



# Lighting Africa Market Trends Report 2012

Overview of the Off-Grid Lighting Market in Africa



A child holding a Greenlight Planet Sunking Pro™, Kenya.  
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## Acknowledgements

This report was commissioned by Lighting Africa, a joint initiative of IFC and the World Bank, and developed in partnership with Dalberg Global Development Advisors.

The report is an update to the original 'Solar Lighting for the Base of the Pyramid: Overview of an Emerging Market' report published in 2010, which provided a snapshot of the off-grid lighting market, industry-level data and analysis on key trends. The current report updates the market trends and developments since 2010. 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.

Lighting Africa would particularly like to thank all the Lighting Africa team members who provided market research input, research support, guidance, and feedback throughout the process. Lighting Africa would also like to extend thanks to the Dalberg consultants and researchers worldwide who conducted the market survey interviews and desk research and the Dalberg Global Development Advisors for their analysis.

The report 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 through [www.lightingafrica.org](http://www.lightingafrica.org).

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*Reading with a solar lamp, Senegal.*  
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## List of abbreviations

a-Si	Amorphous Silicone	NiMh	Nickel Metal Hydride battery
BoP	Base of Pyramid (<\$3000 annual household income)	PLS	Pico-powered lighting system
CAGR	Compounded annual growth rate	PV	Photovoltaic
CIGS	Copper indium gallium selenide (thin-film PV)	RE	Renewable energy
CFL	Compact Fluorescent Light	ROSCA	Rotating Savings and Credit Association
c-Si	Crystalline Silicone	SACCO	Savings and Credit Co-operative
FOB	Free on Board	SHS	Solar Home System
GEF	Global Environmental Fund	SLA	Sealed Lead Acid Battery
GTZ	Gesellschaft für technische Zusammenarbeit	SME	Small and Medium-sized Enterprises
IFC	International Finance Corporation	SPL	Solar Portable Light
kWp	Kilowatt peak	VAT	Value Added Tax
LED	Light Emitting Diode	Wp	Watt Peak
Li-ion	Lithium Ion battery	WBG	World Bank Group
MWp	Megawatt peak	WLED	White Light Emitting Diodes
NGO	Non-governmental organization		

## Background

### About 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 mobilizing the private sector to build sustainable markets that provide affordable, modern off-grid lighting to communities across Africa that are not on the electricity grid. The program and its partners have brought cleaner, safer, and better lighting to nearly 7 million people and are working to increase energy access, providing better lighting to 250 million people by 2030.

Improved lighting provides significant socio-economic, health and environmental benefits. Lighting Africa is a key element of the Global Lighting and Energy Access Partnership (Global LEAP), an initiative of the Clean Energy Ministerial.

Lighting Africa is implemented in partnership with: The Africa Renewable Energy and Access Grants Program • The Climate and development Knowledge Network (CDKN) • The Global Partnership on Output-Based Aid (GPOBA) • The Energy Sector Management Assistance Program (ESMAP) • The Global Environment Facility (GEF) • Italy • Luxembourg • The Netherlands • Norway • The Public-Private Infrastructure Advisory Facility (PPIAF) • The Renewable Energy and Energy Efficiency Partnership (REEEP) • The United States.

For more information, visit [www.lightingafrica.org](http://www.lightingafrica.org)

### About Lighting Global

Lighting Global carries out activities of Lighting Africa and Lighting Asia that are global in nature. As the region-specific activities have evolved, it has become clear that some of them could be more broadly applied to other regions and have a significant positive impact on improving markets for modern lighting. Lighting Global serves as an umbrella for the Quality Assurance framework, which was originally developed out of the Lighting Africa program.

### About the World Bank

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

The IBRD focuses on middle income and creditworthy poor countries, while IDA focuses on the poorest countries in the world. Together, they provide low-interest loans, interest-free credit, and grants to developing countries for education, health, infrastructure, communications, and many other purposes. The World Bank concentrates on building the climate for investment, jobs, and sustainable growth to enable economies to grow, and investing in and empowering poor people to participate in development.

For more information, visit [www.worldbank.org](http://www.worldbank.org)

**About IFC**

IFC, a member of the World Bank Group, is the largest development institution focused on the private sector in developing countries. IFC creates opportunity for people to escape poverty and improve their lives—by providing financing to help businesses employ more people and provide essential services, mobilizing capital from others, and delivering advisory and risk-management services to ensure sustainable development. In a time of global economic uncertainty, IFC's new investments climbed to a record \$20 billion in fiscal year 2012.

For more information, visit [www.ifc.org](http://www.ifc.org)

**Scope**

The off-grid lighting space is fast-growing and encompasses a wide spectrum of products and business models. However, for the purpose of this report, we have chosen to focus on an important sub-section of the market that we term '**pico-powered lighting systems' (PLS)**.<sup>1</sup>

This constitutes a change in terminology from the 2010 report 'Solar Lighting for the Base of the Pyramid: Overview of an Emerging Market', in which we referred to the market for solar portable lanterns or SPLs. The use of PLS terminology acknowledges the emergence and presence of other non-solar energy sources (including hand cranks, pedal power etc.) in the off-grid lighting market in Africa.

We choose to define the PLS market on the basis of function, technology and quality—following from this definition, the scope of the report fits within the factors described on the following page.

- *Function*

Lighting systems range from being task-specific (e.g., torches/flashlights) to the more general ambient lighting functions. Some of these products may include added functions such as mobile phone charging, but light is typically the primary design driver.

- *Technology*

The battery is rechargeable and, for a vast majority of devices, powered by a solar cell that is integrated or in a stand-alone panel. The light source is typically Light Emitting Diode (LED)-based, although a few products still use Compact Fluorescent Light (CFL) technology. The solar panel size is restricted to 10 watts and below, which differentiates these devices from the majority of Solar Home Systems. Dynamo (e.g., hand crank or pedal power) technology is also an interesting emerging option for powering PLSs.

- *Quality*

Products must meet a certain quality standard (e.g., sufficiently long life and truth in advertising). Currently, the most prominent standards are defined by Lighting Global's product quality assurance program and were originally designed to meet the needs of Africa's un-electrified households.<sup>2</sup> As of December 2012<sup>3</sup>, 46 products had passed Lighting Global minimum quality standards, but as products are submitted for testing on a voluntary basis, this does not mean that non-LA verified products are automatically low quality. As the introduction of poor quality products in the market leads to market spoilage, our analysis distinguishes between the quality end of the market in terms of performance and durability, versus inexpensive (USD 1-5), typically dry cell battery-powered, non-solar LED torches/flashlights that have experienced substantial sales over the past few years in Africa.

**Executive summary**

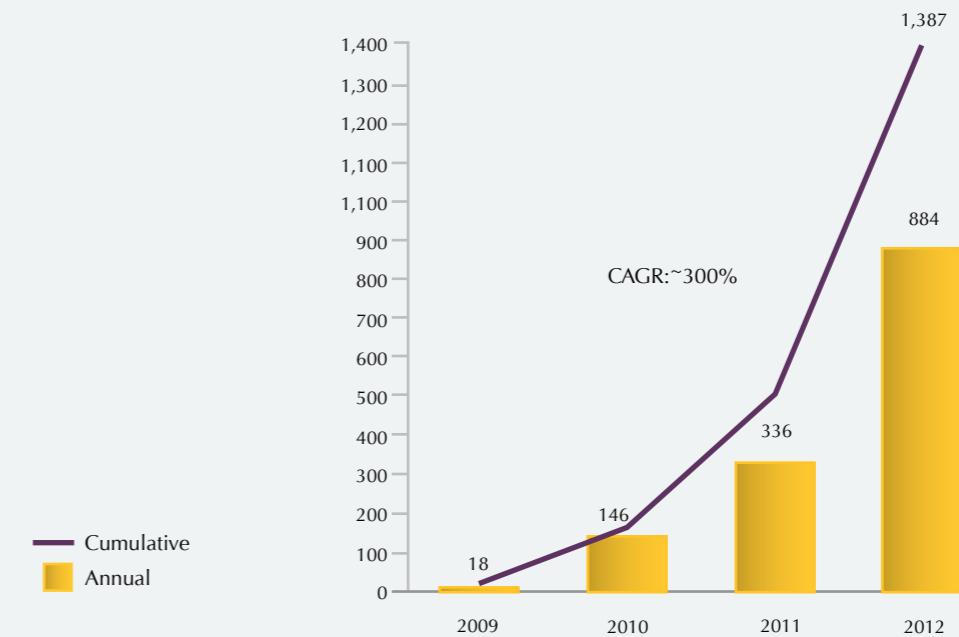
In 2010, when Lighting Africa first released a comprehensive report on the African lighting industry, an exciting future was heralded for a product set to revolutionize clean, affordable lighting for low income households. Annual growth rates of more than 85% were predicted under bullish circumstances, accompanied by rapid price drops and performance improvements, leading to a fast relegation of the traditional kerosene lantern to minority status by 2030.

**Two years on, the market for quality lighting products has matured even more rapidly than predicted.**

- Since 2009, the market in Africa has experienced dramatic growth—starting from approximately 300,000 lighting products in Africa in 2009 annual sales grew at 90-95% per year and reached approximately 4.4 million units by the end of 2012.
- Sales of Lighting Global quality-verified PLSs have grown by 300%. The high volume of sales of quality-verified PLSs suggests an evolving consumer base that is becoming more experienced and aware. Self-reported sales data from quality-verified manufacturers indicate that there were close to 1.4 million quality-verified PLSs in the African market by Q4 2012. According to our best estimates, this represents more than a quarter of the total number of lighting products<sup>4</sup> in the market today.

**Sales of Lighting Global quality-verified PLSs in Africa**

Thousands PLSs; 2009-12



Source: Lighting Africa sales data (Q4 2012 update); Dalberg analysis

<sup>1</sup>Pico-powered lighting systems (PLS) do not include conventional Solar Home Systems (SHS) that are generally larger, with panel sizes typically exceeding 10 watts and device prices ranging from USD 50-100 (as opposed to a median PLS price of USD 30). They also do not include pure battery powered lights that lack an integrated renewable power source.

<sup>2</sup> See Lighting Global Quality Test Procedures for details on relevant quality standards. [http://www.lightingafrica.org/files/LED\\_Lighting\\_TestProcedures\\_Draft\\_FISE\\_Aug09.pdf](http://www.lightingafrica.org/files/LED_Lighting_TestProcedures_Draft_FISE_Aug09.pdf)

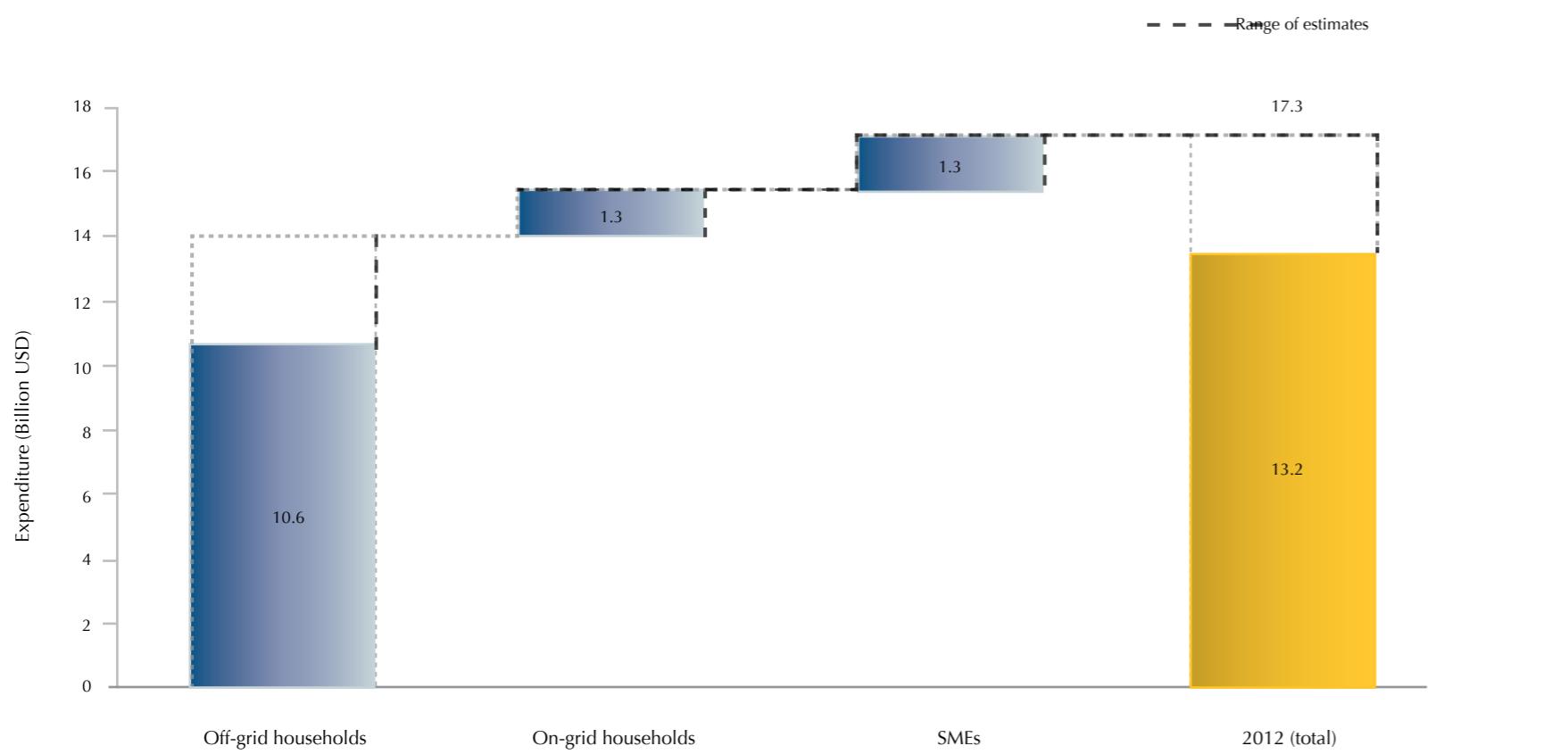
<sup>3</sup>All information in this report is updated till December 2012. From this point forward in the report, 'today' refers to 'end 2012'.

<sup>4</sup> Refers only to the types of pico-powered lighting systems that are specified in the report's scope (Page 7).

- Penetration of lighting products has increased, but conservative estimates indicate that it still remains around 4% in Africa. Thus, there is significant scope for rapid growth in the future.
- Key demand side drivers identified two years ago remain relevant, and in some cases have become more important. These include (1) a population growth outpacing grid connection, implying an increasing off-grid population; (2) a fast-increasing mobile phone subscriber population that requires better and cheaper mobile phone charging options; (3) large and growing expenditure on non-renewable fuels for lighting (due in part to rising fuel costs), estimated to be approximately USD 13-17 billion in Africa in 2012.

### BoP expenditure on lighting in Africa

Billion USD; 2012



1. Includes estimated expenditure on kerosene, batteries, candles and bio-fuel; the higher range of the estimate assumed higher kerosene usage among primary and secondary users, and higher secondary usage of battery-powered devices and candles.

2. Our estimate took into account population segments that paid a kerosene premium for buying the fuel in small quantities.

3. The average price of kerosene across Africa was estimated to be approximately USD 1.13 per liter.

Source: Primary data from the World Bank and the Asian Development Bank; Dalberg analysis.



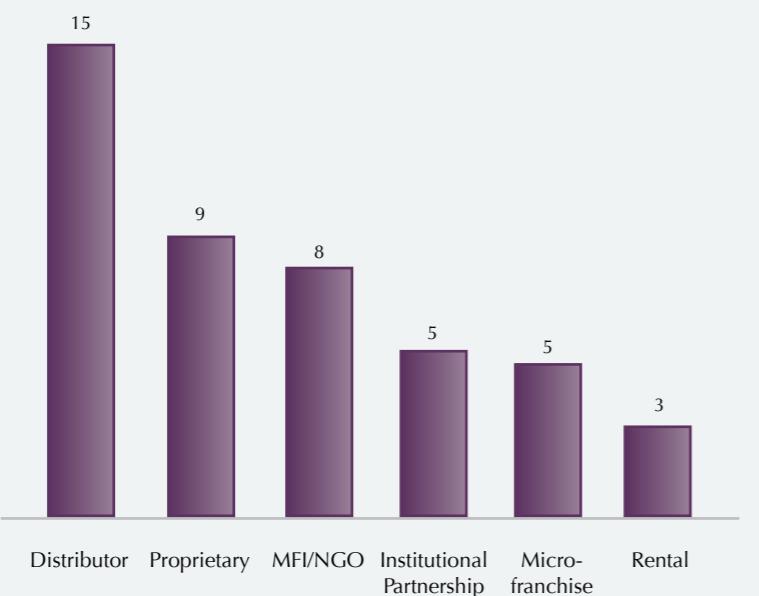
The number of Lighting Global quality-verified PLSs has increased.

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- The PLS market has witnessed the entry of new players. The overall number of manufacturers selling PLSs in Africa has grown sharply from 20 in 2008 to approximately 80 today, and, in tandem, the number of manufacturers of quality-verified PLSs has also increased—from six in 2010 to 25 currently.
- The size and diversity of players have also changed. Not only have several multinationals signaled their serious and long-term commitment, but also, existing players have transformed from small, social start ups to fully professional and maturing businesses.
- Approximately two-thirds of the major manufacturers supplying lighting products to Africa have their factories and production units based in China and these have accounted for almost 90% of estimated cumulative sales up to 2012.
- In the absence of any clear, winning distribution strategy, PLS suppliers have continued to experiment with different channels by focusing on customizing distribution to specific needs of customer segments within target geographies.

### Frequency of distribution model utilization across surveyed market players

Number of respondents; N = 20 manufacturers



1. Manufacturers reported employing more than one distribution model at the same time, therefore, the total across models does not add to N.

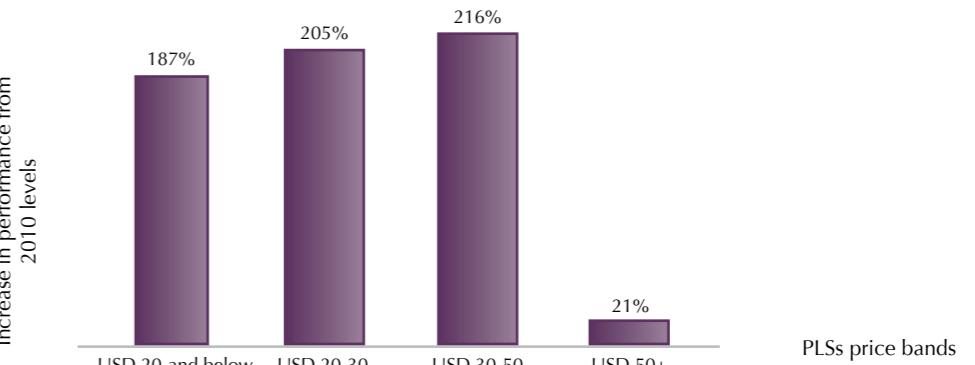
Source: Interviews with manufacturers and distributors; Dalberg analysis

### PLSs offer much greater value to BoP customers than they did two years ago

- The average battery life of a PLS has increased by 20% to approximately six hours in 2012. Similarly, average brightness has increased by 30% to approximately 100 lumens in 2012.
- Average performance of a lantern – measured as a product of light output in lumens and the battery's solar run time – has increased by approximately 140% from 2010; the greatest increases in product performance are seen in mid-priced PLSs.

### Comparison of average performance of PLSs within price bands over time

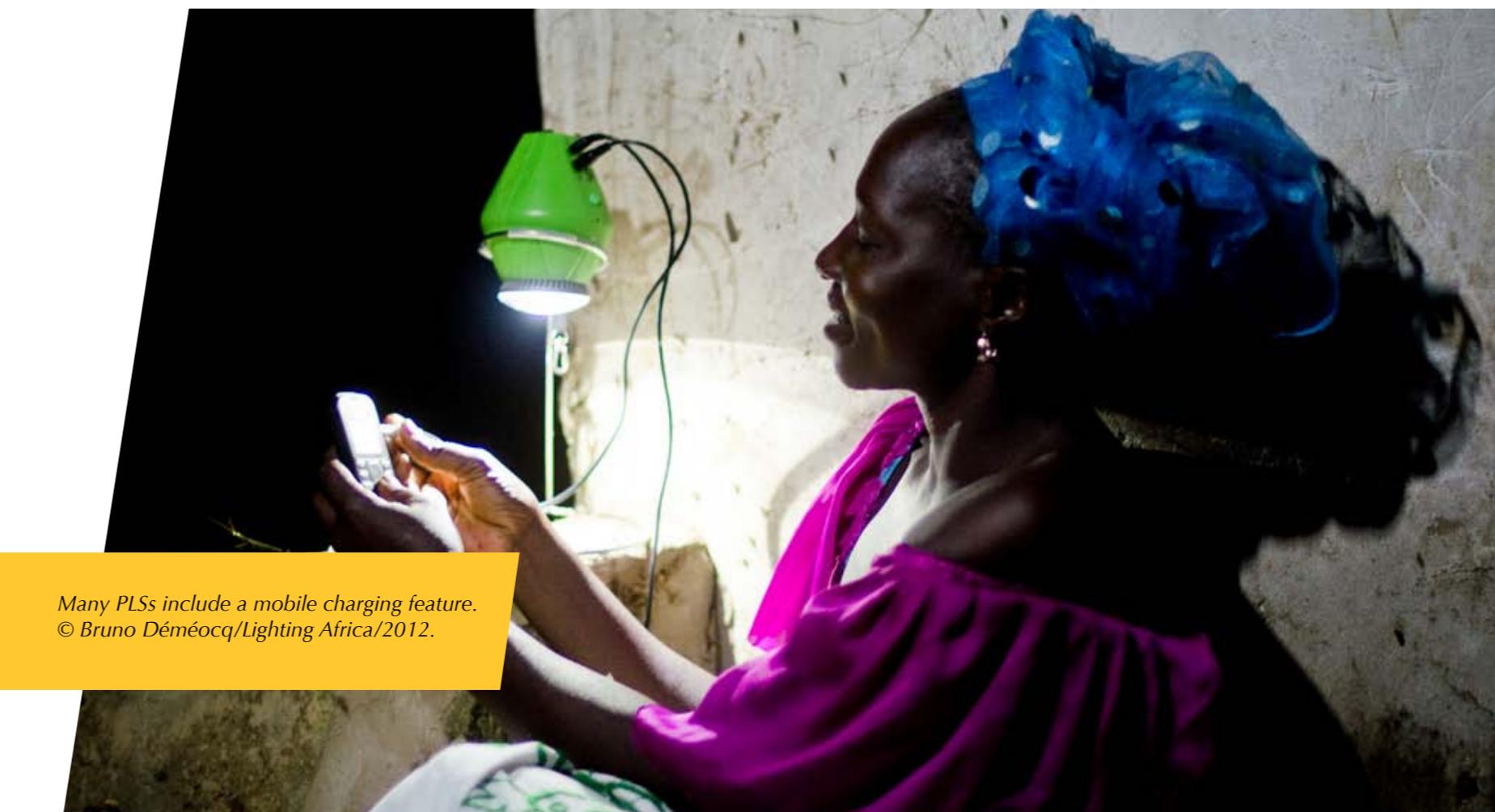
Percentage increase in performance between 2010 and 2012



1. We refer to an increase in the performance per unit price from the baseline of 2010.

Source: Dalberg analysis

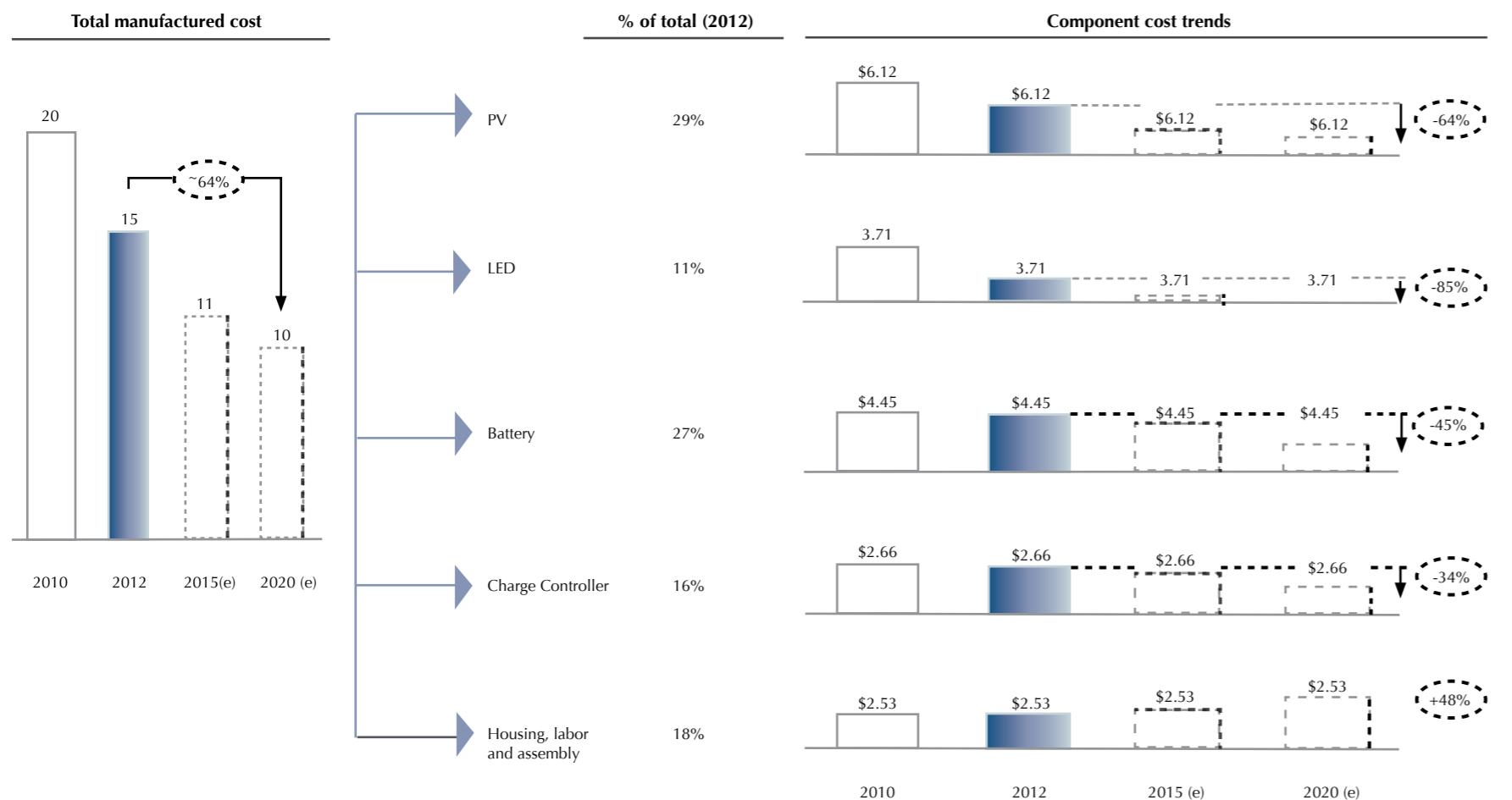
- The ten top-performing PLSs in the African market include two types of players: (1) established brands that have been operating in the African market for at least two to three years and bring a reputation for quality and a history of high sales, and (2) brand new entrants that have been able to bring the latest technologies into the market.



- In addition, the product range has also grown to emphasize consumer-oriented features and design. PLS suppliers are incorporating several value-added features as part of their standard offering to consumers. Mobile phone charging, for example, has become ubiquitous among PLSs. Other well-received and demanded features include charging-effectiveness indicators, a grid-charging option, and a torch mode.

## Decomposition and forecast of the median solar-based PLS component cost

USD; 2010-2020



1. Performance holding constant.

Source: GTM research; Thin Film Industry Forum; IRENA; US Department of Energy; McKinsey Industry reports; Pike Research; Lux Analysis; The Economist; Inter China Consulting Analysis; Interviews with manufacturers and technical experts; Dalberg analysis

- Driven by rapidly declining costs of major components (e.g. PV, LED and battery), the theoretical manufacturing cost (holding performance constant) has reduced by almost 25% from 2010, and is expected to reduce by another ~33% by 2020. Our estimates suggest that the median lantern in 2020 will exhibit twice the battery life and up to five times the brightness of the median PLS in 2012.

Barriers identified by market players have remained generally stable over time. Access to finance, distribution and lack of consumer awareness have consistently been the highest-rated challenges.

## Evolution of market barriers as identified by PLS manufacturers and distributors

Percentage of respondents; 2010-12\*

May 2010: Frequency of citing growth barriers

N = 531



■ Top three

Several interviewees cited more than one barrier, which is why numbers below do not add up to 53. Interviewees represent 65-70% of the quality market

Source: Interviews with manufacturers and distributors; Dalberg analysis

June 2011 and September 2012: Criticality of market barriers

Scale of 1 – 5; N = 37

Scale 1 – 5; N2 = 34



\*the scales for 2010 and 2011/2012 are different, because the methodology used for collecting answers was different in 2010.

- The overriding upstream finance challenge was working capital for distributors attempting to reach remote, off-grid markets. End-user affordability was identified as the major downstream finance bottleneck.
- As the market matures and rural awareness and demand for PLSs increase, we expect distribution patterns and channels to mimic those of other consumer durables in the market such as TVs, fans and pressure cookers. For these products, the majority of rural sales occur at large towns and urban areas retail outlets.
- Consumer awareness among the African BoP for PLSs has improved, but remains low, particularly within remote rural areas. Targeted and effective consumer awareness campaigns, despite their positive impact on consumer willingness to pay, remain difficult to design and expensive to execute. However, as the market matures even further, marketing and advertising will become increasingly important components of product and brand differentiation.

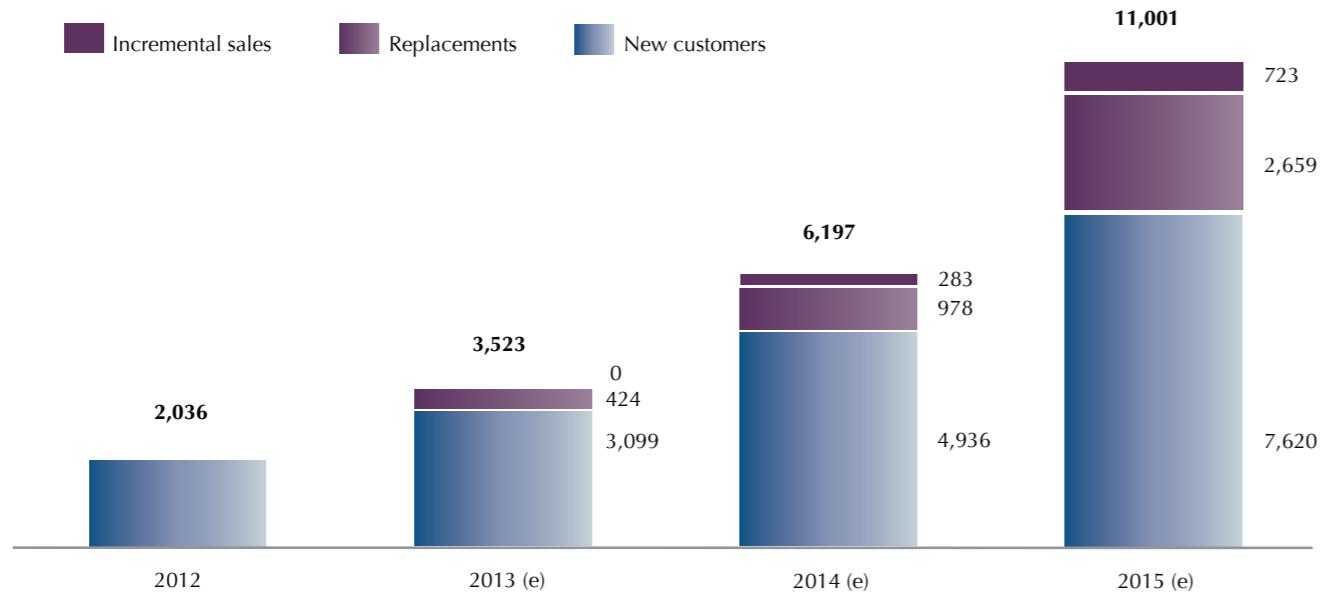
The market for PLSs in Africa remains on a healthy trajectory. Currently, even our most conservative forecasts predict high growth rates over the next two-three years. These forecasts are based on the core macro-drivers including lagging grid growth, expected increase in fuel-based lighting expenditures, growing need for mobile phone charging options, as well as an improving supply of quality products.

In addition, there are several emerging trends that can further accelerate this fast-growing market:

- The market is maturing and has proven itself economically viable, leading to greater interest from global electronic giants such as Schneider Electric, Philips and Energizer. Given their natural scale advantages and established distribution capabilities, a concerted effort by any one of these corporations could drive this market faster and higher.
- We observe the emerging use of technology in 'pay-as-you-go' models to overcome the critical consumer-financing hurdle. PLS companies have begun to incorporate GSM chips and mobile payments as a way of regulating the delivery of light on the basis of micro-payments. This could address a much larger customer-base that is currently severely affordability-constrained.
- We expect the emergence and increased presence of manufacturer-led brands, as opposed to the current market structure of pure manufacturers who focus solely on executing orders to specifications from distributors and branded players. Our conversations with these companies (a significant proportion of which are headquartered in China) indicate a strong inclination to establish a strategic, long-term presence in the African market over the next two to three years with their own branded product.
- Finally, as PLSs become more ubiquitous, manufacturers will see increasing demand from existing customers who have experienced the benefits and are looking to replace, upgrade and extend their PLSs. This aspect of the market could help drive 30% of annual volumes beyond 2015.

#### Evolution of annual sales of PLSs while considering replacements and incremental sales

Thousand PLSs; 2012-15



1. 75% of PLSs replaced every three years;.

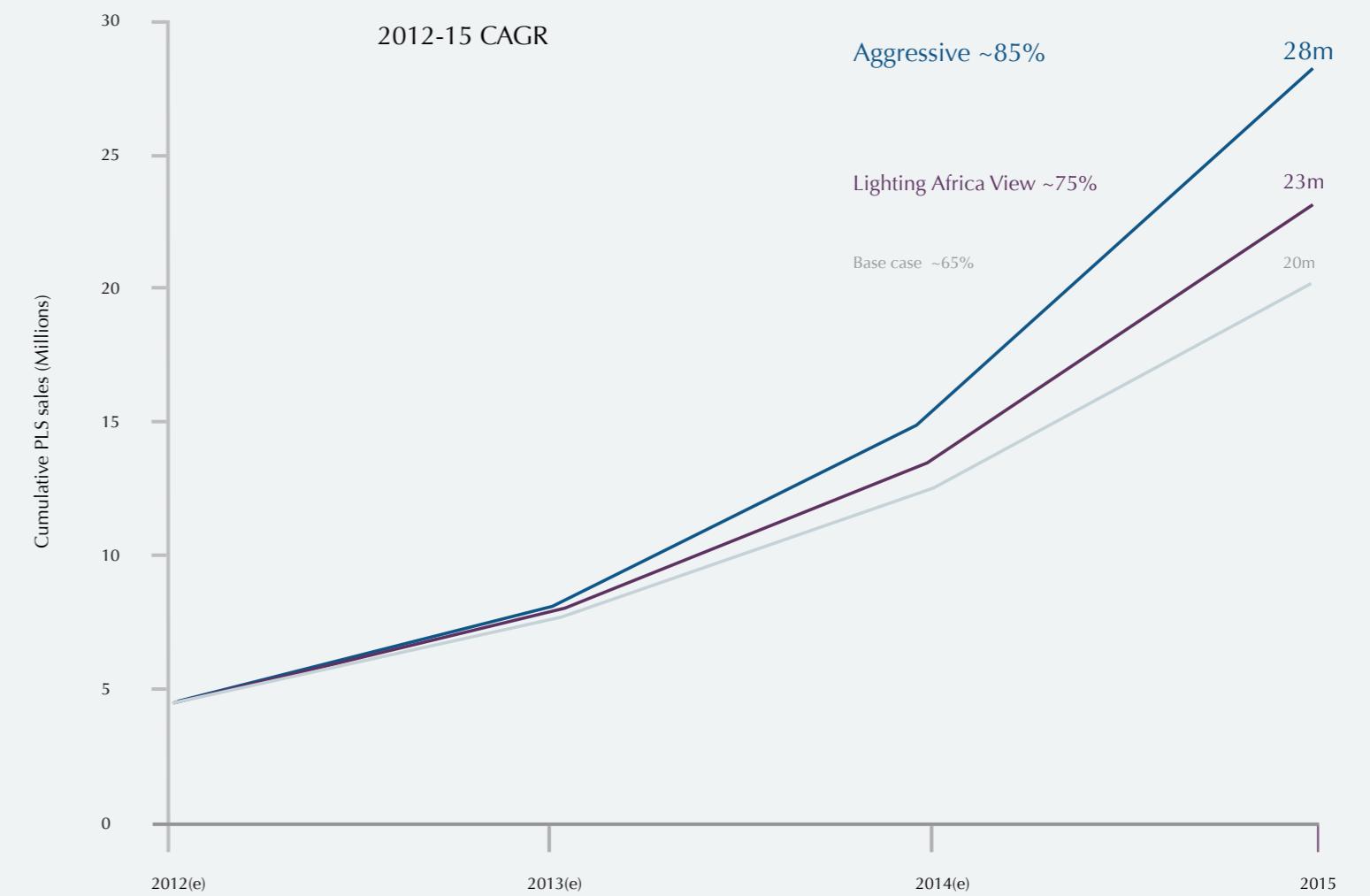
2. 50% of households will purchase an additional PLS every four years.

Source: Lighting Africa sales data; Dalberg analysis

**In the presence of these four catalytic opportunities, the market could reach 5 million in total additional sales by 2015.** This would imply a market growth of approximately 85% between 2012 and 2015, with cumulative sales growing to approximately 28 million PLSs.

#### Forecast of cumulative PLS sales in Africa over time

Million PLSs; 2012-15



Aggressive scenario assumes

- (1) Entry of 2 MNCs;
- (2) Entry of 2 additional manufacturer-led brands;
- (3) High growth of pay-as-you-go models;
- (4) and higher rates of replacement and incremental sales.

Source: Lighting Africa sales data; World bank data set on population; Dalberg analysis

## 1. Introduction

In 2010, when Lighting Africa first released a comprehensive report on the lighting industry, an exciting future was heralded for a product set to revolutionize clean, affordable lighting for low income households. Annual growth rates of more than 85% were predicted under bullish circumstances, accompanied by rapid price drops and performance improvements, leading to a fast relegation of the traditional kerosene lantern to minority status by 2030.

**Two years on, we can report a rapidly maturing market that has transformed and evolved quickly, easily outpacing all expectations.** Faster-than-predicted growth in sales – particularly for Lighting Global quality-verified products – has been accompanied by a sharp decline in price relative to performance. In addition, the value to the end customer, with respect to PLS performance, has improved consistently and substantially since 2010. Other transformational developments in the market have included the entry of a significant number of new manufacturers and suppliers (including several large multinational companies) that drove increased competition and market coverage. The figure below highlights the nature of the market's evolution since 2007 by tracking a few key dimensions.

**Figure 1: Select African off-grid lighting market indicators**

Indicators	2007...	2010...	2012
Total PLSs sold in Africa (cumulative)	170k	1.2 million	3.5 – 4 million
Quality PLS sold (cumulative)	< 2k	176k	~1.4 million
African countries where quality PLSs are sold	3	5-10	20
# of PLS manufacturers globally	10	60+	80+
# of quality-verified manufacturers	0	6	25
PLS price points	USD 25–120	USD 12–100	USD 7–100

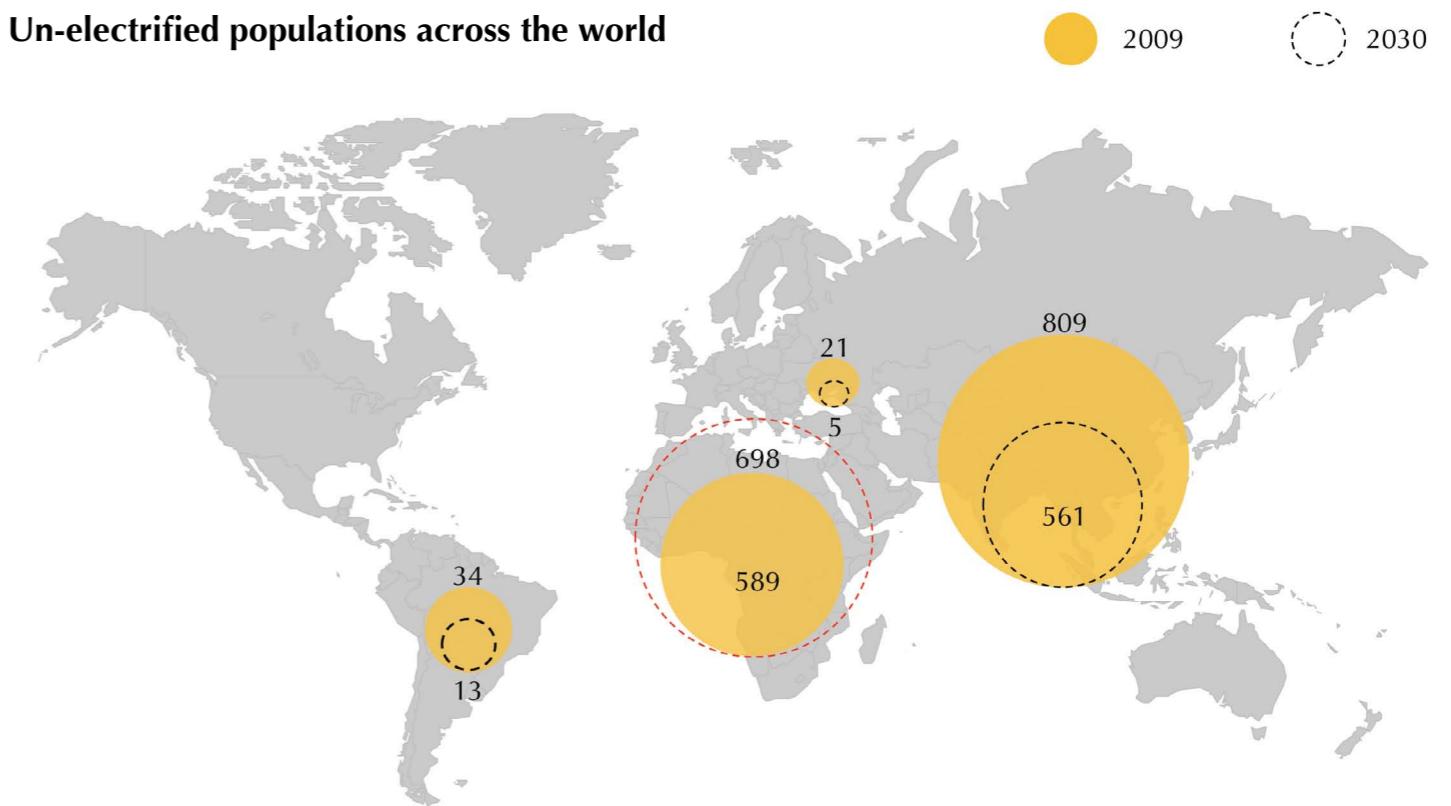
Source: Lighting Africa data; Dalberg analysis

**However, despite this impressive performance, the lighting imperative in Africa remains almost as immediate and urgent as it was two years ago. In some cases, the need has become even more pronounced.** The primary need for off-grid lighting products, driven by poor grid connectivity across Africa, remains critical and is not expected to improve drastically in the future. Africa's grid expansion fails to keep pace with population growth. In fact, by 2030, Africa's un-electrified population is projected to grow to almost 700 million people,

or approximately 140-150 million households (Figure 2). Africa will then have surpassed Asia to become the largest un-electrified market worldwide. This means that, while the lighting need will be material all across the developing world, it will be greatest in Africa in the coming years.

**Figure 2: Un-electrified populations across the world**

Millions



Source: Electricity Access Database (International Energy Agency); Dalberg analysis

At the same time, new evidence on the negative health impact of using kerosene-based lighting products reiterates and further bolsters the case for switching to cleaner alternatives like solar-based lighting products. A recent study by the Lawrence Berkeley National Laboratory of California's Lumina Project surveyed users of kerosene lighting across five Sub-Saharan Africa countries and found up to a fourth of the sampled population have health and safety concerns related to kerosene lighting.<sup>5</sup> Insights from the study included:

- Kerosene combustion products are correlated with higher incidences of diseases like tuberculosis and cataract conditions. For example, researchers found the odds of having tuberculosis in Nepal were more than nine times greater for women using kerosene than those using electric light.
- Unintentional kerosene ingestion is the primary cause of child poisoning reported in most hospital studies. The consequences are severe, including mortality rates ranging from 0% to 25% for those visiting hospitals. In South Africa alone, almost 80,000 children in 3.6% of all households unintentionally ingest kerosene every year. Almost 60% of these children then develop chemically-induced pneumonia.

<sup>5</sup> 'Health impacts of fuel-based lighting,' Evan Mills, Lawrence Berkeley National Laboratory, University of California (2012). <http://light.lbl.gov/pubs/tr/lumina-tr10-summary.html>



- Fuel-based lighting is a significant cause of structural fires and severe burn injuries, with particularly high death rates (24% on average) in cases where kerosene is adulterated with other fuels, resulting in explosions.

Kerosene lighting also generates black carbon particulates that contribute to global climate change. Prior estimates of the climate impact of kerosene lighting that have focused exclusively on carbon dioxide emissions have understated the climate impact by a substantial margin. When black carbon emissions are considered, the climate impact is five to 15 times larger (Lam, et al., 2012; Jacobson, et al., 2013)<sup>6</sup>.

**Moreover, despite the rapid transformation experienced by the market, the penetration of these modern solar lighting devices is still low across Africa. There remains significant scope and potential for continued, robust market growth and transformation.** Important market barriers such as access to finance for distributors and retailers, end-user affordability, low levels of consumer awareness, etc. continue to impede faster market growth and scale. In addition, market structures – such as the Global Off-Grid Lighting Association (GOGLA), among others – are still at a nascent stage and will rely on close collaboration with supporting donors, development organizations, non-governmental organizations (NGOs), etc. for at least the next three to five years.

**The following sections highlight the important market trends and developments, especially the evolution since 2010.** Sections 2, 3 and 4 focus on detailing product and performance transformations, defining the state of the current market, and tracing the path of PLS production economics. Section 5 discusses the key market barriers, the interventions used (successfully and unsuccessfully) thus far to tackle those barriers, and the major lessons learned.

Finally, in section 6, the report shares its perspectives on the most important trends that are likely to influence market transformation going forward, and potentially help unleash an even faster period of growth in the coming years.

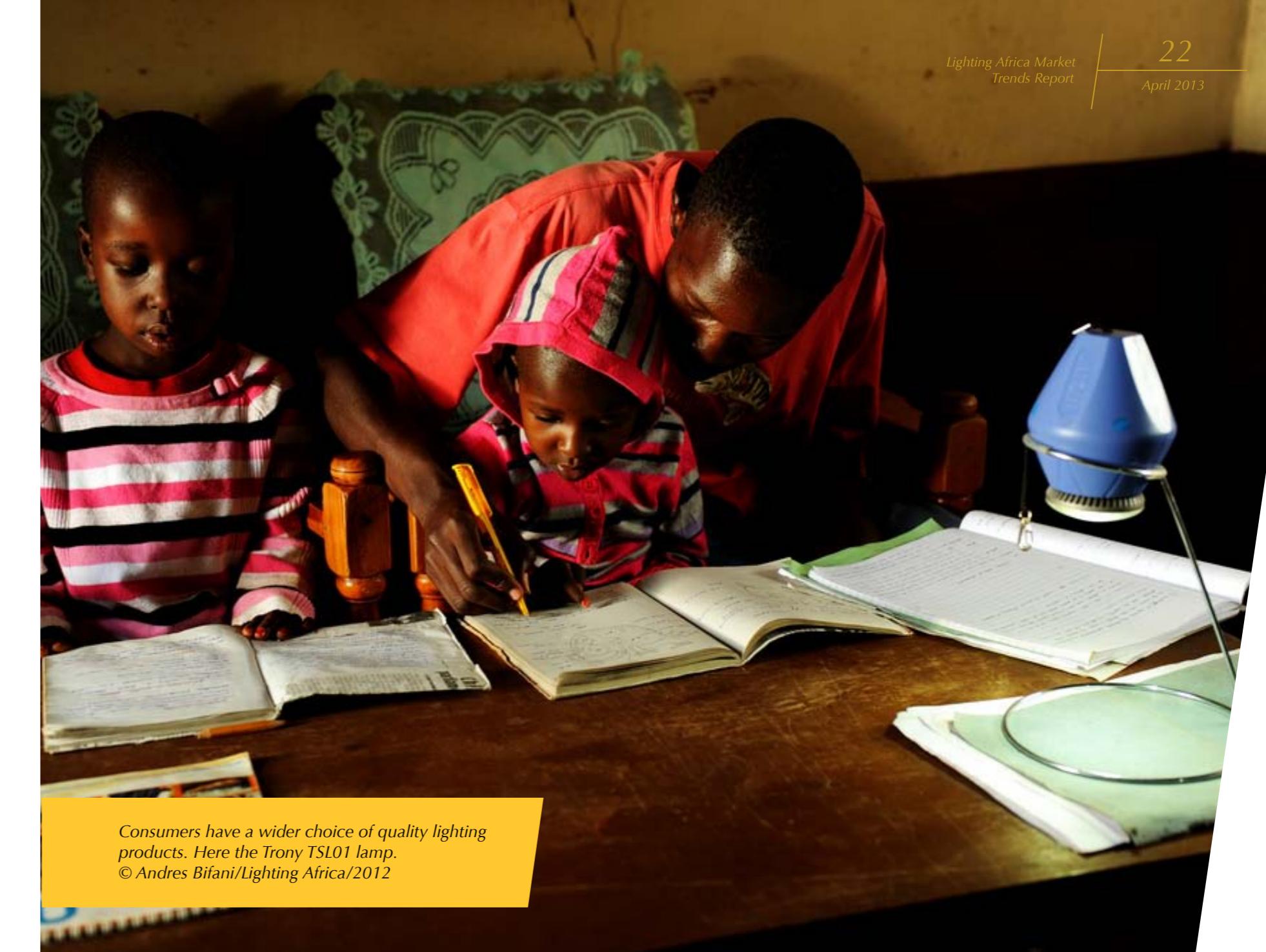
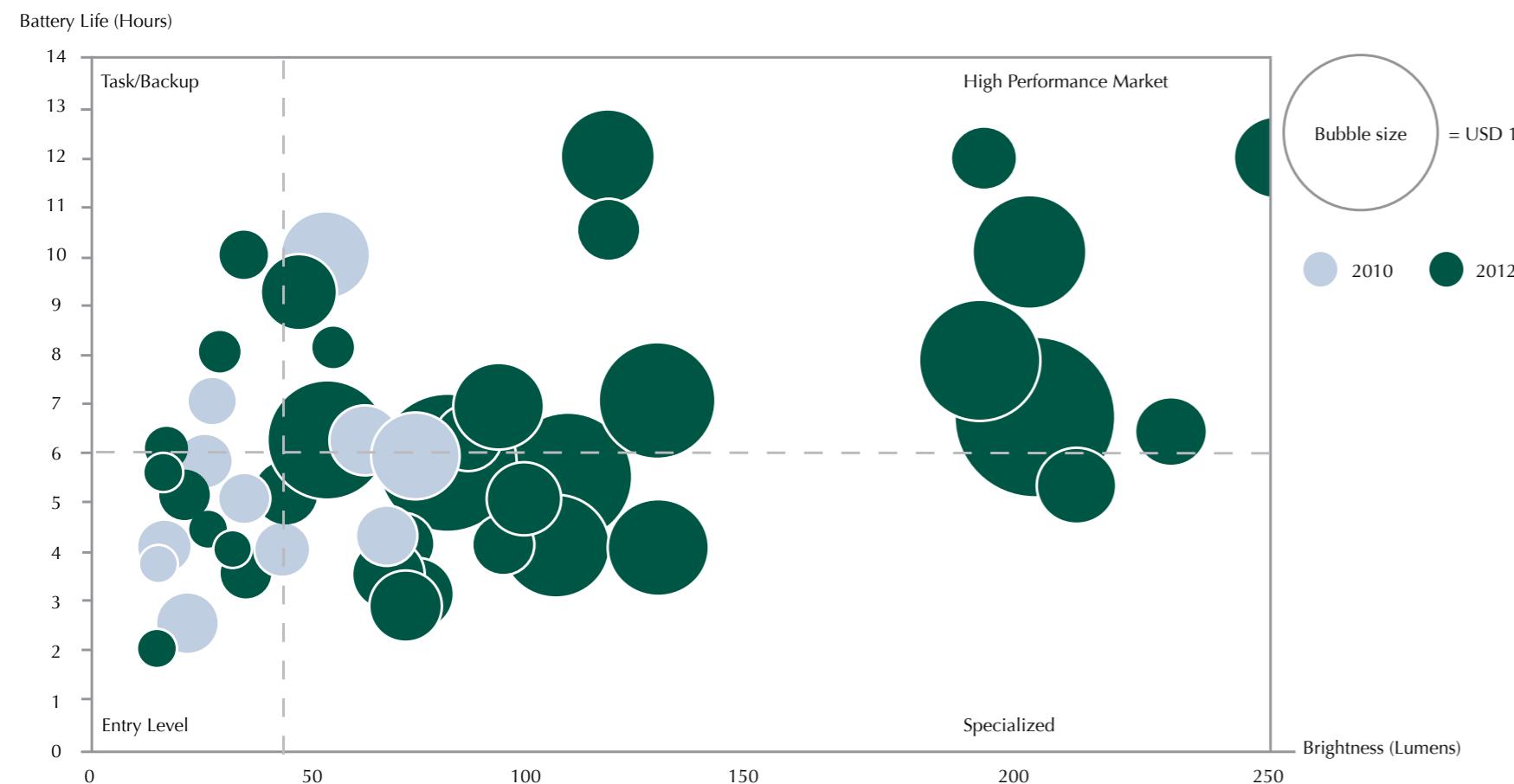
<sup>6</sup> Jacobson, A.; Lam N.L.; Bond, T.C.; Hultman, N. (2013) 'Black Carbon and Kerosene Lighting: An Opportunity for Rapid Action on Climate Change and Clean Energy for Development', The Brookings Institute, Global Views #41. <http://www.brookings.edu/research/papers/2013/04/climate-change-clean-energy-development-hultman>  
Lam, N. L.; Chen, Y.; Weyant, C.; Venkataraman, C.; Sadavarte, P.; Johnson, M. A.; Smith, K. R.; Brem, B. T.; Arineitwe, J.; Ellis, J. E.; Bond, T. C., (2012) 'Household Light Makes Global Heat: High Black Carbon Emissions From Kerosene Wick Lamps', Environmental Science & Technology , 46, (24), 13531- 13538.

## 2. Product and performance

The PLS product set<sup>7</sup> has substantially diversified since 2010 with current models exhibiting a significantly broader range of performance. Figure 3 below outlines the evolution of the product set between 2010 and 2012 based on battery life, lumens and PLS price. Different product categories include task/back up, performance, entry level in the market, and specialization. The segmentation criteria employed are maintained from the 2010 report in order to facilitate an easy comparison of product performance over the last two years.

**Figure 3: Evolution of PLS performance over time**

Light output in lumens; typical battery life in hours; PLS price in USD



The quantity and diversity of PLS products present in the overall market have increased significantly since 2010. The PLS product set in 2012 is, in general, differentiated with respect to price and performance, in order to cater to specialized needs of different customer segments.

<sup>7</sup> Survey of 12 products in 2010 and 38 products in 2012 that were sold in the African PLS market, and for which price information was available.

Source: Lighting Africa data; Internet research; Dalberg analysis

**Across all PLSs, performance levels have dramatically improved in the past two years.** The average battery life of a PLS<sup>8</sup> has increased by 20% to approximately six hours in 2012. Similarly, average brightness has increased by 30% to approximately 100 lumens in 2012. Accordingly, a greater share of products now falls in the high performance segment<sup>9</sup>—rising from less than 10% of the sample set in 2010 to about 35% in 2012.

<sup>7</sup> We only refer to Lighting Global quality-verified products for which pricing information is available.

<sup>8</sup> Battery life, or the battery's solar run time, is the number of hours a product can be used after a full day of solar charging. Note that hours of use are defined by the time it takes for the light output to drop to 70% of its initial value.

<sup>9</sup> As defined in 'Solar Lighting for the Base of the Pyramid: Overview of an Emerging Market', Lighting Africa (2010).

## Measuring PLS performance

**PLS PERFORMANCE = LIGHT OUTPUT (LUMENS) X BATTERY LIFE (HOURS),** where battery life refers to the number of hours a lighting device can be used after one full day of charging.

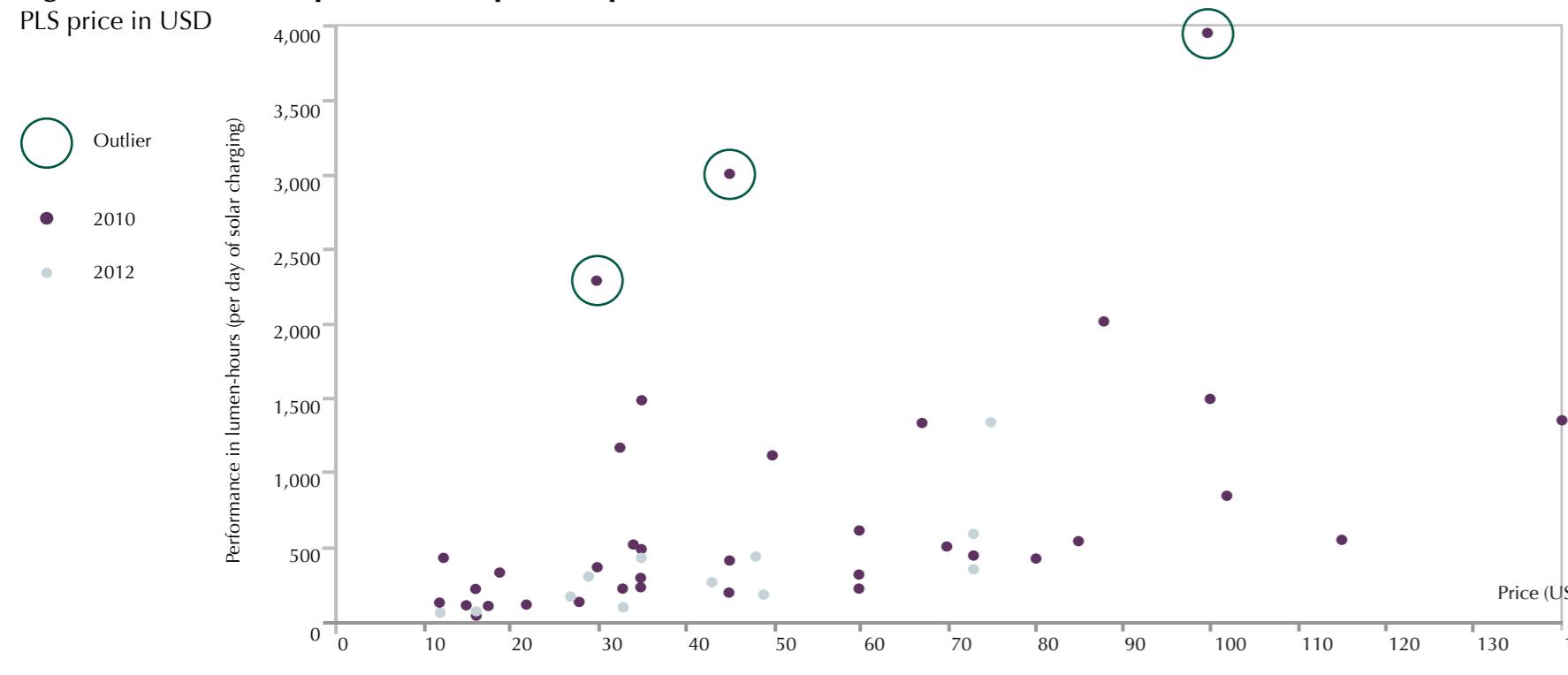
Source: Lighting Africa; Dalberg analysis.

A closer analysis of PLS performance reveals three notable trends:

- **First, clear outliers are emerging in terms of performance among products in a given price range (Figure 4 below).**<sup>10</sup> Although the number of PLS products and brands in Africa have increased substantially in the past two years, the vast majority of these remain inaccessible to the average customer. Poor distribution, particularly at the last mile, means that the target customer faces limited choices at any particular point-of-sale. This is evidence that the market for African PLSs is not yet functioning in a fully competitive manner. Consumers do not yet have the awareness, capacity or opportunity to effectively distinguish among similarly priced products that perform at different levels. However, with greater maturity and competitiveness in the market, we expect these outliers to ultimately dominate sales of PLSs.

Analysis of preliminary sales data from Lighting Africa shows that, on average, higher-performance PLSs outsell lower-performance PLSs. Again, however, the existence of a few significant outliers tends to indicate that customers' options remain constrained and are largely dependent on the ability of marketing and distribution channels to push PLSs of different prices and performance levels.

**Figure 4: Evolution of performance per unit price of PLSs**

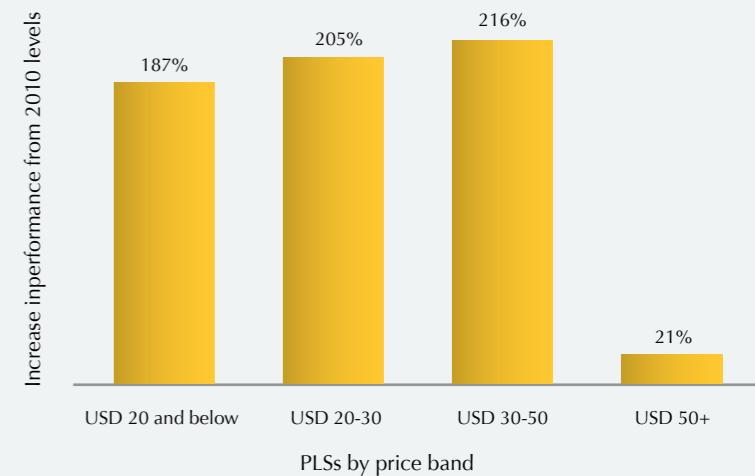


<sup>10</sup> The Dalberg PLS performance metric is a product of light output in lumens and battery's solar run time.

- **Second, the greatest increases in product performance are seen in mid-priced PLSs.** Across the PLS product range, average performance levels have increased by approximately 140% from 2010, as shown below. All products below USD 50 largely drive this increase, more specifically, mid-priced PLSs in the USD 20-30 and USD 30-50 range, whose performance levels have more than quadrupled in the past two years.

**Figure 5: Comparison of average performance of PLSs within price bands over time**

Percentage increase in performance since 2010



1. We refer to an increase in the performance per unit price from the baseline of 2010.

Source: Dalberg analysis

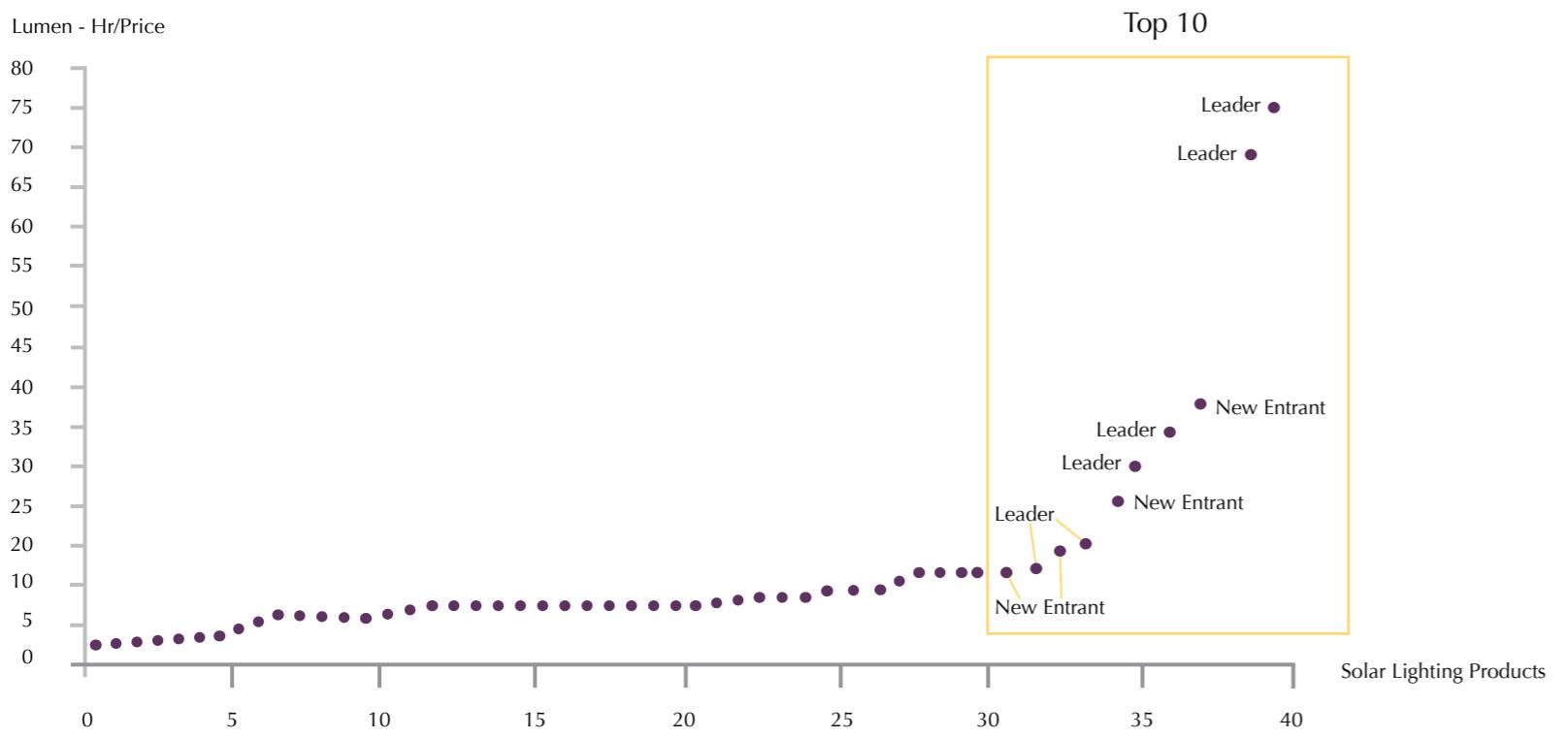
While the value of PLSs to consumers has increased across all products since 2010, when products are compared by the metric of performance per unit price (lumen-hour/USD), products in the USD 20-50 range currently offer customers the greatest value for money.



- Third, a group of clear ‘winners’, or market leaders, is materializing.** Examination of the nature and mix of the PLS performance curve reveals that the group of the ten top-performing PLSs in the African market primarily comprises two types of players: (1) established brands that have operated in the African market for at least two to three years and bring a reputation for quality and a history of high sales (2) new entrants to the market who have the desire to mimic growth experienced by established market leaders, combined with the ability and capacity to leapfrog advances in manufacturing and (3) new entrants to the market with innovative technologies that by far exceed those already in the market place.

**Figure 6: Ranked performance per unit price for PLSs**

Performance in lumen-hour/USD



1. Survey of 12 products in 2010 and 38 products in 2012 that were sold in the African PLS market, and for which price information was available.

Source: *Lighting Africa data; Internet research; Dalberg analysis*

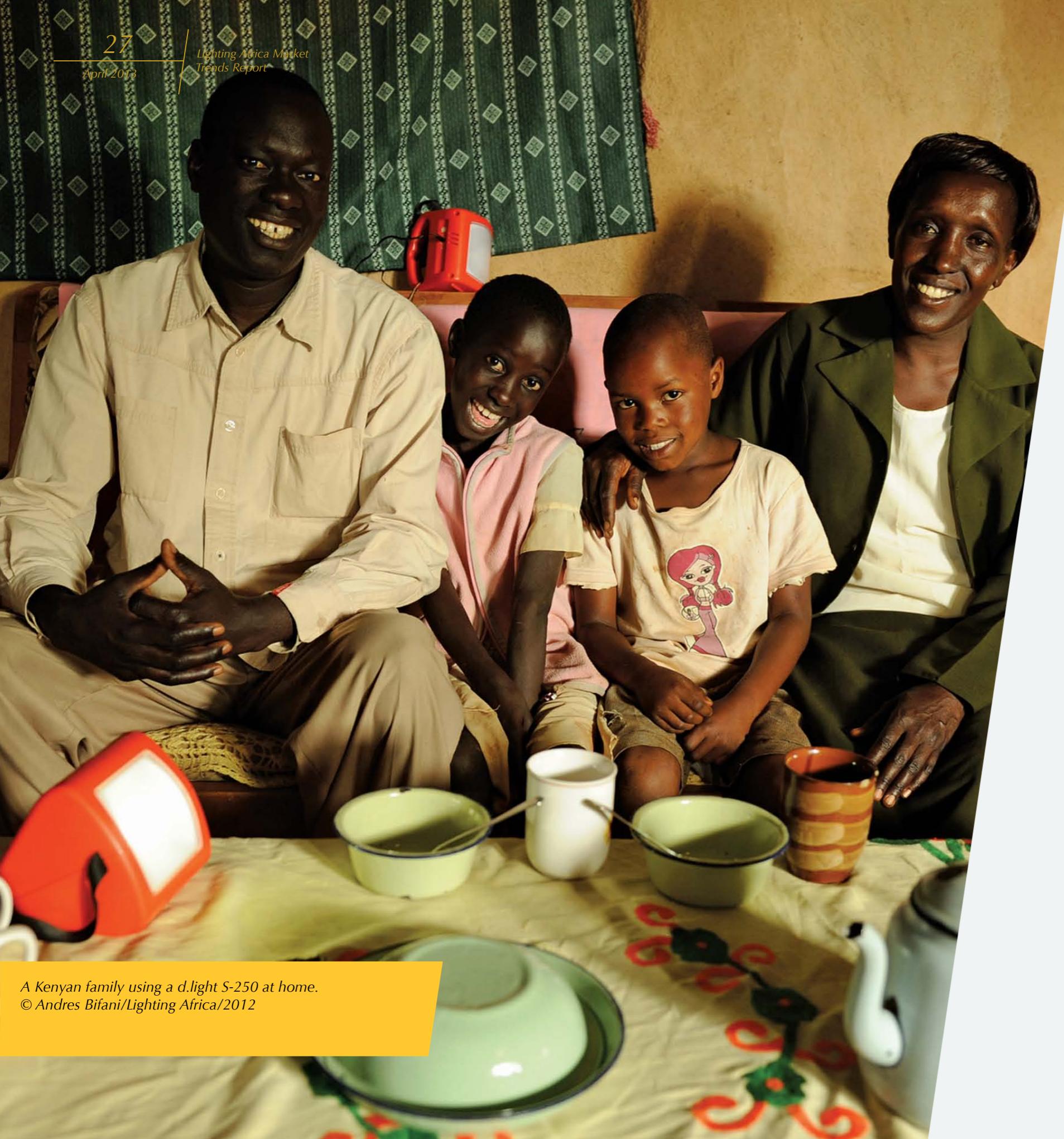
**In addition, the product range has also grown to emphasize consumer-oriented features and design.** In 2010, we noted that PLSs were beginning to be marketed as viable commercial products, whereas previously they were promoted by non-governmental organizations (NGOs) and through corporate social responsibility (CSR) campaigns. This transition was accompanied by the emergence of features and

innovative design elements meant to satisfy consumers’ specific needs and increase their overall economic benefit. The most popular additional features include varying brightness levels, various mounting options, multiple charging abilities, pay-as-you-go options and mobile phone charging. As illustrated in Figure 7, a survey of quality-tested products reveals that this trend has continued to intensify and expand in the past two years. Now, PLS suppliers are incorporating several of the value-added features mentioned above as part of their standard offering to consumers as well as incorporating new features. Mobile phone charging, for example, has become ubiquitous among PLSs—so much so that suppliers have received feedback that PLSs without mobile charging are viewed as sub-standard or poor quality products. The charging effectiveness indicator (which enables consumers to maximize PV charging) is a fairly recent but popular addition to the PLS feature set and is already incorporated in more than a fifth of all quality-tested products.

**Figure 7: Consumer-oriented design features in PLSs**

Feature	Rationale for feature	% of quality PLSs with feature (2012 estimates)
Mobile charging	Saves time and money by charging mobile phones	55%
Grid / alternative charging	Charges PLS battery using grid or alternative sources (crank, car...)	37%
Multiple brightness levels	More efficient and customized use of light; prolongs battery life	34%
Torch mode	Focuses light for longer distances	16%
Charging effectiveness indicator	Increases ease of use, and improves PLS performance significantly	21%
Wall mounting	Flexibility of use by mounting as a ceiling light, reading light, torch, etc	21%
Battery level indicator	Prevents over-discharge and alerts user when charge complete	16%

Source: Database of Lighting Global quality-verified PLSs in 2010 and 2012; Interviews and desk research; Dalberg analysis



A Kenyan family using a d.light S-250 at home.

© Andres Bifani/Lighting Africa/2012

### 3. Current market status

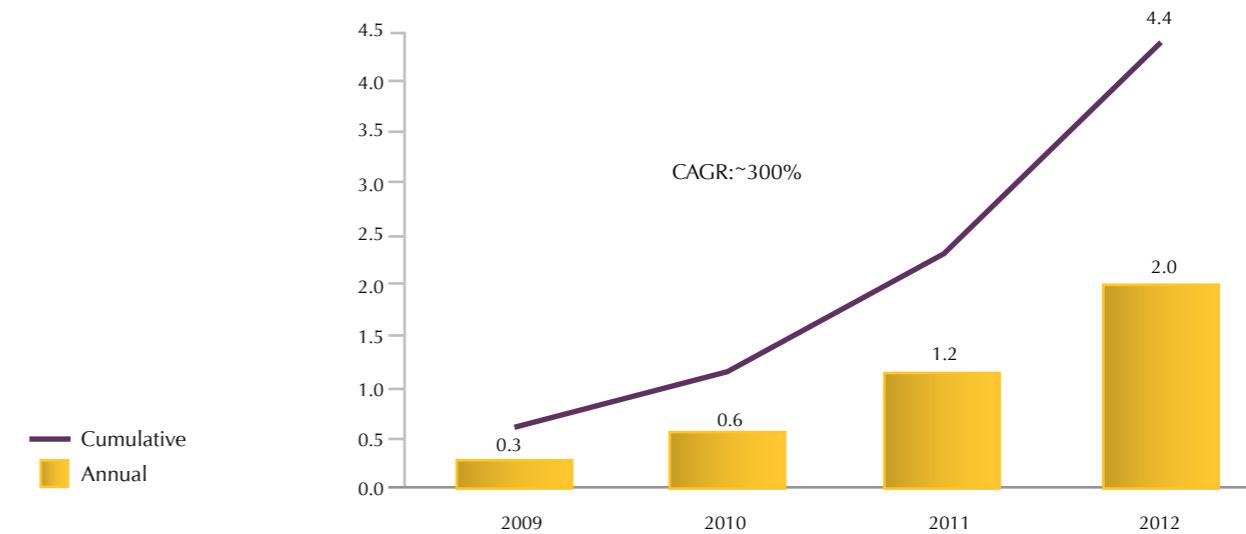
#### Demand

The market for lighting products in Africa has witnessed approximately 90-95% growth in cumulative sales since 2009. The lighting product market is relatively nascent, and as such, data is scant, making it difficult to make accurate growth projections. Our estimates are based on approximate sales data reported during interviews with manufacturers and distributors, who represent more than 65-70% of the good quality PLS market, as well as on historical sales data collected by Lighting Africa.

These sources indicate that since 2009, the market in Africa has experienced dramatic growth—starting from approximately 300,000 lighting products in Africa in 2009, overall annual sales effectively doubled each year, causing the sale of approximately 4.4 million units by the end of 2012. Given that thus far sales have been largely limited to households<sup>11</sup>, we believe that almost 20 million African people have now gained access to safe and cost effective, off-grid lighting products.

**Figure 8: PLS sales in Africa over time**

Million PLSs; 2009-2012



1. Numbers do not account for the availability of primarily battery-powered torches in the USD 1-5 price range. Based on Lighting Africa consumer surveys these are available to at least 10-15% of African households; a substantial share of these products now utilize LED technologies.

Source: Lighting Africa data; Dalberg analysis

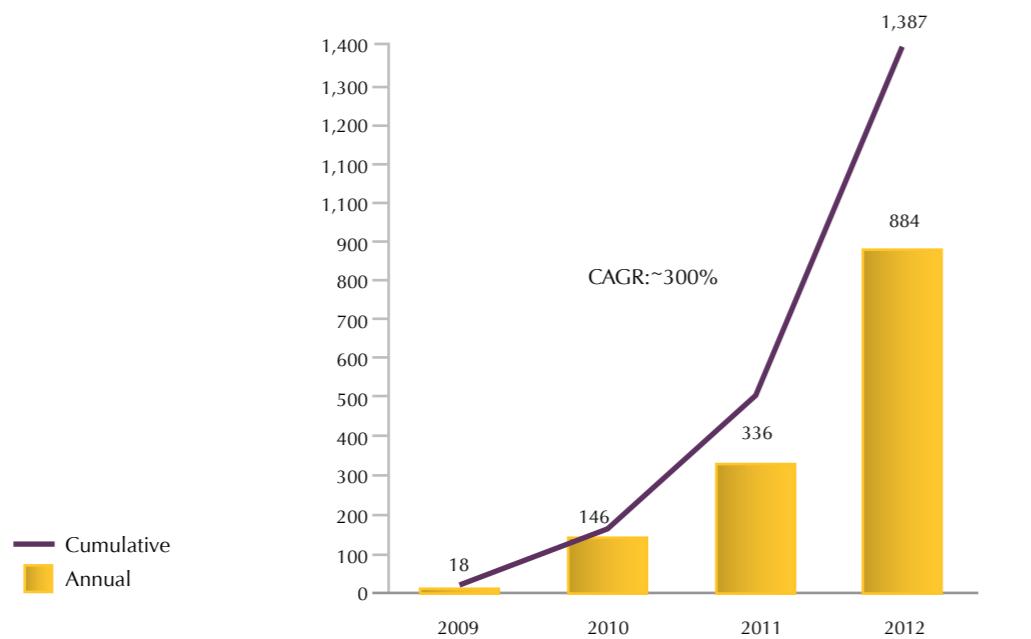
<sup>11</sup> Interviews with market experts.

Interviewed manufacturers unanimously reported a substantial rise in visibility and demand for lighting products in Africa since 2010. Most manufacturers of lighting products that have passed Lighting Global's minimum quality standards reported annual company sales growth in the range of 100-300%. Their own estimates on the overall PLS market growth (products that passed Lighting Global quality standards as well as those that did not) were between 70-100% in annual sales per year.

We expect even more accelerated growth rates in the next two-three years driven by repeat sales (either to replace or supplement existing lighting units) to existing customers, and back-up lighting sales to on-grid customers that have thus far remained low.

**Figure 9: Cumulative sales of Lighting Global quality-verified PLSs in Africa**

Thousand PLSs; 2009-12



Source: Lighting Africa sales data (Q4 2012 update); Dalberg analysis

**Sales of quality-verified PLSs have grown by 300%.** PLSs in the African market can be segmented into two broad categories: PLSs that have passed Lighting Global's minimum quality standards and those that have not<sup>12</sup>. The high sales volume of quality-verified PLSs is emerging evidence of an evolving consumer base that is becoming more experienced and preferential of quality products. Self-reported sales data from quality-verified manufacturers indicates that there were close to 1.4 million quality-verified PLSs in the African market by Q4 2012, with cumulative sales crossing the 1 million mark in Q3-Q4 2012. According to our best estimates, this represented more than a quarter of the total number of lighting products<sup>13</sup> in the market today.

<sup>12</sup> Quality-verified PLSs are those products that have met Lighting Global's recommended performance targets and/or passed its minimum quality standards.

<sup>13</sup> Refers only to the types of pico-powered lighting systems that are specified in the scope section of this report.

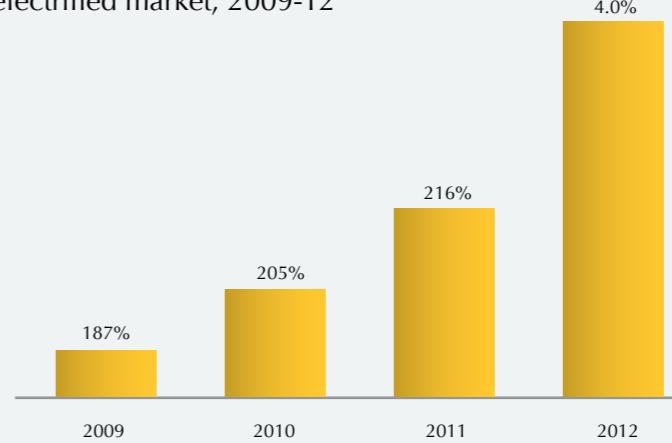
It is noteworthy that several distributors reported up to three months of stock out per year, due to a combination of financial and logistical challenges such as long lead times. This limited growth in the African PLS market. Assuming sufficient latent demand in the PLS market, it is likely that sales could have grown at an even more impressive pace than reported above. For example, while annual sales of Lighting Global-verified PLSs touched 880,000 by the end of 2012, we estimate that the continuous availability of stocks could have raised that to approximately 1.2-1.3 million units.

**Despite rapid sales growth, overall market penetration remains low across Africa.** Current penetration of PLSs in Africa's 115-120 million off-grid households is estimated to be between 3.5-4% (by end-2012), assuming the vast majority of lighting products have been sold to households. Of course, as noted above, even this 4% of the market remains unsaturated, and represents a significant future opportunity for repeat sales.

The penetration numbers imply that almost 100-110 million off-grid households in Africa are still dependent on traditional alternatives like kerosene lamps, candles and batteries as their primary lighting source. Thus, the off-grid lighting opportunity in Africa is vast, and the PLS market is expected to remain very attractive over the next five to ten years.

**Figure 10: Market penetration of PLSs**

Percentage of total off-grid and under electrified market; 2009-12



- Analysis assumes a base of 110-120 million off-grid households (2008-2015); Assumes one PLS per household.
- Penetration numbers do not account for the availability of primarily battery-powered torches in the USD 1-5 price range.
- Penetration is representative of 'best-case-scenario', and does not take into account replacement or incremental sales.

Source: Lighting Africa sales data; World bank population and grid connectivity data; Dalberg analysis

**Penetration of PLSs across African geographies is uneven.** The extent to which PLSs are available in African countries is not solely driven by market need or potential. Instead, it appears that the ease of doing business within a country is also an important market driver. For example, more mature markets, like Kenya and Tanzania, have greater rural connectivity and policy environments that recognize the imperative for off-grid lighting. However, countries such as Nigeria, Ethiopia, and Cameroon represent new markets that have low consumer awareness of lighting products and a challenging regulatory environment—especially in regard to taxes, tariffs and entrepreneurialism.



**Figure 11: Sales of Lighting Global quality-verified PLSs by price**

Percentage of cumulative PLS sales (2009 – 2012)

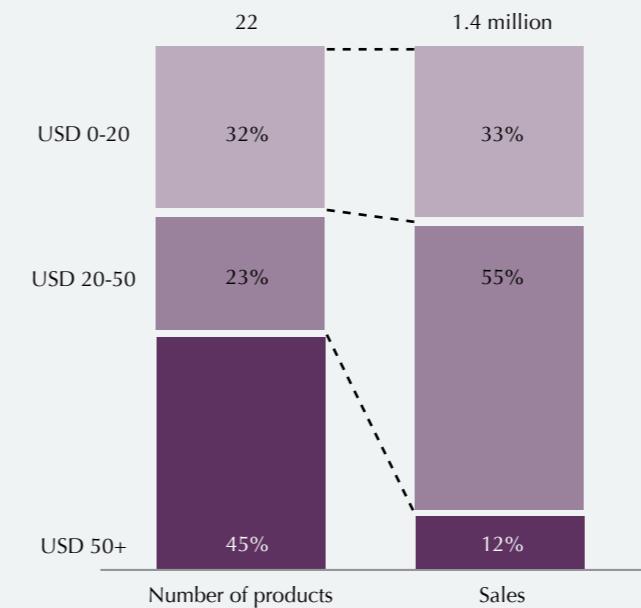


Figure 11 shows that quality-verified products that are priced at USD 50 or below have sold the most over time, accounting for almost 90% of all cumulative sales up to 2012. Higher-priced PLSs, in the USD 50 and above range, comprise only 12% of total sales. This underscores BoP consumers' price sensitivity. However, they do climb up the energy ladder and buy higher-priced PLSs as they gain confidence in the technology, use their savings and tap into financing. It should be noted that sales of small, battery-powered LED/CFL devices in the USD 1-5 price range have not been included in our analysis. Anecdotal evidence and estimates by market experts suggest that cumulative sales of these types of products, which have existed in the market for close to three decades, run into the multi-million units.

Source: Lighting Africa sales data for Kenya (2009-2012);  
Dalberg interviews and analysis

## Key market drivers

The key market driving trends identified in 2010 have generally held true, and in some cases intensified. These are discussed below.

- Lagging grid growth: Across Africa, grid access continues to lag behind population growth rates, implying a growing off-grid population over time, and hence, a growing need for off-grid lighting solutions.
- Mobile charging: With an estimated 735 million mobile phone subscribers in Africa in mid-2012, including at least 175 million not connected to the grid, the need for off-grid charging solutions is growing. As noted in 2010, the increase in mobile subscribers has continued to supersede grid growth in Africa with the number of off-grid mobile phone subscribers expected to reach 400 million by 2015. These customers face serious challenges, travelling several kilometers (often on foot) up to three times a week in order to charge their phones for a fee (usually USD 0.50-USD 3). Therefore, this segment of the African population represents a significant opportunity for market growth, for PLSs offering mobile phone charging facilities.
- Large and growing expenditure on lighting: Our estimates, shown in Figure 12, indicate that the African BoP spent between USD 13.2-17.3 billion annually on non-renewable, fuel-based lighting (including expenditures on kerosene, batteries, and candles)<sup>14</sup> in 2012. Off-grid households account for USD 10.5-14 billion, or about 80%, of the total lighting expenditure, with spending by under-electrified households and SMEs accounting for the remaining 20%. Kerosene remains the most important lighting fuel for off-grid and under-electrified households and SMEs in Africa and accounts for approximately 55% of the total BoP lighting expenditure.

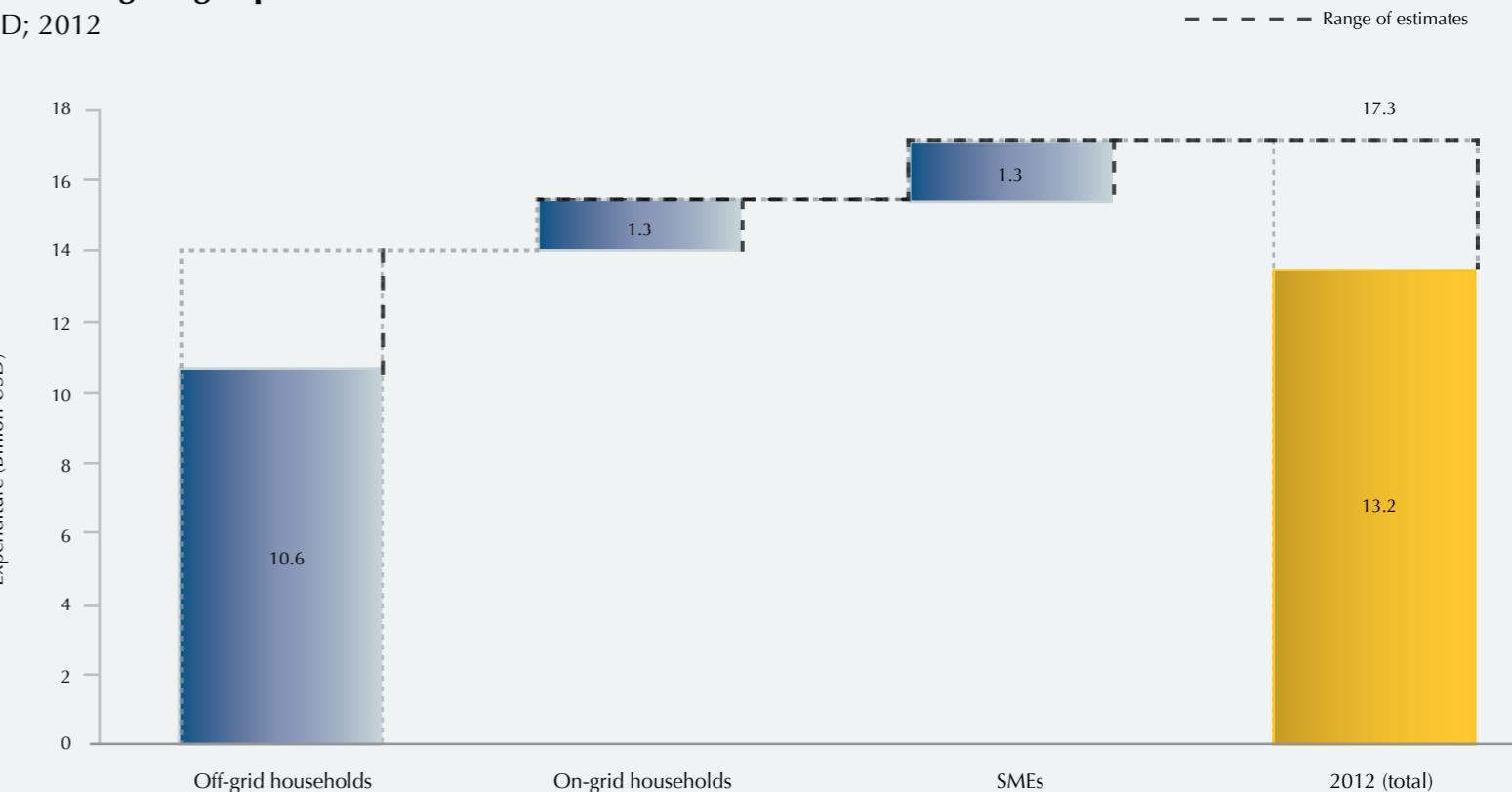
<sup>14</sup> In a recently released study from the United Nations Environmental Program (UNEP), African consumers are estimated to spend between USD 12-17 billion per year on fuel-based lighting ([www.unep.org](http://www.unep.org)). Clearly, UNEP's estimates are well-aligned with the estimates presented in this report at the regional level. However, it must be noted that country-level estimates could differ significantly, given different methodologies and access to different sets of data.



Unfortunately, it is difficult to make a like-for-like comparison between the current level of BoP lighting expenditure and previous years' estimates (such as our 2010 estimate), primarily because the data sets underlying these estimates are not entirely aligned, as data sources are inevitably changed or updated. However, nominally, BoP lighting expenditure has increased by approximately USD 3-7 billion between 2009 and end of 2012, driven primarily by a still-growing off-grid population and an almost across-the-board increase in real kerosene prices throughout Africa.

**Figure 12: BoP lighting expenditure in Africa**

Billion USD; 2012



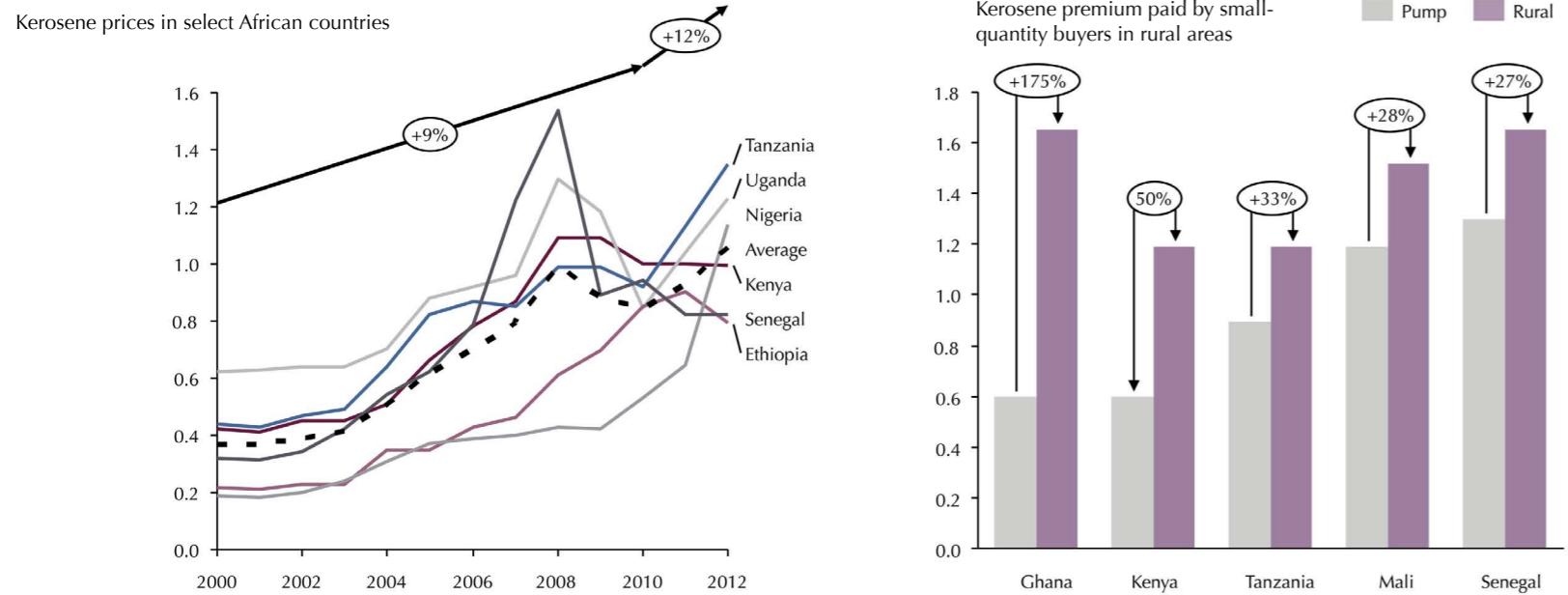
1. Includes estimated expenditure on kerosene, batteries, candles and bio-fuel; the higher range of the estimate assumed higher kerosene usage among primary and secondary users, and higher secondary usage of battery-powered devices and candles.
2. Our estimate took into account population segments that paid a kerosene premium for buying the fuel in small quantities.
3. The average price of kerosene across Africa was estimated to be approximately USD 1.13 per liter.

Source: Primary data from the World Bank and the Asian Development Bank; Dalberg analysis.

The importance of kerosene as a fuel source for lighting, especially in East Africa has two implications for future BoP lighting expenditure. First, emerging data from field studies conducted in five African countries<sup>15</sup> indicate that people buying kerosene in small quantities (primarily in rural areas) have to pay, on average, a premium of approximately 46% relative to their urban counterparts who tend to buy in larger quantities.<sup>16</sup> Therefore, households dependent on kerosene-based lighting in rural areas will continue to be doubly disadvantaged since they generally earn less than urban residents but end up paying significantly more for their lighting needs. Second, based on historical price trends, we expect the price of kerosene to continue rising in the next three to five years at a nominal rate of 12% or an inflation-adjusted rate of 3-5% annually, further driving up overall BoP lighting expenditure in the continent. Clearly, this will bolster the economic case for switching to cleaner, more modern alternatives such as solar lights, and eventually increase the adoption of these solutions, which are at once more cost effective and better-performing.

15 'The True Cost of Kerosene', Lighting Africa (2012)

16 The 'average' premium reported in the above mentioned Lighting Africa report was 35%. We used the size of the un-electrified population in each of the surveyed countries to come up with a weighted-average premium for our estimates, which was 46%.

**Figure 13: Drivers of increased off-grid lighting expenditure in Africa**

1. Average inflation rate in Africa in this period has been 6-8%; real kerosene prices have been rising by approximately 3-4% annually across Africa.

Source: World Bank kerosene price data; Country-specific media reports; 'The True Cost of Kerosene' Lighting Africa (2012); Dalberg research and analysis

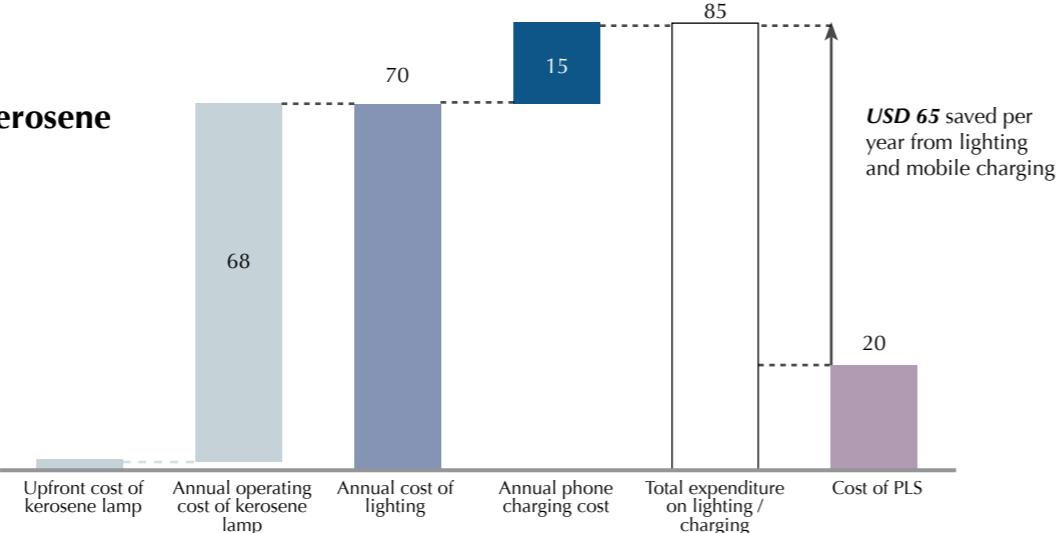
At current prices, households dependent on non-renewable, fuel-based lighting can spend between 70 and 110 USD annually, or approximately between 2 and 5% of their annual household income on their lighting needs; more than 90% of this goes toward ongoing expenditures on fuels like kerosene and disposable batteries for torches. In addition, if we take into account a related and increasingly more common BoP expenditure – charging mobile phones – our estimates suggest that the average off-grid household will spend another USD 15 annually. Cumulatively, this brings total household expenditure on lighting and charging to approximately USD 85 per year. As shown in Figure 14, the use of PLSs for lighting as well as for mobile charging could produce, on average, household savings of approximately USD 65 per year. A greater consumer understanding of the significant economic savings available by the use of PLSs will, in turn, further demand for these products.

**Figure 14: Annual household expenditure on kerosene and mobile charging vs. expenditure on PLS**

USD per year

1. Kerosene assumptions: six hours of usage of kerosene lamp per day; average kerosene price of USD 1.13/liter.
2. Mobile charging assumptions: estimates the charging patterns for the average off-grid user (with at least some access to electricity).
3. PLS assumptions: median entry-level PLS is USD 20, assuming a straight line depreciation in 3 years.

Source: GVEP; Internet research; Lighting Africa data on kerosene prices in Africa; expert interviews; Dalberg Analysis.

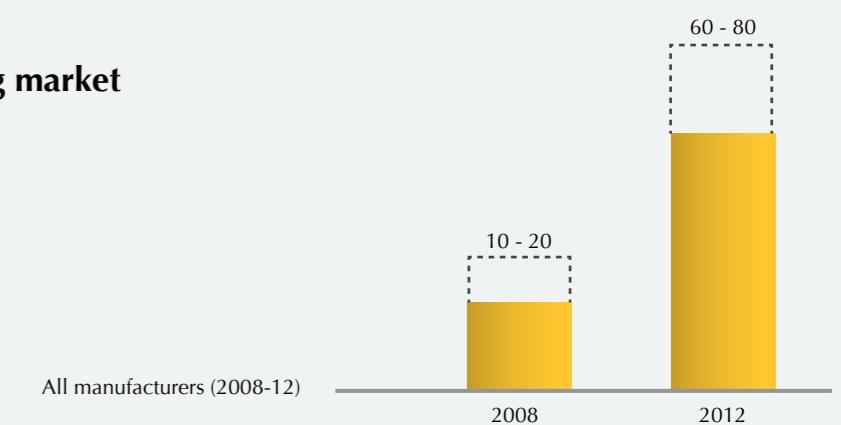
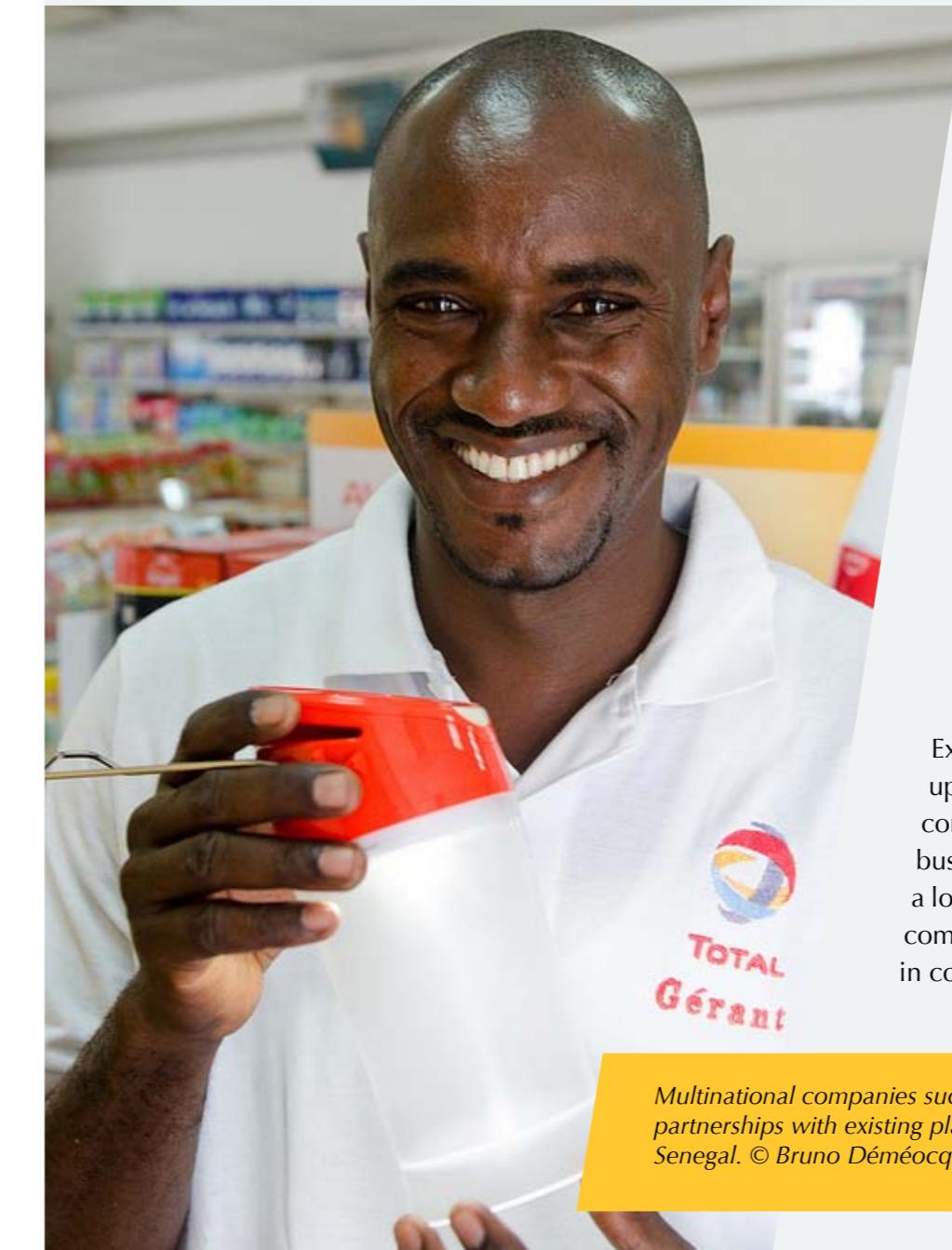


## Supply

The PLS market continues to attract new players rapidly. The overall number of manufacturers selling PLSs in Africa has grown sharply from 20 in 2008 to approximately 80 today. In tandem, the number of manufacturers of quality-verified PLSs has also increased from six in 2010 to 25 currently.

**Figure 15: Entry of new players into the African solar lighting market**

Number of players; 2010-12



1. Quality-verified manufacturers and suppliers are those that have passed Lighting Global's minimum quality standards.

Source: Interviews with market players and experts; Lighting Africa quality-verified list of performance; Lighting Africa data; Dalberg research.



Existing players in this market – typically companies that were in the start-up phase two years ago – have evolved into larger, sophisticated and more complex businesses. These companies have increasingly formalized their business processes, hired professional management teams and established a long-term strategic presence in Africa. Among these players, more than six companies have consolidated their presence by setting up regional offices in countries like Kenya, Ghana, Uganda, Tanzania and Ethiopia.

Multinational companies such as TOTAL have recently entered the market and forged partnerships with existing players. Here, d.light products for sale in a TOTAL shop in Dakar, Senegal. © Bruno Déméocq/Lighting Africa/2012.

In addition to the growth of these existing players, interest from large, multinational companies (MNCs) has increased steadily. MNCs such as Panasonic, Philips, Schneider Electric, Total, Energizer, and Osram have signaled their interest in the burgeoning pico-powered lighting product market by investing in the development of refined and new product lines and by forging partnerships with key existing players. This development is an important indicator of a maturing market and industry confidence in the PLS market. MNCs no longer view this market as simply an avenue for their CSR activities, but now believe in the commercial viability of the market and see significant potential for profitability.

The entry of new market players has expanded the geographic footprint of PLSs all across Africa. For example, the Lighting Africa program has witnessed the penetration of its quality-verified products into more than 25 African countries by 2012, with further expansion expected in the next year.

**The market share of the top-selling companies has remained steady, with the top ten players accounting for almost 70% of annual sales in 2010 and 2012 according to our estimates.** This is despite the rapid influx of new manufacturers and suppliers since 2010. Individual annual sales of the top ten companies grew from 10,000-100,000 annually in 2010 to 100,000-400,000 PLSs annually in 2012.

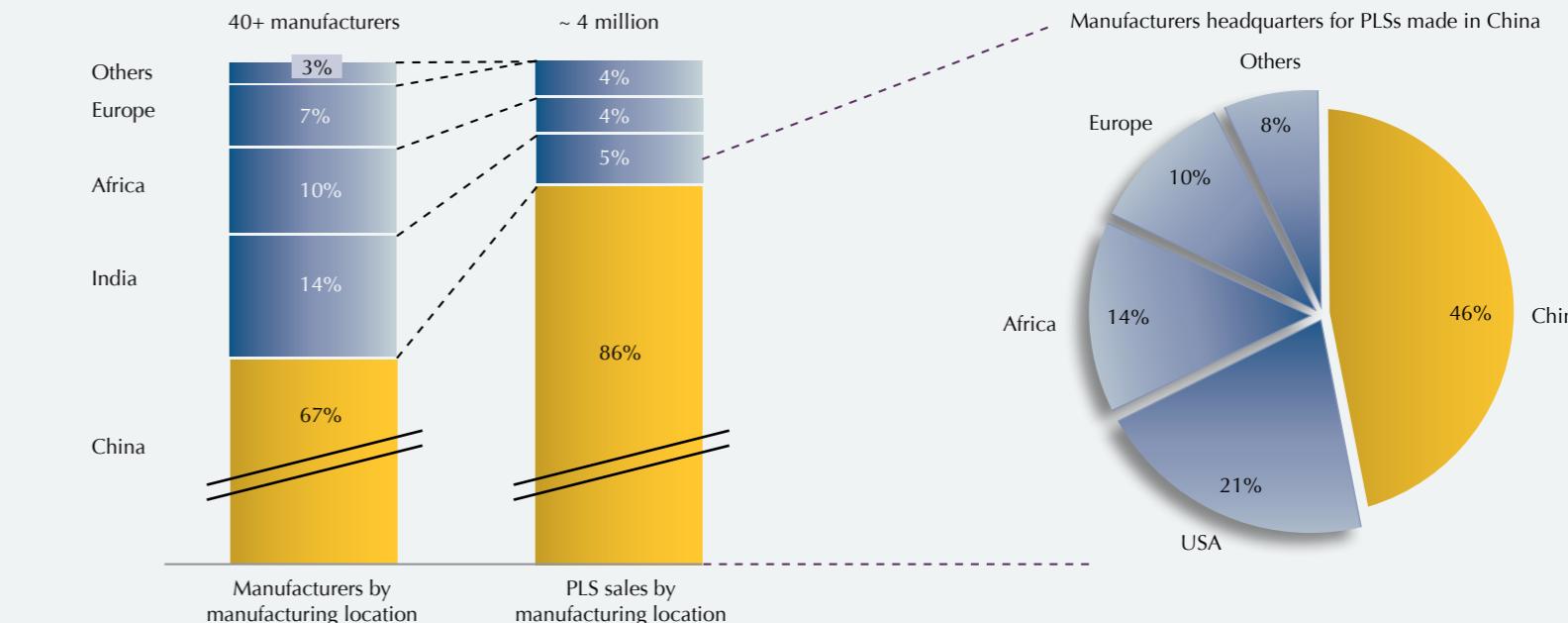
However, as reported in 2010, the remainder of the market continues to be highly fragmented, with approximately half the annual sales in the market coming from 30+ manufacturers. Outside of the top ten players, we expect the market to remain similarly fragmented over the next two to three years. Simultaneously, we expect that the market leaders will continue to consolidate their share, capitalizing on their presence and relationships to develop innovative marketing and distribution channels to reach more off-grid populations. We also forecast that two to three additional players, who are currently selling 50,000-90,000 PLSs annually, will join this group.

There is also potential for certain outliers to emerge with interesting products and, perhaps more importantly, innovative business models that can change or disrupt the market. Given that the off-grid lighting market remains largely under-penetrated (about 4% penetration by 2012), there is still significant room for product development and innovation.

**Estimates indicate that the vast majority of pico-powered lighting products sold in Africa are manufactured in factories located in China.** Approximately two-thirds of the major manufacturers supplying pico-powered lighting products to Africa base their factories and production units in China (Figure 16). These have accounted for almost 90% of estimated cumulative sales up to 2012. China continues to dominate all other production countries. Only 14% of manufacturers have factories located in second-place India, contributing approximately 5% by volume to PLS sales. Due to a wide variety of social, economic and political factors, local assembly of PLSs in African countries is still at a very nascent stage and has been limited to a small number of pilot projects (e.g., Suntransfer in Ethiopia, Fosera in Mozambique and CB Energie in Burkina Faso).

**Figure 16: PLS manufacturing and sales by geography**

Percentage of total, 2012 (year-end)



1. Database of 40+ major manufacturers with self-reported data for 20-25 manufacturers and estimates for the rest.

Source: Lighting Africa sales data; Dalberg Analysis

It is important to note that manufacturers with factories in China do not represent a homogenous group of players. They differ from each other across several dimensions.

- First, although two-thirds of the companies manufacture PLSs in China, only about half of these (approximately 46%) are actually headquartered there, and therefore can be termed ‘Chinese’ companies. Of the rest, approximately 30% are western companies headquartered in the US or Europe, with a longer history of serving the African market. These include commercial players such as d.light and Greenlight Planet, as well as organizations that have historically focused on philanthropy channels such as SunNight Solar and Sun Transfer. Major Africa-origin manufacturers among these are Toughstuff, Betta Lights and Nuru.
- Second, these companies represent the entire spectrum of PLS manufacturers from start-ups, to maturing market leaders that entered the market two to three years ago, to multinationals (e.g., Philips, Panasonic), as well as Chinese companies (e.g., Trony) that have significant and long-term interests in Africa.
- Third, and perhaps most importantly, manufacturers with factories in China vary significantly with respect to their commitment to quality and customer preferences. They include existing brand- and quality-conscious market leaders such as Greenlight Planet and Barefoot Power, as well as several manufacturers of unbranded, low-quality PLSs that tend to flood rural markets and are primarily responsible for spoiling market demand. This segment of unbranded manufacturers from China is rapidly increasing its sales footprint in Africa. Its participation remains low in formal market structures and institutions like industry associations and quality/performance certification programs, but based on feedback from interviews with China-based manufacturers, the desire and potential to engage with the African market is high.<sup>17</sup>

<sup>17</sup> See section 6 on market forecasts for further discussion of manufacturer-led brands from China and their potential impact on the market.

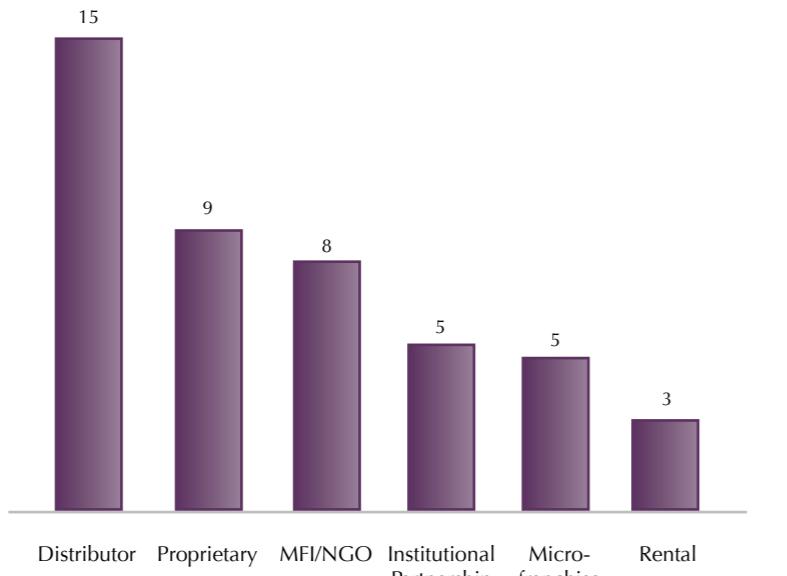
**Distribution:** In the absence of any clear ‘winner’, PLS suppliers have continued to experiment with different distribution channels, customizing them to the specific needs of customer segments within target geographies. The pattern of distribution in Figure 17 has generally remained the same over the past two years, with manufacturers reporting a majority of PLSs sold through dealer-distributor networks. During interviews, PLS suppliers reasoned that tapping into existing dealer-distributor networks was preferred for three major reasons:

- (1) the plug-and-play nature of the channel, which allows PLS suppliers a low-cost point of access to BoP customers, particularly in rural areas;
- (2) the capacity of experienced dealers and retailers to reach large volumes of customers, allowing suppliers to ramp up sales and scale quickly; and
- (3) the opportunity to leverage knowledge on consumer needs and requirements, especially in designing effective marketing and awareness campaigns.

Other effective channels for achieving scale without significant investment include partnerships with community-based organizations like microfinance institutions (MFIs) or NGOs with established networks in rural areas, corporations with large labor forces, and public sector institutions.

**Figure 17: Frequency of distribution model utilization across surveyed market players**

Number of respondents; N = 20 manufacturers



1. Manufacturers reported employing more than one distribution model at the same time, therefore, the total across models does not add to N.

Source: Interviews with manufacturers and distributors; Dalberg analysis

## 4. Product economics

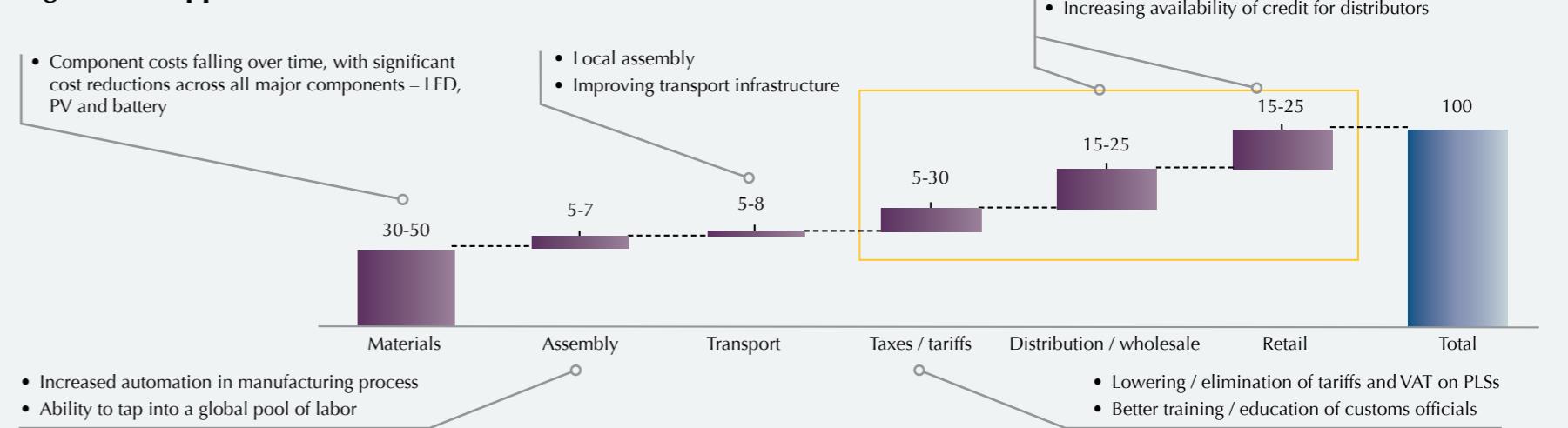
### The PLS value chain

**Relative drivers of costs along the PLS value chain have not changed significantly over the past two years.<sup>18</sup>** PLS manufacturing, materials and assembly, together, account for the majority share – 35-57% – of the final retail price. We expect component costs to fall quite sharply over the next three to seven years (explored in detail in the report’s next section). At the same time, cost of assembly, driven by rising labor costs in manufacturing locations like India and China, has increased. However, on the whole, manufacturing and assembly costs will likely represent a progressively smaller share of the final PLS price over time.

As explained above, the overwhelming majority of PLSs sold in Africa come from China. Over the past two years, transportation costs have remained largely unchanged—a single container costs on average USD 2,000-2,500 to ship to an African port. According to interviews, transportation’s share of final PLS price has remained stable at around 5%.

Interviews with several major manufacturers in the African PLS market also indicated that, on average, irrespective of the channel used, in-country distribution (including retail and margins across the supply chain) accounted for approximately 30-50% of the final consumer price. According to them, any variation in distribution costs depended primarily on the number of intermediaries between the manufacturer and the consumer, and their respective margins. Dedicated distributors who serve as franchisees of their manufacturers tend to charge lower margins, as opposed to large, country-level distributors who carry a range of consumer goods, including PLSs sourced from multiple manufacturers.

**Figure 18: Opportunities for cost reduction across the PLS value chain**



Source: Range of costs reported by manufacturers and distributors representing 65-70% of the quality market; Dalberg analysis

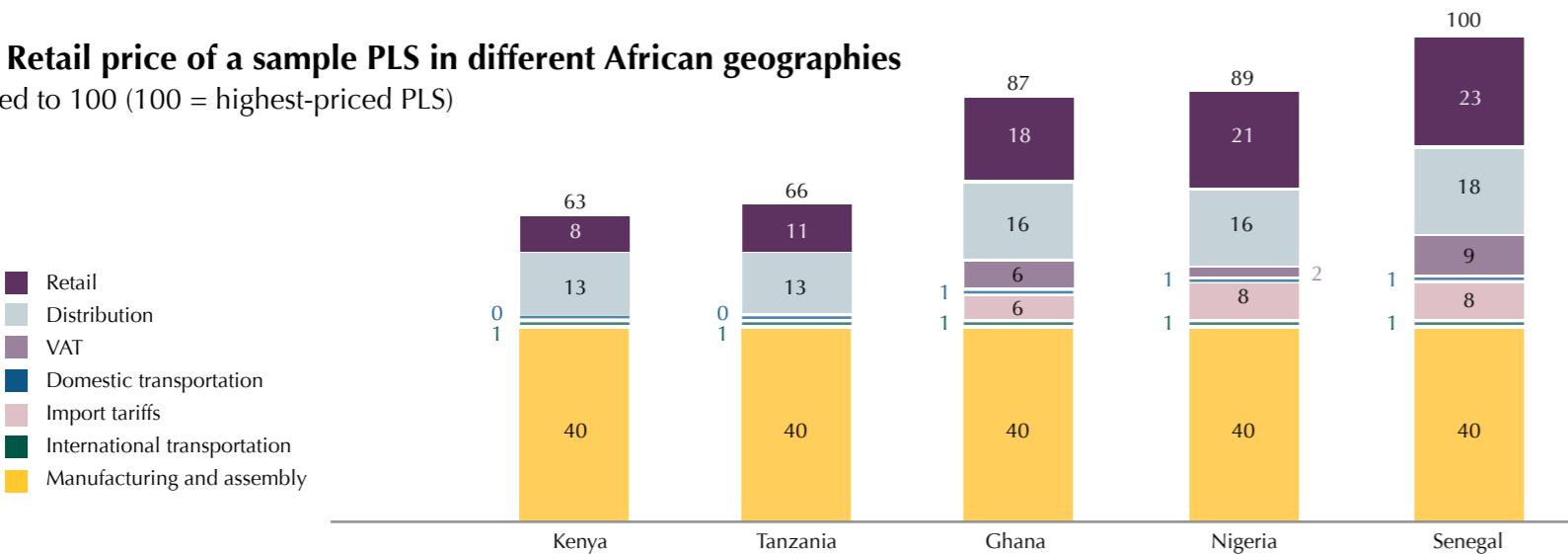
The imposition of taxes and tariffs can add 5-30% to the final retail price of the PLS. Overseas PLS manufacturers are charged import duties as they enter some African markets, and may subsequently also be charged VAT at the point of purchase. The impact of these taxes raises the final consumer price and further exacerbates affordability constraints.<sup>19</sup> In fact, the variation in prices across different African countries is often largely driven by differing taxes and tariffs (Figure 18).

<sup>18</sup> For a detailed description of each stage of the PLS value chain please see pp51-2 of ‘Solar Lighting for the Base of the Pyramid: Overview of an Emerging Market’ (2010).

<sup>19</sup> Taxes, tariffs and other political instruments are explored in further detail in Section 5 of this report.

**Figure 19: Retail price of a sample PLS in different African geographies**

Prices indexed to 100 (100 = highest-priced PLS)



Assumptions: FOB of USD 20 from China-based factory; 3-4 middlemen between importer and customer; international transportation costs (1 container of 5K PLSs) from China to Africa port of entry between USD 2500.

Source: Interview with PLS manufacturer; Dalberg research and analysis

## Economics of manufacturing<sup>20</sup>

Manufacturing methods used to produce PLSs have become standardized over the past few years. While the basic components and the assembly processes essentially remain the same, emphasis on product quality varies from company to company, which has direct implications for economics. Manufacturing costs contribute between 30-50% to the final retail price of the PLS, while the remaining 50-70% of the retail price is associated with expenditure on tariffs, taxes, margins, distributor and retailer expenses, and on awareness and marketing.

The price per Watt of PV panels has dropped since 2008 and is expected to drop further by 2015.

© Bruno Déméocq/Lighting Africa/2012.



<sup>20</sup> This section focuses on an analysis of solar-powered PLS since these types of lighting devices form the majority of pico-powered lighting systems currently sold in Africa.

The production economics of PLSs are largely driven by four sub-components:

- Solar/PV panel
- Battery
- LED
- Housing and assembly (including charge controller)

This section details the key trends in each of the primary cost areas and forecasts the overall cost and technology trends for PLSs between today and 2020.

### Solar/photovoltaic panel

**Prices for PV technologies have fallen at a faster rate than predicted in 2010 due to technological innovation and lower raw material prices (and hence, lower manufacturing costs).** Broadly, there are two types of PV technologies used by PLS manufacturers. The majority of manufacturers use (mono or poly) crystalline-silicon (c-Si) panels, while the rest have adopted amorphous 'thin-film' (a-Si) panels.<sup>21</sup> Thin-film panels tend to be larger than c-Si panels, on account of their lower efficiency rates.<sup>22</sup>

In recent years, the prices of c-Si PV panels have dropped significantly due to sharply declining component costs and significant improvements in the manufacturing process, along with an ongoing supply glut on the polysilicon cell market. Polysilicon, which is the most expensive and important material for production of c-Si modules, contributes about 20-30% of the final module cost.<sup>23</sup> When the solar industry faced a shortage of polysilicon from 2005 through 2008, the prices for solar modules stayed high. Since then, manufacturing processes have evolved to use less polysilicon and there was overinvestment in manufacturing plants with declining demand for on-grid solar in western Europe after the 2008 financial crisis, which resulted in a glut in the polysilicon market and a fall in panel prices. In 2011 alone, c-Si PV panel prices dropped almost 40%.<sup>24</sup> The ongoing surplus of polysilicon is expected to continue, and potentially accelerate, in the next two to three years and will likely bring down the per watt price of c-Si panels to near or below USD 1 by 2015.

Thin-film technologies have also made substantial cost reductions primarily driven by efficiencies in the manufacturing process that account for nearly 90% of thin-film panel costs. These cost reductions have made thin-film PV material cheaper than c-Si on a per watt (peak) basis; however, thin-film modules are generally more expensive because of a higher balance-of-module material costs (e.g. framing, glazing, etc.).

While newer thin-film alternatives such as Cadmium Telluride (CdTe), Copper Indium Gallium Selenide (CIGS), organic polymer cells, light absorbing dyes, and nanocrystalline cells are still a long way from becoming important to the PLS market, they will likely continue to improve and may be in a position to compete with c-Si technology in the future. However, c-Si technology is likely to maintain its position as the leading solar photovoltaic technology in the sector in the near and medium term.

<sup>21</sup> A major technical difference between crystalline (c-Si) and amorphous (a-Si) PV technologies is their efficiency at converting solar energy into electricity. Crystalline panels have efficiencies that range from 12 to 22%, while a-Si panels currently have an efficiency of 6-9%.

<sup>22</sup> Measured by the rate of conversion of solar energy to electrical energy.

<sup>23</sup> IHS Emerging Energy Research (2012).

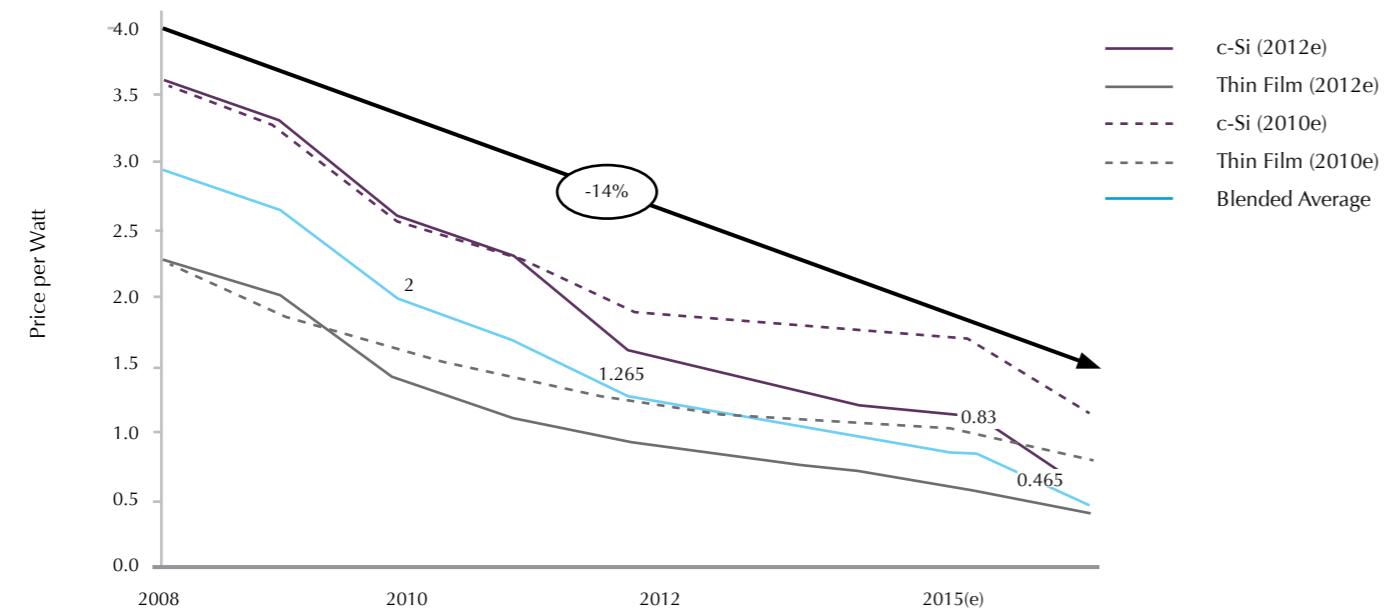
<sup>24</sup> Greentech Media, GTM Research 2012.

These projections reference the costs for large-sized (200-400 Watts) panels and take into account significant economies of scale associated with their production. For lantern manufacturers, the good news has to be tempered by the premium they have to pay for the small-sized panels they require. Small-sized panels of the type used for PLSs face relatively high costs of framing and cabling and typically come at a 20-40% per Watt peak relative to larger modules.<sup>25</sup> However, these numbers can vary depending on the scale of the purchaser and the type of PV technology.

Figure 20 illustrates the projections for price per Watt from 2010 and our revised projections from 2012 based on the trends noted above.

**Figure 20: PV price trends**

USD per Watt; 2008-2020



Source: GTM Research; International Renewable Energy Agency data; Dalberg research and analysis

Over the past two years, the range of PV panel size has increased. PV modules for PLSs generally range between 0.5 Watt (for the smallest portable systems) to 10 Watts (for systems converging on Solar Home System (SHS) performance and functionality. Among the quality-verified PLSs in 2012, the average PV panel size was approximately 3.5 Watts, which is 8-10% more than it was in 2010. The size of the panel remains contingent on an PLS's intended functionality—larger panels can accommodate both lighting and charging needs, for instance, whereas smaller panels fit the form of hand-held, predominantly lighting-only models.

Contrary to our 2010 projections, crystalline silicon (c-Si) is expected to maintain its position as the most popular PV technology deployed by PLS manufacturers in Africa. The PLS market share of thin-film is expected to grow, but at a slower pace than initially expected. In 2010, we noted that several PLS manufacturers in Africa were considering a switch to thin-film technology, based on certain advantages including: form flexibility, improved sturdiness resulting from the lack of glass, ease of local assembly, and lower performance losses under

<sup>25</sup> These numbers can vary depending on the scale of the purchaser and the type of PV technology. From: 'Solar Lighting for the Base of the Pyramid: Overview of an Emerging Market', Lighting Africa (2010).

high temperature and indirect sunlight. Most importantly, improvements in thin-film's manufacturing process, which involves chemically depositing successive layers of semiconductor materials onto a substrate, were expected to significantly widen the price gap between thin-film and c-Si. Based on these trends, we projected that there would be a 50% market share for thin-film modules by 2015.

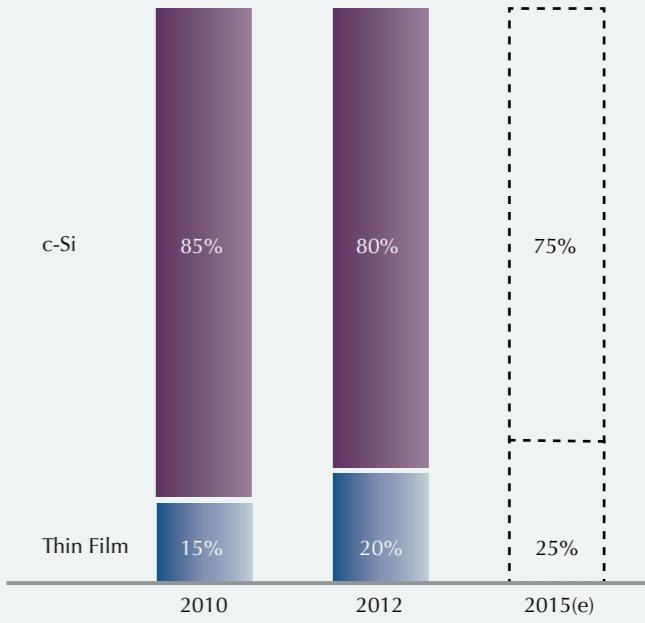
However, this change is unlikely to materialize for a number of reasons:

- Market experience with thin-film technology has not convinced manufacturers to adopt the technology. Importantly, the modest price advantage that thin film technologies enjoyed previously is no longer in play due to rapid price declines for c-Si modules. Additionally, c-Si panels continue to be more efficient (requiring less space to generate the same amount of energy) and are perceived by end consumers as a premium product that is superior in terms of robustness and reliability.
- In addition, thin-film panels generally incur a higher balance-of-module material costs than c-Si modules, which could make the thin-film modules more expensive than c-Si.
- The cost of c-Si has remained competitive in part due to the persistent oversupply in polysilicon feeder stock.
- The thin-film industry as a whole has not been able to emulate the business success of First Solar, a major CdTe-panel producer on which many expectations were based. Globally, the next few years will be challenging for the industry, and according to analysts, the thin film share of the market is expected to rise incrementally to about 18-20% by 2016.<sup>26</sup>

Thus, the split in the solar PLS market in Africa between c-Si and thin-film observed in 2010 remains largely unchanged. Moreover, interviews conducted with leading PLS manufacturers in 2012 suggested that they were unlikely to consider shifting to thin-film in the future unless its technological and economic benefits over c-Si were more categorically established in other markets. These interviews as well as the factors mentioned above, lead us to believe that the PLS market will see c-Si continue to dominate share in the next two to three years (Figure 21). Thin-film panels may potentially capture an additional 3-5%, driven by uptake from manufacturers entering the market.

**Figure 21: Estimated PLS market share by PV technology**

Share of market; 2008 - 2015



Source: Lighting Africa data; Interviews with manufacturers and distributors; Dalberg analysis

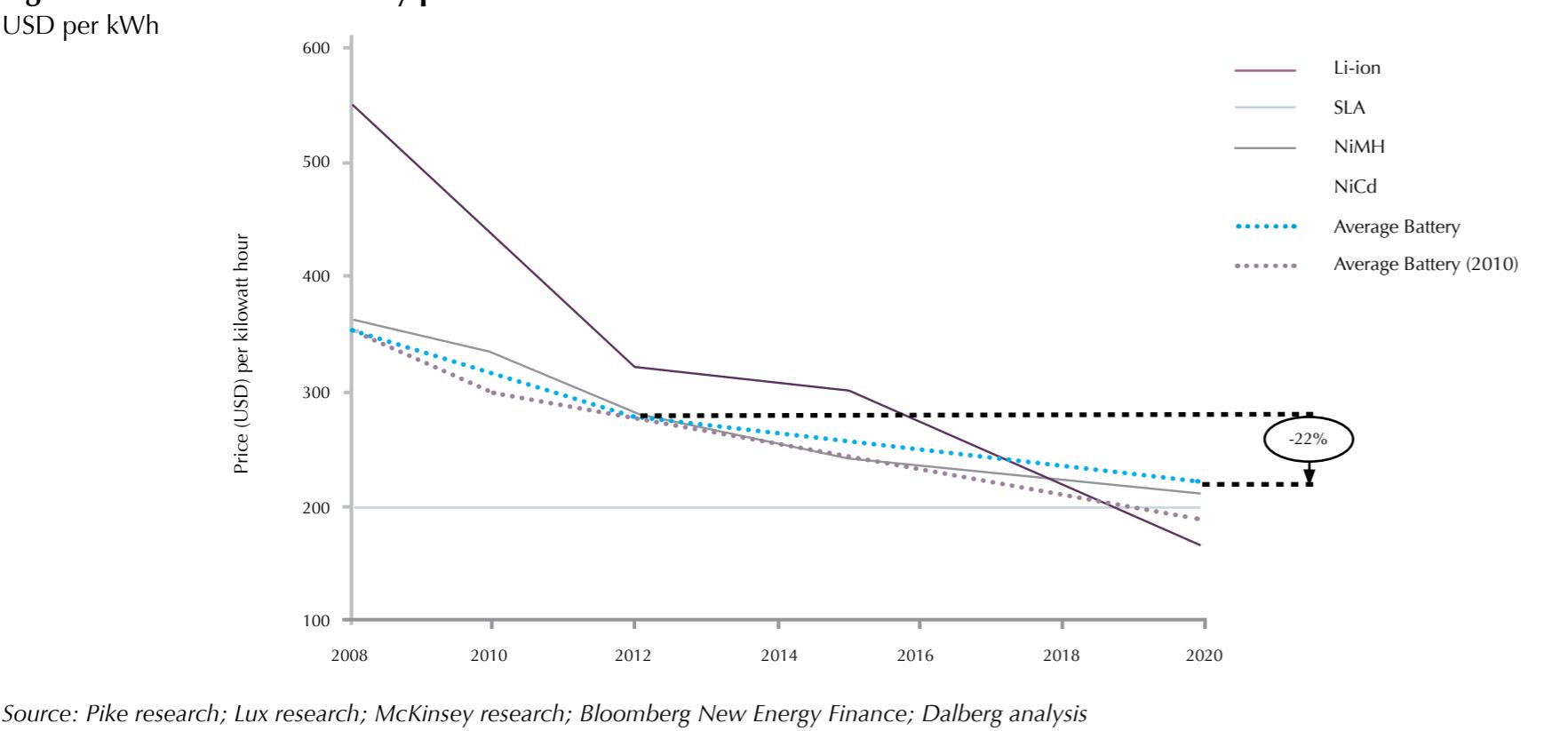
<sup>26</sup> "Is Thin-Film Solar Dead?", GreenTech Media Research (2012).

We also project that the cost of today's median PLS PV panel will likely reduce by 60-65% by 2020, primarily due to advances in technology, market scale and increasing small manufacturer capacity.

### Battery

**Battery prices overall have fallen, as predicted in 2010.** Globally, the battery market is in rapid flux, marked particularly by advances across all battery technologies and, in parallel, steep price declines projected through 2020. We project the single largest price decrease to be within the lithium-ion segment, in which prices have already decreased by 42% since 2008. The average price of all batteries is projected to drop by roughly 20% between 2010 and 2020.

**Figure 22: Evolution of battery prices over time**



**In the past two years, lithium-ion (li-ion) battery technology has emerged as the real winner in the African PLS market, with an increase in market share that has exceeded expectations.** Lithium-ion batteries refer to a diverse set of battery chemistries, which differ from each other in the composition of their positive electrode (cathode). However, all li-ion batteries use a common process known as 'intercalation'<sup>27</sup> for generating electricity and exhibit significant advantages over other battery technologies.<sup>28</sup>

Some of these advantages include:

- *Longer life*: ability to last for up to 2,000 cycles or between three to five years of use before needing to be replaced;
- *Rapid charging*: this is essential, given that battery capacity is only as useful as the charge it can absorb during sunlight hours;
- *Durability*: ability to withstand extreme conditions in rural areas, including heat, cold, abuse and total discharge;
- *Better for powering multiple/larger devices (such as TVs, fans, radios, etc)*: higher energy density – ability to store more energy per unit weight/size – than most other types of batteries. This means that (especially for large applications) a single Li cell can be used, rather than multiple NiMh or NiCd cells ;
- *Environmental sustainability*: the shift towards iron phosphate to replace cobalt in the cathode material for lithium-based batteries reduces safety hazards associated with overheating and the potential for environmental damage.

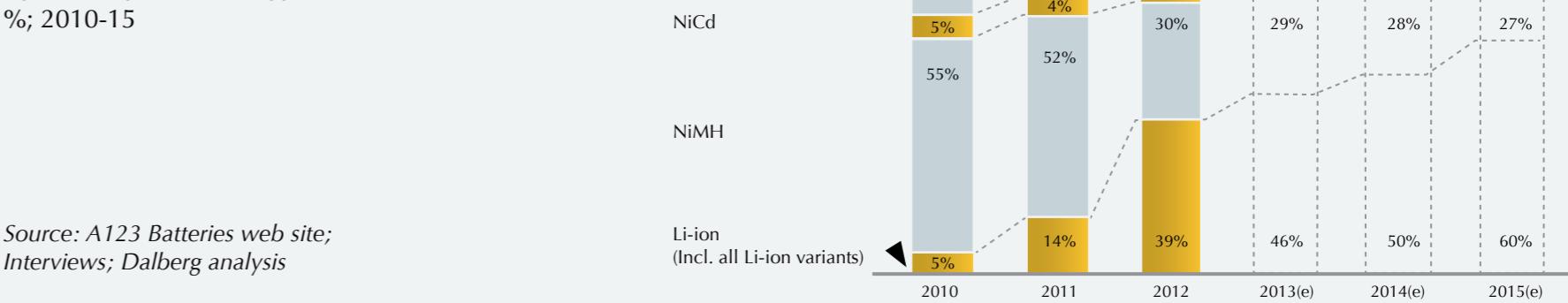
Lithium-based batteries, already well-established in other applications such as mobile phones and laptops, were only marginally adopted in the PLS space in 2010, with approximately 5% of the market share. We predicted that the share of lithium technology batteries would grow rapidly and make up nearly a quarter of the market by 2012, not just due to the technological advantages listed above, but also to rapidly falling production costs. These cost drops were expected based on the following developments in other industries:

- The effect of global economies of scale fuelled by increased demand from the mobile, laptop and electric vehicle sectors;
- Significant investment in research and development by the above-mentioned sectors;
- Increasing product maturity and sophistication of the manufacturing process.

In the past two years the experience of li-ion batteries in the African PLS market has exceeded expectations, as it quickly took over shares from nickel metal-hydride (NiMh) or sealed lead acid (SLA) batteries. In 2012, according to best estimates, li-ion batteries account for nearly 40% of the PLS market in Africa. Interestingly, this accelerated pace of adoption constitutes an even faster adoption of li-ion technology than in the mobile phone industry.<sup>29</sup>

These trends as well as interviews with manufacturers and distributors lead us to believe that the li-ion share of the PLS market will rise steadily over the next two-three years (Figure 23).

**Figure 23: Estimated PLS market share by battery technology**



<sup>27</sup> Lithium ions are incorporated into the structure of the electrode material. Lithium ions move from the positive to the negative electrode during charging, and vice versa during the discharge phase.

<sup>28</sup> 'Lithium-ion Battery Overview', Technical Briefing Notes, Lighting Africa (2012)

<sup>29</sup> Refers to the penetration of mobile phones in Africa between 2005 and 2010. From: 'Solar Lighting for the Base of the Pyramid: Overview of an Emerging market', Lighting Africa (2010).

The PLS market will continue to respond positively to new battery technologies that can provide better performance metrics in safety, lifetime usage, reliability and cost. In particular, improvements in battery capacity and lifetime would be very well received by the industry. The majority of the best-performing batteries in today's market lasts for a maximum of one to two years; therefore, increasing their lifetime would imply even better economics for PLSs relative to candles and kerosene lamps.

One example of such innovation is Lithium Ferrous Phosphate (LFP) batteries, a variant of li-ion batteries that uses iron phosphate in the cathode component rather than the li-ion's traditional cobalt or manganese. This enables LFP-based batteries to offer superior performance in terms of lifetime, charging speed and specific power, while minimizing environmental safety concerns as well as human safety issues. Figure 24 provides a summary of the relative advantages and disadvantages of LFP batteries. Already, more than half of PLSs using lithium technology have switched to LFP batteries, achieving performance advantages without significantly affecting price.

**Figure 24: Key advantages of LFP over traditional li-ion<sup>30</sup>**

Approximate technical capacities, select key factors



Performance criteria	Lithium-ion	Lithium ferrous phosphate
Specific power	250 – 340 W/kg	✓ >300 W/kg
Energy density	250-730 Wh/l	✗ 220 Wh/l
Nominal cell voltage	3.2 V	✓ 3.3 V
Cycle durability	400-1200 cycles	✓ 2,000 cycles
Environmental safety	High, with proper disposal of cobalt	✓ Highest – no cobalt to dispose of
Human safety	High – dangerous if damaged, used at high temperatures or overcharged	✓ Highest – does not decompose at high temperatures

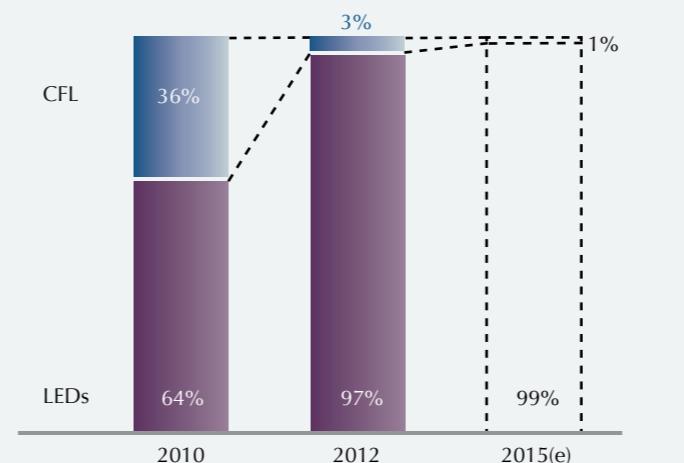
Source: A123 Batteries research; Dalberg research

<sup>30</sup> A123 Batteries ([www.a123systems.com](http://www.a123systems.com)); Internet research.

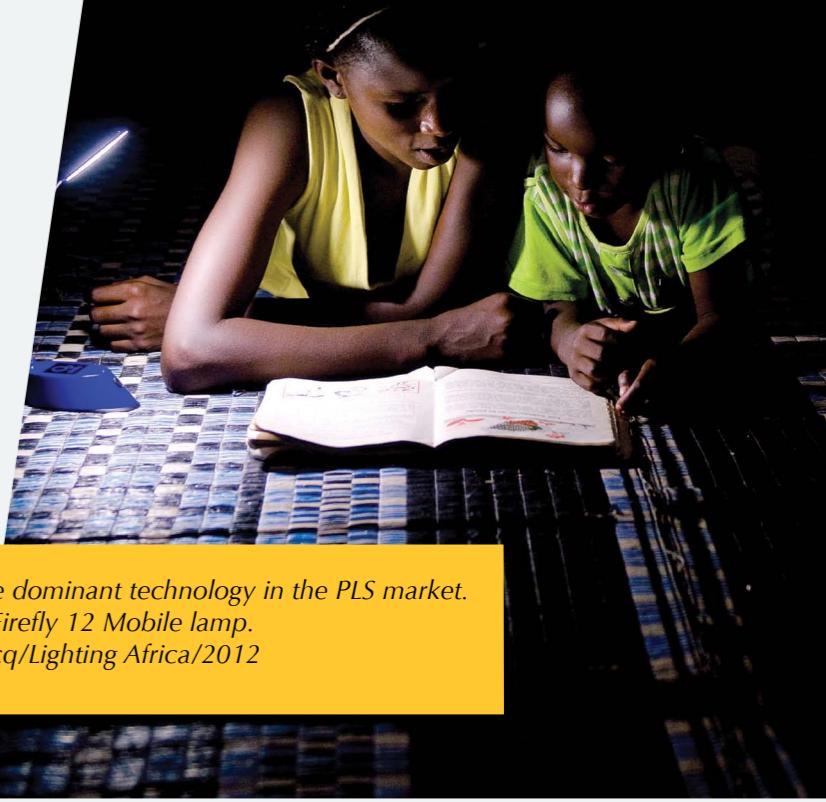
## Lighting source

As predicted in 2010, LED lighting is the dominant technology in the PLS market, leading to significant increases in luminosity. LEDs started at a dominant market position in 2010 and within two years, have nearly captured the entire market (Figure 25).

**Figure 25: Estimated PLS market share by lighting technology**  
Percentage; 2010-12



Source: Lighting Africa data; Interviews with manufacturers and distributors; Dalberg analysis

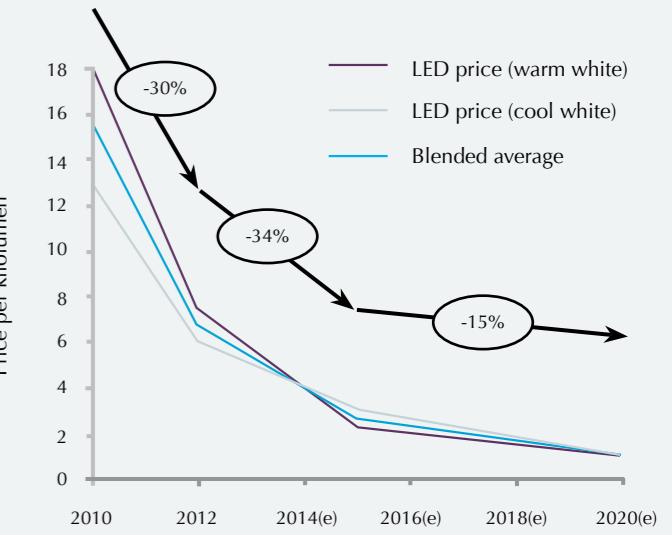


LED lighting is the dominant technology in the PLS market.  
Here a Barefoot Firefly 12 Mobile lamp.  
© Bruno Déméocq/Lighting Africa/2012

**Figure 26: Evolution of LED Prices**

USD per kilolumen; 2010-2020

Source:  
US Department of Energy data ([www.energy.gov](http://www.energy.gov));  
Dalberg research and analysis



Aiding this growth of the LED market are the larger-than-expected decreases in the cost of manufacturing. More efficient and effective manufacturing processes have emerged from global public and private investment in solid state lighting research. Analysis indicates that costs of various LED equipment have, on average, dropped 30% since 2010 and are set to decline another 34% by 2015 before converging and stabilizing around USD 1/ kilolumen by 2020 (Figure 26).<sup>31</sup>

<sup>31</sup> Market studies and technical reports from the Energy Efficiency and Renewable Energy Program, US Department of Energy ([www1.eere.energy.gov](http://www1.eere.energy.gov)); Dalberg research.

## Charge controller

**No significant cost reductions are expected in charge controller technology.** Charge controllers are used to regulate the flow of electricity to and from batteries. They are standardized equipment widely used in many electronic products and appliances. This feature protects battery-powered electronic devices from overcharging, discharging completely, and from destructive spikes in voltage. It serves to lengthen battery life and improve performance over time. Currently, charge controllers account for approximately 10-15% of the total manufacturing cost of a PLS.

Although we do not expect large-scale, cost-cutting innovation in charge controller technology, we project a 5% year-on-year decrease in cost, driven by the general manufacturing optimization of the industry, especially from scale.

## Housing, labor and assembly

**The cost of housing and assembly is likely to increase in the long run due to rising labor costs in China, the manufacturing base of the majority of PLSs.** Although the nominal cost of assembly continues to drop due to standard productivity improvements in manufacturing, the final cost of housing and assembly will be significantly impacted by shifts in the dynamics of the global labor market.

China's trend of rising incomes indicates that wages will increase by up to two-three times relative to their current levels by 2020.<sup>32</sup> Given that almost 90% of the PLSs present in the African market today are manufactured in China, this will drive up housing and assembly costs and slow the otherwise rapid decline in the total manufacturing cost of a PLS. No other production geography has yet to offer better labor terms, combined with economies of scale, to rival production in China.

**Based on the trends outlined above, the overall cost of manufacturing a PLS is set to decrease from today's levels by approximately 25% by 2015 and 35% by 2020.**<sup>33</sup> PLS manufacturing costs will vary depending on the specifications and characteristics of individual products. Below however, for the purposes of projecting total manufacturing costs into the future, we trace the evolution of the cost components of the 'median model'<sup>34</sup> PLS, constructed from baseline data (Figure 27).

When comparing current projections to those made in 2010, we find that solar PV and LED costs have fallen even more rapidly than predicted, and this trend is expected to continue. For example, current estimates indicate LED costs will decline almost 85% from 2012 levels by 2020. Thus, despite the rising labor costs highlighted above, the total manufacturing cost of the median lantern is still expected to fall at an accelerated pace. In addition, we expect that the vast majority of entry-level lanterns will be priced at or under USD 10 (some products such as Nuru Light as well as the d.light S1 have already achieved this price point), which will help open a significant market segment in Africa.

To date, manufacturers have generally chosen to pass on the benefits of lower component costs to consumers by investing in improving the quality and performance of PLSs and bettering their value proposition.

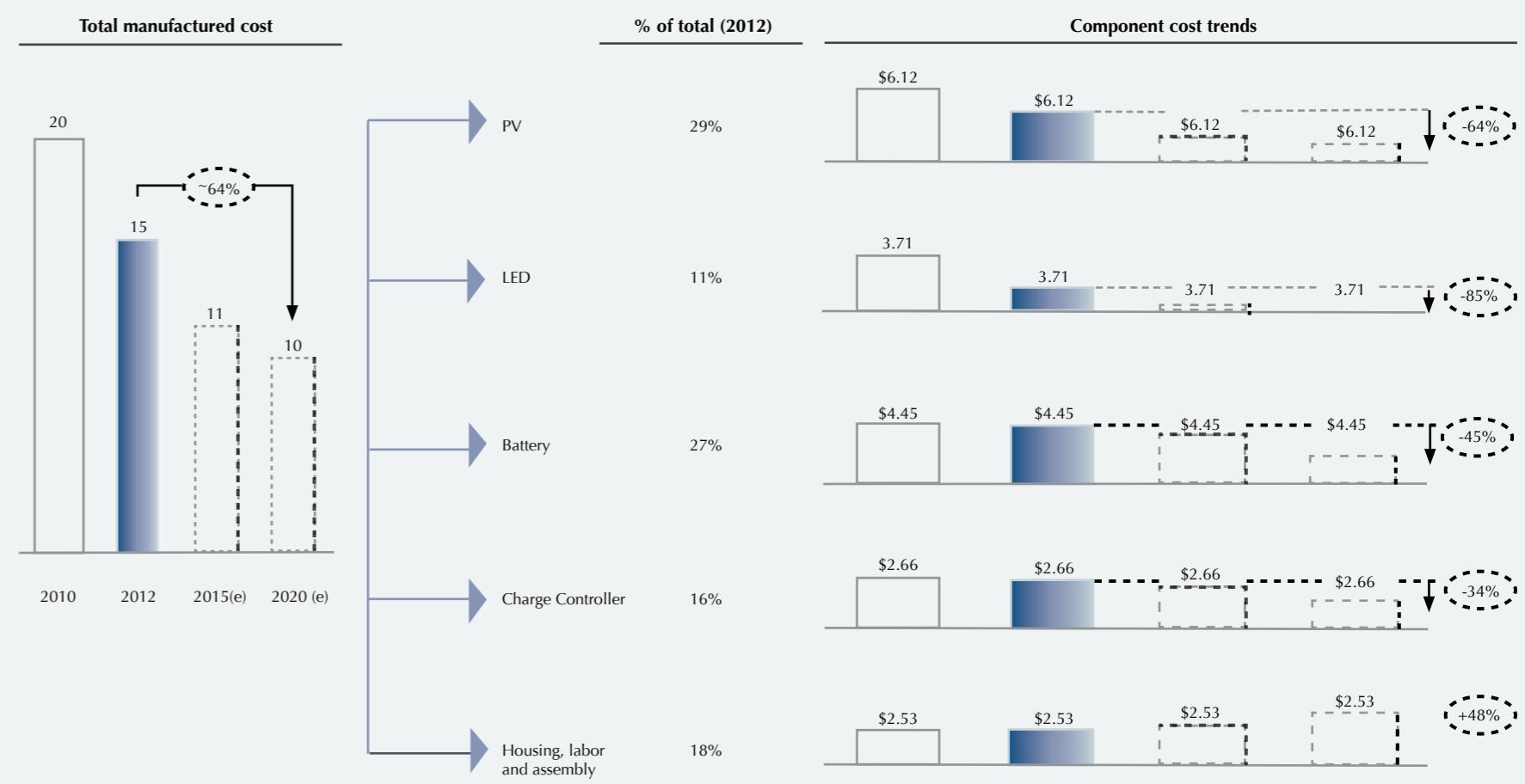
<sup>32</sup> Economist, 2012

<sup>33</sup> Our analysis on the future manufacturing cost of lanterns relies on several difficult to verify assumptions, but directionally it is unquestionable that solar-based pico-power lighting systems will become more attractive and more accessible for households with limited disposable incomes in the near future (by 2020).

<sup>34</sup> Today's median lantern has the following specifications: PV panel of 3.5 watts; LED luminosity of 50-100 lumens; average battery life of six to eight hours.

**Figure 27: Decomposition and forecast of the median lantern component cost**

USD, 2010-2020



Source: GTM research; Thin Film Industry Forum; IRENA; US Department of Energy; McKinsey Industry reports; Pike Research; Lux Analysis; The Economist; Inter China Consulting Analysis; Interviews with manufacturers and technical experts; Dalberg analysis

**We expect the cost structure of the 'median' lantern to change significantly in the next two-three years.** Historically, the biggest cost component of a PLS has been the PV module, which, as mentioned, continues to account for approximately 25-30% of the total manufacturing cost, despite sharp reductions in PV prices. This is primarily because the costs of other important component technologies (LED and battery) have fallen at a similar or faster pace in the past two years.

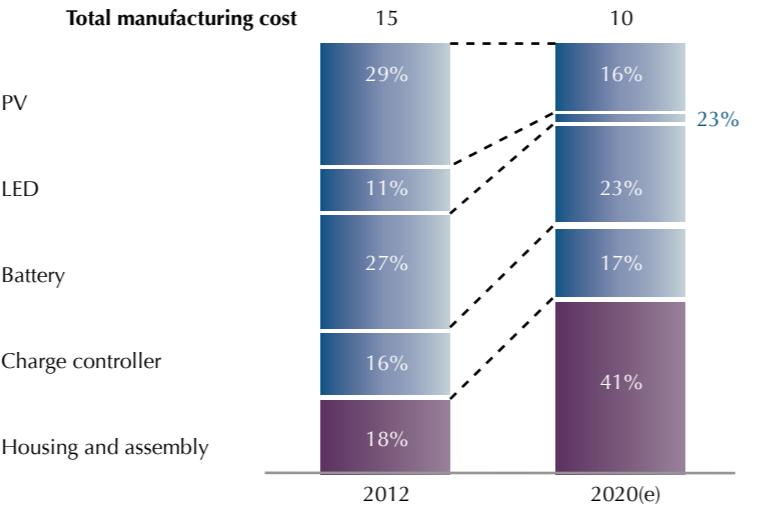
Projecting forward, while the cost of most major components will continue declining, the outlay on housing and assembly costs will increase from approximately 20% of the total manufacturing cost of a PLS in 2012, to almost 40% by 2020 (Figure 28).

This change in PLS cost structure could compel manufacturers seeking further cost reductions to start exploring opportunities for local, African assembly. This shift would be further encouraged by the projected relative cost-effectiveness of African labor over the next few years. Of course, manufacturing and production in Africa continue to be constrained by other challenges, such as unreliable grid access, unreliable supply of materials, high transportation costs, and uncertain political environments and support.

**Figure 28: Breakdown of PLS manufacturing cost by major cost components**

USD; 2012-2020

Source: Dalberg research and analysis



**Improved PLS quality and performance will likely substantially increase end-consumers' regard for products by 2020.** This will be driven by rapidly declining component costs and greater investment in product design and innovation by manufacturers. Key technological improvements expected by 2020 include:

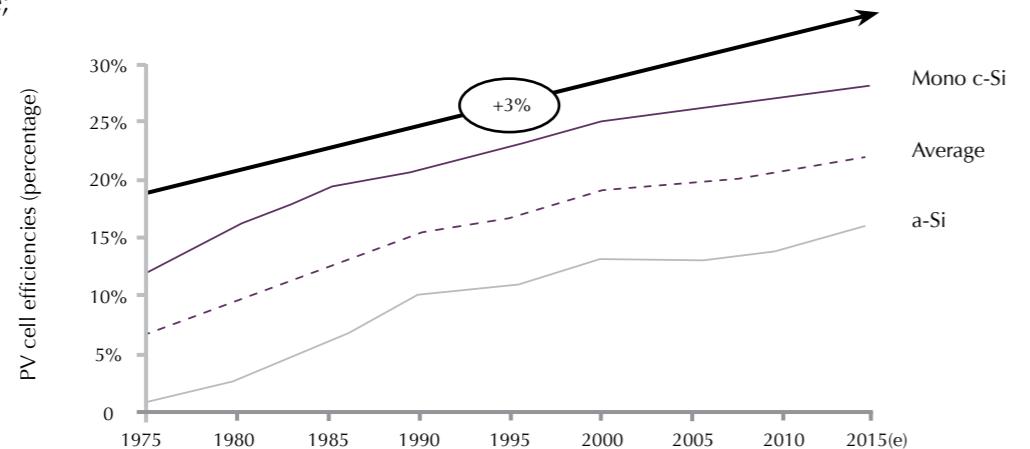
- *Higher-capacity solar PV panels*

We expect higher capacity solar PV panels, with the average panel size increasing to 6-9 Watts from the approximate 3-3.5 Watts available in the market today. Panels will also continue their ongoing trend toward greater efficiency (Figure 29). For the end consumer this implies (1) the ability to charge multiple appliances (radio, televisions, mini fridges, fans etc) of varying – and generally higher – power requirements, and (2) reduced charging times.

**Figure 29: Best research-cell efficiencies**

Efficiency of solar panel in percentage;

1975-2015



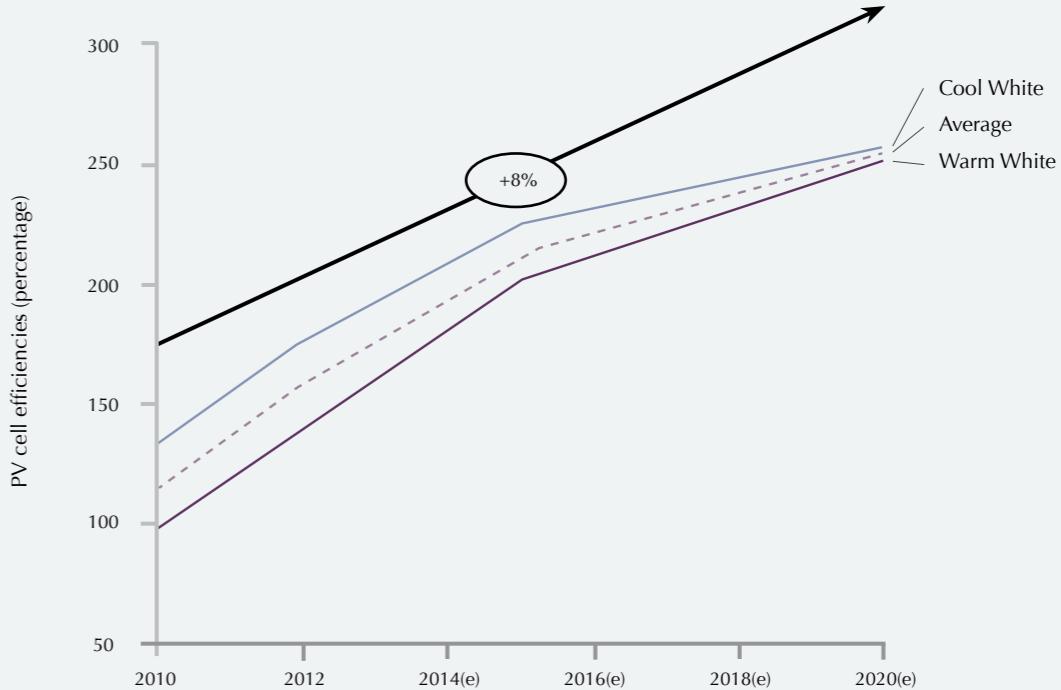
Source: National Renewable Energy Laboratory data; Dalberg Analysis

- *Brighter LEDs, more lights*

Customers can expect to receive roughly five to ten times the brightness levels they experience in 2012. The average PLS currently emits approximately 50-100 lumens. Driven by huge advances in LED technology, this could conceivably rise to almost 500 lumens by 2020. Of course, this level of luminosity represents the highest possible range, potentially restricted to outdoor use—for households, we expect brightness levels to stabilize around 200-250 lumens.

**Figure 30: Evolution of LED luminosity**

Lumens per Watt; 2010-2020



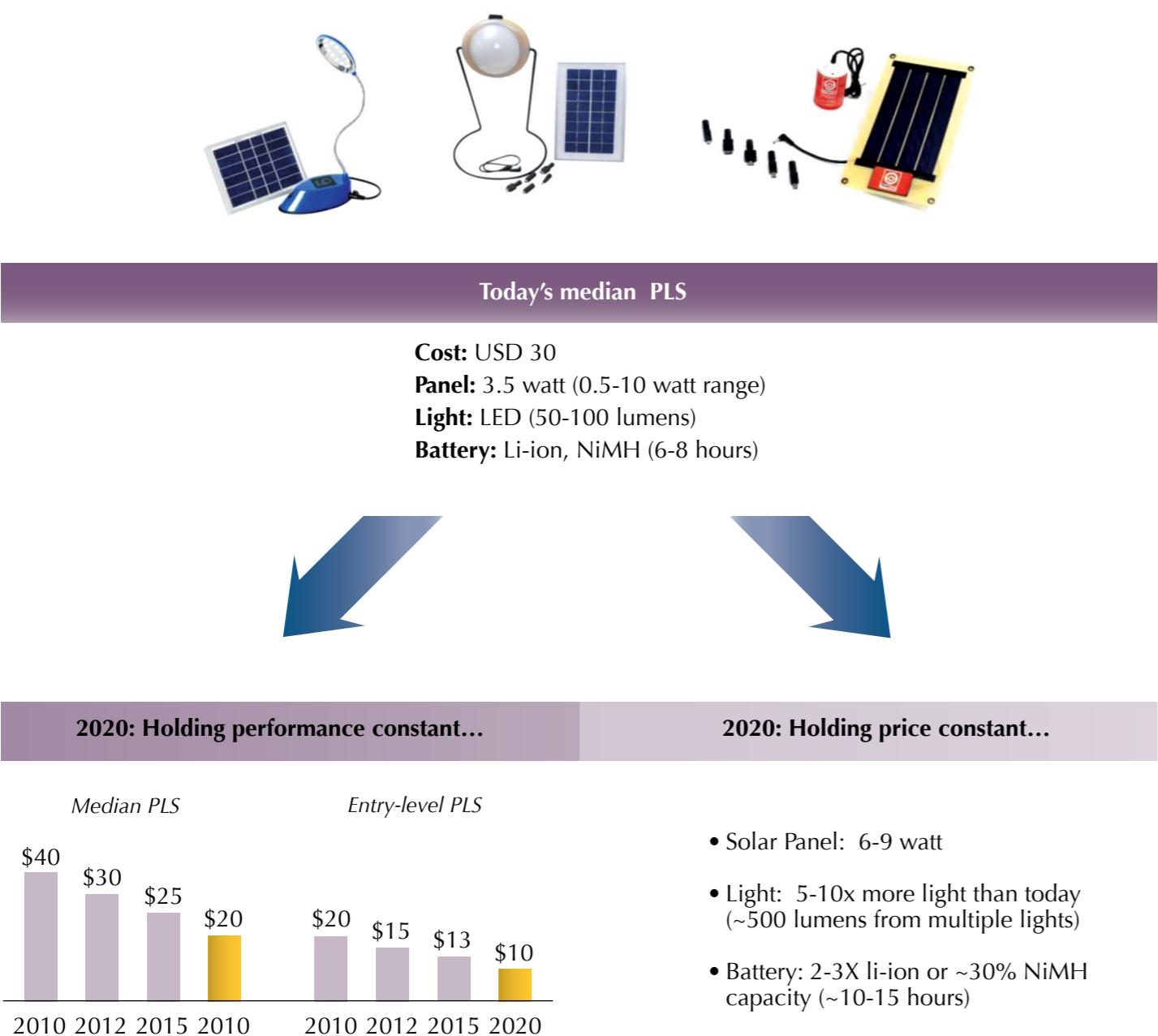
Source: US Department of Energy; Dalberg Analysis

- *Longer battery life*

The average battery capacity could rise to ten or 15 hours at full charge, up from six to eight hours in 2012. In addition, batteries will be lighter and more environmentally friendly. As mentioned above, lithium-ion batteries will likely take over market share, offering higher performance levels at lower costs relative to other technologies such as NiMh and NiCd. SLA batteries are expected to be completely phased out by 2020.

- *Value-add features*

Additional features such as auxiliary charging options, mobile charging capability, multi-brightness settings and wall-mounting will become increasingly standard as targeted consumer research drives product design.

**Figure 31: PLS performance and price in 2020<sup>35</sup>**

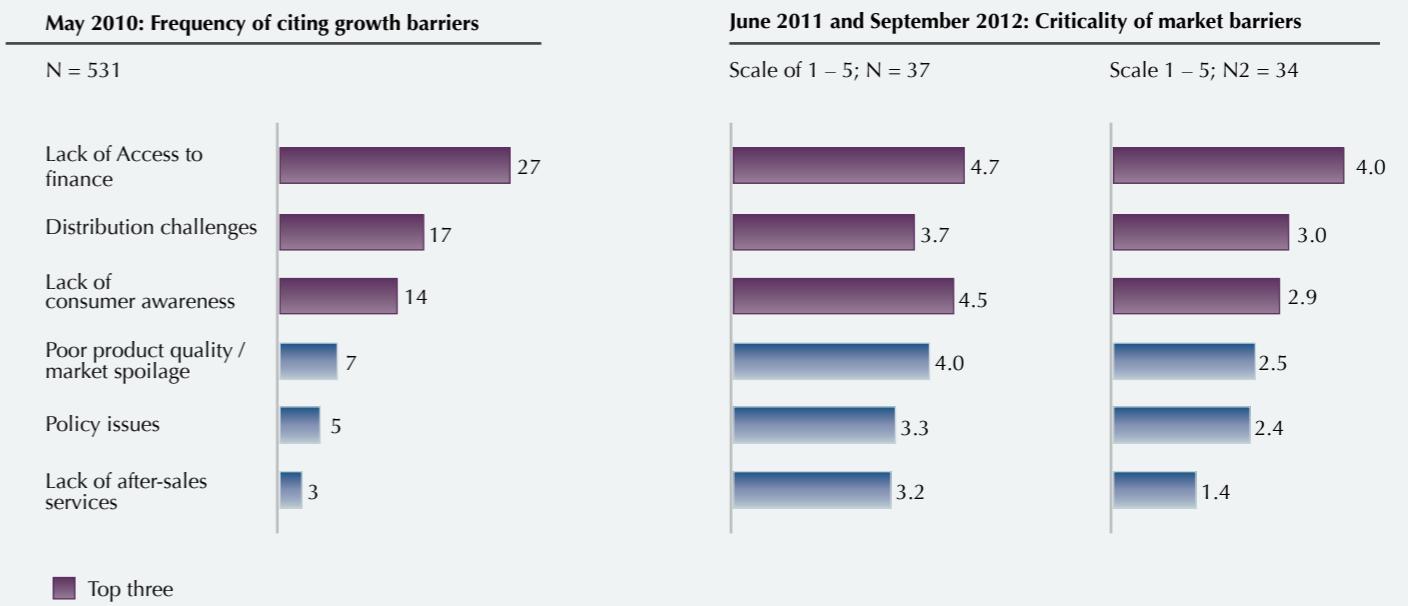
Source: Dalberg analysis

<sup>35</sup> Please note that our analysis does not try to predict the 'average' or 'median' lantern in 2020, but simply displays the significant gains in what will be available to customers in 2020 for the same price as what they are paying by end of 2012. The data underlying this analysis has been presented above in this section, and relies on independent price and performance trends of individual components such as solar PV cells, batteries etc. Actual lanterns and lights will simply demonstrate higher quality, better performance and a broader range of features and options.

## 5. Market barriers

The key market barriers identified by major players in 2010 have remained the same over time. Access to finance, distribution and lack of consumer awareness have consistently been the highest-rated challenges. However, the intensity of each barrier (particularly upstream access to finance challenges) has eased, according to stakeholder anecdotes (see Figure 32).

It is important to note that while all the barriers in Figure 32 limit market growth, their relevance varies according to manufacturers' lifecycle stage. For example, distribution challenges, while still a problem for mature players, are likely to be cited as a much more serious impediment to sales by a new entrant.

**Figure 32: Evolution of market barriers**

Several interviewees cited more than one barrier, which is why numbers below do not add up to 53. Interviewees represent 65-70% of the quality market

Source: Interviews with manufacturers and distributors; Dalberg analysis

In the sections following we discuss each barrier in detail.

**Access to Finance****Barriers**

**Absence of access to finance (A2F) options in the PLS market is a major impediment to its growth.** Discussions with stakeholders have revealed that traditional A2F solutions available to consumer goods markets cannot be directly applied to this sector, which requires tailored financial solutions. The PLS market is significantly different from other markets in that it: serves customers at the base of the economic pyramid; caters largely to remote rural areas; often requires after-sales support; and is a nascent market that benefits from the funding and support of socially driven institutions. These attributes and their implications for A2F solutions are explored in greater detail in Figure 33.

**Figure 33: Key differences between the PLS market and other consumer goods markets<sup>36</sup>**

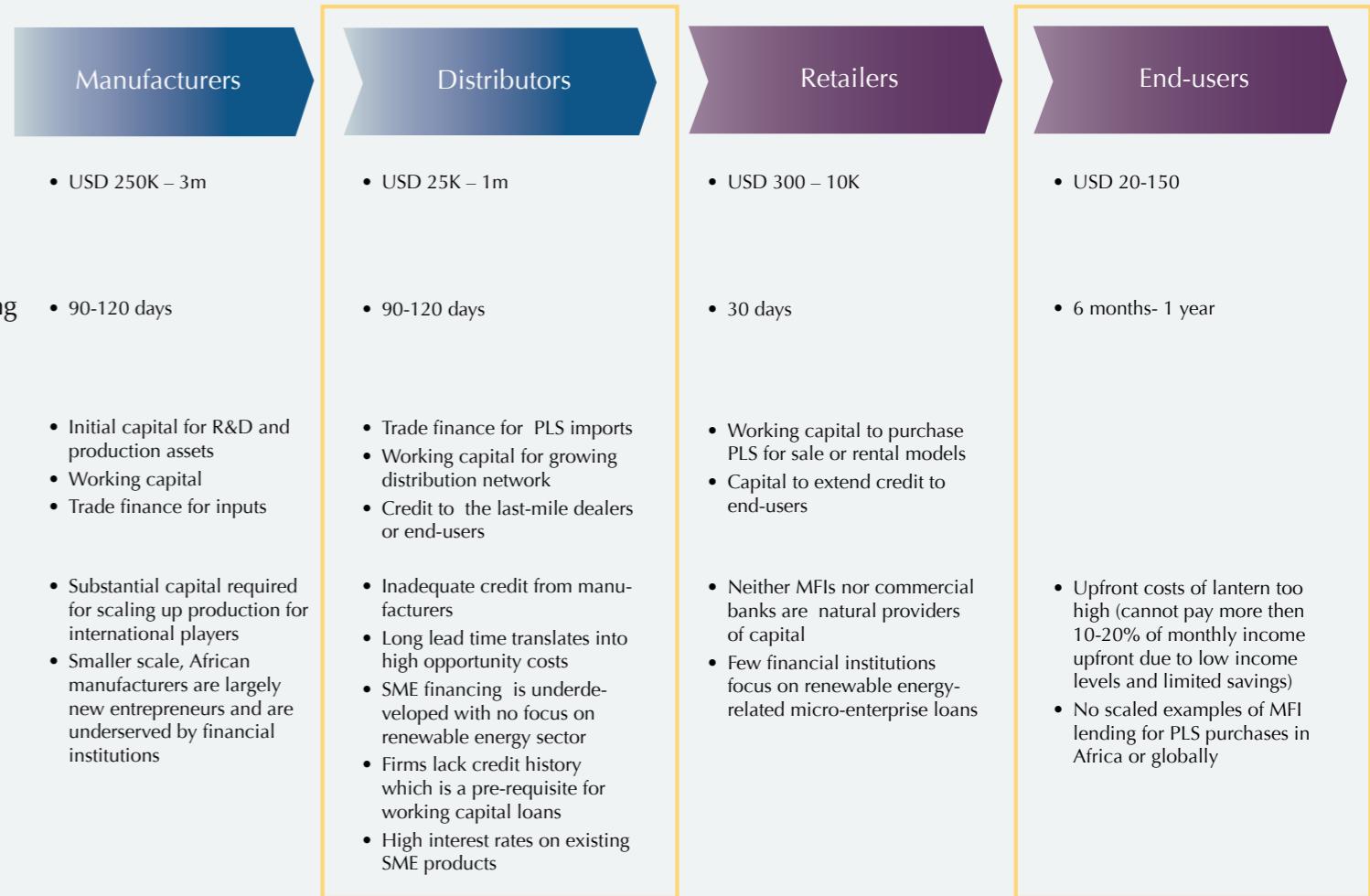
Market characteristic	Implication for access for finance
The PLS market caters primarily to a consumer base at the base of the pyramid.	This requires financing mechanisms to be a core part of the sales process and business model. Without financing, most consumers would be unable to afford PLSs.
PLSs need to be distributed in remote, rural areas.	Traditional finance institutions have limited reach in these areas.
The PLS market is still nascent and needs to achieve scale.	Credit institutions and investors need to be convinced of the products and viability of the PLS business, which faces some disadvantages as it is (1) a nascent industry, (2) established on a relatively new technology platform, and (3) relatively unknown with limited market information available.
The PLS market has high social impact and benefits from the support of socially driven institutions and funding.	The social benefits gained from the expansion of the PLS industry in turn attracts socially driven institutional players and funding in the form of subsidized funds and investment, policy initiatives and subsidies, refunds through programs like emissions trading, collective buying and consumer awareness programs.
Companies entering this space have thus far typically been small start-up enterprises.	These small- and medium-sized enterprises find it very difficult to access sufficient levels of financing, as they are constrained by the lack of a track record, and a small balance sheet.



*The PLS markets cater largely for rural areas. Here, a group of people sitting outside in Senegal, and using a solar lamp.  
© Bruno Déméocq/Lighting Africa/2012*

**While A2F solutions are needed across the PLS value chain, distributors and end consumers need them most. From stakeholder discussions, it was evident that these two primary challenges – identifying working capital for wholesalers/retail distributors and ensuring affordability for the end users – were the most urgent to ensure growth in this sector.**

**Figure 34: Financing needs across the value chain**



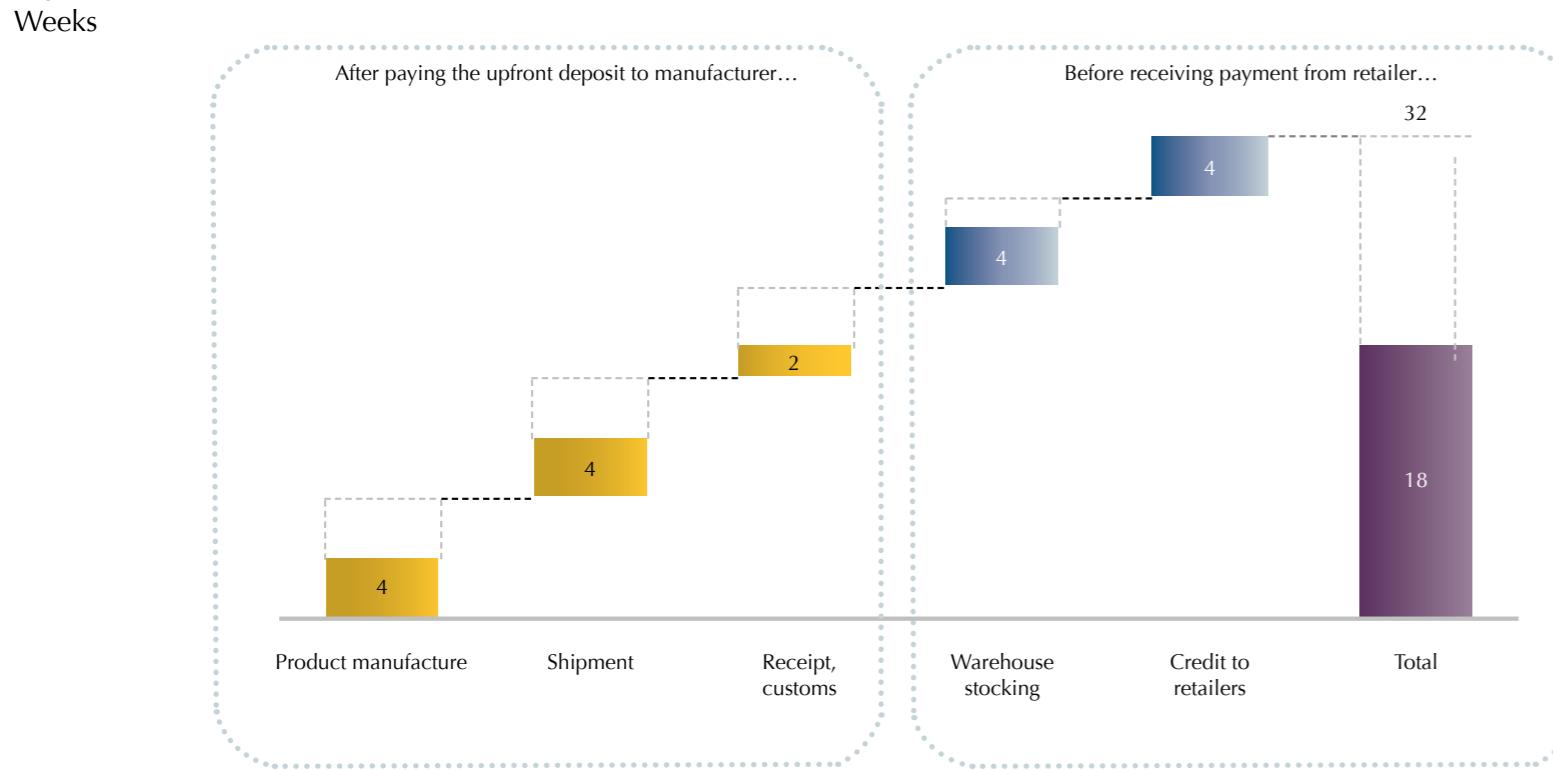
*Source: Interviews with industry stakeholders; Dalberg research and analysis*

**Wholesalers and distributors (excluding small retailers):** Distributors face the greatest upstream financing challenges in terms of working capital and trade finance:

- Distributors are typically offered no credit from manufacturers and, as small institutions with limited trading history, struggle to get credit from mainstream finance institutions like commercial banks; when financing is available, the interest rates are typically prohibitively high.
- They face disproportionately high inventory levels, due to a long global supply chain and poor demand predictions, and are often not able to ascertain accurate working capital requirements.

- They are often required to extend credit to dealers and small retailers in order to facilitate and stimulate sales.
- They often have to lock in capital for 18-32 weeks per sales cycle—between ten to 22 weeks after paying an upfront deposit to the manufacturer, and between eight to ten weeks before receiving payment from the retailer and/or dealer. The comparable sales cycle for fast-moving consumer goods (FMCGs) in the African market is only about four weeks or one-fourth the PLS sales cycle. This is a primary reason why distributors therefore prefer carrying FMCG products over pico-powered lighting products.

**Figure 35: Time taken for distributors from manufacturer to sale**

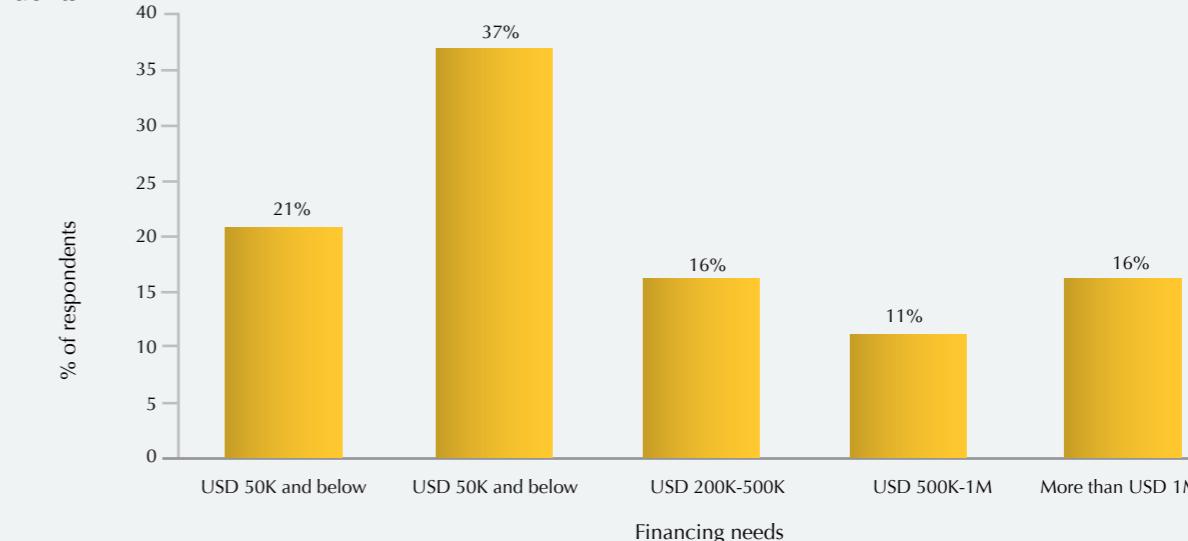


Source: 'Growth Capital for Off-Grid Lighting Companies', Lighting Africa (2010); Dalberg analysis

The working capital squeeze for distributors is the most pressing short-term financing issue, which, in turn, leads to sporadic supply and demand imbalances. Our survey of 30 distributor/wholesalers in 2010-11 demonstrated that approximately 40% of them required financing of between USD 50,000-200,000 per year (with a mean demand of ~USD 100,000) to support their trade and working capital needs. A smaller subset of them (approximately 27% of the total) reported substantially larger funding needs of USD 500,000-1 million in order to support their plans for growth, investment in distribution networks, and, in some cases, extension of credit to their sub-distributors and dealers (Figure 36). With increased financing, a majority of small- and medium-sized distributors claimed they could increase their sales volumes by between 50-200%, a growth rate that they can sustain for the next two to three years based on the demand from the market. These distributors also claimed that this high rate of growth could be sustained for the next two to three years based on demand from the market.

**Figure 36: Financing needs of distributors and wholesalers**

Percentage of respondents



1. These financing needs will grow significantly as the market develops in the next two to three years.

Source: Dalberg survey of 30 PLS distributors (2010); Dalberg analysis

**End users:** While most African BoP consumers are willing to pay for off-grid lighting products, their *ability* to pay is obviously severely constrained. Anecdotal evidence from interviews suggests that most BoP households are unable to afford upfront payments of more than 20%-30% of their monthly incomes.

The above-mentioned forecasted drop in component costs will naturally solve part of end-users' affordability problem. In fact, we have already observed the entry of some PLSs around the USD 10-15 price point. These declining price points will continue to open up new market segments and attract new customers over the long term.

At the same time, it is likely that the majority of PLS sales have only penetrated higher income segments within the African BoP (although even this segment remains underpenetrated). Hence, there could be real value for manufacturers to target that segment and customize their offerings to address the heterogeneous needs and constraints that exist at different income levels within the BoP.

#### Landscape

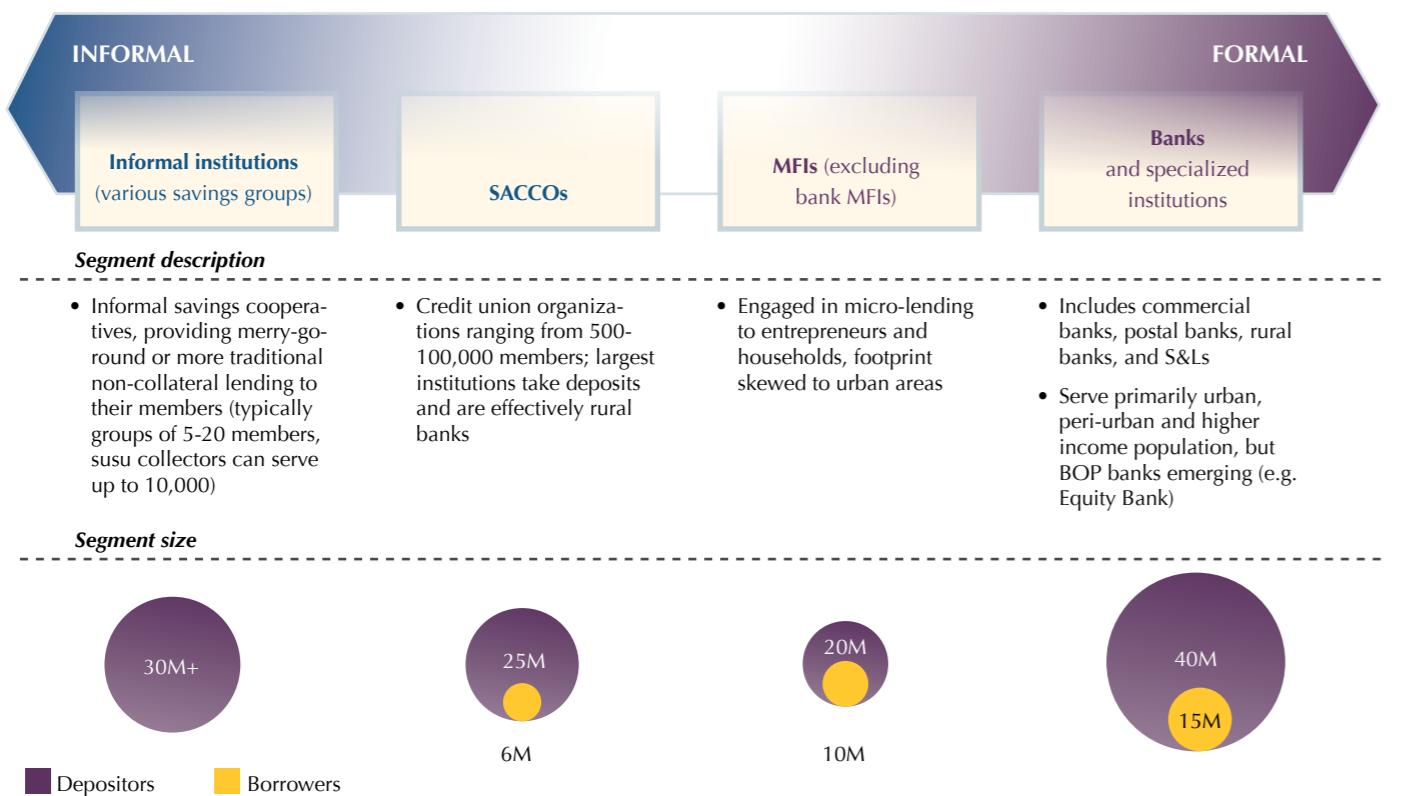
**Financial systems in most Sub-Saharan countries remain poorly developed relative to other regions.** Currently, only 24% of the adult population in Sub-Saharan Africa own bank accounts at formal financial institutions, compared to the global average of 50%. However, both supply and demand for finance is growing rapidly: the number of depositors in Sub-Saharan Africa doubled in the past three years<sup>37</sup> and the

<sup>37</sup> CGAP MIX (2011)

number and diversity of financial service providers is increasing. Banks, cooperatives, and regulated microfinance institutions are playing an increasingly important role in expanding financial services to low-income earners. Banks serve one-quarter of total borrowers and 40% of depositors in Sub-Saharan Africa, despite accounting for only 8% of financial institutions. Banks are experiencing the fastest growth in outreach to borrowers,<sup>38</sup> and in recent years pan-African banking groups have expanded rapidly in the region to hold a significant share of domestic deposits. This change has resulted in increased local competition and the introduction of new technologies and products.<sup>39</sup> Not surprisingly, mobile money is increasingly expanding access to finance in a region where 16% of adults reportedly use a mobile phone to pay bills or send/receive money, compared to a global average of less than 5%.<sup>40</sup>

Despite the recent increase in coverage, the bulk of Sub-Saharan Africa's low-income households continues to access financial services via fragmented, semi-formal and informal community-based organizations. Figure 37 below shows the number of players in Africa ranging from formal, regulated institutions (commercial banks, MFIs with bank licenses, postal banks and rural banks); semi-formal financial institutions (non-banking MFIs and SACCOs); and informal financing institutions and savings groups. Informal and semi-formal institutions like SACCOs cover up to 50 million BoP customers, effectively serving as banks in rural areas where formal financial establishments are unlikely to be present. In order to expand coverage and increase the size of the addressable PLS market, manufacturers, distributors and other stakeholders – including donors and multilateral institutions – must seek to engage these financial players.

**Figure 37: BoP financial landscape overview for Africa**

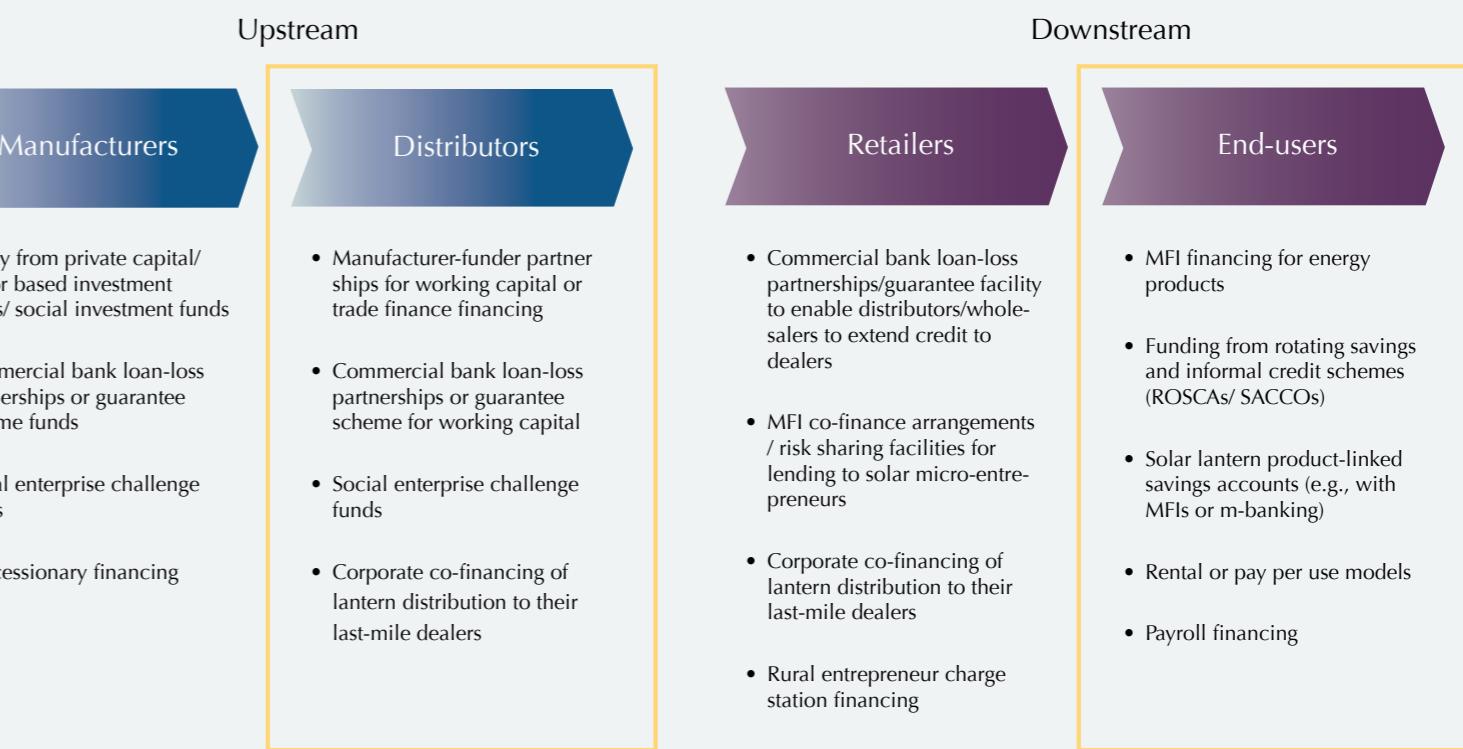


Source: CGAP; Mix Market; FinAccess; FinScope; FSD; various MFI, SACCO, and banking associations; Dalberg analysis

## Solutions

Several innovative and traditional financing solutions are now being applied to this sector. Figure 38 below gives a brief overview of potential access to finance solutions across the PLS value chain.

**Figure 38: Overview of potential solutions to resolve access to finance challenges**



Source: Interviews with industry stakeholders; Dalberg research and analysis

## End-user financing

While some interesting pilots are underway to address the end-user availability challenge, the availability of financing schemes to end-users is currently almost negligible and suffers from limited support from manufacturers, distributors, and the formal financial sector. Some program structures that could help solve this issue are discussed below. These include (1) MFI-based micro-lending for PLSs (2) engaging the semi-formal and informal financing sector (3) mobile payment-enabled lending and pay-as-you-go models, and (4) payroll financing.

<sup>38</sup> CGAP MIX 2010

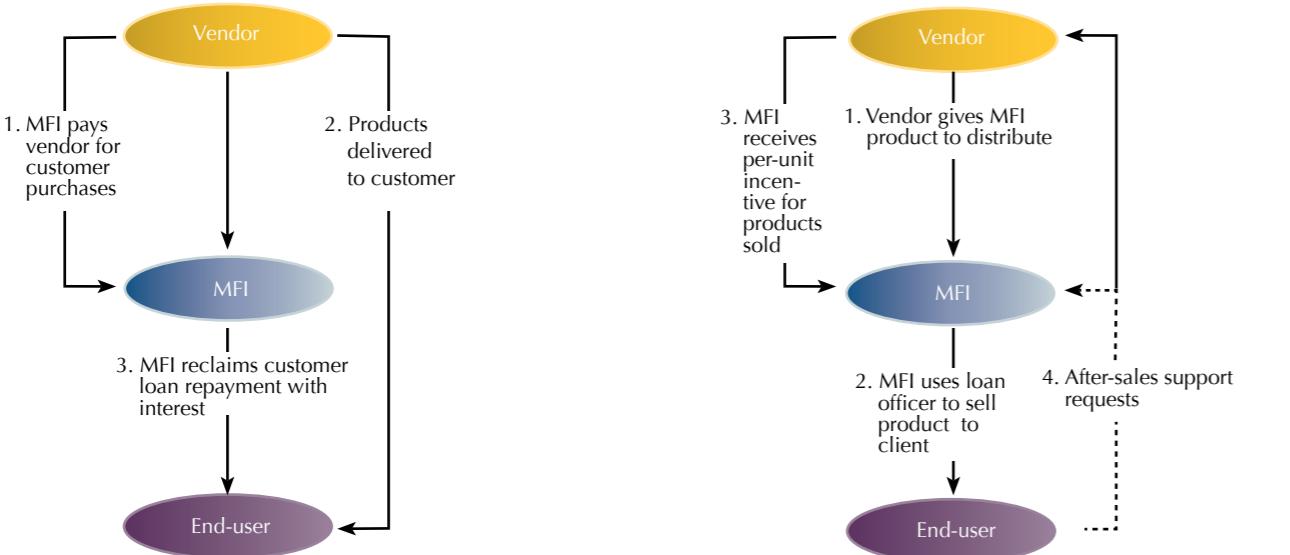
<sup>39</sup> FSB, IMF, and WB 2011

<sup>40</sup> FINDEX 2012 (2011)

## (1) MFI-based micro-lending for PLSs

Traditional MFI lending for PLSs follows a simple model with two variants (Figure 39).

**Figure 39: Lending models used by MFIs for PLSs**



Source: Dalberg research and interviews

In the first model, non-cash loans of USD 25-80 are provided to customers, with the MFI paying the supplier on the customer's behalf to ensure cash is not used for other expenditure. Customers then collect the PLS from the distributor. In the second model, in addition to basic product financing, MFIs are involved at various points in the customer-use lifecycle, including marketing, promotion, order management, delivery, and after-sales support.

However, based on our research, traditional MFI microfinance lending for PLSs has limited prospects for rapid scale-up for three key reasons:

- *High transaction costs for small PLS loans.* The fundamental financial challenge comes down to a misalignment between loan size and transaction costs. For example, lantern prices range from USD 20-70, whereas the average loan balance of MFIs in Sub-Saharan Africa is more than USD 300, making it economically infeasible for MFIs to finance directly the purchase of PLSs.
- *Poor fit of PLS lending with MFI strategic priorities, incentives, footprint and capabilities.* Consumer lending is significantly riskier than enterprise lending. Consequently, PLS-financing programs test an MFI's operational capabilities to conduct non-financial functions like product marketing, processing and tracking orders, logistics, and after-sales service. The most successful programs are those that have minimized the MFI's involvement in these non-core activities.
- *Funding constraints.* Most MFIs have a restricted pool of wholesale debt capital to allocate to their loan portfolios. Debt from commercial banks and development finance institutions (DFIs) is generally restricted to enterprise loans, which are tailored to finance the small businesses of borrowers and cannot be diverted into new experimental programs, like consumer loans for PLSs.

PLS distributor feedback below further illustrates some of these challenges.

### Distributor feedback on working with MFIs to provide consumer loans for PLSs

'Excessive administration fees from MFIs to process loans for the lanterns have proved prohibitive for end customers.'

'SACCOs/MFIs think that it's very expensive to loan out USD 50 due to the administrative expenses and are therefore reluctant to provide loans on a per individual basis for the lanterns.'

'[We] worked with MFIs for a while, but they were cautious of being deemed as 'endorsing' lanterns, especially if they malfunctioned—e.g., initial lanterns had battery issues.'

'[We] have approached several MFIs but it's difficult to work with them since the products are too cheap—administrative costs would be too high.'

Source: Dalberg interviews with manufacturers and distributors (2010).

Despite these challenges, MFIs could still be used to finance PLSs, especially if the loan amount is increased. This is done in one of two ways:

- *Topping up existing loans to finance PLSs.* MFIs could target customers who already have outstanding loans and simply add the cost of the PLS to the outstanding balance. This method would avoid transaction costs created by a new loan, and the same payment plan then could be extended to cover the additional cost of the PLS.
- *Bundling of products to raise ticket size.* MFIs could provide financing for an PLS and a complementary product – such as a clean cook stove, water purifier or cell phone – to raise the combined loan size to a viable amount. For example, the Self-Employed Women's Association (SEWA) has partnered with IFC to provide solar stoves and lanterns to its 200,000 rural women members in the western Indian state of Gujarat. SEWA provides its members with loans of USD 100-150 to purchase the bundled offering, at a 16% interest rate, repayable in manageable monthly installments.

### (2) Engaging the semi-formal and informal financing sector

These organizations include SACCOs, Village Savings Loan Associations, Accumulating Savings and Credit Associations, Rotating Savings and Credit Association (ROSCAs) and Susu collectors via appropriate intermediaries. They have several advantages over the more formal institutions such as MFIs and banks, which include:

- A greater rural footprint and increased ability to distribute physical products;
- A higher tolerance for risk given their mission and communal structure along with a greater focus on engaging in livelihood-enhancing activities such as energy finance;
- Lower operational costs, and;
- Access to cheaper funding through member deposits.

However, despite some clear advantages, this channel has typically faced many of the same challenges as traditional microfinance institutions. First, SACCOs and other such community-based organizations (CBOs) have limited managerial capacity to push energy products and the same transaction costs issues as MFIs. Second, financing experts we interviewed have highlighted the lack of sizeable credible SACCO counterparties. Finally, this channel would require significant technical assistance for implementation.

### Partnering with SACCOs: the case of Women Enterprise Development Institute, Kenya

The Women Enterprise Development Institute (WEDI) is a fund manager for a portfolio of 800 women's savings and credit groups operating in the larger Central Province of Kenya. WEDI's objectives are to mobilize group savings and improve lending amongst members in order to reduce dependence from donor funding and create their own funds for socio-economic development.

WEDI's member groups are introduced to various products that individual members can buy with their savings. In 2010, GVEP, in collaboration with Brazafric –a distributor of quality pico-powered lighting products – began providing pico-powered lighting products to the women's savings groups managed by WEDI. WEDI was responsible for distributing the lighting products to members as well as collecting payments and undertaking any administrative activities.

Key to the program's success was the awareness sessions and trainings for WEDI's loan officers who are key motivators for the project. The success of the scheme also resulted from the incentive schemes in the supply chain. WEDI received the LED lamps at a wholesale price and each loan officer responsible for the deployment of the lamps received USD 1.25 for every lamp sold.

Source: [www.gvepinternational.org](http://www.gvepinternational.org)

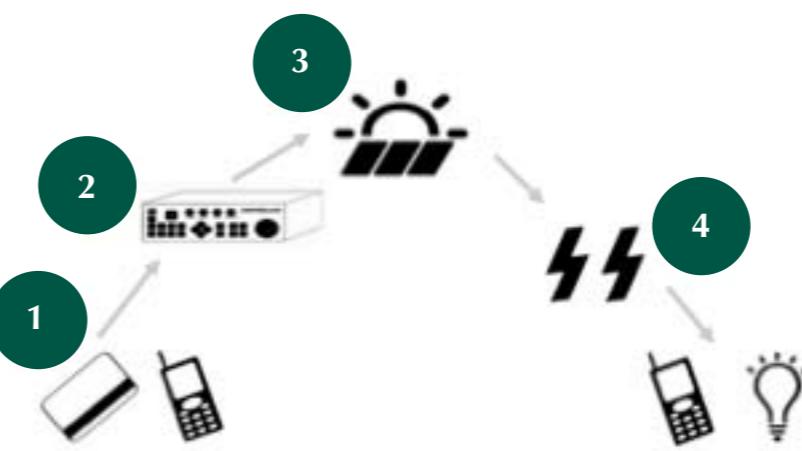
### (3) Mobile-payment enabled PLS lending and pay-as-you-go

Mobile lending for PLS financing is a promising alternative that could break free of the current transaction cost constraints on PLS lending. There are two avenues through which this infrastructure can reduce transaction costs and enhance affordability of PLSs:

- Financial-institution led: MFIs and other financial institutions can use a mobile payment (m-payment) platform to disburse credit and collect repayments, thereby reducing their transaction costs by over 50%. Both Equity and Family Bank, who are well positioned for this concept with their M-Kesha and Pesa Pap products, have expressed interest to explore such products.
- Non-financial-institution led: Other non-financial institutions could develop 'pay-as-you-go' energy businesses enabled by an m-payment platform. This method is gaining popularity with several start-up businesses that are utilizing technology to reduce the transaction size of solar energy, allowing consumers to pay for one day of energy at a time. Azuri Technologies, M-KOPA, and Simpa Networks have recently completed pilots of these models. However, pilots have primarily been restricted to larger SHSs.

Below we provide an example of a typical pay-as-you-go model.

**Figure 40: Overview of a sample pay-as-you-go model of finance and distribution**



#### OVERVIEW

- Model combines mobile technology with solar technology, allowing customers to buy scratch cards to pay for energy, just as they would for mobile phones.
- Customers who have paid off the cost of their unit can upgrade to larger system to cater to expanding energy needs
- All hardware (panel, lights, wiring, control unit) is provided at no upfront cost (although a small deposit is required).

1. IFC estimates that for solar lighting products in the USD20-50 range, a 20% reduction in the upfront cost increases the addressable market size by an equal amount, 'From Gap to Opportunity' IFC (2012).

Source: [www.azuri-technologies.com](http://www.azuri-technologies.com); Websites of Eight19 and Indigo; Dalberg research

### (4) Payroll Financing

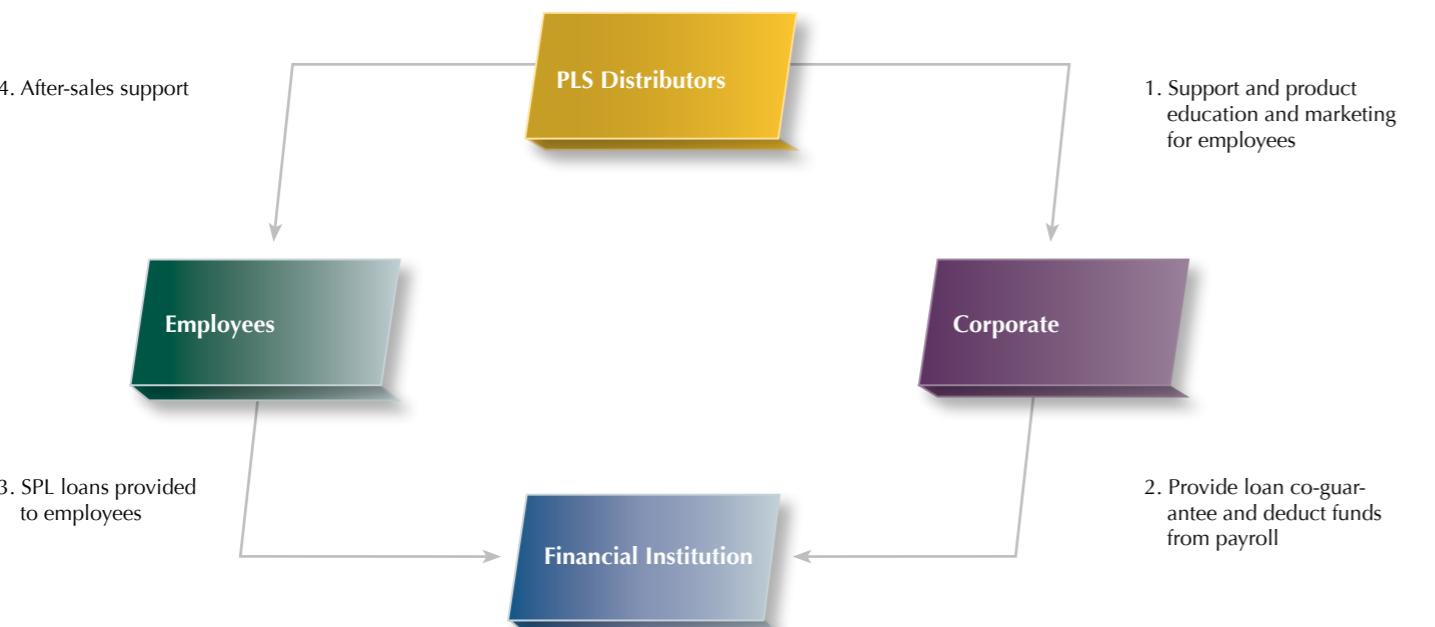
The payroll financing concept revolves around a large employer partnering with a reputable PLS distributor and financial institution to provide its employees with PLS devices and related financing. Several variations are possible, but the broad mechanics of such a scheme are outlined in Figure 41.

#### OPERATING PROCESS

- 1 Customers purchase scratch cards (usually USD 1) from local stores; scratch card is validated via SMS
- 2 Customers receive a one-time access code that is entered into the control unit, unlocking the PLS/SHS for use for a fixed period (usually one week)
- 3 Solar panel is activated; produces electricity
- 4 Customers light homes and charge phones until credit is exhausted, when another scratch card is purchased

#### ADVANTAGES AND DISADVANTAGES

- ✓ Size of addressable market increases substantially due to elimination of upfront costs<sup>1</sup>
- ✓ Poorest customers provided access to quality and safe lighting unlocking health and economic benefits
- ✓ Consumers save up to 50% of weekly spend on lighting and mobile charging
- ✗ Higher capital costs for manufacturers (control unit)

**Figure 41: Illustration of payroll financing of PLSs for employees of corporation and/or large public institutions**

Source: Dalberg research

Once an employee makes a purchasing decision, he or she first receives a non-cash loan from the financial institution. The financial institution (FI) then directly pays the PLS vendor, who delivers the PLS to the employee. Finally, the employee authorizes the FI to deduct loan re-payments directly from his or her payroll. This platform reduces the FI's transaction costs, as it provides an inexpensive means of collection and allows for the rapid scoring of an individual's credit. Additionally, data on individual employment history and income helps the financial institution manage its risks.

#### **Andhra Pradesh State Transport Corporation (APSTC), India**

A payroll financing scheme for PLS distribution was implemented in the Indian state of Andhra Pradesh, through its state-owned road transportation company. The AP State Road Transport Corporation has more than 1.28 million employees, most from rural villages and living in ancestral houses or joint family homes. Solar lanterns were provided to them through a salary deduction scheme. The lanterns, which cost USD 44-66 at the project's 2004-2005 inception, were made available on equal monthly payments over one or two-year periods. APSRTC employees were thus able to buy lanterns for their family, extended relatives, or even friends. The employer ensured repayment of the cost to the manufacturer, by way of a memorandum of understanding, and the PLS manufacturer committed to proper servicing during and after the loan period as part of the contract.

Source: 'Good practices inventory: Market development for solar lantern in post-subsidy regime, Asia-Pacific Environmental Innovation Strategies ([www.enviroscope.iges.or.jp](http://www.enviroscope.iges.or.jp))

#### **Upstream financing**

This section highlights two potential upstream financing solutions that can help solve the financing challenges faced by manufacturers and distributors of PLSs.

##### *(i) Supplying working capital for trade finance at the manufacturer level and extending it to distributors*

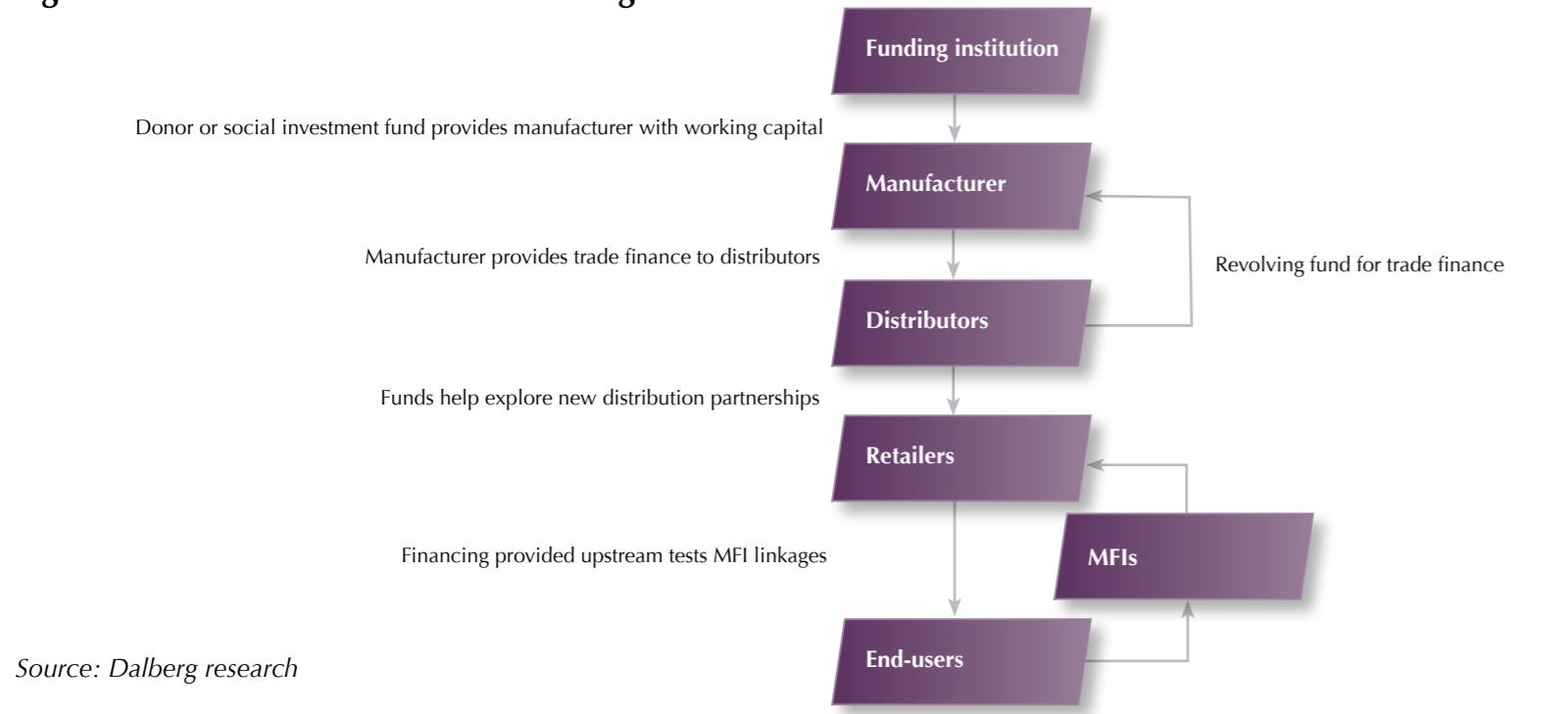
Working capital is a significant constraint to upstream financing. Manufacturers often require working capital loans that amount to double their total sales for the year (given exponential growth rates). In interviews, several manufacturers pointed out that finance facilities that enable manufacturers to extend credit to distributors would be invaluable to both parties.

One key solution to unlocking access to finance in the African PLS market is to develop an innovative and comprehensive trade financing model to encourage credit lines between manufacturers and distributors. Donors or social impact investment funds could drive these models, creating a revolving fund of working capital between USD 250,000-2 million, a range well suited to the needs of PLS manufacturers.

#### **The trade financing model: A partnership between Shell Foundation and d.light**

An example of the trade-financing model is found in the partnership between the Shell Foundation and d.light. In 2010, d.light had little access to working capital loans and was unable to extend credit to downstream customers—these were serious drawbacks when competing with other companies that offered credit terms to dealers and distributors. d.light required long-term working capital at below market rates, prompting a collaboration with the Shell Foundation in 2009 to test MFI linkages, new distribution partnerships and to strengthen distribution models. d.light used Shell's funding as risk capital to jumpstart micro-financing partnerships and to create a revolving working capital pool for distributor capacity building and credit.

Source: [www.dlightdesign.com](http://www.dlightdesign.com); [www.shellfoundation.org](http://www.shellfoundation.org)

**Figure 42: Illustration of a trade financing model**

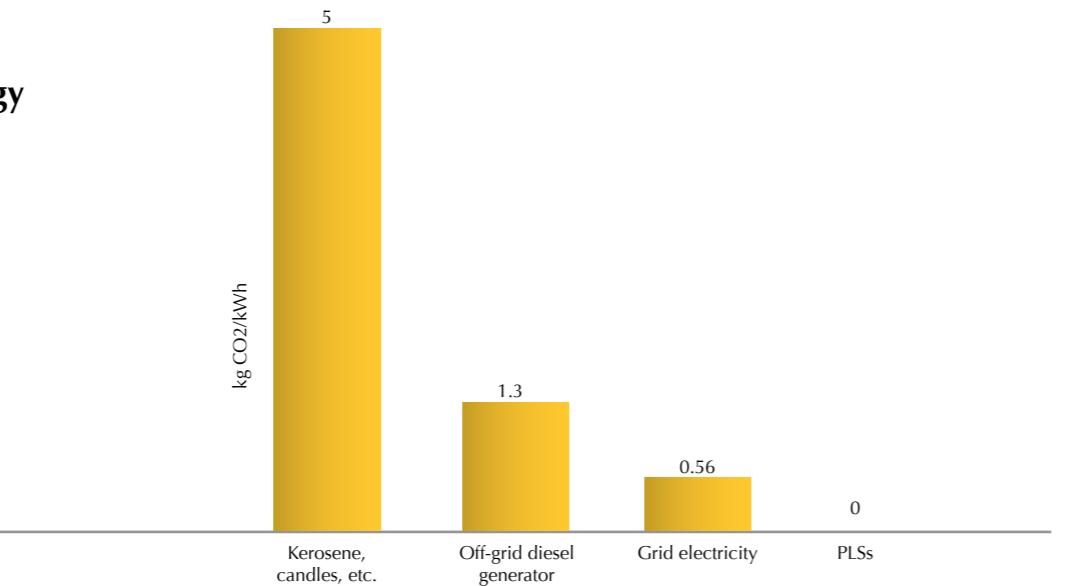
#### (ii) Trading CER credits through the Clean Development Mechanism

The Clean Development Mechanism (CDM) allows PLS manufacturers to gain Carbon Emission Reduction (CER) credits for replacing fuel-based lighting with renewable energy sources. The CDM has helped create a large market for CERs, where manufacturers can sell their credits. PLSs are a good fit for the CDM because they directly displace carbon emissions while contributing to rural development and sustainable energy. While the quantity of CO<sub>2</sub> emission abatement is quite small per household, there is significant potential in large-scale distribution.

**Figure 43: Carbon emissions by energy source for lighting**

Figures in kg Co<sub>2</sub>/kWh

Source: 'Towards a streamlined CDM process for Solar Home Systems', The Energy Research Center of Netherlands (2000); Dalberg research



Very few PLS companies have attempted to qualify their LED lighting programs for carbon credits under the CDM. Requirements are seen as too tedious for manufacturers, especially given their present low scales.

When companies reach significant sales volumes, transaction costs become less of a consideration. The current price per ton of avoided carbon dioxide under the CDM is very low, but if it recovers the potential for returns may be significant. Based on the minimum performance criteria specified in the new verified methodology, savings for PLSs can amount to approximately 0.1 ton of carbon dioxide per lamp per year, or about USD 0.5 per lamp at current CDM carbon market prices. Under favorable market conditions, this additional revenue from the CDM could increase the profitability of PLS companies working at scale in developing countries. The returns from emissions trading could provide working capital and trade finance in the supply chain, increase profit margins, and ultimately, lower prices for the end-user. Moreover, the new method ascribes value based on whether the product is quality-verified by Lighting Global, as well as other predictors of product service, life and performance. In parallel, transaction costs are further lowered by the use of GSM devices inside products or SMS-enabled product registration, both of which have eased the monitoring process.

Despite these potential advantages, significant drawbacks remain for manufacturers using the CDM. First, kerosene baselines vary by territory, therefore earnings per lamp can change dramatically. Second, the viability of the CDM mechanism for PLSs wholly depends on the international market price of carbon, which has recently been extremely volatile. Per the carbon prices of October 2012, manufacturers said it would not be possible to earn viable revenues through the CDM route unless a floor price was negotiated or carbon credits could be sold on the voluntary market through individually negotiated deals.

## Distribution

**Poor distribution continues to impede PLS manufacturers from reaching last-mile customers and achieving scale.** Specific challenges noted by suppliers include:

- A long sales cycle in which distributors are compelled to lock in capital for 18 to 32 weeks;
- High distribution costs, including transactions costs associated with finding reliable partners; in some geographies, this comprises 50-70% of manufacturing costs;
- Fragmented local distribution networks, with small-scale intermediaries that struggle constantly to raise working capital;
- Slow, expensive, unsafe and unreliable transport links due to poor infrastructure;
- A dispersed target population residing primarily in remote, rural locations;
- Heterogeneous customers, partners and market characteristics that make it difficult to replicate successful models;
- A need to sensitize potential consumers to product advantages without any guarantees of purchase.

Manufacturers have thus far targeted particular geographies opportunistically, basing service decisions primarily on the availability of appropriate distribution channels and partners. As a result, manufacturers and distributors have no consistent approach or model for reaching last-mile customers. While standard dealer-distributor networks remain the most popular, suppliers seem to agree that no single 'winning' solution exists at scale. Figure 44 provides an overview of the various channels employed to reach PLS consumers.<sup>41</sup>

**Figure 44: Overview of different distribution channels to reach BoP customers**

Distribution model	Product range	Distributor gross margin	PLS marketing	PLS distribution / logistics	PLS last-mile sales and after sales support
Distributor-dealer network	Broad range of complimentary, competitive and sometimes unrelated products	10-40%	Materials: distributor Cost: last-mile dealer	Logistics: distributor Cost: distributor	<ul style="list-style-type: none"> <li>Final sales: handled by dealer</li> <li>Product financing: informal</li> <li>After-sales support: distributor</li> </ul>
Own distribution / direct-to-consumer	Exclusive to company	20-50%	Materials: distributor Cost: distributor	Logistics: distributor Cost: distributor	<ul style="list-style-type: none"> <li>Final sales: handled by sales team</li> <li>Product financing: rarely formalized</li> <li>After-sales support: sales team</li> </ul>
Institutional partnership (e.g., with MFI, SACCO, NGO)	Typically exclusive or limited to other value-added products	10-30%	Materials: distributor Cost: shared	Logistics: distributor Cost: distributor only or shared	<ul style="list-style-type: none"> <li>Final sales: handled by partner</li> <li>Product financing: if partner is a financing institution (MFI SHG network, etc); rental/ charging kiosk model is optional</li> <li>After-sales support: partner</li> </ul>
Franchise	Exclusive to distributor/ manufacturer	10-30%	Materials: distributor Cost: shared with franchisee	Logistics: distributor Cost: shared with franchisee	<ul style="list-style-type: none"> <li>Final sales: handled by franchisee</li> <li>Product financing: rarely formalized</li> <li>After-sales support: franchisee</li> </ul>
Rental /leasing system to micro-entrepreneurs	Typically exclusive or limited to other value-added products	10-30%	Materials: distributor Cost: shared with leaser	Logistics: distributor Cost: shared with leaser	<ul style="list-style-type: none"> <li>Final sales: handled by leaser</li> <li>Product financing: rental model enables small cash payments</li> <li>After-sales support: leaser</li> </ul>

Source: Dalberg research and analysis

<sup>41</sup> All information on specific models and partnerships are from publicly available information from company websites and internet research.



A retailer in Kenya.  
© Andres Bifani/Lighting Africa/2012

#### (1) Standard retail and dealer-distributor networks

In this model, a company sells its products through the traditional hierarchy of distributors, including both specialist and generalist retailers of consumer durables. For example:

- To penetrate the Nigerian market, d.light partnered with Primplaks, a distributor specialized in roofing materials, thus capitalizing on the overlap between lighting and essential home needs.
- Toughstuff's PLS products can be bought at more than 700 retail stores across Kenya, including electrical shops, supermarkets and mobile phone shops.

#### (2) MFIs and NGOs

PLS manufacturers often partner with other organizations to tap into a large number of potential customers, sometimes even when the organizations' core activities do not directly relate to energy access. For example:

- Toughstuff partners with more than nine non-profits, including Christian Aid and World Vision, to help distribute its products worldwide.

### (3) Institutional (including governmental and corporate) partnerships

Institutional partnerships are similar to NGO/MFI partnerships, although they are often larger in size, enable access to more financial resources, and may include organizations without any social objective. For example:

- Petroleum giant Total has partnered with d.light (and other brands such as Greenlight Planet and Sunda) to offer PLS products in fueling stations in Cameroon, Burkina Faso, Kenya, Senegal and Indonesia.
- CB Energie derives a portion of its sales from institutional agreements with the Government of Burkina Faso.

### (4) Micro-franchise

The manufacturer offers franchising packages and support to micro-entrepreneurs who become responsible for the sales and marketing of the product. For example:

- Greenlight Planet's Saathi model allows rural farmers, teachers and housewives in India to earn supplementary income by selling solar products in their villages.
- Nuru Energy works with entrepreneurs in rural areas to arrange small loans for the purchase of power cycles and establishing a LED-charging business.

### (5) Rental

The company leases the use of its products to consumers, allowing them to avoid paying the relatively high upfront expenditure of buying the PLS. For example:

- Greenlight Planet's distribution channel partners have assisted entrepreneurs in Kenya to operate enterprises managing the daily charging and nightly rental of PLSs to customers.
- Azuri Technology's Indigo system uses mobile phone technology to allow customers to pay for their power as they use it by purchasing weekly scratch-cards.

### (6) Proprietary/ own distribution

Companies with a proprietary distribution strategy move products from the manufacturing location to in-house storage facilities and eventually to final consumers through a dedicated sales force. For example:

- Barefoot Power, through its subsidiary Barefoot Uganda, trains entrepreneurs through a specialized business-in-a-bag program that sells its most popular Firefly product line.

**Most manufacturers employ multiple distribution strategies to maximize their reach into target BoP populations.** We estimate that firms on average derive 30-50% of their sales from partnerships and 50-70% through standard retail channels. In recent times, the ubiquity of one-off bulk sales from philanthropic efforts has faded; while aid-based organizations will continue to figure in the finance and distribution of pico-powered lighting products, it is likely that market-based distribution models will take over prominence. Figure 45 illustrates the different distribution strategies used by five leading manufacturers.

**Figure 45: Prominent distribution strategies used by selected manufacturers**

Dealer	Proprietary	Partnership	Micro-franchise	Rental
✓	✓	✓	✓	✓
✓	✓	✓	✓	
✓	✓		✓	
	✓		✓	✓



**Over time, there is a strong possibility that distribution patterns will mimic those of other, established consumer durables in other geographies.** Consumer electronics, such as fans, pressure cookers, radios and televisions, have already deeply penetrated rural communities in some developing nations. Research indicates that even for rural customers, the vast majority of consumer durables are purchased in urban retail outlets. In India for example, while 53% of all fans are sold to rural households, only about 5% of those sales actually occur in rural outlets.<sup>42</sup>

Research also reveals that rural customers prefer to travel to purchase these goods in urban centers, because they expect to find lower prices, a greater variety of brands, higher quality of products,<sup>43</sup> and cheap consumer financing. Furthermore, many rural families have at least some members in the regional urban center who act as natural urban-to-rural distribution links.

<sup>42</sup> 'Marketing Channel Strategies in Rural Emerging Markets' Neuwirth (2012).

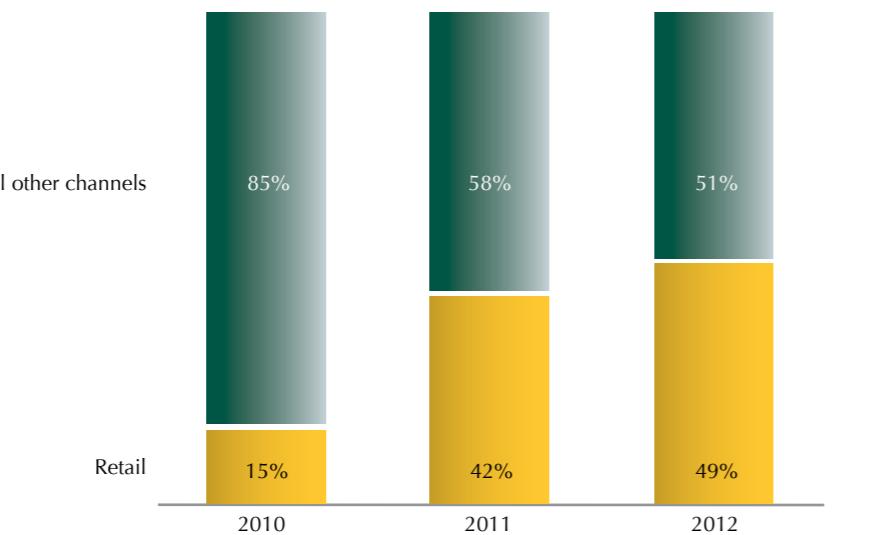
<sup>43</sup> Interviews with manufacturers and distributors; Neuwirth (2012).

Manufacturers also prefer this urban-based, family-facilitated channel because it eases demand aggregation and requires substantially lower investment. However, such distribution poses challenges to both consumers and suppliers. For example, it complicates the warranty claims process, as customers may be compelled to travel large distances to and from the urban centers to address any problems.

Emerging evidence from Kenya suggests that PLS distribution patterns may have already started this transition. While precise estimates are hard to come by, anecdotes from interviews with market stakeholders suggest that Kenya is the most penetrated rural market for PLSs in Africa, with half of the sales occurring in urban retail areas (Figure 46).

**Figure 46: Evolution of sales by retail channel in Kenya**

Percentage of total sales; FY 2010-12



Source: Lighting Africa data; Dalberg analysis

### Consumer awareness and marketing

**Marketing efforts have focused on increasing general solar lighting awareness and education, as well as convincing potential customers that PLSs are superior to traditional lighting sources.** Many potential consumers are unaware of quality solar-powered lighting products and their benefits. Among those who are aware of the products, there is the misperception that PLSs are more expensive than kerosene and biomass lighting. Awareness campaigns have therefore attempted to convince customers that not only are they buying better, safer lighting that will improve the quality of their lives, but also that doing so will result in significant savings over time.

Past campaigns have emphasized the following themes:

- The superior quality of light provided by PLSs relative to kerosene and other alternatives, which supports important, nighttime household activities like reading, schoolwork and cooking;
- The health benefits associated with switching to solar lights<sup>44</sup>;
- The significant economic benefits of an PLS relative to kerosene, given its zero operating cost, including payback periods of typically three to six months;
- The superior functionality of PLSs in terms of lighting quality, ease of operation, durability and additional features such as mobile charging.

**Yet, consumer awareness regarding PLSs remains low.** Effective behavior change communication campaigns<sup>45</sup> aimed at key, rural customer segments which are often in largely inaccessible rural areas are expensive to design and implement. Specific challenges include: (1) developing appropriate and universal messaging, (2) determining the best medium of dissemination, (3) finding appropriate partners for implementation and funding, and (5) overcoming cultural, linguistic and literacy barriers.

**The lack of investment in large-scale consumer marketing, particularly by manufacturers and distributors, is another important reason why consumer awareness remains low.** Returns from investments in marketing efforts – which typically adds 6-10% to device costs<sup>46</sup> – are largely public and not private. Therefore, a company that invests in raising consumer awareness may increase the demand for the products in general, but cannot be assured that consumers will buy from them, rather than a competitor. This is representative of a coordination failure which is being increasingly recognized and addressed by governments and donors.

<sup>44</sup> Existing PLS users reported this to be one of the key benefits of solar lights, according to consumer surveys conducted by the Lighting Africa in 2011.

<sup>45</sup> Behavior change campaigns work at the community or the individual level to change/eradicate harmful behaviors, and promote behaviors that improve the quality of life for an individual or community.

<sup>46</sup> 'From Gap to Opportunity: Business Models for Scaling up Energy Access', IFC (2012)

### Lighting Africa's consumer education and awareness campaign

IFC/World Bank's Lighting Africa program has recognized the need and importance of growing and sustaining consumer knowledge and confidence in modern pico-powered lighting products. The program therefore runs a consumer education campaign to encourage rural communities without electricity to adopt clean lighting. Lighting Africa's consumer education explains the benefits of solar lighting over kerosene and provides objective information about quality products in order to build trust in the new modern lighting products.

The consumer education campaign undertakes a variety of activities including road shows and focus group discussions to introduce and explain how modern lighting products work and where they can be found. These are complemented by public service announcements and media mentions, particularly on radio. In addition, the campaign promotes proven, reliable products that have met Lighting Africa's Recommended Performance Targets.

The program has, in the last three years, organized more than 1,500 road shows and focus group discussions on modern lighting products, reaching more than 22 million people in its pilot countries, Kenya and Ghana.



**Word-of-mouth remains the most important channel to spread awareness and generate customer confidence. Other important channels include mass media initiatives through television, radio and newspaper, and direct marketing efforts such as product trials and door-to-door marketing.** The use of mass media for marketing PLSs has thus far been limited, primarily because the channel remains costly relative to others and does not solely target BoP customer segments. Direct marketing methods have been employed in several geographies.

Some prominent examples include:

**Figure 47: Overview of consumer awareness and marketing channels**

CHANNEL	PRIMARY ACTORS	TARGETING	ATTRIBUTES	COST
TV	• Branded manufacturers;	• Middle/high income households; mainly urban		●
Radio	• Branded manufacturers; DFIs/ donors; governments	• All urban and rural households; not targeted to particular segments		●
Newspaper/ billboards/ posters	• Branded manufacturers; DFIs/ donors; governments	• All urban and rural households; not targeted to particular segments		●
Road shows/ demonstrations	• DFIs/donors; governments	• All HH in selected area; can be targeted e.g. ante-natal clinics to reach women		●
Product trials	• NGOs; CBOs; manufacturers; distributors	• Narrowly targeted to specific market segments; good reach to HH decision-makers		●
Door-to-door marketing	• Manufacturers; distributors	• Narrowly targeted; reach depends on network size		●
Word-of-mouth	• Key opinion leaders; early adopters	• Rural households and communities		●

Source: Interviews with experts; Lighting Africa research; Dalberg research and analysis

- Sunny Money, the largest non-manufacturer distributor of PLSs in Africa, has found that demonstrations and product trials with students drive sales. Through its 'Student Lights' campaign, the company demonstrates the use and benefits of solar lanterns to school children who can then buy the lights for their household. Sunny Money has sold more than 50,000 solar lights in Tanzania through this campaign in the first half of 2012.<sup>47</sup>
- 'Cape Town to Cairo', a road show conducted by Philips, traveled across 12 countries in 2010 and 2011 to promote the benefits of solar lanterns to consumers and other public and private stakeholders.<sup>48</sup>
- Tecnosol, from Nicaragua, buys SHSs from overseas suppliers and supplies them to rural customers. The company then works to convert satisfied 'early adopters' into 'word-of-mouth' marketing agents for their products.<sup>49</sup>

<sup>47</sup> 'Sunny Money hits record sales through its Student Lights campaign' ([www.lightingafrica.org](http://www.lightingafrica.org)).

<sup>48</sup> 'From Gap to Opportunity: Business Models for Scaling up Energy Access', IFC (2012).

<sup>49</sup> [www.ashden.org](http://www.ashden.org) (2010)



Women using a Barefoot Power PowaPack 5W lamp to light a house, Dakar, Senegal.  
© Bruno Déméocq/Lighting Africa/2012

**There is a trade-off between the ability to reach customers and conversion to sales.** The majority of solar lighting marketing has occurred on the ground, via forums, road shows or direct-to-customer sales. Although effective in generating sales, such channels are limited in their coverage compared to conventional mass-media like billboards, posters and advertisements on television, radio, magazines and newspapers.

An analysis of Lighting Africa's consumer awareness campaigns in Kenya suggests that when the goal of a marketing campaign is to raise awareness, direct marketing is more expensive and less effective than mass media marketing. But when the goal is to provide product experience and boost sales, direct marketing is a far better tool. When consumers in Kenya were left with a PLS for five days, their willingness to pay for the product increased by 1.3 - five times (depending on form factor),<sup>50</sup> indicating that customers need to build a personal level of trust with the products before committing financially. This explains, in part, the higher success of direct marketing and advertising in promoting sales growth.

**As the PLS market matures, marketing and advertising are expected to become increasingly important to product and brand differentiation in the following ways.**

- Increasing market penetration will not only offer more PLSs to more consumers, but also enable customers to choose a product best suited to their circumstances.
- The entry of MNCs, with large investments in teams dedicated to marketing and consumer research will shift the focus to brand-building instead of product familiarization.

- As marketing efforts shift increasingly from NGO/DFI-supported initiatives toward the private sector, marketing and awareness campaigns will become more targeted around objectives, costs and partnerships. Technology, in particular, will play an increasingly important role, allowing companies to target consumers in new and innovative ways.
- Mass media will play a key role in the scale up and adoption of PLSs as the market overcomes its initial acceptance barriers.

## After-sales services

PLS price points combined with low levels of product penetration have limited manufacturers' ability to provide favorable and comprehensive after-sales practices cost-effectively. At the same time, end-users are often unaware that they are entitled to warranty and service, which inhibits demand for such services. This leads them to simply write off a faulty product as a bad investment without seeking repair or maintenance services. Insights from the Lighting Africa program as well as manufacturer interviews have further indicated that when consumers do seek support, the majority of complaints have little to do with technical faults in the product, but rather arise from consumers not using PLSs properly.

As the majority of the PLSs sold on or before 2010 approach the end of their product life, after-sales service has become an increasingly important priority for PLS manufacturers and suppliers. Several existing brands, primarily market leaders, have begun providing after-sales support to their end users, including (1) basic repairs and technical support in locations that have a relatively high product density, and (2) replacement of PLSs as per formal warranty agreements.

### (1) Repairs

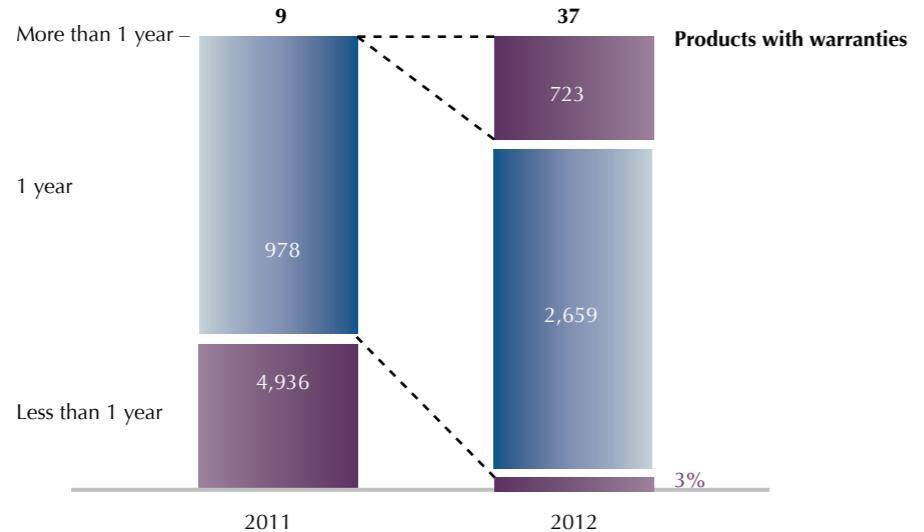
Technically-trained representatives of distributors and/or retailers generally conduct repairs. Manufacturers invest in the distribution network to provide training and warranty stock, following which distributors provide after-sales support to customers on behalf of the manufacturers. Distributors operate service centers, processing complaints and providing both repair and replacement. This requires significant investment in both training distributors/technicians, as well as managing service centers in different regions.

Barefoot Power offers repairs by creating service and repair stations in cooperation with major distributors in the geographies in which it operates. Another manufacturer, Betta Lights, provides regional distributors with stock and training, and has them repair or replace units as needed. Distributors send fault reports and defective components back to Betta Lights.

### (2) Replacement based on warranties

Customers take faulty products covered by warranty back to the point of sale—usually a retailer or last-mile dealer in the same community as the customer. The retailer takes back the faulty product and passes it on to the distributor. The distributor hands down a replacement to the retailer and ultimately to the customer, in lieu of the faulty product. This method is relatively light on investment and only needs an efficient means of sending faulty products and replacements along the supply chain. However, there is likely to be a long lag between the return of a product and its replacement.

Figure 48 on the following page shows the evolution of warranties in the African PLS market: The number of manufacturers offering warranties has increased and the period of warranty has lengthened. While no Lighting Africa-associated manufacturer offered warranties of more than one year in 2010, 24% of quality-verified products in 2012 came with a longer warranty period.

**Figure 48: Evolution of warranties in the African market for Lighting Global quality-verified PLSs**

Source: Lighting Africa data; Dalberg analysis

**Some manufacturers find it more viable to replace the entire product without offering repairs.** Customer service for PLSs has a high relative cost, given the low price of the products themselves and the additional supply chain difficulties in servicing remote rural areas. Given the nature of PLSs – their compact size, portability, limited number of moving and component parts, and long lifecycles – a replacement-focused after-sales model could be more viable. Further reasons are discussed below.

#### (1) *Unfavorable product economics*

Replacements are more cost-effective than repairs for some manufacturers. Nuru Energy, for example, finds it more cost effective to replace its USD 5 lighting product than to repair it. Nuru's village-level entrepreneurs live in the same communities as their customers and are the first point of contact in case of a faulty light. The entrepreneur contacts the field staff representative, who arranges for a replacement.

#### (2) *Lack of local presence*

Companies that export products to a central distributor in a country and that lack local presence tend to take the replacement approach. In the case of Nokero, customers with faulty products are told to contact the company, which replaces the product via a local distributor or reseller. Similarly, in the case of Solux, the distributor or organization that brought the product to a country is responsible for after-sales service. Since Solux does not yet have many professional resellers, these distributors replace faulty products and, in turn, restock from the manufacturer.

**Based on feedback from interviews, manufacturers' choice of after-sales strategy will depend on a variety of product and distribution characteristics.** On the product side, more sophisticated services will be required as the PLS range becomes more complex—from torches and simple lanterns, to multi-functional Solar Home Systems that require installation and periodic maintenance. The price of the PLS will also be a key determinant of investments in repair versus replacement. Finally, the quality of the PLS and its failure rate will influence the after-sales approach adopted—all else being equal, low failure rates favor a replacement-centric after-sales service model.

On the distribution side, geographical penetration of sales (whether sparse or concentrated) will determine how after-sales services can be provided in a particular area. Additionally, the manufacturer/distributors' local presence and capacity will also help decide what touch points can support the after-sales strategy. If distributors have a significant presence in an area with high sales, local investments such as service centers can be made.

**Innovative players are likely to capitalize on modern technologies like mobile phones to develop effective interfaces between customers and after-sales representatives.** Such systems will bring the customer closer to the provider of after-sales services, and strengthen customers' perceptions of brand reliability and trustworthiness. Moreover, since the majority of complaints do not involve technical faults, providing such a system of 'first response' is likely to relieve the load on after-sales support.

**In addition to manufacturer-offered after-sales service, recent research in Kenya has found that many PLSs are being serviced by local technicians.** Though PLSs are not being repaired in high volumes, 65% of the electronics and mobile phone technicians surveyed reported also repairing PLSs in the past three months.<sup>51</sup> The average charge for repairs was USD 4 (Ksh 360), which suggests that though customers are required to shoulder the costs of repairs, these costs are still lower than the purchase of a new product. Technicians were surveyed in a small town of approximately 5,000 people, a mid-size town of 85,000 people and a larger town of 286,000 people. In all three towns, technicians were already successfully repairing lamps, though nearly every technician said it was difficult to find spare parts.

<sup>51</sup> Lighting Africa research.



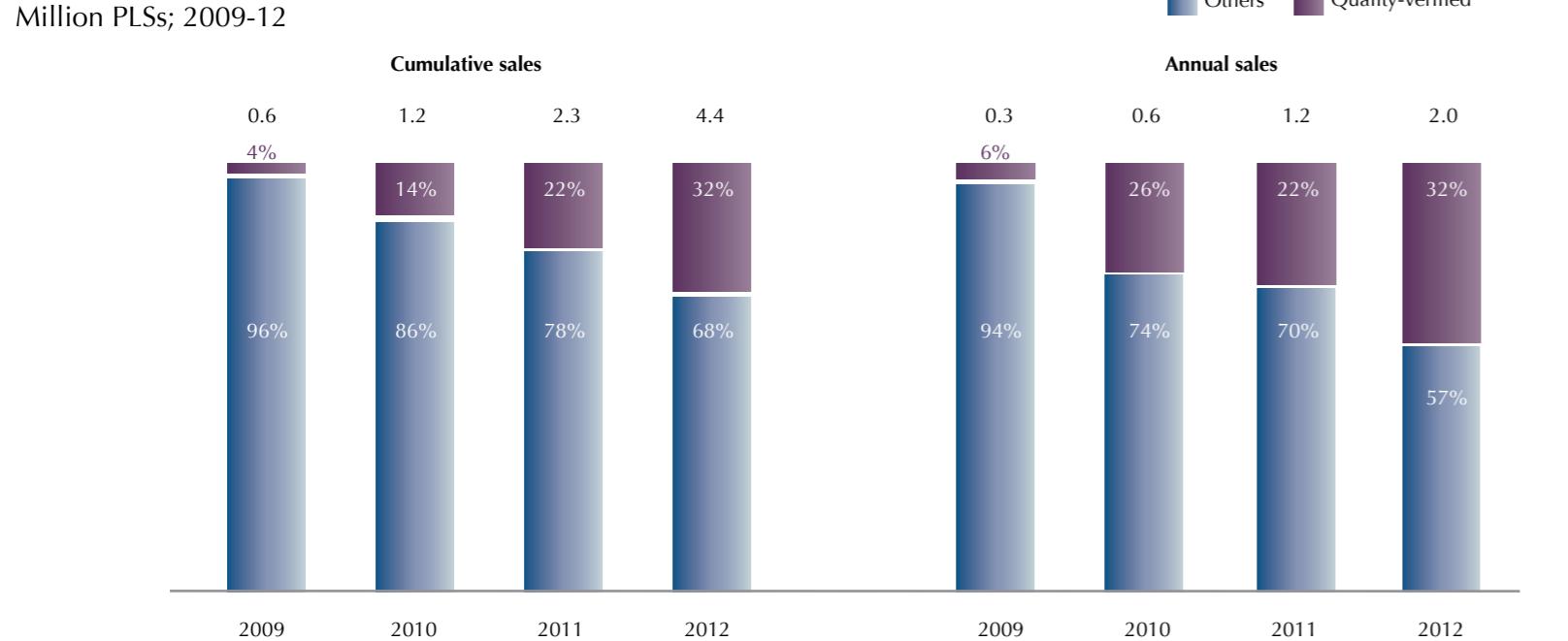
The quality of PLSs available in the market varies widely. Here on a market in Dakar, Senegal.  
© Bruno Déméocq/Lighting Africa/2012.

## Market spoilage

**Market spoilage remains an important obstacle for players in the PLS market in Africa.** For a majority of the BoP in rural Africa, the lighting decision boils down to a choice between kerosene-based and non-kerosene-based sources. Often, for first-time customers in the non-kerosene category, the initial experience colors future purchase decisions significantly. The poor performance of substandard lighting devices (with disposable or grid re-charged batteries) in the USD 1-5 price range<sup>52</sup> tends to bias a large number of BoP customers against modern lighting devices in general, including higher-quality PLSs. It is difficult to quantify exactly the extent of market spoilage, given the opacity of information on the number and performance standards of non-quality tested products. However, interviews with manufacturers and distributors in key African geographies indicate that rural markets have seen a proliferation of these substandard devices over the past two years.

If we restrict our scrutiny to just PLSs, there is increasing evidence that the share of quality PLSs has increased substantially over the last three to four years. The share of quality-verified products as a percentage of the overall PLS market has increased by more than tenfold since 2009, as shown in Figure 49, from less than 5% to approximately one-third of cumulative sales in Africa in 2012. Some individual countries have a better record of combating market spoilage than others. For example, in Kenya, where more market information is available, we estimate that the share of quality products may be more than 70% in recent years.

**Figure 49: Market share of quality-verified solar lighting products**



Market includes pico-powered solar lighting devices that serve as the primary light source for a household, and excludes battery-powered LED/CFL devices under USD 5. Quality -verified products are defined as those that have passed Lighting Global's minimum quality standards.

Source: Lighting Africa sales data (Q4 2012 update); Dalberg analysis

There are two major drivers of the increasing market share of quality-verified PLSs:

- *Growing presence in the African PLS market of manufacturers (including global electronics companies) of quality products.* These manufacturers are eager to leverage the fact that their products have passed Lighting Global quality tests, which provides additional competitive advantage and product differentiation. Faced with the challenge of market spoilage, the aim of these quality products is to send to customers a clear signal of manufacturers' commitment to quality, durability and performance. Often, these manufacturers will engineer products to the exact specifications of quality tests; this increased emphasis on quality has led to a substantial increase in the volume of products for testing, as well as the number of products passing these tests (see Figure 50 below).

**Figure 50: Cumulative number of products which passed Lighting Global's minimum quality standards**



Source: Lighting Global's Quality Assurance M&E Tracking data; Dalberg analysis

- *Increasing levels of consumer awareness available in the market.*

Donor-led initiatives and campaigns seek to combat market spoilage by empowering BoP consumers to distinguish between quality and non-quality PLSs. For example, the Lighting Africa program's consumer education campaign has reached more than 22 million people in Kenya and Ghana, where it promotes proven, durable and reliable PLSs that have met Lighting Global's minimum quality standards and recommended performance targets. Consumers can send an SMS to Lighting Africa to receive the list of Lighting Global quality-verified products.

<sup>52</sup> These devices are not included within the scope of this report.



**Aided by the implementation of key market development initiatives, the growing market share of quality PLSs is expected to continue to increase in the next few years. Two important measures are described below:**

- *Increased adoption and incorporation of quality standards and testing programs at the national level.* Currently, the majority of product testing is voluntary, and a universal mechanism or framework to block or restrict the entry of substandard PLSs into markets is nonexistent. Since governments are the only institutions capable of regulating the entry of products into any given market, it would be beneficial to drive alignment with national testing standards so that national agencies can eliminate the more egregious cases of market dumping and counterfeiting. The International Electrotechnical Commission (IEC) recently published standards that include test methods originally developed through the Lighting Africa program. These standards, published as IEC Technical Specification

62257-9-5, provide a foundation that can be used to create an internationally harmonized framework for quality assurance. This framework will be especially effective if governments and development programs adopt and reference the IEC standards.

- *Introduction of a universal, simple, visually-appealing seal of quality that would aid consumers to easily differentiate between quality and substandard products.* Current verification programs such as Lighting Global tend to offer B2B services by testing the quality of products and sharing the testing results with manufacturers to help them find business partners and financing. More than half of interviewed distributors and manufacturers suggested that testing and verification programs could be substantially more effective in combating market spoilage if anchoring verification in a consumer brand mark or seal for verified products. This feedback is consistent with the success of quality seals in other market transformation programs such as the Efficient Lighting Initiative (ELI) managed by IFC and the GEF in seven countries across the world.

## Policy

**Several African governments have acknowledged the growing importance of modern lighting devices, particularly solar PLSs, and are gradually putting in place policies and regulations that incentivize their adoption and usage among off-grid communities.** Grid extension, and to a lesser extent kerosene subsidies, have traditionally been the primary tools used by governments to increase access to lighting. That dominant view is slowly changing, however, as over the past few years the economic, health and environmental advantages of solar PLSs over kerosene and other traditional lighting alternatives have become more widely known and accepted.

Although commendable, this evolution in governmental priorities remains restricted to a few countries: Kenya and Tanzania in East Africa, for example, have done better than most other countries in promoting PLSs, particularly around easing or eliminating import duties and taxes, and imposing effective quality control mechanisms (Figure 51). In most other countries, therefore, there remains significant scope for improved policies and regulation.

**Figure 51: Mapping of support for solar sectors in African geographies**

	Taxes and tariff incentives	Subsidy on alternatives	Government initiatives	Quality control	Technical assistance
Kenya	■				■
Tanzania	■	■			
Ghana		■	■		■
Uganda	■		■		
Rwanda	■	■	■		
Nigeria		■	■		■
Senegal		■	■		
Ethiopia	■	■	■		■

Source: Lighting Africa policy report notes; Interviews with experts; Dalberg research and analysis.

Governments have a standard set of levers at their disposal to address the issue.

- *Incorporation of off-grid solutions in rural electrification programs*

Due to the high cost of extending the national electrical grid to rural areas, countries such as Ethiopia, Liberia, Mali, Senegal and Tanzania are integrating off-grid solar solutions within their rural electrification programs. Promotion of PLS technology is a faster and cheaper alternative, at least in the short term, to bring lighting to off-grid rural populations. In Liberia, the Rural and Renewable Energy Agency (RREA) collaborated with the World Bank Group to implement the Lighting Lives in Liberia campaign aimed at increasing the access and affordability of modern pico-power lighting devices. Lighting Lives in Liberia takes a commercial approach to rural electrification, and one of its primary goals is to facilitate the creation of a viable commercial market for these lighting products. Accordingly, the RREA is supporting the development and execution of a pilot project that matches high-quality manufacturers of pico-powered lighting products (that are Lighting Global quality-verified) with six local retail partners (including NGOs and MFIs) in order to push lighting products into rural markets. The government plans to reinvest some portion of the sales revenues into a Rural Energy Fund (RE) fund designed to provide project development support and expand the services to more communities across Liberia.

- *Taxes, duties and subsidies*

Several governments have provided fiscal incentives that have both lowered supply barriers and encouraged demand for PLSs. In Kenya, all imported LED-lighting equipment and solar components are exempt from taxation.<sup>53</sup> This policy has the additional benefit of encouraging the local assembly of solar products, including solar PLSs. The Ugandan Government implemented a 45% subsidy on all solar equipment as part of its Energy for Rural Transformation (ERT) program. The scheme encouraged solar equipment suppliers to invest in rural areas. The Government promoted the subsidy through a network of rural MFIs and NGOs that provided cash payouts or loans to those who installed solar systems, in lieu of credit lines from the Government.<sup>54</sup> In Ethiopia, solar products are exempt from inland duties and surtaxes, resulting in a reduced PLS price for consumers.<sup>55</sup>

However, solar components and products in many geographies continue to be hit with multiple taxes (import duty, excise duty, VAT, surcharges), typically leading to a 5-30% increase in the price of the final product. This only further constrains BoP customers and discourages the shift from kerosene. For example, in Ghana, an imported solar PLS faces import duties of 10%, a VAT of 12.5% as well as an additional levy of 3.5%.

Governments in other countries inadvertently suppress demand for modern lighting devices by subsidizing the use of kerosene-based alternatives. In Ethiopia, kerosene is exempt from all taxes, which reduces its effective market price by approximately 30%. Similar tax benefits, including usage-based discounts, reduce the price of kerosene by 18% in Cameroon. In Ghana, industries pay higher prices for kerosene in order to keep consumer prices low. The elimination of these incentives will reduce the opportunity cost of switching to modern PLSs. In addition, governments will gain by easing budgetary burdens. Senegal and the DRC have led the way—Senegal by progressively reducing kerosene subsidies and allowing prices to soar, and Uganda by eliminating tax exemptions.

- *Quality control*

In order to prevent market spoilage, countries such as Tanzania and Kenya are instituting strict quality-control frameworks. In Tanzania, the Ministry of Energy and Minerals provides policy and institutional support for the implementation of national quality control standards and the Government has helped developing the market. In Kenya, the Kenya Bureau of Standards is limited in the scope of the quality control it conducts on imported solar products.



*Better lighting makes it possible to do chores at night.  
Here a woman in Senegal, using a solar lamp.  
© Bruno Déméocq/Lighting Africa/2012*

- *Business development assistance*

The Ministry of Energy and Minerals (MEM) in Tanzania along with the Swedish International Development Agency (Sida) is providing business development services for solar-lighting companies, including technical and marketing training for solar retailers, awareness programs for consumers, and networking among solar industry stakeholders. Policies like these are aimed at helping entrepreneurs build capacity and scale up.

**Positive policy measures and reforms will require competent implementation, which remains an important concern in several African countries.** Even in countries where incentives for the supply and use of PLSs and other modern lighting devices exist, inefficient enforcement can often lead to high transaction and administrative costs that can undermine the original objective of the policy. In countries such as Kenya and Ethiopia, for example, solar lighting products benefit from tax breaks—but accessing those tax breaks is cumbersome, according to manufacturers and distributors. In addition, suppliers are required to file exemption documents for each new shipment, making the process inconvenient and time consuming.

In other countries, transaction costs to access tax breaks become high due to corruption and bureaucracy. In Senegal for example, taxes are determined at the regional level, hence implementation becomes varied and uncertain across regions, and costs become inconsistent. This sort of uncertainty leads manufacturers and distributors to always account for the tariffs, which they pass down to the consumer in higher prices. These implementation challenges prevent the targeted beneficiaries from realizing the full potential of the supportive policies.

<sup>53</sup> Lighting Africa Off-grid Lighting Country Policy Study Note.

<sup>54</sup> www.renewableenergymagazine.com

<sup>55</sup> Lighting Africa Off-grid Lighting Country Policy Study Note.

## 6. Market forecast

The market for PLSs in Africa remains on a healthy trajectory. Currently, even our most conservative forecasts predict high growth rates over the next two-three years. These forecasts are based on the core macro-drivers including lagging grid growth, expected increase in fuel-based lighting expenditures, growing need for mobile phone charging options, as well as an improving supply of quality products. In addition, there are several emerging trends that can further accelerate this fast-growing market, which will be explored in this section.

Our conservative base case projects that annual sales will grow at a yearly rate of 60-65%. This is based on historical sales data and information collected from interviews with market players and experts. While the leading manufacturers grew exponentially at 50-250%, smaller players (35+) grew between 20-40% during 2009-12. Under this scenario, we expect cumulative sales to reach almost 20 million PLSs by 2015, with 7-7.5 million in annual sales in 2015.

Our intermediate case will see the market grow at 70-75% annually over 2012-15. We believe that this accelerated growth scenario is far more likely to occur than our conservative base case. Our expectations are based on improving market trends and developments over the past few years. The most significant among these include:

- Gradually but consistently increasing levels of consumer awareness of and education on PLSs;
- An improving policy landscape, marked primarily by the elimination or reduction of tariffs and taxes, as a growing number of governments recognize the importance of off-grid solutions for un-electrified populations;
- Expanding access to finance, particularly for more established players, in order to help eliminate key bottlenecks in the supply chain and increase the flow of products into the market;
- A base level of repeat sales to existing customers, be they replacements of older models or incremental purchases by customers requiring more than one PLS.

This scenario projects cumulative sales to increase to almost 23 million PLSs by 2015 – approximately 3 million of which could be attributed to repeat sales – with annual sales of approximately 9-9.5 million in 2015.

**In addition to the gradual easing of market barriers, which we expect will continue over the next three years, there are several opportunities that have the potential to catalyze the PLS market towards an explosive growth path.** Four specific opportunities are presented below.

- Commitment to scale up by global MNCs: Global giants of the electronics industry, including Philips, Schneider, and Panasonic, have begun to show serious interest in the African market for PLSs. These MNCs have expressed excitement at the performance of established market players in the space and are conscious about being a part of this growth.

### Quotes from Multinational Corporations (MNCs)

*"We expect the off-grid lighting market in Africa to grow sharply for the next five to ten years. We want to be in this market for the long-term, because we believe we can improve peoples' lives and take advantage of a growing opportunity."*

*"The existing portfolio [of lighting products] caters to the higher-income BoP. We want to make a ten dollar product that everybody can afford. That's what we can do."*

*"Partnerships will be key to drive volumes within the BoP. We are looking to partner with MFIs to reach rural customers. It will also be important to partner with institutions like schools, churches and hospitals that allow you to reach a large number of BoP customers without needing to invest heavily."*

Source: Interviews with MNCs

We expect that MNC presence in the market will expand in the next few years, with potential for joint ventures, mergers and acquisitions of existing market players. MNCs will bring the ability to scale aggressively through their substantially enhanced distribution capabilities and focus on innovation and product development. Consequently, the market will shift from institutional to private sector-led marketing. Research from the consumer durables market in India provides an insightful benchmark on the impact of MNC entry into a market. In India, economic policies and regulations intentionally precluded MNCs from the consumer durables market until the early 2000s. Once granted entry, MNCs such as LG, Daikin, Samsung and Sony were able to rapidly increase market size and increase their combined market share from less than 10% in 2003 to more than 65% in 2010.<sup>56</sup>

Based on our research, we expect at least two MNCs to enter the African PLS market aggressively in the next three years, with the potential to add up to 1.5-2 million PLSs in cumulative sales, by 2015.

**Figure 52: Evolution of MNC market share in Indian consumer durables market**

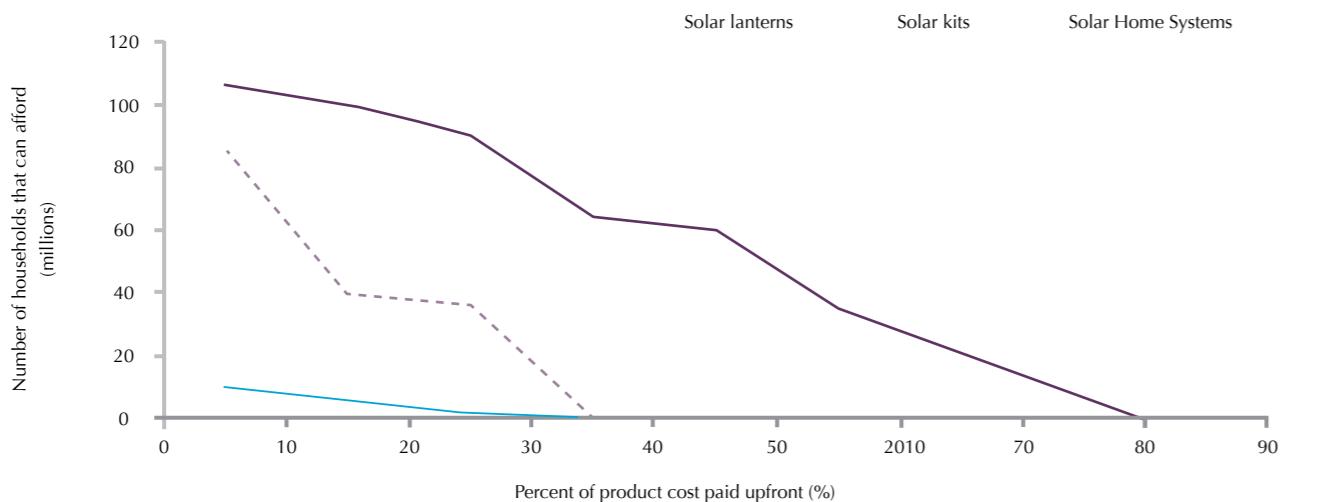


Source: Electronics Industries Association of India; Indian Brand Equity Foundation; Interviews with manufacturers; Dalberg research and analysis

<sup>56</sup> 'Indian Consumer Durables Report', Indian Brand Equity Foundation (IBEF, 2012).

- Adoption of ‘pay-as-you-go’ models: End-user affordability has inhibited market growth by restricting demand. Research has shown that the reduction or elimination of the upfront payment has the potential to significantly drive demand. The figure below charts the sensitivity of end users to upfront cost: For PLSs in the USD 20-50 price range, a 20% reduction in the upfront cost will result in a corresponding percentage increase in the size of the addressable market.

**Figure 53: Sensitivity of end-users to upfront cost**



Source: ‘From Gap to Opportunity’, IFC (2012); Dalberg research

In general, pay-as-you-go models take advantage of significant recent advances in mobile-payments technology that offer customers the opportunity to pay for their PLSs in small installments. The upfront component of payment is greatly reduced or entirely removed, thereby increasing the customers’ ability to pay for the PLS and bringing a larger customer base into the market.

The adoption of pay-as-you-go models is at a very nascent stage in the African PLS market. Our estimates indicate the implementation of three to five pay-per-use pilots has resulted in the sales of approximately 20,000-25,000 PLSs by the end of 2012.

We expect increased adoption of pay-as-you-go models by both new entrants and existing manufacturers as pilots are successfully completed and as access to mobile payment technology expands across Africa. Our conservative expectation is that this could lead to additional PLS sales of approximately 600,000 PLSs by 2015.

- *Emergence of manufacturer-led brands*

Historically, the PLS market in Africa has been typified by two main kinds of suppliers. On the one hand are suppliers of branded products who are primarily responsible for product design, innovation and marketing and who generally outsource physical production to pure manufacturers. On the other hand, pure manufacturers, as the term suggests, concentrate on executing orders from distributors and suppliers to make branded and/or unbranded PLSs.

Over the past year, the market has seen a gradually intensifying trend of pure manufacturers expand their focus to developing independent brands, thereby establishing a strategic, long-term presence in the African market. Several such manufacturers, primarily based out of China, have highlighted their growing interest in interviews (see box on page 90).

Our conversations suggest that the next two to three years will see the growth of several manufacturer-led brands. These will be fully integrated into formal market structures and institutions with the advantage of having shorter customer feedback loops and the ability to ramp up production rapidly to match demand. Our conservative estimate suggests that the emergence of manufacturer-led brands has the potential to add up to 450,000-500,000 PLSs by 2015.

#### Quotes from China-based manufacturers whose products are not yet Lighting Global quality-verified

*“Africa is a very important, core market for us. Our products are designed to cater to the poorest markets. But we have very little knowledge of the market, and don’t feel connected to the customers. We would consider joining Lighting Africa to get more knowledge on what customers want.”*

*“Three to four Chinese-headquartered companies have already sold in large numbers in Africa ... expect this number to grow in next few years, especially as the market matures.”*

*“Getting our products tested is not a problem, especially if the market demands it. But, currently it is too expensive to test products since there are no testing facilities in China. We would get our products tested in China, if it was possible....”*

- *Repeat sales:*

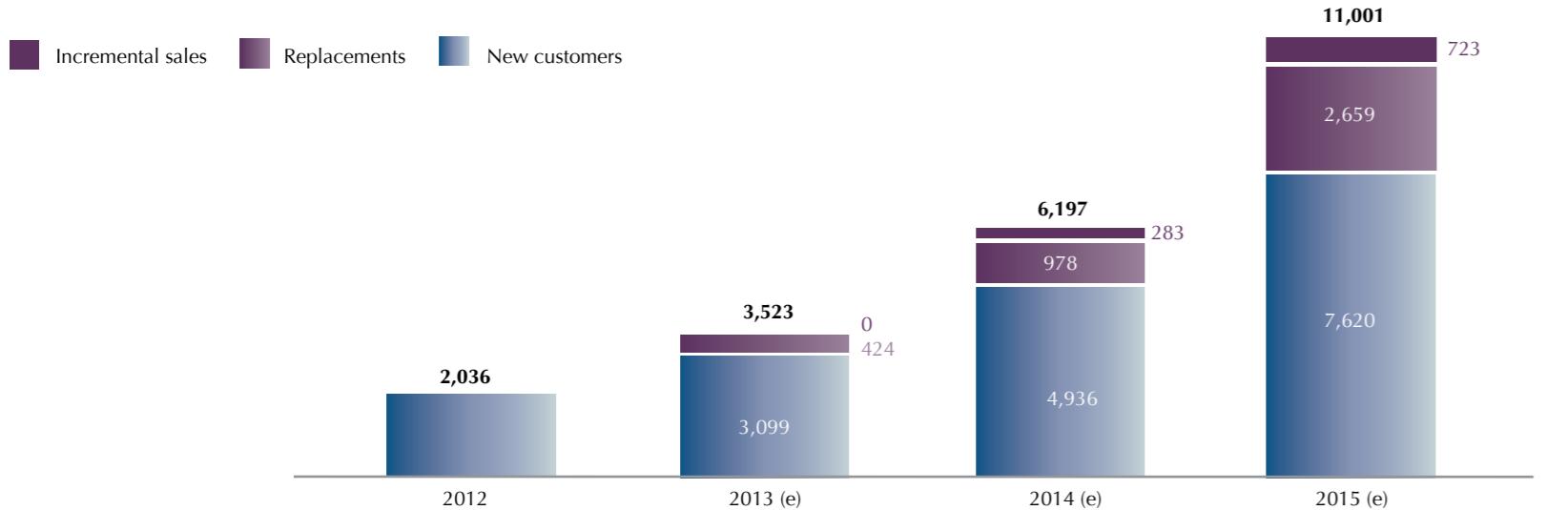
The market for repeat sales to existing customers could expand substantially over the next three years, due to a growing opportunity for replacements and incremental sales.

Thus far, manufacturers and distributors have almost completely focused on acquiring new customers and increasing market penetration. However, with the warranty periods for the majority of PLSs already in the market set to expire within the next one to two year(s), we expect a significant proportion of current owners to seek replacements. At the same time, increasing household incomes, consumer awareness, and access to finance – combined with a growing understanding of customer needs by suppliers – will fuel the demand for incremental purchases by existing customers. While the focus on new customers will remain paramount, PLS suppliers will likely shift part of their attention to their existing customer base, given the size of the repeat sales opportunity and the significantly lower cost of customer acquisition or ‘conversion’.

As explained above, our intermediate scenario incorporated a base line level of repeat sales, accounting for approximately 3 million PLSs out of a total of approximately 23 million PLSs by 2015. We believe that a much faster growth in repeat sales is possible—up to an additional 2 million PLSs (Figure 55). Considered in isolation, the repeat sales opportunity could itself propel significant market growth, causing annual sales to rise to approximately 11 million by 2015, with approximately 30% of that attributed to replacements and incremental sales.

**Figure 54: Evolution of annual sales of PLSs while considering replacements and incremental sales**

PLSs in thousands, 2012-15



75% of PLSs replaced every three years.

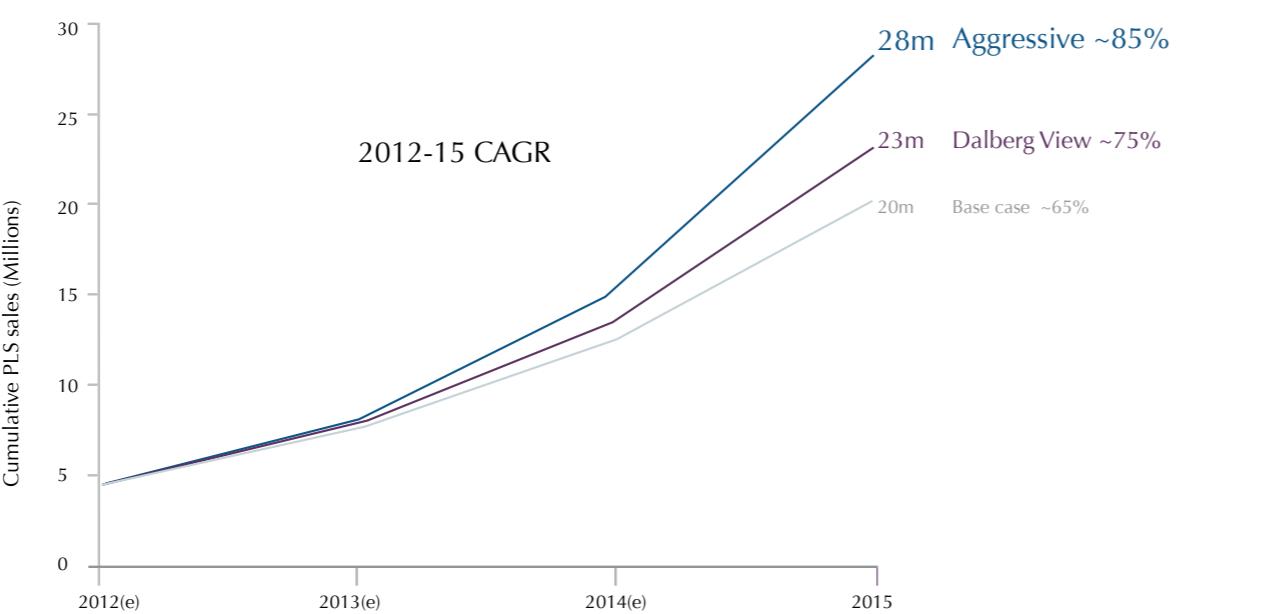
50% of households will purchase an additional PLS every four years.

Source: Lighting Africa sales data; Dalberg analysis

These four opportunities could add up to 5 million in total additional sales by 2015 (over and above the intermediate scenario). This would imply a market growth of approximately 85% between 2012 and 2015, with cumulative sales growing to approximately 28 million PLSs by 2015.

**Figure 55: Forecast of cumulative PLS sales in Africa over time**

Millions of PLSs, 2012-15



Aggressive scenario assumes

(1) Entry of 2 MNCs; (2) Entry of 2 additional manufacturer-led brands; (3) High growth of pay-as-you-go models; (4) and higher rates of replacement and incremental sales.

Source: Lighting Africa data; World bank data set on population; Dalberg analysis

## 7. Conclusion

The market for solar lighting products in Africa has evolved tremendously over the past two years. The immense potential that was identified and highlighted in the past is rapidly materializing. This maturing market has been typified by a very rapid sales growth, an increased preference for and availability of quality products, continued entry of new manufacturers and distributors, growing consumer awareness and confidence, remarkable improvements in performance, and innovation in business models.

Despite the success of the past two years, penetration of PLSs is still estimated at about 4% of off-grid households in Africa, leaving significant room for growth. The market is currently constrained by several crucial and unresolved challenges. Chief among these are access to finance for manufacturers, importers and end-users, distribution of products to hard-to-reach customers in rural areas, and consumer awareness.

Therefore, while strong growth is guaranteed, there is significant opportunity for further market acceleration. Acceleration will require improved collaboration among a range of stakeholders on targeted initiatives. We highlight a few important recommendations below that can further drive industry growth:

- Initiate and develop partnerships between financers and suppliers to increase the supply of capital from conventional and non-traditional institutions. Access to working capital for distributors has been consistently identified as one of the most significant bottlenecks to market growth. In the past year, several manufacturers have implemented initiatives and pilot projects to try and overcome this challenge. However, manufacturers only have limited capacity to deliver this financing on their own. Banks need to be aggressively brought in. One potential solution is to convince many traditional donors in this space to redirect their money from market distorting grants and donations to loan guarantees and risk sharing facilities for financial institutions who provide much-needed working capital.
- Provide incentives, support and build capacity of institutions and organizations seeking to provide finance to end-consumers. While we believe that the consumer affordability challenge will be partially resolved with the predicted drop in PLS retail prices over the next two to three years, focus on increasing consumer finance could help significantly enlarge the demand pool in a short period of time. Some promising interventions that should be explored further include: bundling of PLSs, mobile phones and clean cook stoves by MFIs to aggregate transaction and administrative costs, as well as innovative, technology-led payment plans like pay-as-you-go models and mobile payments. This approach can be self sustaining, but pilots may need to be promoted, as such models are nascent and currently unproven.
- Continue pioneering high-value private partnerships between manufacturers and distributors (from various sectors) to develop and invest in complementary distribution channels in order to extend and deepen product presence within the African BoP. Interviews have revealed that some PLS manufacturers and suppliers are considering partnerships with mobile phone companies given the complementary nature of the two products. Other potential partnerships include FMCG companies, which would allow PLS companies to tap into established channels and distributors.
- Engage the social sector in consumer education campaigns. Churches, schools and the NGO sector – including organizations focused on energy, education, rural livelihoods, and financial inclusion – can play a major role in informing consumers about the benefits of solar off-grid lighting.

- Broaden focus of consumer education and awareness activities to include small retailers and dealers, not just end-users. Retailers are also consumers of PLSs and can use their unique position to directly influence customers, thus acting as natural channels for customer outreach.
- Encourage suppliers, industry associations, governments and donors to drive a pan-African alignment of product quality standards. This would facilitate wider adoption of PLSs in under-penetrated geographies by reducing barriers and prices. It would also promote in-country support for monitoring floods of substandard or counterfeit products. Efforts should potentially include the development of a universal, easy-to-understand PLS quality and performance seal or stamp that would communicate both quality and performance characteristics accurately and easily to end-users.
- Facilitate the development of new testing centers and increase the footprint/activities of market transformation programs like Lighting Africa in countries such as China or India. The incorporation of China and India-based manufacturers into formal market structures and institutions can help drive the African markets both from a supply and innovation front. Awareness on market potential and the active growth of quality PLSs can encourage more manufacturers in China to adhere to quality standards. Engaging with these manufacturers will reduce the risk of market spoilage.
- Continue lobbying governments and policy makers to reduce/eliminate duties and taxes on solar goods (components as well as fully assembled PLSs). This would require various stakeholders to work cooperatively to (1) mandate the reduction/elimination of taxes and duties, and (2) simplify and facilitate the process for obtaining duty/tax exemptions. This could include targeted solar awareness programs for customs and duty officials.
- Explore faster technology transfer/incorporation into PLSs through generating interest with high tech companies. Currently solar lanterns are a third party beneficiary of innovations directed toward mainstream markets in mobile phones, laptops and electric cars (all requiring either better batteries and/or efficient, high-performing LEDs). Many of the leading technology companies are not directly looking at the BoP lighting market (although Panasonic has recently entered with a CSR driven pilot). Innovation and scale in PLSs could be significantly accelerated if leading technology companies could be encouraged to insert their cutting edge technology into PLSs. This can happen through a B2B approach (partner with existing PLS companies). Hence, as per other recommendations above, an awareness drive on the potential of the PLS market is needed as much for manufacturers/technology companies as it is for end-consumers and financial institutions. We recommend a road show to some of the leading technology companies in Japan, South Korea, Europe and the USA.

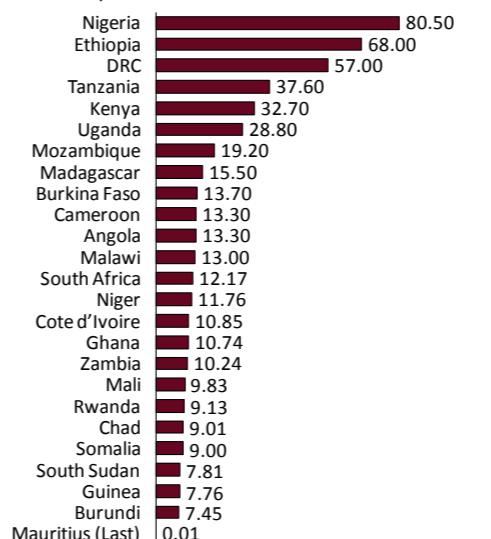
The above recommendations can contribute to an even more vibrant solar lighting market that is already delivering significant development benefits to the African BoP. The market has spawned several new companies that are already setting their sights beyond lighting. With the vast majority of the market still up for grabs, the question is no longer whether free markets can deliver a lighting revolution at scale, but rather, how fast and which company stands to win the most.

## 8. Appendix

Below we present some additional supporting data and information that was collected in preparation of this report.

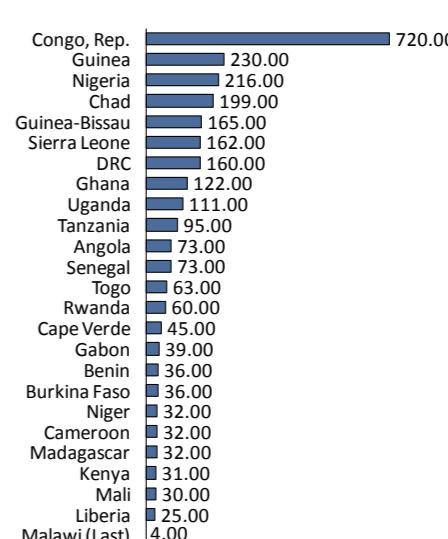
### Access to electricity in Africa

**Total Population without Electricity Access (in millions)**  
2009, Top 24 countries



Source: Dalberg Proprietary Database

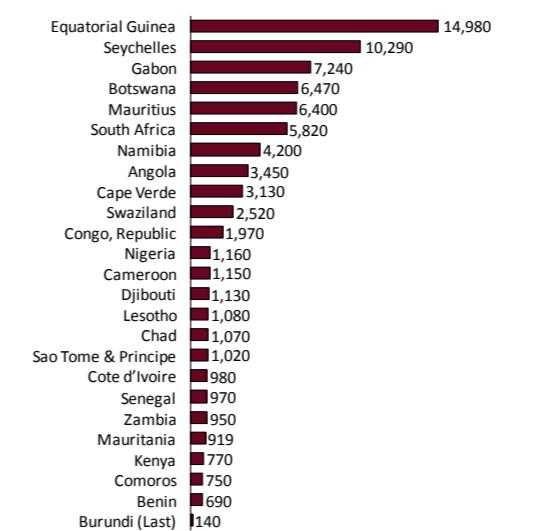
**Total Hours of Power Outages per Month**  
2009, Top 24 countries



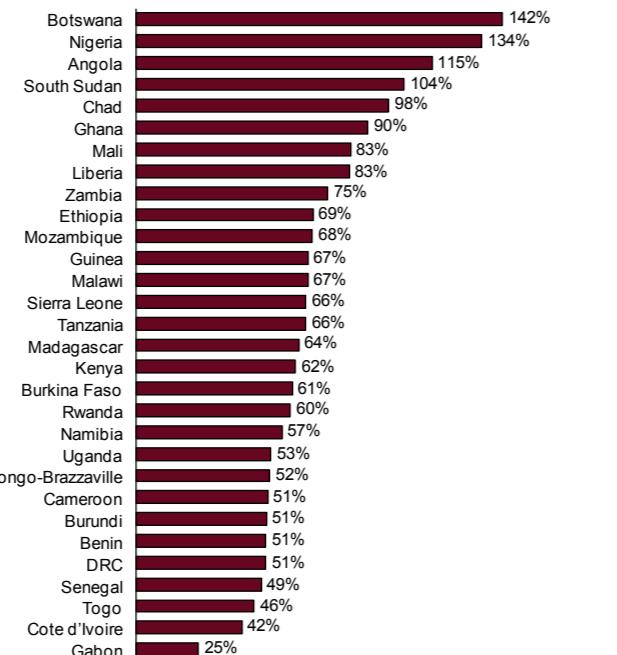
Source: World Bank Enterprise Survey

### Per capita income in Africa

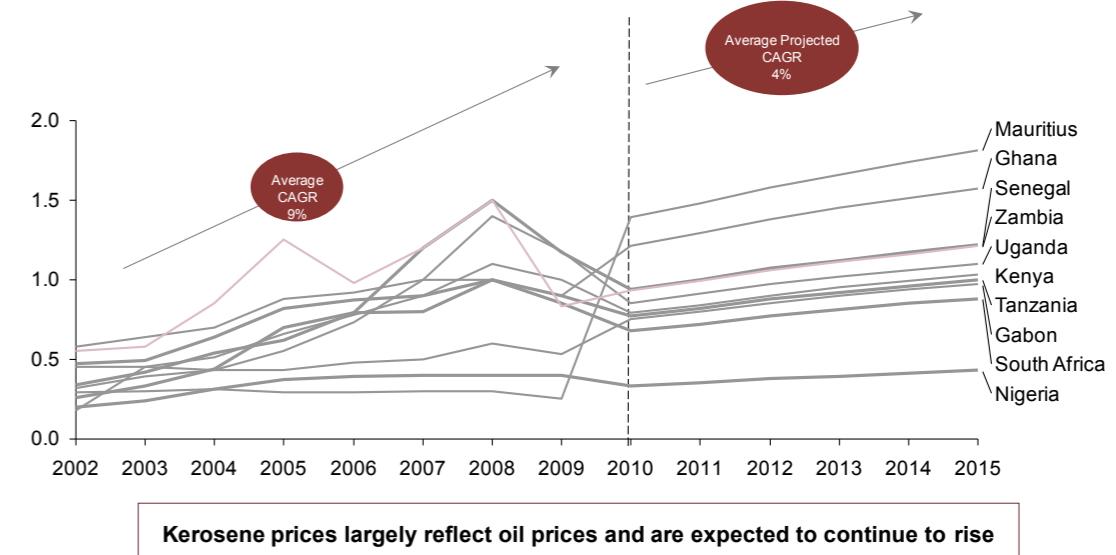
**GNI per Capita (USD)**  
2009, Top 24 countries



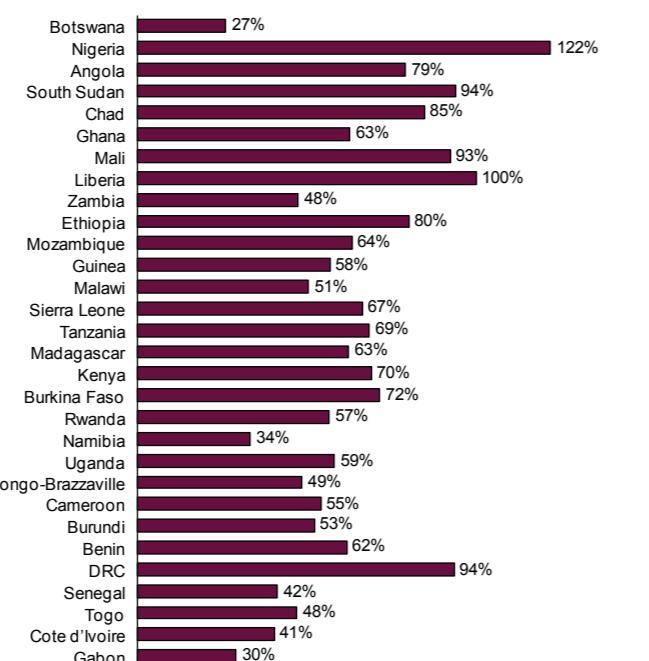
Source: World Databank, World Bank

**Historical cell phone growth rates****Subscription growth during 1 to 16% penetration period**

Source: Dalberg Proprietary Database

**Kerosene prices in Africa (2002-2015)**

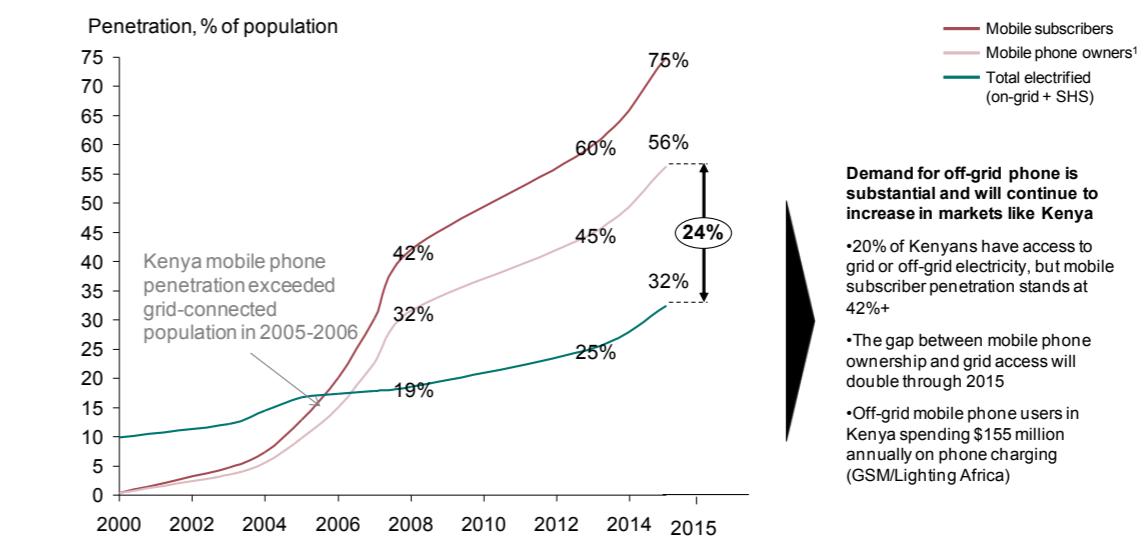
Source: EIA, IEA estimates based on oil barrel prices. Note: Graph includes available data for selected countries in Africa.

**Subscription growth over past decade (2000-2010)**

Source: World Bank Enterprise Survey

**Gap between mobile penetration and grid access**

Penetration, % population



<sup>1</sup> Mobile phone users estimated at 75% of mobile subscribers for developing mobile markets (Wireless Intelligence and LINK Centre)  
Source: ICT, World Bank, Pyramid Group, Daxxis, IEA, various govt electrification authorities, GSMA Development fund, Dalberg analysis.

## Lighting Global quality-verified products as of 8 July, 2013\*

Product	Quality Standards	Performance Targets
	Azuri Indigo Duo Solar Home System	✓ ✓
	Barefoot PowaPack 5W (Gen. 2.5)	✓ ✓
	Barefoot Power Firefly Mini (Gen. 2.5)	✓ ✓
	Barefoot Firefly Mobile Lamp (Gen. 2.5)	✓ ✓
	Barefoot PowaPack Junior Matrix 2.5W (Gen. 2.5)	✓ ✓
	Barefoot PowaPack Junior Matrix 2.5W (Gen. 2.0)	✓ ✓
	Bettalights BettaOne	✓ ✓
	Bettalights BettaTwo	✓ ✓
	d.light S2	✓ ✓
	d.light S20	✓ ✓
	d.light S300	✓ ✓
	Deutrex 818 Foce (Africa) / Austa (Asia) Solar Lamp	✓ ✓

Product	Quality Standards	Performance Targets
	ECCODiva	✓ ✓
	Fosera Pico Solar Home System 7000	✓ ✓
	Fosera SCANDLE 200	✓ ✓
	Goldenwell Schoolchildren Lamp	✓
	Greenlight Planet Sun King™ Eco	✓ ✓
	Greenlight Planet Sun King™ Pro	✓ ✓
	Greenlight Planet Sun King™ Solo	✓ ✓
	Global Telelinks Arundhati Home Light	✓ ✓
	Global Telelinks Solar Ceiling Lantern 3W	✓ ✓
	Global Telelinks Solar Home Lighting System	✓ ✓
	Little Sun	✓
	Marathoner Beacon MB2-090 (Africa) / SooLED B1 (Asia)	✓ ✓

Product	Quality Standards	Performance Targets
	Marathoner Beacon MB2-380 (Africa) / SooLED B3 (Asia)	✓ ✓
Product picture unavailable	Micromark Compact LED Solar Light	✓
	Minda LED Lantern 2W	✓ ✓
	Niwa Multi 300 (Standard)	✓ ✓
	Nokero Solar Light Bulb	✓
	NTL-Lemnis Solar - Pharox Solar Kit	✓ ✓
	NTL-Lemnis Pharox Solar Rooflight	✓
	Nuru Light + POWERcycle	✓ ✓
	Orb Solelectric 15	✓ ✓
	Pharos Great White Light	✓ ✓
	One Degree Solar BrightBox 2	✓ ✓
	Philips Solar Home Lighting System	✓ ✓

Product	Quality Standards	Performance Targets
	Schneider Electric LED Home Lighting System 2.5W	✓ ✓
	Schneider Electric LED Home Lighting System 5W	✓ ✓
	Shanghai Roy Solar Lighting Kit	✓ ✓
	Solux LED-105	✓ ✓
	SunNight Solar Mini BoGo	✓
	SunNight Solar SN-2	✓ ✓
	Sunlite Solar Light G3	✓ ✓
	Schneider LED Solar Home Lighting System Mains	✓ ✓
	Trony Solar Sundial TSL 01	✓ ✓
	Trony Solar Sundial TSL 02	✓ ✓
	Uniglobe SolarMine 100	✓ ✓

