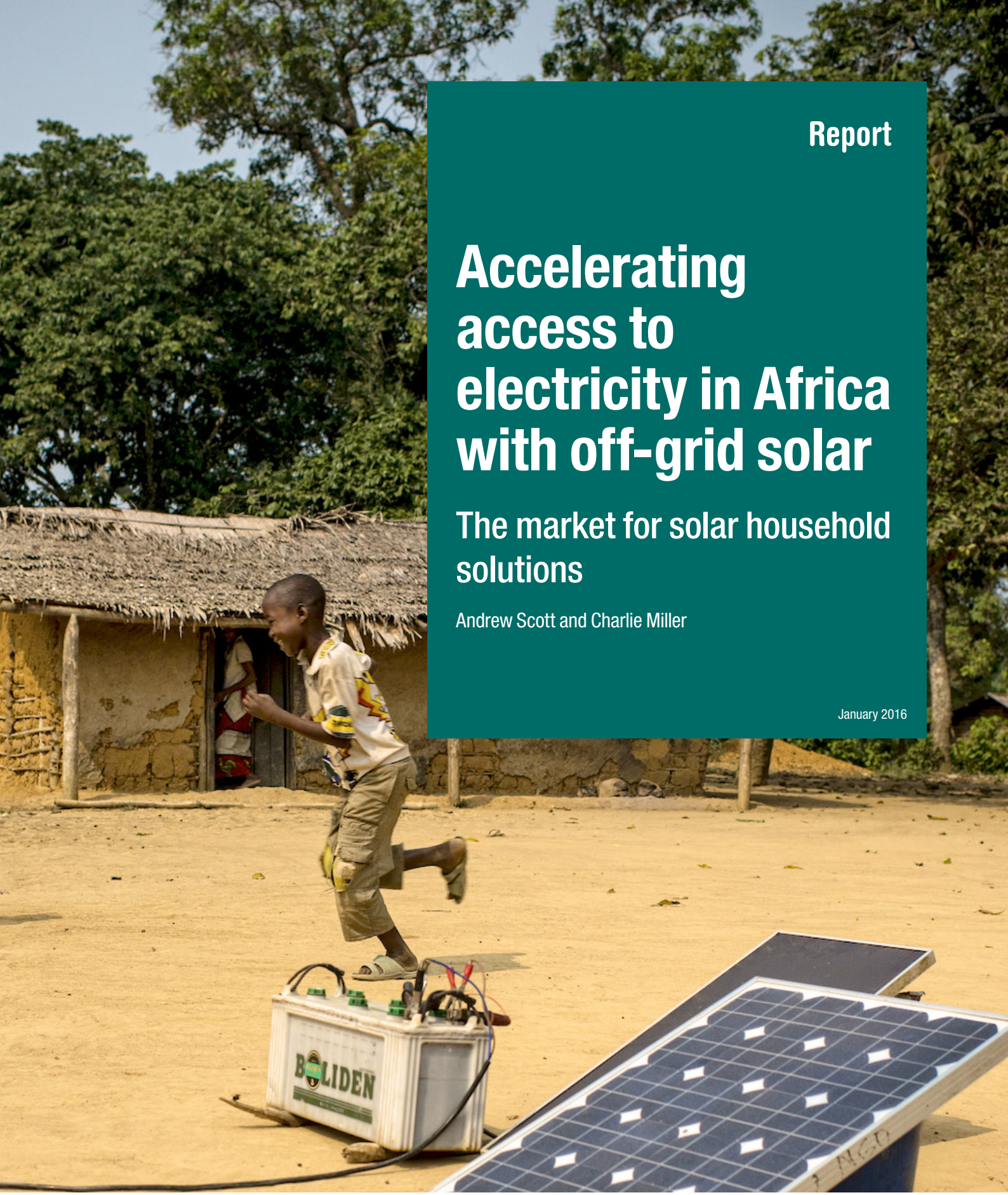

Report

Accelerating access to electricity in Africa with off-grid solar

The market for solar household solutions

Andrew Scott and Charlie Miller

January 2016

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Introduction

Five years ago, when Lighting Africa first assessed the size of the African market for solar household systems, the number of units sold was estimated to be 600,000 solar portable lights (SPLs) and 850,000 solar home systems (SHS).[1] Sales of quality-verified SPLs in 2010 were around the level of 250,000-300,000 a year.[2] The most recent market information, suggests that total sales of quality-verified SPLs were about 3.4 million in 2014.[3] Total sales of all categories of SPL were approximately 7 million. The rapid growth in the market that Lighting Africa anticipated five years ago appears to have occurred.

Market penetration[4] remains low, however, at around 3%. In a region where 620 million people currently have no access to electricity, and electrification is not keeping pace with population growth, this low level of uptake suggests potential for the market to grow further. When access to even small amounts of electricity can substantially improve the lives of people living in poverty,[5] the rapid diffusion of SPLs and other solar household systems could make a significant contribution to the eradication of extreme poverty.

This paper describes how the household solar market in sub-Saharan Africa has grown to date, its current status and possible future trends. The paper, one of three background papers prepared for the Energy Africa campaign launched in October 2015, seeks to understand how universal access to electricity in the region could be achieved through solar household systems. Universal access in this context means every person having access to at least one basic, entry-level solar light.

The paper draws on recent studies, as well as a series of stakeholder interviews, to identify the key drivers, barriers and opportunities to accelerate market growth. These studies include those by Lighting Africa (2010, 2012), Lighting Global (2015) and GOGLA/Kearney (2014). The timing of the study meant that only some of the most recent market data, from Lighting Global/GOGLA, could be taken into account.

The market for solar household solutions embraces a variety of products and services. This report considers the full range of solar devices, using terms such as 'solar household solutions' or 'solar off-grid options', except where it specifically refers to solar lanterns or larger solar home systems (SHS). The availability of information about the market for different categories of product is uneven, and the studies reviewed focus on the market for quality-certified products. While estimates of the total market for pico-solar lights are available, information about quality-certified PSLs is more robust. For the uncertified market and larger solar home systems, market information is patchy. Smaller solar lights have by far the largest share of the market, however, in terms of numbers of units. This assessment of the market therefore focuses on quality-certified PSLs.

A simple spreadsheet model was developed for this background paper, taking account of the identified drivers and barriers, to outline what would need to happen for universal access to be achieved in sub-Saharan Africa and in 13 selected countries,[6] under three scenarios – a 'Business As Usual' scenario where it is achieved by 2080, a 'Sustainable Energy for All' scenario where it is achieved by 2030, and a 'Power for All' scenario where it is achieved by 2025. Summary results from the model are presented in the paper. The spreadsheets are available separately.

Market size and growth

The market for quality-certified products has grown rapidly over the last five years, but growth has flattened, and the market may even have shrunk in early 2015.

The main source of data on overall market growth trends is the World Bank / IFC Lighting Africa programme. The team asked companies manufacturing and distributing products that had been certified under Lighting Africa's quality assurance scheme to report sales every six months. The available data gives no indication of the size or nature of the non-certified market segment, despite some companies estimating that as much as half of products in more developed markets may be non-certified. The Lighting Africa quality certification scheme only covers products up to 10W, so there is less data available relating to the sale of larger solar home systems. GOGLA sought to overcome this second question by consulting companies selling larger systems.

The data show that the market for quality-certified products grew by 165% year on year from 2011 to 2012, accelerating to 204% from 2012 to 2013, before dropping back to just 27% from 2013 to 2014. It is likely that market growth has flatlined and may even have reduced in the first half of 2015. It is likely that if non-certified products were also included, the market would continue to exhibit rapid growth.

1 Lighting Africa, 2010.

2 Lighting Africa, 2012.

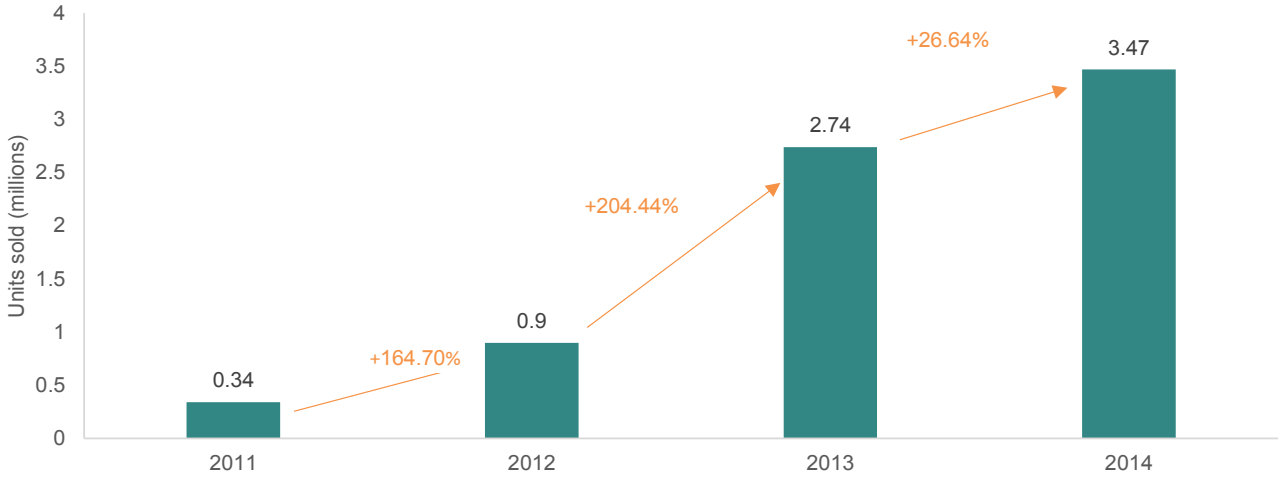
3 Bloomberg New Energy Finance, 2015.

4 Market penetration is defined as the proportion of the potential market that has been reached. The potential new market for solar household systems is taken to be 20% of the total population without access to electricity, in line with estimates by the International Energy Agency (IEA, 2011).

5 See the Impact paper for details of the development gains that SPLs can deliver.

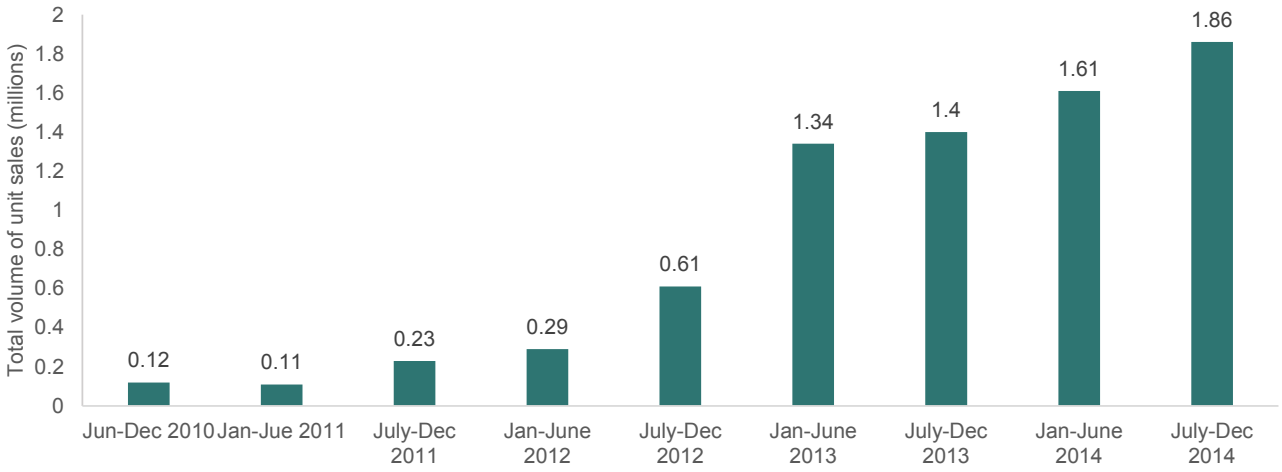
6 The countries were selected by the Department for International Development, who commissioned the study. They are: Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Sierra Leone, Somalia, Tanzania, Uganda, Zambia and Zimbabwe.

Figure 1: Africa annual sales (million units) and market growth rates (%)



Source: Lighting Global, forthcoming

Figure 2: Africa half year results (total volume of unit sales in millions)



Source: Lighting Global, forthcoming

Whilst opinions differ regarding which factors have been the most important in driving the growth trend, there is consensus that competition with cheaper, non-certified products has made trading conditions extremely tough in the most advanced markets in Kenya and Tanzania, especially for lower cost, more basic products.

GOGLA was able to obtain sales data from seven of the main companies selling lights above 10W in May 2015. The figures provided suggested that the vast majority of products – over 90% – still fall below 10W. More up-to-date and detailed market intelligence is being gathered by Bloomberg New Energy Finance for World Bank Lighting Global and GOGLA, looking both at non-certified lights and lights above 10W, and is expected to be published early in 2016. .

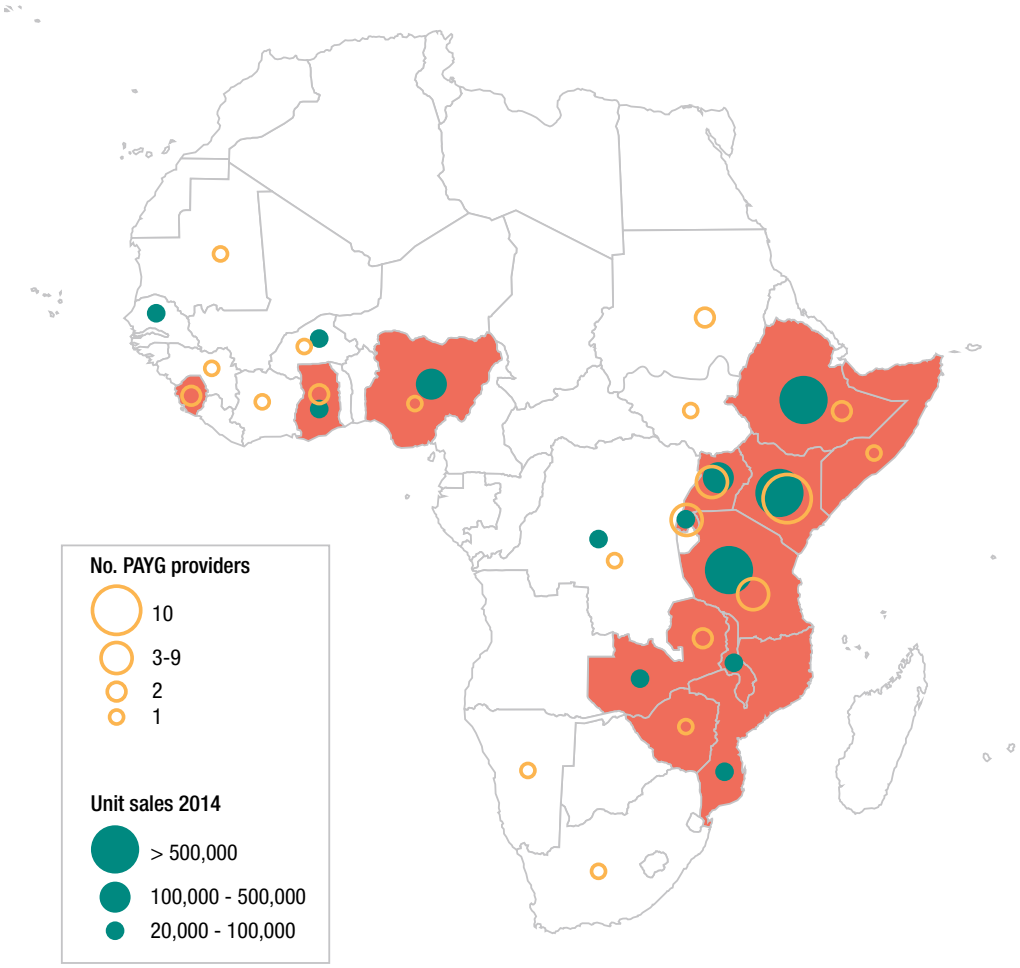
Geographical footprint

By 2012, quality certified products were being distributed in 25 African countries (Lighting Africa, 2012). In early 2015, PAYG solar enterprises were operating in 21 countries (Lighting Global, 2015).

Another key finding from Lighting Africa market intelligence is that growth is highly concentrated, with 78% of sales in just three countries – Kenya, Tanzania and Ethiopia.

Kenya was the first market to emerge and remains the largest in Africa with penetration estimated at around 15-20% of off-grid households. Ethiopia and Tanzania quickly followed suit. Market penetration for the continent as a whole is still quite low, and is generally estimated to be around 3%. Rwandan and Ugandan markets remain small but are widely seen as poised to be the next markets to emerge, with many off-grid lighting companies entering in the last 12-24 months.

Figure 3: Distribution of sales in 2014 and PAYG providers



Source of data: Lighting Global

All of the countries where household solar markets have emerged have had comparatively supportive policy environments, including low or zero VAT/tariff rates on solar products and strong government commitment to support the market.

There may be a clustering effect where companies and investors see less risk in entering markets where others are already operating. There may also be other benefits to entering markets where others are already operating, for example, the availability of experienced staff.

The growth trend of most companies suggests that they tend to expand into countries neighbouring their existing countries of operation, although this is not always the case. This can party be explained by the ease of doing business in countries that are next door to each other, which may be in the same regional market community, have similarities in culture and readily allow the movement of stock from one to the other. Combined with the fact that many pay-as-you-go business models seek to achieve high customer density in a defined area, this suggests that we are likely to see a 'domino effect,' with the market expanding out from the markets which have already emerged in East Africa.

Market segmentation

Low-cost entry-level and mid-range products are the largest market segments by volume. There is emerging evidence of an 'energy ladder' whereby smaller lights pave the way for the emergence of pay-as-you-go and solar home system segments as markets grow.

For the purposes of our market analysis, products are categorised using the GOGLA product categories, outlined in Table 1 below, which build on Lighting Africa's product categories to provide a more nuanced picture of the solar home system market.

Lighting Africa estimated that 88% of the sales of quality-certified products between 2009 and 2012 were at the smaller end of the product range, with a purchase price of less than $ 50 (Lighting Africa, 2012). The latest Lighting Africa data suggests that over 90% of sales in 2014 were in product categories PC1 and PC2.

Kenya, the region's most advanced market, gives an indication of the trend we are likely to see elsewhere as markets emerge. Lights priced below $ 20 increasingly dominated the market until the end of 2013, mainly as a result of SunnyMoney achieving significant sales of

Table 1: Product categories

GOGLA Product Category	Definition	Lighting Africa Product Category	SE4ALL Tier*
PC 1	Single light source without external power outlet/ mobile phone charging < 100 lm	A - Light only	Tier 1 for 1 person
PC 2	Single light source with external power outlet/ mobile phone charging < 100 lm OR Single light source without external power outlet/ mobile phone charging > 100 lm	split between "light only" and "Light and charger"	Tier 1 for 1 person
PC 3	Single light source with external power outlet/ mobile phone charging > 100 lm	B - Light and charger	Tier 1 for 1 person
PC 4	Multi light source application with external power outlet/ mobile phone charging	C - Multi-light and charger up to 10W	Tier 1, for whole household
PC 5	Outdoor lighting, street lighting/ public lighting	Not captured	N/A
PC 6	Lighting products of any other type not mentioned under category 1-5 of any size	Not captured	Tier 1, for whole household
PC 7	Providing multi-lighting, mobile charging, TV and/or fan above 69W	Not captured	Tier 2

Beyond Connections: Energy Access Redefined, ESMAP/SE4ALL, June 2015.

entry-level products through schools nationwide. Then, in 2014, lights below $ 20 dropped from 57% of sales in the first half of 2014 to 38% in the second half, while lights priced $ 20 to $ 40 jumped from 28% to 60% of sales.

Sales of lights above $ 40 in Kenya remained relatively constant over 2014, as market growth was driven by sales of lower cost lights, but their market share dropped from 15% to 2% between the first and second halves of the year (Figure 4 and 5). However, the volume of sales did not drop dramatically.[7]

It is likely that this trend was at least in part driven by entry-level lighting customers choosing to buy a higher-functionality light the second time they purchased. The vast majority of customers continue to be first time buyers, however. Although the data are limited, many companies believe that the increasingly commonplace use of entry-level lighting helped to create trust in solar technology generally. This meant many customers were prepared to invest more and buy a bigger light than the first time around.

Pay-as-you-go products were not counted separately before Jul-Dec 2014, making it difficult to clearly demonstrate market dynamics with the data available. Further research in this area is planned by the UN Capital Development Fund. However many companies believe that, with affordability less of a barrier, customer journeys up the energy ladder are likely to be accelerated by an easier transition from inefficient lighting to solar, and from solar products to pay-as-you-go or full solar-as-a-service models.

The diagram below (Figures 6 and 7) shows that, while light-only systems made up over half of sales by volume (number of units), mid-level and larger systems generated the bulk of the revenue. Inclusion of products above 10W would make the data show an even more pronounced trend, given the higher revenue from these larger products. This was significant for our modelling, which sought to link investment in particular market segments to sales growth in each segment. Higher product categories would require more investment per new customer reached, given the higher level of energy provided.

Energy Ladder

Roberts (2015) supported the argument that new technologies can bring everyone now lacking energy access onto the modern energy ladder. He argued that this shift has been enabled through several intersecting trends: the increased availability and affordability of solar panels, batteries and distributed-energy technology; hyper-efficient end-use appliances; new models of financing that allow

7 This may be a reflection of the way sales are counted. PAYG sales have been counted separately only since mid-2014.

Figure 4: Proportions of sales in Kenya by function (2013 and 2014)

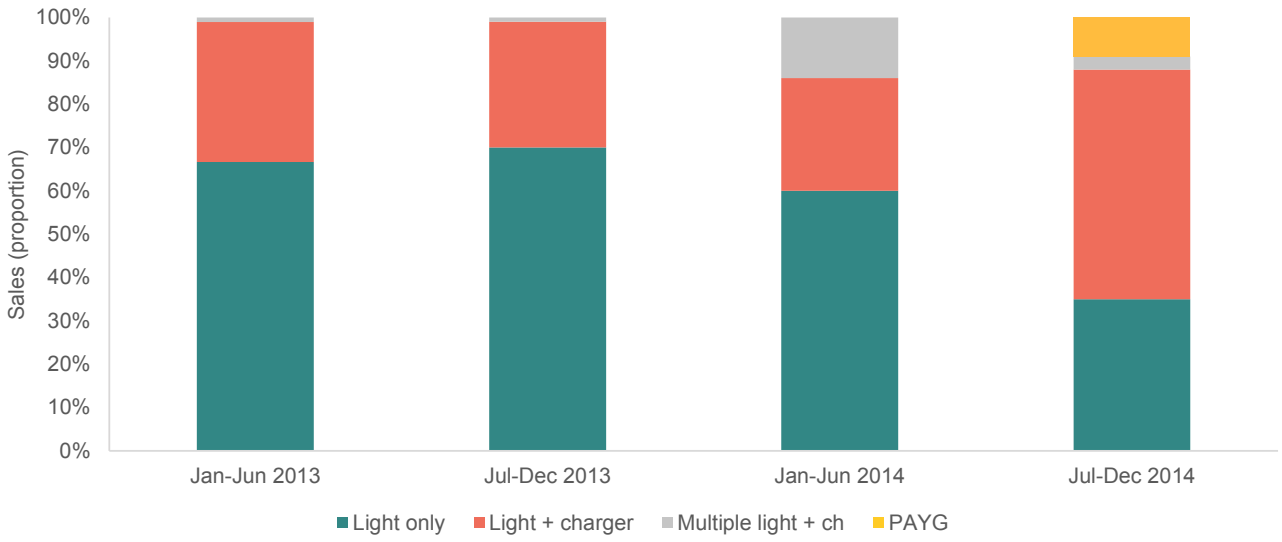
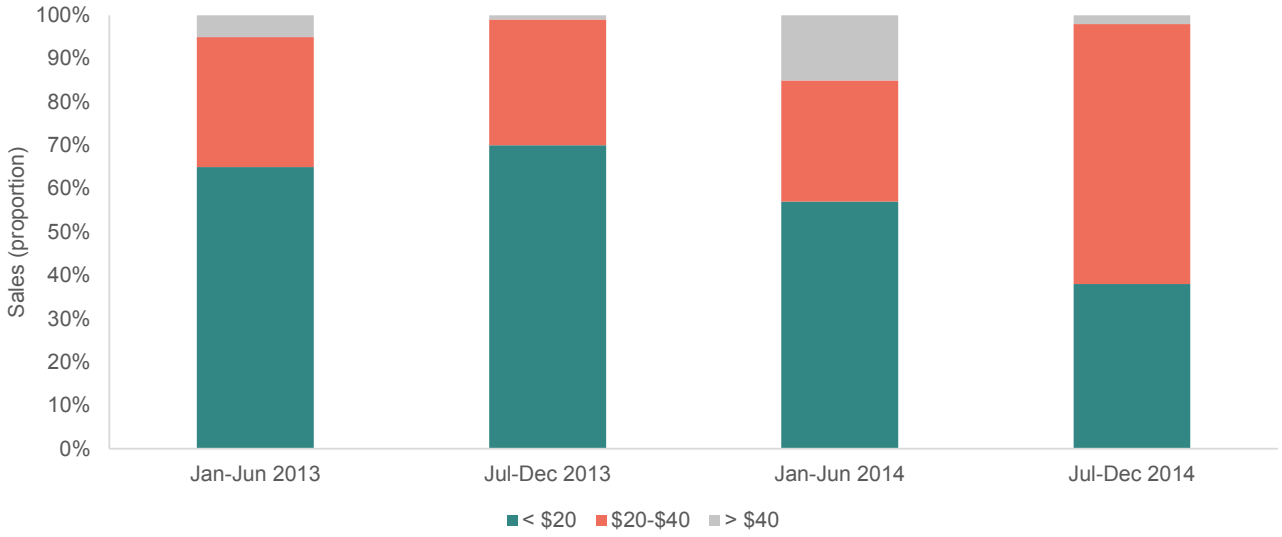


Figure 5: Proportion of sales in Kenya by value (2013 and 2014)



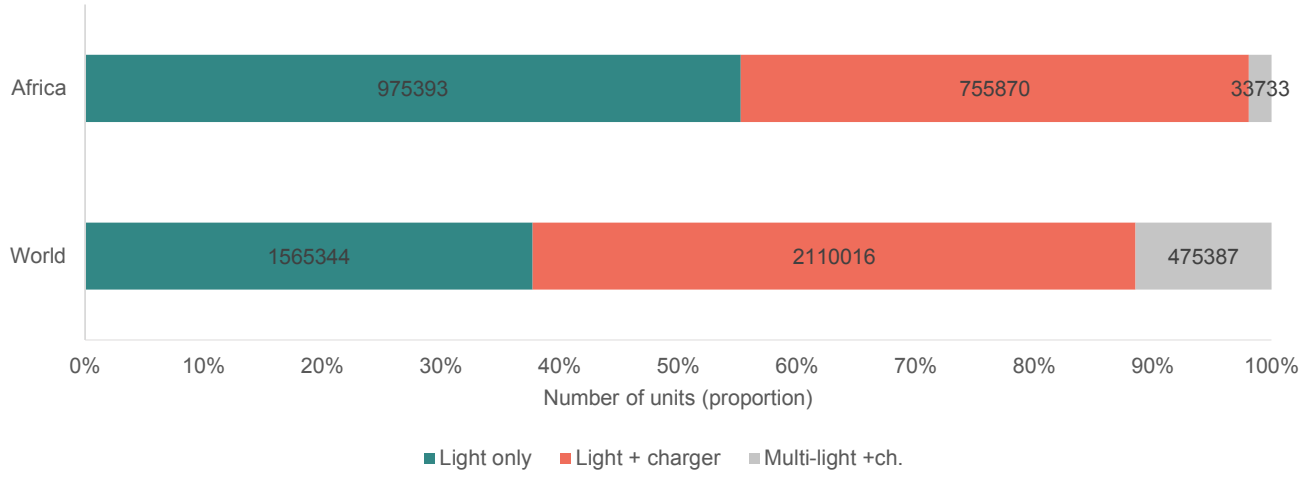
people to pay as they go; and developments in information technology that reduce the transaction costs of coordination among small-scale energy users and producers.

There is some evidence to suggest that pico-solar lights – Product Categories 1 and 2 – can be a first rung on the modern energy ladder for low-income people. Over time people may become more able and willing to upgrade to energy products with more functionality or capacity. For example, they may move up from a solar light to a mid-level system with a higher wattage, longer battery life and mobile phone charging capacity.

In Uganda, one study found that 60% of SHS users were interested in upgrading their systems with additional panels and batteries to be able to increase power output for more lights and to charge more phones (Harsdorff et al., 2009). Unsurprisingly, this study also noted a higher expenditure on electric-powered appliances by microenterprises with solar home systems over the previous 18 months, with the majority of electric assets acquired in the previous six months.

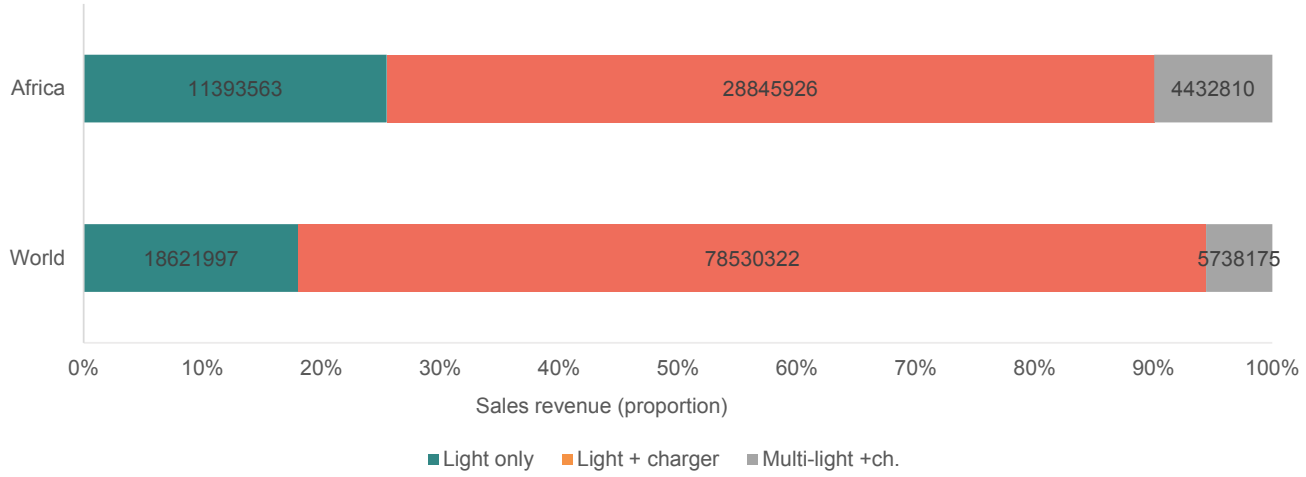
Research by SolarAid (2015) found that 87% of customers return to SunnyMoney solar light agents to buy a second light. In Zambia, 63% of customers said they wanted to buy a solar product with more capacity, and 90% of them felt more able to do so as a result of having a pico-solar light. SolarAid (2014-15) has also found that 94% of pay-as-you-go

Figure 6: Proportions of sales in 2014 by product category (unit)



Source: Lighting Africa (forthcoming).

Figure 7: Proportions of sales in 2014 by product category (value)



Source: Lighting Africa (forthcoming).

customers who bought an entry-level solar light were interested in buying solar lights with added functionality and capacity, such as the ability to charge mobile phones, radio or TV. Of course, this does not necessarily translate to purchase and similar levels of willingness may be seen in households without modern energy.

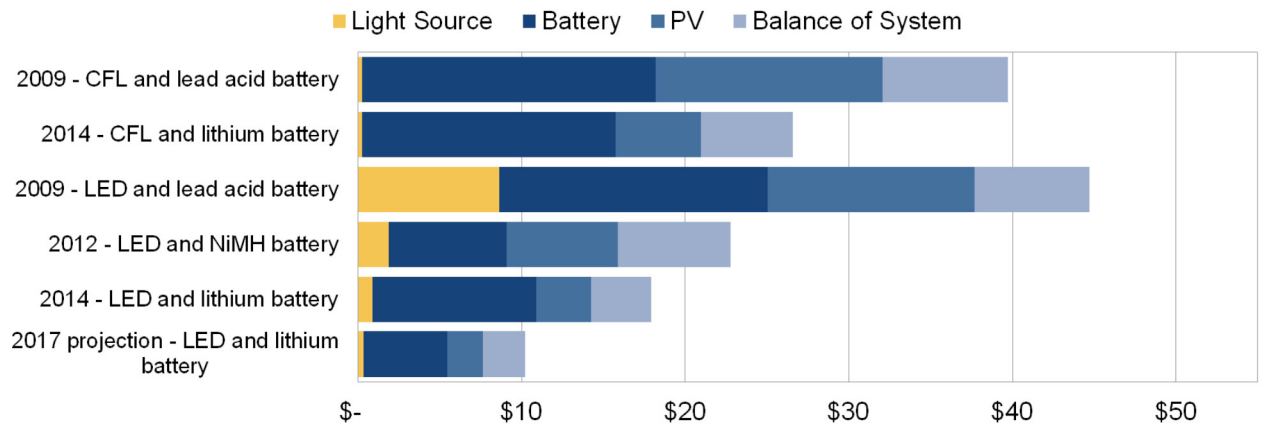
For almost all PAYG customers, the act of completing repayments on a solar light or home system will give them a credit history for the first time. Theoretically this could de-risk them as clients for future lending, accelerating progress up the energy ladder.

Technology trends

Technology advances have led to improvements in performance and reductions in price.

The price of solar PV modules has been, until now, the critical factor determining system cost (Phadke et al., 2015). In 2012, Lighting Africa estimated they accounted for 29% of the manufacturing cost (Lighting Africa, 2012). The price of PV modules has declined sharply over the last decade, by more than 85%, and they now account for less than a quarter of the overall cost (Giannakopoulou, 2014).

Figure 8: Retail prices in 2009, 2014 and a projection for 2017, of pico-solar products that provide lighting service of 120 lm for four hours a day



Source: Lighting Global

Batteries are another significant cost item. In recent years the price of lithium-based batteries has declined sufficiently to allow for their use in household solar products. This has improved performance and durability considerably, but has not contributed to a reduction in price. The price of most other components has been stable.

Two factors have provided upward pressure on the prices of many solar products and systems, the value of the Chinese currency and the cost of labour in China. The Chinese Yuan has gained 10% in value relative to the US dollar over the past four years, making exports from China more expensive (US Forex, 2015), while the cost of manufacturing wages in China has increased at an average rate of 14% annually since 2004 (Trading Economics, 2015).

An analysis of products tested through the Lighting Global program indicates a 70% price decline from 2011 to 2014 (Lighting Global, 2014). Though there are likely to be further reductions in the cost of LEDs and lithium batteries, the cost of appliance use is expected to be the main driver of future cost reductions as a result of efficiency gains.

In practice, manufacturers of household solar products have not developed products that fully realise the cost reductions represented in Figure 6. Instead, companies have sought to strike a balance between increasing product performance and decreasing price. Many products now include additional services such as mobile phone charging that add to the cost of the product.

Common appliances used in households with a solar home system are lights, TVs, radios, fans, and mobile phone chargers (Nieuwenhout, et al., 2000; Jacobson, 2007; Siegel and Rahman, 2011). Most radios and mobile phone chargers used in off-grid systems consume relatively little energy, so the bulk of the energy consumed is typically for lighting, TVs and fans. Gains similar to those discussed above for LED lighting are, of course, applicable for lighting associated with these larger systems. There is also great potential to realise substantial efficiency gains for DC appliances such as TVs and fans. The technical potential to reduce electricity consumption for appliances typically used in solar home systems is substantial, as outlined in Figure 9 below.

There is now near-ubiquitous connectivity for individuals working in supply chains for off-grid power and the majority of potential users have access to mobile phones (Nique and Arab, 2013). One emerging use of mobile technology in the off-grid solar energy sector is pay-as-you-go (PAYG) digital financing. PAYG technology extends micro-finance to previously unbanked buyers using embedded systems that can incentivise repayment without the need for loan agents, by deactivating systems. This can lead to dramatically reduced transaction costs. A variety of combinations of payment systems ("mobile money", scratch cards, etc.) and enforcement mechanisms (remote GSM connections and keypad verification) are currently being deployed (Winiecki and Kumar, 2014). Additionally, the embedded GSM connections, or intermittent connectivity used for payment enforcement in some PAYG systems, present new opportunities for remote monitoring to identify service needs and better understand user behaviour.

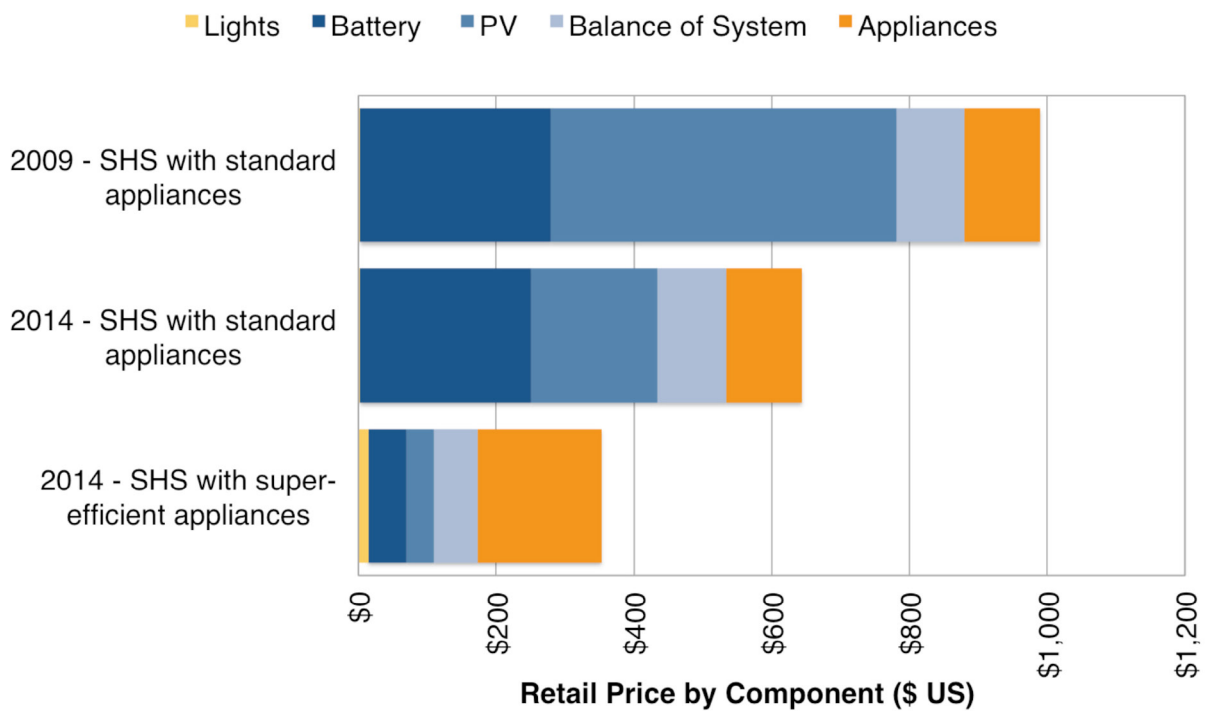
Business model trends

Business models continue to evolve in response to rapidly changing market conditions. The main trend is the emergence of pay-as-you-go technology enabling customers to pay over time, at lower cost than traditional microfinance.

Distribution Models

The five types of distribution model identified by Lighting Africa in 2012 continue to be prevalent in 2015 (Lighting Africa, 2012):

Figure 9: Retail purchase price for three solar home systems



Source: Lighting Global

1. *Institutional Partnerships*: The solar company partners with a relevant institution (e.g., NGO, MFI, rural bank, SHG network, MNC, with a linkage to a material number of potential customers) to market its products to that institution's customer base or membership network. This could also include government schemes.
2. *Distributor-Dealer Channels*: The solar company sells its products through existing networks of generalist or specialist distributors. This model piggybacks on the traditional private sector supply chain of consumer durables and usually engages a distribution hierarchy of at least two levels (distributor and dealer/retailer). The company's product is typically retailed in a basket of other related consumer durables.
3. *Proprietary Distribution Channels*: The solar company maintains a proprietary distribution channel in which its products move from manufacturer to in-house storage facilities to a salaried/contracted salesforce, which exclusively delivers the company's products directly to customers.
4. *Franchise Model*: The solar company offers franchising packages (including features, such as income opportunities, training, marketing support, and financing) to micro-entrepreneurs who wish to become formalized retailers of exclusive company products.
5. *Rental / Leasing System*: The solar company contracts or franchises to micro-entrepreneurs who set up solar charging kiosks. The micro-entrepreneurs either (1) rent products out to consumers on an hourly/daily basis or (2) sell systems without a power source and offer a fixed fee for charging. Charging can be provided via on-grid power or alternative power generation (solar, diesel, etc.).

Financing models

Since 2012 we have seen the emergence of innovative business models for financing energy, neatly summarised by WRI in their Keys to Achieving Universal Energy Access series:[8]

1. *One-Stop-Shop Model*: In this model, sustainable energy products and finance are provided by the same organisation. This happens when a finance provider decides to offer energy products, or when an energy enterprise decides to offer finance.
2. *Financial Institution Partnered with an Energy Enterprise*: In this case, an energy enterprise enters into a partnership with a local financial institution to sell sustainable energy products. This model typically involves a financial institution providing credit to an end-user and managing the monitoring and repayment processes, while the energy company provides the energy product, installation (if necessary), service and maintenance.
3. *Umbrella Partnership Model*: The energy enterprise enters into a partnership arrangement with an

8 Ballesteros, et al., 2013.

"apex institution" that manages a network of local financial institutions (e.g. a union or organisation of credit cooperatives, credit unions, or other village-based financial institutions). The apex institution lends money to the local finance providers, who then lend to an end-user and manage the monitoring and repayment processes. The energy enterprise provides the energy product, installation (if necessary), service and maintenance.

4. *Franchise/Dealership Model*: The energy enterprise provides credit to dealers and/or franchises to allow them to sell to clients on an instalment basis. This particular model is common for relatively inexpensive products — usually those that cost under $50.
5. *Brokering Model*: A third-party organisation or individual is paid by the finance provider and the energy enterprise to market energy products and assess customers' suitability for financing. They will then bring viable customers forward to buy energy products. The broker may also be involved with loan payment collection, after-sales service, and technical upkeep.
6. *Pay-As-You-Go Model*: There is a wide range of business models that fall under the loose category of digitally-financed or "pay as you go" (PAYG) off-grid energy. Some of the common models are described as "DESCO" (distributed energy service companies) that provide a given level of energy service in exchange for ongoing payments. Others are better described as asset finance or microloan providers, with a transfer of asset ownership to the user after a limited payment period. Others still act as business-to-business (B2B) intermediaries, supplying hardware and software support from global operations to last-mile energy service and payment logistics.

The PAYG market is incredibly dynamic. New business models appear almost daily, companies change approaches, funding is raised, and players disappear. Lighting Global market research in May 2015 provides an up to date description of the models being used:[9]

- **System Size:** PAYG solar products can be divided by the system size, which dictates the service level that each provides: pico-solar, basic solar-home systems, standalone systems that are either self-installed or professionally-installed, as in the case of Sun Transfer or Solar Now, and include the ability to power small appliances such as fans, DC televisions, and even small refrigerators with a solar module power rating of roughly 10 to 200 Watts. Pay-as-you-go versions of simple entry-level and mid-level products, being tested by SunnyMoney and Greenlight Planet amongst others, have the potential to help overcome the affordability barrier amongst poorer customers.
- **Customer Relationship:** The broad categories of consumer relationships available are micro-loan, energy service, and business-to-business (B2B) hardware/software.

a. **Micro-loan:** Firms such as M-KOPA, Nova Lumos, Azuri, and Simpa Networks fall under the umbrella of asset finance, or micro-loan. Although the specific criteria differ between firms, typically the same three-step process is followed for end customers:
   - Down payment and a relatively informal credit check
   - Payment series via proprietary or licensed platform
   - Device is unlocked and owned by the customer

b. **Energy Service:** Another approach is the distributed energy service company model, used by firms such as Off-Grid Electric, where rather than financing an asset, the company provides an electricity service much like a modern utility does. That service comes from a company-owned solar system, which is roof mounted. The user provides an installation or down payment, slightly de-risking the investment for the firm, but at no point does the consumer own the asset outright, even after the full cost has been repaid.

c. **B2B hardware/software:** There are significant needs in the PAYG market for specialized IT hardware and software. Some firms focus on B2B offerings that provide critical support for providers to better serve their customers, as exemplified by firms such as Angaza Design and Divi Power.

- **Payment Platform:** PAYG providers employ a number of approaches to enable payments for their product or service. Some, like M-KOPA, rely on an established mobile money network. In their case, a partnership with M-Pesa in Kenya allows for nearly seamless product activation with no agent interaction after the initial purchase. Others, such as Simpa Networks and Azuri Technologies, have developed a scratch card model with distributing agents across the countries where they operate that does not depend on mobile connectivity but does require management of the agent network. Nova Lumos employs mobile airtime as a virtual currency, allowing users to pay for the service using mobile phone credit. Other models require specialized agents to accept cash payments, and then activate solar lights through either (a) a cable, (b) bluetooth, (c) or a manually-entered SMS code. **Overall, 60% of the firms identified use mobile payments and 40% use an alternative** (Lighting Global, 2015).

9 Off-Grid Power and Connectivity: Pay-as-you-go Financing and Digital Supply Chains for Pico-Solar; Alstone, Gershenson, Turman-Bryant, Kammen, Jacobson; Lighting Global; May 2015.

- Product repayment periods vary widely amongst systems and depend on many factors. For the products studied by Lighting Global in Kenya, payment tenors ranged from just over 10 weeks to just under one year for average repayment. Some current PAYG systems in Kenya have terms that extend up to 3 years. Companies build the cost of providing finance to the consumer over different time periods into the payment plans they offer customers. The amount the customer ends up paying in interest on the credit depends on the length of tenor, as well as how companies are themselves financed to extend consumer credit, and the cost to them in doing so. In general, built-in interest rates appear to be significantly lower than traditional microfinance as a result of the lower transaction costs incurred with the use of PAYG technology.
- **Partnership Strategy:** Firms in the PAYG space have diverse levels of integration across the supply chain and approaches to marketing and distribution. Partnerships are being made on hardware, distribution, payment, or other core aspects of the business. For example, some firms (such as Azuri) have an essentially vertically integrated supply chain from manufacturing / design to last-mile distribution and payment. Others, such as Fenix International and Nova Lumos, have partnerships with local telecommunications companies to support sales and delivery to the consumer. Still others, like M-KOPA have a device that is branded with a telecommunications company logo and partner manufacturing logo, but conduct most marketing and distribution themselves.
- **Connectivity:** PAYG technologies can be distinguished by the level of connectivity used for payment, verification, and customer relationship management. The choice depends on the availability and adoption rates for mobile payment and data transfer service, reach into rural areas without continuous connectivity, and other priorities. The spectrum runs from systems that are fully online, including mobile money and remote, real- time connections with the energy system to those that are only tenuously or intermittently connected.

Investment trends

Research by GOGLA and AT Kearney shows that investment in the certified off-grid lighting sector increased more or less steadily between 2010 and 2013 from around $ 9 million to $ 22 million. In 2014, there was an unprecedented influx of capital into the sector totalling around $ 100 million, most of which went into PAYG companies.[10] Investment in 2015, so far, appears to be around the same magnitude as 2014 or a bit higher.

The annual capital demand of companies in the sector is estimated to be around $ 300 million. In general companies say they are able to raise about 20% of their needs.[11] According to data gathered from a survey by GOGLA in mid-2015 and from desk research on publicly announced deals, the sector was able to raise around $100 million in 2014, compared with their reported a total investment need of $300 million. While about 80% of funding was equity in 2010, this has dropped as mixed investments and debt financing have become steadily more commonplace. About 10% continues to come from grants. Most companies say that, above all, they need debt financing.

Only the largest companies are able to raise significant amounts of investment,[12] with many smaller players continuing to struggle. PAYG companies are attracting the most funding, followed by vertically integrated manufacturer-distributors. Product neutral distributors of quality-certified products appear to be raising very little.

Future market growth

The study estimated future growth in the market for solar household systems, for sub-Saharan Africa as a whole and for 13 selected countries. The purpose was to determine when and how universal access to electricity could be achieved through expansion of this market. Could accelerated growth in the market bring electricity services to everyone in Africa before the 2030 target of the Sustainable Development Goals?

A simple model was developed for the study to understand what it would take to achieve universal household electricity access under three scenarios: a 'Business as Usual' case, which would mean universal access is not achieved until 2080; a 'Sustainable Energy for All' case, where it is achieved by 2030; and a 'Power for All' case, where universal access is achieved by 2025.

The market model

The model reflects analysis of the recent trends and market information outlined above. It estimates the number of units that would be sold under different assumptions for each scenario, the total value of these sales and the investment that solar product suppliers and distributors would require to supply the market. It assumes that the

10 Investment and Finance Study for Off-Grid Lighting, AT Kearney & GOGLA, June 2014. Updated by GOGLA in early 2015.

11 Interviewees for this study.

12 The market for quality-certified products is concentrated on a small number of companies (BNEF, 2015).

13 The IEA estimates that 40% of the population without electricity would be best supplied through grid extension, and that one-third of those supplied by off-grid electricity would be best served by stand-alone systems. The model assumes that all of this one-third would be supplied by solar household systems.

Box 1: Variables identified for factors affecting investment raised

Demand
Proportion of the population who are aware of solar products and their benefits
Proportion of the population who know someone with a solar lantern
Proportion of the population living in extreme poverty
Cost of solar technology/appliances
Cost of lighting from kerosene, candles and batteries

Supply
Population density
Local skills (using the literacy rate and a quality of education indicator)
Mobile phone prevalence
Mobile money prevalence

Policy
Off-grid specifically included in national energy policy
Off-grid component of national energy policy well-implemented
Low or zero VAT and import tariffs for solar products
Off-grid market readiness (using Climatescope methodology)
High ease of doing business ranking
Nationally adopted quality standards in line with global standards

Finance
Value of investment (grant, loan, equity) into distributors
Value of investment (grant, loan, equity) into manufacturers
Investor experience of investing in Africa, consumer durables and off-grid solar
Availability of risk-sharing or pooling mechanisms

total size of this market is the number of people currently without access to electricity who would be best served by off-grid stand-alone systems.[13]

The other key underlying assumptions in the model are that demand is not a constraint on market growth and that the most important factor determining this growth is the amount of investment that solar companies can raise. The financial savings that households would make when switching from kerosene lighting to a PSL indicate that in almost every case purchase of the PSL could readily pay for itself.[14] This, combined with high a willingness to pay for electricity, suggests that the demand assumption is reasonable.

The investment required by suppliers and distributors is taken to be the FOB cost of the solar products sold. This investment is for establishing or extending the supply chain and for working capital. The amount that companies can raise is determined by demand, supply, policy and financial factors. For each of these factors, the study sought to identify a number of key variables that have a bearing on market growth and could be used to measure or estimate it. These variables are listed in Box 1.

Given that investment is the key driver of market growth in the model, the scope of the finance factor excludes the actual amount raised (i.e. the value of investment variable listed above). It is limited to an assessment of investor capacity to assess risk and invest in a given market, whether they have relevant experience, capacity or skills, and whether risk-sharing or pooling mechanisms were available.

The study sought to collect data for the region and the selected countries on each of the variables listed in Box 1. It became clear that the data for many of the variables were unavailable or of poor quality to act as a basis for developing the market modelling exercise. For example, there is an absence of data on exposure to PSLs and little information about investment is publicly available, especially at the country level.

There would be other challenges in using these variables to develop the model. Some of the variables could have an effect on more than one of the four factors. VAT and tariffs on solar products, for example, can affect the influence on the market of both policy and demand (affordability). The factors themselves are causally linked. Even where the business case is sound, access to finance can be a bottleneck. Policy, demand and supply issues all filter through into the

14 See the accompanying paper on the impact of solar household systems for more details.

Table 2: Key variable assumptions in market model under each scenario

	Business as Usual	SE4All	Power4All
Rate of increase in investment demand	2.5%	6%	15%
Initial key factor scores	3	3	3
Annual change in factor scores	0	0.1	0.2
Annual change in proportions of product categories	PC1&2: -0.5% PC3-6: -0.25%	PC1&2: -1.0% PC3-6: -0.5%	PC1&2: -1.5% PC3-6: -0.75%

level of investment that companies are able to raise, by impacting on the business case for investment.

The starting point for the model is the number of people who need to be reached with household solar, in sub-Saharan Africa as a whole and in each of the selected countries. The model applies the proportion of the total population without access to electricity in 2012, using the IEA's estimates (IEA, 2014), to UN population forecasts for the years from 2015 to 2030. In line with the IEA's estimates, it was assumed that the electricity needs of 20% of this unconnected population would be best met by off-grid solar household systems. This assumption is consistent with rates of grid electrification being approximately in line with population growth (SE4All, 2015).[15]

The amount of investment by solar distributors and suppliers, the key driver of market expansion, was estimated by first estimating a 'demand for investment' figure. The baseline for this was the estimated demand for investment in 2015 for sub-Saharan Africa as a whole. On the basis of interviews with companies active in the market and market intelligence from Lighting Global this baseline figure was set at $ 300 million. For individual countries the estimate was pro rata in relation to the estimated quantity of sales in 2015. The annual growth in the demand for investment is an assumed variable, different for each of the three scenarios.

To reflect how the demand, supply, policy and finance factors affect how much of this demand for investment is met, and either drive or act as a barrier to market growth, each factor was assigned a score out of ten (i.e. the higher the score, the greater the positive impact on investment). The scores for each factor were added together and converted into a percentage which determined the proportion of the investment demand that was met in each year, and consequently the estimated actual investment.

In the Business as Usual scenario these key factor scores were kept constant throughout the period from 2015 to 2030, to reflect an unchanging business environment. The factor scores improved slowly under the Sustainable Energy for All scenario, and improved slightly more quickly under the Power for All scenario.

The estimated level of investment was then split across three product categories, equivalent to GOGLA's PC1 & 2, PC3 to PC6, and PC7 (see Table 1). Product Categories 1 and 2 were assumed to raise roughly 20% of investment, categories 3-6 raising 55%, and product category seven raising a further 25%, in line with known investment trends. These baseline proportions were assumed to be the same in each country.

The proportions of the market taken by the first two of the three product categories, the lower capacity products, were assumed to decline each year. This was in part to reflect competition with cheaper non-certified products which is likely to make smaller category products less attractive to investors. It was also in part to reflect that emerging PAYG models delivering higher levels of energy service are likely to become more attractive to investors, given that high prices and margins offer greater leeway for investor returns. The different rates of decline for the PC1&2 and PC3-6 product categories under each scenario are shown in Table 2 below.

The model assumes that the investment raised each year is recovered from sales revenue within the year and is available for reinvestment the following year. The amount of investment available for market expansion each year, after year one, is therefore the new investment raised and the amount reinvested.

To determine the quantity of solar products that would be distributed and sold with the investment available each year, the FOB[16] price of each product category was used. This assumes that solar businesses cover their operating and selling costs through a gross margin. The gross margin was taken to be 50% of the retail price, which is consistent

15 The model could be enhanced by building in more nuanced assumptions around urbanisation and grid/mini-grid expansion at country-level.

16 Freight on board, i.e. the cost to the companies of importing the manufactured solar products.

Table 3: Year that universal access is achieved under each scenario

	Business as Usual	SE4All	Power4All
Sub-Saharan Africa	> 2030	2030	2025
Ethiopia	2019	2019	2018
Ghana	> 2030	> 2030	> 2030
Kenya	2019	2019	2018
Malawi	2028	2026	2023
Mozambique	> 2030	> 2030	2027
Nigeria	> 2030	> 2030	> 2030
Rwanda	2024	2023	2022
Sierra Leone	> 2030	> 2030	> 2030
Somalia	> 2030	> 2030	> 2030
Tanzania	2022	2022	2021
Uganda	> 2030	> 2030	2026
Zambia	> 2030	> 2030	2026
Zimbabwe	> 2030	> 2030	> 2030

with the analysis of product costs by Lighting Africa (2012). This allows the model to estimate total annual sales in numbers of units and value.

The useful life of a solar household system is approximately four years. The model assumes that after four years consumers will replace their solar lantern. The number of sales to new consumers each year was therefore taken to be total sales, determined by the investment available, minus the number of units sold four years previously. In the country market models, except for Ethiopia, Kenya and Tanzania, in the absence of detailed market information, it was assumed that there were no sales before 2014.

Finally, the model estimated the number of people reached through new sales, in line with Global Tracking Framework's assumptions that category 1 & 2 products benefit one person, and category 3-7 systems (and above) benefit whole households (assuming an average household size of 5). Subtracting the number of people reached for the first time from the total population that remains to be served by the solar household system market, provided an estimate of how the growing solar household market would deliver improved household energy access over different timescales.

The main findings of the model are summarised in the table above which shows the year that universal access is achieved in the market for solar household systems under each scenario. Under the business as usual conditions, universal access is achieved by 2030 in only four countries, those where the market is already relatively well-developed. Under the initial assumptions used for the Power for All scenario, five of the thirteen countries do not achieve universal access by 2030. Six countries achieve universal access by the Power for All target of 2025.

Conclusions

Although sales of solar household systems in sub-Saharan Africa have increased rapidly in the last four or five years, market penetration is currently estimated by the industry to be around 3% of the potential market. This suggests considerable potential to expand the market, under appropriate conditions.

The simple model developed for this study indicates that total sales in sub-Saharan Africa of quality-certified solar household systems could grow from the 3.3 million sold in 2014 to 17 million in 2030 under the most favourable conditions. The model shows that if improvements in demand, supply, policy and finance related factors can be achieved, there will be greater demand for investment from industry, and investors will meet more of this demand.[17] The Power for All target of universal access to electricity through solar household systems by 2025 is achievable, under such favourable conditions.

The amount of investment that solar product suppliers and distributors can raise will be a key factor determining market expansion. Under business as usual conditions the model suggests that $ 1.7 billion of new investment would

17 See the accompanying policy paper for the kinds of policy measure that would enable market expansion.

be raised between 2015 and 2030. The Sustainable Energy for All scenario, achieving universal access by 2030, has $ 3 billion in new investment. The Power for All scenario has $ 3.8 billion raised, enabling universal access to be achieved by 2025.

The total value of the sales under these scenarios would rise from around $ 111 million in 2015 to $ 943 million by 2030 under Business as Usual, and $ 1.5 billion in 2030 under Sustainable Energy for All scenario. Under the Power for All scenario annual sales of about $ 1.9 billion would be reached by 2026.[18]

Overcoming barriers to market growth will not be easy. Creating the conditions for massive investment and rapid market growth is likely to require sustained government commitment and policy focus, the ramping up of programmes intended to catalyse the market, and the identification and replication of best practice to help address emerging issues such as quality.

18 This is consistent with analysis from the Sierra Club and others.

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Annex: Model results - estimated sales

	Scenario	Population without access 2015 (solar off-grid share) ($)	Estimated annual sales in 2015 ($)	Total sales to 2030 ($)	Average annual sales 2015-30 (2015-25 Power4All) ($)
Sub-Saharan	BAU	130 870 999	3 280 000	186 805 008	12 453 667
Africa	SE4ALL	130 870 999	3 280 000	181 999 252	12 133 283
	Power4All	130 870 999	3 280 000	132 421 870	13 242 187
Ethiopia	BAU	13 517 142	653 000	37 190 143	2 479 343
	SE4ALL	13 517 142	653 000	36 233 388	2 415 559
	Power4All	13 517 142	653 000	26 363 256	2 636 326
Ghana	BAU	3 727 745	20 000	1 139 055	75 937
	SE4ALL	3 727 745	20 000	1 109 752	73 983
	Power4All	3 727 745	20 000	807 450	80 745
Kenya	BAU	6 262 841	970 000	55 244 164	3 682 944
	SE4ALL	6 262 841	970 000	53 822 949	3 588 197
	Power4All	6 262 841	970 000	39 161 346	3 916 135
Malawi	BAU	2 341 272	81 000	4 613 172	307 545
	SE4ALL	2 341 272	81 000	4 494 494	299 633
	Power4All	2 341 272	81 000	3 270 174	327 017
Mozambique	BAU	3 804 989	71 500	4 072 121	271 475
	SE4ALL	3 804 989	71 500	3 967 362	264 491
	Power4All	3 804 989	71 500	3 222 406	322 241
Nigeria	BAU	24 779 467	131 000	7 460 810	497 387
	SE4ALL	24 779 467	131 000	7 268 873	484 592
	Power4All	24 779 467	131 000	5 288 800	528 880
Rwanda	BAU	1 578 915	90 500	5 154 224	343 615
	SE4ALL	24 779 467	90 500	5 021 626	334 775
	Power4All	24 779 467	90 500	3 653 713	365 371
Sierra Leone	BAU	877 633	10 000	569 527	37 968
	SE4ALL	877 633	10 000	554 876	36 992
	Power4All	877 633	10 000	403 725	40 373
Somalia	BAU	1 467 046	10 000	569 527	37 968
	SE4ALL	1 467 046	10 000	554 876	36 992
	Power4All	1 467 046	10 000	403 725	40 373
Tanzania	BAU	7 271 977	545 900	31 090 504	2 072 700
	SE4ALL	7 271 977	545 900	30 290 668	2 019 378
	Power4All	7 271 977	545 900	22 039 359	2 203 936
Uganda	BAU	5 308 404	128 600	7 324 123	488 275
	SE4ALL	5 308 404	128 600	7 135 702	475 713
	Power4All	5 308 404	128 600	5 191 906	519 191
Zambia	BAU	2 204 800	53 500	3 046 972	203 131
	SE4ALL	2 204 800	53 500	2 968 585	197 906

(continued)

	Scenario	Population without access 2015 (solar off-grid share) ($)	Estimated annual sales in 2015 ($)	Total sales to 2030 ($)	Average annual sales 2015-30 (2015-25 Power4All) ($)
	Power4All	2 204 800	53 500	2 159 930	215 993
Zimbabwe	BAU	2 121 974	10 000	569 527	37 968
	SE4ALL	2 121 974	10 000	554 876	36 992
	Power4All	2 121 974	10 000	501 579	50 158

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