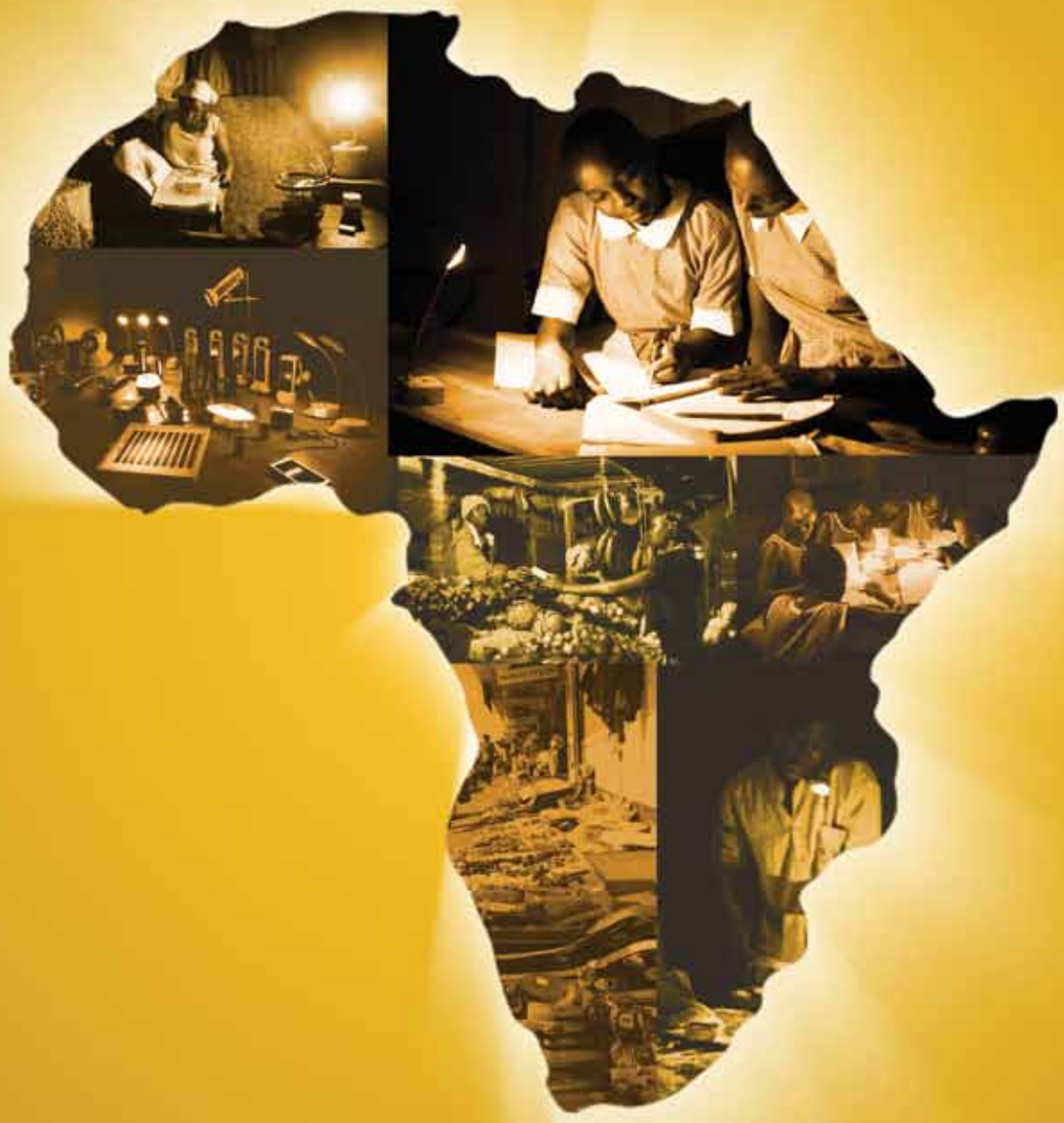
Solar Lighting for the Base of the Pyramid
- Overview of an Emerging Market -



LIGHTING AFRICA
Catalyzing Markets for Modern Lighting

AN INNOVATION OF
IFC International Finance Corporation
World Bank Group
THE WORLD BANK

Authors

This report presents an overview of current and projected market trends for off-grid lighting.

It was commissioned and coordinated by Lighting Africa, a joint initiative from IFC and the World Bank and prepared by Dalberg Global Development Advisors *(www.dalberg.com)*

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This report presents an overview of current and projected market trends for off-grid lighting. It was commissioned and coordinated by Lighting Africa, a joint initiative from IFC and the World Bank.

The report provides a snapshot of the off-grid lighting market and provides industry-level data and analysis on key trends. It relies on the inputs of a broad range of industry experts, manufacturers, distributors, scientists, market researchers, and NGO leaders worldwide who contributed their views, time, and advice to the preparation of this document. This included interviews with over 70 solar market players in 10 African markets, and a range of lighting product manufacturers worldwide. The report will be updated every two years.

The insights and input of many people and organizations were invaluable in the production of this report. Lighting Africa would like to thank all those who contributed to its production.

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We welcome your feedback and support in this effort and encourage you to reach out to the Lighting Africa team with your questions and feedback through www.lightingafrica.org.

A selection of lighting products.

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List of Abbreviations

a-Si – Amorphous Silicone

BOP – Base of Pyramid (<$3000 annual household income)

CAGR – Compounded annual growth rate

CIGS – Copper indium gallium selenide (thin-film PV)

CFL – Compact Fluorescent Light

c-Si – Crystalline Silicone

FOB – Free on Board

GEF – Global Environmental Fund

GTZ – Gesellschaft für technische Zusammenarbeit

IFC – International Finance Corporation

kWp – Kilowatt peak

LA – Lighting Africa program

LED – Light Emitting Diode

Li-Ion – Lithium Ion battery

MWp – Megawatt peak

NGO – Non-governmental organization

NiMh – Nickel Metal Hydride battery

PV – Photovoltaic

RE – Renewable energy

ROSCA – Rotating Savings and Credit Association

SACCO – Savings and Credit Co-operative

SHS – Solar Home System

SLA – Sealed Lead Acid Battery

SME – Small and Medium-sized Enterprises

SPL – Solar Portable Light

VAT – Value Added Tax

Wp – Watt Peak

WBG – World Bank Group

WLED – White Light Emitting Diodes

The Second Lighting Africa International Business Conference and Trade Fair brought together 600 participants and exhibitors from over 50 countries.

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, please visit http://www.lightingafrica.org

Purpose of this Report

A key component of the Lighting Africa landscape is the market for solar portable lights, which covers a range of lighting needs from individual tasks to general household lighting.

This report presents a snapshot of this market and provides industry-level data and analysis on key trends. Excerpts from this report were used to establish a common foundation for the discussions at the Lighting Africa conference on May 18-20, 2010, and the full document is designed to be a reference point for future fact-based analysis of the market opportunities for off-grid lighting.

It should be noted that Lighting Africa is technology-neutral, but has assembled this report with a focus on solar-based lighting products, as this is a dominant and fast-growing sector of the off-grid market deserving lighting industry, donor, and private sector investor attention.

The report relies on the input of a broad range of industry experts, manufacturers, distributors, and NGOs, including interviews with over 70 solar market players in 10 African markets and a dozen lighting product manufacturers worldwide. It will be updated every two years. We welcome your feedback and support in this effort and encourage you to reach out to the Lighting Africa team with your questions and feedback.

Scope

Off-grid lighting is a dynamic and growing market with a spectrum of products and business models. For the purposes of this report, we have chosen to focus on an important cross-section of the market that we term "solar portable lights" (SPL) – this market has been referred to as "pico-solar" in some reports or, more generically, "solar lanterns" in earlier industry and development agency literature. We define the SPL market on the basis of function, technology and quality. Hence the scope of this report is defined within the following factors:

Function - Solar-powered lighting systems that range from the task specific (torches/flashlights) to the general ambient lighting functions of solar lanterns. These products can include added functions such as mobile phone charging, but light has to be the primary design driver. The functionality also has to allow easy portability and therefore is distinct from the solar home system market.

Technology - The light – typically LED-based, though many products still feature CFL bulbs – has to be rechargeable and must be powered by a solar cell (although not necessarily exclusively), that is integrated or is a stand-alone panel. Devices with non-solar charging functionality are included in the study, for instance lanterns that can be recharged from the grid or a car battery, but a solar panel also has to be part of the package. Given the portability factor, the solar panel size is restricted to 10 watts and below. Dynamo (e.g., hand crank) technology is also an option worth considering, however its use at present is limited and we have chosen to restrict the report to solar devices.

Quality - Recognizing the emerging issue of market spoilage from poor quality products, our analysis excludes ultra-cheap (typically battery-powered, non-solar) LED torches/flashlights ($1-10), which have experienced substantial sales over the past few years in Africa. The focus of this report is on products that meet basic quality standards (e.g., sufficiently long life and light intensity) to meet the needs of Africa's un-electrified households.[1]

The above criteria represent a robust space of quality solar products that are a market-ready opportunity for meeting the lighting needs of today's off-grid rural and urban consumers. These products have momentum and are reaching a tipping point in a number of African markets which justifies focused study and effort in commercializing their use.

[1] See Lighting Africa Quality Test Procedures for details on relevant quality standards.
http://www.lightingafrica.org/files/LED_Lighting_TestProcedures_Draft_FISE_Aug09.pdf

Executive Summary

The solar portable light (SPL) market is poised for rapid growth over the next five years.

In its initial phase, the Base of Pyramid (BOP) lighting market was characterized by larger solar PV systems, such as Solar Home Systems (SHS), that have been marketed commercially in countries like Kenya and Tanzania, used to provide fee-for-service electricity services in markets like South Africa, and also supported by many donors as an option for off-grid electrification across the continent. Additionally, the market featured a handful of technologically immature and expensive SPL CFL products often unsuited to the African consumer and a growing array of low cost, low quality LED products retailed commercially at $1-10 each and primarily powered by disposable batteries.

While donor-based models remain and SHS are still an important and growing segment, the lighting market has now entered a new growth phase that is being led by SPL entrepreneurs, often relying purely on market-based models, utilizing the latest technology and designing based on consumer tastes.

Yet, scale remains small, price – even though it has dropped significantly over the past few years – is still a barrier, the technology and product build quality have space to improve, and the vast majority of customers still need to be reached.

The next five years will see the market will reach the inflection point of its growth curve. The community at large is starting to take a significant interest in this market (Figure 1). Technology is improving at a rapid rate, business models are maturing, and the focus by industry players and market facilitators on addressing key market failures means that the SPL market is ready for a substantial inflow of private sector investment and exponential growth.

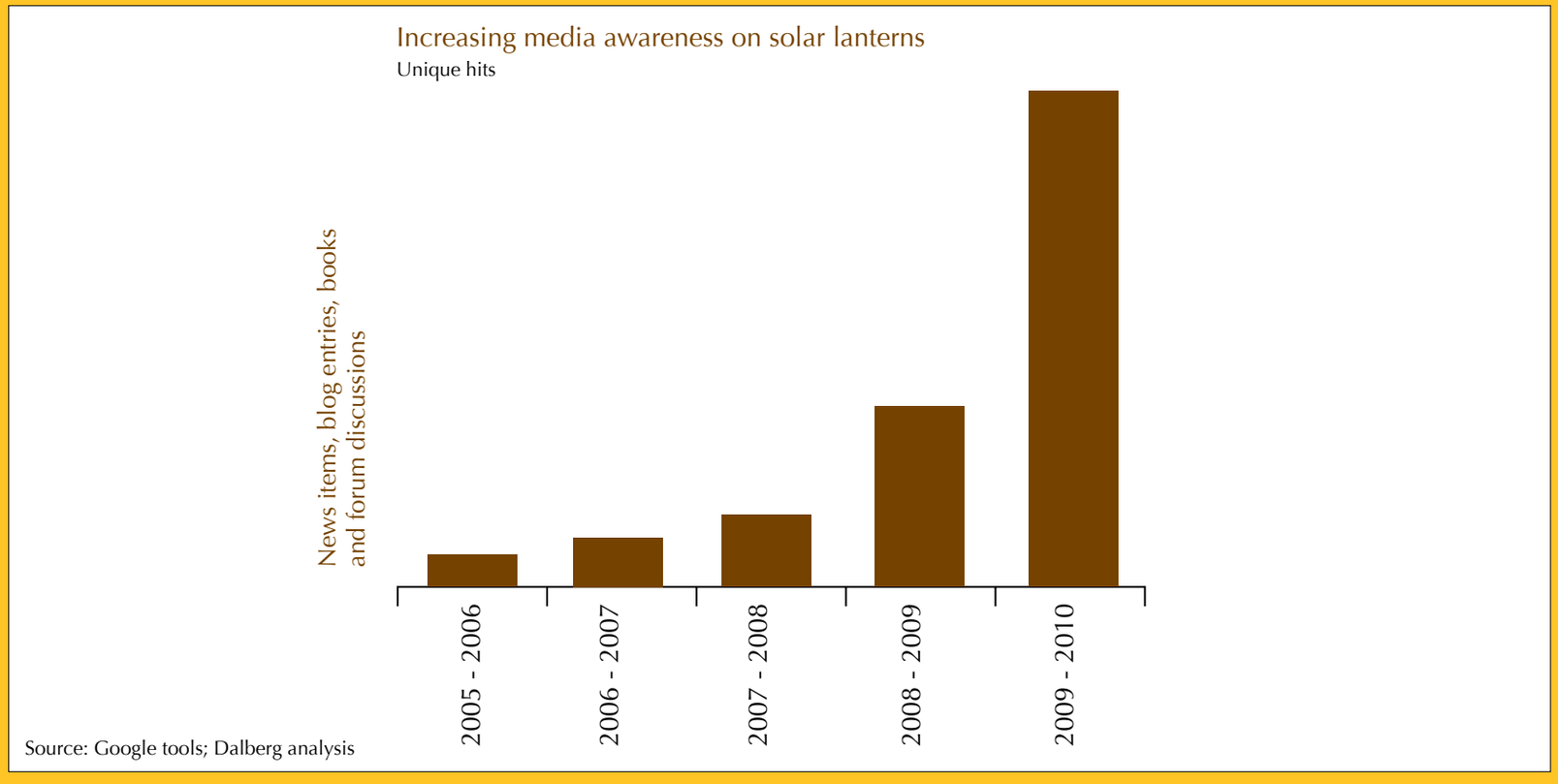


Figure 1: Awareness on Solar Portable Lighting products

Africa is a key geography for solar portable lights today and is set to grow quickly:

- While the rest of the world will begin to increase electrification levels, if we use historical grid growth rates, Africa's non-electrified population will in fact grow from 110 million households to 120 million households and over 10 million small businesses (630 million people) and over 10 million small businesses by 2015. African grid expansion is failing to keep pace with population growth.
- Even the on-grid customers (60 million African households in 2008) presents an opportunity. Intermittency and low quality of grid supply affects at least a third and, in some African geographies, the vast majority of this group, constituting over 20 million "under-electrified" households.
- Conservative assumptions suggest that the African market for off-grid renewable lighting will experience exceptional growth. Based on current growth trends, the market will easily experience 40-50% annual sales growth, and 5-6 million African households will own solar portable lights by 2015. This contrasts strongly with the over 600k SPLs that have been sold into the African market to date over the past five years. As noted earlier, these numbers exclude poor quality battery-powered LED torches (many in the $1-10 range), whose sales are in the millions.
- However, we do not expect 'business as usual' to be the likely scenario. Many new quality oriented players are entering the market and substantial investments are being made to correct for market failures. Should many of the challenges identified in the report be met and likely external factors come into play (e.g. innovation in distribution and access to finance models, large increases in kerosene costs, policy changes on taxes and tariffs), the SPL market will far exceed the business as usual scenario and see annual sales growth rates closer to those seen by the mobile phone market in Africa of over 65%. This could mean nearly 12 million SPLs owned by African households and SMEs by 2015.
- There is no way to quantify and contain pure entrepreneurial drive and innovation and hence we also recognize that if certain technological advancements are brought forward, innovations around distribution are scaled up, consumers are better educated about quality lighting products, and successful access to finance programs come into play (e.g., entry of multiple financing intermediaries to reduce access to finance bottlenecks and provide easier access to CDM), this market could grow at a multiple of the scenarios we describe in the report.

SPL products set to align more strongly with the needs of this market:

- **Rapidly declining manufactured price and payback period:** Sharp decreases in the price of solar components, LEDs, and batteries will mean that off-grid products will become significantly more affordable and erode the upfront cost advantage that kerosene has today. We predict an over 40% drop in the global manufactured costs of today's median lantern within 5 years, with a corresponding decline in payback period from eight to five or as little as two months for the average consumer, depending on distribution economics and CDM market potential.
- **Kerosene unaffordability will further help drive demand:** Ongoing increases in base kerosene prices, estimated at 4% annually increase over the next few years, combined with increasingly expensive to maintain subsidy regimes mean that kerosene will continue to lose its appeal.
- **Technological improvement will mean more and better light:** Along with a decline in price, the market will see a corresponding rise in effectiveness and quality. At today's cost, the solar portable light of 2015 will deliver better quality of build, lighter weight, longer-lasting and environmentally cleaner battery power, a more durable solar panel, and most important brighter light– , 2-3 times the equivalent products of today.
- **Consumer will be King:** Design is as important a need as the amount of light delivered by a SPL. Like many other retail products, the winning players in the market will increasingly be those that can design "design based on the needs of the end-consumer with consumer-orientated features like a more durable and adaptable form factor, charge indicators to prolong battery life, and mobile charging ability, which already is being seen as a killer feature. Our research suggests that there is no one "true" solution for the market but a variety of models for satisfying the needs of very different consumers (e.g., peri-urban back up power users vs. remote rural households vs. small businesses with specific lighting needs).

Significant challenges remain in the African marketplace for realizing full potential:

- Access to finance bottlenecks exist both at the distributor end, through lack of credit for business expansion, and at the end-customer point of the value chain, due to high upfront costs of SPL devices.
- Distributing and servicing effectively is difficult – the markets with greatest need for SPL products are typically the most uneconomic to reach. The market is still at an early stage in identifying scale distribution models that don't entail prohibitive costs.
- High taxes/tariffs on SPL products still characterize, many African geographies and even in geographies where solar products are exempted from duties the difficult-to-navigate exemption and bureaucracy continue to impose costs on distributors and importers.

- Growing problem of market spoilage due to sales of low-quality LED lighting products (including low-quality solar lanterns) with endemic mislabeling, counterfeiting, and durability issues.
- Lack of consumer education with majority of African consumers having limited awareness of the health, environmental, and economic advantages of solar lights over traditional fuels.

Solutions are on the horizon, but will require concerted investment and coordination:

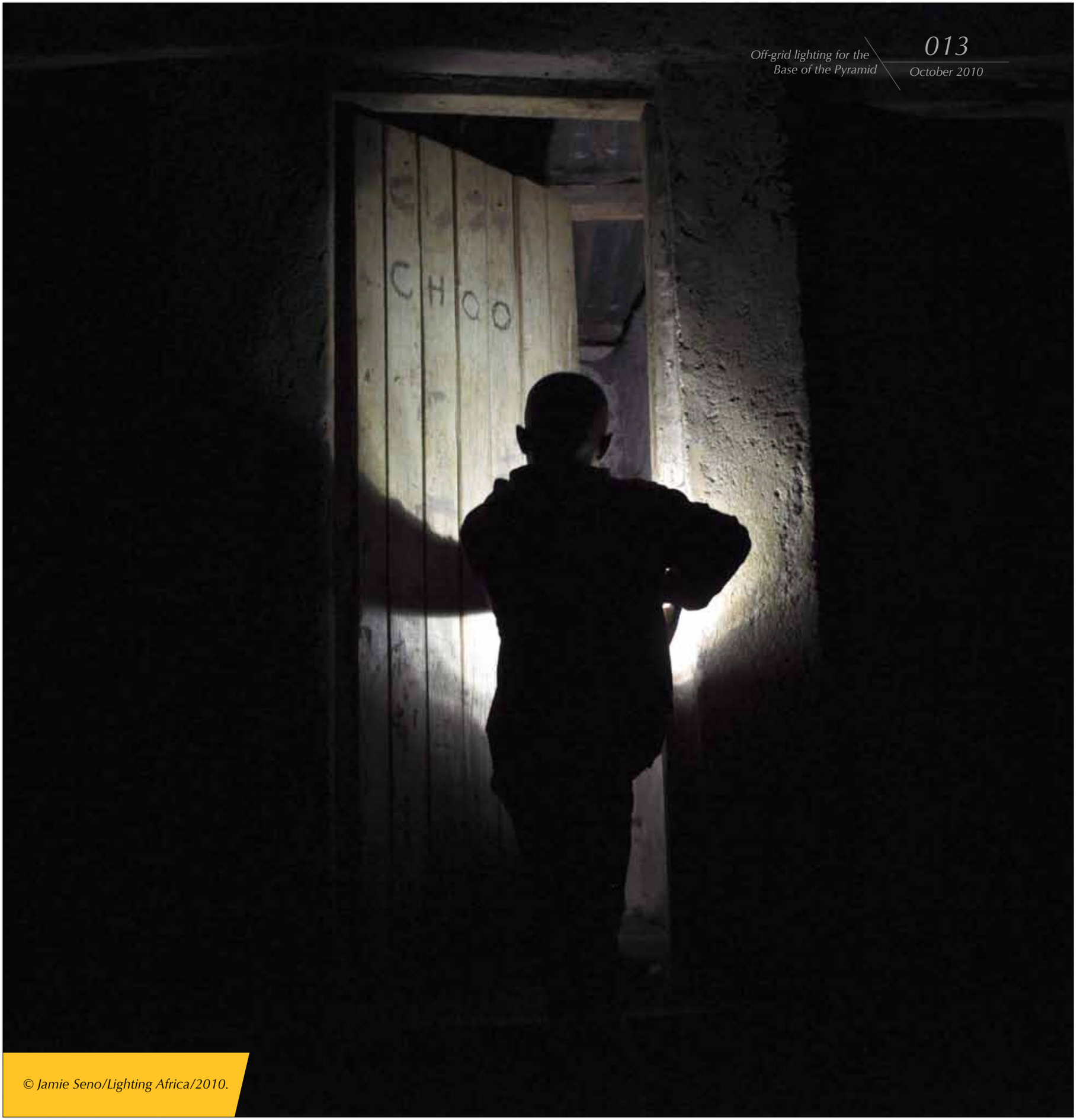
- **Innovative financing for consumers and other efforts to reduce product costs:** While the forecasted reduction in SPL manufacturing costs will translate into lower prices and a dramatically larger market, cost will continue to be an issue for the poorest African consumers. Access to finance innovation across the value chain will therefore be a key enabler for growth. Additionally, market experiments to drive down the price of SPLs – for example, through scaled distribution partnerships – could play an important role in increasing affordability.
- **Distribution will evolve:** Over the next five years multiple distribution models will continue to survive, but industry leaders will consolidate around a few tested approaches, with greater concentration of market share as they find ways of accessing last mile retailers (e.g., village kiosks) through existing distribution channels, partnering with MFIs, SACCOs, NGOs, and the private sector (e.g., mobile providers), and using other aggregation points (e.g., unions, agricultural cooperatives) to deliver solar portable lights at scale.
- **Relaxation of taxes and tariffs on solar technology through regulatory reform:** A number of African markets have already reduced or eliminated such tariffs (e.g., Kenya, Tanzania, Ethiopia, Uganda), but a great deal more engagement is needed in other geographies and further simplification of bureaucratic obstacles is required in countries where exemptions are in place.
- **Market spoilage and quality certification:** market spoilage can be addressed through the growth of quality testing and certification programs at the national level, but well funded and heavily promoted region-wide product quality testing solutions will be necessary to reduce information asymmetries for consumers and improve the quality of existing products by providing vital feedback to manufacturers.
- **Consumer education:** consumer education will to some extent occur naturally as more Africans become exposed to higher quality solar portable lighting products over the next fewyears, with evidence on the ground that willingness to pay for quality SPLs increases as much as fivefold with experience. Nonetheless, government and the social sector have an important role to play in continuing to educate the public about the benefits of solar lighting, the improving quality of SPL devices, and the harms of traditional fuels.

Ultimately, market and product evolution entailing both increased quality and reduced costs will be the largest driver of the coming growth. However, addressing the key market failures above – preferably, without distortionary subsidies by the donor and NGO communities – will bring the market growth forward by several years and allow deeper penetration of the market to those most in need.

To this end, Lighting Africa has a comprehensive set of programs and initiatives in place to address the challenge areas described above with the ambition of:

- **Catalyzing the private sector,** including strengthening ties between the international lighting industry and local suppliers and service providers to profitably manufacture, market, and distribute significantly lower cost products.
- **Facilitating consumer access to a range of affordable, reliable, and high-quality lighting products and services** - for example, by providing consumer education services and consumer finance, and by executing a product quality assurance program.
- **Improving market conditions** for the scale-up of modern lighting products by reducing existing technical, financial, policy, information, and institutional barriers. This includes the development of methods for obtaining CDM credits for distributed lighting.
- **Mobilizing the international community** - governments, private sector, international organizations and NGOs - to aggressively promote the use of modern lighting services for the poor in Africa.

Over the next five years Lighting Africa will continue to build on its mission as the regional platform for market facilitation to address these gaps and bring light to the millions of Africans who need it.



The Lighting Imperative

The social and economic impact of providing clean, safe lighting has been well documented. It has recently gained renewed focus from investments in renewable technologies and concerns raised by emissions from traditional fossil fuel and biomass sources of light. This report cannot do justice to the extensive literature and will instead seek to highlight and summarize the main social imperatives that are driving the interest in off-grid lighting.

Approximately 1.6 billion people in the world live without electricity.[2] The ramifications of this are profound. A lack of reliable lighting access limits the productivity of nearly a quarter of the world's population, hindering their ability to carry out basic activities at night or in the early morning, including household chores, reading and completing schoolwork, and conducting business. Given the slow growth of electrification, the global lighting crisis increasingly separates those with reliable lighting from those who lack it, further leaving a substantial proportion of the world's population further behind.

Africa accounts for a major share of the un-electrified. Our research suggests that of the approximately 110 million off-grid households across Africa (encompassing 580 million individuals), more than half employ kerosene lamps as their primary light source, with many needing several sources to fill their lighting needs. Other non-renewable off-grid alternatives include candles, biofuels like wood, animal dung, and crop waste, battery powered light devices, and diesel generators for the very richest households and small businesses. These traditional lighting alternatives are typically expensive and often both dangerous and environmentally harmful.

A growing body of research has examined the many negative impacts incurred by the use of these lighting options, particularly kerosene. Grid expansion is a vital objective and will be a long-term solution for many African households, but for the majority, grid growth will take decades and many of the benefits of better lighting can and should be captured today through renewable solar light products.

We outline a few of the major impact areas from replacing traditional lighting fuels by high-quality renewable solar lighting below:

Impact on the Environment: The cumulative effect of 1.6 billion people using kerosene and other biofuels for lighting contributes heavily to global carbon emissions although it is important to recognize that on a per capita basis, these people remain at the bottom of the spectrum of CO^2 emitters. The most commonly cited estimate of total official household and commercial consumption of kerosene worldwide is 440 million barrels of oil per year (IEA 2007), releasing 190 million tons of CO^2 into the atmosphere annually, an equivalent of 30 million cars[3] and an amount greater than Australia and the UK combined.[4] Use of kerosene for lighting likely accounts for well over half (100-150 million tons) of these CO^2 emissions.

Beyond the direct impacts of such CO^2 emissions, a nascent set of science on climate change which looks at the impact of Black Carbon, formed from incomplete combustion of fossil and bio-fuels and also commonly referred to as soot, has suggested that such emissions from kerosene and bio-fuel burning, could be a major source of warming in the lower atmosphere and play a strong role in melting of glacial regions. The science on this varies widely, with reports claiming that black carbon is responsible for anywhere from 5% to 50% of the warming caused by CO^2 alone.[5] Furthermore, the blackening effect of soot, which can be deposited on glaciers, also accelerates the warming process in those regions due to a lowering of the reflectivity of the ice (the "albedo" effect). The exact magnitude of impacts remains heavily in debate, but consensus is forming that the impact is significant and deserves serious attention.

Assuming that Africa's share of kerosene-based CO^2 emissions is roughly equivalent to its share of the worldwide off-grid population, the continent's households and small businesses account for at least 30% of this total, or 30-50 million tons of CO^2 annually. Using conservative bottom-up assumptions we estimate that Base of Pyramid ("BOP") African households[6] account for at least 20 million tons of these kerosene-linked CO^2 emissions, with the balance due to kerosene use by businesses and non-BOP households as well as differences in estimation methodology.

Kerosene CO^2 emissions assumptions and methodology

Our assumptions appear below to facilitate comparison with estimates in the literature:

- Kerosene CO^2 emissions factor – according to commonly accepted estimates kerosene emits approximately 2.5kg of CO^2 per liter
- Kerosene use per household – we assume an average of 5 liters monthly per BOP household leading to 150kg of household CO2 emissions a year. The actual range on household kerosne use is wide with a review of 28 surveys from across the globe showing a variation from 3 to 30 liters per month of lighting fuel use. Our estimate draws on Lighting Africa market research on off-grid populations in five African countries and equates to the use of one kerosene wick lamp or two relatively more efficient kerosene hurricane lamps for 3-4 hours daily.
- Number of households – we estimate 110 million African off-grid households and 20 million on-grid households with very poor-quality grid connections and consequent reliance on fuel-based lighting

[2] World Bank (2009)

[3] Mills (2005), Mills (2010), United States Environmental Protection Agency (2010)

[4] Radecksy (2009)

[5] Ramanathan, V. (2008); see also J. Hansen, et al. (2005)

[6] $3000 BOP cut-off

Further research is needed on the African off-grid household's CO^2 footprint – the above numbers do not measure the impact of non-kerosene bio-fuels like wood, for example, which is likely to be very substantial. What is beyond debate and more important than the exact size of fuel-based CO^2 emissions is the fact that these emissions are absolutely unnecessary in view of cheaper and safer solar renewable lighting alternatives.

Beyond CO^2 emissions, another source of negative environmental impact from traditional lighting is the large volume of toxic solid battery waste generated annually from the extensive use of incandescent-based flashlights on the continent. Hundreds of millions of dry-cell batteries are sold annually in Africa for lighting purposes,[7] with the vast majority inappropriately disposed and leading to water source contamination and other downstream problems. The usage of more efficient lighting products should contribute to reduced levels of battery usage and the abatement of related environmental issues if appropriate SPL rechargeable battery technologies are utilized.[8]

Impact on Health: The health implications of fuel-based lighting are two-fold: chronic illness due to indoor air pollution and risk of injury due to the flammable nature of the fuels used.

Kerosene lamps emit fine particles that are a major source of air pollution because they quickly become lodged in the bronchial system and can result in chronic disease and death. Burning a liter of kerosene emits 51 micrograms of PM10 [9] per hour, which is just above the World Health Organization 24-hour mean PM10 standard of 50 micrograms per cubic meter. Since these particles may not disperse easily in the close quarters of a typical BOP household or small business, burning a lamp indoors for just four hours can result in concentrations of toxic particles several times higher than the World Health Organization standard.[10] A recent study estimates that an employee working in a Kenyan small business with a wick kerosene lamp may experience PM2.5 levels of 250 micrograms per cubic meter, seven times the EPA 24-hour limit and 17 times the EPA annual limit.[11] Another study estimates that individuals breathing particulate-laden kerosene fumes inhale the toxic equivalent of smoke from two packs of cigarettes a day.[12] While conclusive studies on the health impact of this kerosene exposure are largely anecdotal, the research suggests that kerosene fumes cause serious health issues, including asthma, bronchitis, tuberculosis, heart disease and lung cancer.[13]

In addition to toxic fumes from kerosene lamps, the danger of the hazard of fire and ensuing risk to life and property is substantial. In India alone, 2.5 million people suffer severe burns due to overturned kerosene lamps annually.[14] A study conducted in Benin between 2002 and 2006 by the University of Benin showed that more than 50% of burn victims brought into hospitals were victims of fires caused by overturned kerosene lamps.[15] Similarly, a Nigerian study has concluded that thousands of Nigerians are maimed each year by kerosene lamp explosions, with a 13% fatality rate in such incidents.[16]

Impact on income generating activity: Several studies in developing countries show that access to proper lighting (of high enough illumination to enable reading and doing household and business-related activities) has significant positive impact on productivity broadly and income-generating activity specifically.[17]

For many rural households, for instance, obtaining fuel for lighting can be a time-consuming task that requires traveling long distances and is often undertaken by women and children, reducing women's available time for income-generating activities.[18] Research on solar home systems has demonstrated that poor Indian households that operate small cottage industries increased their income by using light to extend their productive hours after nightfall. More research is needed on the specific impact of solar portable lights on household income generating activities, but the emerging evidence is promising. In a recent Malawi study of a solar lantern project, ten percent of lantern buyers – many in very low income brackets – noted that the lantern had provided expanded business opportunities by allowing more time to work at night.[19] Similarly, recent Dalberg and SEWA research in rural Bihar and Gujarat in India suggests that solar lanterns contribute to longer working hours for occupational groups ranging from traditional handicraft artisans, to textile workers, and livestock herders.

An important productivity effect of portable solar lighting will also likely be seen with off-grid rural and urban small businesses. Prior Lighting Africa research in countries like Kenya suggesting that African businesses would stay open longer if the insecurity and lack of customers were not a factor due to poor illumination. [20] More broadly, there is an established positive correlation between the quality of the lighting in commercial enterprises and retail sales. Research has shown that the move from kerosene to LED based lighting that improves the quality of illumination also boosts sales since customers pay more attention to the display and engage in purchase-oriented behaviors more often.[21] The Lighting Research Center of Rensselaer Polytechnic Institute has found that customers who could see color more accurately, found products more visually appealing, and had an increased preference for a product display lit by WLEDs, compared to traditional lighting.

[7] Lighting Africa (2008)

[8] Many SPL still feature lead acid and NiCd rechargeable batteries that are worse than disposable dry cells; NiMh and L-ion batteries, which are becoming the SPL industry standard, have much less toxicity

[9] Particulate matter with an aerodynamic diameter less than 10 microns

[10] The Welfare Impact of Electrification, World Bank

[11] Poppendieck and Jacobson (2009)

[12] Lights for Life (2010)

[13] US National Institute of Health (2009); see also an overview of health effects in Cabraal, Barnes, Agarwal (2005)

Lighting Africa research in Kenya provides further anecdotal evidence for the business impact of improved lighting, though more research on solar-enabled SME retailers and small kiosks is needed:

- A small non-electrified enterprise near Lake Victoria which received solar lighting saw its revenues increase 60% as a result of being able to better illuminate its wares at night
- Vendors of shoes, detergent, and food products at a major Kenyan night market reported upon seeing LED-solar prototypes that they would be able to extend their operating hours by 30 to 50% if this form of lighting became available. They also universally believed that their sales volumes per hour would increase as a result of their wares being more easily seen and more attractive due to better color rendering by white LED sources compared to kerosene lanterns
- Outdoor shopkeepers reported that with LED lighting they would avoid periods of market closure due to wind or rain (both of which extinguish their flame-based lighting sources). They also perceived an additional benefit of being able to more easily and accurately count money and make change for customers.

Impact on Education: More Africa-specific research on the education impact of improved lighting is needed, though the limited data points available are encouraging. In the Malawi solar lantern project study mentioned above, 18% of participating households identified children's study time and reading as one of the major benefits of better lighting.[22] Evidence from other regions is more direct and highly positive. In Bangladesh, a study revealed that when solar-powered lighting was introduced, children from the newly solar powered homes remained awake longer each day and used 38% of their additional time for studying and reading. Similarly, a study of portable solar lighting impact in India found that the introduction of solar lighting raised average study hours of students per household from 1.5 hours to 2.7 hours, with a correlative effect on school performance.[23]

Impact on household spending: Another obvious and important impact of fuel-based lighting is the cost burden on poor household of paying for expensive kerosene-based light. Kerosene costs vary across the world, but even in countries where kerosene is heavily subsidized by the government, like India and Sri Lanka, the cost of a month's worth of kerosene can equal between three to five days of income. In Africa this cost burden is often more substantial, with Lighting Africa research and other estimates showing that BOP African households face recurring expenditures on fuels ranging between 10 and 25% of their monthly household budgets.[24]

As the preceding survey of the literature demonstrates, traditional lighting options, particularly those those that use kerosene as fuel, are unequivocally flawed, imposing unnecessary dangers, stiff costs, and insufficient services on the un-electrified and under-electrified poor. Consequently, the need for clean, safe, renewable, and cheap lighting alternatives is one that is both urgent and growing.

[14]Solar Electric Light Fund

[15]Dongo, A. et al. (2007)

[16]Oduwole, et al. (2003)

[17]See generally, Cabraal, Barnes, Agarwal (2005) for a discussion of productive impact of non-fuel based lighting

[18]Adkins, et al. (2009); Batliwala, Reddy (2003); Laxmi, et al. (2003)

[19]Adkins, et al. (2009)

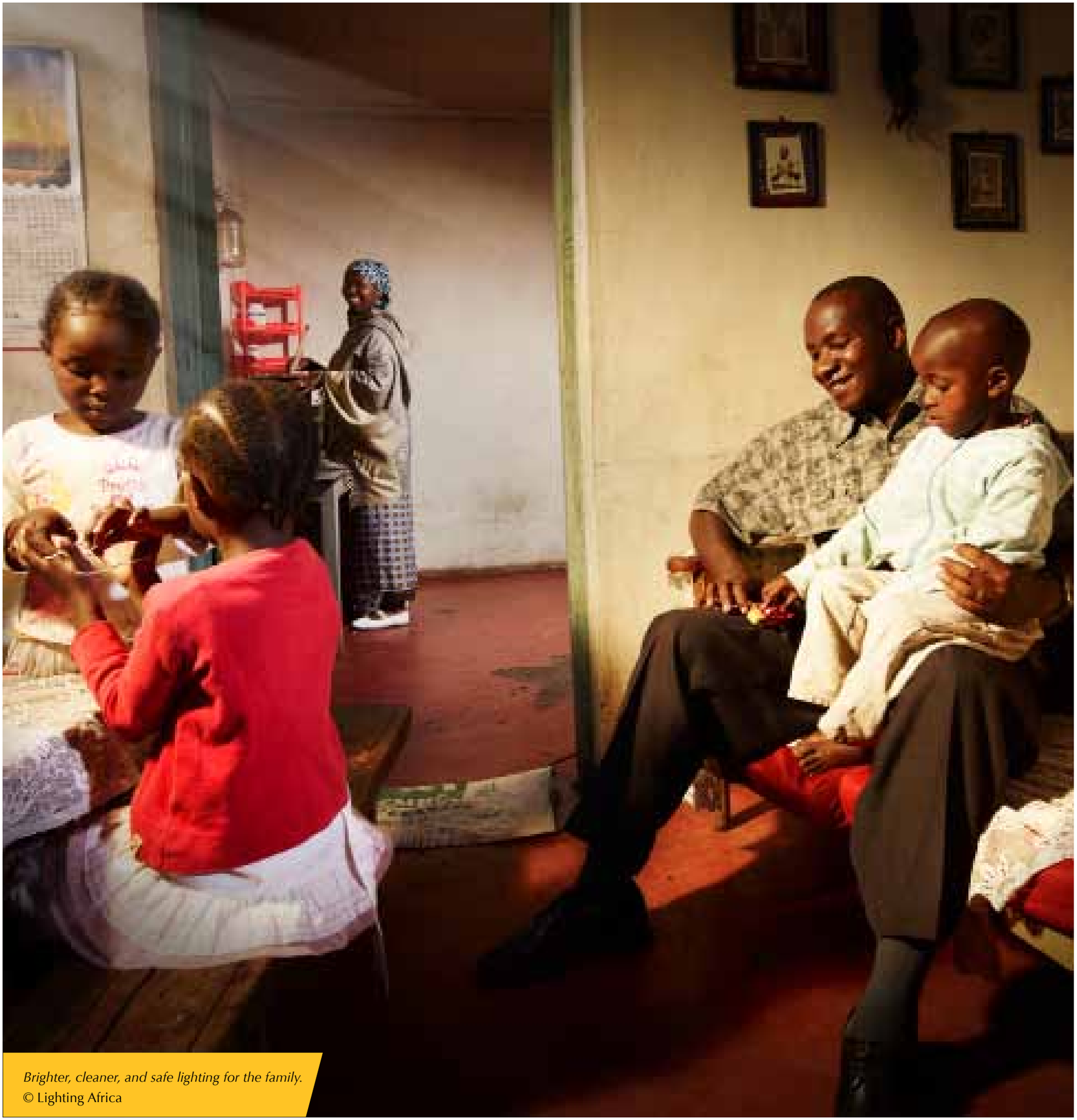
[20]See, e.g., Lighting Africa, "Kenya: Qualitative Off-grid Lighting Market Assessment" (2008)

[21]Display & Design Ideas (2003)

[22]Adkins, et al. (2009)

[23]Agoramoorthy and Hsu (2009)

[24]Peon, et al. (2005); Lighting Africa market research (2008-2009)



Brighter, cleaner, and safe lighting for the family.
© Lighting Africa

Understanding the Product Range

We classify the solar portable lighting (SPL) product range in two ways:

1. Product typology: what is the customer need being served
2. Performance: how many lumens delivered for how long for what price

Product Typology

The industry today lacks a common set of definitions or terminology, with solar lanterns being too generic a term to properly define the spectrum of products available. In addition, we believe that currently consumers select products primarily based on price. Due to this reality, we do not believe a broad proliferation of product categories is currently widely used, but we project a rapid broadening of solar lighting needs and services provided going forward. We forecast the following styles of products to become increasingly differentiated in the future:

Flashlights/Torches - portable handheld devices offering directional lighting at low lumen output. Today's solar torches typically feature integrated solar panels.

Task lamps/work lights – portable or stationary handheld devices, including solar desk lamps, in a range of panel sizes and light output levels utilized for specific tasks (i.e. reading, weaving etc.).

Ambient lamps /"lanterns" – portable or stationary devices that resemble the kerosene hurricane lamp form factor. They typically offer multi-directional light along with a wide variety of size and functionality depending on technology (e.g., from heavy, powerful CFL lanterns to smaller LED-based systems).

Multi-functional devices – portable or stationary devices that can provide directional and multi directional light, a variety of value-added features (i.e. mobile phone recharge), and can be utilized for either task based or ambient lighting needs.

Micro-SHS – semi-portable lighting devices associated with a small portable solar panel that powers or charges 1-3 small lights, mobile phones, and other low-power accessories (e.g., radio, mini-fan).

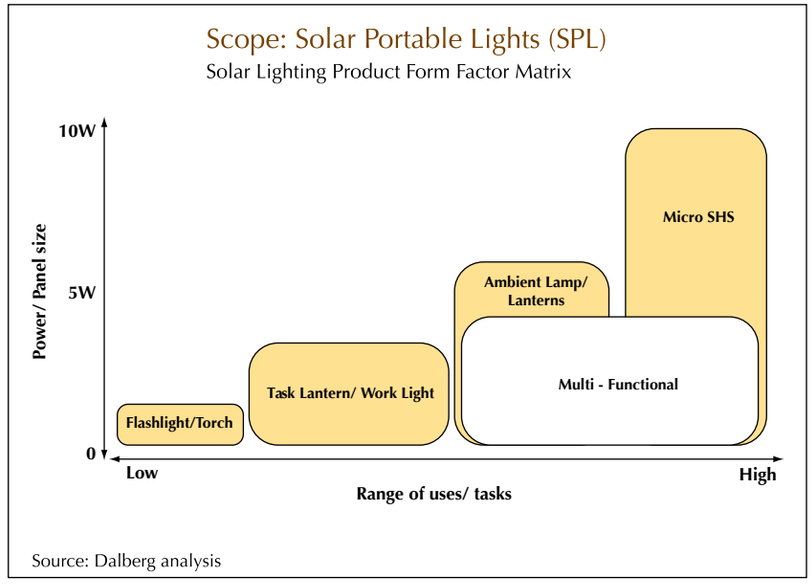


Figure 2: Solar Portable Lighting product landscape

These products are distributed across a spectrum of decreasing specialization and increasing lumen output, which correlates directly with increasing power output of the solar panel typically attached to them (Figure 2).

This comes as no surprise; the bigger the power capacity, the wider the lighting and other functionality that the core product can provide.

Across each of the above, multiple technological options are available based on price, local availability and performance requirements.

Figure 3: Solar Portable Light technology options

Performance

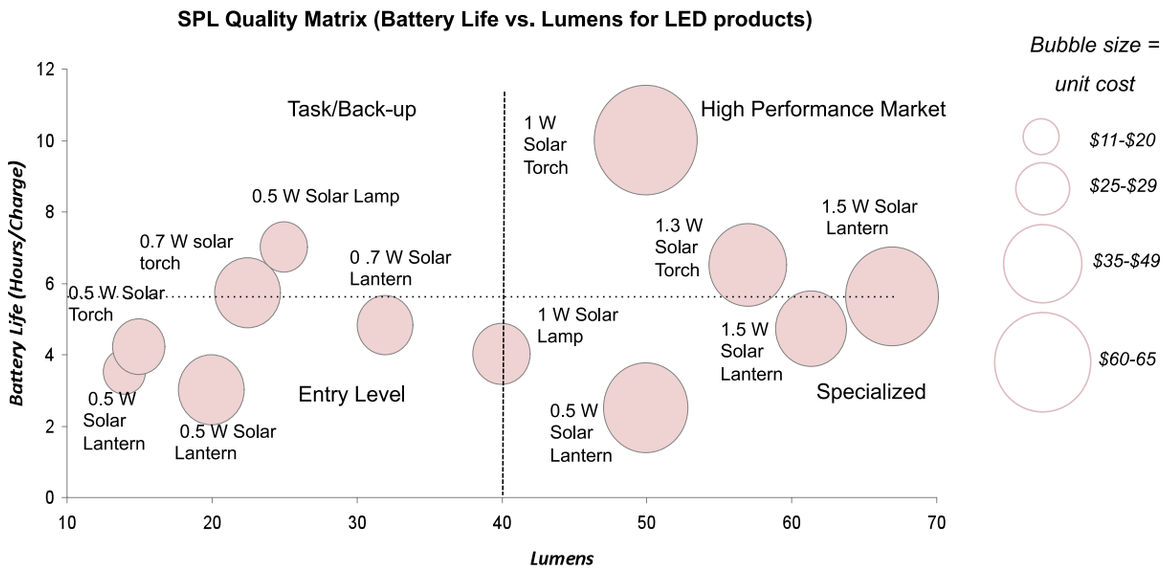
Ultimately, the core characteristic of a lighting product remains its ability to deliver bright light, for a long enough period of time at an affordable cost. However, the ability to deliver a high level of lumen output is in direct competition with battery life. And, both high battery life and high luminosity are associated with higher prices.

Hence, we propose a Solar Portable Light Performance Matrix that demonstrates the range of performance we have witnessed in the market, based on independent testing and the latest price associated with such products (Figure 4):

We see clearly the emergence of premium, budget and specialized segments even within the BOP market. Importantly, while there is some correlation between price and performance, there are also clear price leaders in each segment, even within our small sample set.

It is worth noting that the bottom end of the solar lantern market contains many products that fail to meet minimal quality requirements. This is especially true of many African markets and, discussed in greater detail below, is already leading to problems of market spoilage. Therefore, this report omits low cost, low quality products in all analyses – primarily rechargeable LED torches in the $1-10 range.

Broad spectrum of product performance emerging



Significant outliers exist in independently tested data which have been omitted pending further analysis

Source: REEEP, Lawrence Berkley National laboratory.

Figure 4: Solar Portable Light Performance Matrix

Global industry Trends and Projections – market size and demand

Market definition and size

The solar portable light (SPL) market is focused on the off-grid (no access to electricity) and under-electrified (highly un-reliable access) markets. These markets are further stratified by a range of incomes, as the absence of the grid cuts across income classes in many countries.

Given the alternatives available to wealthier households, including generators and solar home systems, the solar portable light market is predominantly targeted at Base of Pyramid consumers and small businesses. Furthermore, while many countries feature a sizeable urban off-grid population, the problem of electrification is particularly acute for the rural poor (Figure 5) who form the majority of potential SPL customers.

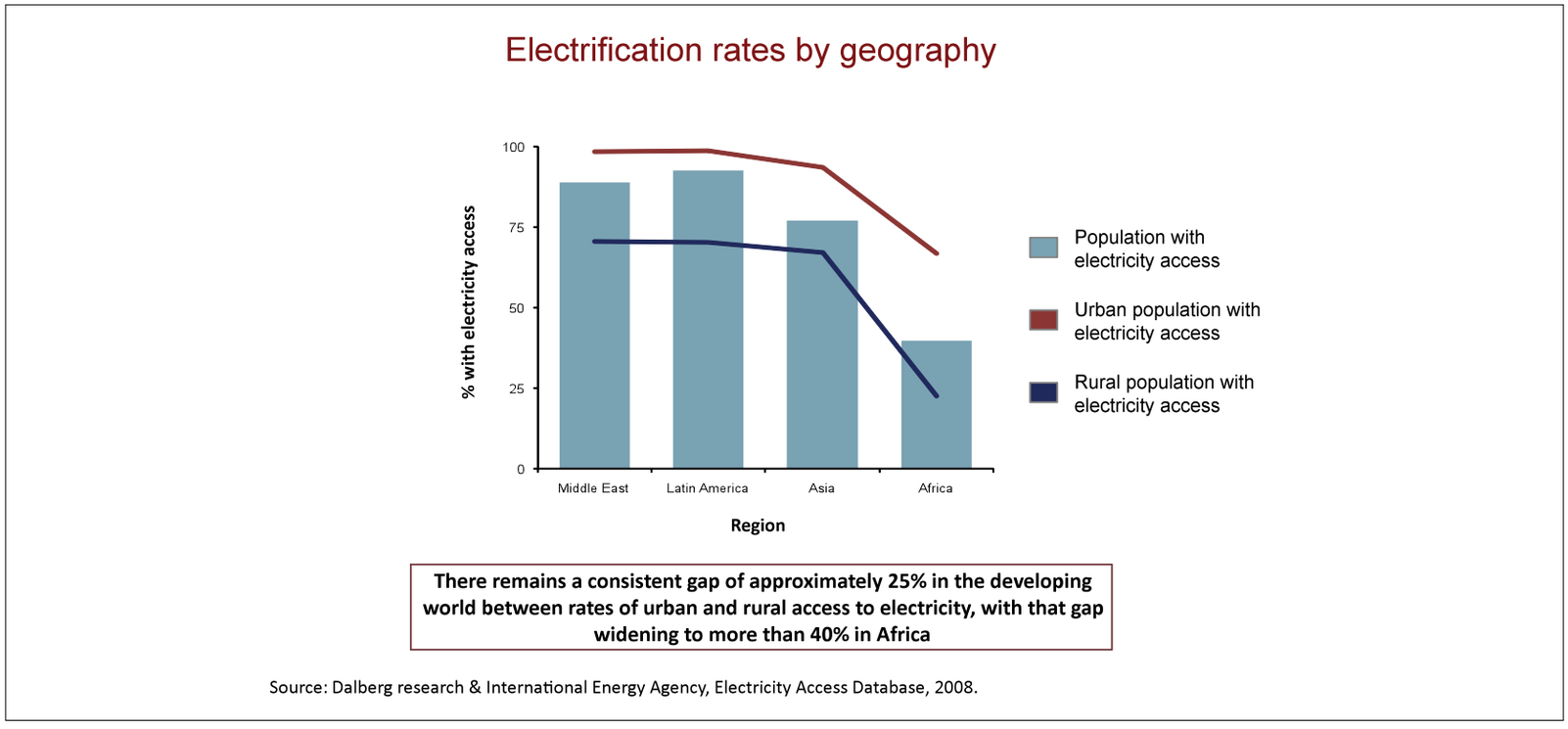


Figure 5: Electrification rates around the globe

While Asia is the largest market currently, with India the dominant force, relative population growth rates and slow grid expansion mean that Africa will be the dominant market in the next twenty years, with close to 700 million people projected to be living of the grid by 2030 (Figure 6).

A common mistake in sizing the solar market opportunity in developing lighting markets is to focus exclusively on the off-grid population figures highlighted above. In reality, many more households lack access to reliable electricity than official statistics suggest. First, official electrification statistics at times overestimate the on-grid population by including households living in grid areas, but lacking a reliable and legal grid connections – in Haiti, for example, the official electrification rate stands at 25%, with only half of these households having legal, secure grid access. More important, many poor on-grid households and businesses in Latin America, Asia, and Africa experience lengthy and frequent blackouts. Our research suggests that this "under-electrified" BOP population (defined as individuals and businesses with weekly or daily power outages) ranges from 10% to over 50% of the on-grid populations in many nations, with the problem being particularly acute in Africa (over 100 million "under-electrified" individuals) and in rural areas of South and Southeast Asia. The under-electrified population is a major potential market for off-grid back-up power solutions like SPLs.

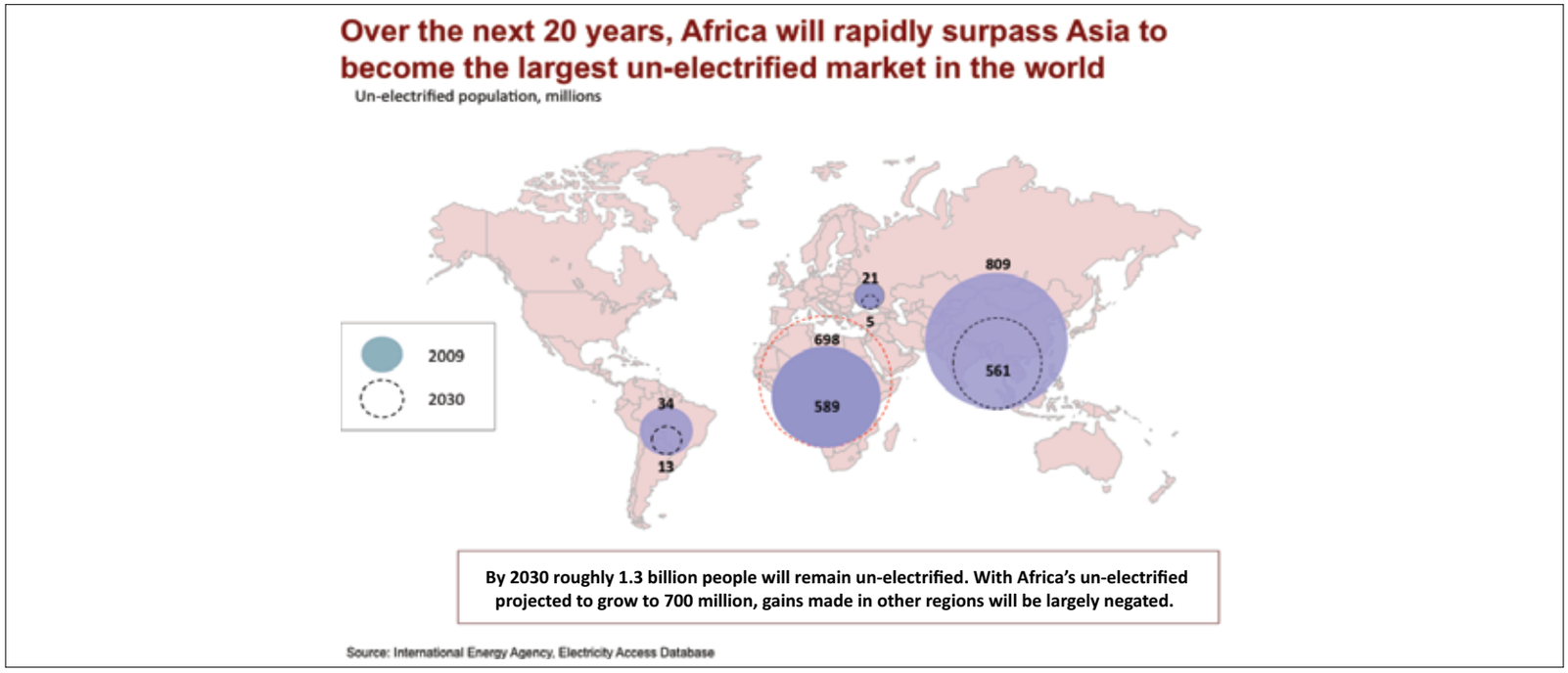


Figure 6: Forecast for global un-electrified populations

Given the current concentrations of un- and under-electrified populations, the largest off-grid SPL commercialization efforts are unsurprisingly focused on Africa and South Asia. A mix of low grid penetration, large populations plus continued population growth, high energy prices, relatively low levels of urbanization and ongoing high levels of poverty, continues to make these two regions high value markets for solar portable products (Figure 7). The need to focus on Africa and South Asia is clear.

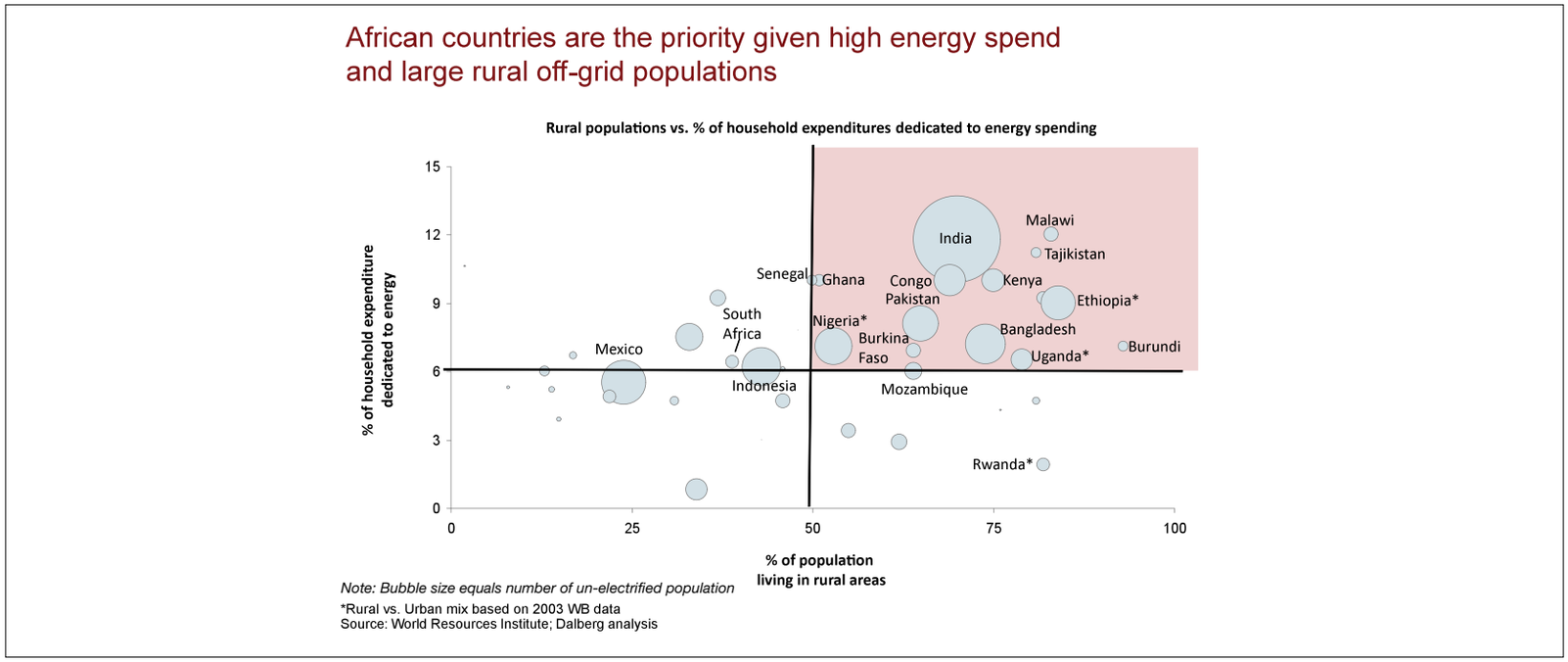


Figure 7: Large rural populations facing high energy costs are high potential markets

Global drivers of off-grid lighting market growth

The potential for off-grid lighting is not only large, but is growing rapidly. The five major drivers of demand globally are:

1. **Lagging grid growth:** the importance of grid growth as a driver for SPL demand varies by region, with rapid grid growth likely in select Asian and Latin American geographies and very slow grid growth seen in many African nations. Grid penetration typically needs to grow by over 2% a year to counteract the effect of population growth – in practice this means that even substantial investments into the grid will leave many large nations with sizeable and growing off-grid populations in decades to come.
2. **Price trends:** rapid technological innovation in basic SPL technologies and a scale-up of commercialization efforts by lighting entrepreneurs is driving a substantial decrease in the manufactured price of solar portable lights, and since affordability is arguably the main obstacle to market adoption, falling manufacturing costs and corresponding declines in the retail product price will be a critical driver of demand going forward.
3. **Technology and design innovation:** Beyond improvements in price, the top of the SPL market is also undergoing a revolution in product design and quality. Most manufacturers have not yet achieved the quality and reliability standards of mass produced consumer electronics, but the market is starting to see a number of products that combine sufficient quality of build, long battery life, and most importantly, value-added features and product designs that address the particular needs of BOP off-grid and under-electrified consumers. Innovation is set to accelerate as technological components fall in price and entrepreneurs invest more resources into studying local conditions and end-users.
4. **Kerosene prices:** kerosene, the main traditional alternative to off-grid renewable lighting, has long been an expensive commodity for the poor and is expected to continue increasing in price. Analysts forecast an average increase of 4% annually over the next five years. This, combined with increasing pressure on kerosene subsidies in Asia and Africa, will drive consumer demand for cheaper alternatives.
5. **Mobile opportunity:** Today, nearly 500 million people worldwide (i.e., a third of the 1.6 billion off-grid population) have a mobile phone subscription but no easy or cheap access to a means of charging their phones.[25] A number of potential charging solutions are on the market, but if lighting manufacturers take advantage of this trend (e.g., partnerships with phone companies, mainstreaming of mobile charging functionality), the mobile charging opportunity could become a major driver for SPL sales globally – providing a value proposition to both consumers, who can avoid mobile phone charging costs, and to the phone companies who can sell more airtime.

Below we focus on the global trends of SPL price, evolution in underlying technologies, and growth of consumer-orientated features and design. Other important drivers, like off-grid population growth, kerosene prices, and growing demand for off-grid phone charging solutions are illustrated in depth in the Africa 2015 market scenario section of the report.

SPL price trends

Solar lanterns are generally composed of five major cost components. However, depending on the distribution margins and taxes, this prices are estimated to account for only for 30-70% of the price seen by the end-consumer.

The core components include: (1) the solar panel, (2) the battery, (3) the light source, (4) the charge controller, and (5) the lamp housing. While a breakdown of component costs can vary by design and manufacturer, we have compiled an averaged view below including 5 year projections (Figure 8):

[25]See GSMA Development Fund (2010). The most common mobile charging option for such off-grid consumers is fee-based charging through electrified neighbors or SMEs.

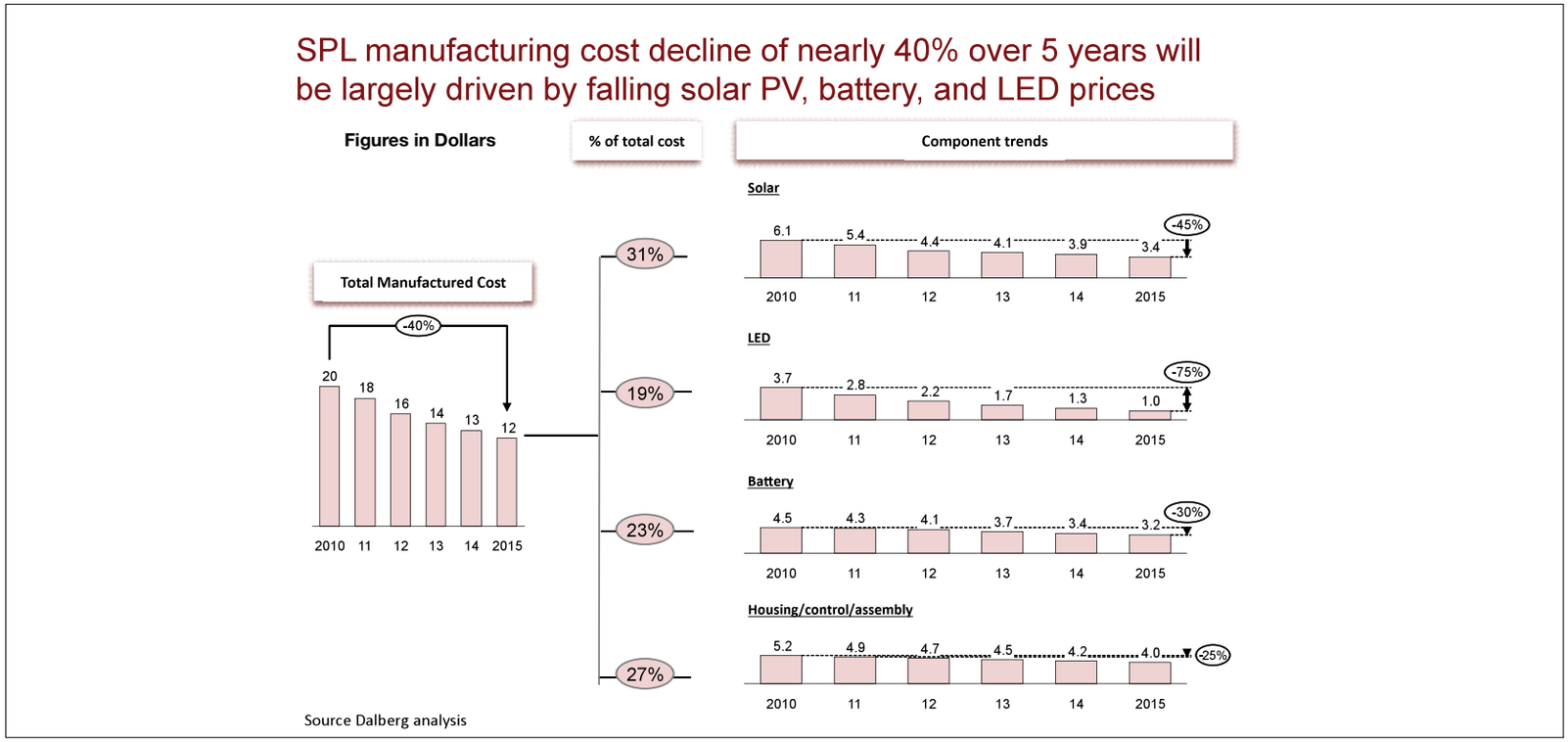


Figure 8: Decomposition and forecast of today's median lantern component costs

Solar

The largest costs in today's SPLs are concentrated in the solar panel, which often accounts for well over 30% of a typical solar lantern or torch component costs. Depending on the portable light device and type of light source, the solar panel can be as small as 0.3W for solar torches or as large as 8W for full-featured CFL "hurricane lantern-style" devices. Our review of over 40 SPL devices tested by Lighting Africa, GTZ, and other researchers suggests an average panel size of 2.5 watts, with obvious differentiation based on form factor and SPL type.[26]

The majority of the SPL devices on today's market feature crystalline silicone solar PV panels, but a growing minority use amorphous "thin-film" technology. The SPL device split that we have seen largely mirrors the industry-wide split in amorphous (15% of the market) and crystalline PV production (85% of the market).[27] A major technical difference between crystalline (c-Si) and amorphous (a-Si) PV technologies is their efficiency at converting solar energy into electricity. Crystalline PV panels have efficiencies that range from 12 to 22%, while a-Si panels currently have an efficiency of 6-9%. The practical implication of these efficiency differentials is that a typical a-Si panel for any given watt rating will be larger than a similarly rated crystalline panel. This has not proven a major obstacle for SPL applications, given the rural BOP consumer's preference for "substantial" products with larger panels that appear sturdier and therefore a better value.

The price of both crystalline and thin-film amorphous technologies for SPL devices has declined substantially over the years and is set to fall further.

The price of crystalline PV modules correlates with the movements of polysilicon spot prices with a volatility roughly half that of polysilicon, as demonstrated below (Figure 9). Since 2008, polysilicon prices have dropped rapidly due to a market oversupply. Over the past year a 32% drop in polysilicon prices has correlated with a 16% drop in solar PV prices. Near-term forecasts predict polysilicon prices will continue to slide as a market oversupply is projected through at least 2012. Analysts we have interviewed believe that this polysilicon glut, along with more efficient manufacturing, will continue to drive down the average price of large crystalline PV panels to under $1.7/watt from $3.3/watt in 2009 (Fig. 10).[28]

[26]Lighting Africa; GTZ; Radecsky (2009) sample of dozens of SPL bought in Kenyan markets.

[27]Photon International (2009); Navigant (2008)

[28]Solar PV cost projections reference the costs for large sized (e.g., 200-400 watt) panels; small panels of the type used for SPL devices typically come at a 20-40% premium depending on scale of purchaser and technology, with an average cost of over $3.3 dollars per watt in 2009 and $1.74/watt by 2015

Thin-film a-Si PV panels will also continue to see substantial price declines due to technological innovation and growing scale of production, falling to below $1 per watt according to industry projections. The analysts we've talked to believe that continuing innovation in the a-Si technology, as well as thin-film alternatives like CIGS, light-absorbing dyes (DSCC), organic polymer solar cells, and nanocrystalline cells will maintain substantial pressure on all thin-film PV panel prices in coming years.

Many of the SPL manufacturers we have spoken to in our survey were considering the switch to thin-film PV components because of their durability and flexibility; others will make their decision purely on the basis of price. We hypothesize a move by SPL manufacturers to 50% thin-film (likely, a-Si) and 50% crystalline (c-Si) in five years, as the increase in efficiency and growing scale of production makes thin-film products more competitive and as more companies pursue more durable, flexible SPL form factors. The projected decline in thin-film prices will therefore further "decrease the blended average price of an SPL's PV panel price (Figure 10).

In light of these trends, and accounting for technology advances, market scale, and growing small panel manufacturing capacity, we project an 35-45% reduction in the cost of today's solar panel by 2015.

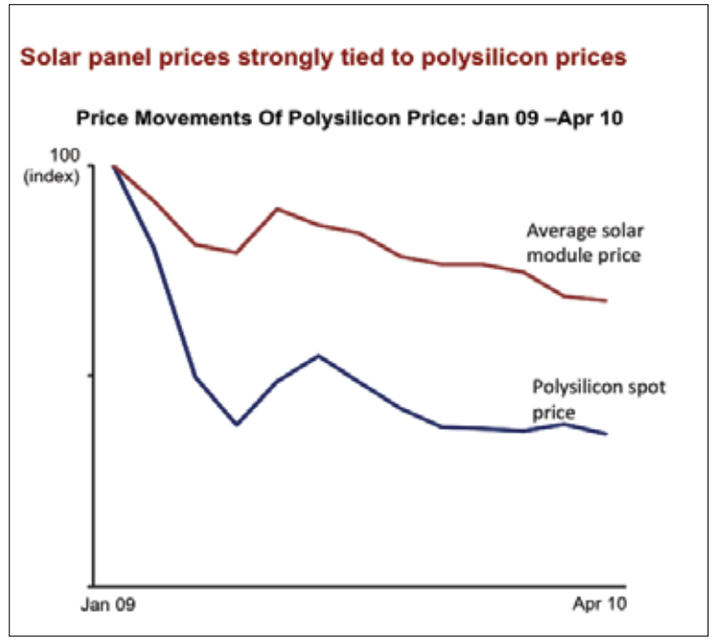


Figure 9: Links between solar PV price and polysilicon

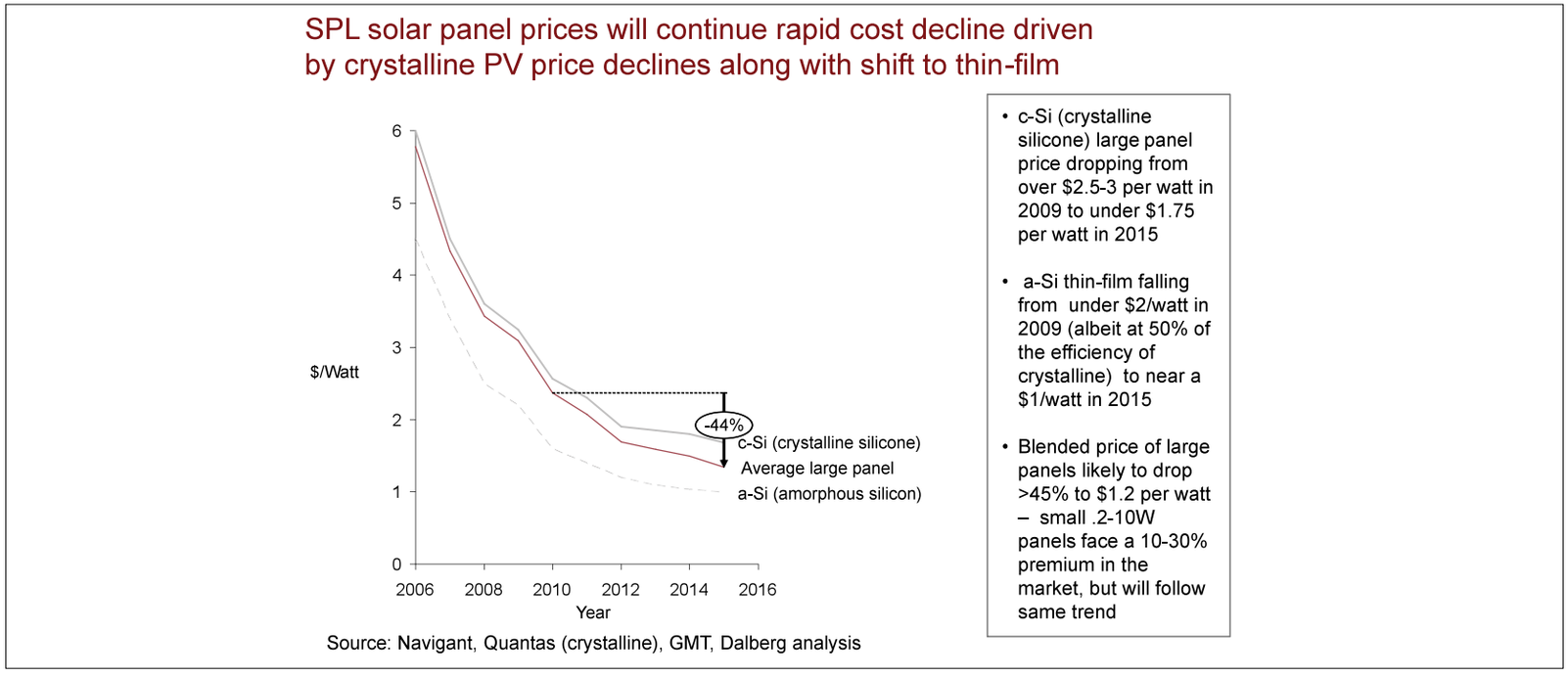


Figure 10: Forecast for solar PV panel price trends

Battery

The emergence of advanced battery alternatives illustrates how the introduction of new technologies can change the cost-by-component breakdown.

Sealed lead acid (SLA) batteries have been the standard SPL industry solution in its early years, given the substantial power required for CFL lights, the wide availability of the technology, and its low cost. With the ongoing shift to LED lights and lower resulting power requirements, manufacturers have trended towards Nickel Metal Hydride (NiMH) batteries which now account for over half of the batteries (across all form factors) for the SPL devices we've reviewed. In the past two years a small number of SPL manufacturers have begun to feature Lithium-Ion (Li-Ion) batteries to take advantage of their smaller size, increased battery life, and substantially greater number of recharge cycles.

Battery Technology Options

Technology	SLA 	NiCd 	NiMH 	Li-Ion 
Energy Density	30-50 Wh/kg	45-80 Wh/kg	60-120 Wh/kg	90-190 Wh/kg
Recharge cycles	200-300	1500	300-500	300-1000 +
Durability	Lowest – performs poorly depending on temperature and overcharge/undercharge	Highest	High	High
Toxicity	Toxic	Acutely toxic	Benign	Benign
User Charging Requirements	Must always be kept in a charged condition	Lasts longer if battery is fully discharged each use	Lasts longer if battery is fully discharged each use	Lasts longer with partial rather than full discharges
Maintenance	Apply topping charge every 6 months	Discharge to 1V every 3 months to avoid memory effect	Less memory effect then NiCd	No Maintenance required. Loses capacity due to age regardless of use

Source: Dalberg Analysis

Figure 11: Battery Technology Options

We believe the shift away from SLA and toward Li-Ion is set to accelerate. Li-Ion is experiencing rapidly falling prices and now receives the bulk of advanced battery research investment fueled by the mobile phone, laptop and hybrid vehicle battery market. Li-Ion is forecasted to be the fastest growing battery segment in the portable electronics segment, with a projected price decline of 13% annually, [29] leading to a lower price point in 2015 than NiMH batteries and a rapid convergence to SLA costs (Figure 12).

Based on the feedback in many of our interviews, we believe this will continue to pull the market away from both SLA batteries and, if the SPL industry mirrors the battery trends in the mobile phone battery market over the past five years, Li-Ion will increasingly steal share from NiMH-powered SPL (see Figure 13, applying Li-Ion share growth in the mobile market over 2005-2010 to the SPL market in 2010-2015).

[29] Pike Research (2009) projects 13% annual price decline

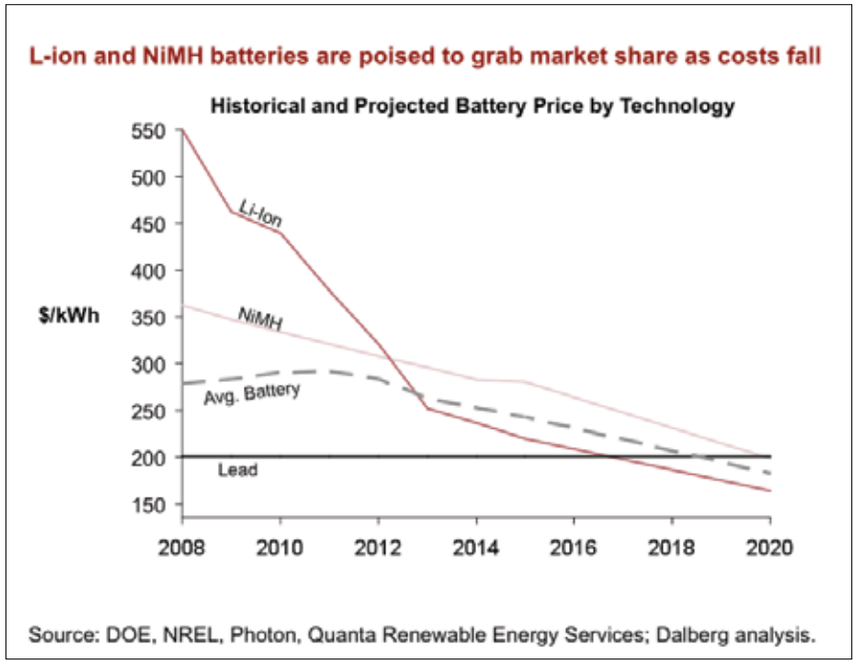


Figure 12: SPL battery price forecast (2009-2015)

A number of factors may hold back Li-Ion adoption in SPL devices, including the need for more expensive electronics (e.g., charge controllers) to ensure safety, charge indicators to avoid over or under-charging, and most significantly, the current lack of easily available Li-Ion battery replacements in African markets. Nonetheless, the mobile market saw Li-Ion batteries take substantial share from NiMH while facing many of the same issues.

Assuming this moderately aggressive scenario of Li-Ion battery adoption, we see the average battery price dropping to $170/kWh and leading to an overall battery component cost decline of up to 30%.

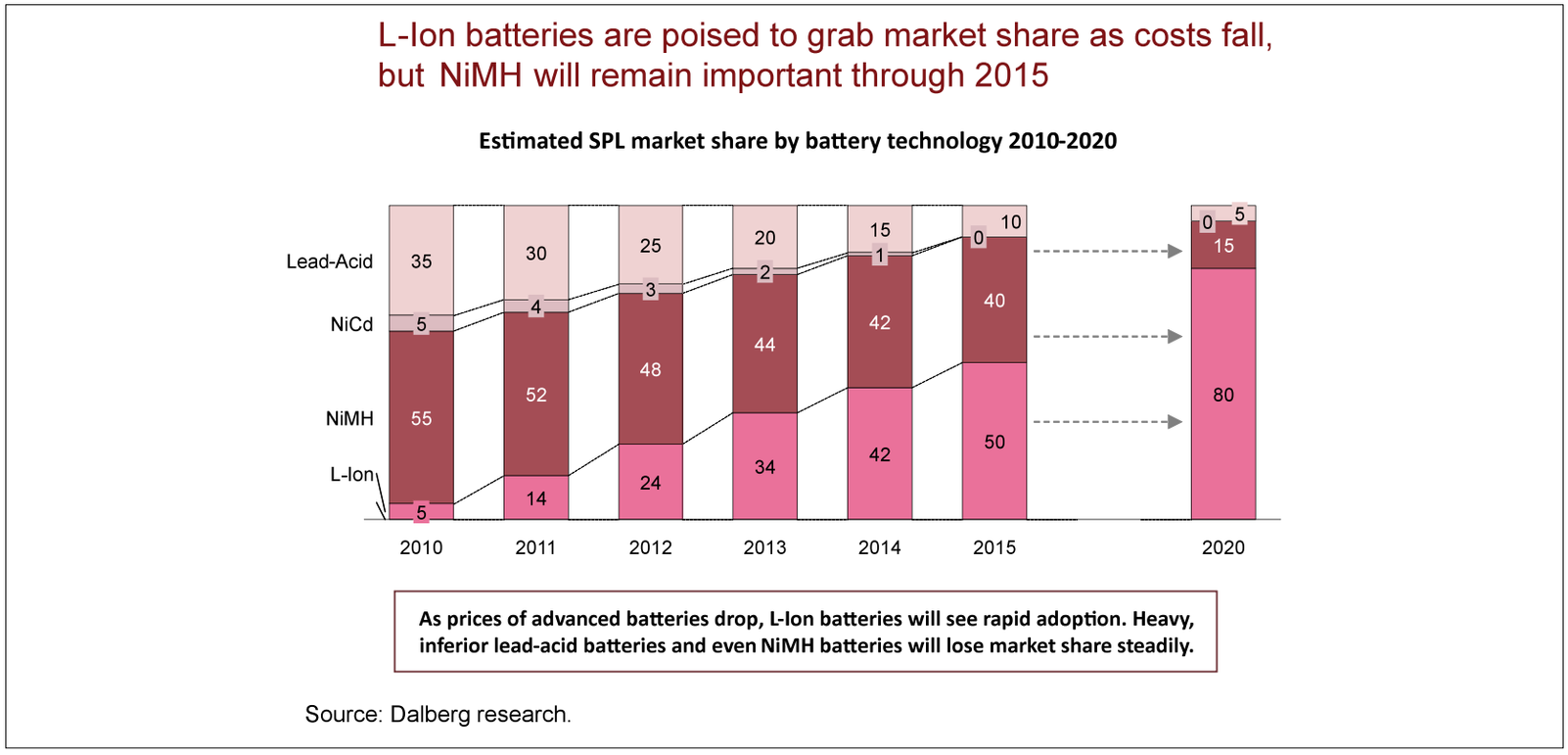


Figure 13: SPL device battery share - a potential scenario

LED

The fastest falling cost-by-component, as acknowledged by all of our industry interviews, is the light source. Light emitting diode (LED) component costs are projected to drop 75% by 2015, and 94% by 2020. The graph below demonstrates projected cost decreases across LED light qualities between 2010 and 2030 (Figure 14). The sharp declines are being driven by both technology improvements and rapid scaling up in production.

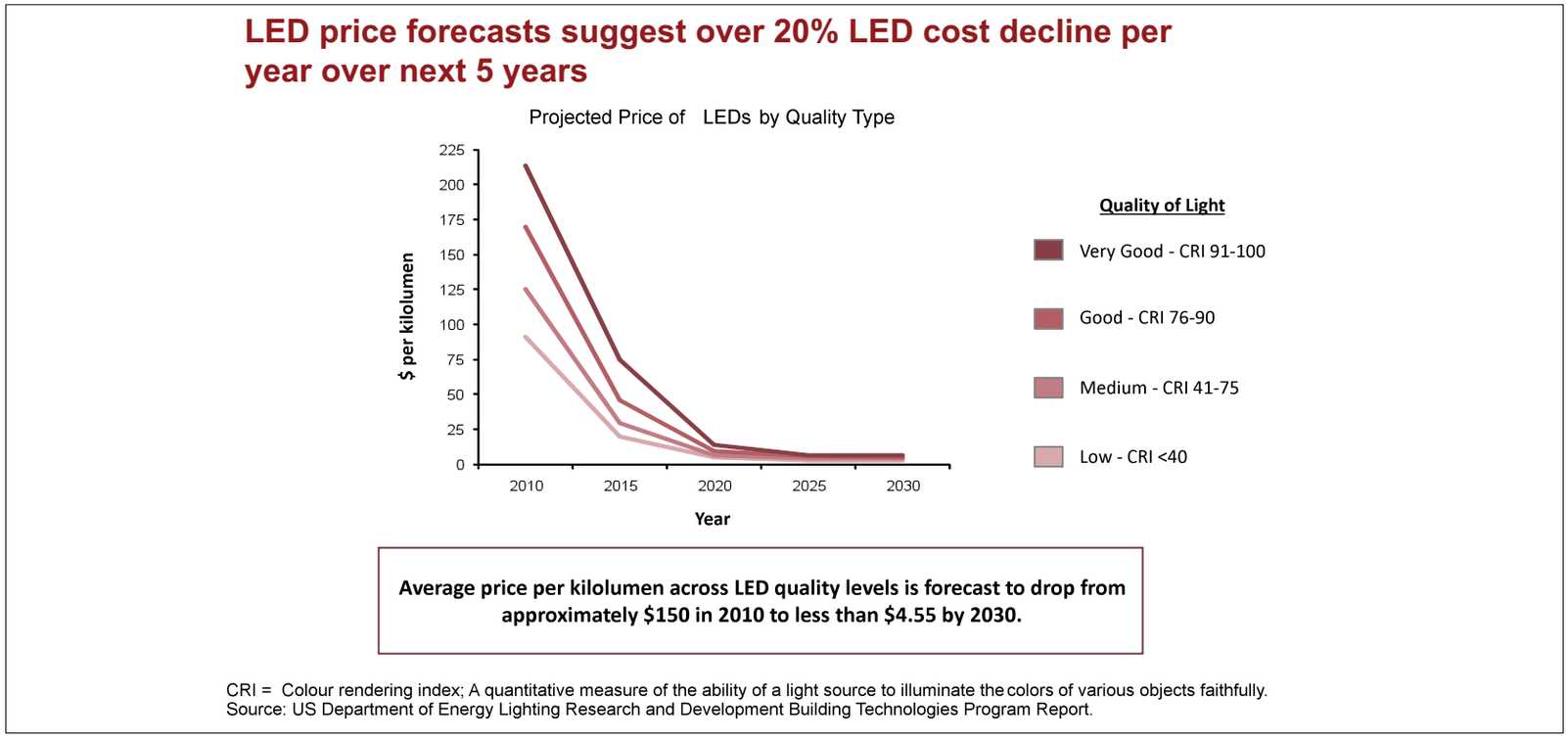


Figure 14: LED price forecast

Future Lantern Price

In light of the trends discussed above, we forecast a 40% decline in SPL component costs by 2015.

At the same time the costs of more prevalent off-grid lighting solutions, such as kerosene, are forecast to continue their rise. The combination of these two trends (falling component costs and rising kerosene prices) will reduce the payback period for lanterns substantially (Figure 16).

Under Scenario 1 in Figure 16, with a 40% reduction in manufacturing costs (and a proportional decline in distribution costs with fixed margins) the payback period declines to 5 months.

Under a more aggressive Scenario 2, if we assume the removal of tax/tariff barriers in more African geographies, additional reductions in distribution costs through scale, and the introduction of a a CDM market for SPL carbon emission abatement over the next five years (e.g., leading to a $5 credit per lantern), the payback period can decline even further to 2 months, equating to average SPL device costs of just $20 versus the average of over $40 today.

The above analysis relies on multiple, difficult to verify assumptions, but directionally it is unquestionable that solar portable lights will not only become more attractive and a better investment, but they will become more feasible for households with severely limited disposable income by 2015.

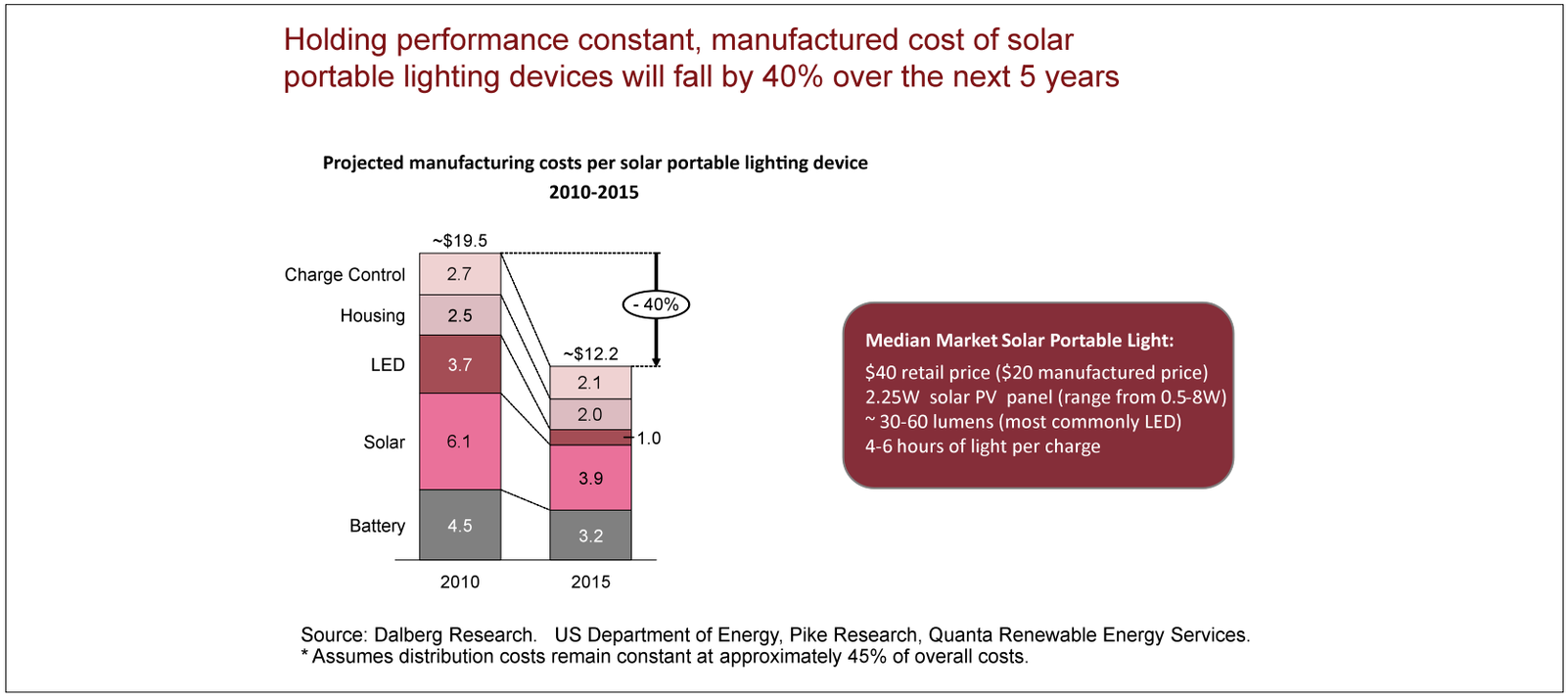


Figure 15: SPL manufacturing cost forecast

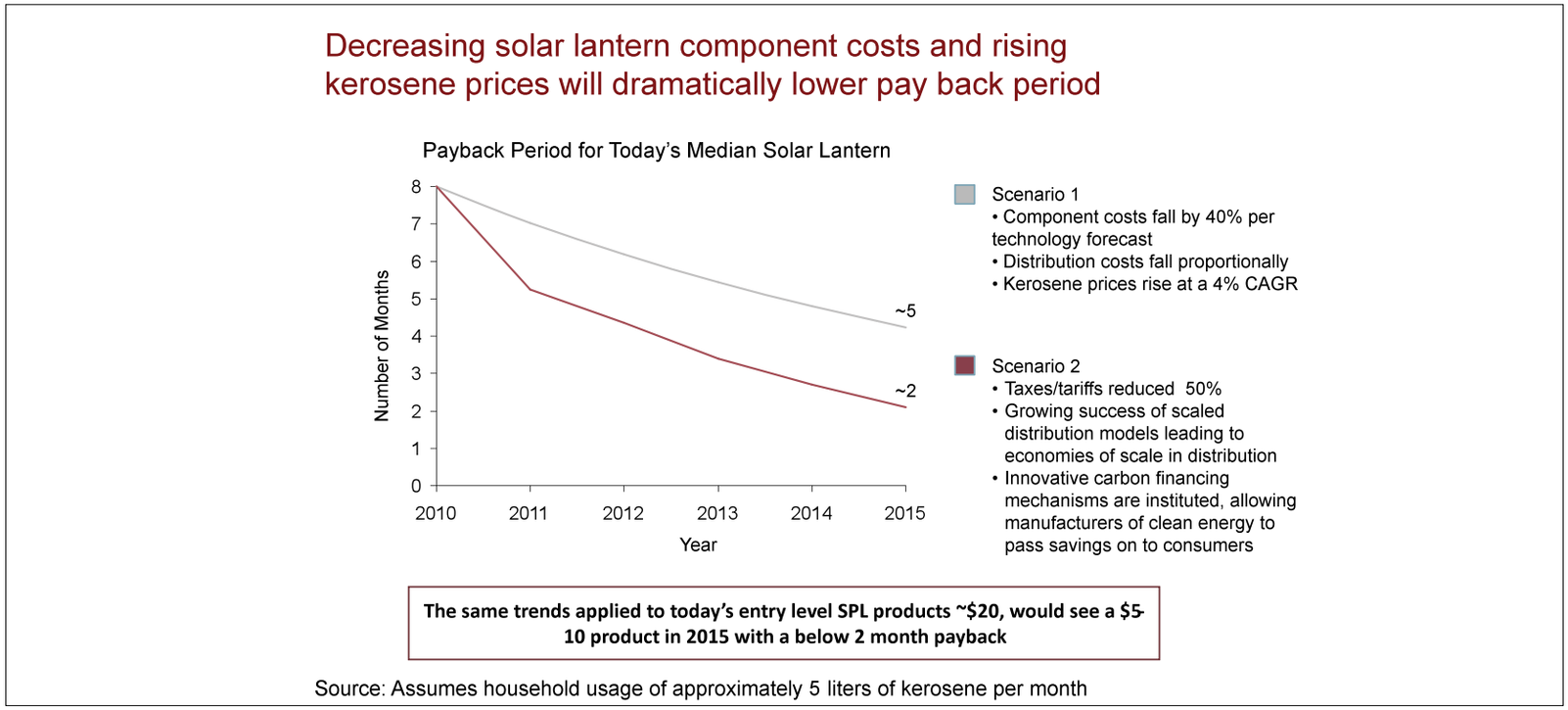


Figure 16: Lantern payback period scenarios

Technology improvements

The reduction in price of major SPL components will in part be reflected in substantial improvements in lantern quality. In 5 years, the average capital cost of $20 per light device, will buy a very different quality and/or quantity of components (Figure 17):[30]

- **Solar panel:** 4 watt panel vs. 2-2.5 watts today
- **Light source:** 3X as effective as LEDs as today
- **Battery:** lighter, cleaner, and 2 times greater energy storage capacity for Li-Ion battery or 30% greater capacity for NiMh batteries that will largely displace SLA technology
- **Accessories:** standard features like charge controller, multi-level light setting, and mobile charger/accessory

Boost in component quality should lead to a much stronger overall performance – we estimate an improvement in lantern battery life to 6-10 hours from 4-6 hours today and an emerging wave of much brighter lights, i.e., over 100 lumens, creating a wider range of available products for consumers.

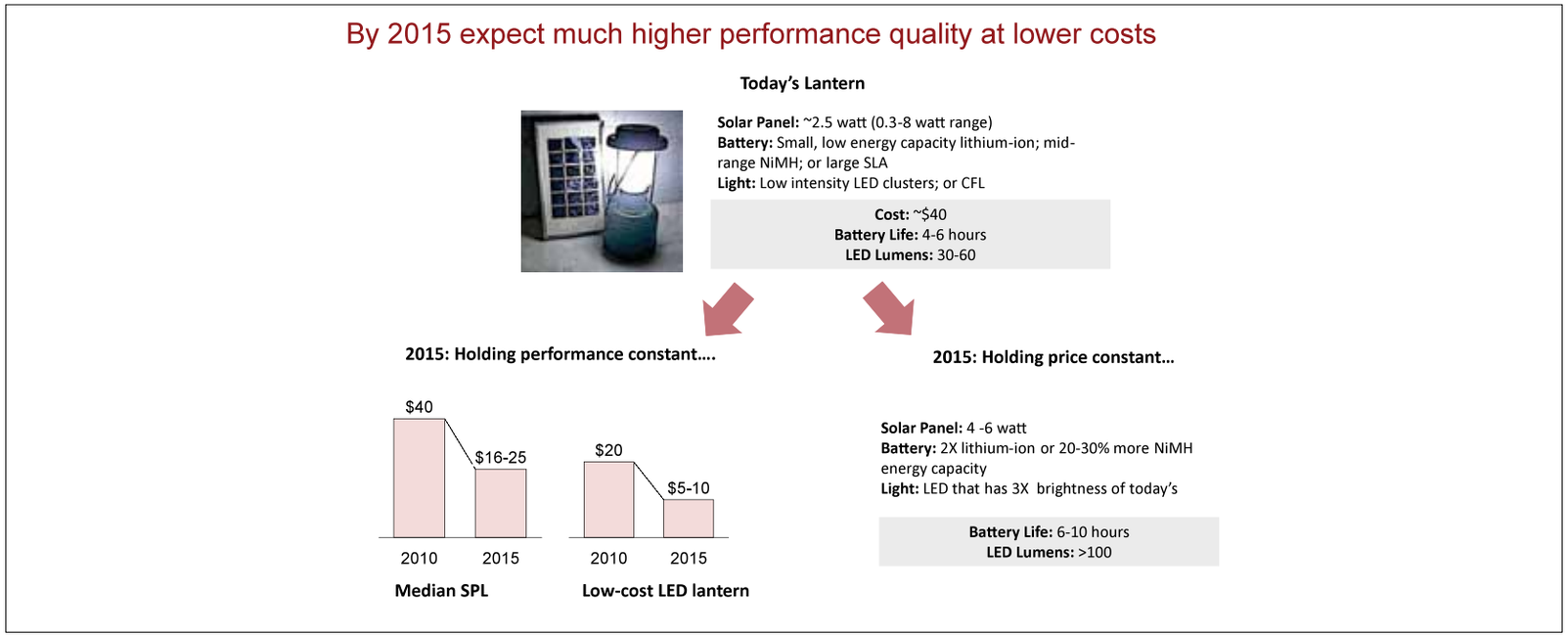


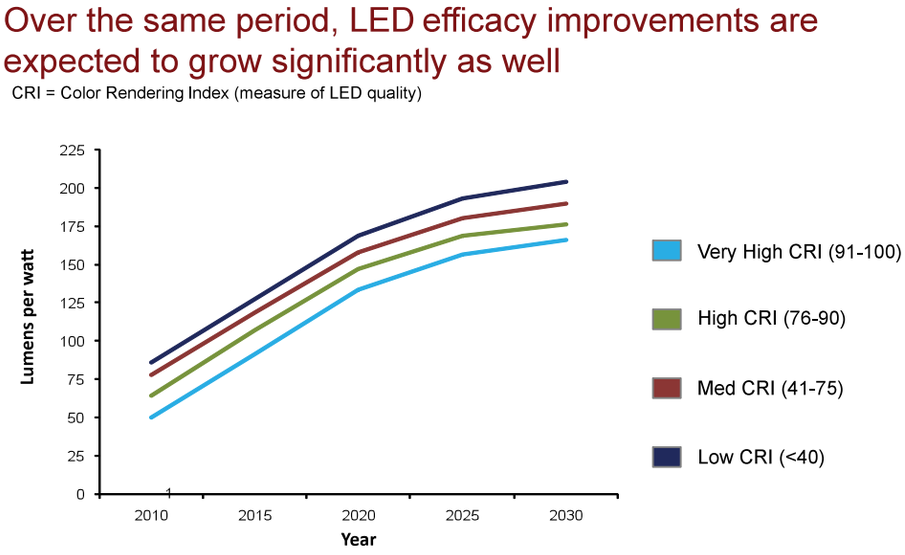
Figure 17: Today's capital costs will buy much more "lantern" tomorrow

Lighting components trends: LED technology is driving a set of trends that have been augmented by declining PV prices to expand the product range and dramatically improve options for low-income households. In the past, product differentiation largely reflected the power requirements of CFL lights resulting in relatively larger solar panel and battery sizes. The emergence of usable LED technology over the past five years has substantially reduced the sizes of both solar panels and batteries, allowing solar lantern options that range from 0.7 W integrated panel solar torches to 2-5 W ambient lanterns.

Hard sales data are not available. However directional estimates suggest that the majority of lanterns sold have historically utilized CFL technology. Today, however, a representative sample of the industry shows that 64% of new product entrants are LED lanterns. Along with decreasing panel costs, the introduction of LEDs as a primary light source has helped significantly reduce lantern costs. In addition, the rapid advancement of LED technology is expected to continue improving the quality and efficiency of light provided.

Between 2010 and 2030, LED efficacies are expected to improve on average 260% across all light quality levels with average LED efficacy exceeding 200 lumens per watt by 2015 (Figure 18). This will enable solar portable lights to provide far more light in the future while using less energy than they do today.

[30]We are not predicting the "average lantern" in 5 years, but simply displaying the significant gains in what will be available in 2015 for the same price today; actual lanterns will simply demonstrate a broader range of features and options



Source: US Department of Energy Lighting Research and Development Building Technologies Program Report1) CRI = A quantitative measure of the ability of a light source the colors of various objects faithfully.

Figure 18: Forecast on LED efficiency

Battery characteristics and trends: The emergence of LED lighting as the dominant lighting source in SPLs has also expanded the use of advanced battery options such as NiMH and Lithium ion which are increasingly replacing the low cost/low power density lead acid battery. The market breakdown of these batteries largely reflects the LED/CFL split with 33% of all lanterns (primarily CFL) utilizing lead acid batteries, 60% utilizing NiMH and 7% using either Lithium Ion or NiCD. NiMH batteries provide higher capacity, longer life span and improved durability in comparison to lead acid batteries. However, NiMH remains susceptible to memory effects and has lower power densities than Lithium ion.

Despite high energy densities and durability Li-ion has seen small market shares due to high costs, but many of the market players we've interviewed expressed the desire to shift to Lithium ion in the near future, leading to a potential breakthrough in overall lantern quality when combined with LED technology.

Solar PV quality: As mentioned in the solar PV price trends discussion above, the reduction in solar panel costs will in part be driven by continuing increases in solar panel efficiency.

Trend towards consumer-oriented design

The market has seen a shift from being an NGO development tool to a consumer product. Social entrepreneurs along with pure profit driven ventures have begun to respond to the choice of the consumer and offered design and features which better align with customer demands. These additional features include, among others

- **Multiple recharge options –** Provides consumers with more robust charging solutions for a range of scenarios. AC compatible options provide increased ease of recharge for under-electrified communities. Hand crank dynamo options provide more robust battery life and charging solutions for more remote rural populations. Some SPLs designed for African markets also feature car battery chargers, a minor but important source for electricity in remote rural locations.
- **Multiple dimming settings and battery life notification –** Multiple dimming settings provide consumers with a means of extending light hours. Battery life notification provides information to ensure adequate and correct charging that reduces wear on batteries. This combination additionally enables consumers to better plan and ration their light use.
- **Mounting features –** Allows flexibility in the use of the light with flexibility to mount on ceiling, as a reading light, as a hand-held torch or as an ambient lamp.
- **Durability –** Increased product durability for both solar panels and lanterns provides added value to consumers in rural areas where products will undergo rigorous use and there are fewer opportunities to repair damaged products.

- **Modular design –** Allows consumers to purchase smaller and cheaper units of light over time. This approach creates added affordability and choice as consumers can "build" upon previous lighting purchases.
- **Mobile phone recharge option –** Serves both under-electrified and rural consumer needs for alternative mobile phone charging options. By far the most value-adding SPL feature, as building a mobile charger into the cost of a lantern typically adds $1-2 to manufactured cost, yet potentially saves an average consumer anywhere from $50-150 annually (assuming $4-12 monthly mobile charging costs depending on geography). This analysis is oversimplified as mobile charging will often drain a typical SPLs battery leaving little capacity for lighting. However, the economics of such a feature are fundamentally positive and the appeal of this option as a "killer feature" was universally recognized in all of our industry interviews.

While lanterns fill a basic consumer desire for light, value added features increase the range of product offerings within this segment. Many of these features help to reduce upfront costs or increase overall economic benefit to the consumer, thereby increasing demand and expanding the market. While this market trend is likely to continue to provide greater choice in the near term, the scope for its expansion into ever newer and more innovative value added features is limited in the long term.

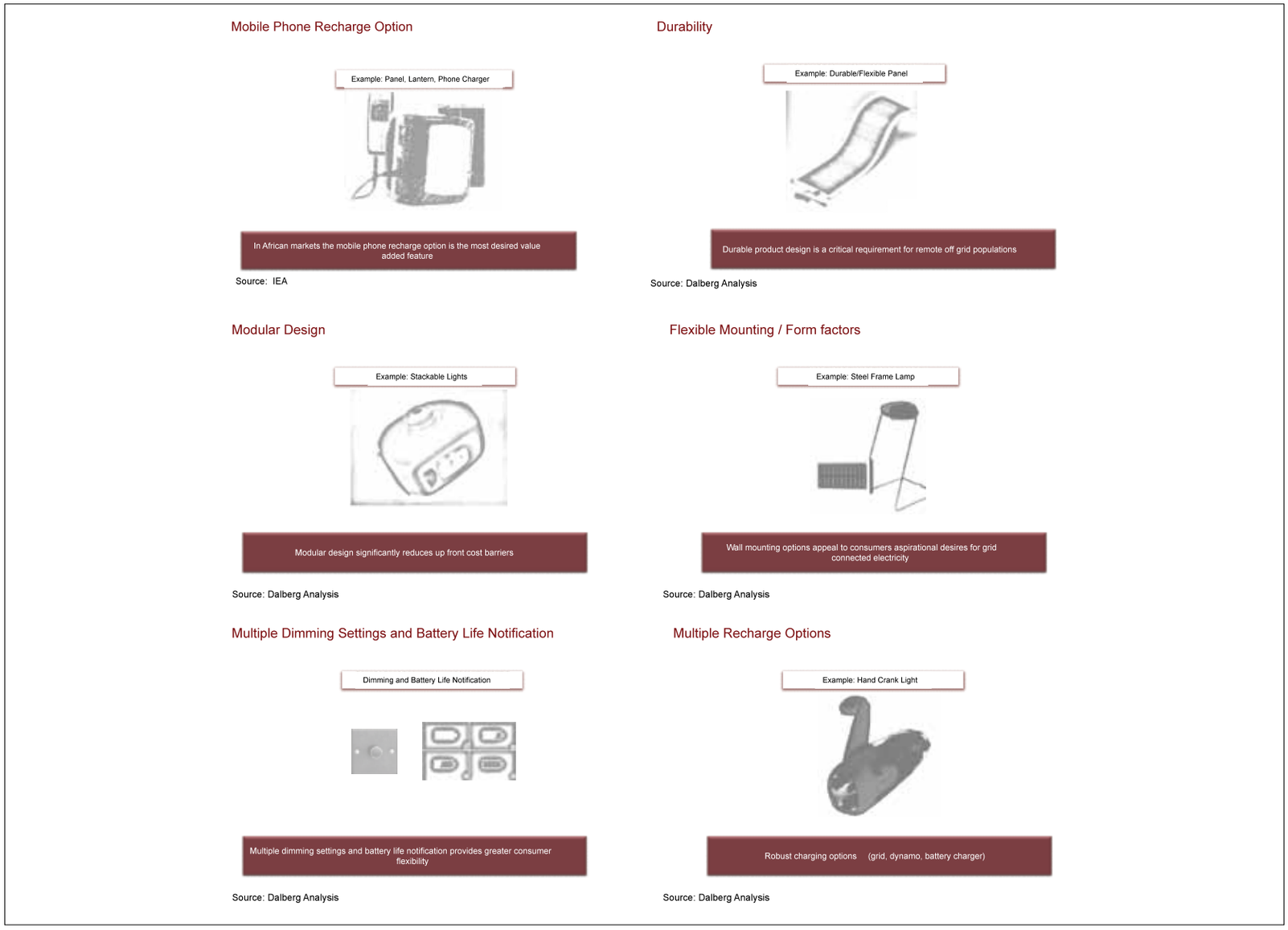
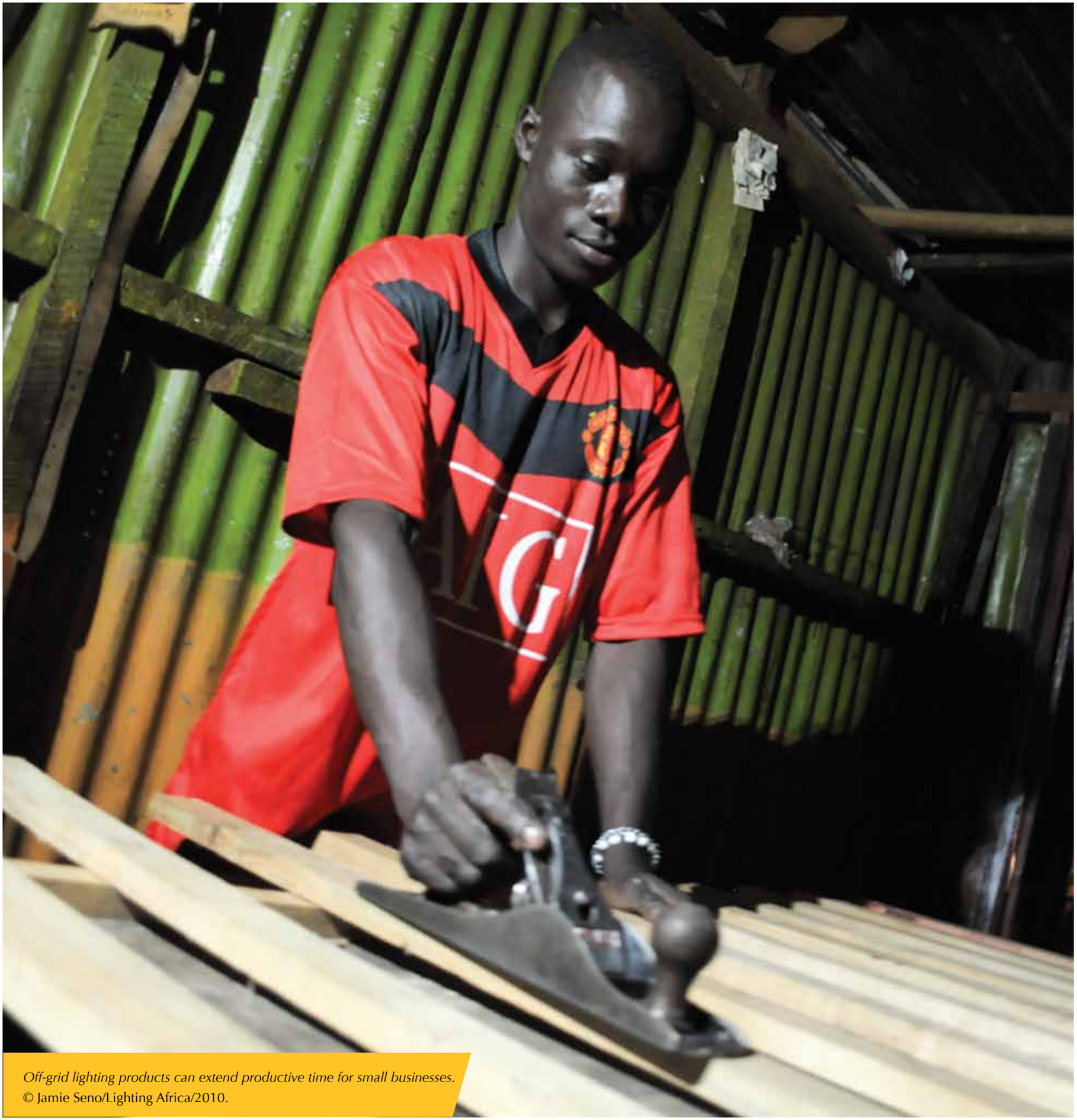


Figure 19: SPL accessory overview



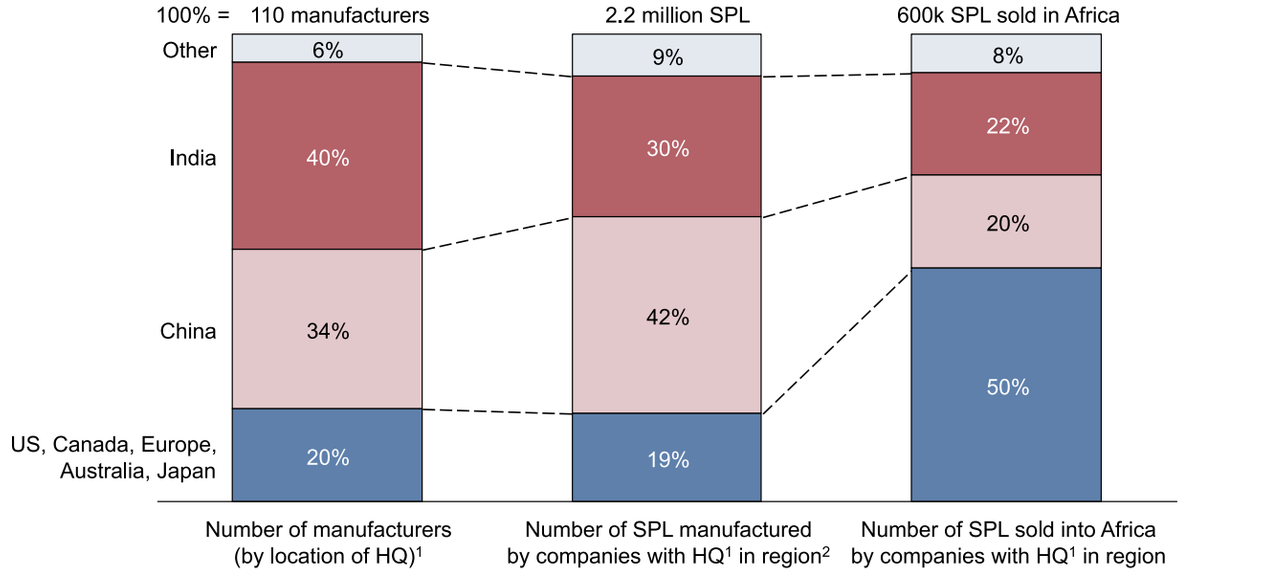
Off-grid lighting products can extend productive time for small businesses.

Global Industry Trends and Projections – supply and distribution

Supply and manufacturing trends

From a supply perspective, the solar portable light space has been characterized by a rapid influx of players, a broader offering of products, and the formation and strengthening of new distribution channels. The surge of market players has led to a market environment with over 100 manufacturers active in the space worldwide. An overwhelming majority of these are small ($150k to $5 million in annual turnover), generally with limited product lines.

Geographically, a majority of manufacturers are headquartered in Asia, but we estimate that 20% of the solar portable lighting devices actually distributed to the BOP in developing countries (and as many as half of current SPL devices in Africa) were manufactured by companies headquartered in developed economies (US, EU, Japan, Australia) [31] – mainly due to the weight of history. Currently ~30% of the manufacturers are headquartered in China, 40% in India, 20% in developed nations, and under 5% in Africa. The largest Chinese and Western companies have multiple product lines focused on clientele in both industrialized and emerging markets. These companies have largely moved into the solar light market from a separate but related base of operations.



1 Company is defined as being headquartered in a geography if the geography is the location of its top management staff, product design team, and typically marketing and quality control divisions
2 Total SPL manufactured 2007-2010 Q1

Source: Dalberg Analysis; database of 110 manufacturers with self-reported data on 40% and estimates for the rest. Includes estimates of 2.2 million global solar portable light sales, and ~600K Africa solar portable light sales.

Figure 20: Solar portable light manufacture and sales by geography

[31] Despite their North American, West European, or Australian headquarters (and, typically, developed world R&D, design, quality control, and marketing divisions), many of the "developed world" manufacturers actually manufacture their SPLs through captive or subcontracted factories in China

This solar lantern market is currently highly fragmented, with over a dozen new players entering annually, but the 5-10 largest established manufacturers account for roughly 50% of total sales (Figure 21):

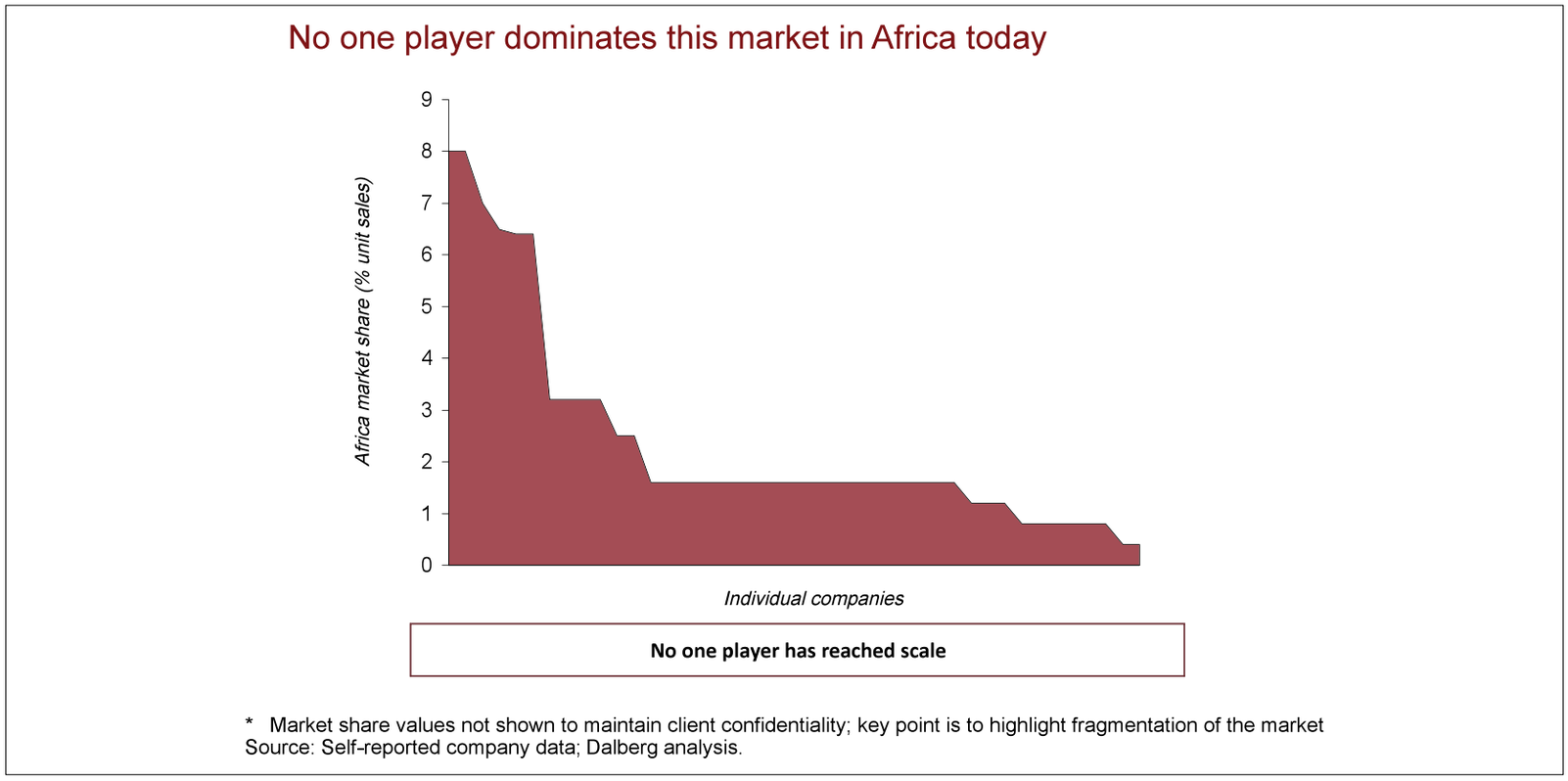


Figure 21: Market share for SPL players

Increasingly start-up social entrepreneurs narrowly focused on the solar lantern market have emerged with low cost, high quality LED lanterns tailored to off-grid markets. They have built off the initial success many players had distributing CFL-based lanterns in domestic and international markets. Many of the emerging LED companies utilize Chinese manufacturing and assembly for most world markets but retain local assembly options for key markets such as India. In most cases, local assembly capacity for African markets is marginal, making international sea freight of assembled lanterns from China the preferred option. In fact, even when assembly is undertaken within key markets many components, such as LEDs, tend to be sourced from China.

As the market matures, we expect that the number of manufacturers to potentially grow in the short term but then consolidate around less than ten major players. The current and short-term growth is due to relatively low barriers to entry and ready availability of solar lantern components. Nonetheless, we believe that a high degree of concentration is likely as leading players focus on innovative marketing and distribution strategies and discover ways to unlock scale and lock-in significant market share.

Solar Portable Light distribution models

Many of the global challenges related to achieving scale in SPL adoption are integrally linked to distribution - which can account for up to 50% of the final product cost in some geographies. Product companies face a range of options - from proprietary distribution to leveraging existing channels, from purely private sector to government/NGO-supported programs and from purchasing to rental models.

The experiences of companies globally has illustrated that there is no silver bullet - each model has its advantages and challenges. The key is to identify the appropriate distribution model for the specific market dynamics of a country or region. The following section simplifies current distribution practices into five leading models and offers an overview of model challenges and opportunities, with illustrations from the Africa context based on our interviews.

Distribution Model	Product range	Company gross margin	Marketing	Distribution/Logistics	Last-mile sales
Distributor - Dealer Network	Broad range of complimentary, competitive and sometimes unrelated products	10-40%	Materials: company Cost: dealer	Logistics: company Cost: distributor	• Final sales: handled by dealer • Product financing: informal • After-sales support: distributor
Own distribution/Direct-to-Consumer	Exclusive to company	20-50%	Materials: company Cost: company	Logistics: company Cost: company	• Final sales: handled by sales team • Product financing: rarely formalized • After-sales support: sales team
Institutional Partnership	Typically exclusive or limited to other value-added products	10-30%	Materials: company Cost: shared	Logistics: company Cost: shared	• Final sales: handled by partner • Product financing: if partner is a financing institution (MFI, SHG network, etc); rental/charging kiosk model is optional • After-sales support: partner
Franchise	Exclusive to company	10-30%	Materials: company Cost: shared	Logistics: company Cost: shared	• Final sales: handled by franchisee • Product financing: rarely formalized • After-sales support: franchisee
Rental/Leasing System	Typically exclusive or limited to other value-added products	10-30%	Materials: company Cost: shared	Logistics: company Cost: shared	• Final sales: handled by leaser • Product financing: rental model enables small cash payments • After-sales support: leaser

Figure 22: Distinctions between the 5 major SPL distribution models

The companies in our interviews were a representative sample, with the vast majority relying on the distributor/dealer or proprietary distribution (i.e., direct to consumer) models.

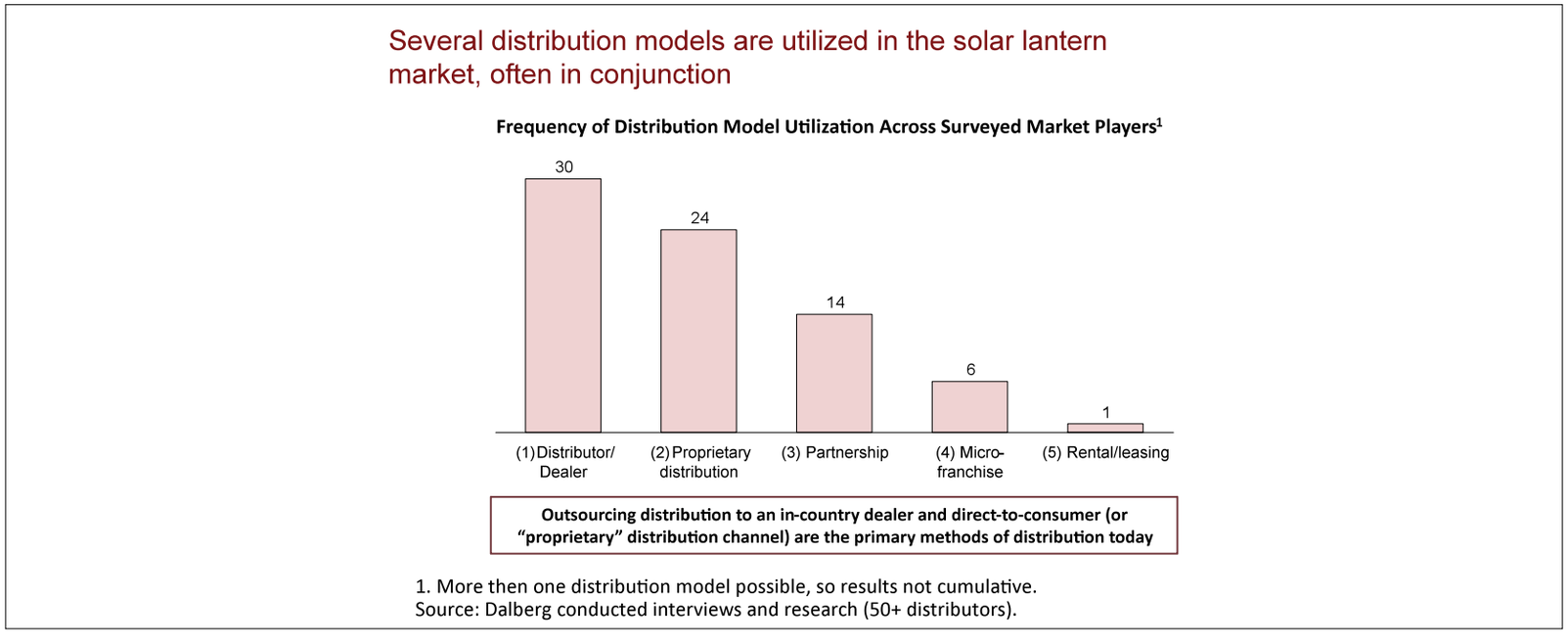


Figure 23: Common distribution models

Distribution Model #1: Distributor-Dealer Channels

Definition: Company sells its products through existing networks of generalist or specialist distributors in the rural/peri-urban market (e.g., sari-sari stores). This model piggy-backs on the traditional private sector supply chain of consumer durables and usually engages a distribution hierarchy of at least two levels (distributor and dealer/retailer). The company's product is typically retailed in a basket of other related consumer durables.

Key Benefits:

- Often the most common and well-understood model in developing markets
- Greater market penetration - leveraging existing infrastructure, particularly for a deep reach into rural areas
- Some control of market price
- Share in marketing & logistics expense
- Moves inventory closer to the end-consumer for "just in time" delivery to respond to demand
- Gain from distributor's/dealer's knowledge of the market & customer

Key Challenges/Risks:

- Gross margin must be shared amongst multiple players, forcing the manufacturer to forfeit at least 20% more than in other options
- Requires qualified master distributors which have historically been difficult to find
- Oversight into the "last mile" of distribution - less leverage to aggressively market and push consumer sales, challenge to compete with other basket of goods in retailer's shop, and difficult to ensure that the retailer completes after-sale support
- Distributors and dealers are often SMEs with limited working capital, which can constrain volumes of sales or demand that the manufacturer/company offer lines of credit.
- Brand dilution risk, if inadequate training and oversight

The African experience with this model of distribution has been mixed. The usage of the model is dominant among most companies we've surveyed but often face a number of roadblocks in implementation:

- Companies entering new markets do not fully understand the distributor landscape and it takes a while to identify "quality" distributors
- Distributors don't always fully understand the products well enough to explain them to consumers and companies have to provide a lot of training and continuous monitoring if they want to maintain standards/build a strong brand
- After-sales support is often found difficult to coordinate for a vast dealership network
- Due to the varied nature of distributors, most companies will require that distributors pay cash upfront for products and this is a key bottleneck to scale up. However, some companies that develop long term relationships with their dealers are able to provide credit facilities

Distribution Model #2: Proprietary Distribution Channels

Definition: Company maintains a proprietary distribution channel in which the products move from manufacturer to in-house storage facilities to a salaried/contacted salesforce, which exclusively delivers company's products directly to the customer.

Key Benefits:

- Complete control over pricing and quality/brand image
- Avoids dealing with external players that would require special arrangements, such as extending of credit, price control of the product in the outlets, quality of goods, after-sale services and the sale of competitive products
- Maintain gross margins in-house
- Proximity to consumer ensures responsiveness in after-sales support, continual product feedback, and growing market knowledge
- Clean inventory controls

Key Challenges/Risks:

- High fixed cost investment in local sales staff/infrastructure for a small basket of goods; there is a considerable risk that, the local market will become saturated before recouping the cost of sales/distribution in that area
- Decentralized web of sales/marketing staff can be challenging to manage
- Difficult to adapt quickly, change geographies, etc.
- International companies may find it difficult to establish sales locations, hire personnel to operate the business, understand and comply with government regulations and local business practices

Given the nascent nature of the industry in Africa, companies find that direct marketing to consumers is one of the most effective ways to get customers to learn about the products. A company would therefore need to have an extensive sales team presence in every area they wish to reach, which is expensive to set up, especially for rural areas. Additionally, building a distribution network for 'one-off' items, which is often the case for solar lanterns, is difficult and expensive, so this model favors companies that have multiple products, for example including solar home systems and solar water heaters, or more plausibly rural retailers of consumer electronics. A key advantage with this system is that it helps companies build their brand and target their messaging to consumers directly. Working closely with sales teams on the ground, helps companies understand the market needs and to continually improve existing and design new products.

Distribution Model #3: Institutional Partnerships

Definition: Company partners with a relevant institution (e.g., NGO, MFI, rural bank, SHG network, MNC, with a linkage to a material number of potential customers) to market the product to that institution's customer base or membership network. This could also include government schemes.

Key Benefits:

- Allows for rapid implementation: potential for high volume orders with lower operating costs
- Leverage an existing network of customers; gain from partner's deep knowledge of the customer base
- Opportunity for product financing, if the partnership is with a finance/credit institution
- Often ensures social impact, depending on the partner institution's mission

Key Challenges/Risks:

- Risk that government and NGO players could distort the market with subsidies and make the market uncompetitive for private sector players
- Distribution may be dependent on a finite level of funding available to the partner institution
- Time and cost to source and manage one institution often far exceeds projected budgets/timelines
- Often partnership with large institutions puts the small lantern company in a position of limited bargaining power
- Frequent disputes over cost sharing, risk sharing, roles and responsibilities

The most common institutional partnership seen on the ground in Africa and elsewhere globally is with local MFIs. There have been a number of success stories outside of the continent of partnerships, particularly in the SHS market, between solar renewable light distributors with sizeable institutional players to drive scale (e.g., SELCO/SEWA in India and Grameen Shakti in Bangladesh). These success stories have lead many providers to consider MFI partnerships as both a financing and distributional asset [32] and most of the large SPL distributors we've talked to in Africa are in talks with or on the lookout for such institutional partnership opportunities. Few in the SPL space, however, have actually done this successfully.

Beyond the problems of identifying and successfully partnering with a large MFI, most distributors report problems of overworked and under-incentivized MFI loan agents in the distribution of solar lanterns as well as other consumer products. In addition, agents are unlikely to sell large numbers of products but face a huge downside risk to their reputation with the communities they serve if even a small fraction of the lanterns are poor quality or fail. Ultimately, in countries where MFI's are not established, advanced institutions, they could be better used as door openers rather than product providers.[33]

Further, since MFI's in Africa tend to be concentrated in urban areas (see graph below), manufacturers and distributors find it very hard to reach out into the rural areas where the majority of the need is. To do this properly, a number of companies are experimenting with micro-franchising, working with schools and community based organizations.

[32] REN21 (2009).

[33] Karamchandani (2009).

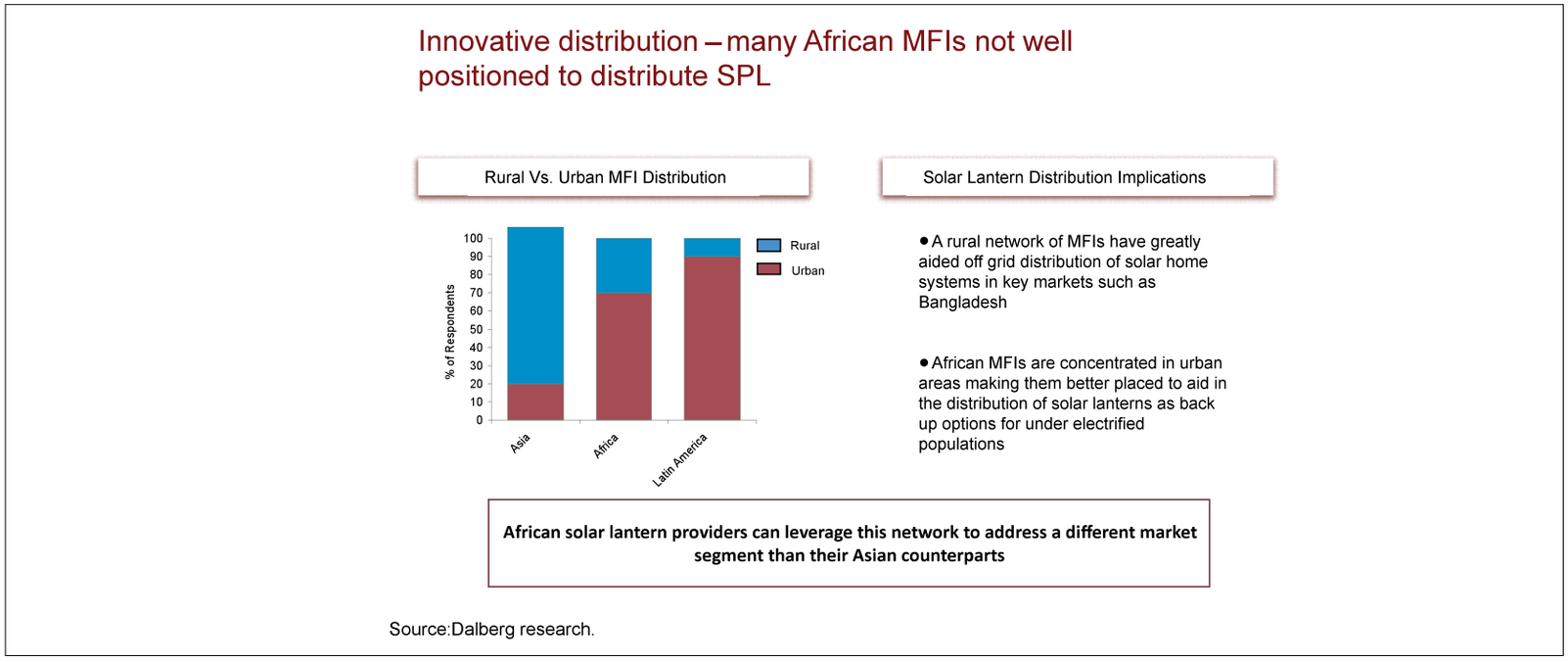


Figure 24: Distribution through African MFIs

Partnerships with SACCOs and NGOs are another alternative for Africa, albeit on a smaller scale. Such partnerships can be instrumental in getting products to remote locations that are inadequately served by the traditional wholesaler/retailer supply chain. Using rural SACCOs or NGOs and community organizations at the grassroots level has also enabled some companies to provide installments payment plans to end customers since the grassroots organizations can follow up with the customers on a regular basis. Some companies are also working with respected NGO/community organization leaders to help them appreciate the products – these leaders can then push the products in the communities.

Though distributors have not yet "cracked" the partnership model, this continues to be a major area of growth and experimentation that will likely reap results for a few of the top distributors over the next few years.

Distribution Model #4: Franchise Model

Definition: Company offers franchising packages (including features, such as income opportunities, training, marketing support, financing) to micro-entrepreneurs who wish to be formalized retailers of exclusive company products.

Key Benefits:

- Rapid scale-up by outsourcing the product retail to a player that will be incentivized to increase sale volumes and raise brand awareness.
- Share in marketing and logistics expense
- Farther reach for product distribution

Key Challenges/Risks:

- Gross margin must be shared amongst multiple players, forcing the manufacturer to forfeit at least 20%
- Significant branding risk, as well as IP risk (if the technology is proprietary)
- Less practical for a solar lantern model, more appropriate for solar home systems and other relevant HH/SME solar installations with higher profitability

In Africa, this model takes two approaches: (1) a big franchise whereby a manufacturer has one or two franchisees in a country and (2) a micro-franchise whereby the manufacturer develops micro-entrepreneurs to become franchisees. In both cases, distributors take the responsibility to market and build a brand around their products. A key obstacle is that it takes a while to identify and build the franchisee network - training, and ensuring brand ownership. On the other hand, companies have found that it enables them to control their marketing message and the after sales support without having to build their own after-sales team, which is more expensive.

Distribution Model #5: Rental /Leasing System (aka, "Solar Electric Utility" or "Fee-for-use")

Definition: Company contracts or franchises to micro-entrepreneurs who set up solar charging kiosks. The micro-entrepreneurs either (1) rent products out to consumers on a hourly/daily basis or (2) sell the lanterns without a power source and offer a fixed fee for charging. Charging can be provided via on-grid power or alternative power generation (solar, diesel, etc).

Key Benefits:

- Outsourcing last mile for more rapid scale-up
- Customer affordability - reach customers that cannot afford the full product cost by mimicking the cash flows of kerosene
- Customers benefit from convenience, minimized risk of device theft due to charging in a secure location and better product performance due to a standardized, supervised charging process.
- Offers a platform for other adjacent enterprises (i.e., other appliance/battery charging, the sale of complimentary products, computer access)
- Potentially better product maintenance, as the rental business has a greater incentive to prolong the product life.

Key Challenges/Risks:

- High capital investment required by the local entrepreneur - land, building, recharge systems, product inventory (especially for a solar-powered model)
- Unproven commercially; often insufficient incentive to the micro-entrepreneur unless overly subsidized (because there is a high capital expenditure for a limited geographic radius)
- Restricts end-user choice (customer feedback in some pilots have shown that, ultimately, customers want to own their light & power source – sometimes a "rent-to-own" model is most suitable.)
- Challenges with maintenance and quality control, as well as potential loss of rental unit.
- Lower ability to up-take latest innovations in the market due to sunk costs

The centralized model of solar lantern distribution has been cited as an ingenious method for providing lighting to the BOP. Examples include Sunlabob in rural Laos, TERI's Lighting a Billion Lives campaign in India, and Soluz operations in Central America,[34] along with smaller African examples in Mali (Mali ESCO) and Botswana (BPC Lesedi). TERI's Lighting a Billion Lives model is probably the best known and follows a fee-for-service delivery approach where a solar charging station is set up by TERI and operated by a village entrepreneur. This not only provides employment opportunities for the local communities but also claims to make the overall process sustainable. In Laos, Sunlabob has had success with a rental service that provides SHS and SPL on a fee-for-service basis. The household pays for the electricity monthly, but the installed equipment remains the property of Sunlabob. The household thereby pays for electricity only when electricity is actually forthcoming. Sunlabob has an interest to keep its installed systems well-maintained and the rent covers all costs including technical servicing, replacements and amortizations, and the operational costs of the service.

African fee-for-use examples are fewer and have not yet seen very large scale. BPC Lesedi operates as a joint venture company BPC and owns all photovoltaic systems in Botswana. It operates as a franchise, with six to eight franchisees taking the PV services countrywide. These franchises install, operate and maintain PV systems and will collectively have between 20 and 30 sub-franchises which offer solar power PV for rental, rechargeable lanterns and improved stoves for rural households.

While the model has experienced demonstrable success, limitations to its scalability exist. For instance, centralized systems are not compatible with heavy demand as charging stations are often overcrowded and lack the ability to grow alongside expanding user bases. The low cost of lamps also prohibits accurate costing methods for charging, as electricity providers don't know which lanterns are fully charged and which aren't. The centralized model is more ideally suited as a back up to grid electricity, with full decentralization (i.e., individual unit sales) for more remote areas a priority.

What Model to Use When?

The appropriate distribution model is highly dependent on the industry characteristics, as well as the specific product offering and market dynamics. The table below suggests to usage of different distribution models under various industry characteristics. This is based on the experience of the global solar lantern companies surveyed for this report. The bottom line on distribution, however, is that there is no one "silver-bullet" model and while many of the models have shown promise, achieving scale in SPL penetration will continue to require a multitude of approaches.

Industry characteristic	Distribution Model
• Nascent industry with little existing sales/marketing channels or infrastructure • Active civil society with large NGO/MFI institutions	Institutional Partnership Rental / Charging Station Model *Suitable product range*: Single or multi-product offering; products with simple after-sales support requirements *Suitable market dynamics*: High density, peri-urban areas; low-middle income brackets
• Nascent industry with little existing sales / marketing channels • Sufficient infrastructure to maintain affordable distribution/marketing	Own-distribution / Direct -to-customer Model *Suitable product range:* Basket of products (not for single product offering); products requiring complex after-sales support *Suitable market dynamics:* High or low density area; low-middle income brackets
• Well-developed distribution channels through rural & peri-urban areas—actively moving consumer durables	Distributor -Dealer Model *Suitable product range*: Single or multi-product offering; products with simple after-sales support requirements *Suitable market dynamics:* High or low density area (typically useful for rural markets); lowest income bracket
• Well-developed distribution channels through rural & peri-urban areas • Thriving SME sector with micro and small entrepreneurs willing to invest and take risk in a franchise venture	Franchise Model *Suitable product range:* Basket of products (not for single product offering); arger / higher-priced products (i.e. solar home systems); products requiring complex after-sales support *Suitable market dynamics*: Mid/High density (franchisee must have enough incentive to sustain franchise); low-middle income brackets

Figure 25: Distribution model fit based on industry characteristics

[34]Karamchandani (2009).

Poor lighting can reduce the productive time for small businesses.

The Africa Scenario – market size

The potential off-grid customer base is large

As of 2009, grid connection rates across Africa stood at just 35%, with more than 110 million un-electrified households, covering over 580 million individuals based on our country-level database for the continent (Figure 26).

Region	% On-Grid	HH millions on grid	HH millions off-grid
Central Africa	18%	4	19
East Africa	15%	9	50
North Africa	76%	18	6
Southern Africa	70%	7	3
West Africa	39%	22	34
Africa Total	35%	60	111

Source: Dalberg analysis based on country-level grid penetration model for 2009

Figure 26: Electrification rates across Africa

As this data demonstrates, the opportunity is uneven across geographies and therefore requires careful prioritization for SPL market players, NGOs, and international financing institutions. Simply in terms of absolute off-grid populations, Nigeria, Ethiopia, Congo (DRC), and Tanzania are the largest unaddressed markets (Figure 27).

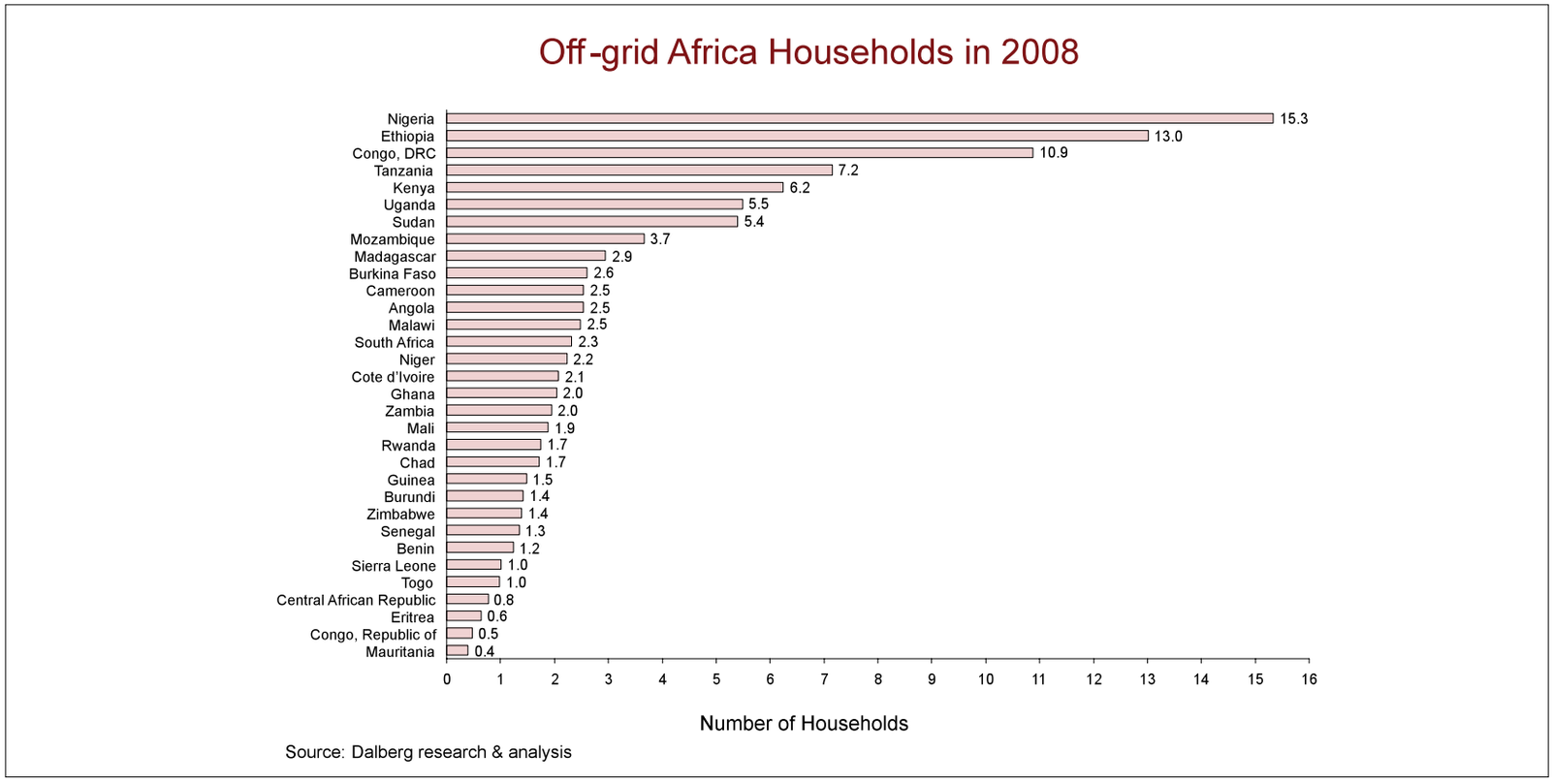


Figure 27: Africa off-grid markets ranked by size

In addition, slightly smaller countries like Kenya, Ghana, and Senegal serve as natural priority markets as these are important hubs for their respective regions and, in the case of Kenya and Ghana, many of the significant barriers to entry and maintenance are currently receiving attention through the activities of the Lighting Africa program.

Other potential prioritization criteria such as historical grid growth and kerosene prices, all point to the untapped demand in most East African geographies (Kenya, Tanzania, Uganda, Malawi, Mozambique) and a few West African markets like Ghana, Mali, Senegal and Chad (Figure 28).

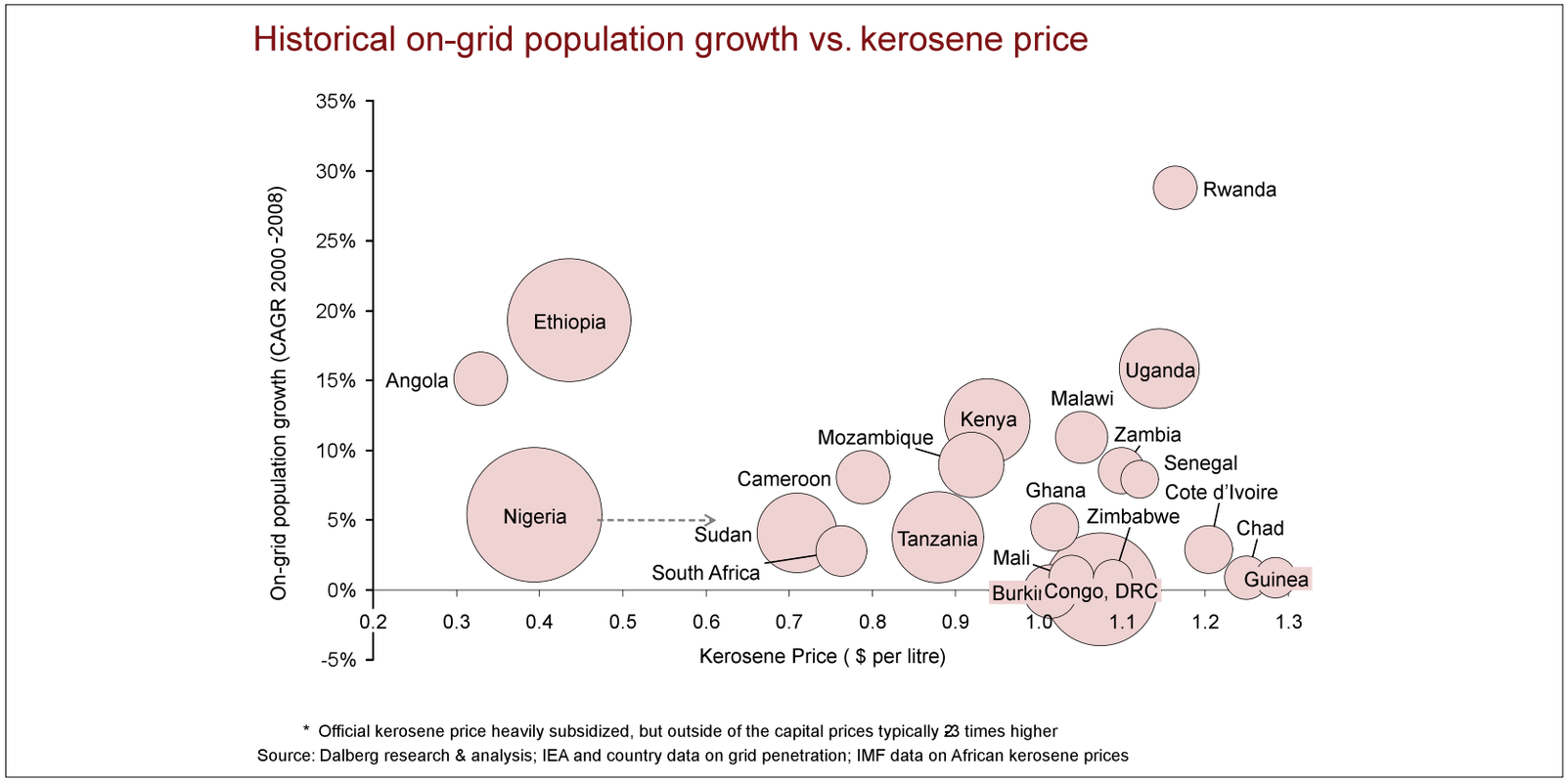


Figure 28: Africa market prioritization – grid growth vs. kerosene price

Major markets like Nigeria and Ethiopia do not appear attractive in this prioritization scheme, but in fact have a lot of potential given their huge size and the fact that official (heavily subsidized) kerosene prices are a poor reflection of what the typical BOP consumer pays once supply shortages, transportation costs, and the resulting pricing power of last mile distributors are taken into account.

African "under-electrified" households

Out of Africa's population of approximately 1 billion, over 400 million are deemed by their governments to be "grid connected" today. As discussed in the international trends section earlier in this report, this data is misleading as it does not reveal the accurate nature of the grid connection.

First, grid-connection statistics may in some cases inflate the actual state of electrification by labeling households living in proximity to the grid as grid-connected (e.g., labeling a village as electrified) even if the hypothetical grid connections remain unused or inaccessible. Second and more important, with rapidly growing electricity demand, supply shortages, and a stretched grid, power outages for businesses and homes alike are daily occurrences across much of Africa, and can last hours at a time.

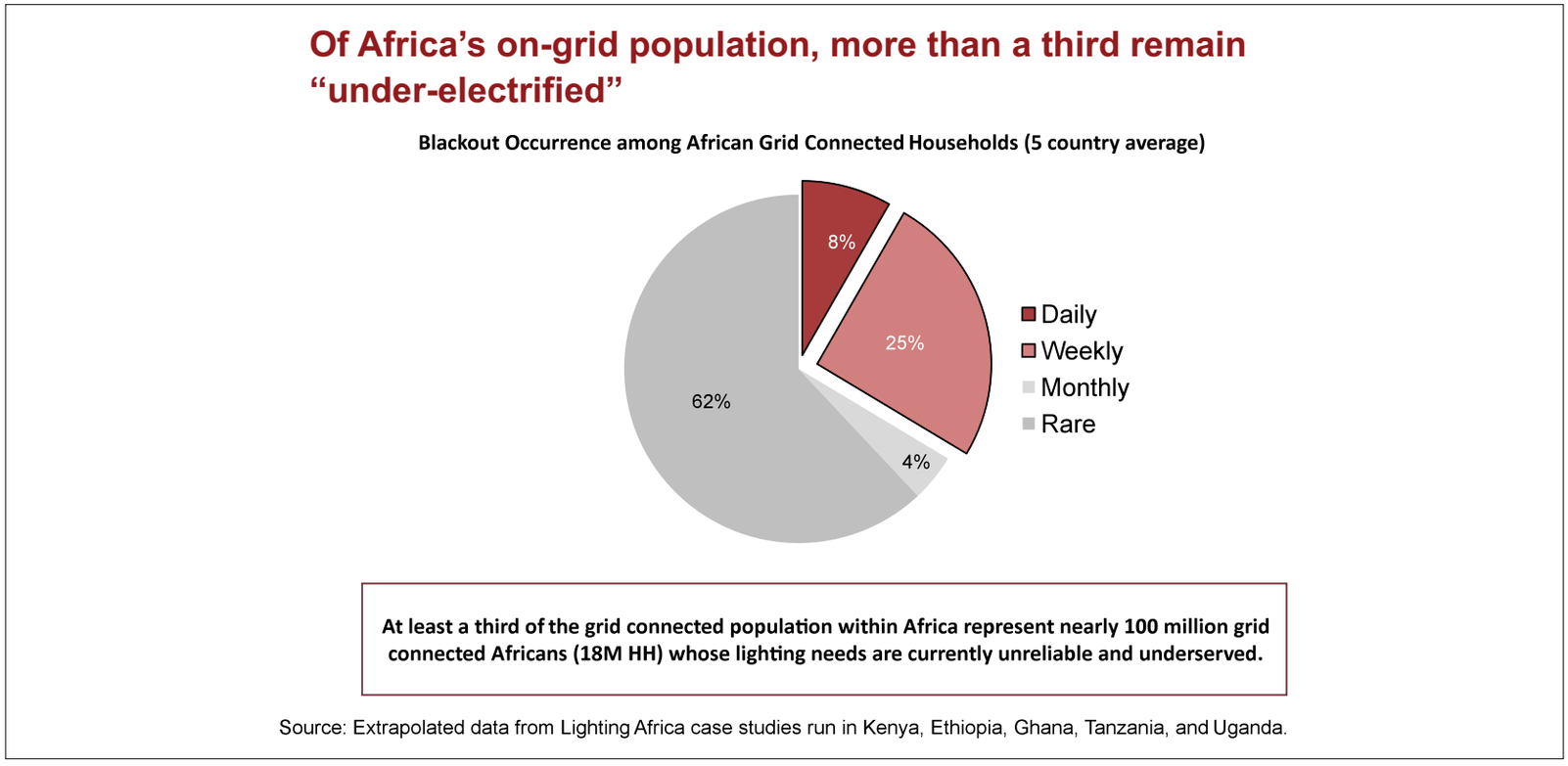


Figure 29: The African "under-electrified" consumer

Lighting Africa research conducted across Kenya, Ethiopia, Ghana, Tanzania, and Uganda reveals that more than one third of the grid-connected population across these countries experience power loss on at least a weekly basis (Figure 29). Electricity blackout data for small businesses across Africa indicate an average of 10 power outages per month, with many outages lasting several hours and at times days (Figure 30). As peak hours create the most pressure on the grid, one can assume these are the times most likely for power outages to occur, especially in lower-priority rural areas. As a result, more than one third of the grid connected population across the surveyed countries is under-electrified at essential times.

Extrapolating this proportion of under-electrified households to all of Africa – a clear underestimate given the poor quality of the grid in populous West African nations (e.g., Nigeria) not covered by current Lighting Africa research (compare in Figure 30) – suggests that well over 100 million Africans with grid connectivity are in need of additional lighting services, if only as a backup option.

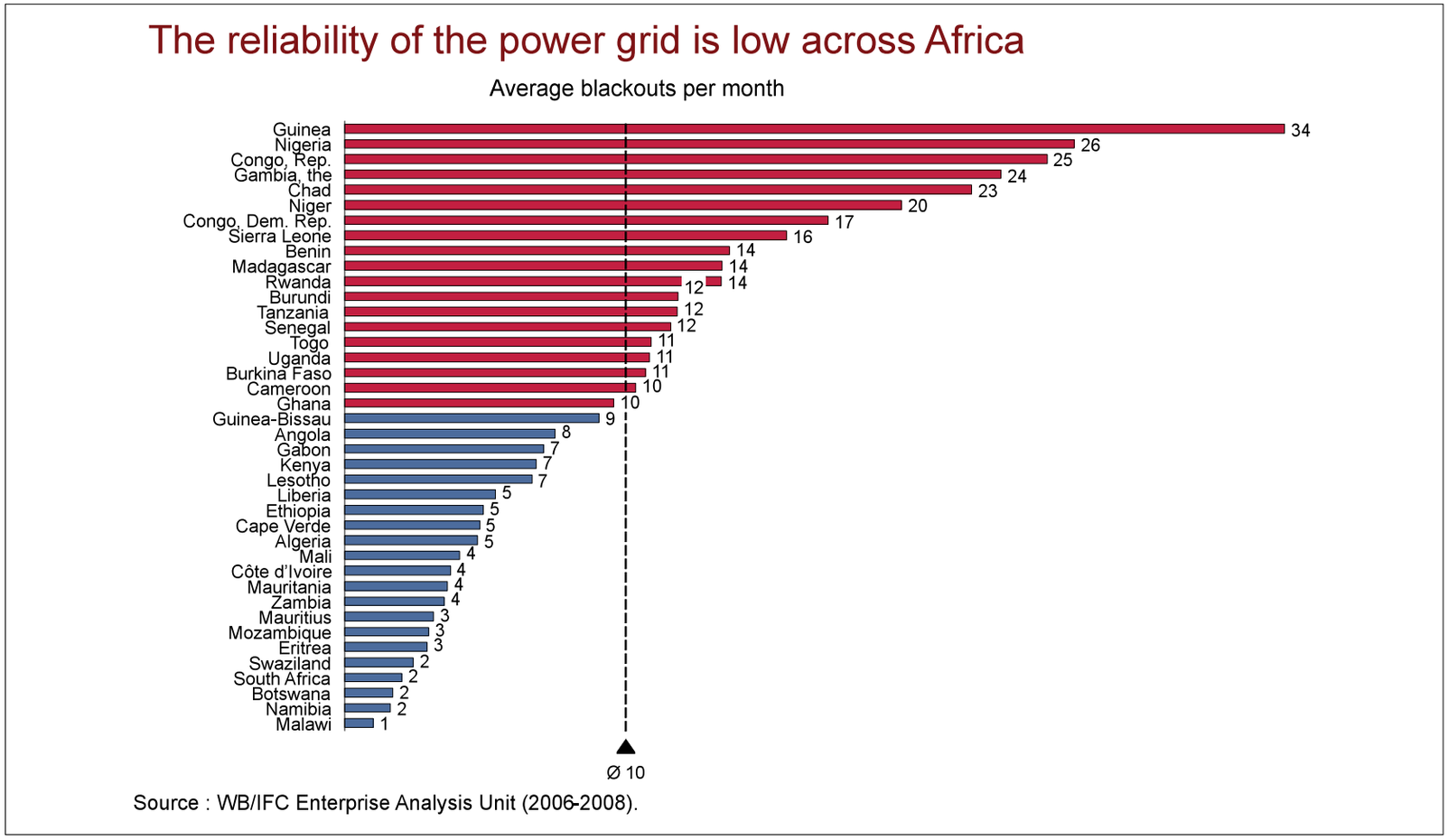


Figure 30: Grid unreliability – monthly power outages by country

Lighting spending by off-grid and under-electrified households is immense

African BOP households and small businesses spend over $10.5 billion annually on lighting. The bulk of the expenditure ($8.2 billion) is due to Africa's 110 million off-grid households, $1.2 billion is spent by the 20 million on-grid households who rely extensively on back-up power, and, conservatively, $1.1 billion is spent by the small-business sector. This spending is projected to increase to over $12.5 billion in 2015 as the off-grid population continues to grow (Figure 31).

Earlier Lighting Africa research has estimated this spending to be as high as $17 billion annually based on a focus on a larger slice of the market (i.e., not just BOP consumers, off-grid businesses beyond SME sector) and triangulation with total kerosene spending on lighting, which in some countries includes substantial "leakage" due to the illicit reconversion of subsidized lighting kerosene into car fuel. Current bottom-up estimates adopt a more conservative approach, but the fundamental point is unchanged – today's $10.5-17 billion spent on traditional lighting fuels is immense and growing.

Kerosene is the dominant energy source for the off-grid lighting applications of most Africans. It is the primary light source for 53% of households and accounts for nearly half of the total expenditure on lighting. The figure below (Figure 32) provides a breakdown of lighting expenditure by sources and illustrates the wide variation between geographies.

Though Kerosene may dominate the market in many African countries today, it is important to remember that other countries see a heavy reliance on batteries, candles (e.g., Zambia) and wood, charcoal, and dung (in the very poorest nations in central and West Africa).

The costs of the latter "traditional" fuels are not fully reflected in our annual lighting expenditure estimates since such fuels are rarely bought, but rather impose a substantial indirect opportunity cost on the environment and on African households who can dedicate hours daily to fuel gathering, denying them time for productive activities.

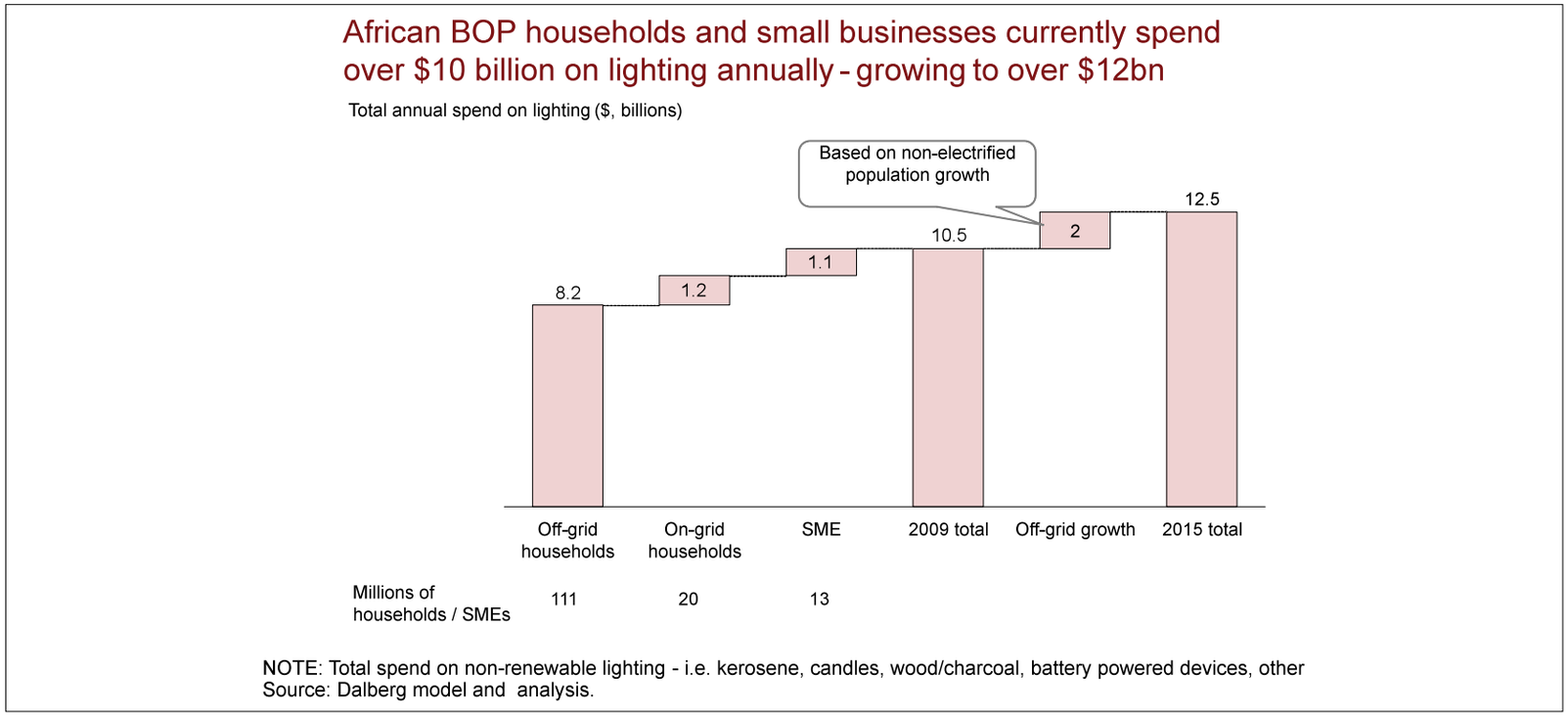


Figure 31: Current spend on lighting by BOP households and SMEs

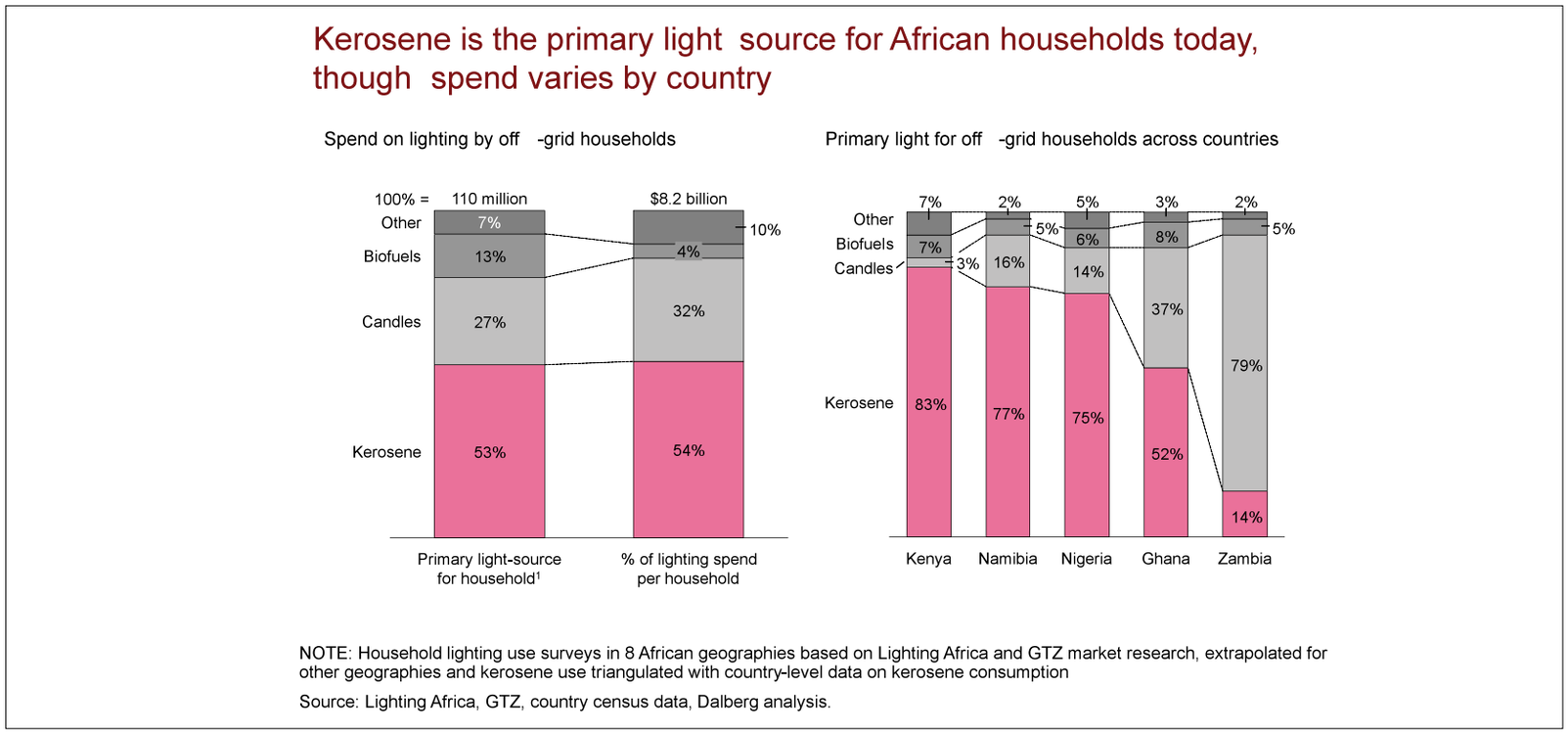


Figure 32: Primary light source by number of users and annual spend

African market penetration for renewables – still at the starting line?

While the annual total spent on lighting by African off-grid and under-electrified BOP households and SMEs is immense, the penetration of this market by renewable lighting products is still extremely low today.

Our best estimates indicate that the solar lighting penetration in the overall African off-grid population of 140 million off-grid and under-electrified households and SMEs is a little over 1%, with a 0.6% share for SHS (850k sold) and less than a 0.5% share for solar lanterns (~600k sold) (Figure 33 above).

For the sake of simplicity, the penetration analysis assumes one SPL or SHS sold per household and ignores potential sales of renewable solar lighting systems to small businesses. The sizing of the "installed" number of solar home systems and solar portable lights is based on proprietary industry databases created by Dalberg and Lighting Africa and triangulated against available public sources and industry expert interviews.

For the solar portable lighting estimate, given the nascent state of the industry and the closely held nature of sales information, the estimate requires a wide range. Based on our industry survey of major market players (70+ participants) and, in select instances, publicly reported data, we have the self-reported total Africa sales covering over 40 SPL manufacturers (including the vast majority of large manufactures) from 2007-2009.

These sales add up to 350-400k confirmed units across the continent. We estimate an additional 250k units in sales from "generic" Asian lantern manufacturers based on import statistics, data reported by large active distributors in 14 African countries, and annual sales reported by the manufacturers themselves to Chinese and Indian export associations.

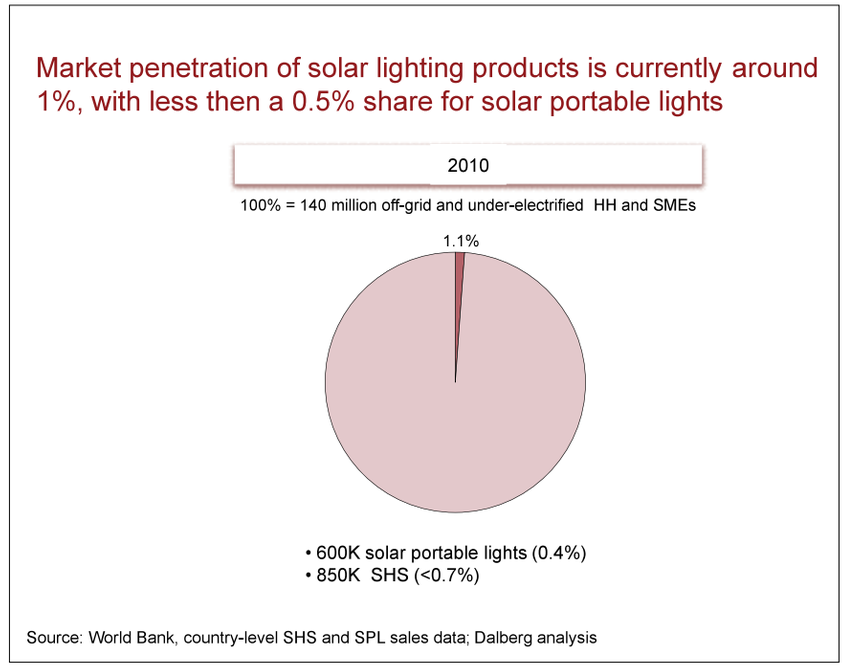
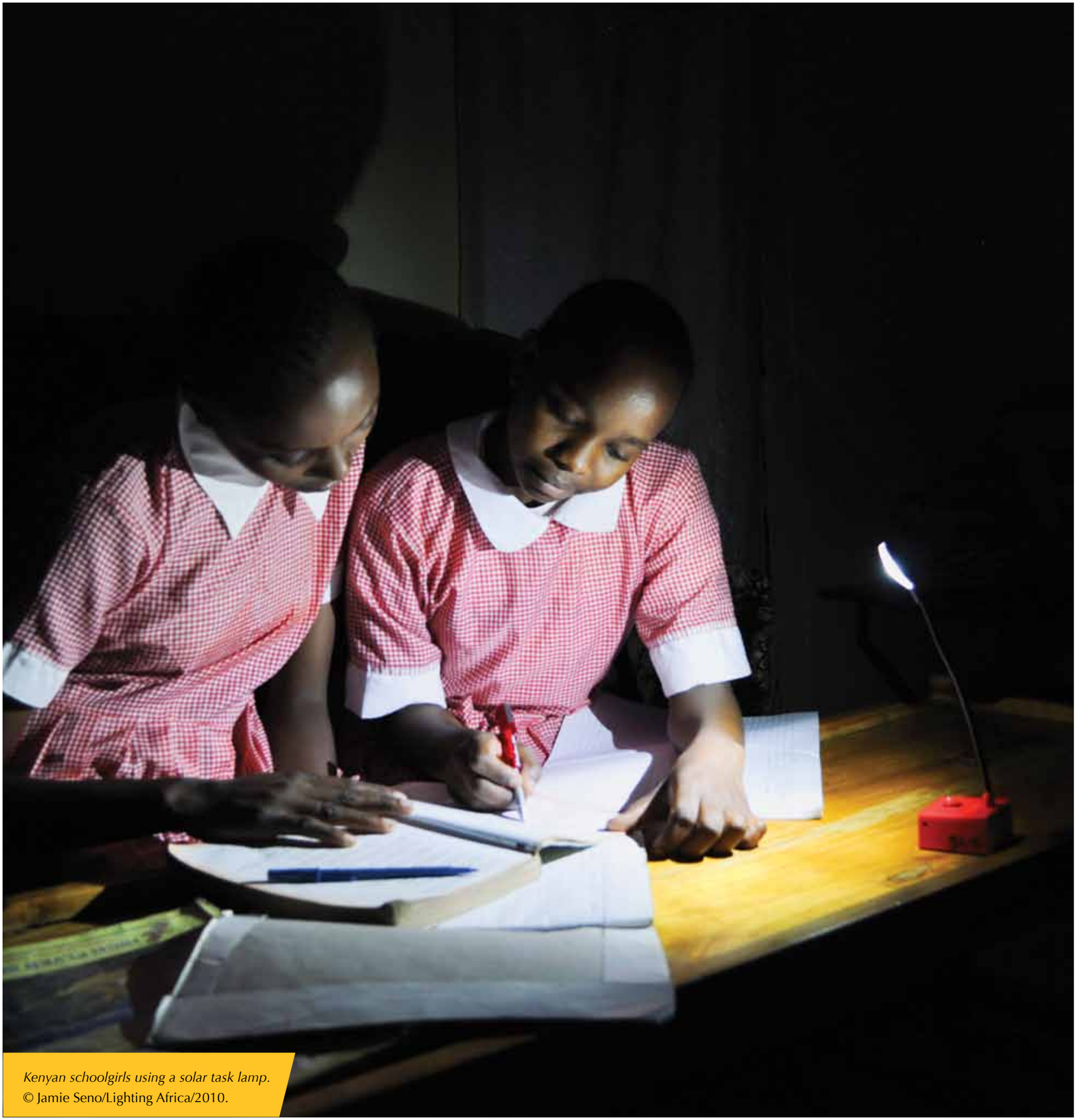


Figure 33: Solar household lighting penetration in 2009-2010

Given the variety of assumptions embedded in the data, a number of caveats are in order:

- Our analysis has excluded sales of cheap, low quality $1-10 LED torches. Distributor interviews suggest that millions of such cheap, low quality LED torches have been sold in Africa to date, but good data on such sales is not available
- The numbers do not include sales of hand-cranked and other dynamo lighting devices (likely over 100k sold over the past few years based on industry interviews)
- We did not include sales of grid or battery charged lanterns without a solar component (e.g., Osram)
- The analysis focuses on 2009 and earlier and hence excludes recent sales or sales by new market entrants over the past 6 months

What is beyond debate is that the current lantern penetration in Africa is far below the total potential market, which points to a significant market growth opportunity.



Kenyan schoolgirls using a solar task lamp.

Africa-specific demand drivers

We have already touched on the major SPL demand drivers – grid growth, SPL pricing, product design, kerosene prices, and mobile grid charging demand – in the global trends section. The discussion below explores these levers in the African context and lays the ground for a base case Africa market forecast for 2015.

Lagging grid growth is a major driver of SPL demand across Africa

Grid growth across Africa continues to lag the growth in the overall population, leading to extremely slow growth in grid penetration. Between 2000 and 2008, the on-grid population grew by 19 million households while the overall population grew by 33 million households (2.7% annually), so on a net basis the off-grid population is continuing its rapid growth.

Even in the most optimistic grid expansion scenarios using official government electrification targets (as opposed to historical grid growth rates), the African off-grid population does not substantially decline in the near to medium term. With more realistic projections, based on historical grid growth rates, by 2015 the number of off-grid households grows by over 10% to as many 120 million, encompassing nearly 630 million individuals (Figure 34).

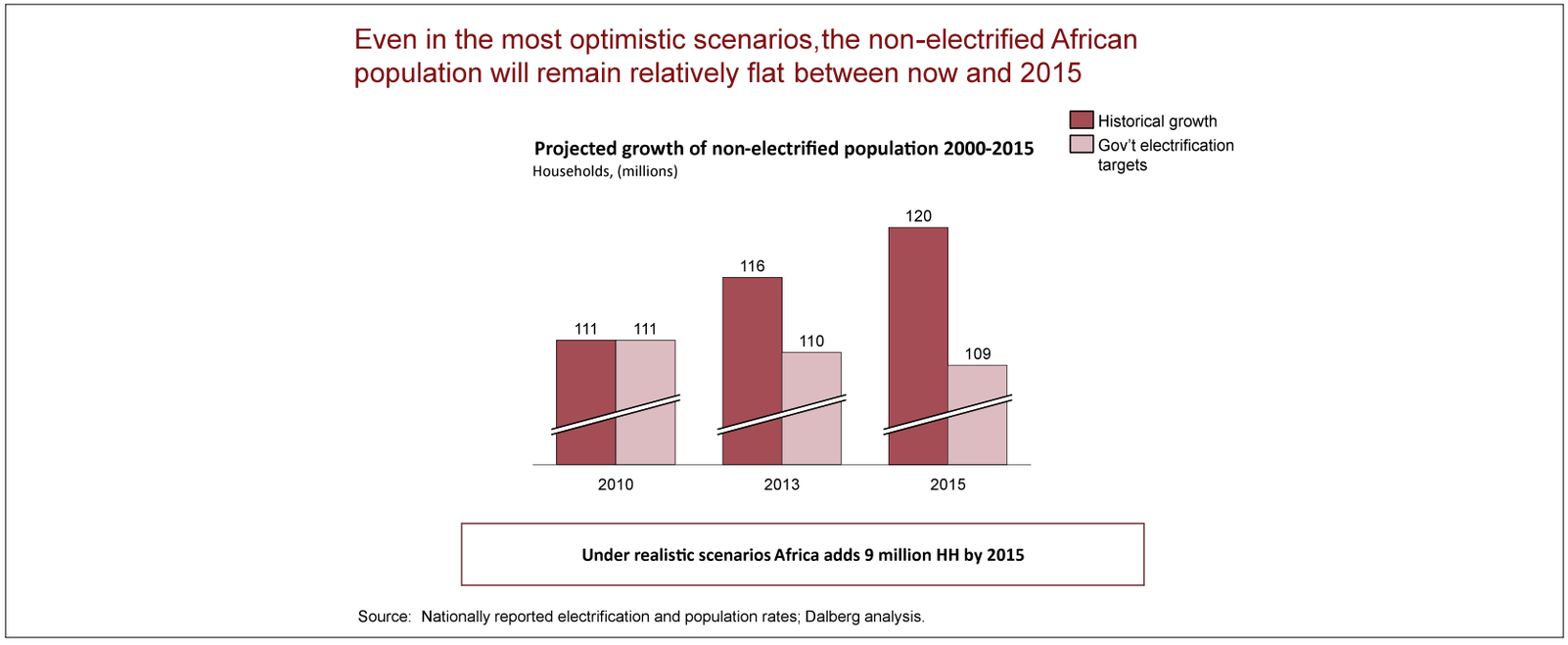


Figure 34: Projected off-grid population (2010-2015)

Over the next five years, the grid supply vs. demand crisis within Africa will only be exacerbated by the expected net addition of nearly 10 million off-grid households. In addition to growing the un-electrified population, the continued outpacing of grid deployment by population growth will ensure the current unreliability and resulting need for back-up power in Africa will not only continue but will likely worsen.

SPL pricing as driver of growth

As we have seen above, the African off-grid lighting market is large and growing, but price has proven to be a major bottleneck to SPL adoption. The price point for fully featured ambient or task style SPLs is over $50 ($30-90 range) when higher cost markets like Nigeria, Ghana, and francophone West Africa are taken into account. In contrast, in South Asia the price of comparable lanterns is 20-50% lower. The high prices faced by African consumers are a major challenge in light of surveys showing that most BOP African households find it difficult to pay more than $10-20 upfront for durables purchases, and are unused to paying more than $3-10 for lighting devices (e.g., traditional hurricane or pressure lanterns), even when such purchases lead to savings over time.[35] Acknowledging these challenges, a small number of relatively high-quality and ultra-affordable SPLs (under $20 retail, as low as $5 FOB) have recently entered the African market – these devices utilize small form factors, small solar panels, simple designs, and powerful single-point LED lights to deliver the 50-60 lumens of a hurricane lamp at a much lower

cost per annum. Awareness of these rapidly evolving lower cost products is still low, and most of the low cost products on the market (e.g., cheaply manufactured LED torches and lower quality lanterns) do not provide the durability and luminosity of an average kerosene hurricane lamp.

Naturally, higher prices are not an absolute bar to sales as the rapid uptake of mobile phones ($20-80 per handset) has demonstrated over the past few years. Furthermore, recent Lighting Africa research suggests that at least in some African geographies households who have experienced the benefits of high quality SPLs are willing to pay up to $58 for ambient lanterns.[36] Nonetheless, the affordability challenge is real, and falling SPL costs – in line with the global trends discussed earlier in the report – will be an important impetus for Africa market SPL demand.

The relationship between global SPL costs and the price seen by the African end-user is complex and to understand the potential price declines in African SPL products it is instructive to (1) trace the path of an average SPL from the manufacturer's lab to the hands of the rural African consumer, and (2) to compare African lantern pricing to the value chain in a lower cost solar portable lighting market like India.

The journey of a lantern – African solar portable light value chain

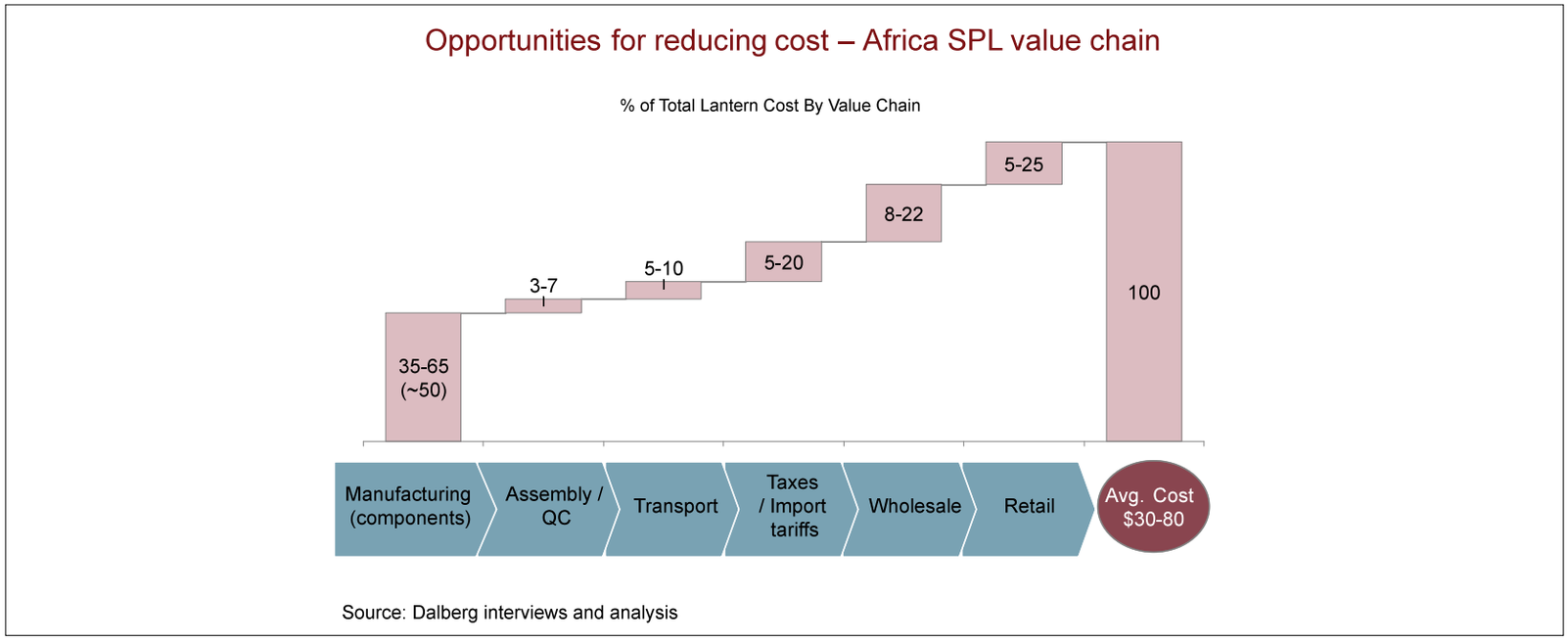


Figure 35: Africa solar lantern value chain

Manufacturing and assembly (38-72%). A typical African lantern starts its journey in a non-African factory, typically in China or India, though a number of African distributors are beginning to experiment with local assembly. On average, component costs are roughly 50% of the final lantern price, though this ranges from 35-65% in African examples we've seen depending on the cost of other layers in the value chain (i.e., local duty/tax levels and distribution margins). In addition, manufacturing costs include the costs of assembly and product QC, which are 3-7% of the total value chain, with the lower end of the range denoting distributors who assemble the solar portable light device in Africa.

Transport to wholesaler (5-10%). The lantern is then shipped as part of a bulk package either by air from US/EU manufacturers or by ship by China and India. Transport costs paid by the wholesaler, including the cost of insurance, are typically high (10-15% of manufactured costs), particularly for smaller scale African importers who often struggle to generate the working capital for substantial purchases without manufacturer financing. An additional obstacle is that average shipment time can be longer than a month, a challenge for small importers operating on shorter time frames.

[35] The $10-20 affordability threshold is 20-80% of average monthly income for many BOP families in Africa – this threshold was consistently quoted in our conversations with distributors and MFIs across a number of geographies

[36] See Figure 48

Import taxes/tariffs (5-20%). Lanterns (or components) face substantial tariffs at port of entry and are taxed (at point of entry or sale). In most African geographies tax and duty costs are extremely high (as much as 25% of the total price seen by the consumer). Tariffs and tax costs are relatively minimal in a few progressive geographies that have exempted solar lantern products (e.g., Tanzania), though many lanterns still face a part of these costs due to the complexity of the exemption process. In Kenya, for example, importers need to apply for the duty exemption for each individual shipment and products are often denied preferential duty status due to unclear regulations.

Distribution – wholesaler margin (8-22%). The wholesaler/importer in Africa typically takes substantial margins, with the lower end of the range reflecting dedicated distributors /wholesalers or franchisees of major international lantern manufacturers and, at the high end of the range, major solar light device importers/ retailers who sell products through their own distribution networks and typically purchase lanterns from multiple manufacturers. The high end of the range also reflects less competitive African markets where distributors currently have substantial selling power due to pent up demand – it's useful to contrast here markets like Kenya with dozens of solar lantern distributors and those like Nigeria with relatively few substantial distributors and far higher prices.

Distribution – retailers/dealers (5-25%). The arrival of a lantern in the wholesaler's warehouse in major entry-points like Kenya, Ghana, Senegal, or Nigeria is often the lesser part of its journey. From here the lantern travels hundreds of kilometers to the rural end-user's doorstep on the back of motor-bikes, public buses, and trucks. Given a broad variety of retail distribution models, geographies, and proximity to the port of entry (e.g., for rural versus urban or peri-urban households), the range on retail margins is wide. At the high end, retail margins reflect a multiple layers with as many as 3-4 distribution sub-layers (i.e., the cascading super-distributor/distributor/retailer/dealer model). The low end of the range, in contrast, is associated with direct distribution models of major wholesalers who push the products at scale through existing rural consumer networks, trade associations, NGOs, agricultural cooperatives, and other "scale" players. In some cases, lower margin structures are found among "mom-and-pop" consumer electronics retailers who focus solely on high-density urban markets in more competitive solar markets like Kenya and Ghana.

Africa vs. India Lantern value chains

A starting point for the comparison is the price – with average Indian solar lighting devices comes in at the $25-45 range for robust ambient LED lanterns in India and $30-90 in Africa (we are not using newer "ultra-affordable" lanterns and smaller form factors for comparison where the price range is much lower, e.g., $10-18 for India).

The overall variance in price points between the Indian and African markets is driven both by supply and demand. The supply-side factors include lower manufacturing, assembly, and transport costs and less onerous levels of duties/taxes for solar products in India. The demand-side factors that have driven down prices in India faster than Africa include: more developed rural distribution channels, greater competition, and higher grid penetration. We illustrate two major supply-side differences below.

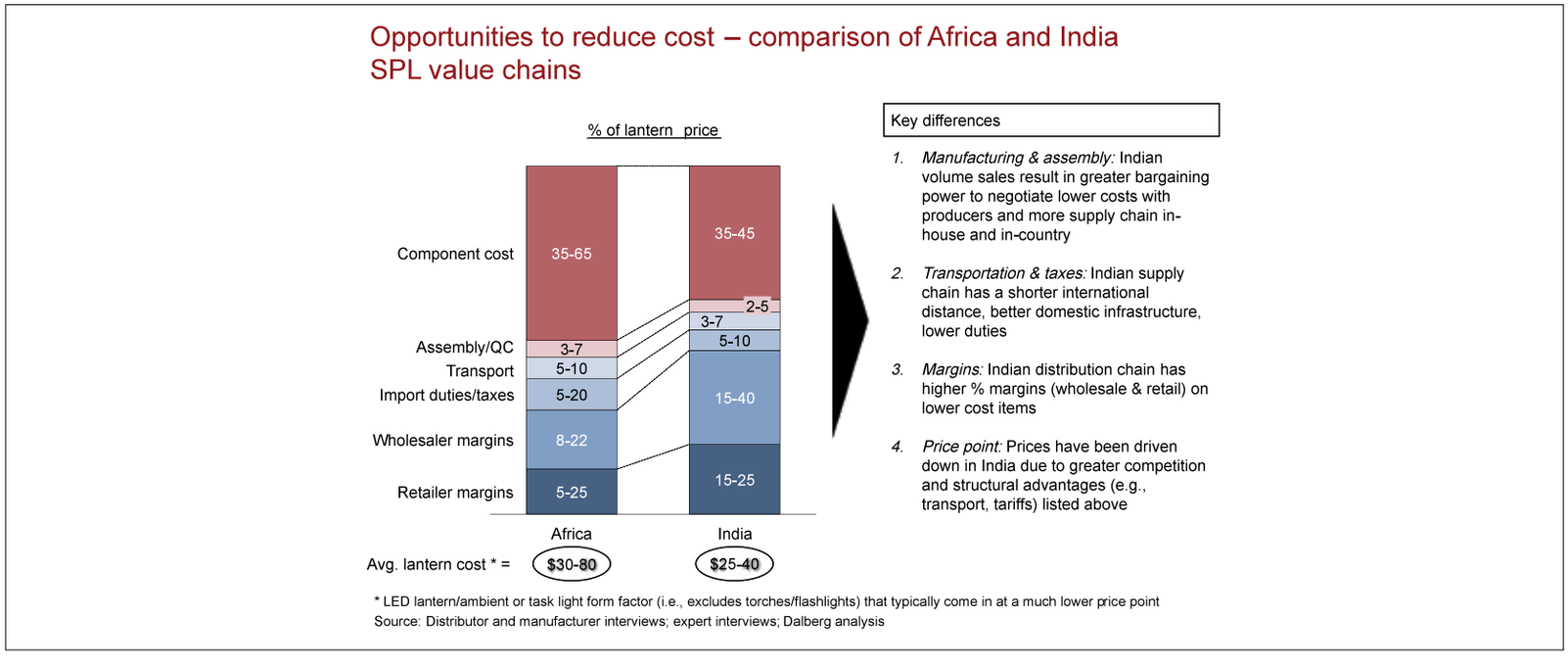


Figure 36: Africa vs. India lantern value chain comparison

First of all, Indian players are using a greater variety of models for manufacturing and assembly. While many products on the Indian market originate out of China, over half of the Indian solar lanterns are either assembled or partially manufactured locally. In contrast, 80-90% of solar portable light devices in Africa are imported from outside the continent, and there is limited experience with local assembly and component manufacturing. This is due in part to a more developed manufacturing base with greater production capacity, and the availability of cheaper quality labor in India compared to most African countries. Further, the higher volume of sales in the Indian market gives Indian players greater bargaining power for lower COGs.

Second, transportation and taxes/duties are lower for India. A factor in the cost of international transport is simply proximity - India is a shorter distance from China. For domestic transport, it is cheaper to move products around India than around many African countries due to slightly better infrastructure, greater population density, and more peri-urban markets. Indian import duties and taxes are lower (12-15% total for most components, translating into 5% of COGs) than the African average, though it should be noted that some of the leading East African (e.g., Kenya, Tanzania) and West African (e.g., Ghana) solar portable lighting markets have attractive exemptions for solar/lighting components and/or assembled products.

Rising kerosene costs will fuel SPL demand

African BOP households spend over $5 billion on kerosene for lighting (out of a total annual lighting expenditure of $8.2 billion), not taking into account additional costs due to subsidies, taxes, market inefficiencies and transportation costs. While there is wide variation in kerosene prices across the continent due to resource endowments, transport costs, and subsidy levels, the average price level is relatively high and has grown rapidly over the past decade along with oil costs (Figure 37). The price variation is even wider than official kerosene price statistics would suggest since rural households often buy kerosene in sub-liter amounts, resulting in premium prices that can be as much as 300% higher than official "port-of-entry" kerosene costs.

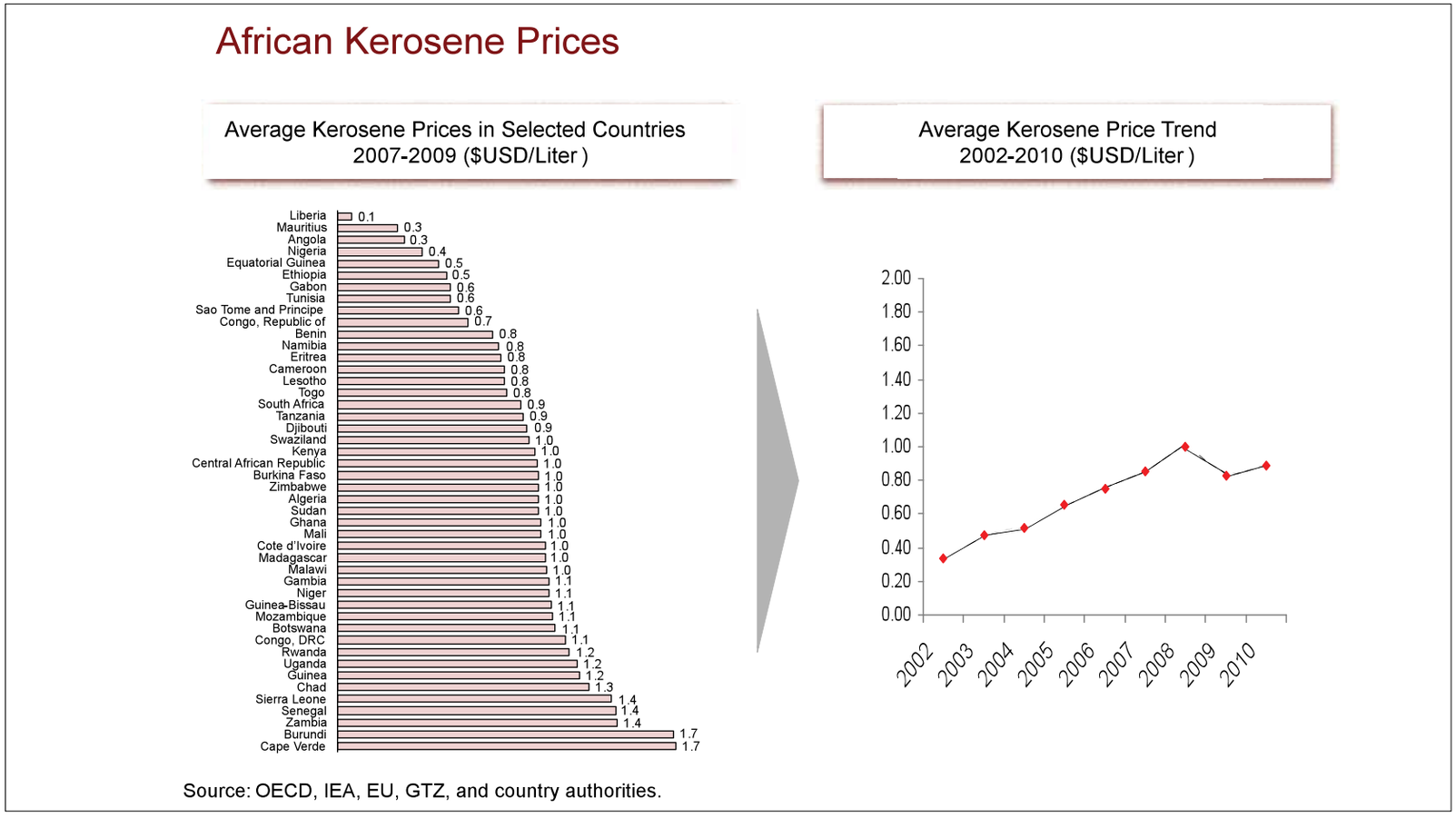


Figure 37: Kerosene prices across Africa

Based on consensus oil price estimates, we expect that the already high kerosene prices will continue to rise in the near term at a consensus rate of 4% annually and will therefore continue to fuel demand for cheaper lighting alternatives (Figure 38).

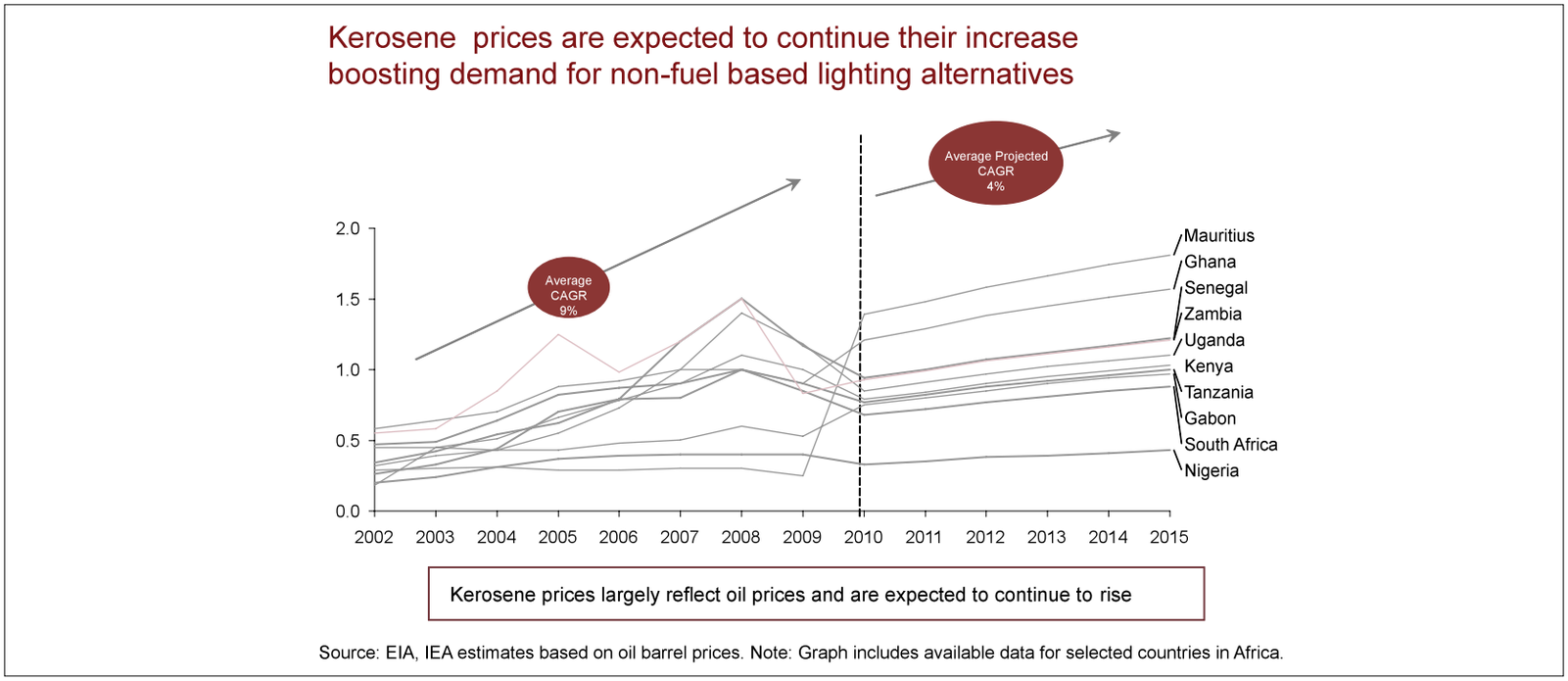


Figure 38: Kerosene price trend

The mobile off-grid charging opportunity as a driver of demand

Demand for off-grid phone charging, while a potentially important driver of SPL adoption globally, will be particularly important in Africa. The number of African mobile phone owners will outgrow the number of people connected to the electrical grid this year, with over 150 million off-grid mobile phone users across the continent.

Current trends indicate that African mobile phone penetration will continue to outgrow grid access, with the gap between the two projected to widen rapidly at 15-20% compounded annually. By 2015, we forecast more than 200 million more African mobile phone owners than grid users and a total of 400 million off-grid phone owners across Africa, an enormous opportunity for expansion of off-grid charging solutions (Figure 39).

In the case of high-growth mobile markets like Kenya - where 20% of Kenyans have access to the grid or off-grid electricity (e.g., SHSs) in contrast to 42% with mobile subscriptions - the demand for off-grid phone charging has long outstripped the grid supply (Figure 40).

This growing off-grid population of mobile phone users largely relies on pay-per-charge facilities that are expensive and inconvenient. Off-grid mobile users in Africa pay anywhere between $0.10 to $3.00 per cell phone charge (e.g., 0.25 in Kibera, Nairobi), with monthly mobile charging expenses amounting to over $10 monthly for many users (GSMA 2010). Africa-wide, mobile phone charging spend is likely in the billions, with Kenya estimates alone totalling to over $155 million annually.

Some existing solutions that have capitalized on this increasing gap in the mobile charging market include phones with integrated solar cells, stand-alone solar or hand-cranked phone chargers, and on a more limited basis – charging kiosks with cheap or free phone charging options (Figure 41).

Solar portable lights are the other logical alternative to this untapped need for charging power and nearly all of the SPL manufacturers we have talked to are eager to exploit this growth trend through a mobile charging accessory for their lights. The logic and economics of this move are compelling. For example, a recent review of off-grid phone charging options in a Nairobi electronics store, for example revealed hand-cranked phone charger costs of $5-15, solar stand-alone phone chargers for $20-50, a phone with an integrated solar panel for $75, and solar lanterns with a mobile charging feature ranging from $20-50. Adjusting for the convenience of solar charging (e.g., versus hand-cranked alternatives), the SPL phone charging feature was by far the most economically attractive option.

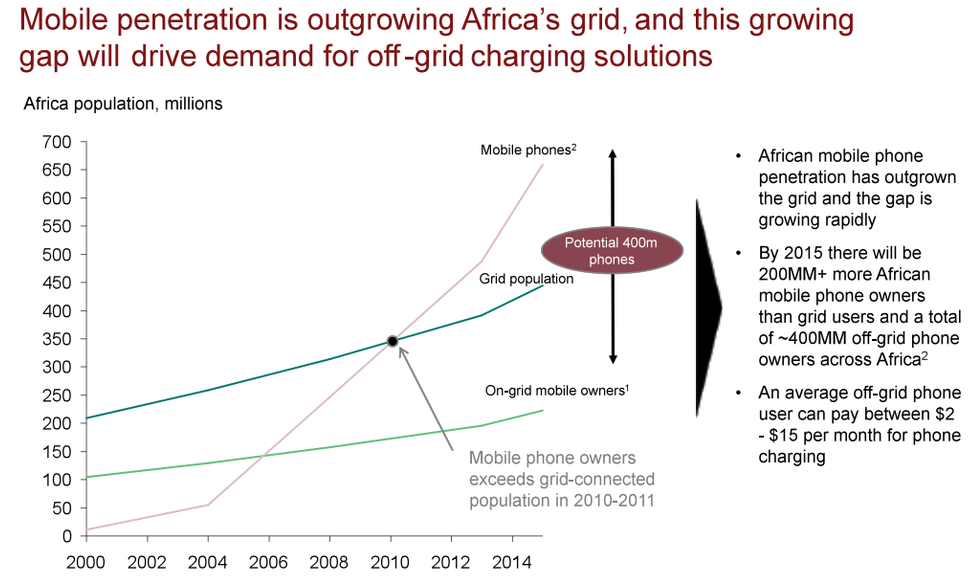


Figure 39: Mobile penetration as a potential engine for SPL growth

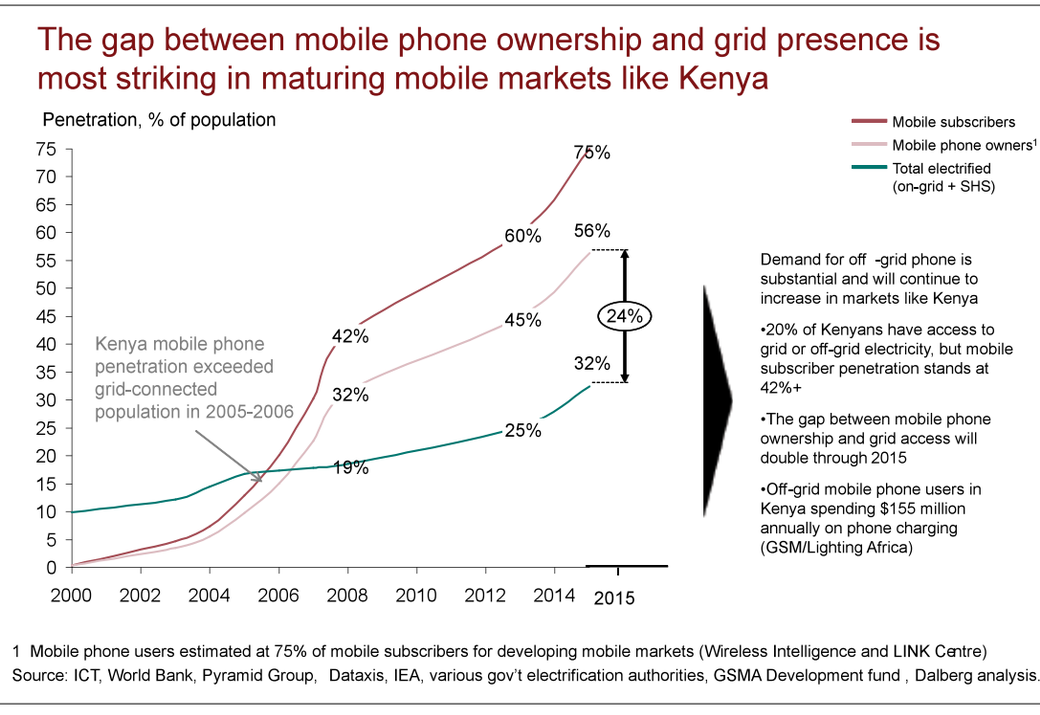


Figure 40: The African mobile-enabled off-grid future is already here in Kenya

Much of this potential for solar portable lights is still untapped, but the presence of other competing phone charging solutions on the market suggests the need for SPL manufacturers to move quickly in promoting the solar charging capabilities of their lighting devices (Figure 40).

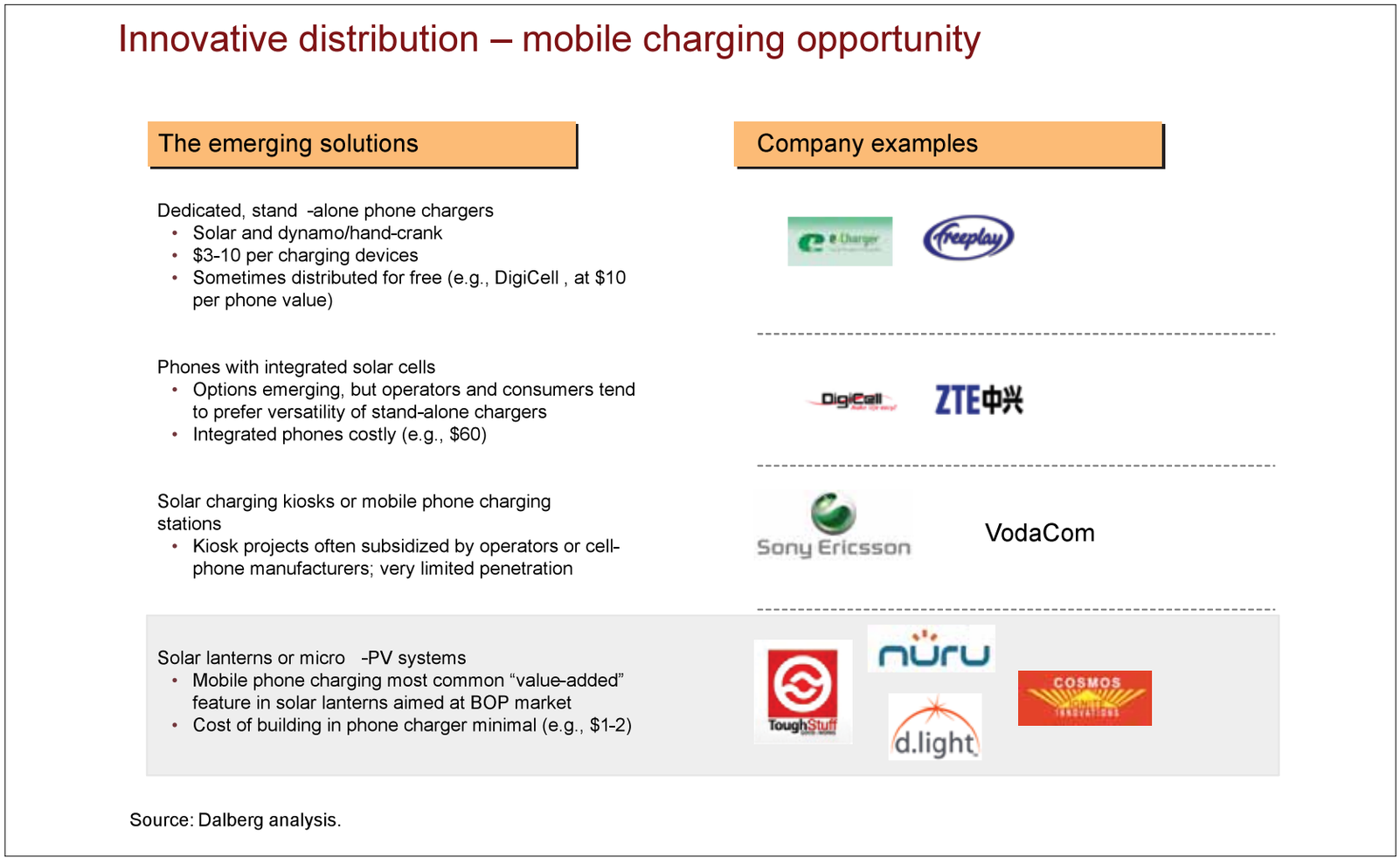
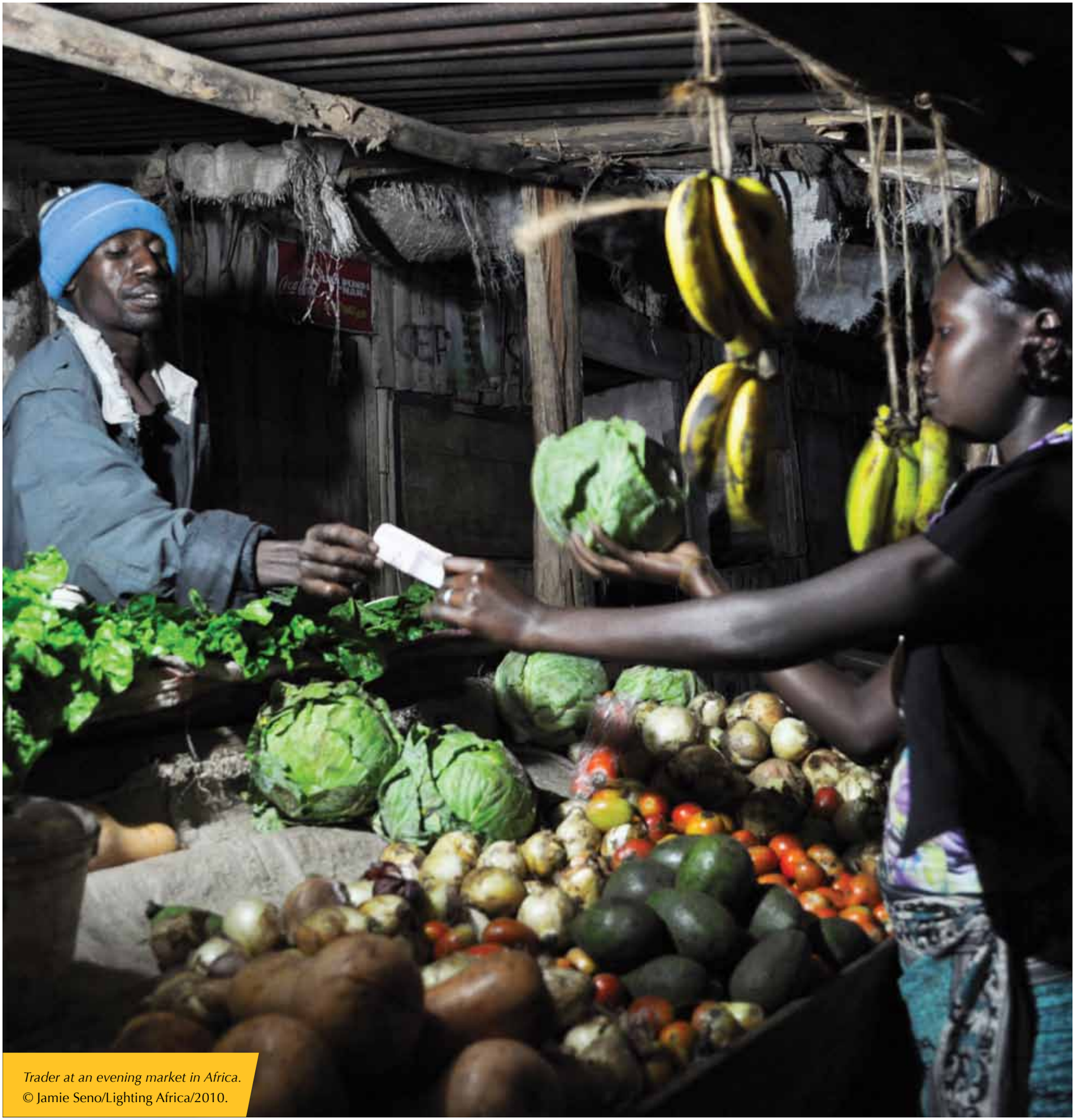


Figure 41: Off-grid phone charging options



Trader at an evening market in Africa.
© Jamie Seno/Lighting Africa/2010.

2015 Africa forecast

We see several potential scenarios for SPL growth over the next five years – a base case scenario (40-50% sales CAGR) extrapolating from historical growth, an aggressive scenario (80-90% CAGR) mirroring the growth of the mobile subscriptions market at a comparable point in its development, and our medium-range forecast of 65% annual sales growth from 2010 to 2015 (Figure 42).

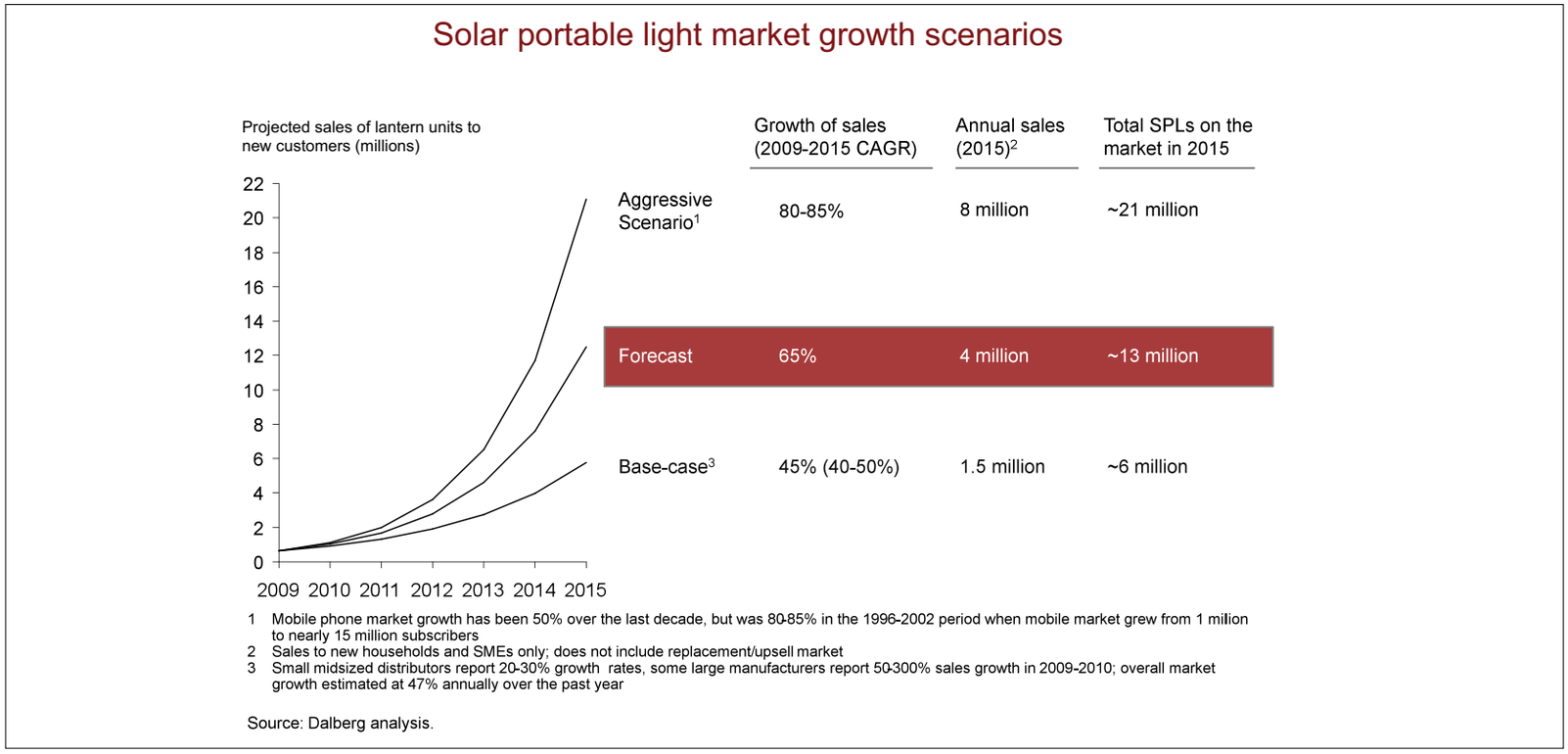


Figure 42: SPL market growth scenarios

Given the booming African market demand for BOP lighting – due to lagging grid growth, rising kerosene costs, falling SPL prices, and the mobile charging opportunity – even in the most conservative "base case" the market will see annual sales growth of 40-50%. At that rate, the market will grow to nearly 6 million SPL-owning households and SMEs in 2015 from ~600k today, with 2015 sales to new African households and SMEs averaging 1.5 million units annually.

This conservative scenario corresponds to the historical SPL sales growth in 2008-2009 EOY, based on our proprietary database of self-reported Africa sales by over 40 SPL manufacturers. Many of the smaller distributors in our interviews have seen sales growth of 20-30% annually; however, the top 5-10 SPL manufacturers with regional or continent-wide sales have seen annual growth of 50-300% over the past 18-24 months leading to a blended annual growth rate of nearly 50% for the market as a whole.

For the purpose of simplicity, the numbers above only include sales to new customers. We project, however, that by 2015 existing SPL sales will have generated a healthy market for replacements and incremental unit sales that will add 40-50% to sales annually later in that period (e.g., leading to over 2 million annual sales by 2015 even in the conservative base case scenario) – see Figure 43.

While this base case scenario points to substantial SPL market growth, given the low initial penetration level of SPLs the resulting market penetration by 2015 of 6% is still relatively modest (Figure 44).

We believe that much faster growth is probable and do not expect the "business as usual" base case to be the likely scenario.

The African mobile subscriptions market at a comparable stage in its development grew by nearly 90% from ~1 million to 47 million in the six year period between 1996 and 2002 (ICT). While the mobile market is arguably a special case, given the extremely rapid and accelerating SPL growth and the comparable price point on mobile phones and SPL devices, the comparison is not unreasonable. Furthermore, the 2010 Lighting Africa conference has confirmed that many new players are entering the market and substantial investments are being made to develop scaled distribution models and correct for market failures.

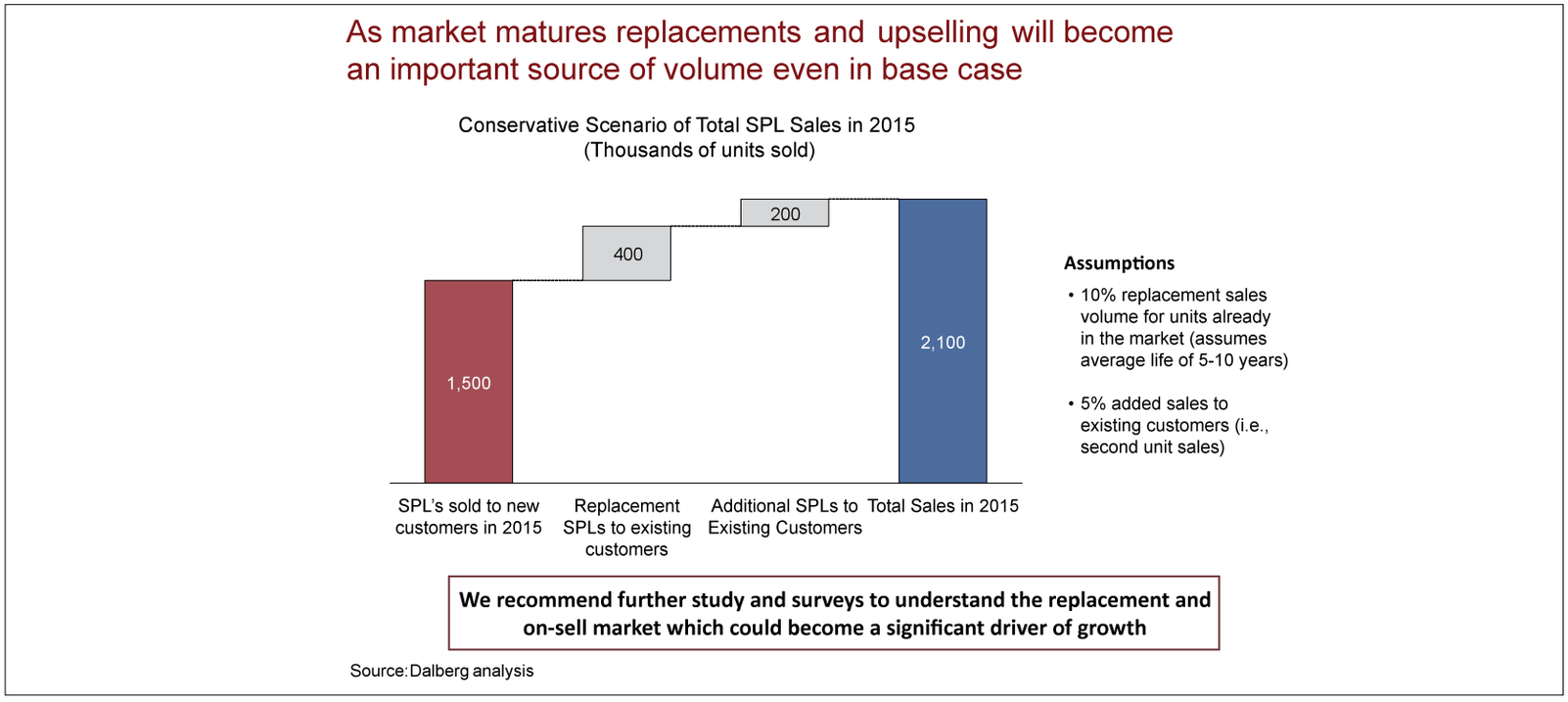


Figure 43: Replacement and upselling market for SPLs

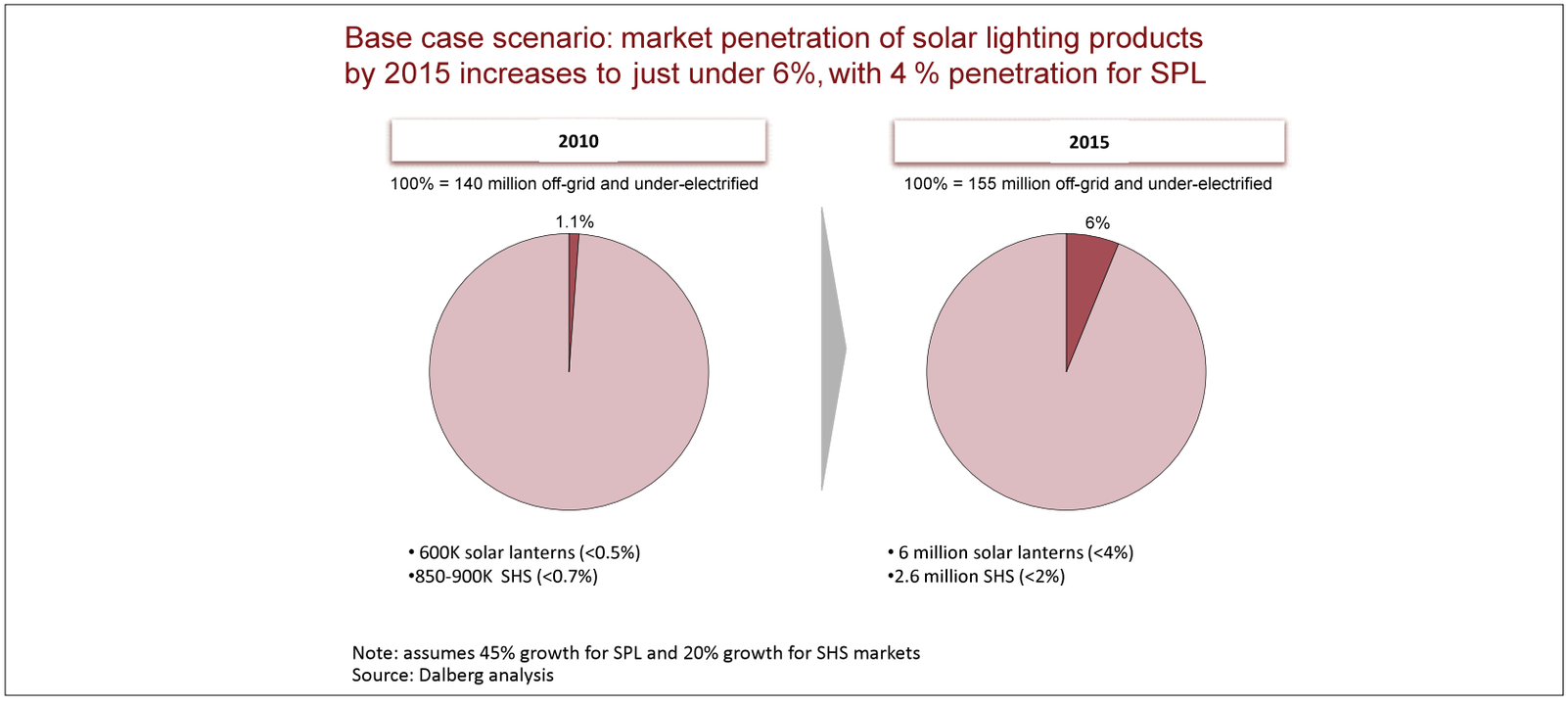


Figure 44: Market forecast - base case scenario

Given this investment by SPL market players and donors, we expect that a number of the challenges to faster growth will be met over the next five years and, particularly if external factors like kerosene price come into play, SPL growth should far exceed the base case and reach rates exceeding 65% annually, leading to a market penetration of 8% with over 12.5 million SPL owners (Figure 45).

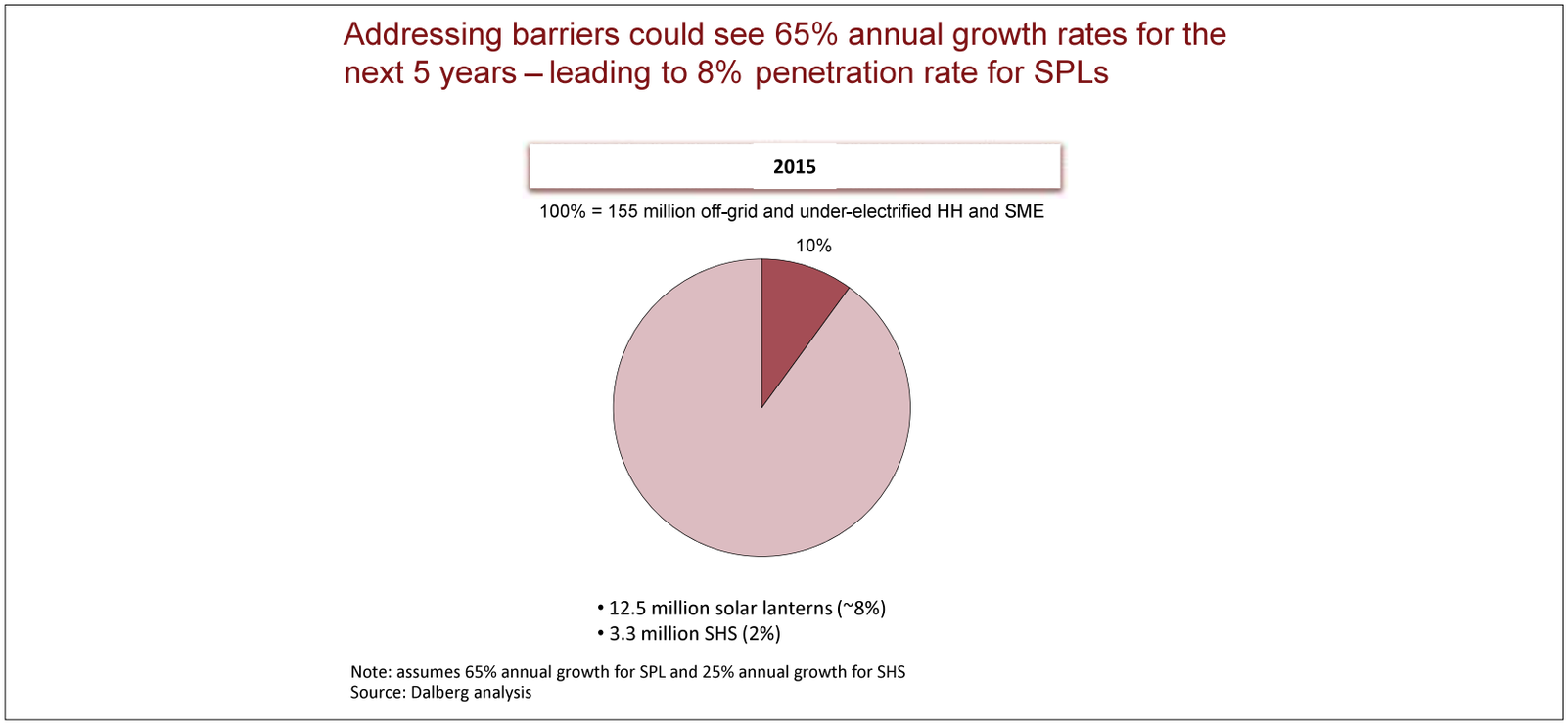
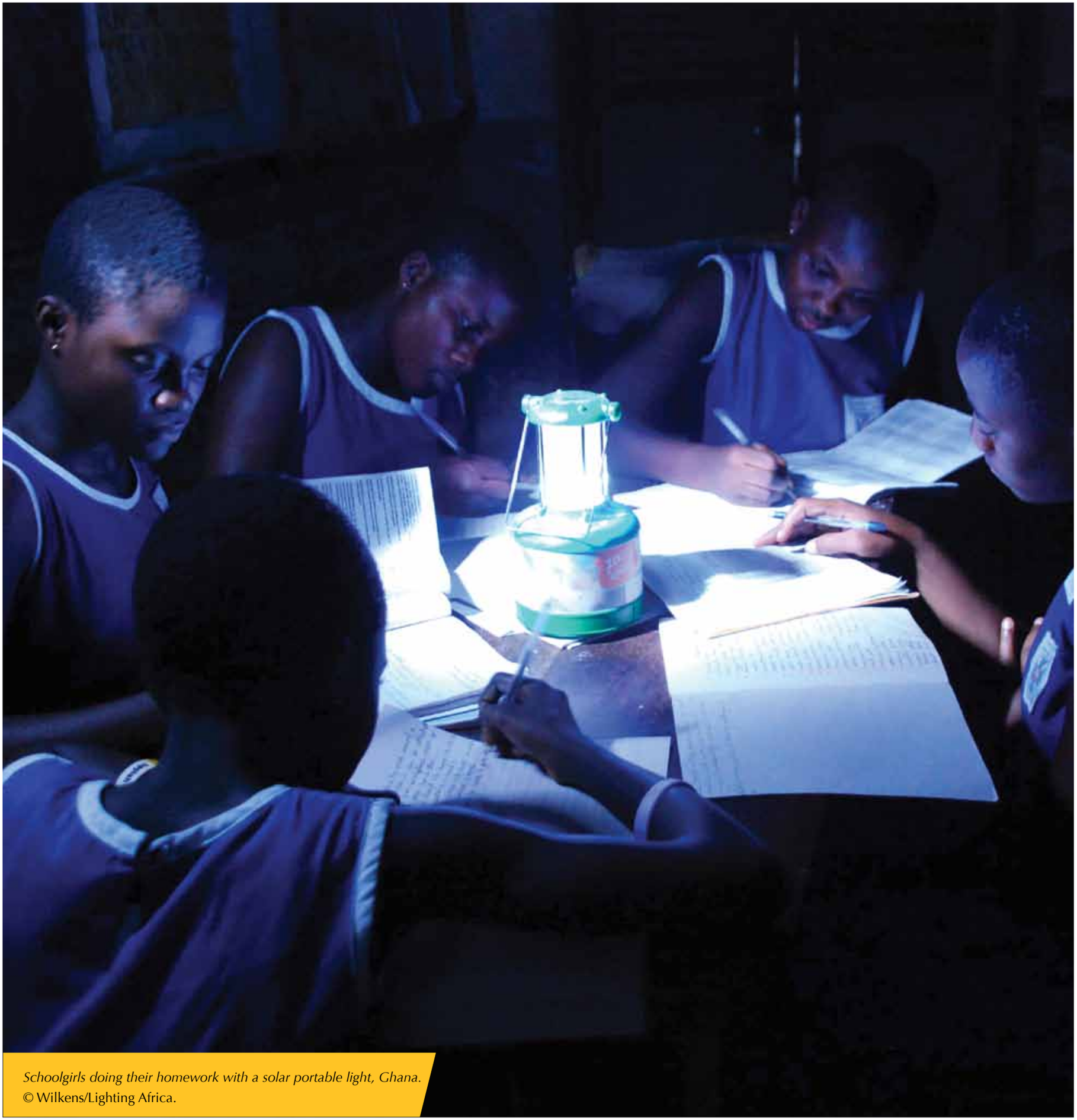


Figure 45: SPL market growth forecast for 2015

Among the likely catalyzing factors over the next few years to reach this growth will be:

- Growing innovation in the $5-20 SPL segment – several lower priced SPL products with decent quality on the market today and over a dozen Lighting Africa conference participants have told us that they intend to launch additional products in this price range in the coming 1-3 years
- Breakthroughs in distribution and access to finance – entry of major retail banking players in end-user finance, launch of mobile lending and SPL savings products, growing familiarity and involvement by the SACCO and MFI sector in SPL product distribution
- Growing consumer awareness of SPL products – already increasing rapidly, but will likely see a quantum leap due to the marketing efforts of Lighting Africa, governments, NGOs, and social entrepreneurs
- Policy changes on solar technology taxes and tariffs – with more countries following the lead of markets like Kenya in abolishing taxes/tarrifs on solar panels and LED-based lamps
- Larger-than-anticipated increases in kerosene costs and/or reductions in kerosene subsidies. We have projected a moderate growth of 4% annually, but kerosene price growth rates greater than the historical 9% CAGR average are entirely plausible and kerosene subsidies are under pressure across the continent

We explore market growth barriers and the potentially transformative opportunities to address those barriers (along the lines of those listed above) in the report sections that follow.



Schoolgirls doing their homework with a solar portable light, Ghana.
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Challenges To Scaling Up in Africa

In our survey of over 70 African market players, which focus on 15+ African countries but are centered on Kenya, Ghana, Tanzania, Ethiopia, Uganda, Senegal, and Nigeria, we heard a great deal of optimism about the potential for the solar portable lighting market. All interviewees rated the market's potential as high and the consensus view was that the market would see rapid growth in sales over the next few years.

When asked about what it would take to supercharge the SPL market to follow a trajectory like that of mobile phones, manufacturers and distributors highlighted a number of obstacles to accelerating the historical growth trend:

- Access to finance challenges both upstream and at the consumer end due to high SPL prices
- Difficulty in distributing at scale, despite many ongoing experiments on this front
- Lack of consumer awareness of the benefits of SPL or the harms of traditional lighting
- Market spoilage problems due to the influx of low quality products in select geographies
- High tariffs and taxes that can at times nearly double the price of SPLs

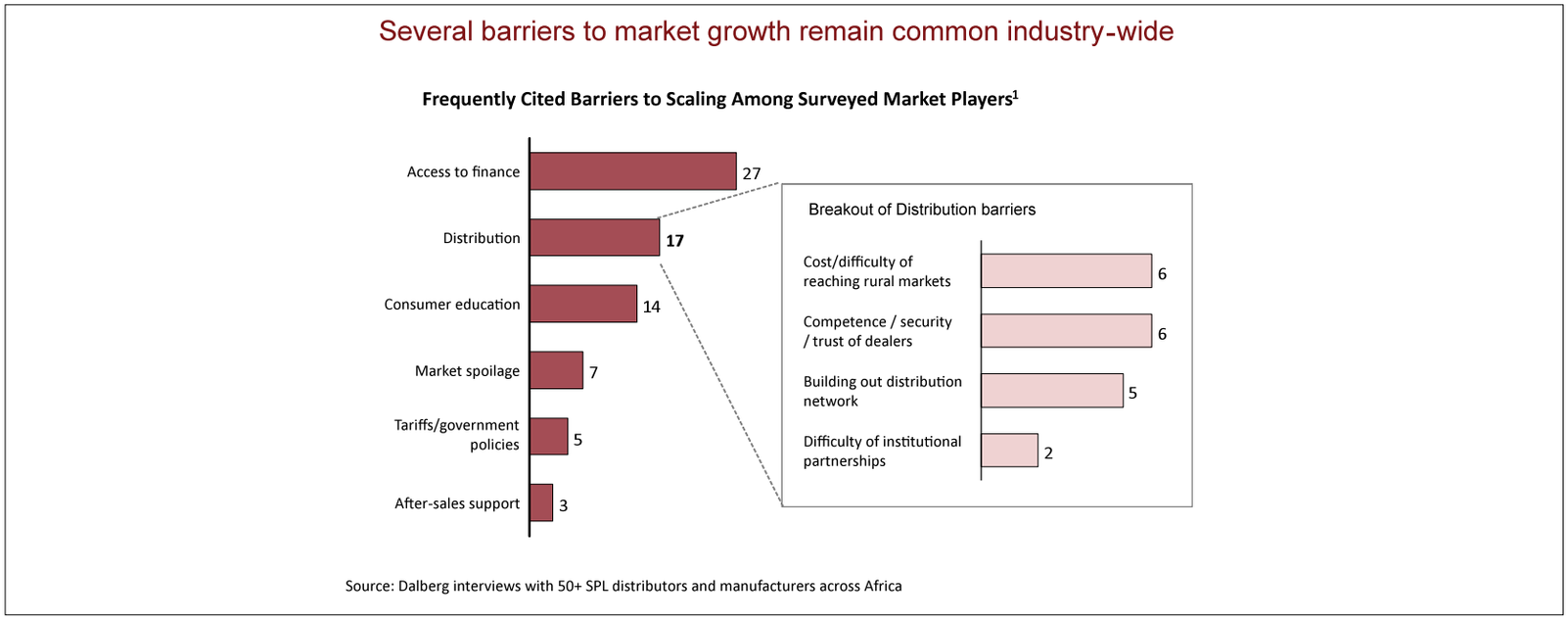


Figure 46: Voice of distributors/sellers – main SPL market challenges in Africa

Access to finance challenges

This multi faceted challenge was top of mind for most of the distributors and sellers we interviewed (27%) and is likely the biggest challenge to scaling the solar lighting market. Lack of appropriate financing creates bottlenecks along the entire off-grid lighting market value chain. Most of these financing pain points are related to each other and stem from a lack of liquidity amongst both low-income consumers and the small and medium enterprises (SMEs) that comprise the majority of players in this market.

The primary financing challenges for each step of the supply chain are highlighted below:

(1) Manufacturers: Producers face two financing challenges. The first lies in initial capital for both R&D and the fixed assets for a production facility. If manufacturing is outsourced to an existing facility (as is often the case in China), this capital expenditure requirement may already be taken care of. The second challenge lies in working capital - having sufficient liquidity to purchase inputs and produce finished goods before receiving payment.

(2) Wholesalers and large distributors: As wholesale distribution is a relatively "capital light" operation, the biggest burden comes in working capital. The wholesalers (whether they are the product owner who have outsourced its manufacturing or country-wide master distributors) are hit hard from a number of angles: (i) as small businesses, they are typically offered little credit from producers; (ii) they typically face disproportionately high inventory levels due to a long global supply chain or poor demand predictions in early years of operations; and (iii) they are often required to extend credit to dealers in order to stimulate sales.

(3) Small retailers: The last-mile dealers are similarly squeezed on working capital liquidity, as they are usually small rural/peri-urban operations and face the consumer's limited ability to pay.

(4) Customers: Affordability is quite clearly one of the leading barriers to the rapid adoption of off-grid lighting products in the developing world. Lower-income households typically cannot afford to pay a lump sum of $10 or more. It has been proven that poor consumers are willing and able to pay for off-grid lighting products under an appropriately designed credit scheme. However, we have yet to see rapid adoption of these schemes, due to the small ticket size of the product, the lack of financing for these programs, and the challenges of risk-sharing and logistics coordination between financial institutions and product companies, to name a few obstacles.

The overview listed above identifies A2F challenges that would be familiar to solar portable light manufacturers and distributors in any geography. Our interviews revealed a few additional or cross-cutting themes for the African context:

- A limited understanding of the solar lighting industry by African banks and MFIs: A stronger emphasis must be placed on incorporating potential financial backers into industry-wide strategy going forward. Strong partnerships and relationships with lenders are an essential aspect to building trust and understanding in the market, enabling the loosening of finance markets.
- An inherent cautionary attitude to lending by banks: In part driven by a lack of market understanding among lenders, the solar lighting market must be able to demonstrate transparent market economics that demonstrate a fundamentally strong and high-potential industry.
- Available financing is often security-based, while most suppliers do not hold collateral
- High interest rates (up to 40% in certain countries): Prohibitively high interest rates negate the fundamental purpose of alternative financing plans, providing little to no incentive for their utilization.

"Banks have limited understanding of the solar market and hence are not interested in financing us – it might be useful to educate the banks on the potential of the solar market" (Ghana distributor)

"Banks prefer to lend to growing businesses – it is therefore very difficult to obtain start-up financing from the without prior sales records" (Nigeria wholesaler)

"Lanterns are not viewed as fast moving products hence most retailers will only accept to stock them on a consignment basis (they only pay after selling the product), a real drag on working capital" (Ghana retailer)

"We have developed an installment plan whereby customers hire-to-own lanterns at a daily rate of 40 US cents. Unfortunately, it hasn't fully taken off as hopped since it takes a lot of convincing to get people to appreciate the value of the products and lanterns are still really expensive for the majority" (East Africa retailer)

Prohibitive import tax systems and procedures

Tariffs and taxes on solar lighting products are extremely high in many African countries. This is a rapidly changing space with great complexity such as varying tax and duty rates for "fully assembled lanterns" vs. lantern sub-components. Some tax rates on fully assembled solar lanterns based on recent Lighting Africa research are listed below:

Country	Customs Duty	VAT	Details of Waiver (if applicable)
Tanzania	0%	0%	
Kenya	0%	0%	DC lighting not exempt unless packed with PV module
Uganda (not part of study)	0%	0%	
Rwanda	0%	18%	DC Lighting not exempt unless with packed PV module.
Ethiopia	0%	16%	
Ghana	10%	12% + ECOWAS/EDIF FEES	Only PV Modules exempt, not SPL device
Senegal	WAEMU: 10% (intermediary products) or 20% (final products) + 2% complementary taxes	18%	New Act on renewable energy development under consideration, with possibly tax exemption

Source: Mark Hankins / Lighting Africa

Figure 47: Taxes and tariffs on SPL in select geographies

Our survey of a dozen additional geographies in West Africa where solar lighting products are less prevalent evidenced import duties ranging from 5-30% and taxes/VAT up to 19%, leading to a total tax and duty burden of up to 50% of the end-consumer cost of the SPL in some geographies.

In many cases the tax/duty policies were quite nuanced – for example imposing different rates on products with integrated vs. external solar panels – leading interviewees from the same geography to report dramatically different effective tax rates. Furthermore, our survey has found that solar lantern components are often taxed at substantially higher rates than fully packaged products, creating perverse disincentives for local assembly and disrupting the market for replacement parts.

Additionally, while a number of countries have eliminated or substantially lowered such taxes (e.g., Tanzania, Ethiopia, Kenya), most interviewed suppliers in these geographies complained of lengthy procedures at the port of entry that stem from customs agents lack of understanding of solar products, corruption, and/or inconsistent tax treatment of goods at the airport.

"Customs officials are very inconsistent in how they handle the products. It would be important to educate relevant government agencies to encourage a more standardized tax /duty application" (Tanzania distributor)

"While solar lanterns are not by law subject to customs duty, there are many grey areas that require clarification. Also the procedure to obtain duty exemptions is very cumbersome, instead of getting a blanket pass, one must apply for an exemption for each shipment" (Kenya)

"The company would like to assemble the products locally but currently would need to pay duties for all parts on the assembly kit which becomes very expensive – we would need a lot of government incentives around VAT & duties" (Kenya distributor)

"We could reduce price by at least 20-30% in most West African markets we sell in, if duties and taxes were less onerous" (Senegal distributor)

Market spoilage due to low quality products. Cheap low quality products in the market that have biased the consumers against solar lanterns are a growing problem. Consumers have increasingly become cautious and have at times chosen to continue using kerosene lamps, the economic, health and social disadvantages notwithstanding.

Compared to a number of other consumer products, SPLs are relatively new to most markets, especially African markets. Due to the low numbers of lanterns that have been imported to most African countries to date, the quality standards required to properly screen the lanterns are largely non-existent or exist on the books but are not enforced at the national level due to a lack of equipment and the unavailability of qualified personnel to conduct these tests.

Based on a number of the respondents for the interviews conducted by Dalberg, a number of standards testing bodies were considered to be bureaucratic and slow to respond. For countries where certification programs exist with overseas export product testing agencies, the tests conducted there (overseas in the exporting country) do not fully address the key quality metrics.

"There are no governing standards on the quality of products that should be in the market so customers don't know which products to trust" (Senegal wholesaler)

"Low quality lanterns in the market are poisoning the consumers' perceptions of solar lanterns" (Tanzania distributor)

"There have been many substandard or counterfeit solar products in the Kenyan market and the problem is growing, hence most customers tend to be skeptical about solar lanterns in general; the company has to work very hard to build credibility with the customers" (Large Kenyan wholesaler)

"Substandard products from Asia undercut the market as they offer very low prices. Difficult to convince my dealers that the solar lantern I'm distributing is different and will last longer than a month without losing charging capacity or experiencing other malfunctions" (Nigeria distributor)

Consumer education. Many consumers are unaware of how solar lanterns work, but more importantly, they are unaware of the harmful effects of kerosene lamps or the economic benefits of buying a solar lantern as they have not calculated their monthly/annual expenditure on kerosene or other nonrenewable sources of lighting. And, finally, the move from kerosene lamps to solar lanterns actually requires a culture change, and this can only be effectively achieved through education.

"We need to have a culture shift that makes people comfortable with using solar lighting as they are with the kerosene lantern" (Ghana distributor)

"Most Kenyans are yet to accept solar as a viable alternative solution to lighting either because of a lack of exposure or because of bad experiences with poor quality products... it has been frustrating trying to sell the value of the products to the market" (Major Kenya distributor)

"Consumers are so suspicious of our dealers' claims, would be fantastic if there was a recognized "stamp" of quality we could show." (Kenya distributor)

Addressing these consumer education challenges can have a dramatic effect on SPL uptake because solar portable lights, with their new technologies, relatively high upfront cost, and delayed economic benefits are quintessential "experience" goods, not fully appreciated by the target consumer until extensive and repeated exposure. A recent Lighting Africa analysis of consumers' willingness to pay for SPL illustrates the point well, with post-use willingness to pay (after 5 days of experience with product), exceeding pre-use "ideal price points" by 1.3-5 times depending on form factor (Figure 48):

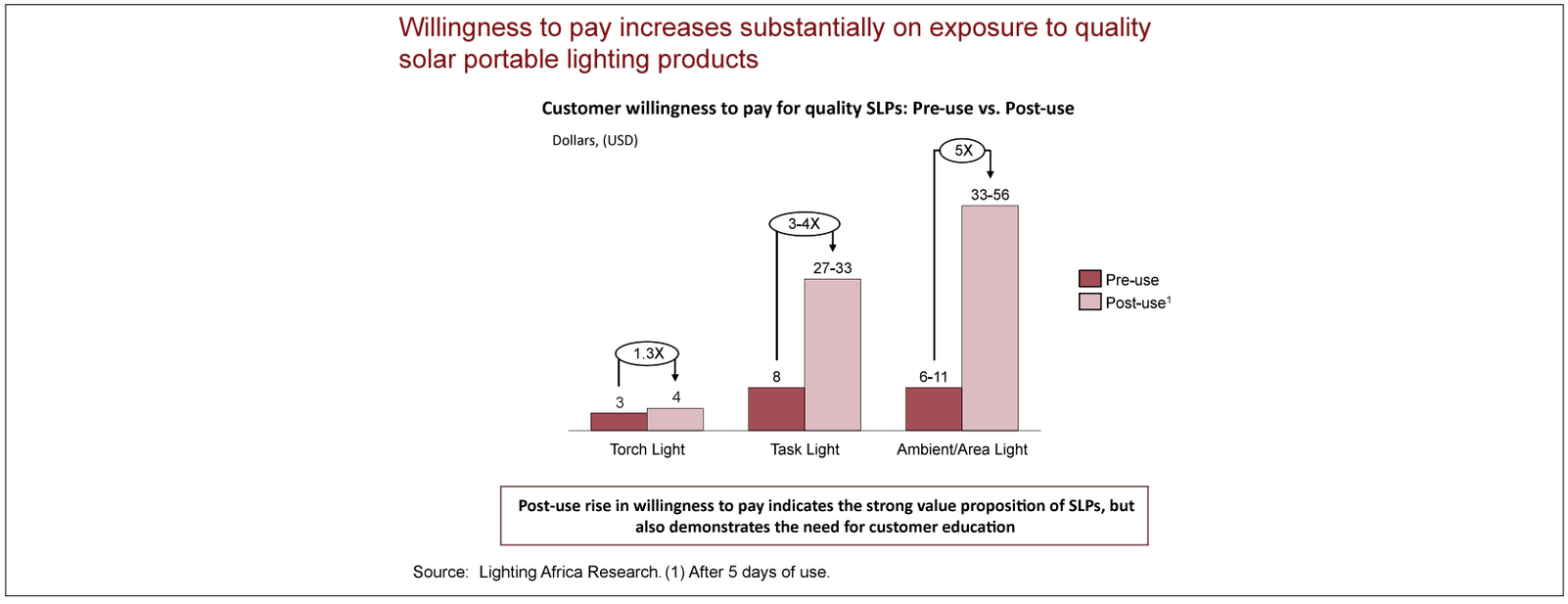
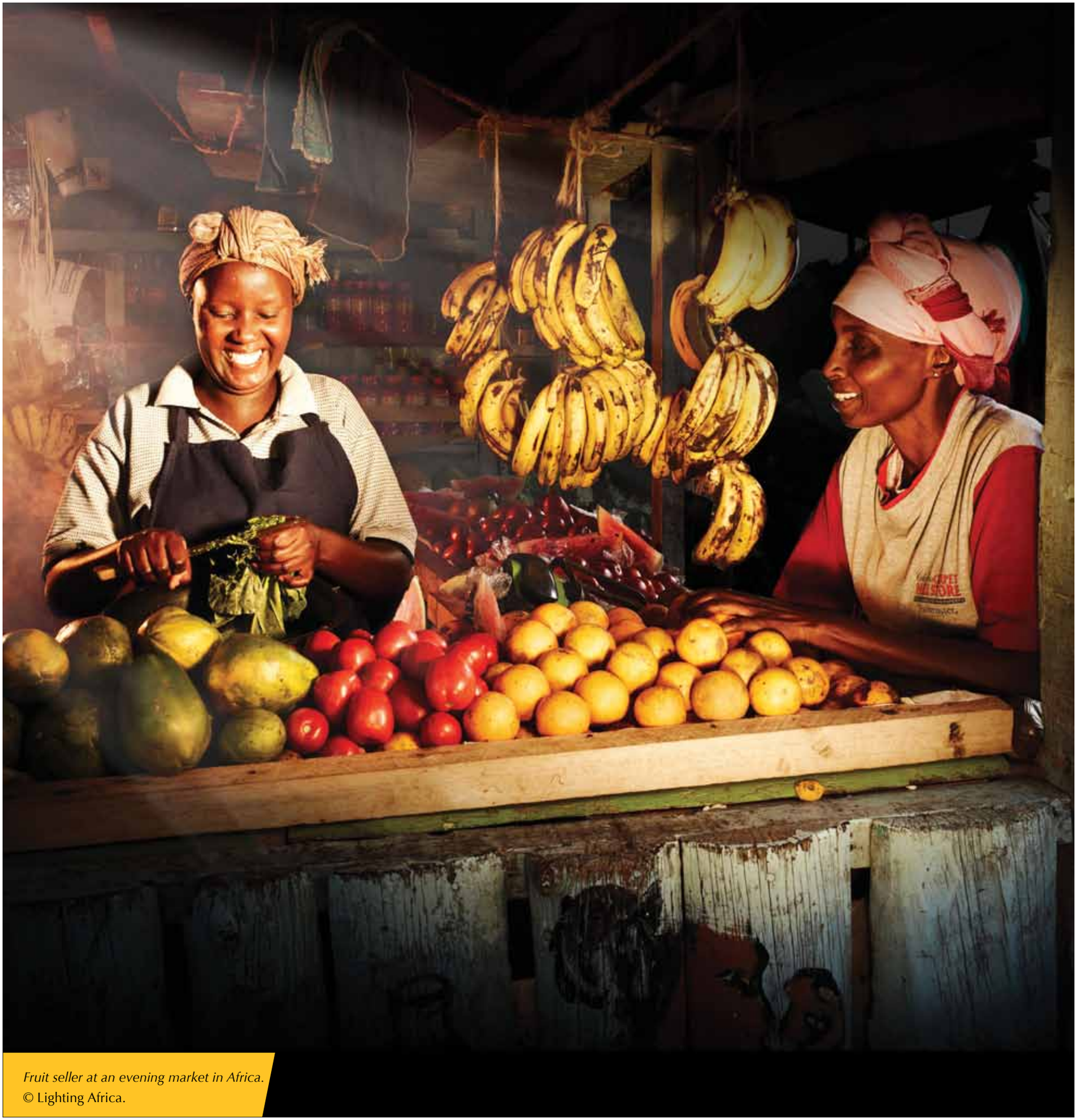


Figure 48: Consumer willingness to pay increases with product exposure



Fruit seller at an evening market in Africa.
© Lighting Africa.

Addressing Challenges To Scaling Up

The challenges to the SPL market listed above are substantial and will impede market growth if left unaddressed. Our research suggests, however, that many promising solutions are on the horizon and can be put in place (and in some cases, can reach needed scale) over the next five years, helping the market achieve our forecasted growth of 65% annually.

Access to finance – targeted financing solutions

African nations have opportunities for policy-level initiatives, enterprise-level initiatives, and private sector solutions to overcome the upstream liquidity and downstream affordability bottlenecks in the off-grid lighting market.

One set of solutions may be needed to address the working capital squeeze faced by SPL manufacturers, wholesalers and retailers. The critical aim of such initiatives is to improve the creditworthiness of these small enterprises, while increase the risk appetite for banks to lend to this sector.

(1) Government mandates for lending to priority sectors: Governments have the option to mandate that public and private banks invest a certain portion of their loan portfolio in "priority sectors" (often agriculture, small-scale industry, microfinance, housing, education, etc). For example, the Reserve Bank of India has adopted this regulation. This policy is a well-intentioned attempt to channel liquidity to rural and socially relevant industries, but on the whole such interventions are not recommended, as they carry the risk of creating substantial market distortion in nascent markets like that for small-scale renewable energy.

(2) Working capital loan guarantee fund: There is potentially a role for a public or private fund to be used strategically to open up the financing bottleneck for players in the off-grid lighting market and adjacent industries. The concept is that this fund would guarantee affordable debt to SMEs in need of working capital for high-impact products, such as off-grid lighting. This could stimulate an institutional shift where the banking sector can increase its risk tolerance for SME finance. The following step would be to reduce transaction costs for small loans, so banks can further reduce high interest rates. Such an intervention may not be.

(3) Collateral "salvage" fund: the need for good collateral is a major bottleneck to an increased flow of working capital financing for distributors (particularly new distributors without extensive market record). Most banks don't appear to believe that lantern inventory is credible collateral because of a lack of familiarity with the technology and the lack of a secondary market for solar renewable lighting products (e.g., in contrast to commoditized goods like agricultural inputs). A repurchase facility for quality SPLs (e.g., 80 cents guarantee on $ of FOB), either on a standalone basis or as part of a commercial bank working capital facility, could help alleviate this bottleneck. One could envision NGOs or social enterprises sponsoring such an initiative, since, in the case of distributor default, they could get access to cheaper lanterns for their clients.

On the consumer front, the challenge lies in the limited income and cash flows of consumers. Over the past 3 years, there has been increasing talk of the synergies between microfinance and high-impact products. While the opportunity seems apparent, few MFIs globally have jumped at the chance to scale up solar light financing beyond the pilot stage. There are several ideas for overcoming this hurdle:

(1) Energy product financing fund: some have argued that MFIs have thus far not been adequately incentivized to make a big leap into product financing, given the high growth and returns of the standard savings and loan products. The challenge comes in a finite pool of funds with which to on-lend. If affordable funds earmarked for SPL financing were available to MFIs , this would enable MFI to experiment further and at lower risk. Of course, these specified energy product funds would need to be designed properly and potentially be time-limited, so that MFIs would eventually take on the full risk of this financial product. Based on early indications, MFIs have cautioned us away from this approach. The clear preference was for added wholesale lending focused on RE over concessionary risk-sharing mechanisms, but further research is needed.

(2) Product finance company: One of the main arguments for why MFIs have not adopted energy product loans is that they are poorly equipped to handle the logistics, marketing and after-sales support that is required to effectively scale solar lights. This suggests that product financing could be decoupled from microfinance and provided through an independent institution. The viability of an independent product financing company has been proven successful in the past (e.g., Grameen Shakti in Bangladesh financing of energy products) but no compelling examples exist for small-scale RE like SPLs.

(3) Other downstream ideas: To avoid transaction cost issues inherent in small loans ($20-80) for SPLs, MFIs and rural banks in African countries have the opportunity to experiment with financial products like product-linked savings accounts, mobile payment-enabled micro-lending, top-up loans for SPL, and payroll finance of lantern distribution. Lighting Africa is currently exploring these downstream ideas and others in its conversations with MFIs, retail banks, and corporates.

LIGHTING AFRICA'S ROLE IN ACCESS TO FINANCE

Access to finance is at the core of Lighting Africa's mission and the program is working through several potential approaches to help resolve the market's A2F challenges:

(1) Leverage IFC's investment and advisory services through both existing programs and potentially new initiatives, to support local commercial banks in Africa on providing working capital and trade finance to distributors and manufacturers of off-grid lighting products

(2) Address financing constraints of small-scale distributors and consumers by facilitating bank/MFI/SACCO micro-lending to end-users and SPL micro-entrepreneurs through targeted wholesale loan funding, risk-sharing and technical assistance

(3) Work with banks and MFIs to develop and pilot innovative, low transaction cost SPL financing products for end-users (e.g., product-linked savings accounts, mobile-payment loans)

After-sales support capabilities and, potentially, lower costs through assembly in Africa

Since price is the major A2F bottleneck from the consumer perspective, initiatives to bring price down are also part of the solution set. Beyond reductions in component costs and policies on taxes/tariffs (covered below), there may be a price reduction opportunity in Africa assembly, though the appeal of this idea rests less on cost savings and more on the creation of local employment and generation of local talent for after-sales SPL support.

In theory, local assembly may help shave a few percentage points off the final cost due to lower African labor costs vis-à-vis European or North American SPL manufactuers. Furthermore, local assembly helps save on high SPL tariffs and taxes whenever component duties are taxed at a lower rate than fully assembled products. Realistically, however, any cost advantage of local production in comparison to low-cost Asian producers will be slight or non-existant, especially once the generally high costs of doing business in Africa are taken into consideration (e.g., lack of infrastructure, red tape, trained staff, etc.).

More important than cost, the use of local assemblers for some of the components is a way to transfer valuable skills to the population. In a number of countries, there are already businesses set up that deal with large quantities of solar panels and solar home systems. Some of these local assemblers may have the capacity and expertise to meet the demands for the solar lantern market. Elsewhere, the assembly capabilities would need to be built and further tariff reform may be required to increase appeal of assembly in Africa.

Following are two examples of a few companies that are currently experimenting with local assembly:

- A large Kenyan distributor of solar lights believes in offering high quality products at affordable prices to the rural and urban poor in Africa and in line with this core objective, they are currently in the process of starting an assembly plant in Kenya to produce lanterns and offer after-sale service. Representatives from the organization believe that installation of a local assembling process will (1) localize the products and easily adapt specific design requests from Kenyan customers, (2) avoid the double taxation that occurs when customs duties are paid both in the country of assembly and the destination country, and (3) increase employment in Kenya
- A French manufacturer active in West Africa believes in providing African countries with employment opportunities, particularly at the BOP, and does so by partnering with local distributors to assemble their products locally. The company has set up partnership in countries such as Benin, Cote d'Ivoire, Gabon, Mali, and Senegal. Their commitment to development is also evident in their training of local partners to install, maintain, and repair their systems in order to ensure the longevity of local employment and create a sustainable system for maintaining solar energy systems. Assembling their products locally has proven cost effective. The company's assembly cost as a percent of final wholesale price, if outsourced to Africa is only 2% compared to 10% if assembled in France. The company also avoids paying import taxes since it is the local partner that imports and assembles the products locally.

Innovative distribution models

We have seen no "magic" solutions to the problem of distributing solar portable lights at scale in Africa, but our research suggest a number of ideas for reducing distribution costs and leap-frogging "last-mile" distribution challenges:

(1) Reduce the number intermediaries between the manufacturer and the local dealer. The direct presence of distributors in rural areas eliminates many of the markups inherent in multilevel distribution structures and thus increases the number of customers who can afford lanterns. In addition, distributor presence in rural areas increases consumer confidence since end-users are assured that they do not need to travel far in the event they encounter any quality issues that they encounter. Naturally, building a rural distribution network is costly, so the scale solutions will likely need to take advantage of existing rural distribution channels (e.g., consumer goods company networks, battery retailers, general goods shops)

(2) Develop distribution partnerships with institutional market "aggregators"

- MFIs/MFI banks – MFIs have so far not proven to be useful partners for the distribution of lanterns in Africa due to their at times overly-cautious attitude, lack of understanding of lighting market, and limited operational capacity and appetite for distributing "physical" products like lanterns on the ground. The very largest MFIs and MFI banks (e.g., Equity Bank in East Africa) do have the right network and capabilities that can be accessed by one or a few of the highest quality SPL players, so the opportunity warrants further investigation.
- SACCOs – many African countries, most notably Kenya, have a substantial Saving and Credit Cooperative (SACCO) presence. These institutions, which in Kenya can reach a size of over a hundred thousand members for the larger credit unions, account for over 20 million members across the continent.[37] Unlike MFIs, which typically have a more urban footprint, SACCOs are true "last-mile" entities, straddling the gap between formal financial institutions and the informal and fragmented financing sector of ROSCAs (Rotating Savings and Credit Associations), village self-help groups, and money-lenders. While the sector is highly fragmented, partnerships with apex SACCO organizations and associations (e.g., KUSSCO in Kenya) could be a major opportunity.
- Unions and cooperatives – a few of our interviewees were considering approaching or already in negotiation with large membership organizations (e.g., coffee farmers association) to distribute their products through existing channels (e.g., same physical channel and bulk-purchase pricing advantages for agricultural cooperative members as for distribution of fertilizer or seeds).

(3) Partner with mobile operators – as noted previously in this report, there is a tremendous and growing need for off-grid mobile phone charging in Africa. Given the mobile subscription economics, mobile operators may be incentivized to provide cheap charging solutions to their customers since, beyond expanding the potential customer base, such solutions tend to increase spending on airtime (with one study suggesting an increase of average revenue per user of 10-14%) [38] and a boost in mobile penetration in off-grid regions. Given the profusion of low cost mobile providers across the continent, established, reputable SPL distributors should have opportunities for finding distribution partners in this space, though a clear business case would need to be made to such partners (who, based on preliminary conversations, are likely to be weary of direct involvement in and risks of being involved in SPL distribution).

Taxes/Tariffs – the reduction of duties and taxes on solar goods is one of the more promising public policy levers for unlocking the growth of the market. This issue has two separate components: the actual level of duties/tariffs and the process for obtaining solar light duty exemptions.

The most direct policy impact can be achieved by lowering or abolishing taxes/duties on a clearly-defined subset of solar lighting products. Our interviews suggest that lower tariffs can often catapult the SPL market to the next stage of growth. For example, the elimination of VAT and tariffs for solar panels in Tanzania led to the reduction of PV costs by half and, according to a number of distributors, served as a major stimulus for increased sales. The potential for such reductions is substantial since, by our count, well over half of Sub-Saharan African nations – including many of the largest off-grid markets like Nigeria, and Senegal – still have extremely high duties and taxes on solar goods.

Even where such duties have been reduced, exemptions are often difficult to obtain, so the reform has to happen both at the level of regulations/policy and at the operational level of customs administration. In Kenya for instance, a number of distributors have highlighted that the tax regime is still very cumbersome: one has to first pay VAT on solar goods, and then claim it back, leading to uncertainty on payment timing, customs officials often apply inconsistent standards in the handling of solar products, and distributors typically have to apply for exemptions for each container on a case-by-case basis, leading to tremendous transaction costs. Similarly, some of the solar distributors we've interviewed in Rwanda reported that while taxes/duties have in theory been removed from solar goods, customs officials were still imposing duties on such products due to lack of awareness and lack of clarity on regulations.

The exact nature of these bureaucratic hurdles warrants further country-level research, but the solution will likely include:

- A code of best practices for solar tax and tariff regulations, that can be lobbied at the country level or promoted through pan-African tariff harmonization mechanisms
- Training for customs agents to help identify and/or exempt solar lighting goods
- Pre-certification for "quality" SPL manufacturers and dealers, allowing bulk imports of solar devices without need for shipment-by-shipment review

Market spoilage. The issue of market spoilage can be addressed through rigorous independent testing of lanterns and components, combined with a marketing program to promote the new seal of quality.

The creation of such product testing and certification programs is an integral part of the Lighting Africa agenda (see box below). Additionally, the market faces the challenge of individual countries pursuing their own standards even if they are based on IEC standards. This leads to higher costs for manufacturers to have to re-certify products for entry into each country while poor-quality products leak in. It also creates opportunities for rent seeking. The solution will require reciprocity agreements to ensure that products certified to internationally accepted standards are accepted by a country without retesting – a common practice that UL and other certifying bodies adopt.

[37] ACCOSCA /KUSSCO (2008)

[38] GSMA (2010) – field trials by Digicell in Haiti and PNG, for example, demonstrated an ARPU lift of 10-14%

Lighting Africa Product Quality Program

In order to address the market spoilage concerns, Lighting Africa has developed a five-part quality assurance strategy which supports market development, provides technical advisory services to quality oriented companies, and protects the interests of low-income consumers. The quality assurance program strategy seeks to support technological innovation and recognizes that market segmentation results in a need for a variety of products at multiple price points.

1) Standardized product testing method for off-grid lighting products:

Lighting Africa has developed a standardized testing methodology that can be used to evaluate the performance of off-grid lighting products sold in African markets. Bulk-purchasing agents, government regulators, NGOs, importers, and other buyers who need to identify good-quality products or verify compliance with minimum performance levels can use the Lighting Africa Test Method or contract with a test laboratory who will undertake testing. Additionally, a subset of the test procedures with small sample sizes can be used to do initial screening of products to determine if they are likely to perform well.

2) Product performance verification

Lighting Africa is testing commercially available off-grid lighting products to verify truth in advertising and to determine if products meet minimum performance levels. Companies that manufacture products that meet Lighting Africa's criteria are invited to become Lighting Africa Associates, provided that the companies also agree to a standardized set of conditions. The agreement includes a set of environmental, social, and business principles. Associate companies are in a position to benefit from Lighting Africa sponsored business services and promotional activities.

3) Product awards

To further support high performance, affordable products, Lighting Africa has established an Outstanding Product Awards program. This effort is designed to provide public recognition to product lines that hold the best promise to deliver affordable, high quality off-grid lighting to low income people.

The winners of the first ever awards were announced at the Lighting Africa 2010 Global Business Conference and Trade Fair in Nairobi, Kenya on May 18, 2010. The winning products were successful in laboratory testing using the Lighting Africa Test Method and field evaluations by representative end-users of SPL in Sub-Saharan Africa (http://www.lightingafrica.org/awards).

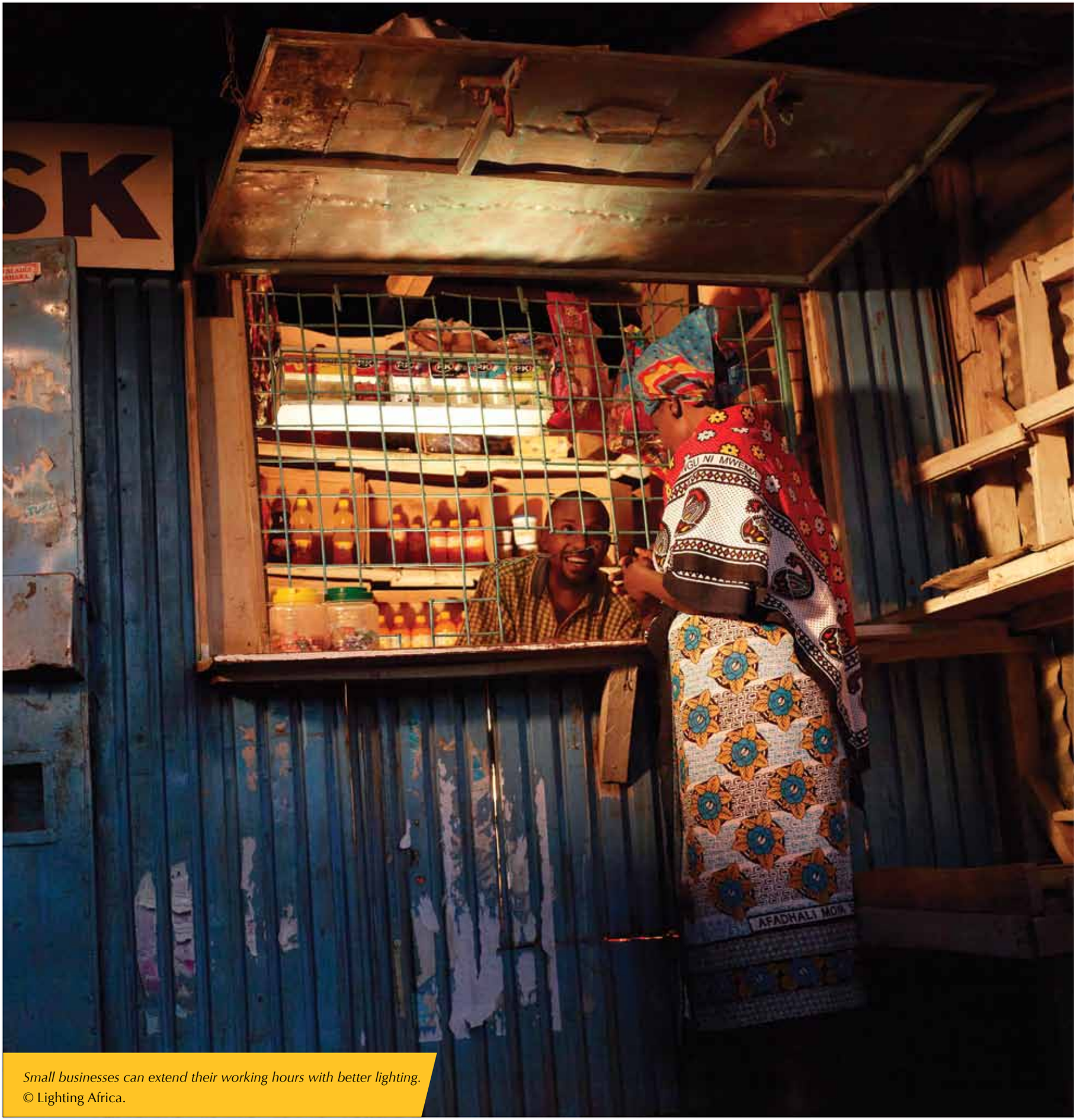
4) Technical advisory services

Lighting Africa has recognized that certain technical challenges are recurrent in the design and manufacture of off-grid lighting products. While solutions can be found, in some cases manufacturers lack the capacity to carry out the research required. To address this, Lighting Africa is publishing a series of Technical Briefing Notes that address issues related to the design or manufacture of off-grid lighting products. Some notes will present the results of research sponsored by Lighting Africa; others will summarize current best practices.

5) Test Laboratory Capacity Building

Many manufacturers, distributors, NGO's, and other players in the off-grid lighting market do not have the capacity to make accurate performance measurements of lighting products. To address this information gap, Lighting Africa is working to establish low-cost testing services at centers around the globe. To date, Lighting Africa has worked with test laboratories in Germany, China, and Kenya. In the near future, Lighting Africa will expand this effort to build capacity at additional test laboratories in West Africa and Asia. The program welcomes manufacturers, distributors and importers of off-grid lighting products to use these facilities to verify or enhance the quality or performance of their products. -grid lighting products. Some notes will present the results of research sponsored by Lighting Africa; others will summarize current best practices.

Consumer education – for those manufacturers and distributors that have a marketing budget, the methods required to inform and educate the customers about products and their benefits are expensive. A number of distributors have stated that door-to-door marketing is their most effective strategy especially in rural settings. The logistics' costs involved in this touch marketing are high given the low margins for these products. Thus, instead of subsidies, messages from NGOs, governments and other agencies to get the message out on the utility and benefits of SPLs will contribute to lower distribution costs and higher SPL uptake.



Small businesses can extend their working hours with better lighting.
© Lighting Africa.

An alternate ending

Till now, our report has considered the key drivers of the market and conservatively understood where those drivers are headed. Summing up these parts paints the picture of exciting but still limited growth, when considering the overall size of the market and the strong social imperative. It is therefore worth stepping back and imagining an alternate scenario which bottom up feels unlikely, but which in its sum of parts feels achievable:

- Technology improves at the rate analysts expect, providing twice the light and twice the batterly life for the same price as today
- Kerosene rises in price at its historic rate of 9% per annum
- Governments recognize the social and economic imperative and remove all taxes associated with the SPL market
- Any kerosene subsidies are sharply reduced due to budgetary pressures and enlightened policy
- An approved, trusted platform appears that can access carbon credits for SPL products
- Competition drives distribution costs down by 20%
- Local MFIs/Banks create a SPL-specific loan product linking repayments to kerosene savings
- A scale player enters and creates the “Maglite” of solar portable lights

With the right focused efforts and strong institutional support, the above set of conditions are wholly possible. If they were put in place over the next five years, we believe the SPL market will follow growth rates closer to mobile phones - the must-have product. This would mean sales that are 3-5 times what we have indicated in our estimates.

Conclusion

We have established that the solar portable lighting market in Africa has immense promise and, assuming progress on some of the challenges listed above, it will experience transformative growth and evolution in quality over the next 5 to 10 years.

At present, the size of the market and the fragmented nature of the consumer base (geographically and by end-user needs) means that multiple models in manufacturing, product design, distribution, and financing will continue to thrive and we have attempted to reflect this diversity in our report.

Some approaches will, however, be more successful than others, and unleashing the next wave of growth will require a healthy continuing dialogue both within the African SPL community and with other regions that have seen solar lighting success. India, for example, has already seen sharp reductions in pricing, an increase in product variance and a multitude of emerging distribution and financing schemes. Indian counterparts have begun to heavily influence African lantern initiatives. Conversely, Indian, South-East Asian, and Latin American markets continue to face market distortions and heavily subsidy-based approaches. A market led, pan-African approach, such as that being pioneered by the Lighting Africa team, could position African players on the leading edge of the global dialogue on lighting products.

Our report highlighted the following important trends that reinforce the importance of developing the market for SPL in Africa:

- Africa to be the main global market, growing to a possible 630 million non-electrified people by 2015, plus nearly 100 million under-electrified.
- Low existing penetration into this market but potential to sell 5-6 million solar portable units over next five years under arguably conservative estimates and over 12 million units if market obstacles can be removed
- A rapidly declining manufactured price – potentially 40% in five years for today's median lantern
- Technological improvement will mean more and better light - over 100 lumens for the larger full-featured SPLs vs. 30-60 lumens today
- Consumer will be King - with more and more design variations aligning closer to consumer demand

Unlocking and even going beyond our own estimates for potential growth requires addressing some significant challenges

- Access to finance bottlenecks across the value chain
- Distributing and servicing effectively:
- Removing high taxes/tariff burden
- Addressing the growing problem of market spoilage
- Improving consumer education

In light of the various challenges and opportunities highlighted in the report, Lighting Africa intends to continue building on its current program and facilitate the market's move to the next stage of growth in seven ways:

1. **Establish and promote minimum quality standards –** a source of independent testing and information on lantern quality as well as serving as a clearinghouse for information on quality standards and technology trends
2. **Invest in consumer education** to grow market demand in lagging markets and reduce marketing costs that are often too onerous for small-to-midsized SPL businesses
3. **Lower cost of innovation and encourage consumer orientated design** by lowering information costs and awarding innovative solutions (e.g., Lighting Africa's awards, Ashden award)
4. **Facilitate the further growth and experimentation in distribution models** by serving as forum for coordinating activities of the private sector, NGOs/MFIs, and policy makers and potentially financing more pilots of various distribution models in African geographies
5. **Address "access to finance" bottlenecks** by helping to identify market bottlenecks across the value chain, suggesting solutions, and identifying partners (banks, MFIs, Corporates, NGOs) that can best implement these
6. **Serve as an advocate for the reduction of tax/tariff levels** Africa-wide and at the country level and work for the rationalization of solar exemption requirements. Market facilitators can also address this challenge directly by helping certification programs for high quality distributors to facilitate solar tax/tariff exemption
7. **Serve as a clearinghouse /intermediary for CO2 abatement credits –** done right, solar portable light initiatives can be worth as much as $5-15 per solar lantern at today's CO2 market rates depending on assumptions, but these credits are difficult to access without a large market platform and hence a natural niche for market facilitators like Lighting Africa. Furthermore, facilitation can extend to other potential grants/funds aimed at supporting the health, education, etc. impact of solar portable lights

Lighting Africa will address these questions in greater depth, most immediately the critical access-to-finance issues, in forthcoming reports and conferences.

In the meantime, our hope is that this report stimulates fruitful discussion among the private and public sector players and policy makers who are building Africa's brighter solar future. Our objective was to bring some valuable information and perspectives to enrich the debate and we look forward to comments from the 2010 Lighting Africa conference participants.

Annex

Solar portable light alternatives – is SHS the next step up?

Because of their low price, durability, and low maintenance costs, solar portable lights (SPL) are today's most promising low-cost technology for the lighting needs of off-grid BOP populations. But there are several other options like mini-grids and solar home systems (SHS) that compliment the SPL product range today and, in some cases, will become increasingly important alternatives for BOP electrification.

Solar Home Systems (SHS) are the most prominent of these small-scale alternative technologies. With over 2.5 million SHS installed globally and more than 850,000 installed in Africa,[39] this technology is currently the main renewable household-level alternative to SPLs in Africa and across the globe.

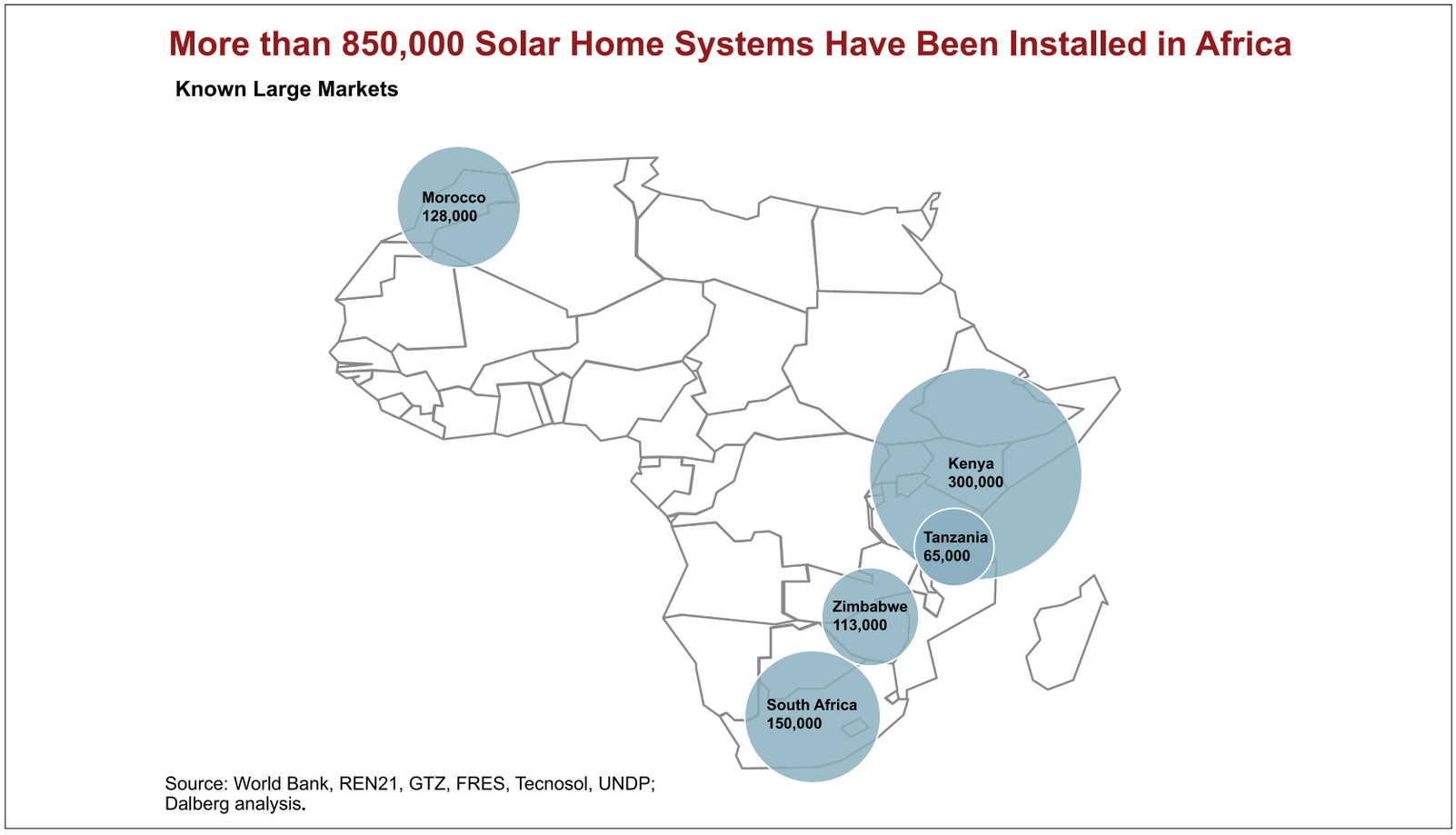


Figure 49: Solar Home System (SHS) Sales in Africa

[39] Worldwide estimate based on World Bank SHS reports, country studies for major Asian markets like India, Indonesia, and China, government import statistics where available, and extrapolation for smaller markets; Africa estimate based on World Bank data, Foundation for Rural Energy Services analysis, GTZ 2009 country reports on the solar market, and gov't statistics for select markets.

The African SHS market has experienced a great deal of challenges over the years. Previous generations of solar home systems achieved limited market penetration due to high costs.[40] Furthermore, solar home systems in Africa and elsewhere in the developing world have been criticized for poor components, system design, installation, and maintenance challenges.[41] Despite these setbacks, the sheer volume of donor-driven investments in SHS and market-driven growth in geographies like Kenya helped drive a compounded annual growth of 13% in the number of installed SHS over between 2000 to 2009 (See figure below).

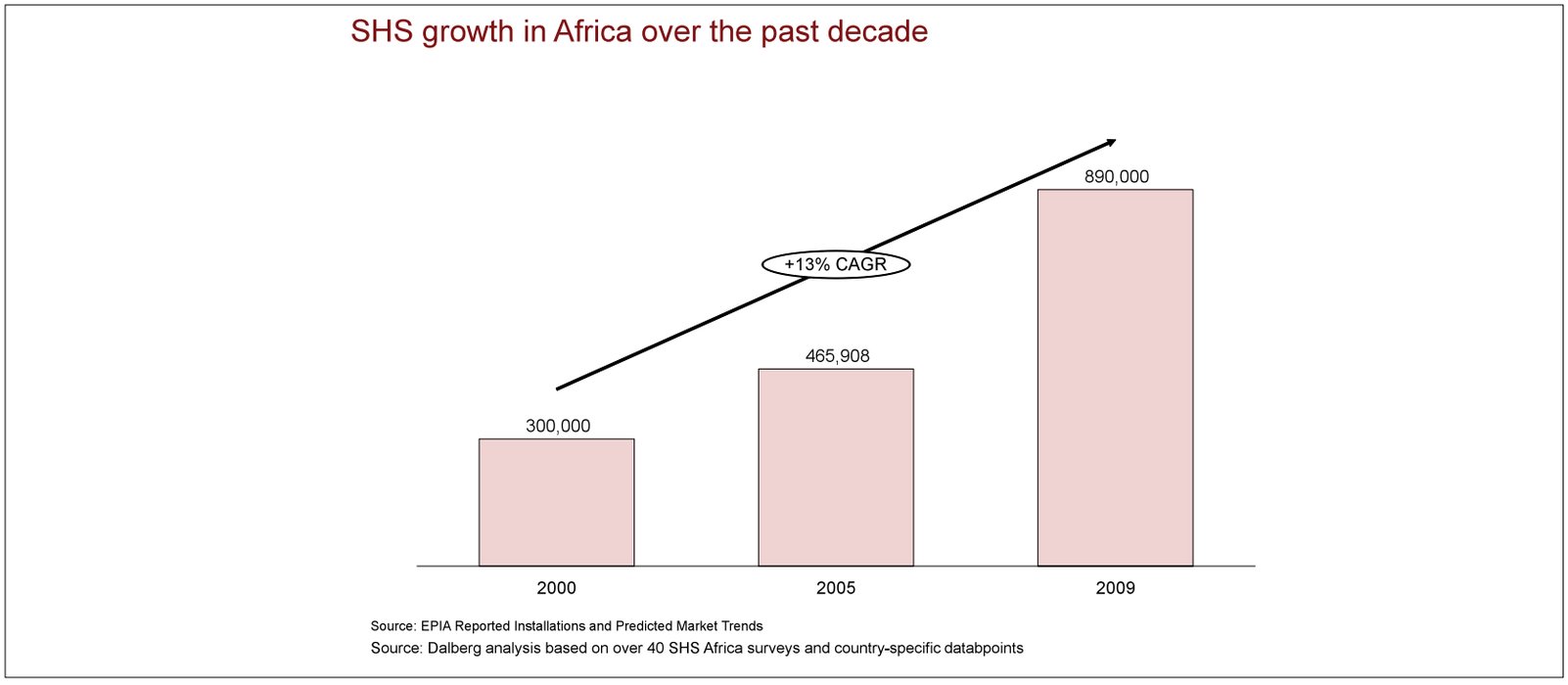


Figure 50: SHS sales historical growth (2000-2009)

The SHS market may be turning the corner, with substantially reduced prices, market-driven growth for smaller SHS systems (recent GTZ-sponsored research estimates an annual growth rate of 15-25% in a number of key African markets),[42] and early signs of local assembly and/or manufacturing in Africa.

How are the SHS and SPL markets related?

The overall off-grid population figure is often quoted as the "market" for lanterns and we've expanded the envelope further in this report by focusing on the large "under-electrified" population. However, it is important to note that at least a part of the market for renewable primary and back-up lighting will be addressed by the alternatives to solar portable lighting devices – chiefly SHS.

Market research on the household and SME solar renewable opportunity in Africa is still at an early stage, but a number of surveys by GTZ, SEF, and others (e.g., Niewnhout) have attempted a rough market segmentation to understand the potential share of devices across different available technologies and solar power levels, largely based on the population's purchasing ability. These surveys suggest that Solar Home Systems are unlikely to be accessible to more than 50% of the African population in the near to medium-term even given projected price declines and access to finance innovations.

The finding is unsurprising given the current price point of the technology – average SHS costs of $150 for a 20Wp system ($100-250 range) and $600 or a 50Wp system ($400 - $1200 range) in Africa, which is significantly higher than the average price of solar lanterns at $30-80.

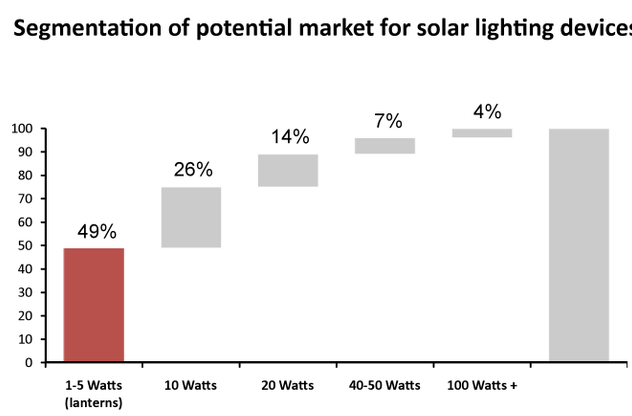
The market segmentation above further suggests that the potential market size for 1-10W SPLs (i.e., mini-SHS, lanterns, torches, task lights) will be at least half of the African population. However, it is key to note that consumers prefer solutions which can light multiple lights or devices (e.g., a light in combination with charging a phone or powering a radio/TV).

[40] Wamukonya (2007) and Urmee and Harries (2009)

[41] Jacobson et al. 2000; Cabraal et al. 1996; Nieuwenhout et al. 2000

[42] Recent (2009) GTZ reports on the solar energy markets in Kenya, Ethiopia, Rwanda, Tanzania, Uganda

While the resulting SPL market will be large, a significant portion of the market will be for larger panel solar lighting products



1-5W solar lanterns account for at least 50% of the potential off-grid solar system lighting market based on the expense of larger solar systems

Source: GTZ, SEF, Newenhout surveys across Kenya, Tanzania, Rwanda, Ethiopia, and Uganda. (1) Average market segmentation projections based on purchasing ability and on-the-ground expert assessment.

Figure 51: Solar Market Segmentation - SHS vs. SPL

We consequently forecast that over the next five years will see increasing convergence between the SPL and SHS markets, as falling component prices make the smallest SHS packages available at price points comparable to the highest end solar lanterns of today. Distributors in Africa are already beginning to acknowledge the fact that SPL and SHS are part of the same continuum by adding solar lanterns and torches to their SHS product lineups. Additionally, the blending of lines between the two markets is visible in the "micro-SHS" products currently being targeted by some SPL manufacturers – portable solar lighting devices that are built around the concept of a PV panel that can be attached to one or several LED lights and minituarized accessories like mobile chargers.

We believe the convergence between the SHS and SPL markets is a positive development. Given the still high gap in affordability between average SHS and SPL systems in Africa and, more important, the minimal penetration of solar products (both SHS and SPL are at less than 1% of their addressable markets), there can be no serious talk of competition. Both products will continue their impressive growth and distributors and consumers will increasingly see these as a range or continuum of solutions to their lighting needs.

Bibliography

Adkins, E., Eapen, S. et al ,. “Off-grid energy services for the poor: Introducing LED lighting in the Millennium Villages Project in Malawi”, 2009.

Agoramoorthy, G. and Hsu, M. “Lighting the lives of the impoverished in India’s rural and tribal drylands”, 2009.

Batliwala, S. and A.K.N. Reddy. “Energy for women and women for energy (engendering energy and empowering women)”. Energy for Sustainable Development VII (3), 33–43, 2003.

Cabraal, R. Anil; Mac Cosgrove-Davies; Loretta Schaeffer. “Best Practices for Household Electrification Programs: Lessons from Experiences in Selected Countries”. World Bank Technical Paper No. 324, Asia Technical Department Series, Washington, D.C., USA, 1996.

Cabraal, A.; Douglas F. Barnes; Sachin G. Agarwal. “Productive Uses of Energy for Rural Development”, 2005.

“Designing Sustainable Off-Grid Rural Electrification Projects: Principles and Practices”, The World Bank Group, 2008.

Display and Design Ideas, “Hera research shows lighting as a retail moneymaker”, March 1, 2003.

Dongo, E. A., et al. “A five-year review of burn injuries in Irrua”, BMC Health Serv Res, 2007.

“Ethiopia: Qualitative Off-grid Lighting Market Assessment”. Lighting Africa, 2008.

“Ghana: Qualitative Off-grid Lighting Market Assessment”. Lighting Africa, 2008.

GSMA Development Fund, “Green Power For Mobile: Charging Choices. Off-grid charging solutions for mobile phones”, 2010.

GTZ, Project Development Programme, Target Market Analysis: Solar Energy Market Kenya, 2009

Hansen, J., et al., “Efficacy of Climate Forcing”, 110 J. Geophys. Res. D18104, 1, 2005

IEED, “Power to the poor: sustainable energy at the base of the pyramid”, Nov. 2009.

Jacobson, A.; D. M. Kammen, R. Duke, and M. Hankins. “Field Performance Measurements of Amorphous Silicon Photovoltaic Modules in Kenya”, 2000.

Jacobson, A. and Poppendieck, D. “Characterization of Particle Matter Size Distributions and Indoor Concentrations from Kerosene and Diesel Lamps”, 2010.

Karamchandani, A.. “Emerging Markets, Emerging Models”. Monitor Group, 2009.

“Kenya: Qualitative Off-grid Lighting Market Assessment”. Lighting Africa, 2008.

Laxmi, V.; J. Parikh; S. Karmakar; P. Dabrase. “Household energy, women’s hardship, and health impacts in rural Rajasthan, India: need for sustainable energy solutions”. Energy for Sustainable Development VII (1), 50–68, 2003.

Mills, E. “The Specter of Fuel Based Lighting”, 2005.

Mills, E. “From Carbon to Light A New Framework for Estimating Greenhouse-Gas Reductions

from Replacing Fuel-based Lighting with LED Systems”, Technical Note #5, Lumina Project, 2009.

Nieuwenhout, F. D. J.; A. van Dijk; V. A. P. van Dijk; D. Hirsch; P. E. Lasschuit; G. van Roekel; H. Arriaza; M. Hankins; B. D. Sharma; and H. Wade. “Monitoring and Evaluation of Solar Home Systems: Experiences with applications of solar PV for households in developing countries”, 2000.

Oduwole, E.O.; O.O. Odusanya; A.O. Sani; A. Fadeyibi. “Contaminated Kerosene Burn Disasters in Lagos, Nigeria”, 2003.

Peon R.; G. Doluweera; I. Platonova; D. Irvine-Halliday; G. Irvine-Halliday. “Solid-state lighting for the developing world– the only solution”. 2005.

Radecsky, K.; P. Johnston; A. Jacobson; E. Mills. “Observed minimum illuminance threshold for night market vendors in Kenya who use LED lamps”. Lumina

Project Research Note #3. 2009.

Radecsky, K., "Understanding the economics behin off-grid lighting products for small businesses in Kenya", Humboldt State University (2009)

Ramanathan, V. and G. Carmichael. "Global and regional climate changes due to black carbon", 1 Nature Geoscience 221-22, 2008.

"Renewables Global Status Report: 2009 Update". REN21 Renewable energy policy network for the 21st Century, 2009.

"Solar Lanterns Test: Shades of Light". GTZ, 2009.

"Tanzania: Qualitative Off-grid Lighting Market Assessment". Lighting Africa, 2008.

Tracy, J.; A. Jacobson; Evan Mills. "Assessing the Performance of LED-Based Flashlights Available in the Kenyan Off-Grid Lighting Market". Lumina Project Research Note #6, 2010.

Urmee, T. and D. Harries. "Renewable Energy Based Rural Electrification Programs in Developing Countries: Lessons and Perspectives, The 2nd Joint International Conference on "Sustainable Energy and Environment (SEE 2006)", 2006.

Wamukonya, N. "Solar home system electrification as a viable technology option for Africa's development", 2007.

"The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits: An IEG Impact Evaluation". The World Bank, 2008.

"World Bank Asia Sustainable and Alternative Energy Program". The World Bank Group, 2002.

"Zambia: Qualitative Off-grid Lighting Market Assessment". Lighting Africa, 2008.

Notes

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