • Not functional without sunlight (for solar)

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4.3.2 Feedback on recharging methods

Solar recharging was very well received across all countries due to the lack of operating cost. There were also some drawbacks to be taken into account.

The first is that solar recharging is perceived to add to the overall cost of the device. This could mean that consumers assume such devices are expensive, even if in fact they are not. Because of this, price communication will be important.

In devices where the solar panel is attached to the device, this is perceived as a security risk because the device might be stolen if left outside to charge. This is particularly true in urban areas, where more than five separate families often share the same compound.

Another perceived problem is that solar would not work in the rainy season and that it takes a long time to fully charge a solar panel on a less-sunny day. These latter two issues were experienced by some of those testing solar products at home. There are significant periods of cloudy skies in many parts of Africa, so devices should be designed with this in mind.

Not being able to tell if the device is fully charged or not is also a problem leading to having to leave the panel in the sun for longer than may be necessary; an indicator gauge should be included in the design.

Charging via **AC grid electricity** was deemed the fastest and most efficient way to recharge a lighting device, but was the least-liked charging option due to the ongoing operating cost associated with it. On a normal day, those not connected to the mains have to go to a recharging shop and pay a fee to recharge the device, which is typically high per kWh. Frequent recharging consequently becomes a very pricey affair.

The **crank handle** recharging method, where a lamp is recharged by winding a handle, was considered unique and cheap, but also very tiring. Some respondents also did not believe that a lamp would get fully charged through this method, and most mechanisms were perceived as insufficiently sturdy. It may be necessary to emphasize the ease and effectiveness of this charging method in a marketing or communication campaign.

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4.4 How much would consumers be willing to pay?

The optimal price point is a particularly difficult value to estimate for new products. The information we gathered in various phases of our market research indicates that:

- Potential buyers' **willingness to pay[17] for modern off-grid lighting products increases with increasing exposure to good quality off-grid lighting products**. The increases are on the order of doubling with step in exposure level between seeing a photograph of a product, handling the product, and trying it in their home.

- While potential buyers indicated a willingness to pay near the recommended retail price after full exposure to good quality off-grid lighting products, many of them expressed that their **ability to pay would is hindered without access to finance**.

- The intended use (home or business), income level, and geography (urban or rural) of potential buyers has little to no impact on their initial willingness to pay for off-grid lighting products. People's "opening bid" for generic lighting products is in the US$5 to US$10 range, regardless of the quality or features. However, there may be distinction between the groups at subsequent levels of exposure that reflect differences in their needs and income levels.

In phases 2 and 3, we found that potential retail buyers' willingness to pay for lighting products depended strongly on their level of exposure to modern lighting products, and that it rose with increasing exposure.

Consumers who were simply shown photographs (by way of "concept boards" – i.e. informational placards with photographs and descriptions of the attributes of the products – in phases 2 and 3) indicated the lowest willingness to pay, on the order of US$5 to US$10 for a range of products regardless of their performance. These consumers' level of information could be compared to someone who has seen an advertisement for a product in print or on television.

Potential buyers who had physical access to products for handling in addition to information about their attributes indicated a higher willingness to pay, and after a five night trial period they tended to agree that the recommended retail prices were appropriate. For some, those prices were out of reach, but those who had the ability or access to financing indicated a willingness to pay and intention to purchase at or near the retail prices after seeing how modern off-grid lighting products perform.

Graphs 6, 7, and 8 below show how potential buyers' willingness to pay for off-grid lighting products evolved over various levels of exposure, ranging from seeing a photograph of the product to trying it in their home or business. The three graphs are for particular lighting products. They are the focus of our analysis because data are available for them over multiple research phases. Each graph shows box plots that depict the range of the average willingness to pay in each of the five

[17] i.e. their perception of value and the acceptable price, not necessarily intention to purchase at that price (due to financial barriers).

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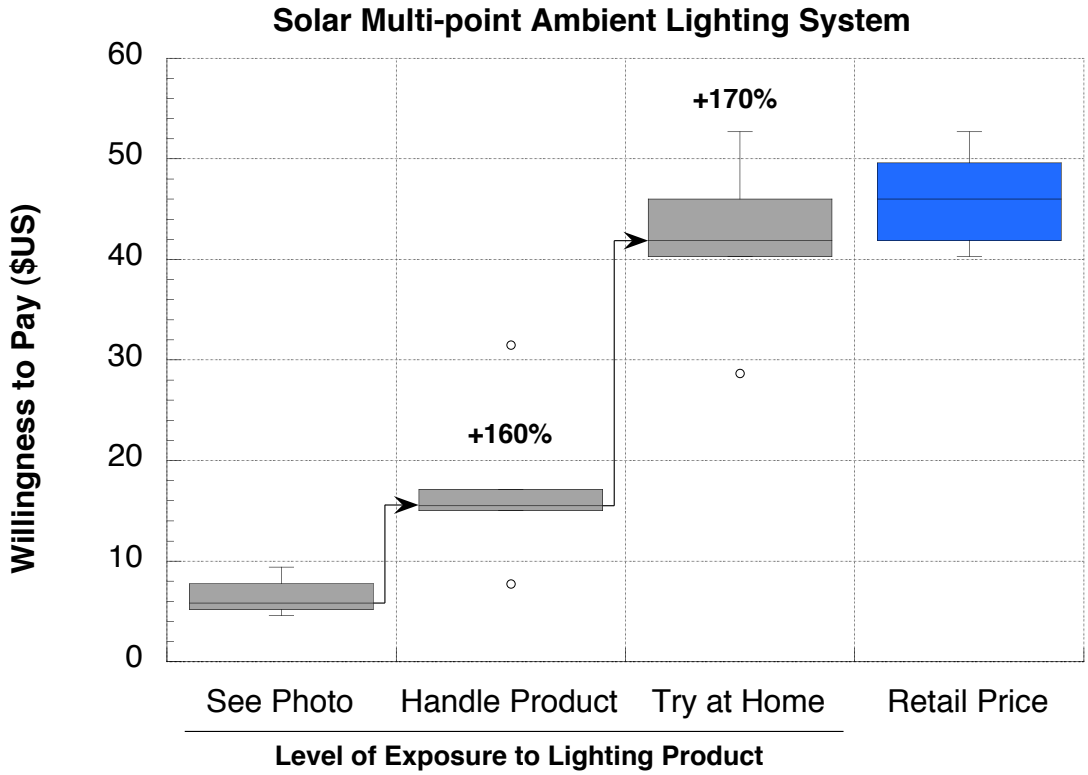
countries where research was conducted. The retail price varies between countries because of differences in their import duty and tax structures.

The key message from these plots is that consumers tend to be very skeptical (not willing to pay much) for lighting products that they have limited exposure to. This could be due to early market spoiling by low quality torches, based on inherent skepticism of new technology, or reflect a general lack of understanding about the benefits from improved lighting technology. As they have increasingly greater exposure to good quality products, their perception of product value and acceptable pricing rises, with willingness to pay reaching near the recommended retail price.

In the case of the two solar products (Graphs 6 and 7), one of which is a multi-point ambient lighting system and the other a task light, consumer response was initially very low compared to the retail price. Their willingness to pay rose quickly at each increased "step" of product exposure, approaching the recommended retail price in both cases.

In the case of the grid-charged flashlight, a much more common product in the marketplace, people generally were willing to pay closer to the retail price from the start because they are already familiar with the technology and its typical pricing.



Graph 6. Evolution of potential buyers' willingness to pay for a solar multi-point ambient lighting system at different levels of exposure. Each point in the box plots represents the average in one of the five countries covered in the project. The percentage changes are based on the difference between the median country-wide result at the new and the previous levels of exposure.

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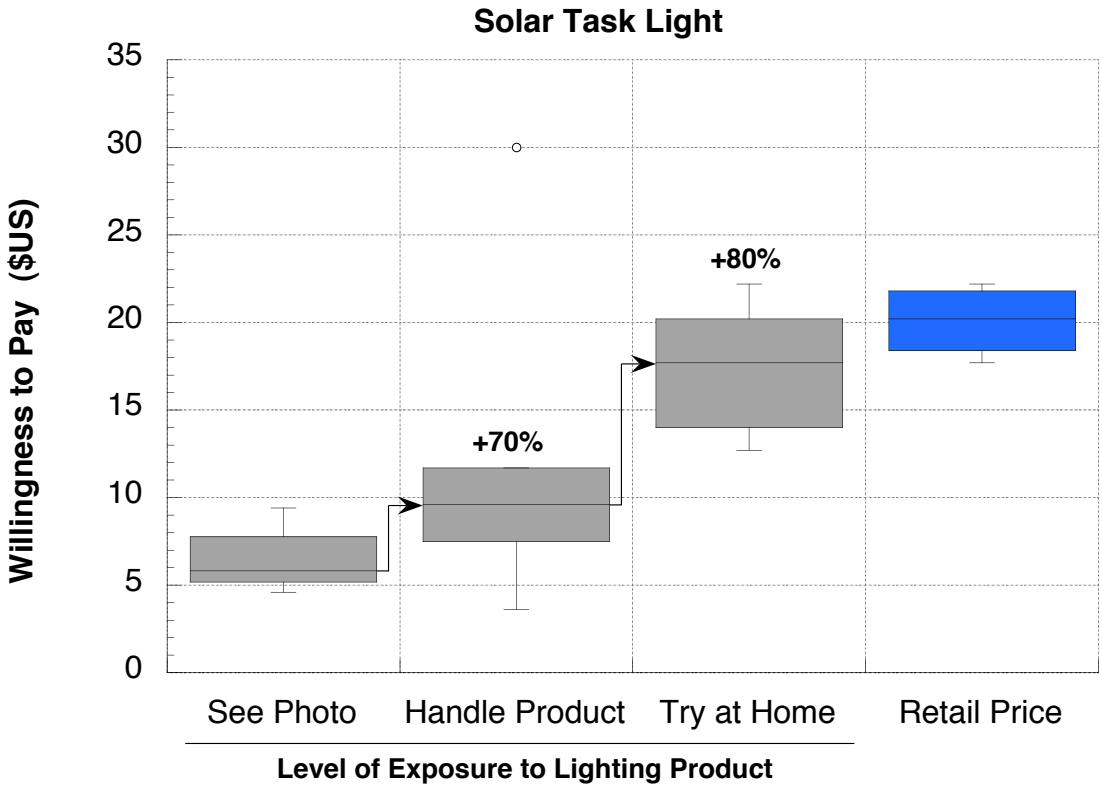

Graph 7. Evolution of potential buyers' willingness to pay for a solar task lighting system at different levels of exposure. Each point in the box plots represents the average in one of the five countries covered in the project. The percentage changes are based on the difference between the median country-wide result at the new and the previous levels of exposure.

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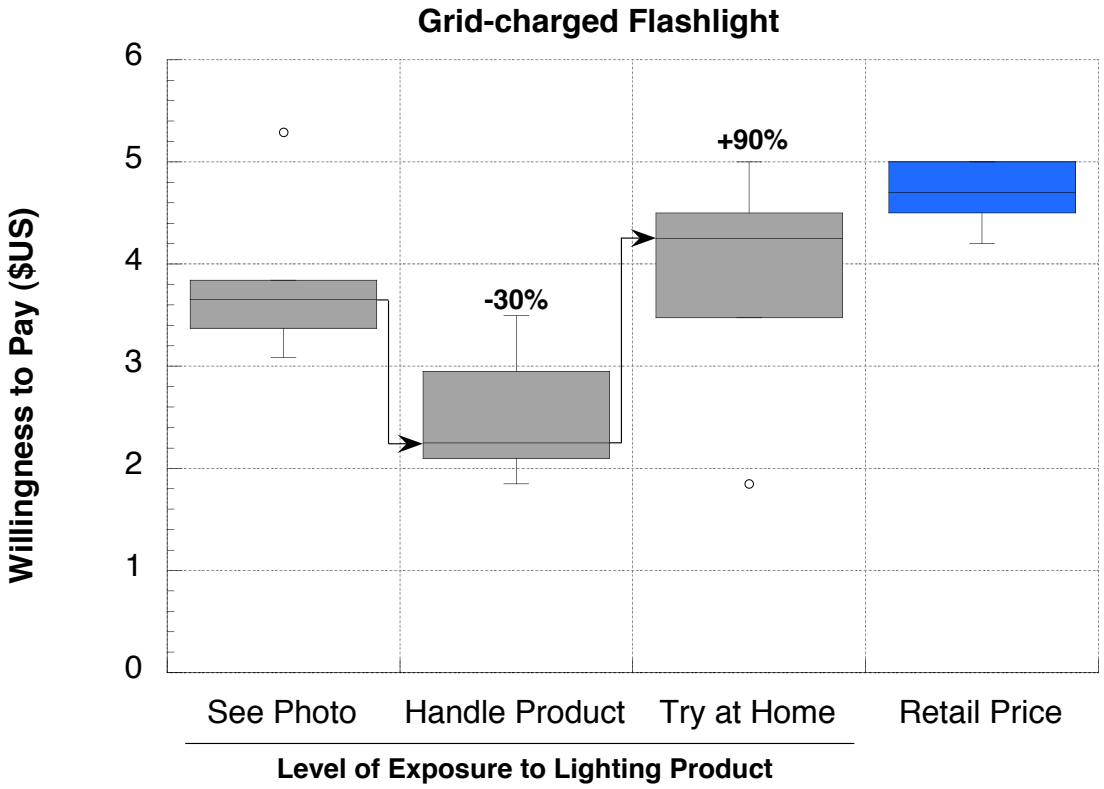

Graph 8. Evolution of potential buyers' willingness to pay for a grid-charged flashlight at different levels of exposure. Each point in the box plots represents the average in one of the five countries covered in the project. The percentage changes are based on the difference between the median country-wide result at the new and the previous levels of exposure.

In phase 2 of this research, survey techniques were used to estimate the optimal price point for different rechargeable products based on photos and descriptions. For this part of the study, generic products were used, not specific off-grid lighting products. The large sample size and breadth of the Phase 2 survey was segmented along consumer/trader use categories, living standards measures income groups, and rural/urban geographic groups. A key result from this phase is that the optimal price for lighting products was uniformly low across use categories, income levels, and geography. In general, potential buyers' willingness to pay was about US$5 to US$10 regardless of the design or features.

The graphs below show the ideal price point, as well as the most acceptable price range, of each lighting product category for the various groups averaged across all the countries.[18] The square block in each chart below shows the overall best price from the consumer or trader point of view, and the grey line represents the optimal price range. Optimal price was established by describing to respondents in the quantitative use and attitude survey a generalized description of the four product areas, then asking a series of questions to establish price sensitivity.

[18] Phase 2 Quantitative Usage and Attitude Study

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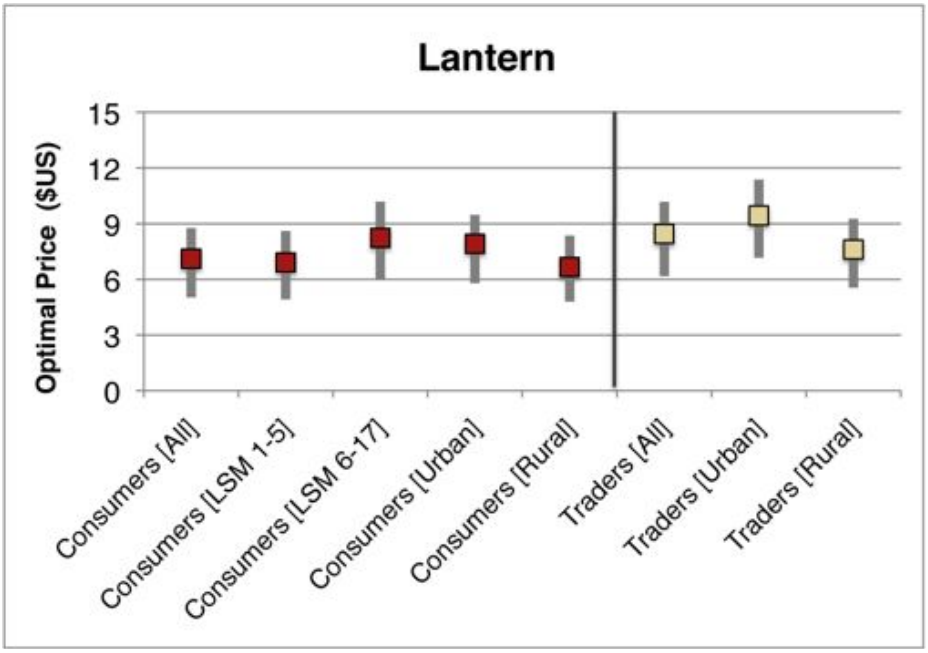
However, as noted above, these price points were developed in an environment where consumers are unfamiliar with the potential product benefits and where the risks of buying sub-quality products are high. Availability of financing, as well as increased familiarity with the products and building of brand recognition, is likely to increase these price levels. Direct marketing campaigns that allow consumers to see products used by friends and neighbours, as well as marketing aimed at the aspirational value of the products (i.e. creating an aura of modernity and progress around modern off-grid lighting), may have an additional effect over time.

These charts provide an overview combining all countries; for pricing specifics on each market, the reader should consult appendix 7.14.



Graph 9. Average ideal price and price range for a rechargeable lantern based on a generic photo and description of the product attributes.

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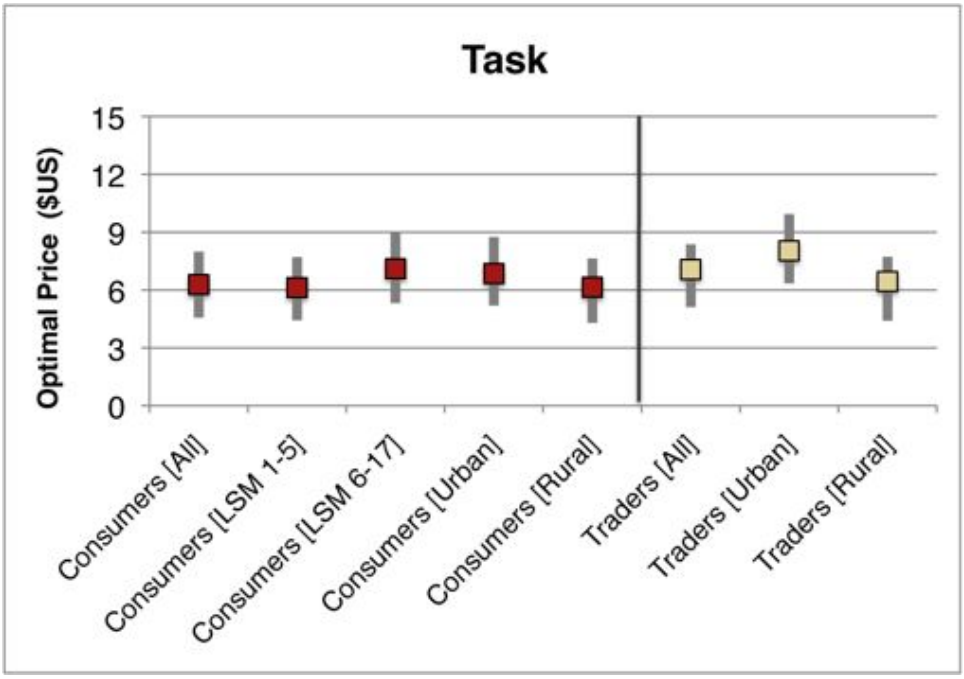
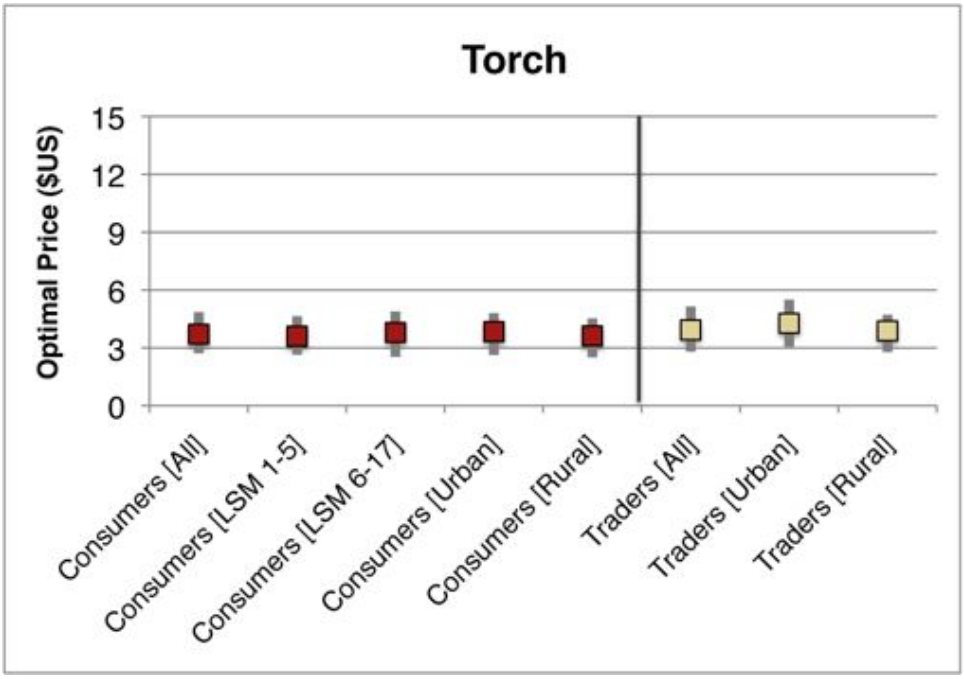


Graph 10. Average ideal price and price range for a task light based on a generic photo and description of the product attributes.



Graph 11. Average ideal price and price range for a torch based on a generic photo and description of the product attributes.

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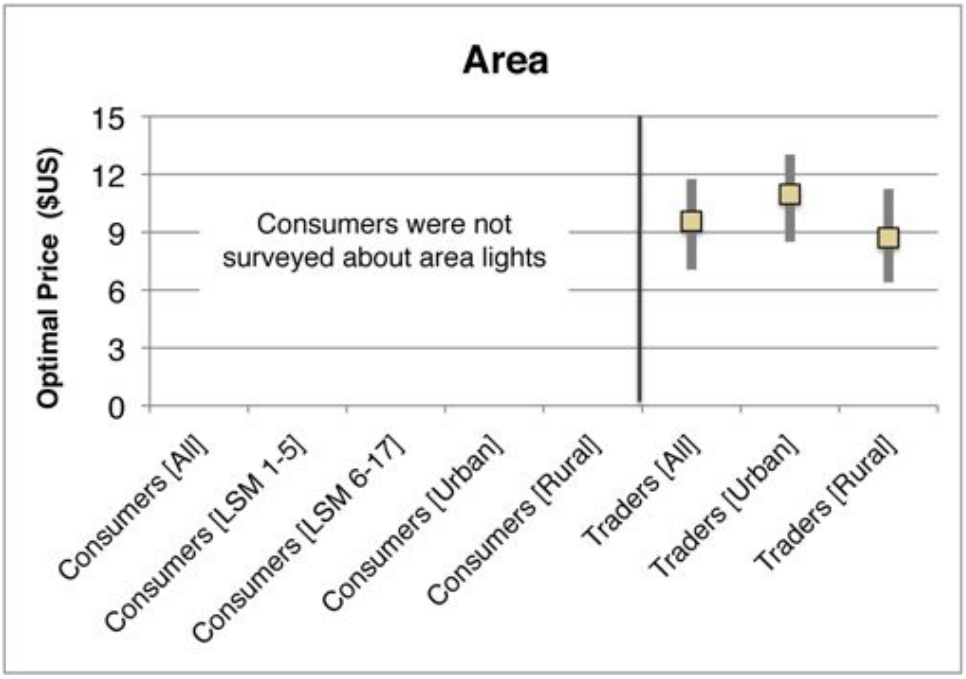

Graph 12. Average ideal price and price range for an area light based on a generic photo and description of the product attributes.

4.5 Financing

Modern lighting devices tend to have higher initial purchase prices but lower operating costs[19] compared to fuel-based lighting. Financing can help people overcome the upfront cost barrier to modern lighting – which is less expensive overall than the incumbent technologies.

To explore the impact of access to finance on people's willingness to pay, we targeted questions in phase 4 of the study to respondents who were not willing to buy the product for the recommended retail price. They were asked whether they would be willing to buy the product if financing was available to offset part of the purchase price and any maintenance costs.

In general, respondents were very interested in the option of buying the lighting products if financing were available to offset part of the initial purchase cost, especially for the more expensive products. The main reason is that most people are not able to save money and do not have the disposable income to pay the whole amount upfront. If financing for consumers on these modern lighting devices is employed, it should be made very clear what it entails, as some respondents believe financing will reduce the price of the device, particularly in Ethiopia. The idea of financing for capital items is not familiar to many people in these markets.

In order to bring down the initial purchase price, the product could be offered without the solar panel. This was discussed with respondents in the same qualitative research phase of the study

[19] Solar charged products have nearly zero on-going operating costs; grid-charged product operating costs depends on electricity access.

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(phase 4). This does not, however, seem a viable option; it reduces likelihood of purchase since the solar panel reduces the monthly operating cost, which is one of the key benefits they are seeking. In addition, most people are not connected to the grid, which makes charging the products without the solar panels difficult.

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5 Market size estimates: how many potential customers for modern lighting are there in each country?

5.1 What is the number of households and traders that are potential customers for off-grid lighting solutions?

The table below shows the approximate number of households in each country that are not connected to the electric grid.

In total, an estimated 42,610,000 households are not grid connected in the five countries included on our research. As noted in previous sections of this report, there is also high potential interest among currently connected households due to the poor reliability of power in these countries.

Table 7. Estimated number of households per country including number of households connected to the electric grid.

	Ethiopia	Ghana	Kenya	Tanzania	Zambia
Population (2009 estimates)	85,240,000	23,830,000	34,000,000	41,050,000	11,860,000
Average persons per household	3	5	5	5	5
Estimated total number of households	28,410,000	4,770,000	6,800,000	8,210,000	2,370,000
Estimated number of households connected to the grid	3,690,000	2,190,000	540,000	1,150,000	380,000
Estimated number of off-grid households	24,720,000	2,580,000	6,260,000	7,060,000	1,990,000

The following table shows the results of the test of the product ideas among respondents. Respondents were asked their likelihood of purchasing each product described to them at a particular price (as shown in table). For the purpose of this broad-brush analysis, we have assumed the figures from these test samples to be representative of the national picture, and have projected national totals based on the same percentage of total population. In reality, however, the concept test study only covered a section of the population. We should note that the total apparent market based on our estimates is larger than the number of off-grid households in these countries. It seems likely that rather than purchasing multiple lights that have similar functions; households would end up choosing their favourite (i.e. if they purchase a lantern, it is unlikely they will purchase a different one as well, even if their response to the survey was that both were "likely purchases.") The numbers in Table 8 represent the potential for each product in a vacuum, without the influence of competition from other products.

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Table 8. Estimation of potential buyers of the tested lighting products (number of households).

	Ethiopia	Ghana	Kenya	Tanzania	Zambia
Estimated number of off-grid households	24,720,000	2,580,000	6,260,000	7,060,000	1,990,000
Estimated potential*					
Torch A RRP: US$ 28.99 - 36.38 	11,000,000	1,510,000	3,000,000	2,820,000	800,000
Torch B RRP: US$4.24 - 5.00 	10,630,000	1,520,000	4,070,000	2,750,000	780,000
Task Light C RRP: US$16.10 - 20.21 	7,900,000	1,510,000	3,070,000	1,940,000	550,000
Lantern A RRP: US$52.56 - 61.88 	1,480,000	1,390,000	1,690,000	1,910,000	540,000
Lantern C RRP: US$61.13 - 76.72 	1,480,000	1,340,000	2,030,000	1,690,000	480,000
Area Light C RRP: US$36.60 - 45.94 	5,930,000	1,470,000	3,130,000	2,120,000	600,000
Area Light E 	10,630,000	1,440,000	3,510,000	3,320,000	1,210,000

*Total potential sales = Number of off-grid households / (definitely buy + (probably buy / 2))
Area Light E was tested in Phase 1 Qualitative Study
Torch A, Torch B, Task Light C, Lantern C, Area Light C and were tested in Phase 3 Qualitative Concept Study (sample based on the capital of each country only). Recommended retail price (RRP) is a range as it varies from country to country

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5.2 What is the total amount spent on lighting products?

It is important to understand the current amounts spent on lighting in this market, as they can be viewed as the lower bound for the actual market size for modern off-grid lighting products. The following estimates are based on average amounts spent on devices and operating costs over the average lifetime of a paraffin lamp with glass cover, projected to the estimated total number of households in each country. This focuses on the paraffin lamp with glass cover only, since this product is most similar to a modern lighting device and is currently the most widely used device across the markets. Note that these estimates are broad-brush only.

Table 9. Consumers: Total amount spent on lighting including both purchase and operating cost based on the lifetime of each paraffin lamp with a glass cover per country.

	Unit	Ethiopia	Ghana	Kenya	Tanzania	Zambia
Purchase price of paraffin lamp with glass cover*	US$	2.30	5.80	8.90	5.00	2.00
Average monthly operating cost of a paraffin lamp with glass cover*	US$	3.30	3.20	8.10	5.10	3.50
Average yearly operating cost of a paraffin lamp with glass cover	US$	40	38	97	61	42
Duration one lamp lasts*	years	2.9	2.6	3.2	2.5	1.4
Total spent on operating costs over lifetime of a paraffin lamp with glass cover	US$	110	100	310	150	59
Total spent per household per lamp	US$	120	110	320	160	61
Estimated number of off-grid households** (in millions)	HH	24.72 M	2.58 M	6.26 M	7.06 M	1.99 M
Estimated % of households that use a paraffin lamp with glass cover***	%	14	72	67	60	6
Estimated number of households that use a paraffin lamp with glass cover (in millions)	HH	3.46 M	1.86 M	4.19 M	4.24 M	0.12 M
Total annual budget pool (in millions)	US$	$140 M	$75 M	$420 M	$270 M	$5.2 M

* Phase 2 Quantitative Usage and Attitude Study
** Table 7, this report section 5.1
*** Phase 2 Quantitative Usage and Attitude Study – Question for consumers (base: total sample): "What, if anything, was used to light the main room last night?"

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Table 10. Traders: Total amount spent on lighting including both purchase and operating cost based on the lifetime of each paraffin lamp with a glass cover per country.

	Unit	Ethiopia	Ghana	Kenya	Tanzania	Zambia
Purchase price of paraffin lamp with glass cover*	US$	6.30	4.10	7.40	5.30	1.80
Average monthly operating cost of a paraffin lamp with glass cover*	US$	2.60	4.60	10.00	2.20	3.00
Average yearly operating cost of a paraffin lamp with glass cover	US$	31	55	120	26	36
Duration one lamp lasts*	years	2.9	2.6	3.2	2.5	1.4
Total spent on operating costs over lifetime of a paraffin lamp with glass cover	US$	90	140	390	66	50
Estimated % of traders that use a paraffin lamp with glass cover**	%	47	70	48	75	4
Total budget pool per trader per lamp	**US$**	**97**	**150**	**400**	**71**	**52**
Total annual budget pool per trader per lamp	US$	33	57	120	29	37

* Phase 2 Quantitative Usage and Attitude Study

** Phase 2 Quantitative Usage and Attitude Study – Question for traders (base: all who use lights in their business): "What, if anything, is used to light the business?"

Note: The estimated number of off-grid retailers, required to calculate the total budget pool, is not available

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6 Paving the way: conclusions, recommendations and caveats for entering the African market

6.1.1 Is there an opportunity for new lighting products in the African market?

Africa is home to one of the world's largest off-grid populations; approximately 590 million people are not connected to the electric grid, a number projected to grow. As a result, large segments of the population in Africa rely on hazardous forms of flame-based lighting with low levels of light output. This status quo represents a sizeable market opportunity for producers of low cost alternative lighting products.

African consumers spend an estimated US$10 billion annually on fuel-based lighting. Currently, this market is largely untapped by the international lighting industry. Introducing modern lighting products to this market has the potential to trigger a change in African lighting standards, with fundamental improvements to life and livelihood at the bottom of the pyramid.

Currently, a paraffin lamp with a glass cover is the most commonly used lighting device in Kenya, Ghana and Tanzania while in Ethiopia most consumers use a paraffin lamp with a simple wick (no cover), and in Zambia 80% of consumers use candles as their main source of light. These lighting devices cause a number of problems for their users, and do not satisfy users' needs on a number of levels, which presents a large opportunity for manufacturers of modern lighting devices. The main concerns are:

- **Light intensity**: The majority of current lighting devices are directional and / or do not have adequate light intensity to illuminate the whole room
- **Cost**: Most of the lighting devices that are capable of meeting respondents' needs have a very high initial purchase cost, high operating cost (fuel or batteries), or both
- **Health**: Currently-used fuel-based lighting devices emit smoke, which can irritate eyes and increases the risk of developing various lung diseases for the respondents and their families
- **Safety**: Current lighting devices with an open flame carry the risk of starting a fire

Most consumers consider their households to be under-lit. Almost two-thirds say that not all areas in the house that need light are lit. They indicate that lack of lighting restricts activities such as reading, doing homework and preparing food. In addition, about fifty percent also report that they are currently inhibited in performing some outdoor activities due to lack of lighting, such as visiting friends and family after dark or looking after livestock. Although most respondents say they do wish to have better lighting, they haven't changed anything due to lack of available funds or because they simply haven't seen better lighting devices available in the market. This prevailing lack of choice in lighting hints at a strong potential market.

The majority of the traders say that they are very or fairly dissatisfied with the current lighting of their business. Insufficient lighting causes concerns of insecurity. Poor outside lighting also limits the visibility of the business itself; customers might think the shop has closed or not see the shop at all. Improved lighting is one of the priorities for most business facilities. Half of the traders not operating regularly after dark say would do so if they had adequate lighting, as they would be able to

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attract more customers. Another 25% would open after dark occasionally with better lighting. This represents a significant opportunity for improved lighting. Light is used both to be able to operate and to attract customers. Outside lighting for businesses is another potential area of opportunity for lighting.

All of this shows that there is an opportunity for improved lighting in Africa.

6.1.2 What is the size of the opportunity?

Roughly 80% of the households in the countries included in our research are not connected to the electric grid. In total, we estimate this segment represents 40,000,000 households in these five countries.

Based on people's self-reported likelihood of purchasing new modern lighting products, we estimate that with the appropriate segmentation at least one product per household could be sold, and more than one in many cases, as shown in Table 8. The annual sales of modern off-grid lighting products will depend on how deeply the potential market is penetrated, ongoing consumer satisfaction with the products, and the lifetime of the products that are sold. It should be noted that the estimates we made are based on consumers' stated intent to purchase based on prices significantly higher than the optimum price for consumers (see section 6.1.3 below); if products were available at lower prices, demand could be even greater.

There is also a high potential among households currently connected to the electric grid due to the poor reliability of grid power in these countries at this point in time.

Off-grid users of glass-covered paraffin lamps in these five countries spend an estimated total of US$910,000,000 every year, including both purchase and operating cost of the lamps.

6.1.3 What should manufacturers consider if they intend to target these consumers?

Price

Limited income is the single most pressing challenge for African consumers. Their priority is meeting their families' most basic needs on a day-to-day basis. This leaves very little room for savings, so affordability of lighting products is very important. The average monthly household income in the countries included in our research ranges from US$90 to US$154 (based on the averages from the surveys we conducted).

The initial acceptable price point for unfamiliar buyers is only US$5 to US$10, but increases to near the recommended retail price as they gain exposure and experience with modern off-grid lighting products. This indicates that a the current-day recommended prices for many lighting products may be acceptable to consumers once they see the products in operation, perhaps in friends' and neighbours' houses. Direct marketing would have a greater impact in rural communities, as they would get to touch and feel the products. However, many consumers expressed reservations about their ability to make lump sum payments equal to the retail prices, particularly for products priced above US$30.

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In general, respondents were very interested in the option of buying the lighting products if financing were available to offset part of the initial purchase cost, especially for the more expensive products. The main reason for this is that most people are not able to save money and do not have the disposable income to pay the whole amount upfront. However, if financing for consumers on these modern lighting devices is employed, it should be made very clear what it entails, as the idea of financing for capital items is not familiar to many people in these markets

Offering the products without a solar panel to bring down the initial purchase price did not seem to be a viable option; it reduces consumers' likelihood to purchase, since the solar panel reduces the monthly operating costs, which is one of the key benefits they are seeking.

Product features

The main features for manufacturers to consider are the following: The product should have an adequate light intensity, preferably one that can be adjusted. Portability of lighting products is important and devices that are multifunctional are preferred, especially those products that are able to light two rooms simultaneously. The battery life of the product should be at least 5 hours, long enough to provide light for one day of normal use. Consumers prefer devices that can stand on a table and have a handle or strap that allows them to hang it from the ceiling or wall. Safety of lighting products is very important as well as ease of use and maintenance. These features are discussed in detail below.

Adequate light intensity is an important feature for each lighting device category. Most respondents prefer to have one lighting device that is adequate to light the whole room, which avoids having to use more than one device in the same room.

Adjustable light intensity is also preferred as devices are often used in more than one room for different purposes in the evening or early morning (e.g. for reading, cooking, chatting) or as lighting during the night in the bedroom.

Multipurpose: Many people often have only 1 or 2 lighting devices, but more places to light. Therefore lighting devices that are able to light two rooms at once were positively rated. Devices that can be used both as a lamp to light the household and as a torch to move around the homestead are also appreciated for their versatility.

- The majority of toilets in off-grid households are outside pit latrines. This means that the family has to travel some distance in the dark to reach them. Thus, there is a requirement for torches as well as lamps, or combination products.
- In businesses, lighting is used to attract customers, improve security, illuminate products on the shelves, light the faces of customers, and to see money. Current lighting used may not satisfy the multiple requirements of business lighting, and any new product has to take this multiple feature requirement into account.
- Another frequently mentioned feature is an additional output from the solar panel to run other electrical equipment, e.g. a radio or TV.

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Portability: Both traders and customers currently carry their lighting devices from one room to another, as well as outside, as toilets, bathing rooms and kitchens are often detached from the main dwelling. This indicates that there is a need for portable lighting devices. The lighting device should not be too big or heavy, and it should have a good handle or strap to carry it around easily. For torches, respondents prefer a size that fits in their pocket easily.

Product placement (hanging or standing): It is important for product designers to understand where respondents place their lights. Generally, households place their lamp in the main room on a table or coffee table. The exception is Ghana, where half place their lamp on the floor, and Ethiopia, where half hang their lamp from the wall. A quarter of all households in the study say they move their lamp around as required. In addition, many traders conduct their business outside, on tables, or in market stalls, where there may not be a place to easily hang a lantern at night. Therefore, it is important that a product is able to stand on its own (e.g. includes a lamp stand) and has a hook or strap to hang it from the roof or ceiling.

Long battery life: Lighting products with a charge that lasts at least 5 hours are required, as most respondents use lighting devices for a few hours in the morning and evening.

Ease of use and maintenance: Make sure the products are easy to use and don't look too complex. If required, provide education or demonstrations on how to use the products.

Safety: The lighting devices should be safe regardless of where it is placed or whether it is left on overnight – i.e. no possibility of starting a fire at night or electrocution.

Recharging methods should be considered carefully as the operating cost and the effort necessary to charge a product are important factors in the purchase decision. The opinion of respondents on solar and AC mains recharging as well as crank handle charging are mentioned below.

- **Solar** recharging was very well received across all countries due to the lack of operating costs. There were, however, some drawbacks to be taken into account:
    - Consumers assume that devices with solar panels are expensive, even if in fact they are not, meaning that price communication will be important.
    - Devices with an attached solar panel are perceived as a security risk, as they might be stolen if left outside to charge. Therefore, a detachable solar panel is preferred.
    - Another perceived problem is that solar would not work in the rainy season and that it takes a long time to fully charge a solar panel on a less-sunny day. There are significant periods of cloudy skies in many parts of Africa, so devices should be designed with this in mind.
    - Not being able to tell if a device is fully charged or not is also a problem, leading to having to leave the panel in the sun for longer than may be necessary; an indicator gauge should be included in the design.
- Charging via **AC mains power** was deemed the fastest and most efficient way to recharge a lighting device, but was the least-liked charging option due to the ongoing operating cost associated with it.

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- The **crank handle** recharging method, where a lamp is recharged by cranking a handle, was considered unique and cheap, but also very tiring and unreliable. Some respondents also did not believe that a lamp would get fully charged through this method. It may be necessary to emphasize the ease and effectiveness of this charging method in a marketing campaign.

Marketing

Lack of lighting restricts activities; respondents showed particular concern that the education of their children is hampered by a lack of light to do homework. Since education is seen as key to escaping poverty, this is an emotionally potent issue that can be used in marketing lighting.

The marketing process must make buyers aware of the problems they are currently dealing with, and how the new lighting devices overcome these problems.

The lack of negative health effects is one of the key benefits of modern lighting devices, and can be used in marketing.

Manufacturers designing modern lighting products need to bear in mind the "competition" of the currently used fuel-based lighting devices when considering pricing, especially for mass-market consumers. With regards to pricing strategy, it is important to emphasize the zero or greatly reduced operating cost of LED products, along with the length of time they last, as this will be a critical factor in encouraging consumer uptake. It would of course be possible to market more expensive lighting products to the higher LSM groups, and a dual variant approach could be employed to serve the two different markets.

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7 APPENDICES

7.1 Market Research Program

7.1.1 Flow chart of methodologies and research phases

Both qualitative and quantitative research approaches were used to understand the nature of the market for modern lighting products. The structure of the research program and its phases are outlined below.

Phase 1: Qualitative Study (March/April 2008)

To define profile and behaviour as well as wants and needs regarding lighting

- Observation and in depth interviews with respondents in their own environment. Respondents tested representative devices in familiar surroundings for three nights
- n=55 off-grid consumers and traders per country, urban and rural

Phase 2: Quantitative – Usage & Attitudes Study (June/July 2008)

To quantify usage, habits and attitudes as well as acceptable price ranges for modern lighting products

- Questionnaire specifically related to lighting wants & needs, lighting behaviour and expenditure on lighting
- n≈1000 consumers and n≈400 traders per country, urban and rural, of which a maximum of 10% was connected to the grid

Phase 3: Quantitative - Concept test Study (November/December 2008)

To quantify and identify which specific types and designs of lighting products were most acceptable

- Highlighting strengths and weaknesses of various lighting products
- A concept board was used which clearly depicted the modern lighting product to be evaluated and included a short description of its features, battery life and price
- n=300 consumers and traders per country, urban and rural

Phase 4: Qualitative Study (April/May 2009)

To test a selection of new modern lighting products & identify which designs were most acceptable

- Observing and interviewing respondents in their own environment. Respondents tested a selected group of devices in their own house for five nights
- n = 20 consumers per country, urban and rural

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7.1.2 Qualitative research

Qualitative phase 1

This phase took place in March and April of 2008 and was primarily used to define the profile and behaviour, as well as the wants and needs, of consumers within the off-grid lighting market in each of the five countries. Individual in-depth interviews were conducted at the home or business premises of the respondent. This method was chosen so that respondents could be observed and questioned within their own environment. The methodology allows probing below the surface to understand drivers and motivations of observable behaviour.

In this phase of the study, 55 respondents in each test market who were not connected to the grid were interviewed over two visits. In the initial visit, respondent behaviours, attitudes, and needs with regard to current lighting products were explored, as well as their desired lighting improvements.

In total 11 products were tested in this phase; for details refer to appendix 7.4. A set of two of these products was then placed with them for a period of 3 nights. Products were placed on a rotational basis to avoid order bias.

Respondents were then briefed on how to use and recharge the products, after which they completed an initial evaluation with the interviewer about aesthetics, make, perceived quality, and reliability. During the second visit, the interviewer recorded the user's experience with each of the two products: level of light, how long the battery lasted, ease of recharging and likelihood of product uptake.

Qualitative phase 4

This phase took place in May 2009, and was the final stage of the overall study. Exactly the same methodology was used as in Qualitative Phase 1. The focus in this phase was on selected "high-performing" devices, i.e. lighting products that had characteristics that were identified favourably in the past (either in phase 1-3 of this research or in comparable other market studies). Examples of favourable characteristics include light output and quality, battery size, shape and feel of the product.

20 in-depth interviews were conducted with respondents in each test market (among consumers only). Two products were placed with each of them for a period of five nights. After this test period the respondent was interviewed on his or her experience with each of the two products.

7.1.3 Quantitative research

Quantitative Usage and Attitudes Study phase 2

This phase took place over June and July of 2008, and consisted of a robust sample within each market, of 1,000 consumers and 400 small business owners. Of these, a maximum of 10% were to be connected to the grid[20]. The sample was spread over three major geographic areas in each market and included urban and rural consumers.

[20] This was as dictated by the Lighting Africa programme

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The main objective of this research phase was to quantify the usage, habits, and attitudes of consumers and retailers. Additionally it focused on current spending on lighting products and fuel, and optimum prices for modern lighting products. A face-to-face interview was conducted with a random sample of households and businesses within the areas covered.

The sample included 1,000 households and 400 retail traders in each country: Kenya, Ethiopia, Zambia, Tanzania, and Ghana. The off-grid section of the sample is representative of off-grid consumers in these areas, while the on-grid section is representative of on-grid consumers. The sample quota required that the sample would include only 10% on-grid consumers. Due to this restricted sample, and the fact that only certain areas of the countries were covered, the overall sample was not representative of the population of each country as a whole. However, the results give a good indication of the situation in each country.

Concept testing using eValuate™ phase 3

The second and final part of the quantitative study was conducted in November and December 2008 and took the form of a concept test exercise using TNS Research International's proprietary concept testing tool, eValuate™.

The main objective was to identify which lighting types (torches, task lights, areas lights, etc.) and designs were most acceptable to consumers and small business proprietors, and to highlight the strengths and weaknesses of each product tested. In conjunction with the Lighting Africa project team a concept board was devised that clearly depicted the modern lighting product to be evaluated, and included a short description of the product's features, price point, and operating costs. It also highlighted light output compared with a paraffin lamp, or, in the case of an LED torch, with a regular torch. An example concept description is shown below.

This is a desk / reading lamp that can be recharged either by plugging it into the mains or using a solar panel. The Cost of using the rechargeable Solar Lamp in the long run is lower than cost of buying paraffin for the lamp, which would add up to 200 Ksh per month. The rechargeable Lamp does not generate smoke and thus does not irritate the eyes, cause coughs or lung diseases.

Features:

- It is charged using Mains Electricity or a Solar Panel
- Brightness: On/Off
- Can last for about 4 hours on brightest setting when fully charged
- Purchase Price: Ksh 1,150 (option with Solar Panel and Electricity charging)

Monthly Cost to Charge the lamp:

Option 1: Charging using the Solar Panel: Ksh 0

Option 2: Charging via the Electricity grid: Ksh 420

The sample included 300 households in each country: Kenya, Ethiopia, Zambia, Tanzania, and Ghana. This sample was selected to give a reasonable impression of the population as a whole.

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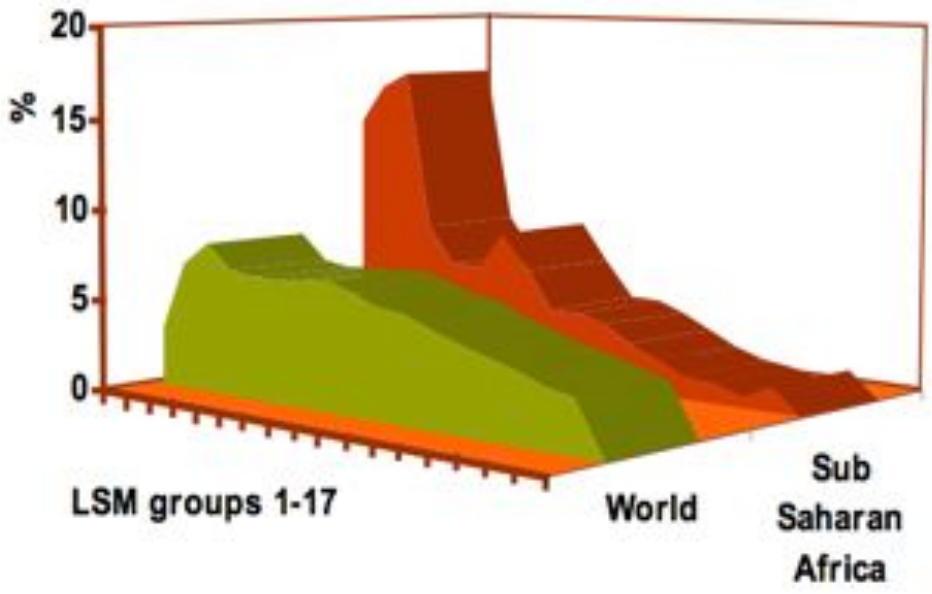
7.2 Living Standard Measures

This section gives a definition and explanation of the term living standard measure (LSM), as used in the report.

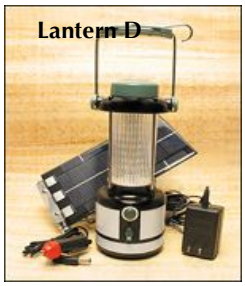
Generally, LSM is comparable to the Socio Economic Classification (SEC) used in Western Europe and America; it differs in that LSM classification is not solely based on personal or household income. As African social structures and responsibilities are more complex than in the West, basing a person's living standard solely on his or her income would not be a realistic measure. Additionally, in any country with third world characteristics, where a large portion of the economy is informal rather than formal, targeting consumers effectively becomes a formidable challenge.

Therefore, the Living Standard Measure has been devised to compensate for shortcomings of the SEC measurement and is a complex measure of income, wealth, spending power, standard of living, and participation in the formal economy. LSMs are measured by asking a large number of questions – around 20 in total – of a household or a person. After calculation of the LSM score, the population is then divided into 17 LSM groups. This rating, ranging from 1 (lowest) to 17 (highest), forms the Pan-African LSM and allows for comparisons between different African countries.



7.3 Products and concepts tested per phase

Phase 1: Qualitative Study (March/April 2008)



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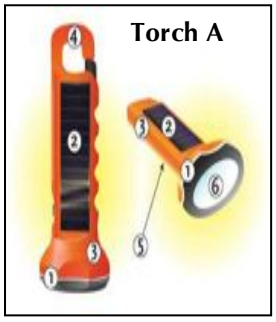
Phase 2: Quantitative – Usage & Attitudes Study (June/July 2008)



Phase 3: Quantitative – Concept test Study (November/December 2008)

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Phase 4: Qualitative Study (April / May 2009)

Table A1. Products tested in Phase 4 – Qualitative Study, with instructions on use that were given to consumers.

Product code	Product notes
Torch B 	• Has an easy-to-tuck-away power lead. • Torch can be hung on the wall or from the ceiling to provide light.
Task Light C 	• The first time you click the switch on, the lamp is on full beam. • The second time you click the switch on, the lamp is on single beam. • You need to click the switch 3 times before it goes off. • The lamp will not come on if the solar panel is plugged into the device. • There is a switch at the bottom of the solar panel. Make sure that it is in the ON position; otherwise the device will NOT charge. • Please be careful NOT to lose the bottom flap of the solar charger. You may need to tape them shut. • The solar panel requires a fair bit of sunlight before the charging light comes ON. It may not light indoors. • Device has a hook, which enables it to be hang on the roof, it can stand, and the flexi stem enables you to bend it in all directions. • It can be put on a desk to illuminate your work, or on a fridge or cabinet to light the whole room.
Area Light B 	• Will require a fair bit of light before the charging light comes ON. • Device can stand, hang on a wall, carried on the wrist or even be hang of the roof. Kindly show all these options to the respondent. • Unlike the other devices, the power cable can be neatly tucked away around the solar panel, creating neatness and order.
Area Light C 	• The solar panels that are packed separately in the box are to be used to charge this device. • The device has long leads and “Firefly” like lamps. • The switch can be placed to control either one or both lamps. • Switches for the lights are connected to the power pack itself. • Cables are loose on some of the devices. • For all the devices, optimal charging is obtained when the solar panel is pointed at the overhead sun.

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Area Light D 	• Device has a slot to charge a radio. • Cables are long to ensure that the lamps can be situated using a hook on the roof, or a stand and far away from the power pack. • There are slots to light two bulbs. • The solar lead is loose against the power pack for some of the devices and seems to pop out. • Switches for the lights are connected to the power pack itself.

7.4 Conversion rates

Table A2. Currency conversion rates as of April 2008.

Exchange Rate	Unit	Ethiopia	Ghana	Kenya	Tanzania	Zambia
Exchange rate as of April 2008	US$1=	ETB 9.95	GHC 1.04	Ksh 66.00	Tsh 1,181.00	ZK 3,333.33

7.5 Tables for section 3.1: Understanding the profile of typical African households and traders

Table A3. Wall material of consumer dwelling.

	Ethiopia n=1006	Ghana n=995	Kenya n=1000	Tanzania n=1000	Zambia n=1000
	%	%	%	%	%
Mud/mud bricks	94	54	46	50	52
Wood planks	2	5	19	3	2
Bricks or stone	4	22	24	44	41
Corrugated Iron	-	3	11	2	3
Other	-	15	-	2	2

Phase 2 Quantitative Usage and Attitude Study

Table A4. Type of road near consumer dwelling.

	Ethiopia n=1006	Ghana n=995	Kenya n=1000	Tanzania n=1000	Zambia n=1000
	%	%	%	%	%
Tarmac	36	22	13	20	23
Murram or rough road	43	51	61	52	59
Pathway (no vehicle access)	21	27	26	28	18

Phase 2 Quantitative Usage and Attitude Study

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Table A5. Dwelling environment (households).

	Ethiopia n=1006	Ghana n=995	Kenya n=1000	Tanzania n=1000	Zambia n=1000
	%	%	%	%	%
Planned urban centre	3	8	5	15	19
Unplanned/informal settlement	19	23	18	24	28
Rural – planned settlement	4	13	9	22	8
Rural – other	75	56	68	40	47

Phase 2 Quantitative Usage and Attitude Study

Table A6. Roof material on the dwelling (households).

	Ethiopia n=1006	Ghana n=995	Kenya n=1000	Tanzania n=1000	Zambia n=1000
	%	%	%	%	%
Grass or other thatch	41	29	11	16	42
Corrugated iron	58	69	88	83	55
Tiles	1	2	1	2	3

Phase 2 Quantitative Usage and Attitude Study

Table A7. Colour of the walls in the main business room.

	Ethiopia n=400	Ghana n=395	Kenya n=400	Tanzania n=400	Zambia n=396
	%	%	%	%	%
White or bright colour	12	35	38	34	40
Brown / natural clay / dark clay	41	24	28	24	34
Other clay	30	28	16	20	13
Not observed	15	13	18	22	13

Phase 2 Quantitative Usage and Attitude Study

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Table A8. Size of the main business structure.

	Ethiopia n=400	Ghana n=395	Kenya n=400	Tanzania n=400	Zambia n=396
	%	%	%	%	%
3 Square meters or less	26	43	48	47	61
3.1 - 8 Square meters	45	48	38	30	32
More than 8 Square meters	29	9	14	23	7

Phase 2 Quantitative Usage and Attitude Study

Table A9. Business environment.

	Ethiopia n=400	Ghana n=395	Kenya n=400	Tanzania n=400	Zambia n=396
	%	%	%	%	%
Planned urban centre	6	13	16	18	19
Unplanned/informal settlement	17	20	16	23	21
Rural – planned settlement	5	25	45	29	23
Rural – other	72	42	23	30	37

Phase 2 Quantitative Usage and Attitude Study

Table A10. Roof material of the business structure.

	Ethiopia n=400	Ghana n=395	Kenya n=400	Tanzania n=400	Zambia n=396
	%	%	%	%	%
Grass or other thatch	36	5	5	12	22
Corrugated iron	63	93	93	84	75
Tiles	1	2	2	4	3

Phase 2 Quantitative Usage and Attitude Study

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Table A11. Wall material of business structure.

	Ethiopia n=400	Ghana n=395	Kenya n=400	Tanzania n=400	Zambia n=396
	%	%	%	%	%
Mud/mud bricks	69	17	16	23	25
Wood planks	16	49	27	19	21
Bricks or stone	5	18	36	55	47
Corrugated Iron	3	3	21	3	5
Other	7	13	-	-	2

Phase 2 Quantitative Usage and Attitude Study

Table A12. Type of road near business structure.

	Ethiopia n=400	Ghana n=395	Kenya n=400	Tanzania n=400	Zambia n=396
	%	%	%	%	%
Tarmac	39	28	39	30	32
Murram or rough road	46	50	55	60	64
Pathway (no vehicle access)	15	22	6	10	4

Phase 2 Quantitative Usage and Attitude Study

Table A13. Average monthly sales, profits, and household income for traders.

	Average monthly sales	Average monthly profits	Average monthly household income
	US$	US$	US$
Ethiopia	182.0	54.6	130.3
Ghana	246.0	68.3	130.2
Kenya	327.2	83.9	146.5
Tanzania	279.6	116.5	175.4
Zambia	503.2	175.9	179.8

Phase 2 Quantitative Usage and Attitude Study

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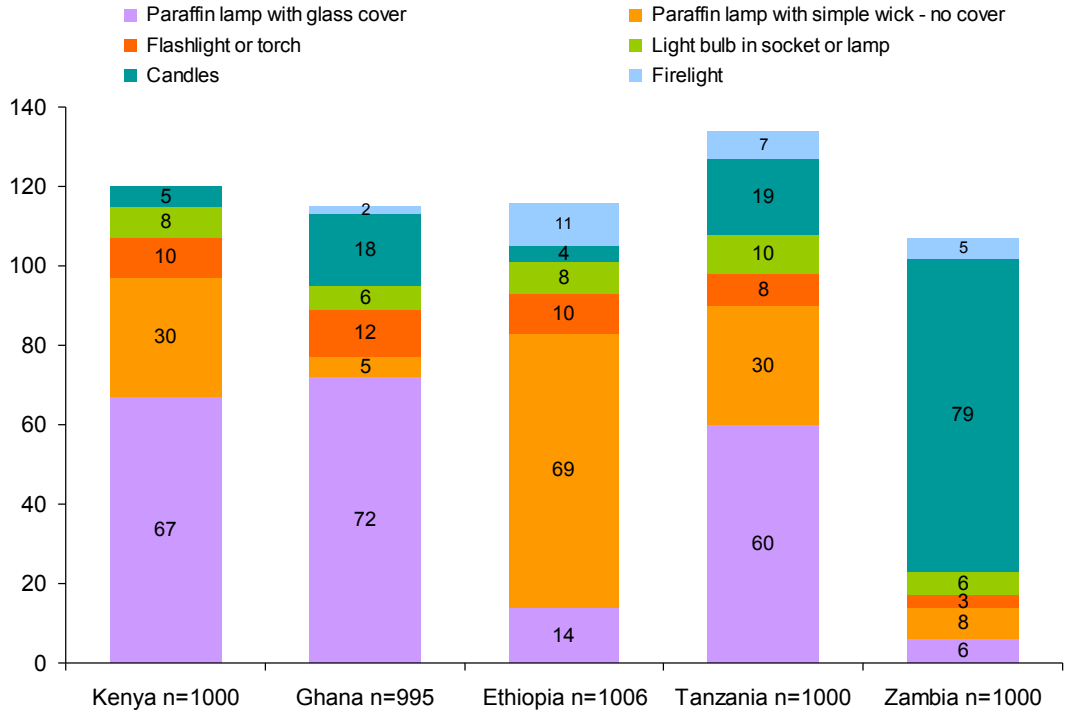
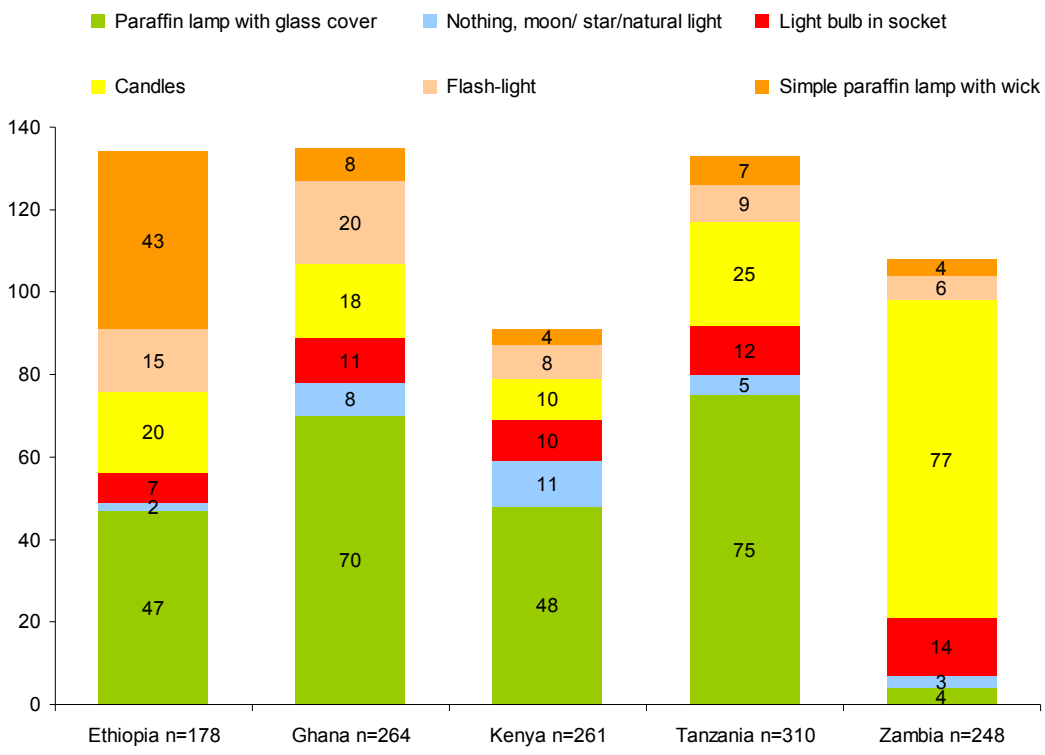
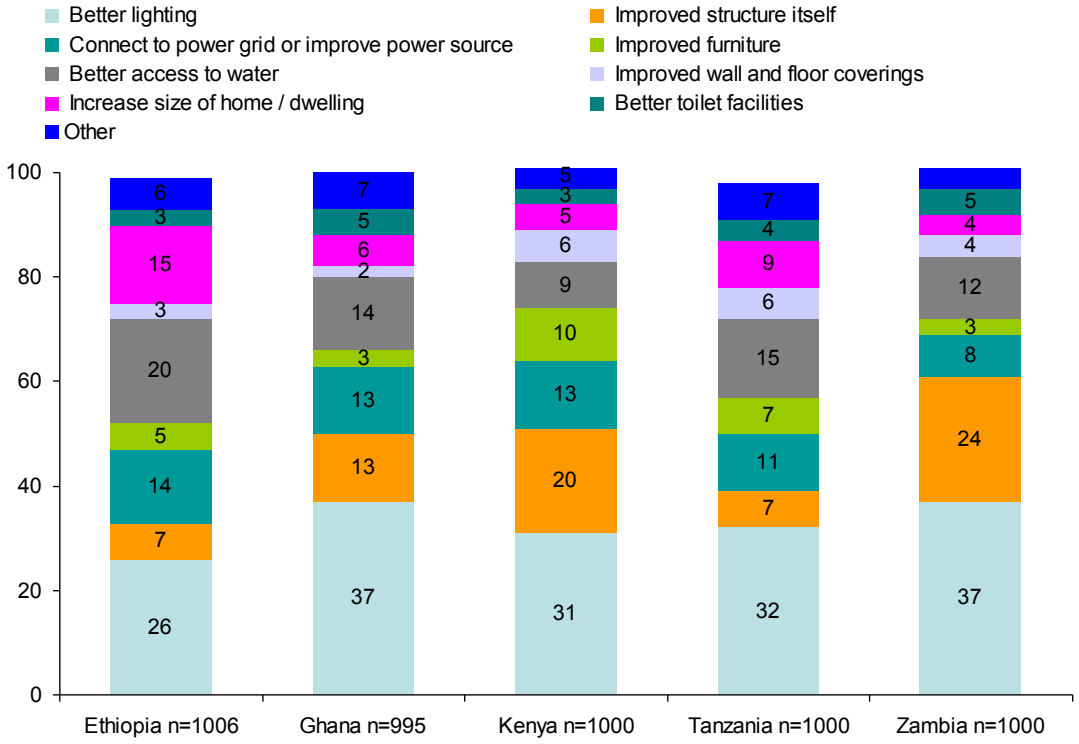
7.6 Tables and graphs for section 3.2.1: Consumers



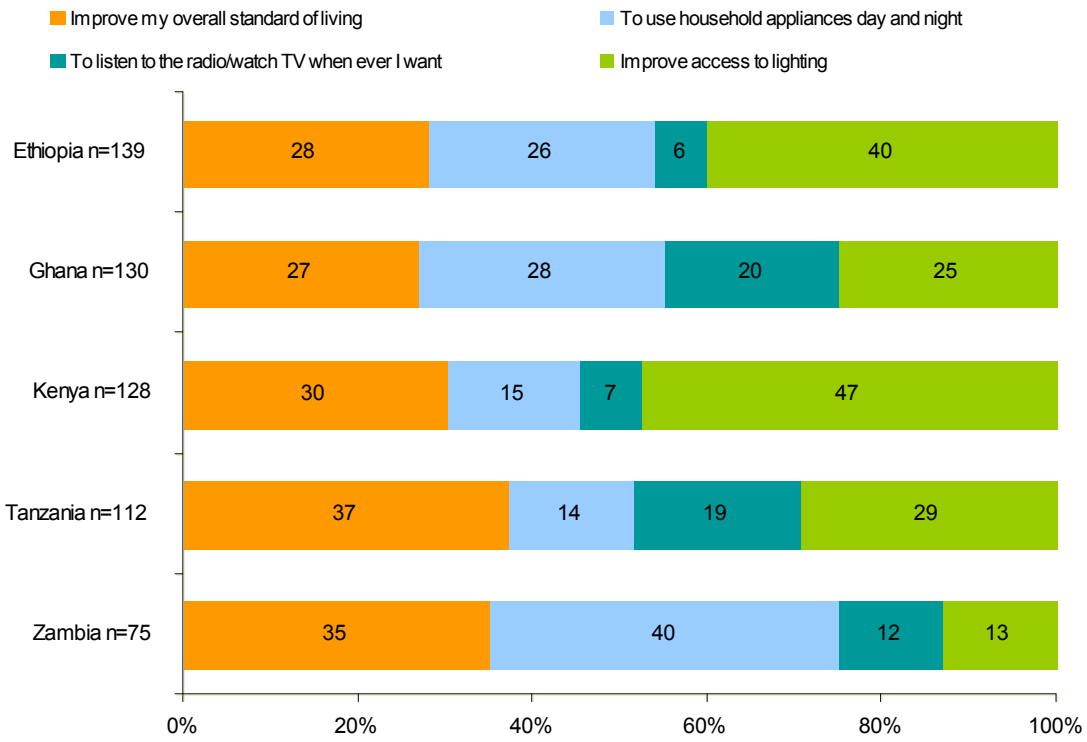
Graph A1. Consumers: Types of lighting devices used (Base: total sample) – Question "What, if anything, was used to light the main room last night?" Phase two Quantitative Usage and Attitude Study.



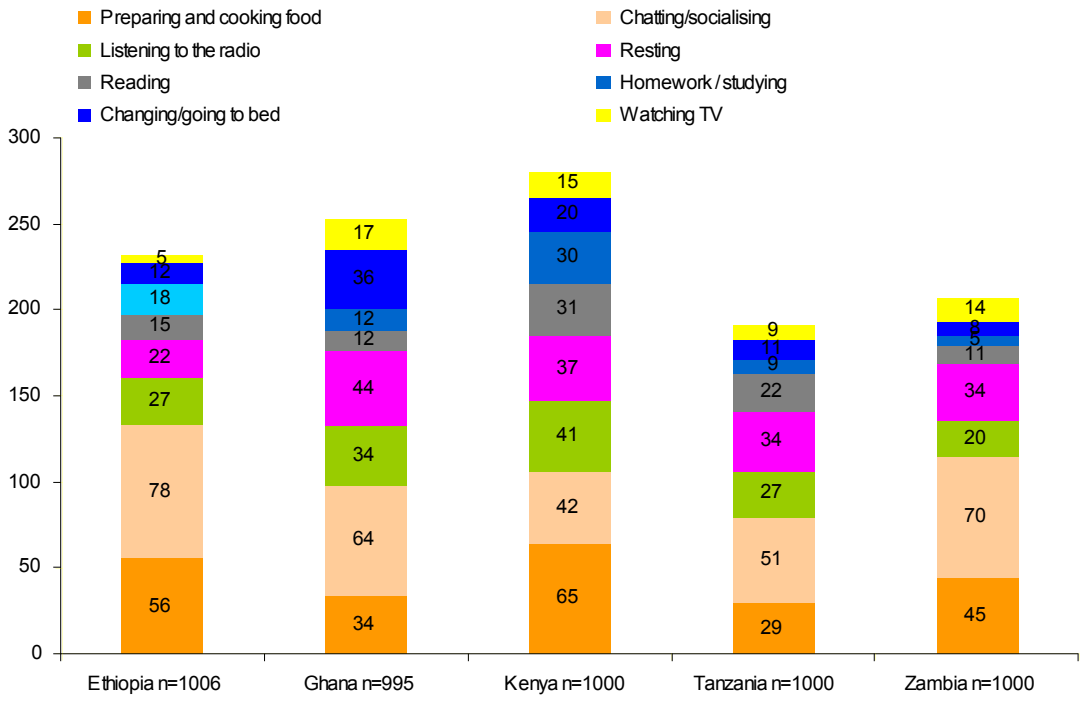
Graph A2. Traders: Types of lighting devices used (Base: all those who use lights in their business) – Question "What if anything is used to light the business?"



Graph A3. Consumers: Improvements to the household (Base: total sample) – Question "If there was one thing you could do to improve your household or its facilities, what would it be?"



Graph A4. Consumers: Reasons for wanting to improve power source (Base: all those who would improve power source) – Question "You mentioned you would like to connect to a power grid or improve your power source by purchasing a generator.



Graph A5. Consumers: Nighttime activities (Base: total sample) – Question "Which activities were people doing last night?"

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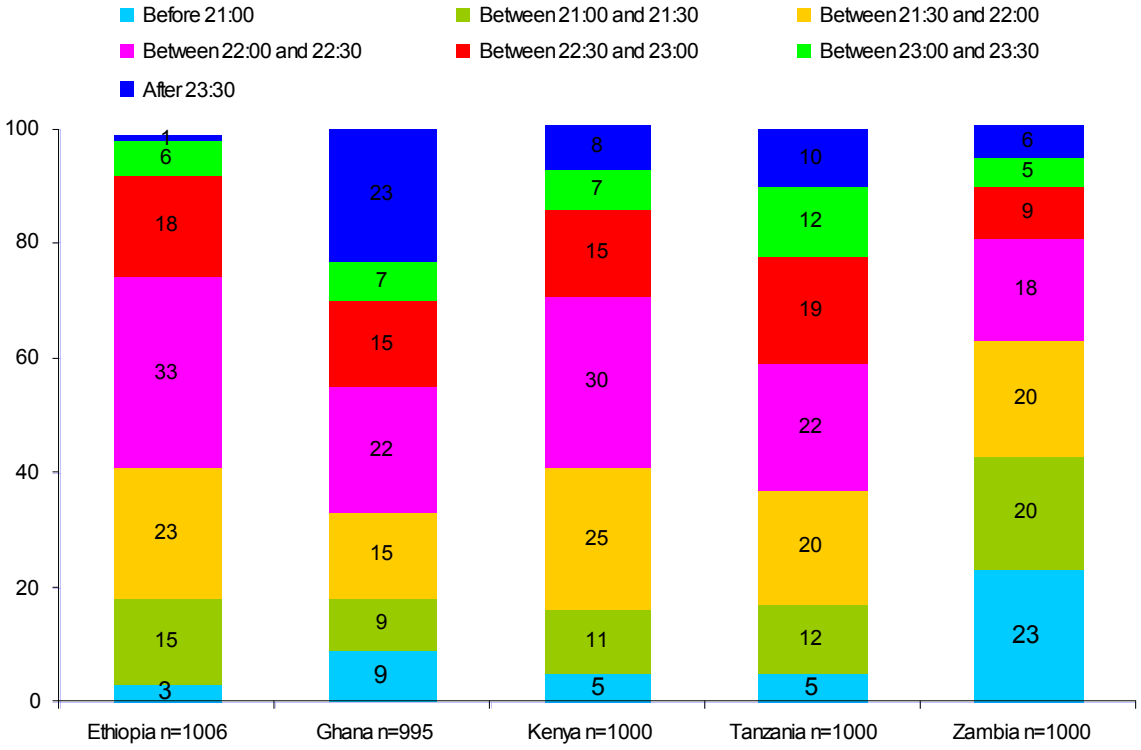
Graph A6. Consumers: Time when lighting products are switched on (Base: total sample) – Question "When do you begin using lighting products/devices each night?"



Graph A7. Consumers: Time when lighting products are turned off (Base: total sample) – Question "What time did the last light go off in the household last night?"

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Table A14. Consumers: Use of light in the rooms (Base: total sample) – Question 1 "How many rooms in this dwelling were used after dark yesterday evening?" Question 2 "How many rooms in this dwelling were lit at all yesterday evening?"

	Ethiopia		Ghana		Kenya		Tanzania		Zambia	
	Q. 1	Q. 2	Q. 1	Q. 2	Q. 1	Q. 2	Q. 1	Q. 2	Q. 1	Q. 2
	%	%	%	%	%	%	%	%	%	%
1 room	38	57	21	32	22	29	7	12	17	30
2 rooms	40	31	33	32	32	35	25	32	40	35
3 rooms	15	8	19	14	25	21	26	29	18	18
4 rooms	4	3	13	10	12	9	21	15	13	10
5 rooms	1	1	6	6	0	0	10	6	0	0
>5 rooms	0	0	8	6	9	5	9	4	10	7
Mean	**1.8**	**1.6**	**2.8**	**2.5**	**2.7**	**2.3**	**3.3**	**2.8**	**2.7**	**2.4**

Mean values assume an average of 7 rooms in households responding greater than 5.

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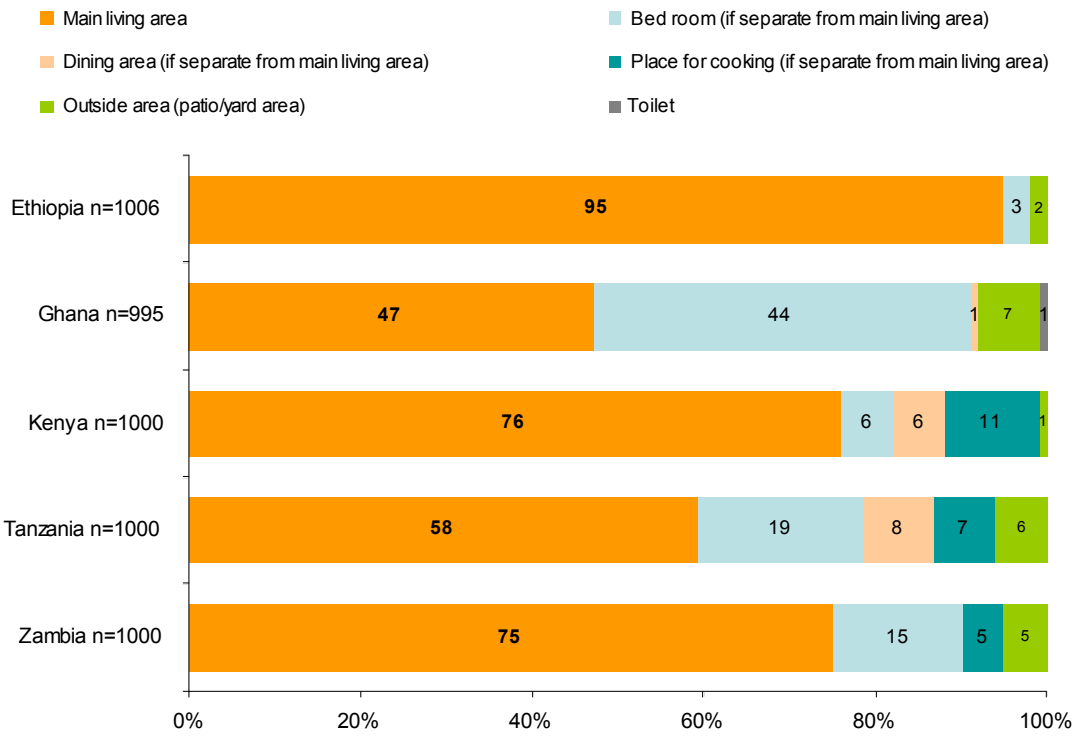
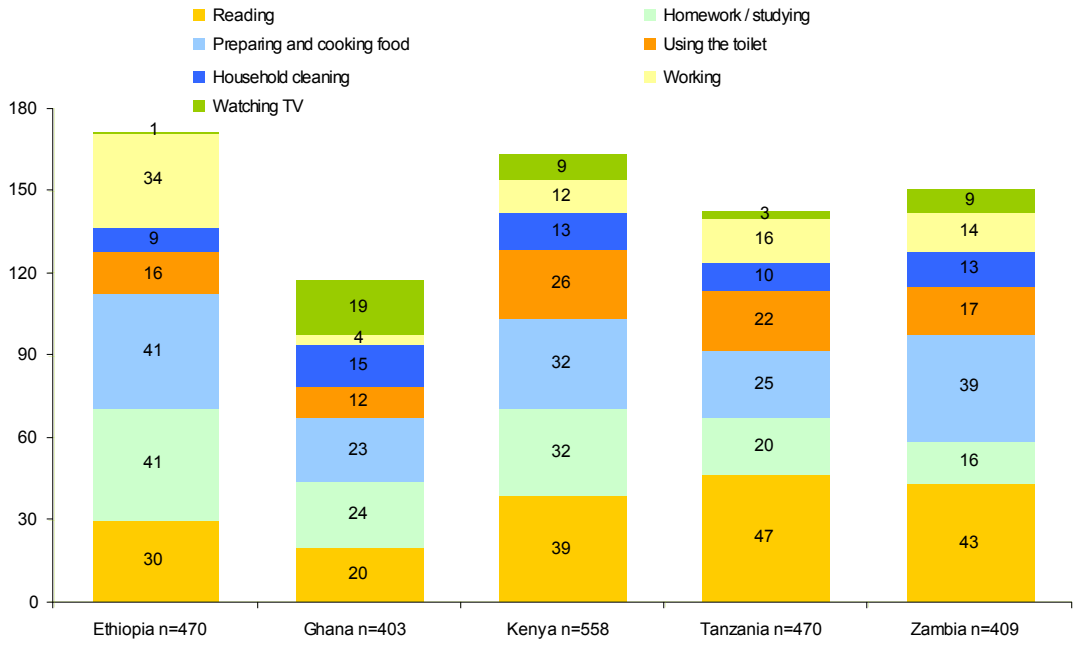


Graph A8. Consumers: Use of light in the rooms (Base: total sample) – Question "Which one room/area did the household residents use for the longest time after dark last night?"



Graph A9. Consumers: Activities that could not be performed well due to lack of lighting (Base: all those not comfortable doing activities in the main room) – Question "Which activities could not be done well or comfortably due to lack of lighting?"

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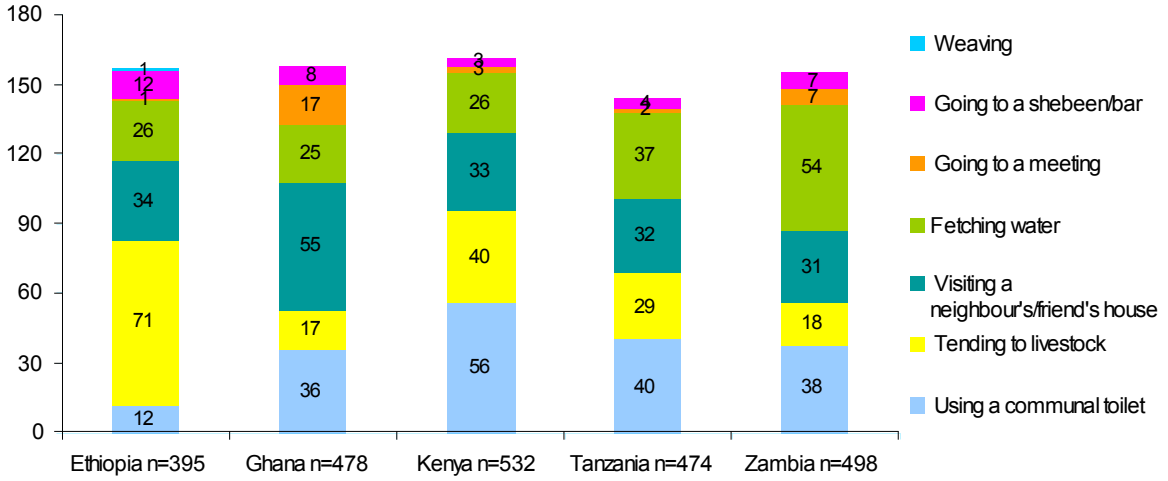
Table A15. Consumers: Outdoor activities unable to do due to lack of lighting (Base: total sample) Question "Are you currently inhibited to performing certain types of outdoor activity due to lack of lighting?"

	Ethiopia n=1006	Ghana n=995	Kenya n=1000	Tanzania n=1000	Zambia n=1000
	%	%	%	%	%
Yes	39	48	53	47	50
No	61	52	47	53	50



Graph A10. Consumers: Activities that could not be performed well due to lack of lighting (Base: all those who could not perform certain types of outdoor activities due to lack of lighting) – Question "Which types of outdoor activities can you currently not perform due to lack of lighting?"

Table A16. Consumers: In-home lighting (Base: total sample) – Question "How would you rate the lighting in your home nowadays?"

	Ethiopia n=1006	Ghana n=995	Kenya n=1000	Tanzania n=1000	Zambia n=1000
	%	%	%	%	%
Well Lit	28	39	28	41	33
Poorly Lit	72	61	72	59	67

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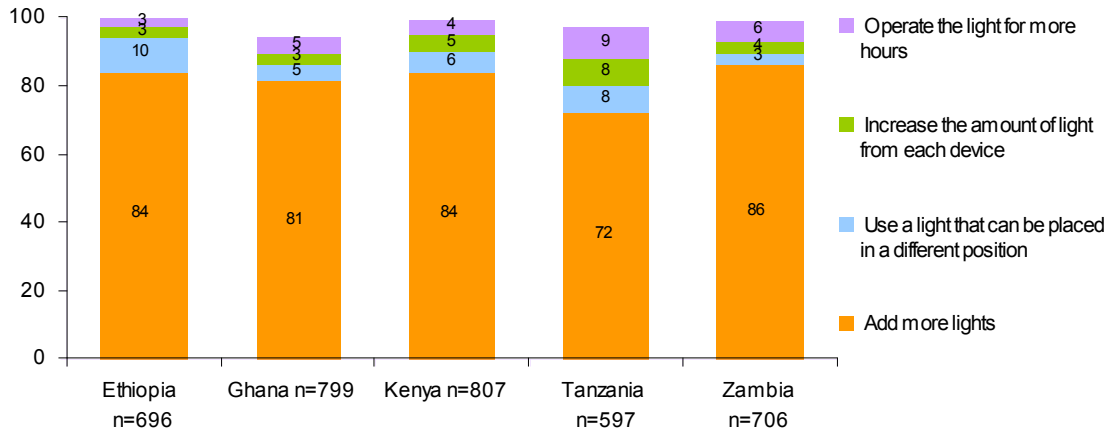
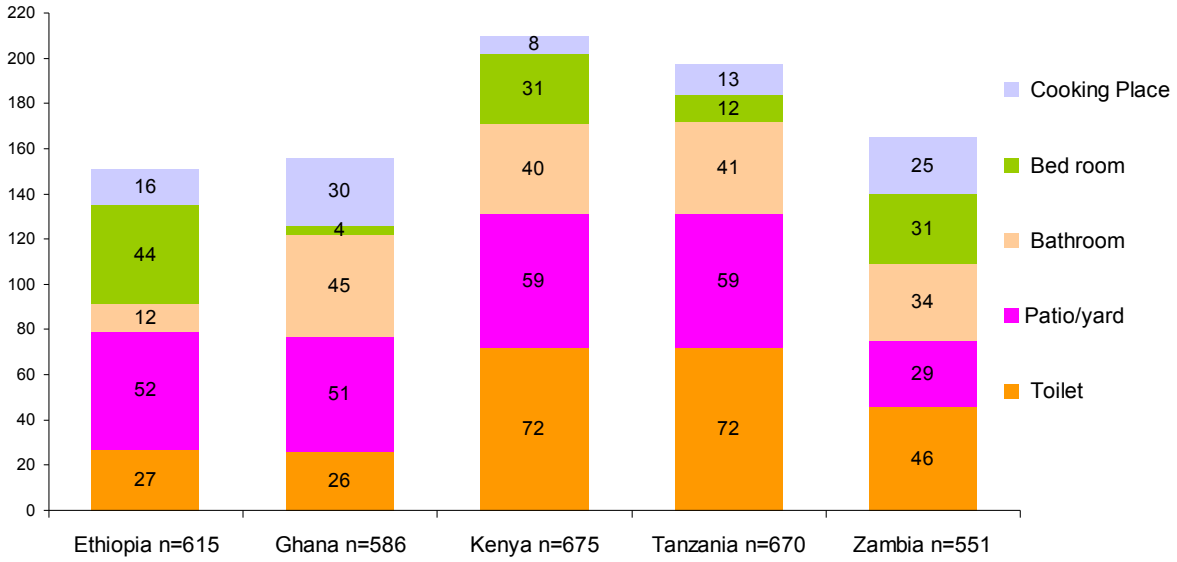


Graph A11. Consumers: In-home lighting (Base: households whose lighting can be improved) – Question "How would you improve the lighting situation in your home?"

Table A17. Consumers: Rooms not lit last night (Base: total sample) – Question "Was your home lit in all the areas that you needed it last night?"

	Ethiopia n=1006	Ghana n=995	Kenya n=1000	Tanzania n=1000	Zambia n=1000
	%	%	%	%	%
Yes	39	41	33	33	45
No	61	59	67	67	50



Graph A12. Consumers: Rooms not lit last night (Base: all those with homes not lit in all areas) – Question "Which rooms or areas were not lit last night?"

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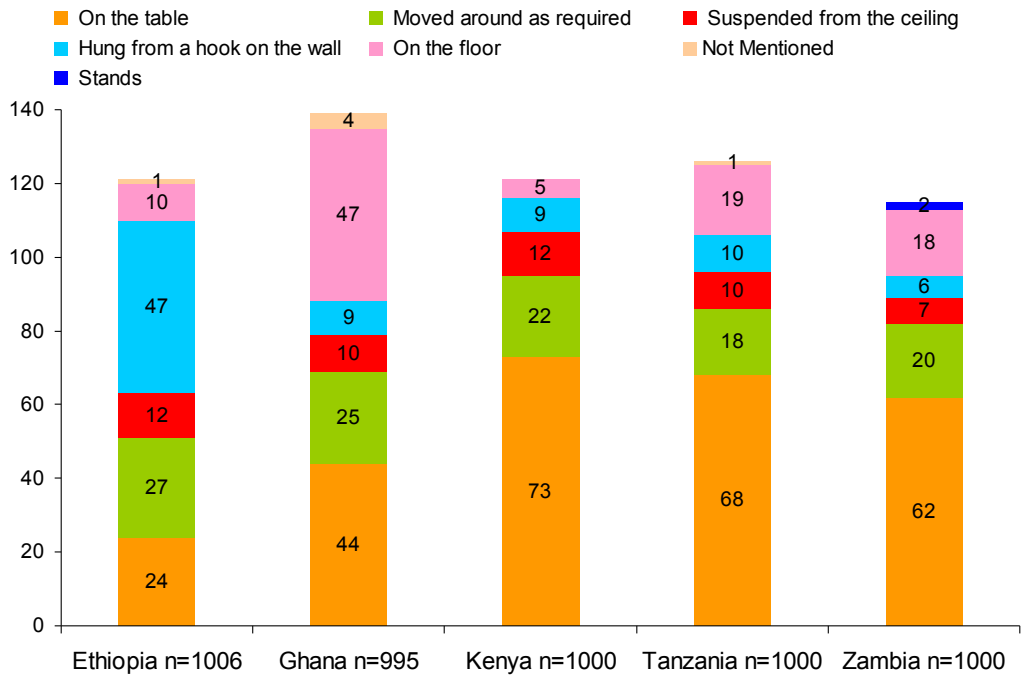

Graph A13. Consumers: Placement of light devices (Base: total sample) – Question "Where were the lights in the main room located?"

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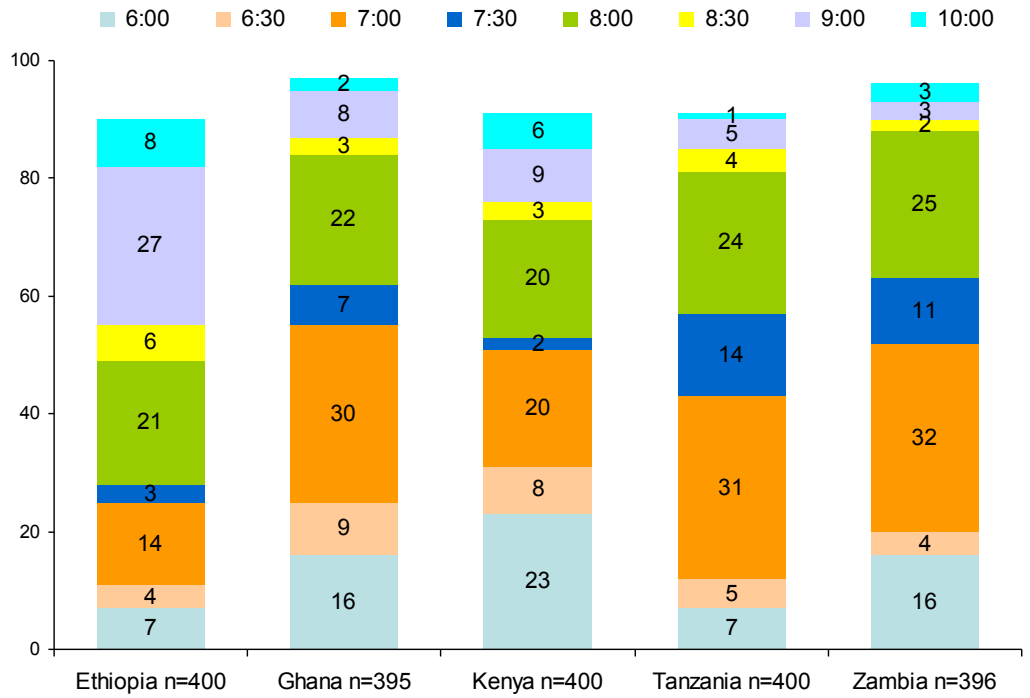
7.7 Tables and graphs for section 3.2.2: Traders

Table A18. Traders: Operating the business after dark (Base: total sample) – Question "Does this business ever operate after dark?"

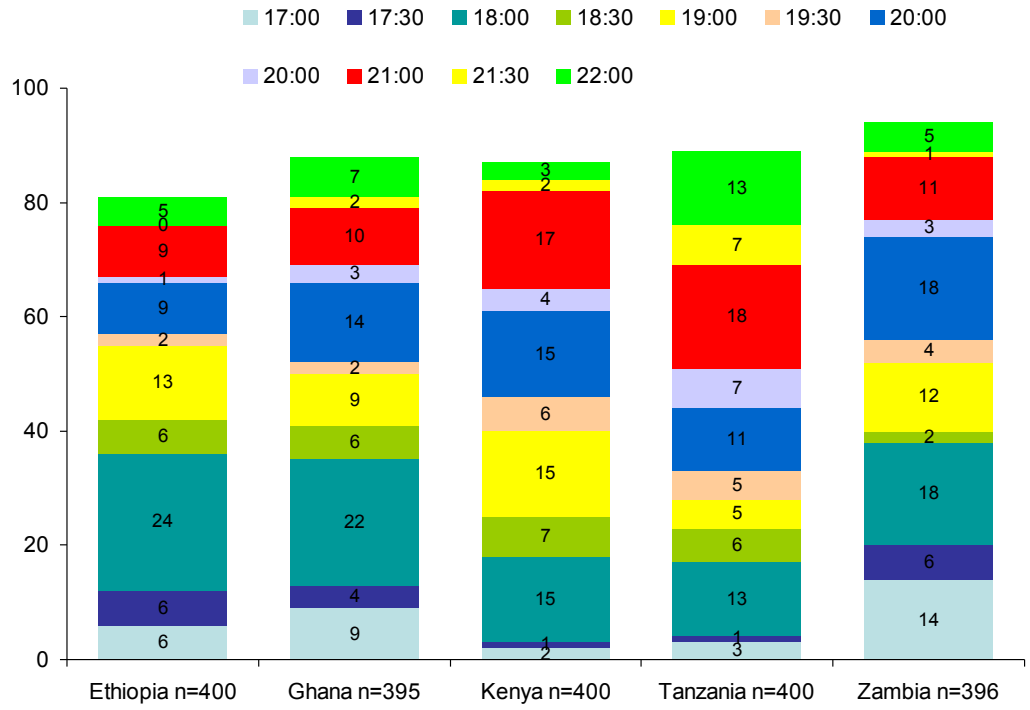
	Ethiopia n=400	Ghana n=395	Kenya n=400	Tanzania n=400	Zambia n=396
	%	%	%	%	%
Yes, regularly	35	45	49	62	45
Occasionally	10	21	16	14	16
No, never	55	34	35	24	39

Table A19. Traders: Use of light (Base: total sample) – Question "Are any lights used at the premises during the day time?"

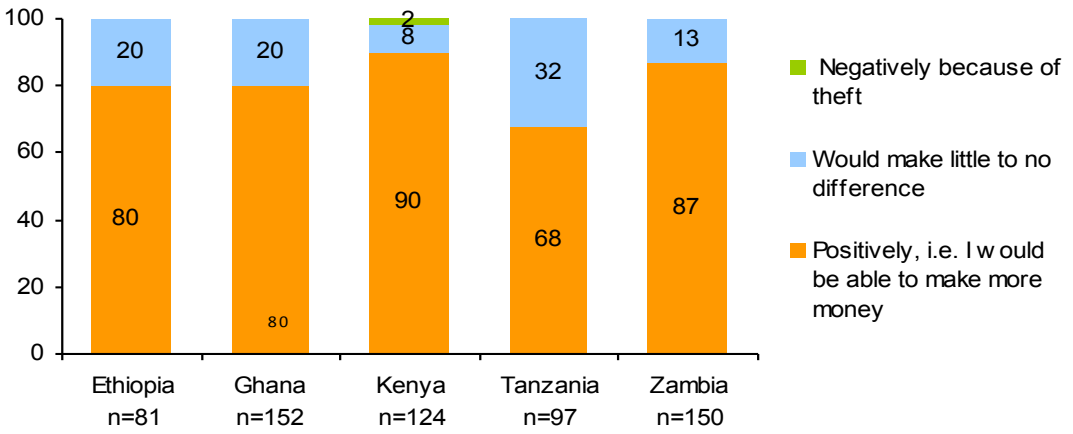
	Ethiopia n=400	Ghana n=395	Kenya n=400	Tanzania n=400	Zambia n=396
	%	%	%	%	%
Yes	5	9	11	16	15
No	95	91	89	85	85



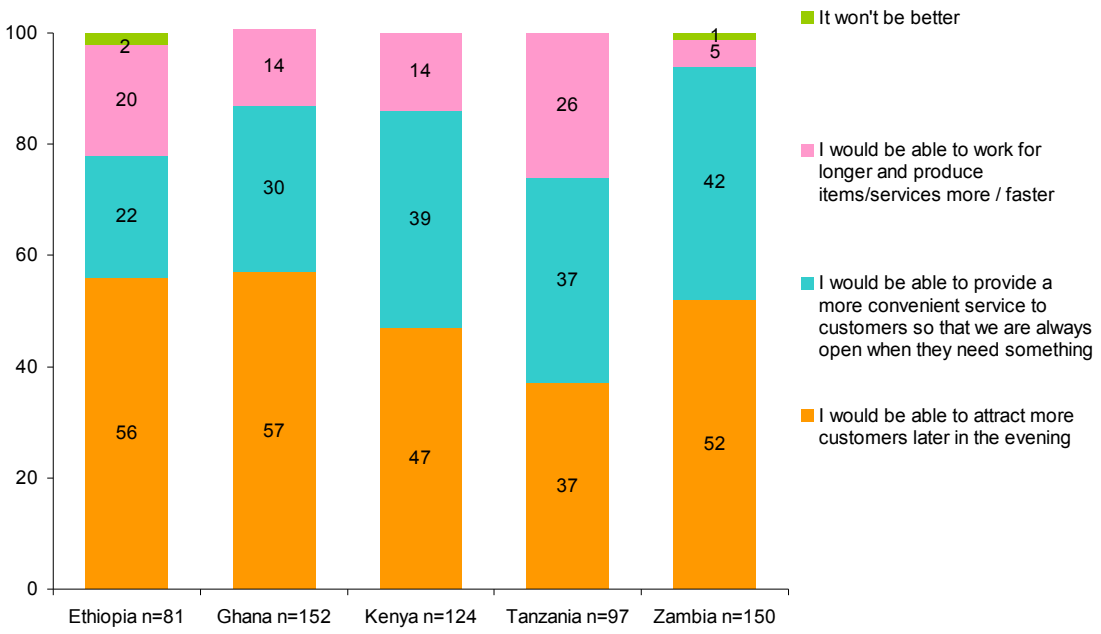
Graph A14. Traders: Opening time (Base: total sample) – Question "What time does your business usually open?"



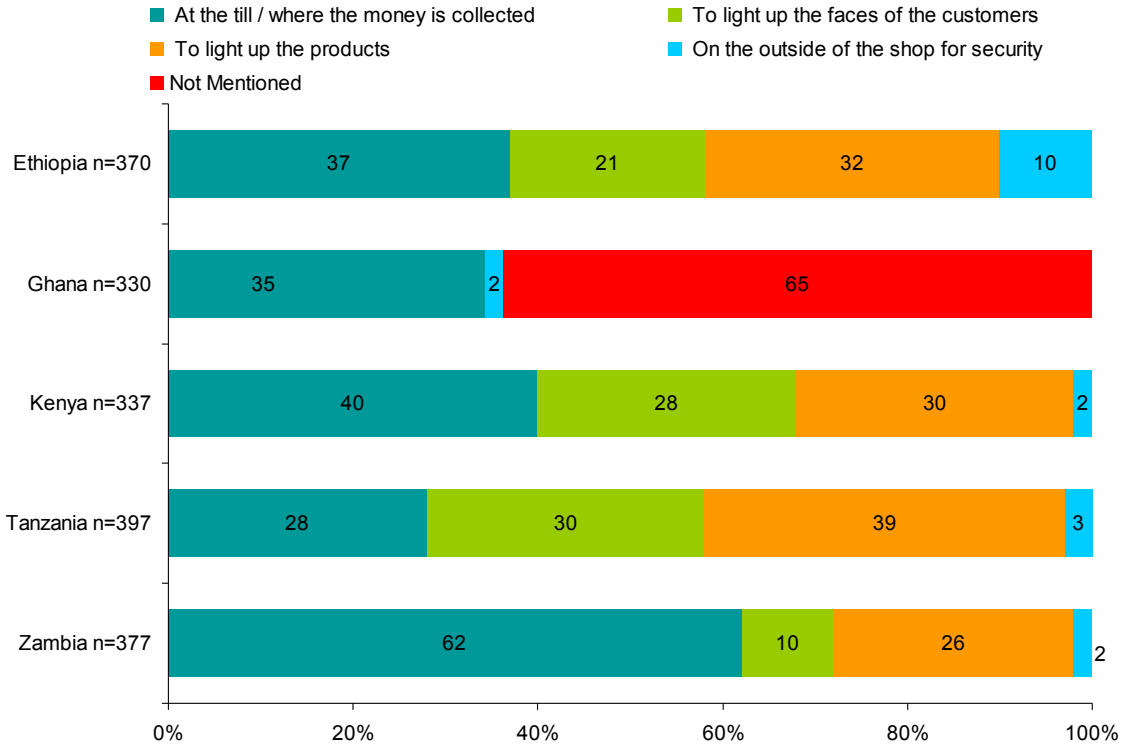
Graph A15. Traders: Closing time (Base: total sample) – Question "What time does your business usually close?"



Graph A16. Traders: Closing time (Base: all those who would open after dark) – Question "How would staying open during dark hours affect the finances of your business?"



Graph A17. Traders: Likely response to opening after dark (Base: all those who would want to open after dark) "How would customers respond to you staying open at night?"



Graph A18. Traders: Preferred light position (Base: retail shops) "What or where in the shop would you like to position lamps?"

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Table A20. Traders: Effects on finances from opening after dark (Base: all those who do not open regularly after dark) – Question "If you had adequate lights would you operate after dark?"

	Ethiopia n=261	Ghana n=216	Kenya n=206	Tanzania n=151	Zambia n=220
	%	%	%	%	%
Yes, regularly	13	48	43	46	51
Occasionally	18	22	17	18	32
No, never	69	30	40	36	17

Table A21. Traders: Rating for lighting outside the business and its limitations (Base: all those who light their business) – Question "How would you rate this level of lighting outside the business?"

	Ethiopia n=178	Ghana n=770	Kenya n=261	Tanzania n=310	Zambia n=248
	%	%	%	%	%
Well Lit	7	23	16	21	17
Poorly Lit	93	77	84	79	83

Table A22. Traders: Rating for lighting outside the business and its limitations (Base: all those who light their business) – Question "How does the available lighting outside of your business limit you in terms of running your business, if at all?"

	Ethiopia n=178	Ghana n=770	Kenya n=261	Tanzania n=310	Zambia n=248
	%	%	%	%	%
It is hard to display goods outside the shop after dark		1	6		11
Not mentioned		83	75		
It's very expensive	9				7
There is no security, hence cannot operate the business after dark	41	3	15	42	22
Customers don't see the shop clearly, so they don't shop after dark	41	4	5	19	27
I cannot see customers' faces clearly, because they buy from outside		2	4	12	13
Sometimes customers tend to think that the business has closed down due to lack of light	9	6	2	15	22
The customers feel insecure		1	1	6	

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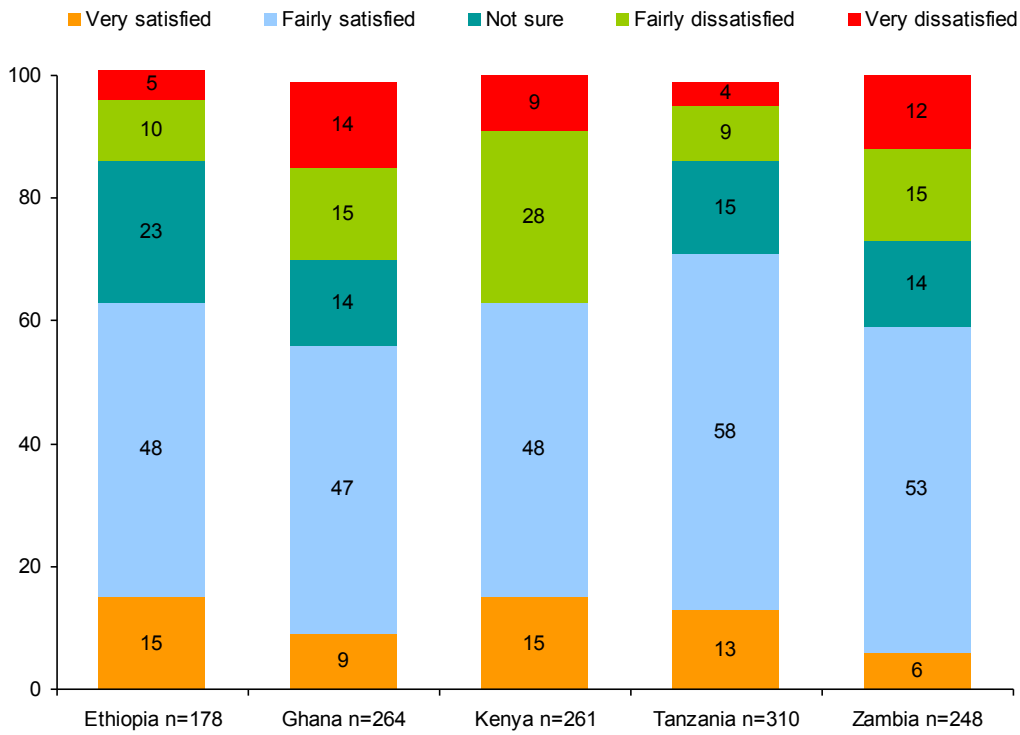

Graph A19. Traders: Satisfaction level with current lighting (Base: all those who light their business) – Question "How satisfied or dissatisfied are you with the way your business is lit?"

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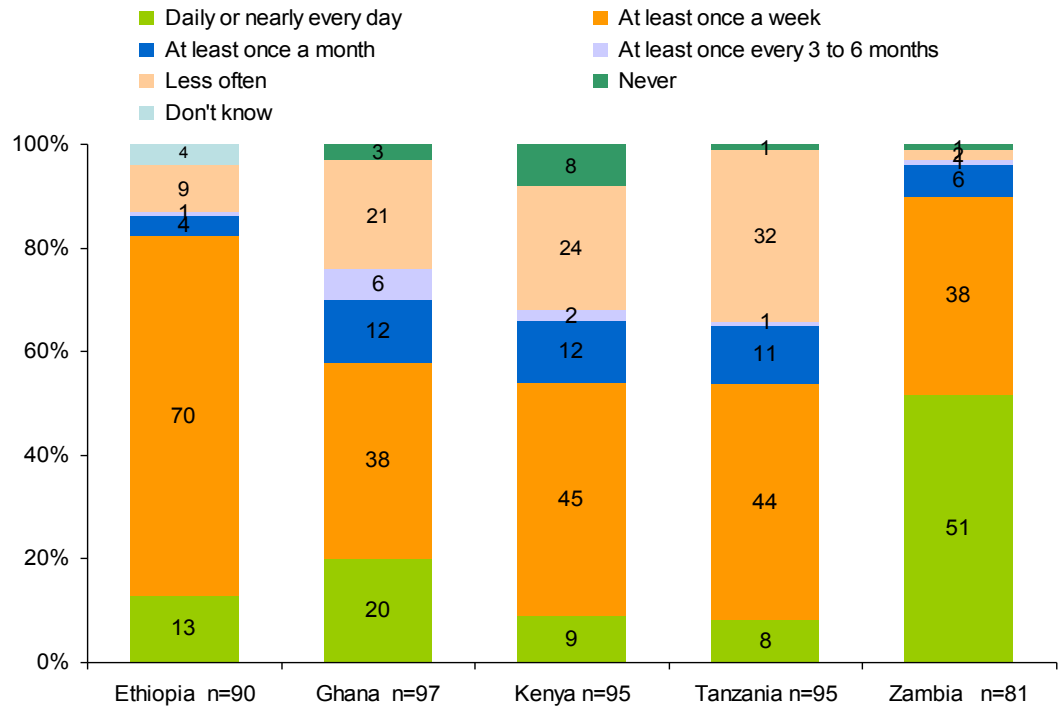
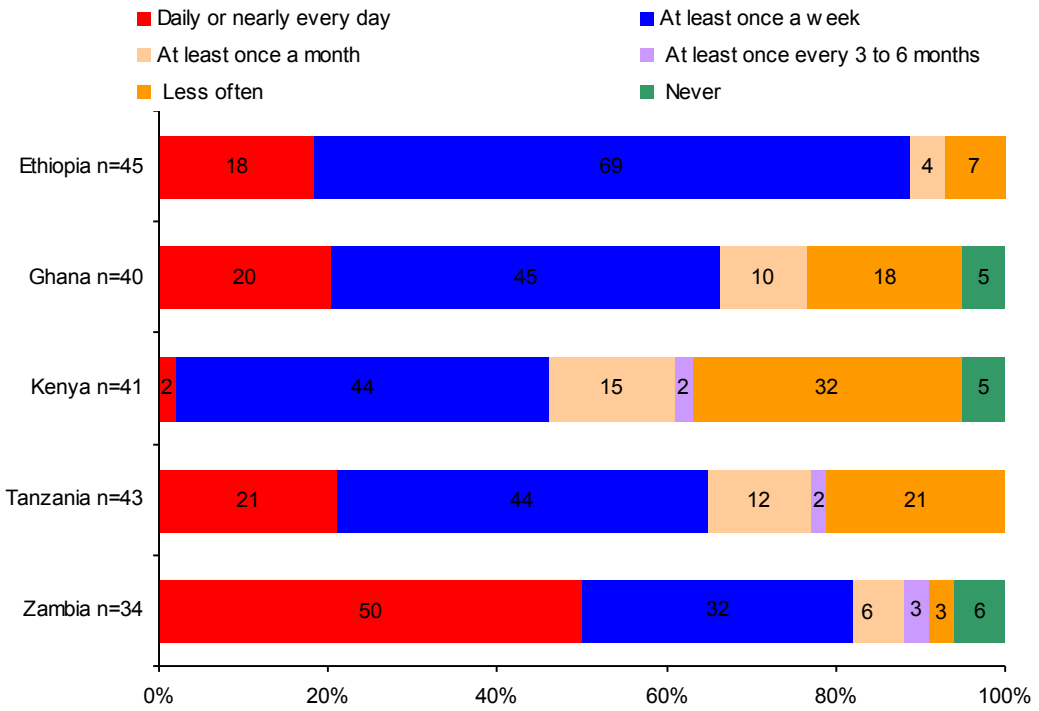
7.8 Graphs for section 3.2.3: Electric grid



Graph A20. Consumers: Power cut frequency (Base: all those currently connected to main power grid) – Question "How often, if ever, do you experience power cuts?"



Graph A21. Traders: Power cut frequency (Base: all those currently connected to main power grid) – Question "How often, if ever, do you experience power cuts?"

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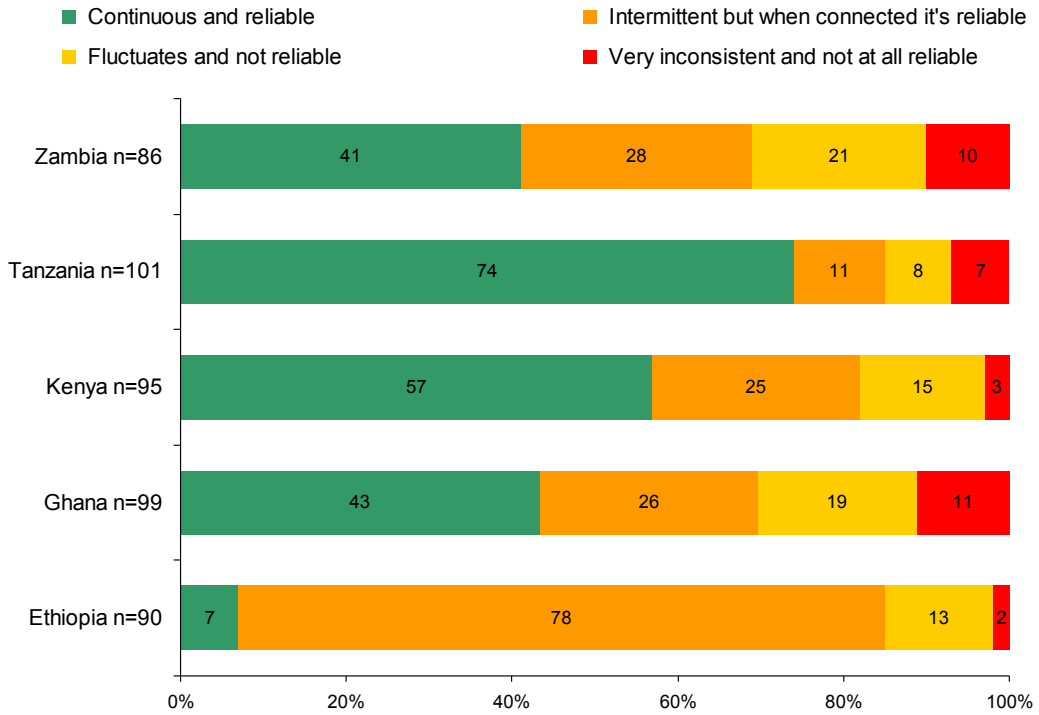
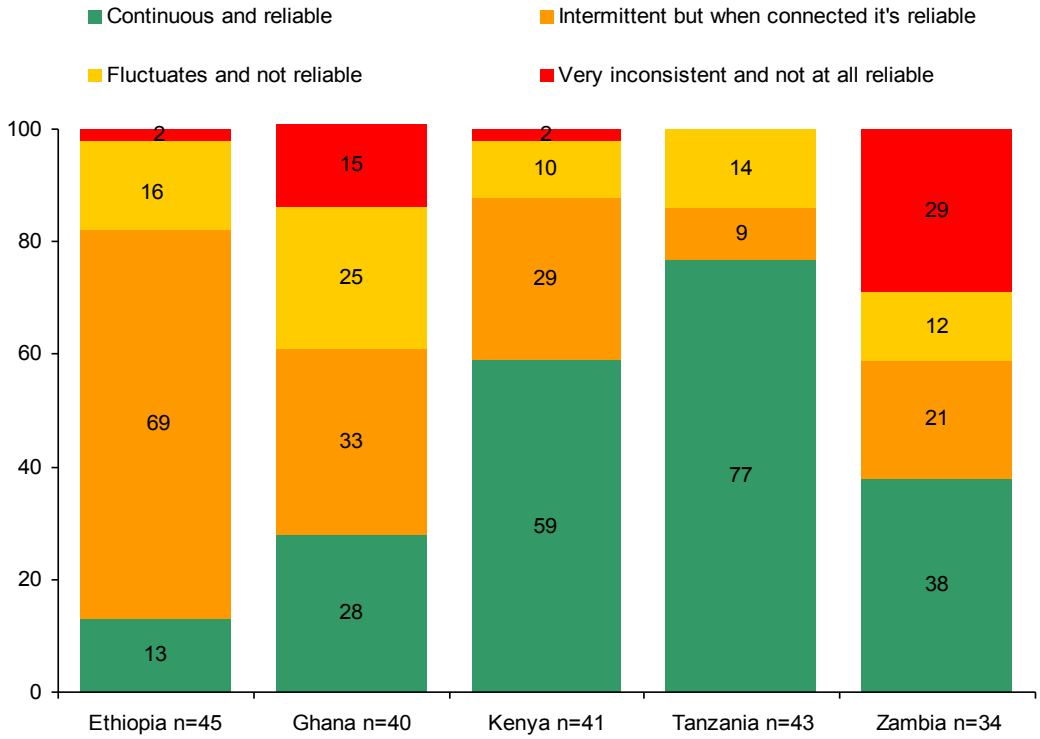
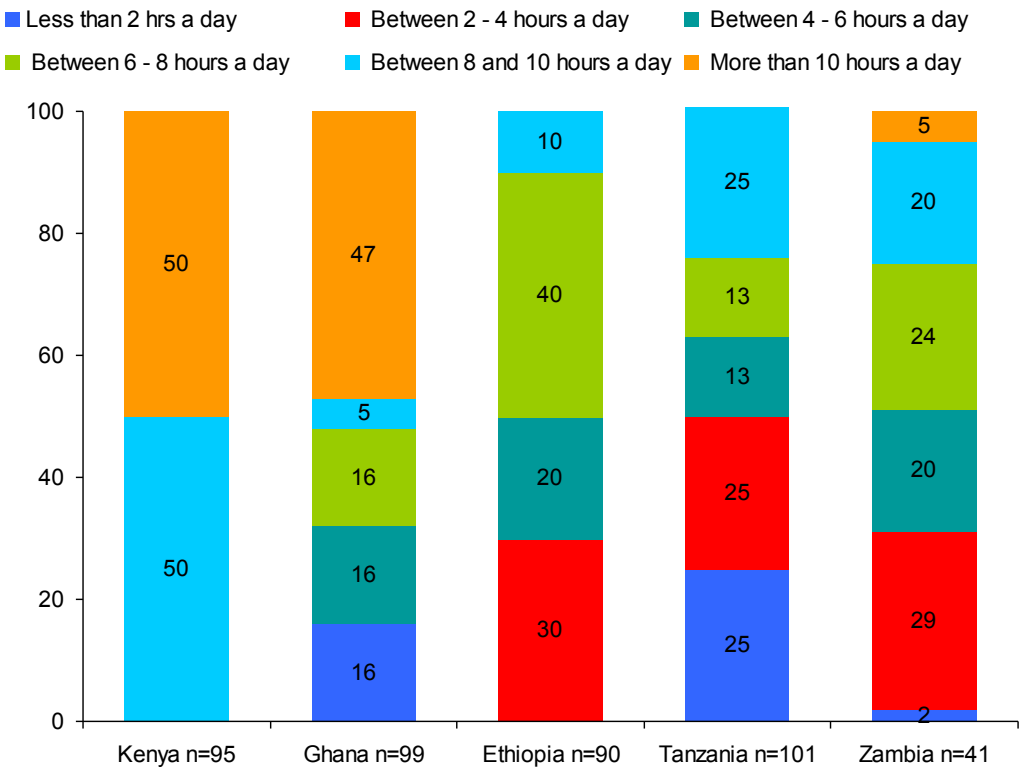


Graph A22. Consumers: Quality of electricity (Base: currently connected to main power grid and have electricity) – Question "How would you rate the quality of electricity?"



Graph A23. Traders: Quality of electricity (Base: all those currently connected to main power grid) – Question "How would you rate the quality of electricity?"



Graph A24. Consumers: Number of hours electricity is received in a day (Base: all those who experience power cuts daily or nearly daily) – Question "On average how many hours a day do you receive electricity?"

7.9 Table for section 3.3.1: Number of lighting products per household

Table A23. Consumers: Average number of each lighting device used (Base: all those who used one of the lighting devices listed in the table last night) – Question "How many were used of each lighting device?"

	Ethiopia	Ghana	Kenya	Tanzania	Zambia
Candles	1.3	1.6	1.8	2.0	1.8
Lantern (battery or solar)	-	1.4	1.3	1.3	1.6
Firelight	1.9	1.4	1.1	-	1.5
Paraffin lamp without cover	1.4	1.4	1.7	1.2	1.5
Paraffin lamp with glass cover	1.2	2.1	1.4	1.3	1.4
Torch (flashlight)	1.6	1.2	1.3	1.1	1.2
Light bulb in socket or lamp	1.8	-	2.7	1.9	-
Lamp connected to gas bottle	1.5	-	-	1.5	-
Pressure lamp	-	-	1	1.2	-

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7.10 Table for section 3.3.4: Expenditure on grid electricity currently

Table A24. Monthly expenditure on electricity for those connected to the grid (average)[21].

	Consumers	Traders
	US$	US$
Ethiopia	8.0	13.1
Ghana	14.4	15.4
Kenya	9.8	10.4
Tanzania	24.4	25.8
Zambia	52.7	69.4

7.11 Tables for section 3.3.5: Purchase price and operating cost of existing lighting devices

In Phase 2 of this research (quantitative usage and attitudes study), consumers and traders were asked about the costs of their current lighting devices. This included the current purchase cost of the lighting device and the operating cost per month (e.g. batteries, paraffin). The results of this part of the quantitative usage and attitudes study are described below, divided into purchase and operating costs for consumers and traders, respectively. Respondents answered the questions in their own currency (the exchange rates used are included in appendix 7.5). For details and graphs of these data, please refer to section 3.3.5 in this report.

For consumers, purchase costs of lighting devices are lowest in Ethiopia compared to the other four countries included in this study. Paraffin lamps with glass covers have, in general, the highest purchase price, whereas the price of candles is the lowest.

[21] Phase 2 Quantitative Usage and Attitude Study

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Table A25. Consumers: Lighting device purchase cost.

		Ethiopia	Kenya	Zambia	Ghana	Tanzania	Average
		US$	US$	US$	US$	US$	US$
1	**Paraffin lamp with glass cover**	2.3	8.9	2.0	5.8	5.0	4.8
2	**Tin lamp with simple wick**	1.2	0.8	2.5	1.9	0.6	1.4
3	**Battery powered flashlight**	1.5	2.0	1.3	1.9	1.5	1.6
4	**Candles**	0.6	0.3	0.3	1.9	0.4	0.7

For consumers, the operating costs for paraffin lamps with covers are the highest, while candles have the lowest operating costs. This can be explained in part by the fact that candles are used to supplement other lighting devices, and so have a lower average operating cost due to infrequent use (for details about lighting devices used per country refer to appendix 7.6). Note that, on average, households use lighting devices for 5.5 to 6 hours per day, which is approximately 170 hours per month (for details refer to section 3.2.1 of this report).

Table A26. Consumers: Lighting device operating cost per month.

		Ethiopia	Ghana	Kenya	Tanzania	Zambia	Average
		US$	US$	US$	US$	US$	US$
1	**Paraffin lamp with glass cover**	2.3	5.8	8.9	5.0	2.0	4.8
2	**Tin lamp with simple wick**	1.2	1.9	0.8	0.6	0.8	1.4
3	**Battery powered flashlight**	1.5	1.9	2.0	1.5	2.0	1.6
4	**Candles**	0.6	1.9	0.3	0.4	0.3	0.7

For traders, purchase costs of lighting devices are lowest in Zambia, compared to the other four countries included in this study. Paraffin lamps with glass covers have the highest purchase price, whereas the price of candles is the lowest.

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Table A27. Traders: Lighting device purchase cost.

		Ethiopia	Ghana	Kenya	Tanzania	Zambia	Average
		US$	US$	US$	US$	US$	US$
1	**Paraffin lamp with glass cover**	6.3	4.1	7.4	5.3	1.8	5.0
2	**Tin lamp with simple wick**	0.7	1.5	1.1	0.6	1.1	1.0
3	**Battery powered flashlight**	1.4	2.4	2.1	1.2	1.7	1.8
4	**Candles**	0.8	1.3	0.3	0.7	0.4	0.7

Lighting operating costs for traders vary considerably from country to country; in most countries the costs to run a light bulb on non-mains power sources is highest. The differences in costs vary between US$2-4 per month in Ethiopia and Tanzania, and US$10-12 in Kenya and Tanzania. Zambia is an exception, as the tin lamp with simple wick has the highest monthly operating cost, followed by candles; this is due to the fact that these lighting devices are most frequently used as the primary source of light in this country (for details about lighting devices used per country refer to appendix 7.6).

Table A28. Traders: Lighting device operating cost per month.

		Ethiopia	Ghana	Kenya	Tanzania	Zambia	Average
		US$	US$	US$	US$	US$	US$
1	**Paraffin for lamp with glass cover**	2.6	4.6	10.1	2.2	3.0	4.5
2	**Paraffin for tin lamp with simple wick**	2.1	2.4	6.3	1.7	14.0	5.3
3	**Batteries for torch**	1.9	1.2	2.1	1.6	3.8	2.1
4	**Candles**	1.3	2.4	1.3	1.1	5.0	2.2

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7.12 Table for section 4.1: What are consumer perceptions of currently available lighting devices? Do they satisfy their lighting needs?

Table A29. Ease of operation of current lighting devices.

	Ease of operation*
Paraffin lamp with glass cover	4.2
Flashlight or torch	4.3
Candles	4.2
Solar powered lantern	3.8
Light bulb in socket	3.7
Paraffin lamp with wick – no cover	3.7
Battery powered stand up lantern	3.4
Pressure lamp	3.4
Lamp connected to a gas bottle	2.9

* (1 = hardest, 5 = easiest)

7.13 Tables for section 4.4: What is the optimal price?

In Phase 2 of this research the ideal price and most acceptable price range was determined for three different generic modern lighting product categories: rechargeable lantern, torch, and task light. Respondents were asked what price they would consider cheap, too cheap, expensive, and too expensive. Based on these data, the acceptable price range and ideal price were calculated, as shown in the tables below. Graphs of these data can be found in section 4.4 of this report. The data are shown for consumers and traders separately, as well as for urban and rural respondents, and lower and higher LSMs. **It should be noted that these prices are generally low compared to consumers' willingness to pay after increased exposure to specific off-grid lighting products, as was shown in section 4.4.** After exposure, consumers generally indicated that the acceptable price was at or near the recommended retail price but they indicated that they might not be able to pay for expensive products without access to financing.

The overall average optimum price for each product amongst consumers and traders respectively are as follows: rechargeable lantern US$7 and US$9, rechargeable torch US$4 and US$4, rechargeable task light US$6 and US$7, and rechargeable area light at US$10 (tested among traders only).

In general, the ideal price and the acceptable price range are higher for traders than for consumers; this is perhaps not surprising given that the lighting product represents a businesses investment that may result in increased sales. The ideal price is highest for the lantern, followed by the task light and the torch. Overall, the ideal prices and acceptable ranges are highest in Kenya and lowest in Ethiopia.

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Table A30. Consumers: Willingness to pay without exposure to product.

		Rechargeable lantern	Rechargeable torch	Rechargeable task light
		US$	US$	US$
Ethiopia	Range	3.92 - 6.03	2.41 - 4.02	3.52 - 6.03
	Ideal price	5.02	3.22	4.82
Ghana	Range	5.77 - 9.62	3.37 - 9.62	4.81 - 7.88
	Ideal price	7.7	4.3	6.25
Kenya	Range	8.33 - 15.76	2.65 - 4.55	7.20 - 12.88
	Ideal price	13.63	3.40	10.30
Tanzania	Range	5.08 - 9.31	3.13 - 5.08	4.57 - 7.87
	Ideal price	8.00	4.00	6.00
Zambia	Range	7.50 - 15.00	3.30 - 6.30	7.20 - 13.20
	Ideal price	11.10	5.10	10.20

Table A31. Traders: Willingness to pay without exposure to product.

		Rechargeable lantern	Rechargeable torch	Rechargeable task light	Rechargeable area light
		US$	US$	US$	US$
Ethiopia	Range	4.52 - 7.04	2.36 - 4.42	3.82 - 6.03	5.03 - 8.44
	Ideal price	6.23	3.32	5.02	7.24
Ghana	Range	8.17 - 12.5	3.94 - 6.73	5.58 - 7.69	8.65 - 14.42
	Ideal price	9.60	5.20	7.60	10.5
Kenya	Range	12.12 - 24.24	2.65 - 4.92	8.33 -15.91	12.12 - 21.21
	Ideal price	18.18	3.79	14.40	16.67
Tanzania	Range	6.77 - 10.58	3.39 - 5.93	5.76 - 8.89	7.54 - 12.70
	Ideal price	8.50	4.7	8.10	9.40
Zambia	Range	8.70 - 15.0	3.60 - 6.60	7.80 - 13.50	11.40 - 18.30
	Ideal price	12.30	5.10	10.50	15.00

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Table A32. Consumers, urban: Willingness to pay without exposure to product.

		Rechargeable lantern	Rechargeable torch	Rechargeable task light
		US$	US$	US$
Ethiopia	Range	5.23 - 7.34	2.21 - 3.92	4.52 - 7.14
	Ideal price	6.43	3.22	5.53
Ghana	Range	5.77 - 10.58	3.94 - 6.97	5.00 - 8.94
	Ideal price	9.13	5.05	7.40
Kenya	Range	8.48 - 15.45	2.88 - 4.62	7.58 - 12.73
	Ideal price	13.03	4.02	10.61
Tanzania	Range	5.67 - 9.14	3.05 - 5.50	4.66 - 8.04
	Ideal price	8.04	4.23	6.77
Zambia	Range	6.90 - 14.70	3.30 - 6.75	7.20 - 13.50
	Ideal price	10.80	5.25	10.65

Table A33. Consumers, rural: Willingness to pay without exposure to product.

		Rechargeable lantern	Rechargeable torch	Rechargeable task light
		US$	US$	US$
Ethiopia	Range	3.52 - 5.53	2.31 - 3.92	3.22 - 5.43
	Ideal price	4.52	3.07	4.52
Ghana	Range	5.19 - 9.52	3.27 - 5.53	4.42 - 7.98
	Ideal price	7.93	4.42	6.06
Kenya	Range	8.48 - 16.67	2.35 - 4.39	6.82 - 13.03
	Ideal price	13.64	3.33	10.00
Tanzania	Range	5.17 - 8.89	2.58 - 5.00	4.23 - 8.04
	Ideal price	7.20	4.02	6.77
Zambia	Range	7.50 - 14.40	3.00 - 6.00	7.2 - 12.9
	Ideal price	10.80	5.10	9.90

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Table A34. Traders, urban: Willingness to pay without exposure to product.

		Rechargeable lantern	Rechargeable torch	Rechargeable task light	Rechargeable area light
		US$	US$	US$	US$
Ethiopia	Range	5.73 - 8.44	2.31 - 4.22	5.23 - 7.64	7.04 - 10.05
	Ideal price	7.64	3.22	6.13	9.05
Ghana	Range	8.65 - 14.42	3.85 - 6.73	5.77 - 10.58	9.62 - 18.27
	Ideal price	10.58	5.77	8.65	14.42
Kenya	Range	11.82 - 22.37	3.11 - 6.06	8.33 - 16.67	11.97 - 18.94
	Ideal price	16.67	4.55	13.79	15.15
Tanzania	Range	7.54 - 12.36	3.81 - 7.03	7.11 - 11.01	7.87 - 12.36
	Ideal price	8.98	5.42	8.55	10.16
Zambia	Range	9.75 - 15.90	4.80 - 8.10	9.00 - 14.40	12.60 - 20.40
	Ideal price	13.20	6.45	12.00	15.90

Table A35. Traders, rural: Willingness to pay without exposure to product.

		Rechargeable lantern	Rechargeable torch	Rechargeable task light	Rechargeable area light
		US$	US$	US$	US$
Ethiopia	Range	3.92 - 6.03	2.62 - 4.12	3.32 - 5.33	4.52 - 7.84
	Ideal price	5.03	3.52	4.52	6.13
Ghana	Range	7.69 - 11.54	3.85 - 6.73	5.77 - 8.65	5.77 - 12.5
	Ideal price	9.62	5.77	7.69	10.58
Kenya	Range	12.42 - 22.73	2.95 - 4.70	8.03 - 15.15	12.88 - 22.73
	Ideal price	17.42	3.79	12.88	16.67
Tanzania	Range	5.93 - 9.99	2.96 - 5.33	4.66 - 8.81	6.77 - 11.85
	Ideal price	8.47	4.23	7.45	8.64
Zambia	Range	7.80 - 14.40	2.85 - 5.70	6.30 - 12.15	10.50 - 18.00
	Ideal price	11.70	4.35	9.60	14.40

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Table A36. Consumers, Lower LSM (1-5): Willingness to pay without exposure to product.

		Rechargeable lantern	Rechargeable torch	Rechargeable task light
		US$	US$	US$
Ethiopia	Range	3.82 - 6.03	2.41 - 4.02	3.32 - 5.53
	Ideal price	4.92	3.07	4.52
Ghana	Range	5.38 - 9.52	3.37 - 5.67	4.71 - 7.98
	Ideal price	7.88	4.42	6.25
Kenya	Range	7.88 - 15.15	2.42 - 4.24	6.97 - 12.27
	Ideal price	12.88	3.33	9.55
Tanzania	Range	5.17 - 9.23	2.88 - 5.08	4.45 - 7.96
	Ideal price	7.62	4.23	6.77
Zambia	Range	7.35 - 14.40	3.15 - 6.30	7.35 - 13.35
	Ideal price	10.80	4.8	9.90

Table A37. Consumers, Upper LSM (6-17): Willingness to pay without exposure to product.

		Rechargeable lantern	Rechargeable torch	Rechargeable task light
		US$	US$	US$
Ethiopia	Range	4.62 - 7.74	2.21 - 4.22	4.62 - 7.54
	Ideal price	6.23	3.32	5.73
Ghana	Range	7.88 - 11.06	3.94 - 6.73	5.29 - 9.52
	Ideal price	10.10	5.20	8.17
Kenya	Range	9.70 - 18.18	2.88 - 5.08	7.73 - 14.77
	Ideal price	15.15	4.32	11.82
Tanzania	Range	6.10 - 10.16	2.96 - 5.76	4.87 - 8.55
	Ideal price	8.47	4.23	7.79
Zambia	Range	8.70 - 15.60	2.80 - 5.85	7.35 - 12.30
	Ideal price	12.00	4.50	9.30

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