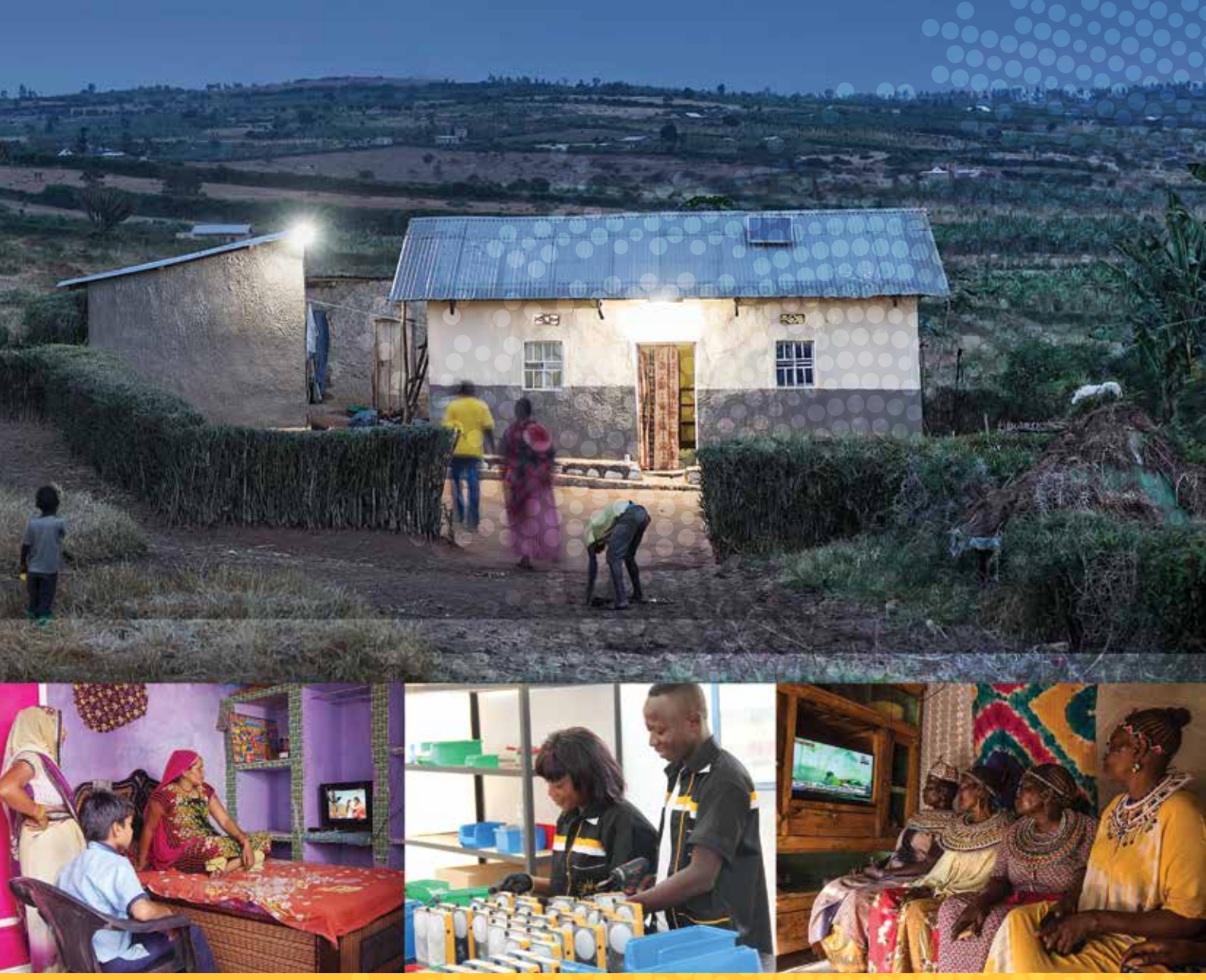

Off-Grid Solar Market Trends Report 2018

JANUARY 2018

Dalberg Advisors and LIGHTING GLOBAL
Catalyzing markets for modern off-grid energy

AN INNOVATION OF WORLD BANK GROUP
THE WORLD BANK IBRD • IDA IFC International Finance Corporation

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We welcome your feedback on this effort and encourage you to reach out to the Lighting Global team with your questions and comments through www.lightingglobal.org or by emailing info@lightingglobal.org.

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ABBREVIATIONS

Segment	Definition
A2F	Access to finance
B2C	Business to consumer
BNEF	Bloomberg New Energy Finance
BoP	Base of the pyramid
C-Si	Crystalline silicon
CAGR	Compound annual growth rate
CGAP	Consultative Group to Assist the Poor
COO	Chief Operating Officer
CRM	Customer relationship management
CSR	Corporate social responsibility
DC	Direct current
DESCO	Distributed energy services company
DFI	Development finance institution
EAP	East Asia and Pacific
FMCG	Fast moving consumer goods
FOB	Free on board
FOREX	Foreign exchange
GDP	Gross domestic product
GOGLA	Global Off-grid Lighting Association
GSM	Global System for Mobile Communications
GSMA	GSM Association
GW	Gigawatt
H1	First half of calendar year
H2	Second half of calendar year
HHI	Herfindahl-Hirschman Index
IEA	International Energy Agency
IDA	International Development Association
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
KES	Kenyan shilling
kV	Kilovolts
kWh	Kilowatt hour
LAC	Latin America and Caribbean
LED	Light emitting diode

LG	Lighting Global
Li-ion	Lithium ion
lm-hr	Lumen-hour
M&A	Mergers and acquisitions
MENA	Middle East and North Africa
MFI	Microfinance institution
MIV	Microfinance investment vehicle
MTF	Multi-Tier Framework
NGO	Non-governmental organization
OEM	Original equipment manufacturer
OGS	Off grid solar
PAYGO	Pay-As-You-Go
$PM_{2.5}$	Particulate matter, 2.5 micrometers
PnP	Plug and play
PPP	Purchase power parity
PV	Photovoltaics
QV	Quality verified
R&D	Research and development
RCT	Randomized control trial
ROGEP	Regional Off-Grid Electrification Project
RISE	Regulatory Indicators for Sustainable Energy
SA	South Asia
SACCO	Savings and credit cooperative
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
SHS	Solar home system
SIV	Specialized investment vehicle
SME	Small and medium enterprises
SPV	Special purpose vehicle
SSA	Sub-Saharan Africa
TELCO	Telecommunications company
TV	Television
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States dollar
VAT	Value added tax
VC	Venture capitalist
Wp	Watt (Peak)

CONTEXT AND KEY DEFINITIONS

In 2010, the World Bank Group published the first Lighting Africa report which quantified the significant business potential of delivering lighting to over 600 million people in Africa through portable solar lights. Seven years later, that market has borne out the initial excitement and has evolved and expanded substantially.

The market is more complex and fluid than in 2010, when it was marked by low levels of awareness, a single, lighting-oriented product, and a limited geographical presence primarily in Sub-Saharan Africa. Since then, the sector's growth has been impressive:

- Sales of over 130 million devices since 2010, penetrating approximately 17% of the global potential market, and generating 3.9 billion in cumulative revenue.[1]
- Emergence of multiple product categories sold via cash and Pay-As-You-Go (PAYGO) business models, and expanding beyond lighting to increasingly include off-grid appliances.
- Significant market entry and private sector engagement from an increasingly diverse, global pool of manufacturers and distributors.
- Increasing interest and commitments from investors, including more than USD 500 million raised in the past two years.
- Growing acknowledgement from governments and development institutions who are committing significant resources to the sector.

Given this complexity and dynamism, the informational needs for the sector are also considerably different today than they were seven years ago, or even two years ago, when the last report was written. There is a need to go beyond a monolithic framing of the market, and delve into trends and dynamics of different segments and geographies. To do so in a clear and structured manner, it will be important to define and contextualize important terms related to the market that will be used heavily over the course of the report (Table 1). To aid in navigation throughout the report, several product-related terms are also matched with icons, as shown below.

[1]Note: Cumulative sales refers to all devices sold to date, including those that have lapsed their warranties or have been discarded. Estimate includes affiliate and non-affiliate pico and PnP SHS, as well as component-based systems via institutional/government distribution and open-market sales. See definitions in Table 7 of full report. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

Table 1: Key definitions

Term	Definition
Access to electricity	Traditionally, access to electricity has been measured on the basis of household connections to the national electric grid of their respective country. A recent shift, driven by SEforALL's Multi-Tier Framework (MTF) for electricity access, seeks to understand electricity access not in binary on or off terms, but as a continuum of service levels that may be satisfied by a range of technologies.[2] Using global baseline surveys that are currently underway, the MTF captures more robust granularity of electricity access including capacity, duration of supply, reliability, quality, affordability, legality and safety.[3]
Off-grid population	Households (or people) that lack access to an electricity connection to the national grid. These households lack Tier 1 access to electricity according to the MTF, barring the minority that have access to alternative sources of electricity such as off-grid or mini-grid technologies.
Unreliable-grid population	Households (or people) that have a poor-quality or inconsistent connection to the national electric grid. For the purpose of this report, "unreliable-grid" households are assumed to receive electricity for less than 12 hours a day. It should be noted that there is no universally accepted definition of unreliable-grid areas. Nor is there reliable data on the size of the population that lives in these areas globally. The estimates underlying this study are detailed in Section 1A.1 of the full report (see Figure 19).
Potential market	The overall market of households (or people) that either lack access to an electricity connection (off-grid) or have a poor-quality electricity connection (unreliable-grid), forming the total potential customer base for OGS devices. This estimate includes customers that currently use OGS devices, as they continue to be a market for additional sales, replacements, and upgrades.
Addressable market	The share of the potential market that can be addressed by current OGS business models. This study analyses the affordability of the devices by the potential market to arrive at an estimate for the addressable market, and provides directional estimates of the market's reachability. The methodology for these estimates is in Section 1A.1 of the full report (see Table 6).

[2]Source: (World Bank ESMAP/SEforALL, 2015b)

[3]Note: While most major methodologies tracking electricity access have focused on grid electrification to date (including those by IEA in 2016 and prior), many are shifting to include all forms of electricity access, including OGS. For example, the IEA Energy Access Outlook Special Report released in October 2017 provides data that also incorporates renewable off- or mini-grid connections with sufficient capacity to provide a minimum bundle of energy services, including several lights, phone charging and a radio. For full definition, see World Energy Outlook Methodology for Energy Access Analysis (International Energy Agency, 2017b)

Off-grid solar devices (OGS)	Pico solar devices, plug-and-play solar home systems (PnP SHS), and component-based systems.[4]
Affiliate	Companies that are Lighting Global Program Associates, companies with products that meet Lighting Global Quality Standards, or companies that are GOGLA members. These companies report sales data to GOGLA on a quarterly basis. As a result, much more is known about this universe of players/products. The report will aim to broadly use affiliate data as a proxy for trends and developments in the wider sector. The report will also articulate and comment wherever trends diverge by affiliate versus non-affiliates.
Non-affiliate	Companies that are not affiliated to Lighting Global or GOGLA in any way, and whose products are either branded or generic (comprising no-names, copycats and counterfeits).[5] These companies do not report their sales to GOGLA.
 Pico	Lanterns and simple multi-light systems (which may enable mobile charging) of 0-10.999 Wp. These enable partial or full Tier 1 electricity access to a person or household.
 Plug-and-play SHS	All-in-one packaged SHS kits of 11+ Wp, typically powering several lights as well as energy-efficient appliances, and enabling full Tier 1 or higher electricity access for a household.
 Component-based systems	Devices in which components (i.e. PV module, battery, lights, inverter, wiring, etc.) are compiled independently. These devices are typically SHS (11+ Wp), but can be smaller.
 Pay-as-you-go (PAYGO)	PAYGO refers to a business model that allows users to pay for their product visa embedded consumer financing. A PAYGO company will typically offer a solar product (predominantly solar home systems and multi-light pico devices) for which a customer makes a down payment, followed by regular payments for a term ranging from six months to eight years. Payments are usually made via mobile money, though there are alternative methods that include scratch cards, mobile airtime and cash. PAYGO is typically used on large pico devices (multi-light plus mobile charger <10.999Wp, per the Lighting Global/GOGLA product categories[6]) as well as PnP SHS (>11Wp). This report also refers to PAYGO SHS as shorthand for multi-light systems enabled with PAYGO technology; most of these are PnP SHS, but some may be multi-light pico.

[4]Note: See Table 7 of full report for definitions of off-grid solar device categories
[5]Note: Generic terminology adopted from Bloomberg New Energy Finance, 2016
[6]Source: (GOGLA, 2017)

Off-grid appliances	As defined by Global LEAP, off-grid appliances are electricity-consuming products that plug into and can operate on an off-grid energy system. They are typically highly energy efficient and use DC power to be compatible with and make the most effective use of OGS device wattage.

The Lighting Global/GOGLA Off-Grid Solar Market Trends Report has been established over the past 8 years as the report of record for the off-grid solar industry. It is the biennial anchor of the Lighting Global/GOGLA franchise of market data and trends reports, which is the go-to source of sector information for investors, industry members, policymakers, and other stakeholders in the sector. The biennial flagship publication provides an opportunity to step back for reflection on trends in the sector to deepen understanding among market players and illuminate the pathway forward for the sector.

This iteration of the Market Trends Report reviews the OGS industry's evolution in the preceding years around six topic areas: market fundamentals, sales, the competitive landscape, finance, the enabling environment, and impact. It then provides projections on likely trends in the market for the coming five years, and provides a blueprint for how actors in this market can be competitive. Given this wide-ranging scope and multiple audiences, it is important to note that this report is not exhaustive in its coverage of each topic area. Numerous targeted publications are available on specific topical areas and to meet the information requirements of specific stakeholder groups. For example, the enabling environment section of this report comprises a summary of largely external research sources rather than fresh analysis and evidence; these sources can be referenced as deeper dive resources. Relevant publications are detailed in the references at the end of the report, and further resources are available on the GOGLA, Lighting Global, and ESMAP websites.

EXECUTIVE SUMMARY

High-growth, high-impact market to-date

In 2017, the global off-grid solar (OGS) sector is providing improved electricity access to an estimated 73 million households, or over 360 million people, thus transforming lives that were previously reliant on kerosene and solid fuels for most of their lighting needs.[7] This market has evolved and expanded substantially since 2010, when IFC released its first off-grid lighting report.[8] At that stage this was a market marked by low awareness, a single category of lighting-oriented products, and a limited geographical presence (mainly in Sub-Saharan Africa and India).

The sector's growth since 2010 has been impressive. It has seen:

- Substantial cumulative sales (over 130 million devices since 2010), growth (~60% CAGR), and significantly increased penetration (~17%) of the global potential market of off- and unreliable-grid households. The total sales value generated by the OGS sector has exceeded USD 3.9 billion.[9]
- Emergence of three product categories (pico, plug-and-play SHS, and component-based systems), catering to lighting and beyond (e.g. communication, cooling, entertainment, refrigeration), and two distinct business models (cash-based versus Pay-As-You-Go).
- Significant market entry and private sector engagement from an increasingly diverse, global pool of manufacturers and distributors. These include "affiliates," who are engaged with Lighting Global and/or GOGLA, and "non-affiliates," who belong to a broader universe. Less is known about these non-affiliates, who comprise an estimated 71% of pico sales today.[10]
- Increasing interest and commitments from investors, including commercial debt and equity players, since 2014. More than USD 500 million has been raised in the past two years alone.
- Growing acknowledgement from development institutions who are committing significant resources to the sector. For example, more than 25 countries are now engaged in partnerships with the World Bank Group (mostly in SSA) to build capacity and deploy funding to the sector.

The estimated *impact* of this growth has been far-reaching:[11]

[7]Note: Current improved access estimate incorporates sales of all actively in-use OGS devices, including both affiliate and non-affiliate products (see Table 4 in full report for definitions). This analysis relies on the methodology developed by GOGLA for affiliate products (with known performance) and extrapolates it to the broader industry. Given the unknown performance of non-affiliates, however, this number should be treated as a range. Penetration figures are discounted to assume 10% sales to repeat customers and 3% loss of devices sold, and assume a 3-4 year product lifetime. See GOGLA Impact Metrics for calculation methodology (GOGLA, 2016a). Source: (Dalberg, 2010)

[8]Source: (Dalberg, 2010)

[9]Note: Cumulative sales refers to all devices sold to date, including those that have lapsed their warranties or have been discarded. Estimate includes affiliate and non-affiliate pico and PnP SHS, as well as component-based systems via institutional/government distribution and open-market sales. See definitions in Table 7 of full report. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

[10]Note: See Section 1B.2 of the full report for details regarding this estimate

[11]Note: GOGLA metrics utilize company output data (sales, product cost etc.). They project or estimate impact, they do not showcase impact being created on-the-ground. It should be noted that these numbers include the estimated impact for affiliates, non-affiliates and component-based systems. These analyses rely on the methodology developed by GOGLA for affiliate products (with known performance) and extrapolate it to the broader industry. Given the unknown performance of non-affiliates, however, these numbers should be treated as purely directional

- Approximately USD 5.2 billion in economic savings[12] to households as they switch from kerosene and/or other conventional fuels to affiliate OGS devices. When considering the entire universe of OGS devices, which includes non-affiliate products and component-based systems, total savings could be more than double.[13]
- 28.6 million tons of greenhouse gas emissions have been avoided through the reduced use of traditional lighting sources due to the uptake of affiliate devices.[14] When considering the entire universe of OGS devices, emissions avoided are likely to be substantially higher.
- Across geographies, an estimated 1.9 million people have used OGS devices to support income-generating activities.[15]
- Improved health reported by 45% of OGS users who previously used kerosene, especially regarding respiratory and eye issues, and reductions in burns and accidents.[16]

In parallel to OGS sector growth, grid expansion is finally outpacing population growth in many countries. The grid serves nearly 140 million more households today than in 2010, although the progress has been uneven. South Asia leads the way (11 percentage-point increase in coverage since 2010, reaching over 80% coverage in 2017), while Sub-Saharan Africa lags significantly (7 percentage-point increase, leading to less than 40% coverage in 2017).[17]

Despite these strong advances in energy access, the size of the potential market, in terms of people to be served, has remained largely unchanged. This is by virtue of a complex set of dynamics that will maintain a substantial potential market for at least a decade. These include:

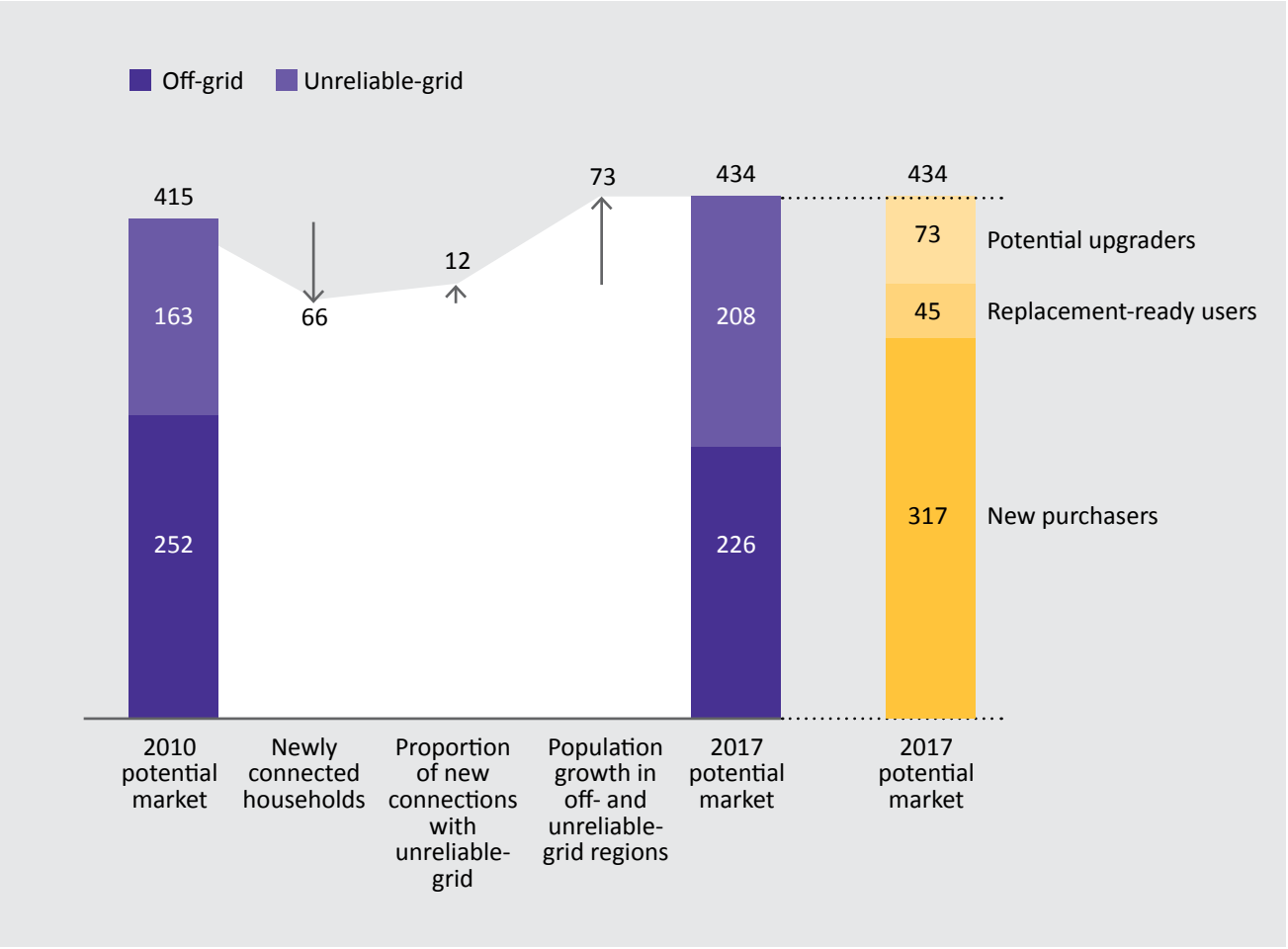
- A large portion of off-grid populations that were connected to the grid since 2010 are receiving inadequate power. They have effectively transitioned from off- to unreliable-grid, and continue to represent a potent market for OGS devices.
- High population growth in some of the most poorly electrified regions (especially Sub-Saharan Africa) keeps the market size large in absolute numbers.
- Customers that the OGS market has already served require replacement devices every 2-4 years, and therefore remain part of the potential market. Energy products also display the characteristics of an "experience good," i.e. as customers gain access to electricity for the first time, they desire more (and in some cases, are willing to pay more for each unit of electricity) and therefore may be targeted for upgrades to systems that offer higher levels of service.

These trends are summarized in Figure 1.

[12] *Source: (GOGLA, 2017)*
[13] *Note: Refer to Footnote 11*
[14] *Source: (GOGLA, 2017)*
[15] *Note: This reflects only the universe of affiliate products. Given the opacity around the value chains of non-affiliates, this number has not been calculated for the entire OGS universe. Source: (GOGLA, 2017)*
[16] *Source: (Acumen, 2017a)*
[17] *Source: (International Energy Agency, 2016); (International Energy Agency, 2017a); Dalberg analysis*

Figure 1: Change in potential market[18]

Million households (2010-17 est.)

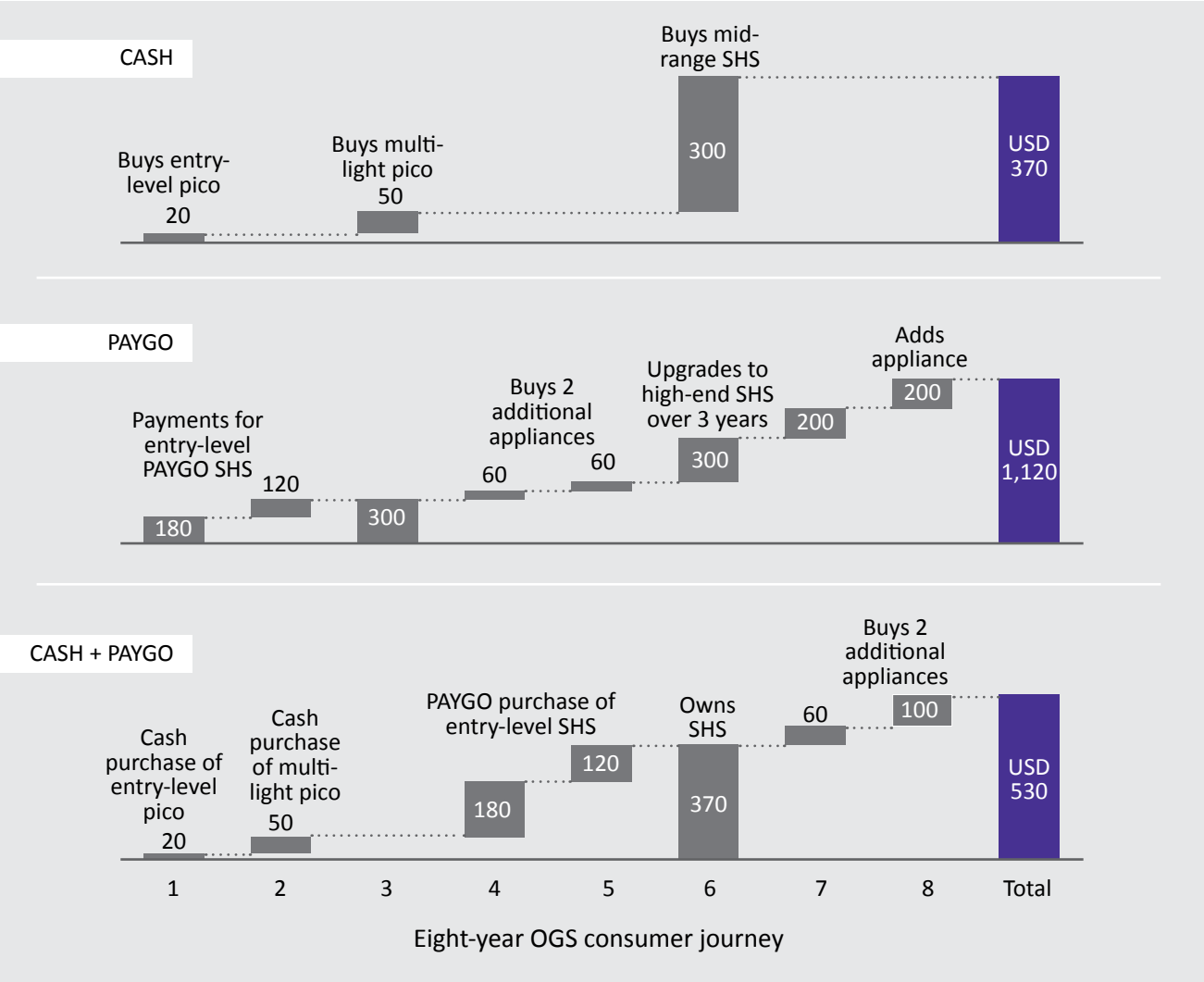


This figure illustrates that despite significant electrification gains since 2010, the potential market remains vast, at 434 million households. It accounts for some of the competing drivers in this dynamic market, which include the following: (1) grid improvements provided new electricity connections to 66 million households since 2010, (2) at least 12 million of those 66 million households received unreliable-grid access and so continue to represent a potential market, (3) population growth in off-grid and unreliable-grid regions added an estimated 73 million new households to the potential market. Together, these global trends resulted in an addition of nearly 20 million households to the total potential market, which grew from 415 million in 2010 to 434 million in 2017. Based on this report's estimates of the total market (see Section 1B of full report) about 73 million of these are current OGS users who have made purchases within the last three years and could be targeted for upgrades and up-selling. Another 45 million households purchased devices more than three years ago (2010-2014), and may be ready for a replacement device. Finally, there remain about 317 million untapped households who represent potential new users.

Importantly, potential revenues for the sector have risen as companies come to recognize customers' lifetime value, rather than just as one-off transaction points. This has entailed a shift among players toward viewing

[18]Note: Estimates may not add up to totals due to rounding. Sales are discounted to assume 10% sales to repeat customers and 3% loss of devices sold (GOGLA, 2016a). For unreliable-grid estimation methodology, see Footnote 82 in full report. For total sales estimation methodology, see Section 1B in full report. Source: (International Energy Agency, 2016); (International Energy Agency, 2017); (United Nations, 2014); Lighting Global/GOGLA sales data; Dalberg market model and analysis

Figure 2: Lifetime value potential of off-grid solar consumer *(Illustrative)*
USD; 8-year horizon



energy as having a long consumption ladder with initial product sales being the start of a long-term relationship. The main drivers behind this shift have been:

- Innovations in financing that are allowing higher overall spend on energy (e.g. PAYGO is relaxing the norm that customers will only spend up to 2-3 months of saved disposable income on a given product).
- Access to a wider product set including household appliances and services, allowing the sector to provide services for a wider array of consumer needs.
- Rising real incomes (7% annual increase in South Asia and 3% increase in Sub-Saharan Africa since 2009), although the distribution of this rise is uneven across geographies and income groups.

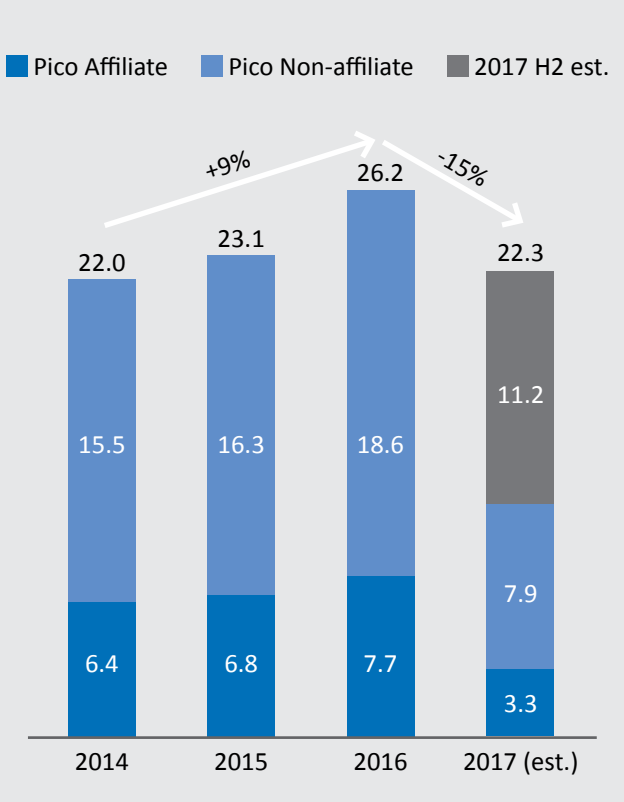
As shown in Figure 2, an average customer who in 2010 was estimated to spend USD 30-80 on an OGS product, is now estimated to have a lifetime value of USD 370-1,120, depending on the mode of purchase (i.e. cash versus PAYGO or both). Sophisticated, branded players have created an internal energy product ladder that not only caters to customers' differing willingness to pay, but also induces customers to migrate from basic to more feature-rich products over time. As explored in detail in the full report that follows, this bodes well for the outlook of the industry overall, and pushes companies to either evolve or perish by managing newer sets of competitive dynamics.

Slowing pico sales. Potential to return to solid growth.

Long the engine of growth, the pico segment's estimated overall market growth in terms of units sold has recently slowed. While slowing growth rates are natural for a sector that, as of 2016, had a base of over 90 million cumulative devices sold (including close to 30 million affiliate devices), the sharp decline was still surprising. In particular, there has been a recent slowdown in the pico sales of many Lighting Global and GOGLA affiliates (with 2017 H1 sales 20% lower than 2016 H1 sales).[19]

Figure 3: Estimated annual pico sales[20]

Million units (2014-17 est.)



Why the slowdown in the pico segment? Localized shocks in several key markets, as well as structural trends in the OGS market globally are responsible:

Localized shocks in several key markets.
Disruptions in key national markets have impacted this sector adversely. Demonetization in India (the sudden removal of INR 500 and 1,000 bills from circulation) caused a rural cash crunch in the world's largest pico market. A major drought in Kenya and Tanzania constrained consumer incomes in the region. And Nigeria's economic crisis devalued the naira, which inhibited customers purchasing power and led to lower access to foreign exchange for OGS suppliers. These four countries represented over two-thirds of global affiliate pico sales in 2016, and each experienced pico sales drops of 35-60% between 2016 H1 and 2017 H1. These localized shocks affected sales of many fast-moving consumer goods (FMCGs), although many sectors have revived since.

In some cases, localized shocks were specific to OGS devices. For example, in Ethiopia, mandated local testing of every product (including systems passing Lighting Global quality verification standards) in an environment with low testing capacity led to already quality-verified products being held up in customs, while multiple non-affiliate products bypassed authorities and went directly to customers. This led to an immediate, rapid decline in affiliate sales in 2016, though this has since been resolved.

Structural trends across the OGS market globally.

- *Exhaustion of the low-hanging fruit in major markets.* Due to the difficulty of large scale distribution to remote markets, most companies have focused on relatively easier commercial options. These include targeting customers that are closer to cities, have higher spending power, and are often already connected to some level of electricity. While by no means saturated, the industry cannot maintain previous growth rates if it continues to focus on easy-to-reach markets. Innovations and investment will be required in order to expand to untapped last-mile areas.

[19] *Source: Lighting Global/GOGLA sales data; Dalberg analysis*

[20] *Note: See Table 8 and Footnote 149 of full report for details on non-affiliate estimation. 2017 H2 estimate assumes H2 sales are equivalent to H1 sales and comprises both affiliate sales and non-affiliate estimates. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis*

- *Uneven real income growth.* Past forecasts relied partly on strong real income growth, however, while average incomes have risen, many of the gains have not gone to those that typically consume OGS products (for example, in India, the share of the country's wealth held by the top 1% grew from 40% in 2010 to 58% in 2016).[21]
- *Cannibalization* at the upper end of the pico market by plug-and-play (PnP) SHS products. PnP SHS products (especially lower-wattage devices) now have product economics that resemble those of pico products due to the emergence of PAYGO financing models. Yet these products deliver a much higher value proposition—a boon for consumers. At the same time as sales in pico have slowed and recently dipped, affiliate PAYGO sales grew at a CAGR of ~140% in the last three years.
- *Increasingly commoditized pico market,* where differentiation among players is substantially based on price. In the early days, companies affiliated with Lighting Global and GOGLA represented cutting edge design and quality. Yet as the industry matures, that product advantage has diminished. This has led to increasing market share for non-affiliate sales (estimated at 71% globally, based on a weighted average of 16 countries for which estimates were developed[22]), who typically have greater flexibility on pricing and margins. Due to increased competition in some countries, a few markets have started to see exits, whereas previously the industry only saw the entrance of new players.

Globally, it is clear a sizeable potential market continues to exist. To capture it, pico players must adopt a more aggressive stance on geographic expansion and further financial innovation to support consumer ability to pay. This report's projections (see Section 2 of the full report) estimate business-as-usual annual sales growth in the pico sector of 15-20% over the next five years, reaching approximately USD 1-1.5 billion in annual revenue. However, a higher growth rate is expected if the following hurdles are addressed:

- **Innovative financing mechanisms**, such as the application of PAYGO with PnP SHS, are effectively deployed further in the pico segment (early experiments have shown some success, but examples of scaled players are rare). The cost of consumer financing—estimated to amount to 20-40% of the final price—will need to fall. This price drop is to be expected if PAYGO platforms and players achieve economies of scale in operating countries and once investors gain confidence in assessing and investing in PAYGO models (e.g. through local currency funding, growth of receivables-based financing, etc.).
- **Expansion into nascent markets** continues, buffered by patient capital that offsets the risk of entry. For example, PEG Africa leveraged a grant from GSMA Mobile for Development Utilities in 2014 to build its business in West Africa, an emergent market, and subsequently raised more than USD 21 million for growth. The vast scope for expansion can be seen in that penetration of OGS products has reached 10% in just eight countries to date; by contrast, over 40 countries continue to have at least one million off-grid households.
- **Gap-funding for last-mile households** is made available without distorting the market. While few market watchers would advocate a return to the indiscriminate giveaways that plagued the industry in its infancy,[23] most recognize that a substantial portion of potential pico customers are both highly remote and significantly cash constrained. Support mechanisms such as vouchers, targeted tax incentives, or rebates can help unlock a large part of this market, such as EnDev's results-based financing program in Tanzania, which provides private-sector suppliers a cash incentive based on the performance (mainly lumen-hours) of each high-quality product they sell in rural areas.

[21] *Source: (Jha, 2017)*

[22] *Note: See Section 1B.2 and Table 8 of the full report for non-affiliate estimation methodology details*

[23] *Note: These can distort commercial market product pricing and contaminate the market for businesses that sell a product that consumers believe should be free*

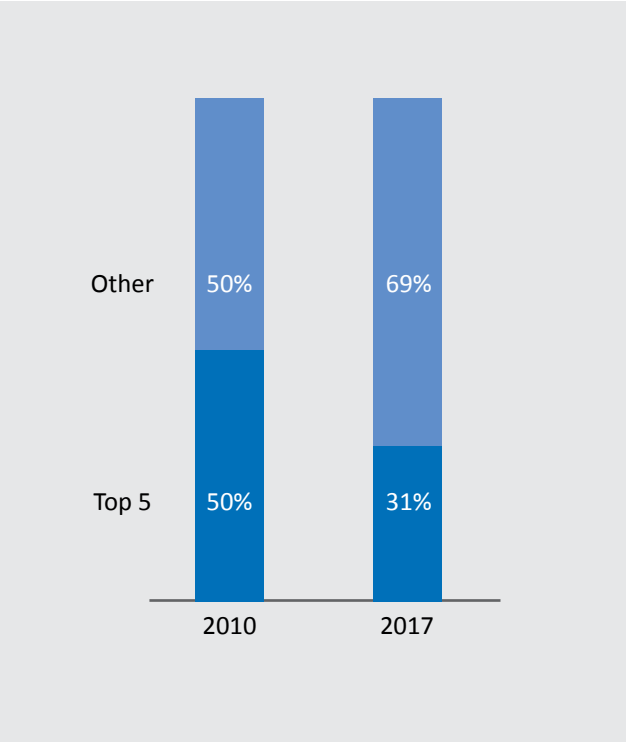
- **Policymakers continue to recognize and buy into the energy access and impact potential** of pico products (and OGS as a whole) and provide a favorable business and trade enabling environment. In particular, as noted by GOGLA in a guidance note to governments, "temporary or permanent removal of VAT and tariffs – covering the entire product, including any appliances – is one of the most effective ways for governments to support the growth of the standalone solar market, improving affordability, boosting uptake and accelerating energy access." To illustrate the potential impact: a study in Kenya found that reducing the price of a solar lamp from USD 7 to USD 4 increased household uptake from 37% to 69%.[24]

But even with significant growth, profitability has eluded most players in the market. At the same time there has been significant market entry to date: the known universe today comprises more than 300 players, where there were only 60 in 2010. Companies must rise to meet the demands of increased competition and commoditization through specialization or by delivering an integrated energy ladder offering. Currently, many operators are stuck in between those two positions, with leading first-mover firms relying on their local monopoly positions, which will prove to be fragile in the long run.

Even with high levels of entry and low net profitability, there is no expectation of consolidation. The significant under-penetration of the sector and the wide geographic spread of the customer base have kept the market open. Across the pico and PnP SHS industries, the top-5 players today command only ~30% of annual sales, down from 50% in 2010. Several leading players, such as Greenlight Planet and d.light, have put investor and management focus into fast-growing PAYGO SHS portfolios, further adding to this report's expectation that the market (as-a-whole) will remain competitive in the near future.

Figure 4: Market concentration of pico affiliates and non-affiliates[25]

% of total annual unit sales (2016)



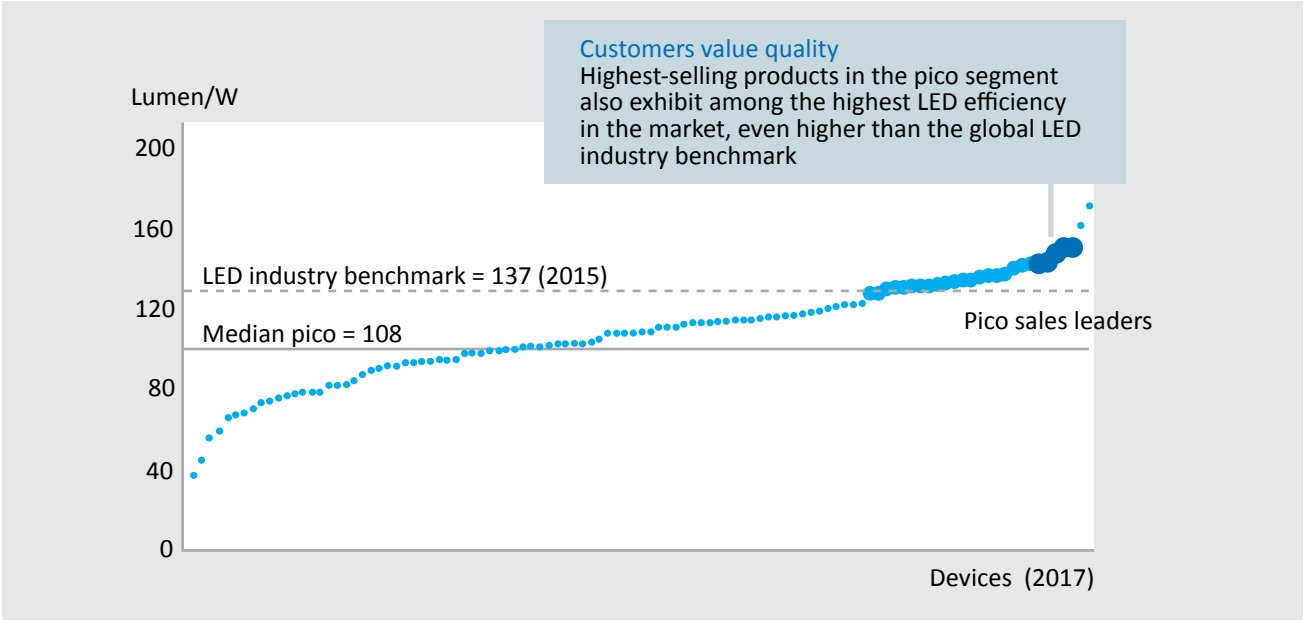
Customer sensitization to quality has also risen. As a result, the market will continue to see returns for strong investments in quality, both in terms of revenue and margin. The industry's top sellers continue to put out objectively higher-quality products (see Figure 5).


Photo credit: Greenlight Planet

[24]*Source: (GOGLA, 2017); (Rom, Gunther, & Harrison, 2017)*

[25]*Note: Individual market shares have not been shown to protect confidentiality. Number of suppliers in 2016 collated using the GOGLA and Lighting Global websites, Alibaba and desk research. Source: Industry interviews; Dalberg research and analysis*

Figure 5: Lighting efficacy industry performance[26]
Lumen/Watt; n=107; select affiliates and non-affiliates (2017)



It is important for the industry to have pico sales return to a strong trajectory. Not only is it the fastest and often most cost-effective means to deliver partial or full Tier 1 electricity to the most under-served (see Table 1 for discussion of energy access tiers), it also acts as the main engine for the OGS market by bringing customers onto the energy ladder and in time moving them onto higher feature (and potentially higher margin) products. Some options for pico companies to gain competitive advantage in an increasingly crowded field are covered in Section 3 of the full report.

A rapidly-growing plug-and-play SHS market, driven by PAYGO. Some risks ahead.

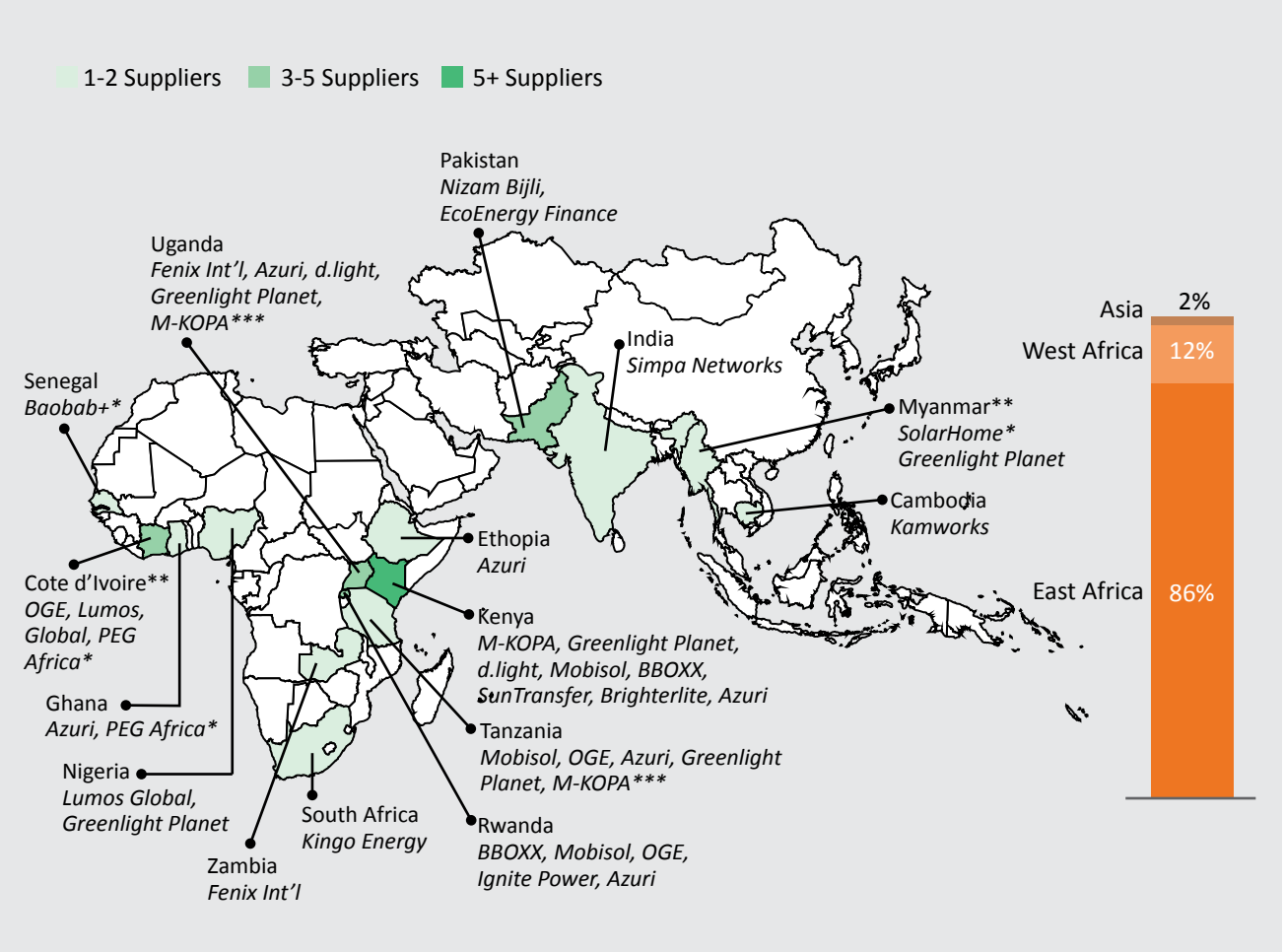
Plug-and-play SHS sales have grown rapidly from a small base since 2013-14. The segment accounts for less than 5% of total annual OGS distribution, yet makes up 20-30% of annual revenues. The standout OGS growth story of the last three years has been PAYGO-based PnP systems (most of which are SHS, but some are pico), with an average annual growth rate of ~140% (2013-2016). While still small in overall numbers, the PnP SHS segment's revenues are expected to overtake total pico revenues in the next three to five years. This is due to strong growth, a much higher average unit price compared to pico prices, as well as the opportunity to up-sell.

Thus far, growth has been limited to countries with strong mobile money ecosystems, with particular crowding-in in East Africa. This signals both high growth potential in the future, but also the challenges of operating successfully in different regulatory environments (see Figure 6). Several countries in West and Central Africa (especially Nigeria and the Democratic Republic of the Congo) are already showing healthy mobile money growth.[27] India, the largest OGS market in the world, currently has very low PAYGO penetration corresponding largely to its minimal mobile money market and relatively low uptake of PnP SHS to date. It is, however, poised for significant growth in mobile and digital transactions over the next five years. Mobile money has proved the most streamlined mechanism of payment for PAYGO operators, but as PAYGO technology and business models mature and diversify, digital money may be less of a constraint.

[26]Note: Industry benchmark based on stated average efficacy of commercial A-type LED bulbs as per U.S. Dept. of Energy. Source: Lighting Global data; U.S. DoE; Dalberg research and analysis
[27]Source: (Patterson, 2016)

Figure 6: Presence of PAYGO players by country, and geographic share of the PAYGO market[28]

Left: number of players; Right: % cumulative unit sales; n=11 players (2013-17)



A flood of investments in the PAYGO segment have enabled aggressive customer acquisition. The PAYGO segment has been the main magnet of investments into the OGS sector. **From 2012 to 2017 PAYGO businesses raised USD 773 million, equal to ~85% of all funds raised. These investments are highly concentrated, with just four companies accounting for 67% of total PAYGO investments.** This suggests that investors have aggressive expectations on how fast PAYGO companies can grow.

[28]Note: Figure does not consider pilots, only companies with an established sales presence in a country. The data are not exhaustive, but are representative. Key: (*) Distributor (**) New entrants (2015-2017) with low overall in-country sales; (***) M-KOPA has presence but bulk of their sales come from Kenya. Source: Dalberg research and analysis

This initial investor optimism (which latest numbers show dampening somewhat) was built, in part, on the recognition that PAYGO is not just an energy product, but a broader debt offering. **For many customers, it constitutes their first meaningful banking relationship.** In this respect, it has helped drive financial inclusion (CGAP estimates that 30-50% of PAYGO customers outside of Kenya opened mobile money accounts to pay for electricity).[29] This opens a world of opportunity for energy companies, including:

- **A wider product offering thanks to integrated debt financing.** The majority of these have been efficient household appliances that integrate with a core solar home system product. Among household applications, fans, radios and televisions dominate.
- **Acquiring an explosion of data.** Billing, credit scoring and asset monitoring require amassing a significant amount of product usage data. Aggregated, this can be a powerful management tool (PAYGO players spoke of the ability to tell if a wedding was coming up in a village based on electricity usage patterns alone). It also allows tailored on-sell/up-sell opportunities. Monetizing this data is key to the industry's valuation.
- **A lifelong customer.** The nature of the PAYGO product is such that it lends itself to local monopolies and customer stickiness.[30] Data collection over time means that an incumbent player understands a current customer (and importantly, the customer's credit worthiness) better than a new entrant. Technology barriers, though on the decline, have also limited entrants.

While the segment is growing strongly, there are several challenges that existing players will need to address:

- **Four businesses in one.** Most PAYGO businesses make or assemble their own product, distribute their own product, create the technology platform for running PAYGO operations and run an effective lending bank. It is hard to be a leading performer across all four of these.
- **Deteriorating asset quality.** In search of new customers, many PAYGO companies have expanded into customer segments that have increased their bad-debt ratios significantly (i.e. higher number of customers default on payments). Across the top-10 PAYGO players, rates vary widely, suggesting that portfolio quality will be a key competitive advantage going forward.
- **Increasing competition, including from entry of pico companies and specialists.** Companies such as Greenlight Planet and d.light have entered PAYGO markets and have shown strong growth. They come from strong product heritage giving them an edge in the fundamental product design while also leveraging a wide set of existing distribution relationships, given the scale of their pico business. Specialized technology providers such as Renewit (hardware) and Angaza (PAYGO platform) are also allowing new entrants to leapfrog technology development requirements. While increasing competition is not inherently negative for the sector, existing players will need to respond effectively to justify investor enthusiasm.
- **Limited economic engine.** Perhaps the biggest challenge for PAYGO companies to achieving exponential growth is that they are currently competing for a very limited share of wallet. While debt financing solves the challenge of saving for otherwise large upfront costs, it does not translate into more money in consumers' pockets. Beyond affording lighting, the ability to pay for other devices rapidly diminishes. As such, most PAYGO companies have been serving the apex of pyramids in each community. This lack of intensification within the geographies in which they operate is raising service costs and limiting any scale economies.

[29] *Source: (Winiecki, 2015)*

[30] *Note: Emerging research from UNCDF's Energy Ladder research in Uganda suggests that consumers purchasing PAYGO products are most likely to purchase future products and modular upgrades from the same company, while consumers buying products on a cash basis purchased from their original supplier and new suppliers in equal measure. Source: (UNCDF, 2017); industry interviews*

- **Data and privacy issues.** There exists a potential risk around the all-important data assets that PAYGO companies are building. The level of data collected can reduce a customer's bargaining power and lead to predatory behavior. If data can predict that a wedding is coming up in a village, as noted above, bombarding people with advertisements for a wedding loan (to make the wedding grander) could be the next step. Some investors would see that as a measure of progress, and potentially replacing loan sharks, while others would consider it irresponsible.

There are several ways in which PAYGO players can respond to these emerging challenges. Chief among them are:

- **Find the core and outsource or spin off the rest.** PAYGO companies, as they stand today, are too complex. This is because the culture and capabilities for successfully running a lending business versus a consumer electronic product business are fundamentally different. Reducing vertical integration is part of the maturation of the industry.
- **Link sales incentives to long-term customer value.** Many companies have a mismatch between what the sales team wants to achieve in sales growth versus what the finance team wants to achieve through a healthy balance-sheet. Persuading sales agents to maximize long term value from customers can help align incentives.
- **More aggressively explore productive use applications.** For PAYGO to thrive, incomes need to rise. While many will argue that using energy devices such as lights, fans, fridges, and TVs enhance productivity, there is limited evidence to suggest that they have significant impact on household income beyond delivering savings relative to alternatives. Therefore, exploring specialized income generating opportunities (such as through efficient sewing machines, PAYGO water pumps, etc.) is in the interests of both sector players (some like Mobisol have already ventured in) and customers.
- **Utilize off-balance sheet financing.** The long term financial health of PAYGO companies will require an influx of financial specialists that can effectively manage both the credit risk of the portfolio of consumer receivables and a company's treasury function, including external fundraising to meet working capital needs. The expected increased use of off-balance-sheet financing can leverage cash flows from the portfolio of receivables in order to enable debt fundraising, thus resulting in a more rapid turnover of capital.
- **Establish customer protection mechanisms and principles:** As the segment expands, consumers will require protection in two important respects: First, from misleading marketing and low-quality PnP SHS devices, especially given that their exposure (in terms of money spent and share of income) is much higher than in the pico segment.[31] Second, PAYGO companies need to get ahead of the data and privacy issue by either individually, or preferably as an industry, signing up to transparency and outlining guidelines for the handling of customer data. The World Bank's focus group study with retailers and distributor networks showed universal concern over private consumer data being shared externally by the providers, while recognizing the potential for benefits to consumers from prudent and confidential uses of their data.[32]

PAYGO is poised to continue being a significant growth driver of the PnP SHS segment in particular, and the overall OGS sector. This report's business-as-usual projection sees the PnP SHS segment (overwhelmingly driven by PAYGO companies as far as low-income consumers are concerned) set to achieve growth of 80-90% over the next five years. This would enable it to reach over 20 million in annual sales units and USD 6-7 billion in annual revenues in 2022.

[31] *Source: (Diecker, Wheeldon, & Scott, 2016)*
[32] *Source: (Alstone, Gershenson, Turman-Bryant, Kammen, & Jacobsen, 2015)*

Component-based systems: No longer an industry focus in most regions, and quality remains highly variable.

For over two decades, large institutional programs such as Bangladesh's Infrastructure Development Company Limited (IDCOL) and India's National Solar Mission have distributed approximately seven million "institutional component-based"[33] SHS for free or at variously subsidized rates. In parallel, consumers in these and other markets are independently assembling "open-market component-based" systems using PV modules, batteries and other components. Given the decentralized and often informal nature of component sales, conclusive data on these open-market component-based systems remains unavailable.

New estimates suggest that the open-market segment may represent as much as 9% of all OGS system sales globally to date.[34] Little is known about the changing share of open-market component-based systems over time. It is clear, however, that market share varies significantly by country, from as much as 60% of all OGS devices in Myanmar, where such systems are the norm, to less than 5% in most of East Africa (where plug-and-play devices dominate) and other markets where institutional distribution programs have not primed the market.

Outside of Bangladesh and India - which have had continuous institutional distribution programs for more than a decade - the spread of component-based systems has largely been driven by direct consumer demand. Open-market component-based systems present several advantages, namely that they are often less expensive on a per watt basis than PnP SHS. They can also be tailor-made to a household's changing needs, and they can be serviced locally, consequently supporting jobs for local technicians. However, open-market component-based systems do not enjoy the protections often provided by major institutional program distribution like Bangladesh's IDCOL and India's National Solar Mission, which vet suppliers and provide financing or subsidies. As such, they tend to have high failure rates as well as quality and safety issues related to using components with mismatched power or lacking a control box.

The question for those approaching off-grid solar in all its forms from an impact lens is whether opportunities exist to increase quality, safety, and financing within the open-market segment while maintaining the above advantages.

While little data is available about the outlook for component-based systems, Kenya provides a useful case study: component-based systems comprised an estimated 70-80% of all OGS in the country in 2010. Yet today, following intensive investment to build the market for quality-verified and easy-to-use pre-packaged pico and PnP SHS, open-market component-based systems are believed to represent just 1-4% of annual OGS sales.[35] Kenya's shift, from a component-centric market to one in which pre-packaged devices are nearly ubiquitous, suggests that component-based systems will have an uphill challenge in an increasingly sophisticated product market that values quality.

[33]Note: See Table 7 of full report for segment definitions

[34]Note: Figure is calculated on a base of all affiliate and non-affiliate pico and PnP SHS, as well as institutional and open-market component-based systems. It is calculated as a weighted average of 16 markets for which directional estimates exist. Estimates are included in this report as a constant over time due to limited information on annual sales in the past five years, however findings from the MTR IVR and field surveys suggest that sales remain significant. Source: (Hansen, Pedersen, & Nygaard, Review of Solar PV Market Development in East Africa, 2014); (Hansen, Pedersen, & Nygaard, Review of solar PV policies, interventions and diffusion in East Africa, 2015); (Ipsos, 2016a); (Ipsos, 2017); (Lighting Global/Dalberg, 2017) (Galpaya, 2016); (Government of Myanmar, 2014); (Government of India, 2011); (Jain, 2017); (IRENA, 2016b); industry interviews; Dalberg analysis

[35]Source: (Hansen, Pedersen, & Nygaard, Review of Solar PV Market Development in East Africa, 2014); (Hansen, Pedersen, & Nygaard, Review of solar PV policies, interventions and diffusion in East Africa, 2015); (KEREA, 2014); (Ipsos, 2016a); Dalberg analysis

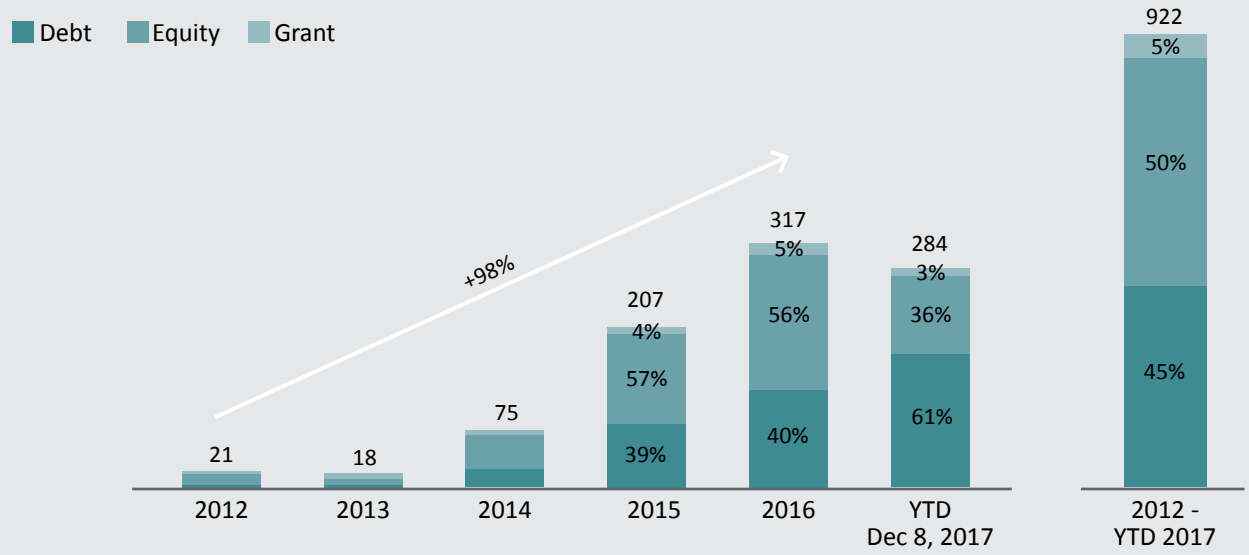
Investment into the OGS sector has grown significantly, but expectations are not being met on the impact and commercial fronts.

The UN Sustainable Development Goal 7 has helped refocus investor attention toward electrification. Sustainable Energy for All reported that during 2014, at least USD 20.1 billion dollars were invested to improve electricity access and that national governments, drawing on their own budgets, accounted for roughly half of those investments. Support for electrification projects notwithstanding, finance for decentralized energy (which included the financing discussed in this report) received only 1% of total financial commitments.

Despite the fact that investment into decentralized energy is small compared to total investment into electrification, OGS investments have experienced strong growth, doubling annually from 2012 to 2016. In 2017, annual investments touched USD 284 million with USD 922 million raised since 2012.

Figure 7: Annual investment in the OGS sector over time, by financing instrument[36]

Millions; USD equiv. (2012-17)



	2012	2013	2014	2015	2016	YTD Dec 8, 2017
Avg. size of top 5 transactions	2.8	2.4	9.8	21.3	31.7	25.4
Avg. size of overall transactions	1.4	1.0	3.1	5.6	4.0	5.0
Number of transactions	15	18	24	37	79	57

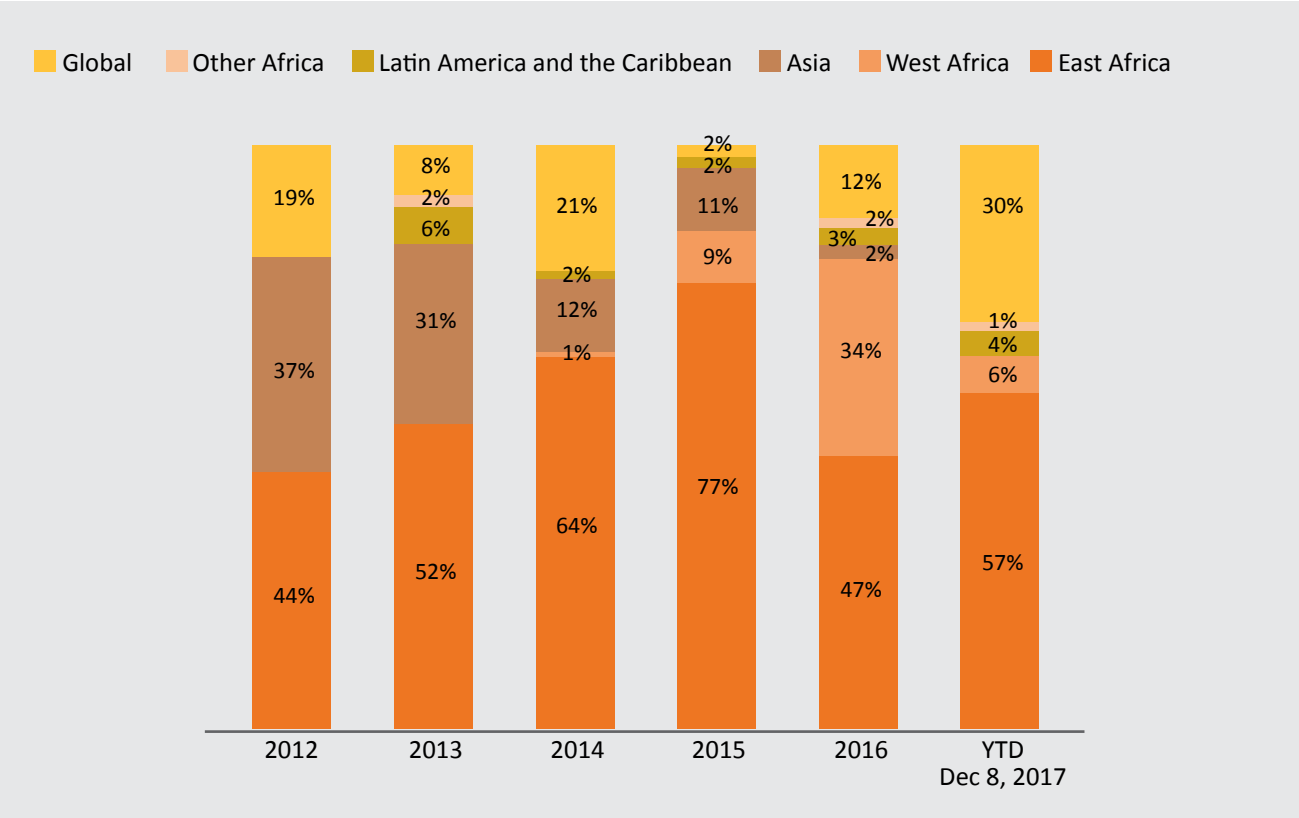
[36]Note: Figures may not add to 100% due to rounding. As details of these two transactions were not publicly disclosed, YTD 2017 figures include Dalberg's best estimates (which in total fall in the range of USD 30 – 45 million) on the value of the Engie acquisition and the follow-on investment by Investec into Mobisol. Details on all other financial transactions in the database are from publicly disclosed sources or confirmed in interviews. Source: GOGLA 2018 Deals Database

Deal sizes have grown considerably in the past five years, reflecting the shift toward using PAYGO SHS business models. The largest transactions are now in the range of USD 50–80 million and are generally funded by a group of co-investors or a syndicate of lenders. Nevertheless, large individual investments of up to USD 40 million are still made by large lenders and commercial equity investors. Investment that was primarily focused in East Africa is now diffusing outwards, as competition enters the market and incumbents seek virgin markets. Several large investments are also helping fund the transition of traditionally pico players into the PAYGO PnP SHS space.

Total investment in 2017 is likely to be slightly less than in 2016. While not a positive trend, this dip in funding should be understood in the context of a very lumpy funding environment, where a few transactions could materially change year-over-year investment trends. Ultimately, 2017 marked a year of reflection for the industry, as several interviewees mentioned that slowing industry sales may have led to some firms missing their projected sales targets. This in turn has resulted in some investors taking a pause to reassess corporate valuation and investment strategies. Investors to-date were riding a wave of optimism. This pause is not a sign of investor souring on the industry, as nearly all investors interviewed were positive on the long-term trajectory of the market. However, concerns of a possible short-term overvaluation in some companies may have dampened equity investments.

Figure 8: Geographic split of funding[37]

% of total funds raised (2012-17)



[37]Note: Figures may not add to 100% due to rounding. The geography assigned to each specific investment was based on the primary geography where the investment would be channeled. For example, an investment to expand a company's operation into West Africa would be classified as West African. In circumstances where specific project details were unavailable, the geographical focus of the investee's operations was assigned to the investors. In instances where a company's operations spanned multiple geographies, a global geography was applied. 2017 figures included two transactions related to the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study was not able to verify the sizes of these transactions prior to publication, and has thus included estimates, which in total fall in the range of USD 30 – 45 million. 2017 YTD total also includes investment in Asia representing less than 1% of the global total and thus does not appear on the graph. Source: GOGLA 2018 Deals Database

Development finance institutions (DFIs) and impact investors who have historically seen the OGS market as something of a silver bullet—able to serve the BoP while being financially sustainable—are reassessing their positions. In the words of one DFI, "the honeymoon is over." The impact investment community is increasingly aware that for these companies to be financially sustainable, they cannot strictly serve the lowest-income populations. Majority of efforts today are focused on the higher-income segments within villages and peri-urban segments. There has also been a shift among impact investors who had previously offered very concessionary terms on their financing toward demanding commercial terms.

With overall OGS sales slowing and some companies missing projections, investors have broadly favored debt over equity investments, as some investors looked to cover against (in their opinion) overstated company valuations. This may give the market a chance to cool down. However, the view that OGS firms are overvalued is not shared by all investors. Some are more bullish on the potential of the OGS industry driven by a large potential market and an ability to leverage PAYGO technology in new and profitable ways. A shift to debt also better reflects current industry needs which center on funding working capital requirements.

Table 2: Sources and uses of capital - Forecasted total financing needs by top OGS affiliate companies
USD millions (2017-22)

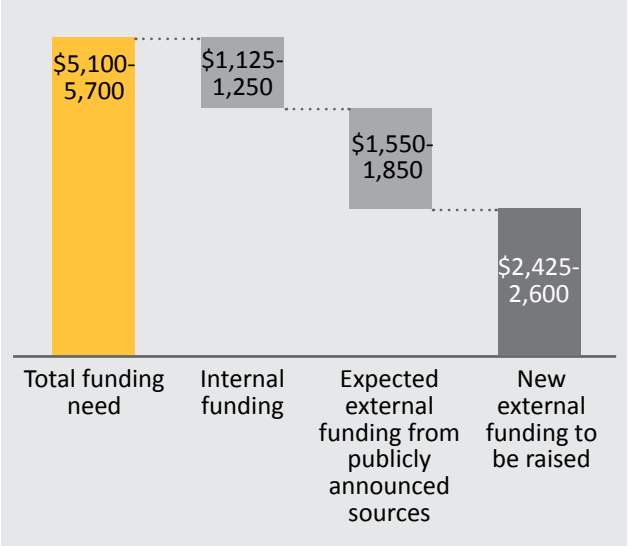
Uses of capital		Sources of capital	
Funding receivables	3,350 – 3,725	Operating cash	900 – 1,000
Funding inventories	1,275 – 1,425	Change in payables	225 – 250
Capex	475 – 550	External (Debt)	2,600 – 2,850
		External (Equity)	1,175 – 1,325
		External (Grants)	200 – 275
Total	**5,100 – 5,700**	**Total**	**5,100 – 5,700**

For OGS to hit its potential, this report estimates that about USD 5.1 – 5.7 billion of investment will be needed by the sector from 2017-22 (as outlined in Table 2). It is important to note that this range does not comprise an aggressive or pessimistic scenario, but reflects the uncertainty of individual variables within the underlying forecast model (as detailed in Section 1D of the full report).

While most of the need for investment has evolved toward debt for working capital, targeted equity and grant capital is still required to spur innovation and finance business development. This will help the sector reach hard-to-serve consumers and open new markets.

With an estimated USD 2.7 - 3.1 billion of funding already in place, a further USD 2.4 – 2.6 billion must be raised from the market over the next five years, largely for PAYGO working capital needs.

Figure 9: New external funding to be raised
Projected funding sources; Millions USD (2017-22)



How will these funds be raised? Current patterns provide some clues. Leveraging the value of consumer receivables on a company balance sheet to support commercial loans is an important fundraising tool. Some companies have chosen to borrow from local banks (supported by DFIs & impact investors), using the consumer receivables to form the foundation for a borrowing base. Other companies have used off-balance-sheet structures where the receivables are sold to a special purposes vehicle ('SPV'). Cash flows from the repayment of those consumer receivables, which are diverted into the SPV, service the commercial loan repayment. In either case, leveraging these consumer receivables allows companies to raise working capital before net profitability is achieved. Companies also benefit as these types of lending transactions can help to limit foreign exchange risk.

What's next for the OGS sector?

Overall, the OGS sector is expected to provide improved current energy access to 740 million people in 2022, compared to 360 million today.[38] Annual revenues will grow to around USD 8 billion. This report projects a CAGR of 25% in terms of units sold with revenues expected to rise faster. While meteoric growth rates are expected to be a thing of the past, especially for the pico segment, the downward swing of 2016-17 is likely to be temporary.

Table 3: Estimated sales and revenues across OGS segments[39]

% annual growth; units; USD (2010-2022)

	2016			2022 Est.		
	Sales units CAGR (2010-2016)	Annual unit sales	Annual revenue (USD)	Sales units CAGR (2017-2022)	Annual unit sales	Annual revenue (USD)
Pico	~99%	26 Mn	$600-650 Mn	~16%	47 Mn	$1-1.5 Bn
PnP SHS	~125%[40]	<1 Mn	$150-200 Mn	~87%	24 Mn	$6-7 Bn
Open-market component[41]	n/a	2-2.5 Mn	$200-250 Mn	n/a	2-2.5 Mn	$200-250 Mn
TOTAL	**~100%**	**~30 Mn**	**~$1 Bn**	**~25%**	**~72 Mn**	**~$8 Bn**

While sector level growth potential is attractive, individual countries are at very diverse starting positions. Figure 10 identifies the current status of several key markets based on their market penetration and sales growth over the past several years. This data provides directional insight into the future robustness of each market, and four possible strategies to follow based on their starting points:

1. *Harvest:* Markets where sales continue to rise despite relatively high penetration, suggesting that suppliers can continue to harvest revenues.
2. *Upgrade:* Highly penetrated maturing markets, where suppliers may consider upgrading existing customers to higher quality technologies and service levels, and should seek innovative distribution

[38]Note: Based on Dalberg calculations using the "improved energy access, current" metric of the GOGLA impact metrics. Source: (GOGLA, 2016a)

[39]Note: Revenue estimates include all product categories except institutional distribution of component-based systems, as these are typically not fully market-based. Estimates for non-affiliates are based on affiliate product category mix, and assume 30% lower prices among non-affiliates. Affiliate revenues based on GOGLA data (cash only) and on price estimates based on supplier interviews and the Lighting Global and Sendea/Mangoo databases; Estimates uses cash prices to estimate all sales due to limited reliable data on PAYGO revenues. See Section 1B of full report for further details and sources. 2022 projections assume prices and product mix at 2017 levels. Source: Lighting Global/GOGLA sales data; (Lighting Global); (GOGLA, 2016b); (Sendea, n.d.); Dalberg market model and analysis

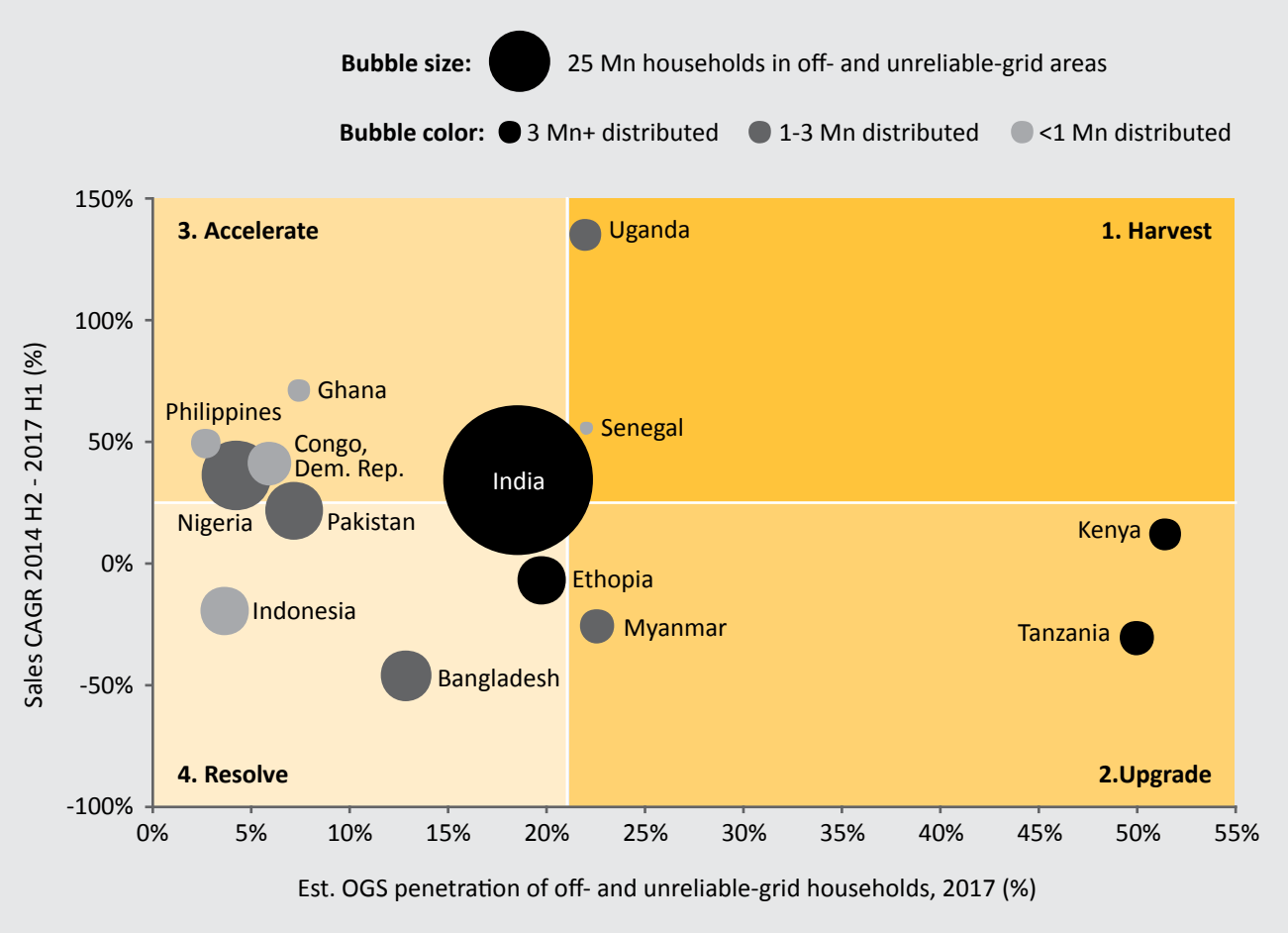
[40]Note: PnP SHS growth is provided for 2014-2016 only, due to lack of sales data prior to 2014

[41]Note: Due to limited data and research scope, this report has not provided an estimate of the rate of change for open-market component-based sales, and the figures here are based on the assumption that open-market component-based sales will remain constant in absolute numbers to 2022. Revenue calculations are based on price assumption of USD 90-100 per open-market component-based device. Source: (Lighting Global/Dalberg, 2017)

partnerships to penetrate the harder-to-reach customers.

3. *Accelerate:* Up-and-coming markets which show promising growth and where suppliers can continue to scale operations to take advantage of large unpenetrated populations.
4. *Resolve:* Under-penetrated markets which have seen sales fall, and which would need concentrated supplier investment to resolve context-specific issues.

Figure 10: Estimated sales and penetration of OGS devices in select markets[42]
% (2014 H2 - 2017 H1)

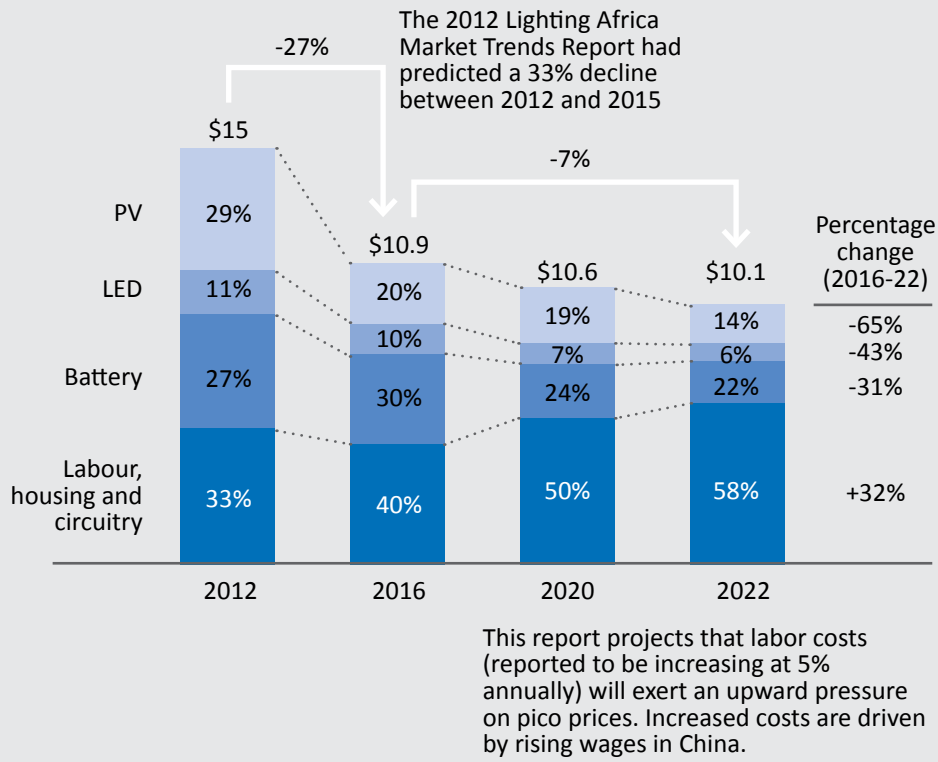


Looking ahead, this report projects a strong overall OGS market based on the following expectations:

- *The market fundamentals will remain buoyant*, with a stable and underpenetrated potential market (including a growing market for replacements and upgrades for current OGS consumers), ongoing real income growth, improvements in distribution infrastructure and ease-of-doing business within countries, an increasingly enabling policy environment, and a maturing private sector that continues to be hungry to expand. Ongoing technological improvements, efficiency gains and price drops for OGS components and appliances (albeit slower than in the past) will continue to fundamentally expand the value proposition for customers.

[42]*Note: Estimate includes both affiliate sales and non-affiliate sales estimates of pico and PnP SHS, as well as institutional component-based (India, Myanmar and Bangladesh) and open-market component-based devices. Sales are discounted to assume 10% sales to repeat customers and 3% loss of devices sold, and assume a 3-4 year product lifetime (GOGLA, 2016a). Source: Lighting Global/GOGLA sales data; industry interviews; Dalberg market model and analysis*

Figure 11: Decomposition and forecast of the median pico component cost[43]
USD (2012-20)



- *Expansion of PAYGO, including cheaper systems as well as wider appliance availability, will continue to drive growth.* Improvements in appliance performance and affordability, especially fans and TVs, will boost SHS sales, and vice versa. Industry experts have noted that these two technologies are farthest ahead in their development cycles for efficient off-grid use. Three PAYGO companies have already launched self-branded televisions in 2016-17, with one player, M-KOPA, having sold up to 70,000 units by July 2017.[44] Based on inputs from interviews and desk research it is conservatively estimated that up to 60% of SHS sold in the market over 2017-2022 could have bundled DC fans, and about half would likely include DC-powered TVs. This means the OGS sector will command a higher share of customers' wallets.
- *Virgin and under-penetrated markets will offer incremental growth opportunities*, including those with large off-grid populations like the Democratic Republic of Congo. As depicted in Figure 10, few countries have achieved penetration in excess of 20% of their potential markets, implying large scope for expansion into harder-to-reach areas, including in maturing markets. Moreover, there are at least 40 countries that together account for around 200 million off- and unreliable-grid households that remain largely unaddressed by OGS.
- *Growth or expansion of second-generation companies is expected*, particularly non-vertically integrated players in the PAYGO space. The growth of these companies (and new ones, including local players) will be essential to support the projected growth of the OGS sector. It is likely that that these second-generation companies will continue to be increasingly focused on relatively untapped markets, enabling them to capture first-mover advantage. They can also leverage the innovations developed by the first-

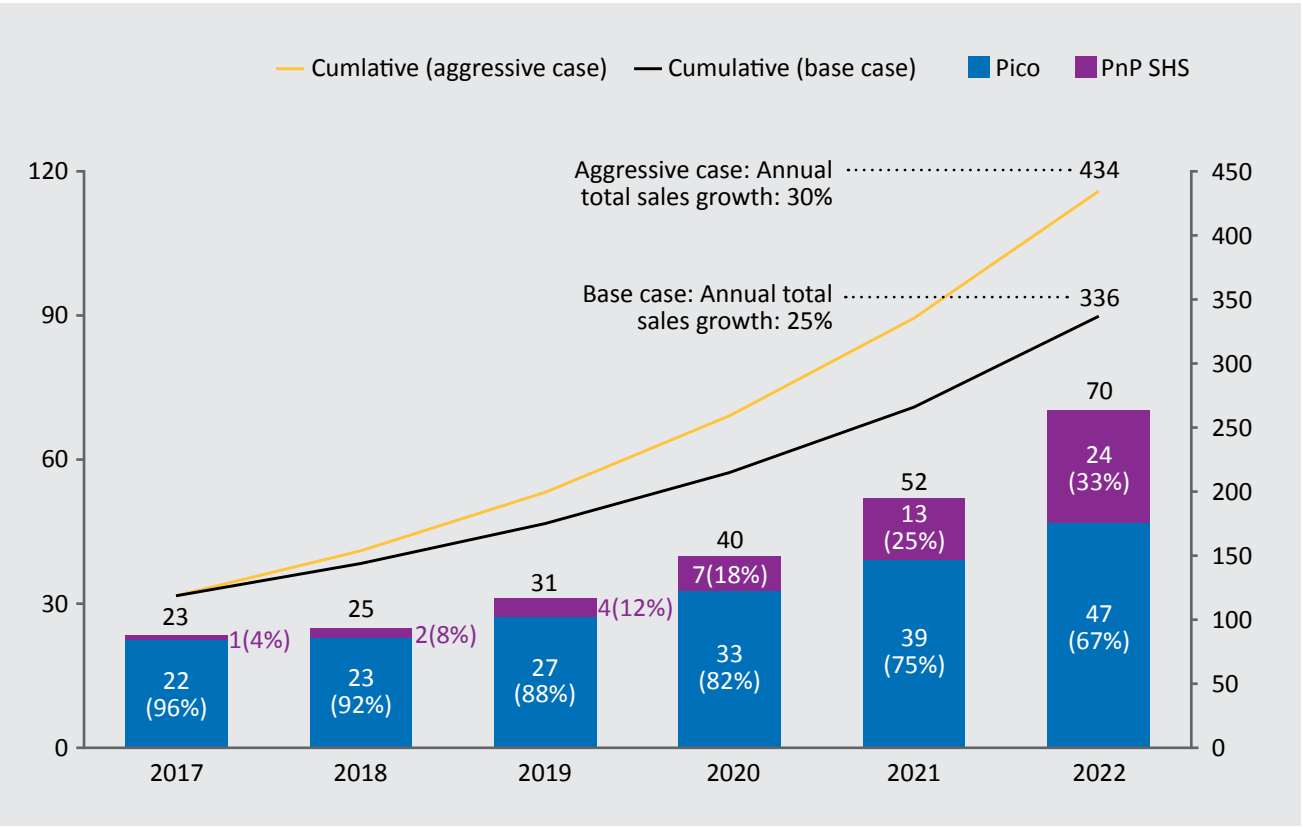
[43]*Note: Holding performance constant for a PV of 3W, light output of 75 lumens and battery size of 14 Wh. Source: Dalberg research and analysis*
[44]*Source: (M-KOPA, 2017a)*

generation of companies in order to focus their efforts on operational excellence, building out their internal finance capacity and external fundraising methods, and understanding the nuances of their local target markets.

- *Well-targeted gap funding from development and public-sector partners is available.* There is a rising focus on achievement of universal sustainable electrification, as enshrined in the SDGs and the SEforALL agenda. This has led to significant DFI, government, and foundation funding that could help plug the gap between investor hurdle rates and where the market is today.[45] The impetus to achieve this target counters the decline in initial investor exuberance, however any such investments must be carefully designed to avoid undermining the commercial market.
- *Consumer awareness of the category is largely established.* By now, even in many virgin markets there is basic awareness of OGS devices. This report expects consumer loyalty toward individual brands to become the next battleground although price will remain the overwhelming driver for pico products.
- *Policymakers will continue to recognize and buy into the energy access and impact potential of OGS as a whole, and work toward providing a favorable business and trade enabling environment.* High-level government endorsement and incorporation of off-grid technologies into national electrification plans, are an important signal to other players regarding the stability of the off-grid sector. It is also important to coordinate with the private sector on regulation, particularly when dealing with issues such as OGS quality standards, taxation, and e-waste.

Figure 12: OGS market forecast for pico and PnP SHS[46]

Million units; left axis: annual sales; right axis: cumulative sales (2017-22)



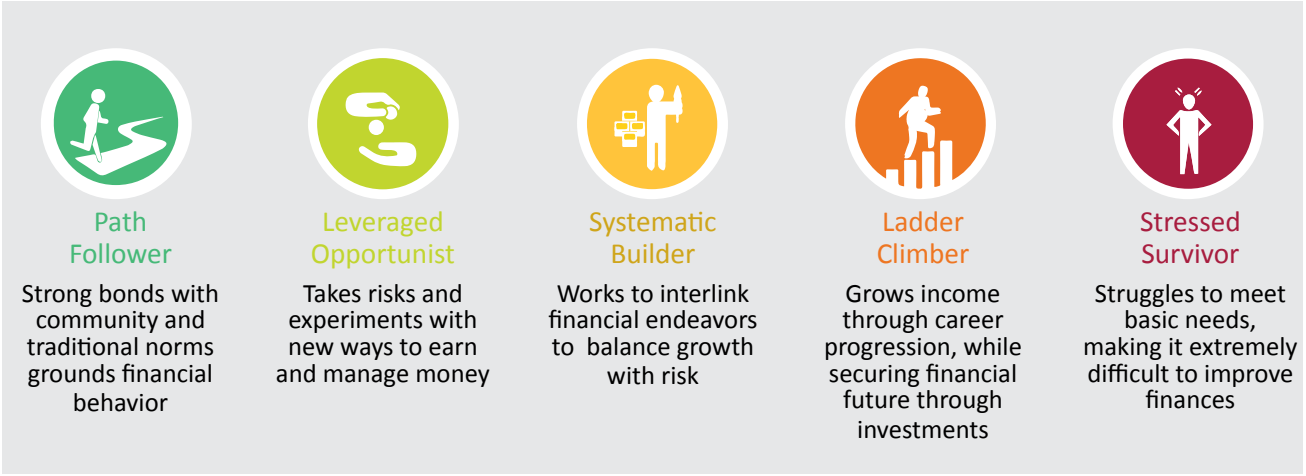
[45]*Note: Key examples include EnDev's results based financing program in Tanzania, which incentivizes distribution in rural areas, and the World Bank's ROGEP partnership with 15 ECOWAS member states, which aims to foster the enabling environment in West Africa*

[46]*Source: Dalberg market model and analysis (see Table 12 of full report for methodology and sources)*

Several cross-cutting initiatives/scenarios can help supercharge the OGS sector. This report's business-as-usual scenario, as described above, would still leave approximately 300 million households without improved access to electricity.[47] There are several high potential opportunities to drive the mandate for stronger growth. Most impactful among these are:

- *Defining the next level of customer segmentation.* A common refrain among OGS companies interviewed for this report is the difficulty of penetrating beyond an initial core set of users in a village, even though macro indicators of income would suggest an ability to pay. The experience of other electronic goods and FMCG companies suggests that segmentation needs to move beyond economic indicators and dig deeper into customer behavior. Greater investment in human centered design-based segmentation can help all players better target product design, communications and offerings to the various behavioral segments present in a village.

Figure 13: Example of behavior segmentation: Personas of digital finance users in India, Kenya



- *Major corporations enter the segment in a substantial way.* The OGS industry has attracted interest from large multinational corporations for some time. However, this has not materialized into sustained market entry or long-term presence. Players such as Schneider, Panasonic and Phillips that explored OGS in the past 5-8 years have limited their scope and are marginal players to the sector. Recently, two other international conglomerates, Total and Engie, formalized their interest by acquiring stakes in OGS companies: Total acquired a stake in Off Grid Electric in 2016 and Engie completed its acquisition of Fenix International in 2017. Salesforce also took part in Angaza's Series B round in late 2017.

  These types of transactions are likely to build steam over the next few years as several large global utilities and/or oil and gas companies seek to build their renewable assets substantially in the face of falling oil prices and long-term decline of that industry. In addition, distribution partnerships have shown success, such as Total's Awango initiative which is among the largest sole distributors of OGS with a footprint in over 30 countries globally. The entry of additional corporate players could help existing OGS companies address key challenges by: (1) increasing access to capital (both debt and equity), (2) leveraging supply chains and economies of scale in procurement and distribution, (3) increasing access to technical skills and expertise, (4) promoting access to global and local networks including strong government contacts, and (5) helping develop a higher brand equity. At the same time, it should be noted that competition from companies with

[47]*Note: Current improved access estimate incorporates sales of all actively-in use OGS devices. See GOGLA Impact Metrics for calculation methodology (GOGLA, 2016a). Source: (International Energy Agency, 2016); (International Energy Agency, 2017a); Dalberg market model and analysis*

far superior access to finance via their parent corporations could crowd out prospective small and medium entrants.

- *Mobile money penetration increases in key OGS markets such as India, Nigeria, and Ethiopia.* The growth and scale up of digital finance and payments (including mobile money penetration) is expected across many developing markets. This would most notably include India and Nigeria, which also have the largest potential markets for OGS in the world with a total of nearly 200 million potential household customers in off-grid and unreliable-grid locations as of 2017.[48] This, in turn, is expected to translate into an increase in end-user affordability on the demand side, and to significantly ease and facilitate the growth of PAYGO business models at an accelerated pace for operators. Bolstering symbiotic relationships between PAYGO companies and mobile money operators could accelerate this trend. In fact, market watchers observed that first time mobile money usage is often driven by the need to make energy payments. PAYGO providers will therefore need to ensure careful communication and support to such customers to avoid some of the risks that new users of mobile money often face, such as fraud and low awareness of transaction fees.[49]
- *Growth of off-balance-sheet, structured asset financing.* One way to address the emerging funding gap described above is to deploy off-balance-sheet asset financing models. Investors and companies alike have pointed to the prospects of unlocking financing for PAYGO companies based on their underlying receivable assets. Until recently, off-balance-sheet structures were funded by DFIs and impact investors with a higher risk tolerance than typical commercial investors. However, as companies improve their credit risk assessment capabilities, commercial uptake could increase quickly. Segmenting customers into different risk pools and raising funding accordingly is one option that could become feasible once off-balance-sheet structures prove effective in fundraising. Better data on these transactions and standardization of performance metrics will help to bring in new investors. However, the OGS industry offers a complex environment for this kind of financing. As a result, several legal and administrative hurdles will need to be resolved before these off-balance-sheet financing models can deliver their potential.
- *Local-currency financing materializes and is deployed effectively.* The last two years have seen greater prevalence of local currency financing, which will only go up courtesy of a large set of bilateral and multilateral funding agreements for energy access (inclusive of OGS, mini-grid, and grid). These agreements, primarily between the World Bank and Sub-Saharan African countries, involve investments of close to USD 600 million of which over 60% will be available to the OGS sector. Much of this funding will target the local currency needs of OGS companies and could be catalytic due to the reduced currency risk and resultant increase in local bank involvement in the space. It could improve on-the-ground understanding as well as offer a nuanced view on risk management. At the same time, it will be important for local banks to build the requisite expertise to assess the risk in the OGS sector in order to effectively lend to it.
- *Emergence of specialized investment vehicles (SIVs).* In the early days of the microfinance industry, finding appropriate debt providers was a challenge. Over time, specialized investment funds called microfinance investment vehicles (MIVs) emerged. They developed specific expertise in the industry and provided wholesale debt to MFIs. The dynamics of PAYGO business models lend themselves to similar funding opportunities. In fact, there are likely to be direct opportunities for MIVs to also invest in PAYGO solar companies as they look for new growth opportunities. Currently, MIVs collectively manage over USD 10 billion of capital and could be a significant source of future funding, as has been noted by several impact funds interviewed for this report.[50]

[48] *Note: See Section 1A of full report for estimation methodology. Source: (International Energy Agency, 2016); (International Energy Agency, 2017a); Dalberg market model and analysis*

[49] *Source: (Kiiti, 2012)*

[50] *Source: (Sotiriou, CGAP, 2017)*

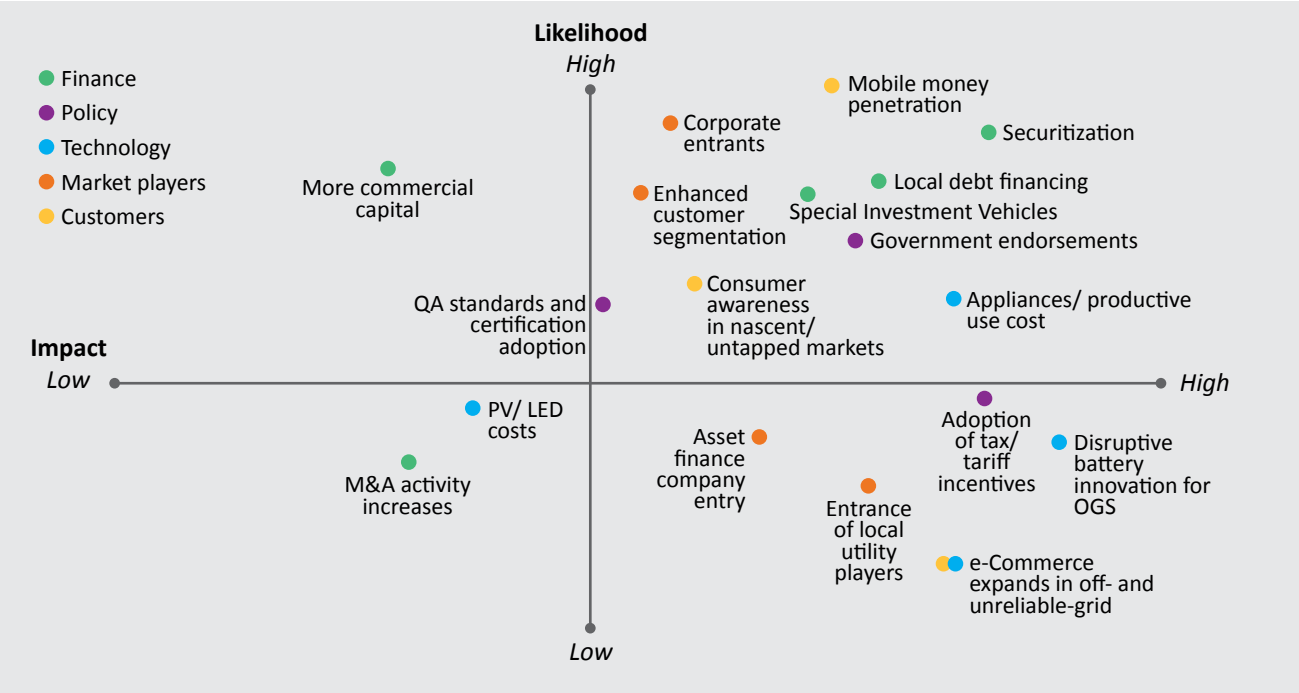
- *Increased integration of productive-use appliances with SHS.* It is clear that the industry needs to help put money back in the pockets of consumers if it wants to help move customers up the energy ladder. Several industry players have noted in interviews that they are likely to increase their R&D budget to develop and pilot productive use solutions such as agricultural implements and refrigerators. An increase in investment levels above existing plans could help catalyze the integration of productive-use appliances. Importantly, significant potential exists for convergence between larger capacity solar players (mini-grids, captive plants) that are already experimenting with productive use applications, and the capabilities of PAYGO OGS players with know-how of product level financing and remote asset management.
- *Increased government endorsements and regulatory support for OGS.* Policymakers are increasingly incorporating OGS into their energy access strategies to complement grid and mini-grid approaches. It is expected that this trend will intensify in the next three to five years, as more governments become convinced of the positive impact of OGS markets as seen on millions of households in energy-poor countries. In addition, as noted above, stronger government coordination with the private sector and the adoption of tax and tariff exemptions and incentives for OGS systems, components, and energy-efficient appliances could transform the industry as occurred in early winner markets in East Africa. These instruments are non-distortionary, increase end-user affordability (by directly reducing prices by up to 30% in certain countries), and level the playing field for enterprises. In addition, recent studies have shown that VAT and import tariff exemptions may deliver a boost to government finances in the long-run, while offering broader household and macroeconomic benefits. One model in Mozambique found that standalone solar market growth would increase business taxes by offering multiple benefits. It would enable businesses to stay open longer, increase time spent working (by improving health), and encourage job creation in the standalone solar supply chain.[51] However, governments will need to be careful to ensure that support provided does not distort commercial markets (e.g. through end-user subsidies).
- *Accelerated adoption of universal quality standards among countries.* Wide adoption of internationally agreed-upon quality assurance standards can provide a significant boost to country markets, ensuring that consumers experience with OGS is based on quality products and increasing the likelihood that they will be repeat purchasers. However, as evidenced in the experience of Ethiopia, implementation and enforcement are key to ensuring that quality standards have the desired effect. Without coordination with established international standards and testing schemes, customs regulations can do more harm than good by creating unnecessary costs, unproductive barriers to entry and enable poor quality goods provided by actors who simply avoid customs to flood the market.

These and other potential game-changers are mapped according to their potential industry impact and likelihood in Figure 14.

[51] *Source: (GOGLA, 2017)*

Figure 14: Relative ranking of game-changers for the OGS industry

Subjective ranking (5-year time horizon)



Winning in the OGS market: The profitable growth challenge

Few OGS companies are declaring profits today, and price competitiveness is only going to escalate. While the long-term prize, a market worth USD 8 billion by 2022, is large, there is a question mark over the ability of companies to serve it profitably in each market. For those players seeking to be the leaders in the sector and deliver outsized returns, the authors expect the following common traits:

- A reach across multiple countries, as opposed to a narrow geographic focus
- A broad product portfolio that lowers the per-unit customer acquisition cost
- Products sourced from low-cost manufacturing bases
- Access to low-cost capital that enables companies to move faster and further than competitors

However, no one model will dominate. Below, four distinct models that will have a competitive advantage in the long-run are characterized. While many hybrids emerge, the characterizations below serve as a guide and reflect elements already witnessed in leading companies today.

Model 1: The Energy Ladder Companion

This model provides a full suite of energy products, ranging from entry-level pico, to large SHS, to associated appliances. Such companies focus on a lifelong association with the customer, helping them transition up the energy ladder irrespective of their starting point. This enables them to both reduce their per-unit customer acquisition costs (which are substantial, and more than the cost of upgrading a customer), as well as spend more (in absolute terms) on marketing. Key ingredients to the success of this model include a strong entry product (which helps set the foundation for future interactions with the customer), consistency in branding (demonstrated by quality, after sales service and longevity of the product), a flexible business model by geography (different forms of payment and delivery), and effective customer relationship management.

Model 2: The Banker

This model is followed by PAYGO SHS players focused on deepening a loan product relationship with customers using OGS as an entry point. While the firm may use PAYGO to finance OGS compatible appliances, PAYGO services can extend to meet other consumer needs such as loans or to purchase other consumer goods as well. This ability to upsell is important, given the heavy costs of establishing the initial loan relationship. Key success factors for this model include the ability to mine customer data (which can reduce portfolio risks and support product and service sales), effective banking capabilities (such as credit scoring, portfolio management and loan collection), a technology advantage (resulting in differentiated design and efficiency of large appliances), and access to cheaper capital.

Model 3: The Fast Follower

This model is used by OEM or non-affiliate manufacturers that focus on replicating tried and tested models and markets. Such players take advantage of a low-cost manufacturing base and limited investment in design, marketing and proprietary distribution to focus on providing good, established design at highly competitive prices. For some players, this can also be a starting point to becoming a brand. This strategy is well-established in consumer electronics, and comes into its own as a high-volume, low-margin approach once initial trust in the product category is established. Key success factors include scale economies across multiple products (such as emergency lights, torches and broader electronics), flexible manufacturing to follow market trends, and the ability to leverage distributor relationships (both formal and informal).

Model 4: The Value Chain Specialist

This model pertains to companies that opt to achieve excellence on a specific part of the OGS value chain, and outsource or partner on the other parts. Examples of this are emerging on all parts of the value chain, be it technology, distribution, manufacturing or even financing. The increase in specialization has been driven by a maturing market that allows for it, in comparison to the early days of the market which necessitated vertical integration (to account for lack of suppliers in various parts of the value chain). Specialization allows parts of the sector to scale faster; companies such as Renewit (design and manufacturing), and Angaza (PAYGO platform technology) are testimony to this. At the same time, one potential exit for such players is to be bought out by a market leader (such as the acquisition of Lumeter by Mobisol). Success in this model is driven by scale economies (which help make specialists the de-facto market standard), and effective client servicing abilities.

The authors' view of a potential future: From OGS to a consumer electronics company

As avid followers, researchers, and advisors in the OGS space, the authors of this report have consistently felt that the sector has defined itself around a critical challenge, but in addressing that challenge, leading sector players have developed impressive and broadly applicable capabilities. The future of the sector lies in going beyond the initial clean, safe, and affordable lighting challenge.

Leading OGS players have the ability to transform themselves into broader consumer electronics companies that have a DNA for making products work in tough conditions and in frontier markets. This applies not only to the integrated B2C players, but also the specialists in the value chain (e.g. PAYGO technology specialists) who can serve additional product segments.

This study, by definition, focuses on the OGS sector, but the players within it don't need to. Energy provision itself promises to be lucrative, and all signs point toward significant growth in energy demand as the more than 430 million off- and un-reliable grid households globally experience the transformative shift to dependable energy access. But in the long-run, leading companies will leverage their brand and customer relationships to serve broader electronics needs. Investors, should take note as that is potentially an even bigger prize.

SECTION 1:

THE EVOLUTION OF THE MARKET

1A. MARKET FUNDAMENTALS

KEY MESSAGES

- POTENTIAL MARKET: The off-grid solar sector is buoyed by a vast and diverse potential market, made up of populations in off-grid and unreliable-grid areas, mostly in Sub-Saharan Africa and Asia.
- POTENTIAL MARKET SPENDING: Off-grid household expenditure on basic energy needs dwarfs OGS market-based sales, implying significant value on the table.
- ADDRESSABLE AND REACHABLE MARKET: Device price and cost of distribution reduces the size of the potential market among low-income and hard-to-reach populations.
- DRIVERS OF THE OGS MARKET: Main drivers include rising incomes, favorable product economics, increases in infrastructure and rural connectivity, and increased availability of consumer finance.

> "As a sector, there is a risk that the solar revolution will just serve 'appealing markets' in urban and peri-urban areas. Entire countries with significant off-grid populations are being ignored. We are missing an opportunity for social impact as well as profitable opportunities in those regions."
>
> **- Affiliate supplier**

The OGS sector has evolved to be a dynamic space with high potential for growth overall, as well as localized challenges. What's more, it has transformed the energy access conversation, taking it beyond grid electrification to cover a range of market driven initiatives. To channel its promise to support the provision of energy access to all, it is important to understand the key drivers of OGS market potential, and consider the share of the potential market that is currently addressable and reachable by the OGS industry.

Table 4: Definitions of key terms used in this section

Term	Definition
Off-grid solar devices (OGS)	Pico solar devices, plug and play solar home systems (PnP SHS), and component-based systems.[52]
Access to electricity	Traditionally, access to electricity has been measured on the basis of household connections to a country's national electric grid. A recent shift, driven by SEforALL's Multi-Tier Framework (MTF) for electricity access, seeks to understand electricity access not in binary terms, but as a continuum of service levels that may be satisfied by a range of technologies.[53] Using global baseline surveys that are currently underway, the MTF captures more robust granularity of electricity access including capacity, duration of supply, reliability, quality, affordability, legality, and safety.[54] While most major methodologies tracking electricity access have focused on grid electrification to date (including those by IEA in 2016 and prior), many are shifting to include all forms of electricity access, including OGS. For example, the IEA Energy Access Outlook Special Report released in October 2017 provides data that also incorporates renewable off- or mini-grid connections with sufficient capacity to provide a minimum bundle of energy services, including several lights, phone charging and a radio.
Off-grid population	Households (or people) that lack access to an electricity connection to the national grid. These households lack Tier 1 access to electricity according to the MTF, barring the minority that have access to alternative sources of electricity such as off-grid or mini-grid technologies.
Unreliable-grid population	Households (or people) that have a poor quality or inconsistent connection to the national electric grid, resulting from generation shortages or inadequate transmission and distribution infrastructure. For the purpose of this report, households with unreliable-grid are assumed to receive electricity for less than 12 hours a day. It should be noted that there is no universally accepted definition of unreliable-grid areas. Nor is there reliable data on the size of the population that lives in these areas globally. The estimates underlying this study are detailed later in this section (see Figure 19).

[52]Note: See Table 7 for full definitions of off-grid solar device categories

[53]Note: See also Figure 99. Source: (World Bank ESMAP/SEforALL, 2015b); (SEforAll, 2017b)

[54]Note: For IEA's full 2017 access definition, see World Energy Outlook Methodology for Energy Access Analysis. Source: (International Energy Agency, 2017b)

Potential market	The overall market of households (or people) that either lack access to an electricity connection (off-grid) or have a poor-quality electricity connection (unreliable-grid), forming the total potential customer base for OGS devices. This estimate includes customers that currently use OGS devices, as they continue to be a market for additional sales, replacements, and upgrades.
Addressable market	The share of the potential market that can be addressed by current OGS business models. This study analyses the affordability of the devices by the potential market to arrive at an estimate for the addressable market, and provides directional estimates of the market's reachability. The methodology for these estimates is detailed later in this section (see Table 6).

1A.1 MARKET POTENTIAL AND ITS KEY DRIVERS

Potential market size: There is buoyant and stable market potential.

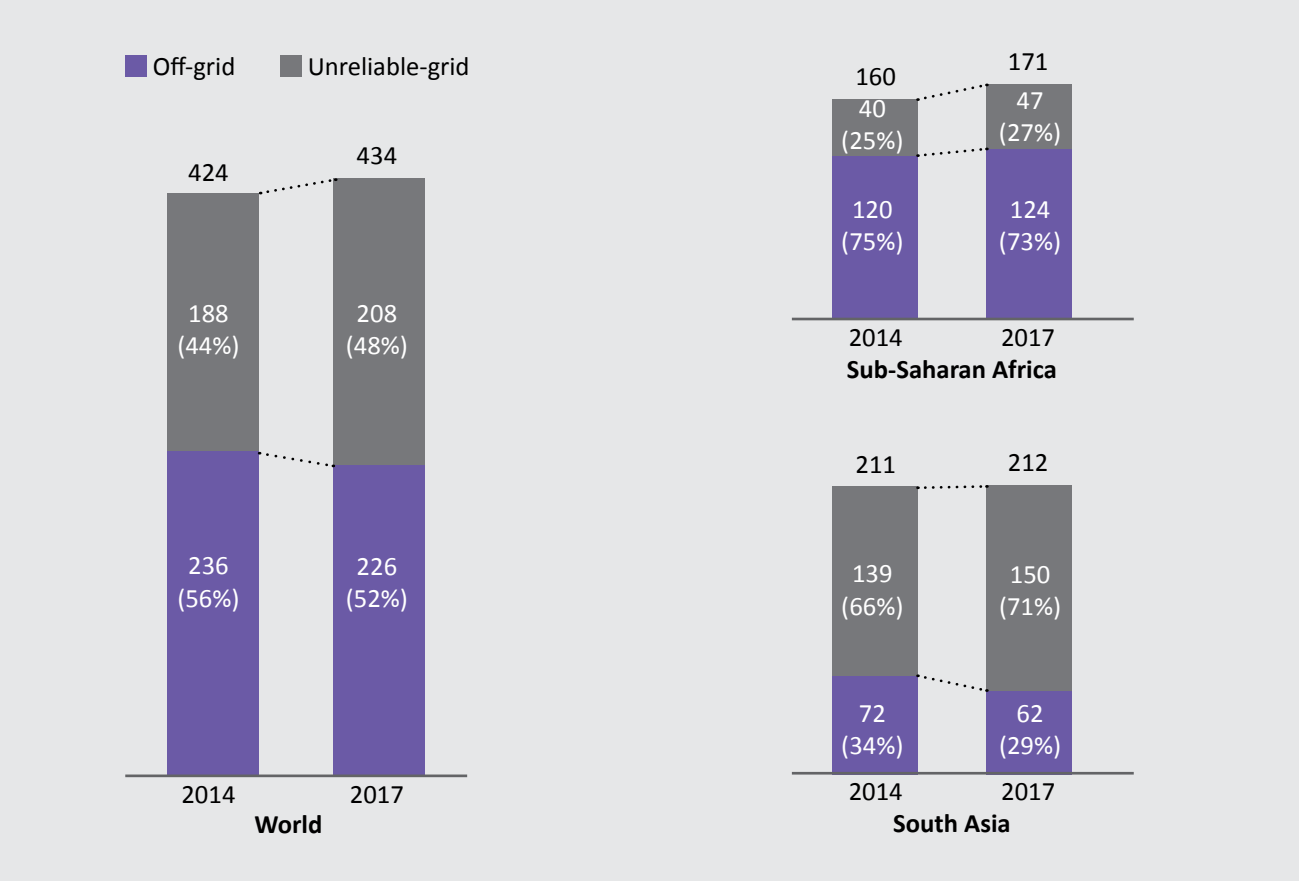
Household penetration has risen steeply over the years. From a base of approximately one million households served by OGS devices in 2010, OGS devices are now providing improved energy access to 73 million households in 2017, or over 360 million people. However, 2017 also sees a potential customer base of over 430 million households (nearly 2.2 billion people).[55] This customer base represents the people who live in off-grid and unreliable-grid energy access areas (see Table 4).

Photo credit: Lighting Asia-India

[55]Note: Current improved access estimate incorporates sales of all actively-in use OGS devices including both affiliates and non-affiliates (see Table 7 for definitions). Sales are discounted to assume 10% sales to repeat customers and 3% loss of devices sold, and assume a 3-4 year product lifetime. Note: Based on Dalberg calculations using the "improved energy access, current" metric of the GOGLA impact metrics. Source: (GOGLA, 2016a); (Dalberg, 2010)

Figure 15: Global potential market[56]

Million households (2014-17 est.)



This suggests that despite the success of grid electrification and OGS market penetration, there is unchanged overall potential in the market. This is by virtue of a complex set of dynamics that will maintain a substantial potential market for at least a decade. These include:

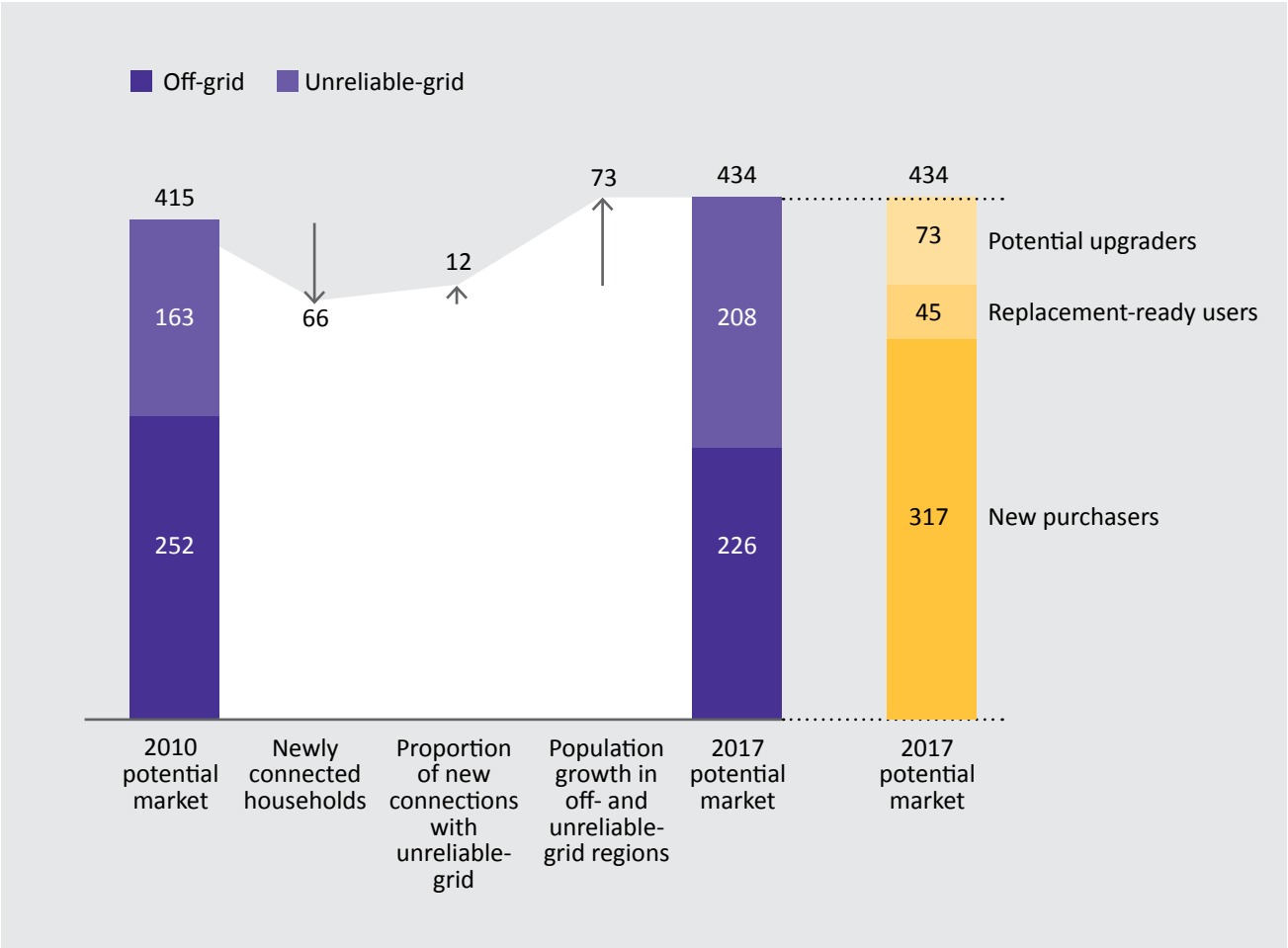
1. A large portion of off-grid populations that were connected to the grid since 2010 are receiving inadequate power. They have effectively transitioned from off- to unreliable-grid, and continue to represent a potent market for OGS devices.
2. High population growth in some of the most poorly electrified regions (especially Sub-Saharan Africa) keeps the market size large in absolute numbers (and in a few cases, such as Angola, relative percentage drops as well).
3. Customers that the OGS market has already served require replacement devices every 2-4 years, and therefore remain part of the potential market. Energy products also display the characteristics of an "experience good," i.e. as customers gain access to electricity for the first time, they desire more (and in some cases, are willing to pay more for each unit of electricity) and therefore may be targeted for upgrades to systems that offer higher levels of service.

Figure 16 lays out these dynamics.

[56]*Note: An estimated 50 million additional households are distributed in off- and unreliable-grid regions of other parts of the world, chiefly in East Asia and Pacific. For unreliable-grid estimation methodology, see Footnote 81. Source: (International Energy Agency, 2016); (International Energy Agency, 2017a); Dalberg market model and analysis.*

Figure 16: Change in potential market[57]

Million households (2010-17 est.)



This figure illustrates that despite significant electrification gains since 2010, the potential market remains vast at 434 million households. It accounts for some of the competing drivers in this dynamic market, which include the following: (1) grid improvements provided new electricity connections to 66 million households since 2010, (2) at least 12 million of those 66 million households received unreliable-grid access and so continue to represent a potential market, (3) population growth in off-grid and unreliable-grid regions added an estimated 73 million new households to the potential market. Together, these global trends resulted in an addition of nearly 20 million households to the total potential market, which grew from 415 million in 2010 to 434 million in 2017. Based on this report's estimates of the total market (see Section 1B) about 73 million of these are current OGS users who have made purchases within the last three years and could be targeted for upgrades and upselling. Another 45 million households purchased devices more than three years ago (2010-2014), and may be ready for a replacement device. Finally, there remain about 317 million untapped households who represent potential new users.

[57]Note: Estimates may not add up to totals due to rounding. Sales are discounted to assume 10% of sales are to repeat customers and a 3% loss of devices sold (GOGLA, 2016a). For unreliable-grid estimation methodology, see Footnote 81. For total sales estimation methodology, see Section 1B. Source: (International Energy Agency, 2016); (International Energy Agency, 2017); (United Nations, 2014); Lighting Global/GOGLA sales data; Dalberg market model and analysis

The section that follows describe the key trends within the off-grid and unreliable-grid segments which comprise the potential market for OGS. Later, Section 1A.2 provides details and estimates of the share of the potential market that is currently addressable and reachable by the OGS industry.

Off-grid population: The off-grid population is reducing, although progress is uneven.

According to new data from the International Energy Agency, grid electrification has accounted for 97% of the global increase in electricity access since 2000, but non-grid approaches including OGS devices and mini-grids have begun to make headway as well.[58] In fact, recent geospatial analysis suggests that decentralized technologies, including OGS devices and mini-grids, will be the most cost-effective solution to deliver electrification for at least two thirds of rural households projected to gain access by 2030.[59] This widespread market has witnessed significant regional variations, namely:

- *South Asian countries, especially India and Bangladesh, have made remarkable progress in expanding grid access in recent years.* South Asia has seen an 11 percentage-point increase in grid coverage since 2010, achieving over 80% coverage today. In India, according to the IEA, the household electrification rate grew from 43% in 2000 to 82% in 2016; this represents a gain of half a billion people.[60] Over 99% of people that gained electricity access in India since 2000 have done so because of grid extension.[61] Similarly, in Bangladesh, grid access increased from 32% in 2000 to 62% in 2014, and utilities connected an estimated 300,000 new customers per month in late 2017.[62] Going forward, universal access is expected in most Asian countries by 2030.[63] The only exceptions are expected to be Lao PDR, Cambodia and Myanmar.[64]
- *Sub-Saharan Africa has lagged South Asia in electrification; moreover, progress has been uneven within the region.* Expansion of the grid in Sub-Saharan Africa has been slower (a 7 percentage-point increase since 2010), reaching less than 40% overall coverage today. In contrast to the trend in South Asia, the overall population lacking electricity access increased from 518 million to 588 million people between 2000 and 2016.[65] While new findings from IEA suggest that the absolute number of people without electricity access may have begun to decline slightly in the past several years, this trend will soon reverse again due to population growth in large countries with low electrification rates.[66] Within the region, reductions in populations without access are concentrated in East Africa, while West African countries remain the most under-accessed.[67]

East Africa has accounted for over 80% of the decline in the number of people without access in Sub-Saharan Africa since 2012.[68] At a high-level, this has been the result of three factors: (1) aggressive grid expansion

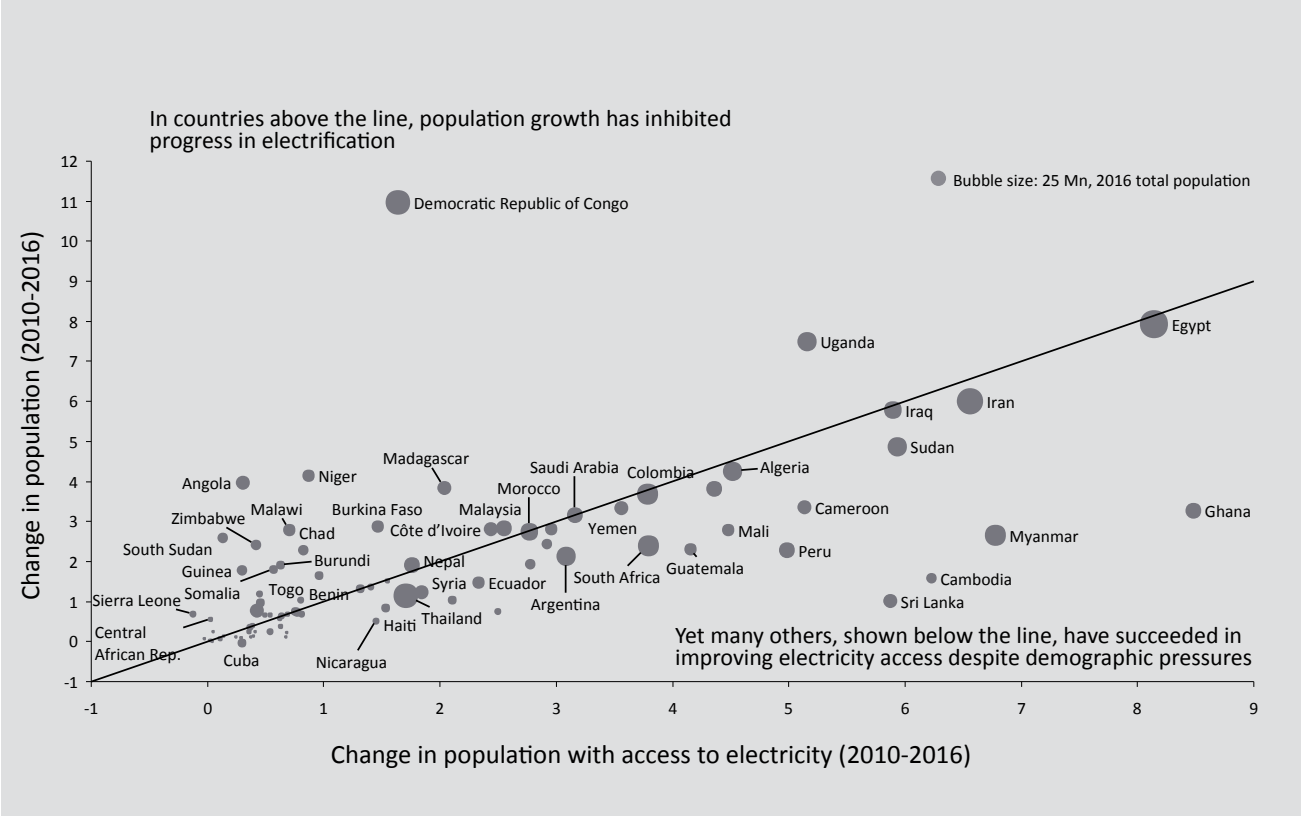
[58]*Source: (International Energy Agency, 2017a)*
[59]*Note: This IEA analysis on decentralized energy encompasses solar, hydro and wind technologies. Source: (International Energy Agency, 2017a)*
[60]*Note: The Indian government's electrification programs target both household electrification and village electrification (a village is considered electrified if 10% of households are electrified, and electricity is provided to public places such as schools and community centers). The figures provided here are based on IEA's World Energy Outlook methodology, which exclusively focuses on household electrification. Source: (International Energy Agency, 2017a); (Government of India, 2017)*
[61]*Source: (International Energy Agency, 2017a)*
[62]*Source: 2014 figure: IEA World Energy Outlook (2016); 2000 figure: World Bank World Development Indicators: EG.ELC.ACCS.ZS (2000); 2017 estimate: Industry interviews*
[63]*Note: Electrification does not imply access reliability. See Table 5 for further details on "unreliable-grid" prevalence. Source: (International Energy Agency, 2017a)*
[64]*Source: (Deccan Herald, 2017)*
[65]*Source: (International Energy Agency, 2017a)*
[66]*Source: (International Energy Agency, 2017a)*
[67]*Source: (International Energy Agency, 2017a)*
[68]*Source: (International Energy Agency, 2017a)*

(especially in Kenya and Ethiopia, which are on track to reach near-universal access by 2030 according to IEA's New Policies Scenario projections[69]), (2) a relatively stable regulatory and investment climate, and (3) increasing availability of decentralized systems, mainly OGS (especially in Kenya, Tanzania, Ethiopia and Uganda).

Progress has been slower in West and Central Africa, which together comprise about 50% of the total off-grid population in Sub-Saharan Africa.[70] Outliers include Ghana (where electricity access increased from 45% to 84% between 2000 and 2016), Senegal (increased from 30% to 64%), and Gabon (increased from 31% to 90%); nearly all of the increase in these countries was driven by grid expansion.[71] In addition to slower grid-growth, higher population growth rates in West and Central Africa have also offset gains in electrification, due to people being born in off-grid locations (see Figure 17). By 2030, 602 million people, which amounts to 80% of the global population without access, will be concentrated in Sub-Saharan Africa.[72]

Figure 17: Population growth and growth in population with electricity[73]

Million people (2010-16)



[69]*Note: IEA's New Policies Scenario comprises a projection of "where existing policies as well as announced policy intentions will lead the energy sector." Source: (International Energy Agency, 2017a)*

[70]*Source: (International Energy Agency, 2017a)*

[71]*Source: (International Energy Agency, 2017a)*

[72]*Source: (International Energy Agency, 2017a)*

[73]*Note: Figure based on 2017 IEA electrification data, which includes electrification via grid, as well as decentralized renewables including mini-grid and off-grid technologies using solar, hydro and wind power. Unreliable-grid populations not included. Source: (International Energy Agency, 2017a); (United Nations, 2014); Dalberg analysis*

Unreliable-grid: Unreliable-grid population is expected to rise alongside grid electrification, globally.

According to the IEA's baseline New Policies scenario,[74] grid extension will account for two-thirds of the total number of people gaining access to electricity between 2017 and 2030. However, a large portion of new grid users remain a part of the OGS market. This is because grid connections frequently under-perform, and some connected populations may receive only a few hours of electricity per day, resulting in similar conditions and aspirations as off-grid populations. For example, 15% of the customer base for one PnP SHS company in East Africa were already connected to the grid, and early findings from an ongoing study sponsored by IFC in India suggest that a substantial fraction of off-grid solar products are used by households in unreliable-grid areas.[75] Similarly, in India, it is not uncommon for OGS, mini-grids and the national grid to operate side by side in unreliable-grid areas, and for some customers to have connections to all three.[76]

Table 5: Drivers of grid connection unreliability

1. **Electricity demand-supply mismatch and poor-quality transmission and distribution networks.** Grid extension is an exercise in expanding distribution networks and—at times—transmission networks. Moving beyond simply providing connections toward providing reliable electricity often also requires an increase in generation capacity to meet the additional demand, as well as upgrading aging or low-quality transmission and distribution networks. When faced with a shortfall in supply (either through low supply or higher than anticipated demand), utilities often resort to "load-shedding." For example, in India, utilities regularly resort to cutting off an entire feeder (11 kV voltage) of approximately a few thousand customers.[77] Beyond load-shedding, the quality of equipment across transmission and distribution networks as well as the geographical proximity of generation sites affect the quality of electricity provided as well as unplanned outages (which can be caused by extreme weather events, collisions, animal contact with lines of transformers, etc.).[78] Figure 18 demonstrates that most countries with large off-grid populations also face the challenge of an unreliable and irregular grid.

[74]Note: IEA's New Policies Scenario comprises a projection of "where existing policies as well as announced policy intentions will lead the energy sector." Source: (International Energy Agency, 2017a)

[75]Source: (Acumen, 2017c); industry interviews

[76]Source: (Okapi Research and Advisory, 2017)

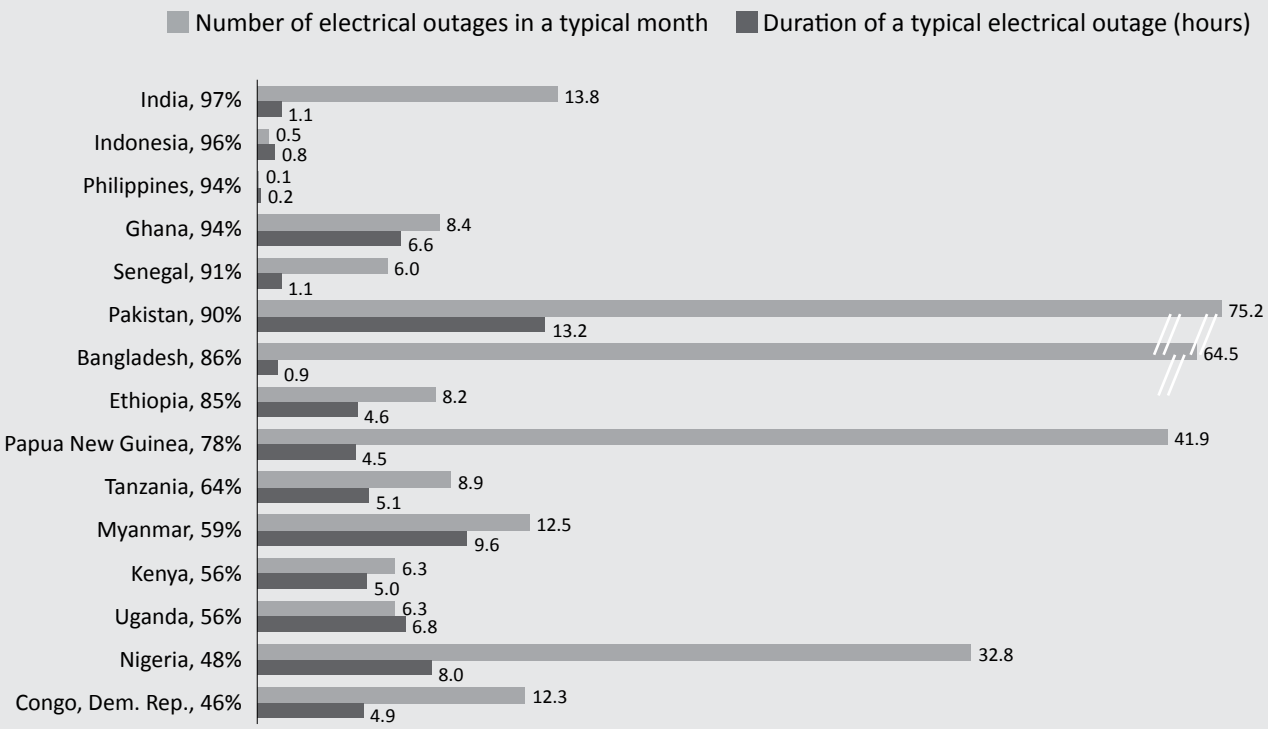
[77]Source: (Harish, 2014)

[78]Source: (Millien, 2017)

Table 5, continued

Figure 18: Urban grid reliability[79]

% urban grid access; select countries (2013-15)



2. **Use of informal grid connections.** Unreliable-grid customers also include those who cannot access or afford formal utility subscriptions and instead use illegal connections. This trend is particularly prevalent among populations in urban slums, many of whom migrate from off-grid rural areas to on-grid urban centers. For example, over six million Kenyans (equivalent to 16% of the potential market) were estimated to live in such slum settlements in 2014, relying on poor quality, unsafe electricity, often through illegal connections from local cartels.[80] In the short term, as urbanization within poor energy-access countries continues, this is likely to add to the number of unreliable-grid customers.

Figure 19 gives a view of estimates for unreliable-grid populations within selected off-grid countries. Based on a weighted average of the countries shown in Figure 19 and other countries for which anecdotal or point estimates exist, this study estimates that in countries with significant off-grid populations, an average of 60% of rural on-grid customers and 20% of urban on-grid customers live in unreliable-grid areas (or 47% nationally).[81]

[79]Note: Data shown is as reported by firms, in urban areas only. Source: (World Bank, n.d., b); (International Energy Agency, 2016); Dalberg market model and analysis

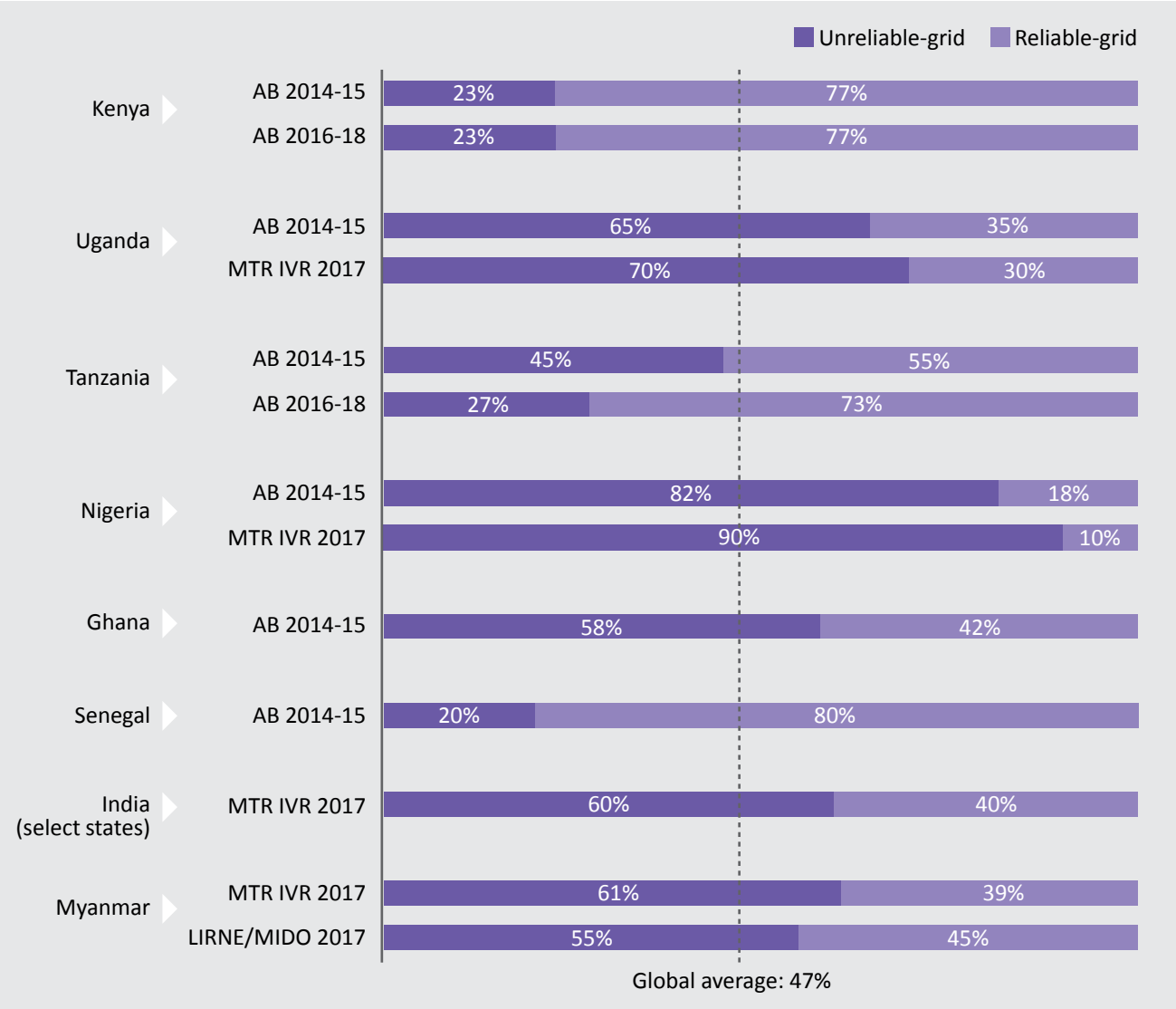
[80]Note: This number has fallen since 2014 following a partnership between Kenya Power and Lighting Corporation and the World Bank that used a community-centric approach to provide formal connections. Connections jumped from 5,000 connections in 2014 to over a 150,000 by May 2015. Source: (World Bank, 2015); World Bank World Development Indicators: EN.POP.SLUM.UR.ZS (2014)

[81]Note: The Dalberg market model used in this report relies on country-specific estimates of unreliable-grid prevalence, with differentiated rates for rural and urban areas. This global estimate is provided for refence only, and represents countries where at least 5% of the population lives off-grid (typically low-income countries); it therefore does not apply to countries with near-universal electrification. Source: (Afrobarometer, 2017); (World Bank, n.d., b); (World Bank, 2017e); (USAID, n.d.); (Lighting Global/Dalberg, 2017); (Bloomberg New Energy Finance, 2016); (Galpaya, 2016); (Danson Cheong, 2013); (Sangraula, 2017); (Choragudi, 2013); (Ghosh Banerjee, Barnes, Singh, Mayer, & Samad, 2014); (Asian Development Bank, 2013); (Council on Energy, Environment and Water, 2015); (Lighting Asia, 2014); (Annual Status of Education Report 2016, 2016); industry interviews

Across countries, grid reliability challenges are expectedly much more severe in dispersed rural areas than in urban centers. This disparity is estimated to be especially high in countries like India, Myanmar, Papua New Guinea, Pakistan, and Kenya, where investment in urban infrastructure far exceeds that of isolated and lower income rural areas.[82]

Figure 19: Estimates of electricity reliability among households with grid access[83]

% of on-grid households; select countries (2014-17)



[82]Note: The difference between rural and urban unreliable-grid estimates exceeds 30 percentage points for each of the countries named (see Footnote 81 for full sources)

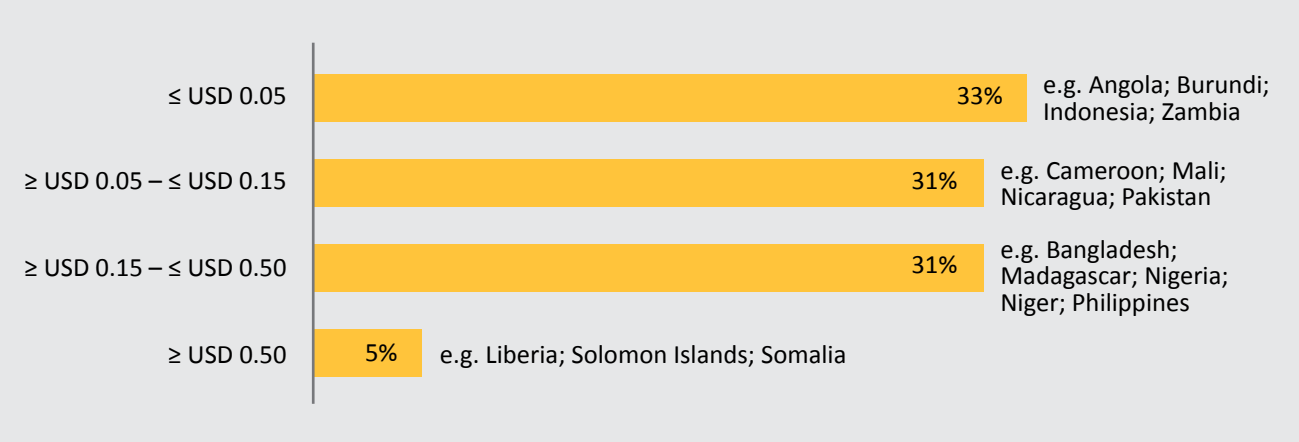
[83]Note: Figure is based on available data from surveys which used different methodologies; the data has been adjusted for comparison, but may differ in representativeness of each country. Based on the data available, unreliable-grid is defined here as receiving electricity less than half the time, or 12 hours per day. India estimate shown is based on the IVR survey conducted for this report (see Appendix A), which covered mobile phone respondents in Uttar Pradesh, Uttarakhand, Bihar, Rajasthan, Haryana, Jharkhand, Gujarat, Maharashtra, Telangana, and Tamil Nadu, and may not be representative of national grid reliability. Figure displays national-level estimates for all other countries. Afrobarometer survey results shown are from both Round 6 (2014-2015) and Round 7 (2016-2018). See Footnote 81 for further details on unreliable-grid estimation, and Appendix A. Source: (Galpaya, 2016); (Afrobarometer, 2017); (Lighting Global/Dalberg, 2017); Dalberg market model and analysis

Affordability issues also exclude households from grid access. In addition to challenges in grid reach and reliability described above, prohibitive grid connection charges and high electricity tariffs keep many households from enjoying the benefits of the grid. Research in 2011 found that of the 93% of urban households in Sub-Saharan Africa that lived close to the grid, only 75% had a connection.[84] For these populations, the grid's presence increases exposure and aspiration for modern energy services, including from OGS devices.

According to RISE, the full cost of connecting to the grid can vary from USD 22 in Bangladesh to USD 500 in several African countries. Funding support for connection costs through direct subsidies to consumers or consumer financing mechanisms, is prevalent in less than one-third of the 55 energy-access deficit countries listed by RISE.[85] Those with connections often face high tariffs for electricity: the cost of a subsistence volume of electricity - about 30 kWh a month for residential users - varies among countries, ranging from USD 0.1/kWh in Angola to USD 1/kWh in Somalia (Figure 20).

Figure 20: Cost of subsistence electricity consumption across 55 energy-access deficit countries[86]

% of selected countries; USD/kWh for 30 kWh monthly consumption (2016)



Countries that face the most severe affordability issues for electricity are typically small island states, small landlocked states, and conflict-affected areas that face high power generation costs; most are among the world's least electrified countries, such as Liberia and Somalia.[87]

Market location: High-impact countries in Sub-Saharan Africa and Asia dominate the market.

11 countries in Sub-Saharan Africa and Asia comprise nearly three quarters of the global potential market, and will remain at the center of global access to electricity efforts. Some of these – such as India, Bangladesh, Kenya, and Tanzania – are well-recognized as having been relatively early focus-markets for OGS devices, and have seen significant investment in developing the local market. Others – such as Nigeria, Uganda and Ethiopia – have more recently come into focus. Finally, Pakistan, Indonesia, the Democratic Republic of the Congo, and

[84] *Source: (Eberhard, Rosnes, Shkaratan, & Vennemo, 2011)*

[85] *Note: World Bank Group's RISE is a set of indicators to help compare national policy and regulatory frameworks for sustainable energy. Source: (Banerjee, Moreno, Sinton, Primiani, & Seong, 2017)*

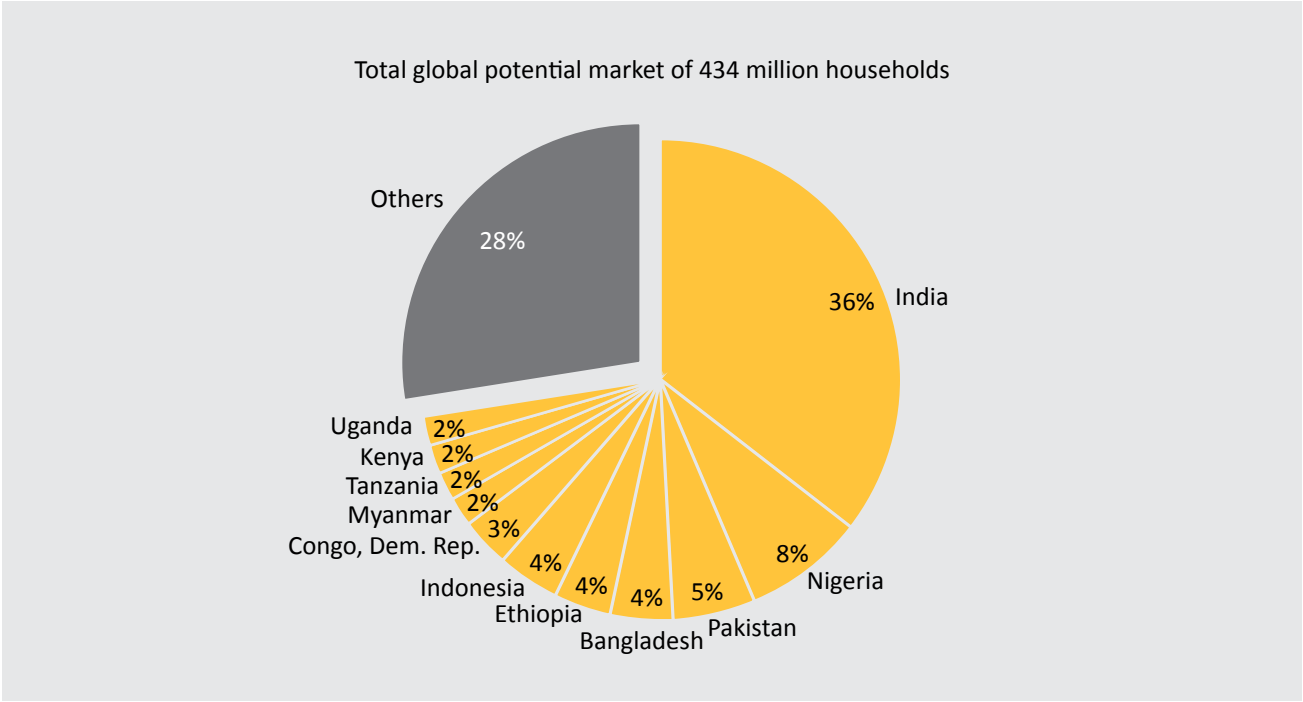
[86] *Source: (Banerjee, Moreno, Sinton, Primiani, & Seong, 2017)*

[87] *Source: (World Bank & IEA, 2017b)*

Myanmar are regarded as relatively nascent markets. They form one-fourth of the overall potential market, and are yet to see significant penetration of OGS devices or entry by more than a few select suppliers. Within markets, rural regions—especially in Sub-Saharan Africa—are projected to represent a growing share of the potential market, comprising 80% of the population without access to electricity by 2030, according to IEA's New Policies Scenario.[88]

Figure 21: Countries with largest potential markets[89]

Million off- and unreliable-grid households (2017 est.)



Potential market spending: Off-grid household expenditure on basic energy needs dwarfs OGS market-based sales, implying significant value on the table.

A majority of off-grid and unreliable-grid households rely on dirty and expensive fuels to address and supplement their basic energy needs.[90] While regional and rural-urban variations exist, most households end up paying a prohibitively high premium and must choose from a common basket of energy sources to cover their basic needs (aside from OGS devices). These include kerosene, candles, and—increasingly[91]—dry-cell battery torches for lower levels of service, and diesel generators and mini-grids (where available, including solar, mini-hydro, and biomass) for higher levels of service.

[88]Note: IEA's New Policies Scenario comprises a projection of "where existing policies as well as announced policy intentions will lead the energy sector." Source: (International Energy Agency, 2017a); (International Energy Agency, 2016)

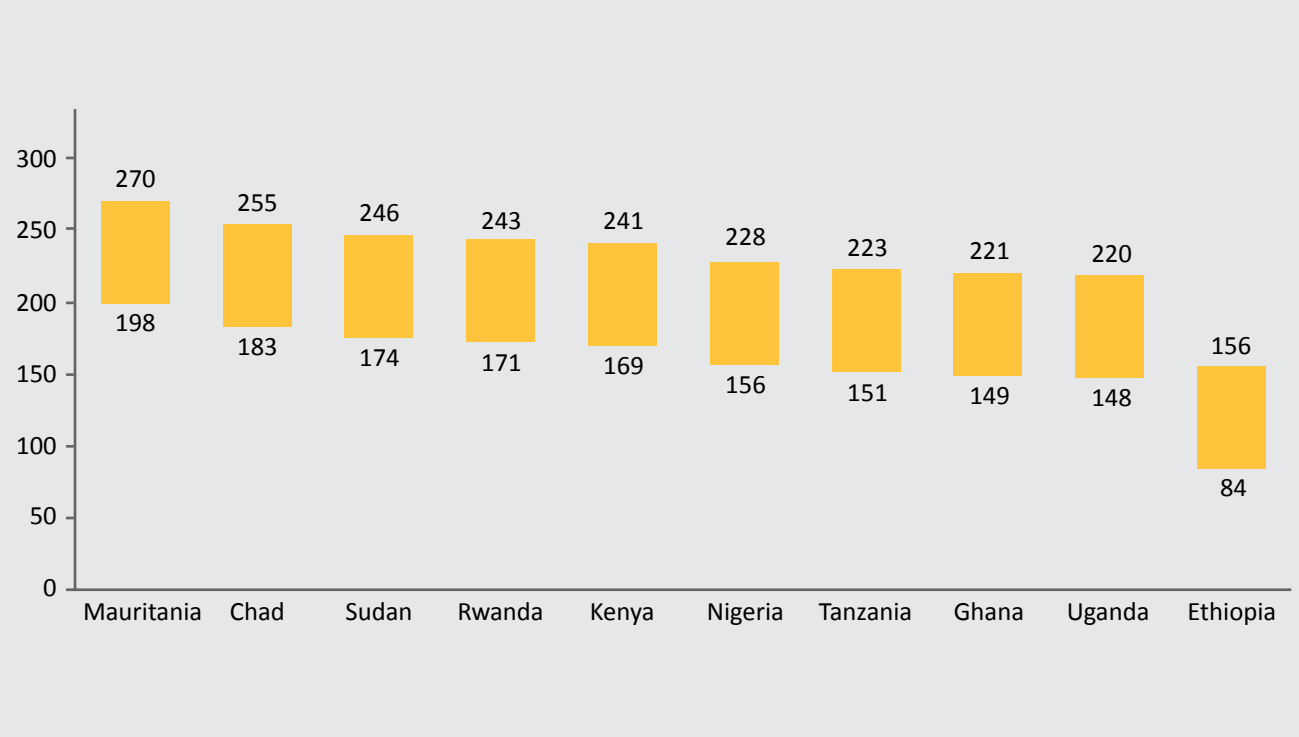
[89]Note: For unreliable-grid estimation methodology, see Footnote 81. Source: (International Energy Agency, 2016); (International Energy Agency, 2017a); Dalberg market model and analysis

[90]Source: (International Energy Agency, 2017a)

[91]Source: (UNCDF, 2017)

Figure 22: Annual off-grid household expenditure on traditional lighting sources and mobile charging[92]

USD (2015)



These households pay heavily for their limited access, since most traditional fuels are far more expensive than electricity or other modern solutions.

Off-grid and unreliable-grid households can spend up to the equivalent of USD 100/kWh for lighting through kerosene, which is about 1,000 times more than what on-grid customers pay.[93] In Kenya, for example, an on-grid household can spend up to USD 0.73 per month for lighting,[94] while kerosene users can spend as much as 20 times more (USD 14 per month) for substantially less service. At an annualized level, IRENA estimated that expenditure for off-grid lighting and mobile phone charging in Africa can range between USD 84 in Ethiopia, and USD 270 in Mauritania, which is between 3-5% of annual household expenses (Figure 22). This does not account for transportation costs for trips dedicated to mobile phone charging, which can amount to USD 25 per month in some cases.[95]

Based on a review of the literature, off-grid households in the potential market spend anywhere between USD 16 billion and USD 61 billion annually on basic energy needs. Currently, spending on market-based OGS sales accounts for just USD 1 billion annually. Estimates for the total spend by off-grid households on lighting and mobile charging vary. To provide a range, this study has used the annualized expenditure estimates from studies by BNEF (reporting estimates from 2014), IRENA (2015), Jacobson and Mills (2011), and Lighting Africa (2012) referenced earlier in this section to estimate the total annual expenditure of the 226 million off-grid households in the potential market (Figure 23).

[92]Source: (IRENA, 2016b); Dalberg analysis

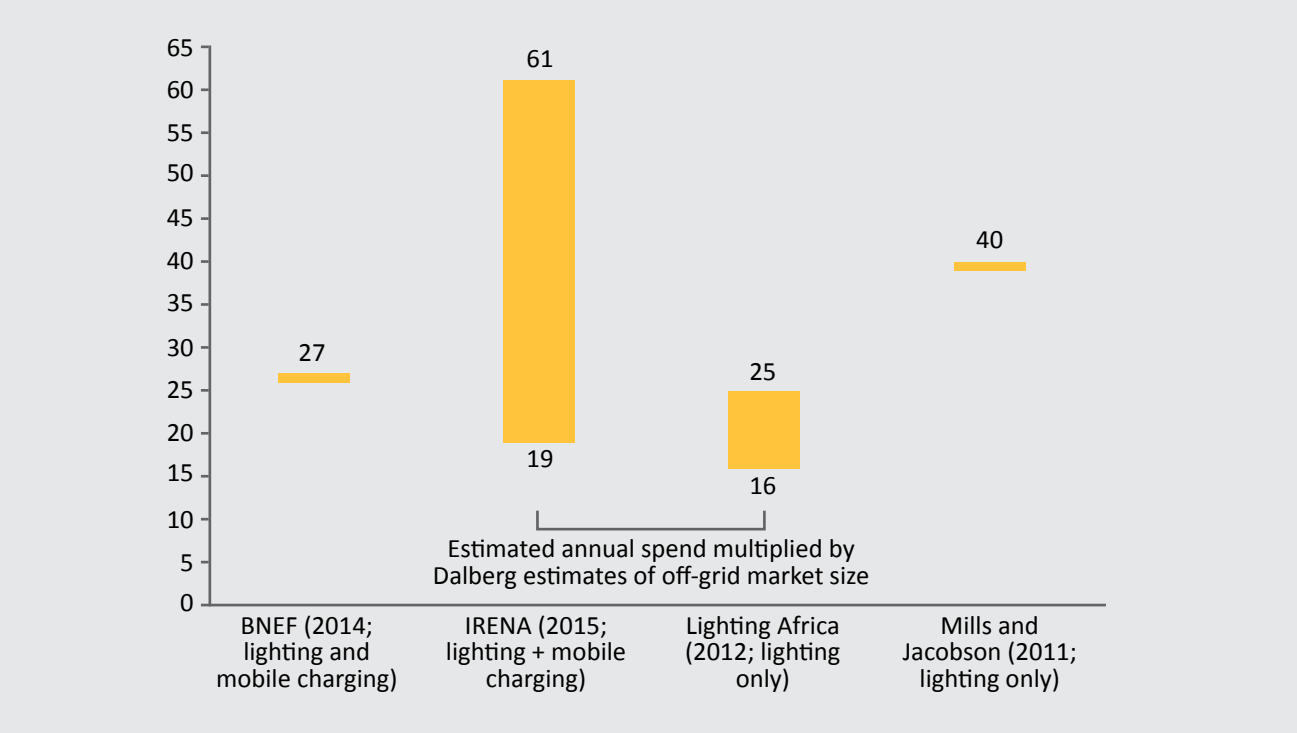
[93]Source: (The Economist, 2015)

[94]Note: Use of two 10W LED light bulbs (comparable to a 60W incandescent bulb) for six hours a day at Kenya's basic tariff of USD 0.2/kWh costs a total USD 0.73 per month

[95]Source: (IRENA, 2016b)

Figure 23: Estimated annual spend on lighting and mobile phone charging by off-grid households[96]

USD billions



It is important to note that this expenditure range (on lighting and mobile charging) is a conservative estimate since it does not account for expenditure by unreliable-grid households on alternative sources of energy. It is well-known that unreliable-grid households often continue to purchase kerosene and other fuels; however, there are few existing estimates around the degree of prevalence globally, as well as the level of expenditure. For higher levels of service, households and businesses typically opt for diesel or gas generators. For instance, in Nigeria, an estimated 80% of consumers with electricity connections have an alternative source of electricity, mostly diesel or gas generators. This costs households and businesses almost USD 22 billion annually in fuel costs alone.[97]

Importantly, potential revenues for the sector have risen as companies are beginning to recognize customers as representing a lifetime value beyond a one-transaction relationship. The main drivers of this change in perspective have been:

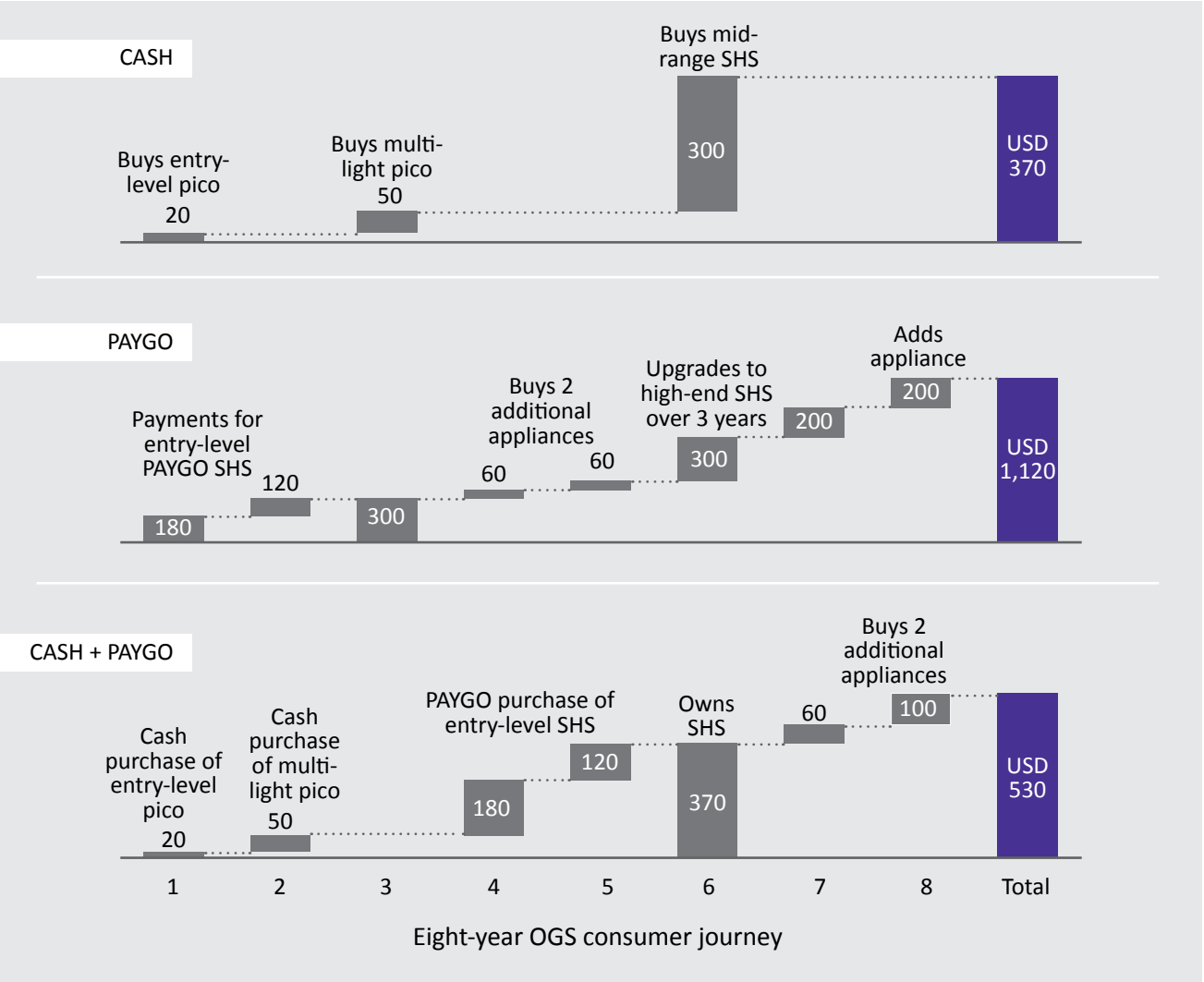
- Innovations in financing that are allowing higher overall spend on energy (e.g. PAYGO is relaxing the norm that customers will only spend up to 2-3 months of disposable income on a given product). For instance, Acumen's Lean DataSM project (discussed in detail in Section 1F) found that households that purchased OGS devices spent, on average, USD 72 more a year as compared to their baseline expenditure prior to purchase.
- Access to a wider product set including household appliances and services, allowing the sector to provide services for a wider array of consumer needs.
- Rising real incomes (7% annual increase in South Asia and 3% increase in Sub-Saharan Africa since 2009), although the distribution of this rise is uneven across geographies and income groups.

[96]*Source: (Bloomberg New Energy Finance, 2016); (IRENA, 2016b); (Mills & Jacobson, 2011); Lighting Africa (2012) referenced in Acumen, 2017c; Dalberg analysis*

[97]*Source: (International Energy Agency, 2017a)*

Figure 24: Lifetime value potential of off-grid solar consumer *(Illustrative)*

USD; 8-year horizon



As shown in Figure 24, an average customer who in 2010 was estimated to spend USD 30-80 on an OGS product, is now estimated to have a lifetime value of USD 370-1,120, depending on the mode of purchase (i.e. cash versus PAYGO, or both). Sophisticated, branded players have created an internal energy product ladder that not only caters to customers' differing willingness to pay, but also helps migrate customers from basic to more feature rich products over time. This bodes well for the outlook of the industry overall, but represents an entirely new set of competitive dynamics that require many companies today to evolve or perish.

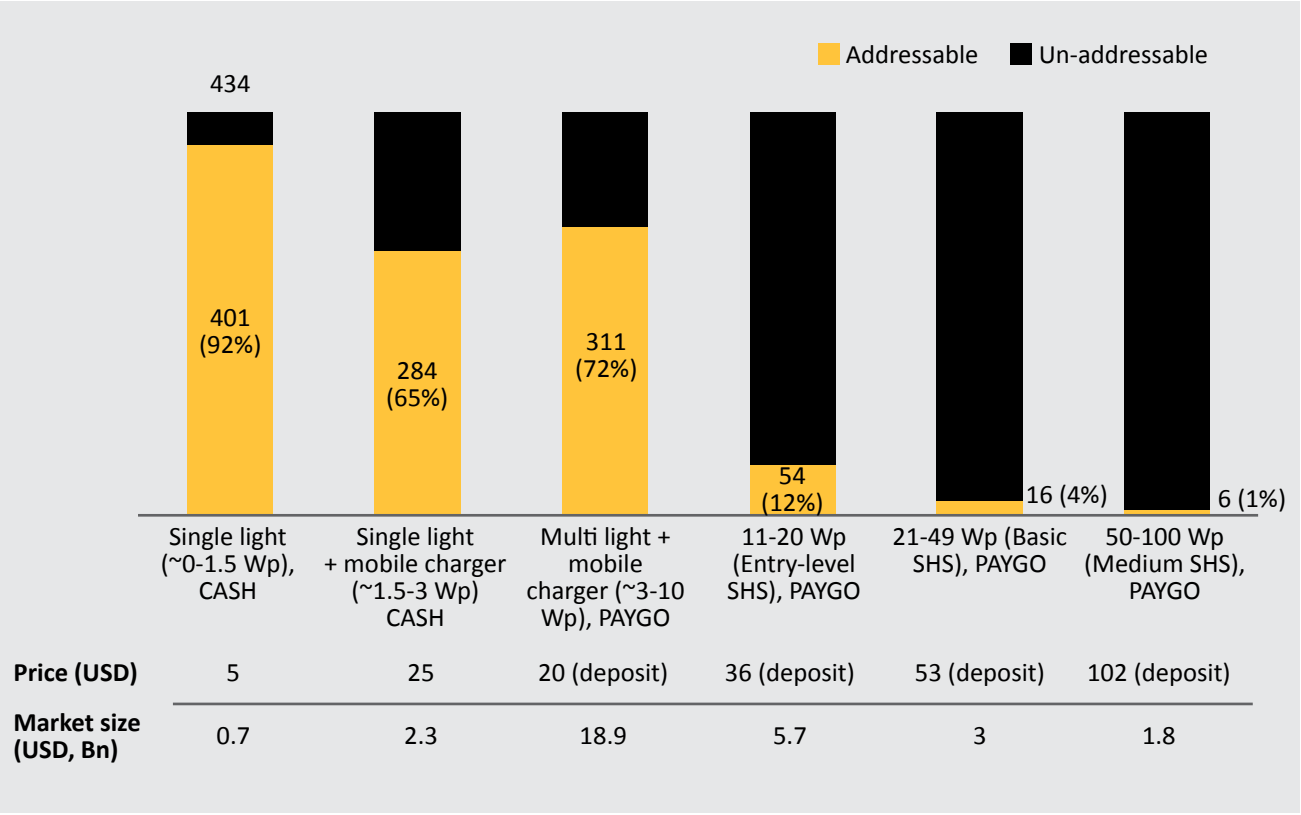
1A.2 THE ADDRESSABLE MARKET FOR OGS

There are robust opportunities available in the addressable market worldwide for varying levels of OGS devices and services. Temporary slow-downs in certain regions teach us that success in developing this sector hinges on taking into account the way localized challenges and context-specific realities influence change.

Addressable market: Device price affordability remains key for low-income consumers.

There is a large and flexible market based on affordability. If only affordability is considered, then over 400 million households can afford an entry-level pico device, and over 50 million households can afford the deposit for an entry-level PAYGO PnP SHS (hereafter referred to as PAYGO SHS). The potential value of the addressable market, which varies for each device size and cost, ranges from USD 720 million to almost USD 19 billion (Figure 25).

Figure 25: Estimated global addressable market based on affordability[98]
Million households (2017)



[98]*Note: Estimated annual market size based on average total cost of ownership (assuming a three-year product lifetime), using estimates based on supplier interviews and the Lighting Global and Sendea/Mangoo databases; it is provided on cash basis for single light and single light + mobile charger pico devices, and on a PAYGO basis for all other products. Monthly payments for PAYGO devices range from USD 10-45 dollars, based on supplier interviews. This analysis, however, targets consumers' ability to pay an upfront cash price or PAYGO deposit rather than monthly payments. This is rooted in findings from industry interviews which suggest that ability to pay an upfront deposit is the main barrier to affordability, and suppliers adjust monthly payment amounts based on their target customers' current spending. Emerging research from UNCDF (UNCDF, 2017) supports this, and suggests that the income levels of most PAYGO customers are similar to consumers buying basic pico devices, and that customers opt for higher-service level devices through PAYGO if they are able to pay the deposit. See full methodology and sources in Table 6. Source: (Sendea, n.d.); Dalberg market model and analysis*

This market is subject to substantial regional variation. Accounting for both its larger population as well as higher average income levels, South Asia represents approximately more than half of the addressable market for single light pico devices, while Sub-Saharan Africa represents approximately one-third. South Asia's proportion rises to three times higher than that of Sub-Saharan Africa for multi-light + mobile charger (~3-10 Wp) devices, due largely to nearly 60% higher share of wallet allocated to lighting fuels by low income rural populations in India compared to Sub-Saharan Africa.

Table 6: Addressable market estimation methodology

This study examines the number of households in the *potential* market (all off- and unreliable-grid households) that can afford off-grid solar devices, and therefore comprise the *addressable* and *reachable* markets. It is based on an analysis of consumption patterns and rural infrastructure in select countries, and extrapolated where relevant to arrive at world estimates.

Potential market segmentation:

1. *Rural/urban consumption segments:* This analysis is based on the four global consumption segments defined by the World Bank Group.[99] This model then overlays rural and urban population data from UNPD's World Urbanization Prospects[100] using data on the rural/urban splits within the four consumption segments based on the World Bank World Consumption Database.[101] Then, poverty headcount ratios within each segment are calculated using the World Bank PovcalNet.[102]
2. *Electricity access per segment:* This model assumes electricity access is evenly spread across these segments, using urban and rural electrification data (for off-grid populations) from IEA's World Energy Outlook[103] as well as assumptions about under-electrification (for unreliable-grid populations) from Afrobarometer, the World Bank Doing Business and Enterprise Surveys, USAID Demographic and Health Surveys, and a variety of country-specific sources.[104] Using these figures, the analysis arrives at a view of the total potential market in each country, segmented by consumption level and rural/urban status.

Addressable market consumption expenditure:

1. *Consumption patterns:* This analysis incorporates World Bank Global Consumption Database data on current consumption patterns on "Other Fuels," and "Household Appliances" to determine a household's ability to pay for solar devices at various price points. This is calculated for each of the rural/urban and income segments noted above, for each country in the model.
2. *Expenditure assumptions:* The analysis assumes consumers can divert 60% of their current spending on "Other Fuels" (comprising lighting, cooking and heating fuels), and 70% of their spending on household appliances in a given three-month period toward purchases of off-grid solar devices. If a consumer's spending in these categories exceeds the upfront cash price or PAYGO deposit of a solar device, they are assumed to be addressable.

[99] *Source: (World Bank, n.d., d)*
[100] *Source: (United Nations, 2014)*
[101] *Source: (World Bank, n.d., c)*
[102] *Source: (World Bank, n.d., a)*
[103] *Source: (International Energy Agency, 2016)*
[104] *Note: See Footnote 81 for details and sourcing*

Table 6, continued

This model focuses on base-of-the-pyramid populations, who consume less than USD 8.44 a day per the World Bank's definition; it may underestimate the market among middle and higher-income customers, who have more control over their discretionary spending and saving patterns.

Reachable market accessibility:

1. *Reachability:* The analysis uses the World Bank Rural Access Index[105] to estimate the proportion of rural customers that are costlier to reach than typical consumers, using the economics of a USD 25 single light + mobile charger pico device as a case study in Ethiopia and Bangladesh. It assumes all unreliable-grid populations and urban off-grid populations have road access, and use the Rural Access Index to segment rural off-grid consumers into two categories:
   - Those with access to a "good" road within 2 km: These populations are assumed to live within reach of typical markets and would pay a standard price.
   - Those without access to a "good" road within 2 km: These populations are assumed to live far from typical markets, and would have to cover additional transport costs equal to 20-50% of the products price on their own.[106]
2. *Implications for affordability:* Using these higher price estimates, the addressability calculations from PovcalNet are then re-run using the method and assumptions described above. Customers living far from markets who are able to pay the added transport costs remain part of the reachable market. Customers who are unable to pay the added transport costs are considered unreachable for the purposes of this analysis.

Reachable market: High cost of distribution reduces addressability in hard-to-reach areas.

Physical availability of OGS devices shrinks the addressable market in real terms. Even if products are affordable they may not be physically available to certain segments, which lowers the addressable market. Here as well, a spectrum of growth potential exists across markets, based on geographic nuances.

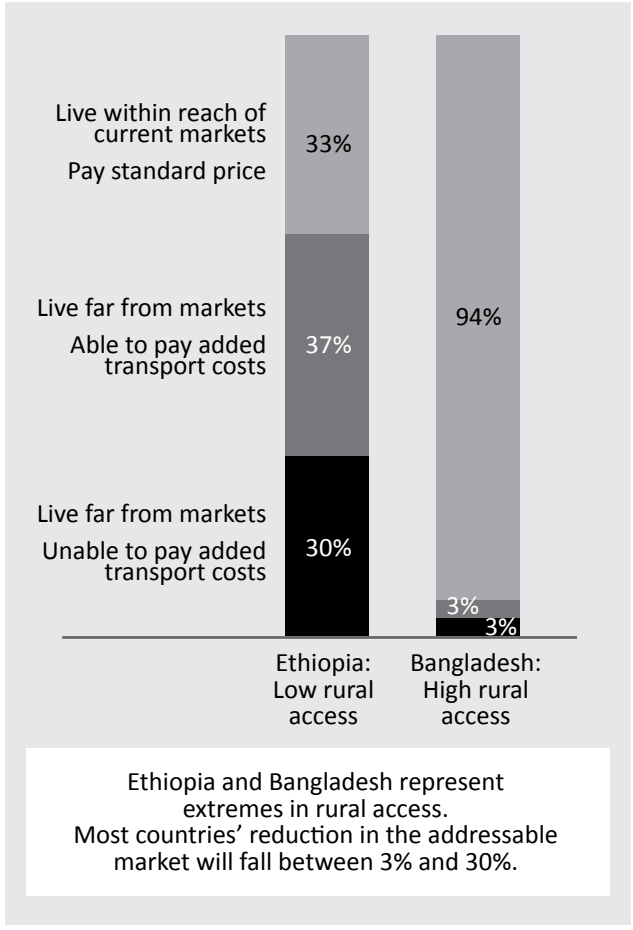
- *Distribution costs, when passed on to consumers, affect affordability.* Clearly, the cost of selling an OGS device increases for customers living away from population centers who are not easily reached through existing distribution networks and infrastructure. As manufacturers and distributors are typically unable to pass these additional costs on to customers (who already have a low ability-to-pay), they prefer to limit stocks instead. As a result, the addressable market expectedly shrinks once the cost of distribution to remote regions is priced in.

[105] *Source: (World Bank Transport & ICT, 2016)*

[106] *Note: Estimated markups for semi-limited and very-limited access populations are based on supplier interviews. Due to lack of differentiated data on ability to pay in rural vs. urban areas, the rural addressable market reductions shown here are likely to be conservative. Source: (World Bank Transport & ICT, 2016)*

Figure 26: Reachable market for single light + mobile charger pico[107]

% of addressable market for ~1.5-3Wp pico at a USD 25 standard price



Ethiopia and Bangladesh represent extremes in rural access.
Most countries' reduction in the addressable market will fall between 3% and 30%.

- *There is great regional variation in the addressable market based on accessibility*. This study uses the 2016 Rural Access Index, which combines census, survey, social media, and administrative data alongside spatial and satellite datasets to estimate the proportion of people who have access to an all-season "good" road within 2 kilometers.[108] Figure 26 displays this analysis for Ethiopia and Bangladesh, which represent two extreme cases that respectively have a low (22%) and high (87%) share of the rural population that live within 2 kilometers of a "good" road. Using the methodology described in Table 6, the potential market is then segmented into three groups: consumers for whom prices remain unchanged given their proximity to standard markets and supply chains; those who live beyond the reach of "good" roads, but who have sufficient income to afford transportation to a market themselves; and finally, those who live beyond the reach of good roads but would not be able to afford the added transportation cost. This "unreachable" third segment represents the reduction in the addressable market. As shown in Figure 26, the higher distribution costs result in a 30% reduction in the addressable market for Ethiopia. However, this would only reduce the addressable market by 3% in Bangladesh, which has stronger road infrastructure. It also has much higher population density of 1,222 people/km^2 compared to 97 people/km^2 in Ethiopia, which means that populations are more concentrated and thus less reliant on expansive and dispersed connectivity infrastructure. The share of the addressable market that would be priced out of reach in countries covered by the Rural Access Index – Nepal, Kenya, Mozambique, Tanzania, Uganda and Zambia[109] – have access indicators that broadly fall in between Ethiopia and Bangladesh. Which is to say, they lie within this spectrum of 3-30% seen in Figure 26.
- *Context-specific data can help address consumer reachability challenges*. Entrepreneurs and energy planners stand to benefit from research that identifies context-specific data on consumption patterns, population density, road networks, and energy needs. New work in Tanzania by the World Resource Institute layers geospatial data on these factors together in a series of Energy Access Maps, making it possible to identify future markets.[110] Such efforts are critical to developing a nuanced understanding of each market's unique reachability challenges.
- *Public-private partnerships and business model experimentation can improve distribution.* Innovation in schemes and services to increase

[107]*Source: Dalberg market model and analysis (see Table 6 for full methodology and sources)*

[108]*Source: (World Bank Transport & ICT, 2016)*

[109]*Note: 30 additional countries expected to be added to the new Rural Access Index by 2018. Source: (Purdie, 2016)*

[110]*Source: (World Resources Institute, 2017b)*

accessibility to OGS in segments that are priced out by higher distribution costs can yield material advantages. For example, SunnyMoney leverages donor funding to target such markets, investing heavily in reaching the "last-mile" via school campaigns, where solar lights are first introduced to communities at promotional prices.[111] Government distribution schemes represent another method to serve hard-to-reach consumers; some provide pico devices and component-based SHS at subsidized prices or for free (see Section 1B), and others are exploring other forms of public-private partnership to make OGS products affordable in remote and poorer regions. Another route to market, pioneered by SolarKiosk, involves establishing a retail presence that offers a range of products (from FMCG goods to solar products and appliances), helping to spread the costs of distribution across multiple products at varying price points.

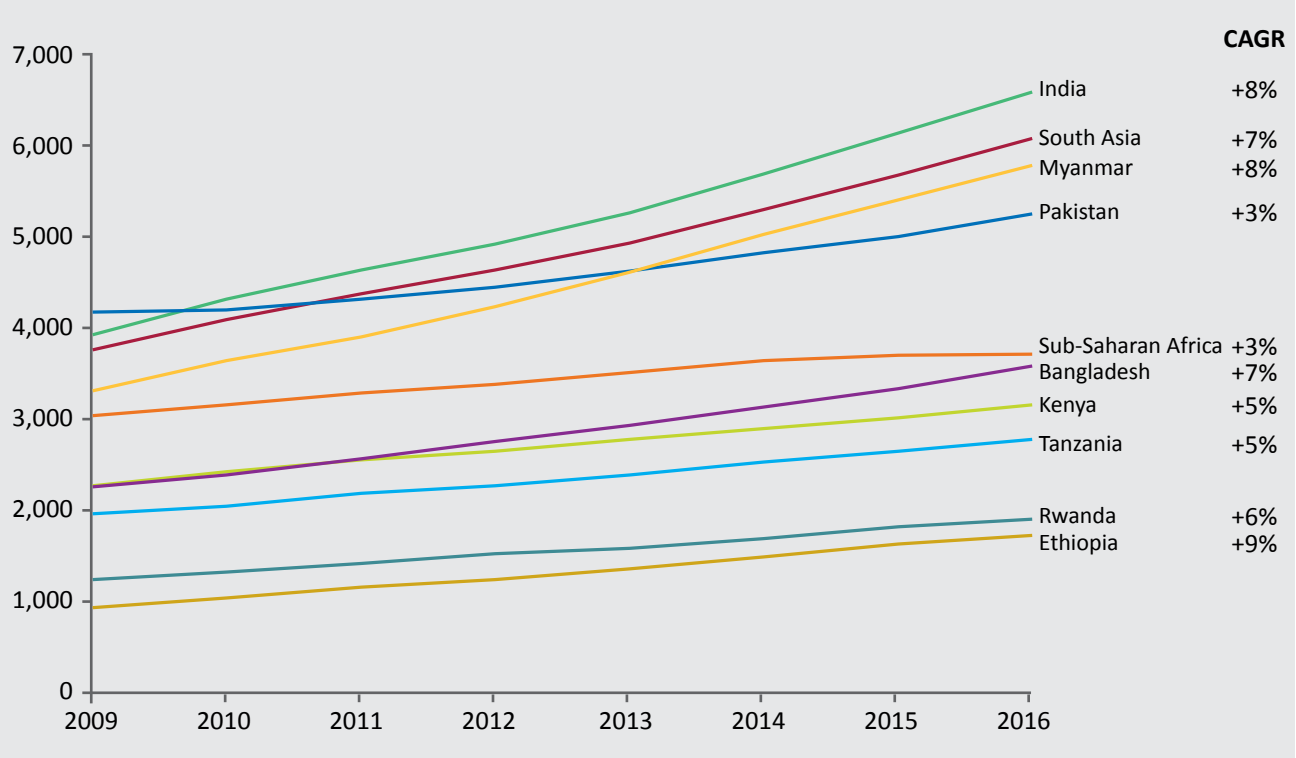
Drivers of the OGS market: Main drivers include rising incomes, favorable product economics, increases in infrastructure and rural connectivity, and increased availability of consumer finance.

These are strong fundamentals that are likely to improve over time. The first three factors are explored below, while consumer finance will be explored in detail in Section 1D.

1. **National incomes: South Asia and Sub-Saharan Africa show rising GDP, with country-level variations.** At an overall level, affordability has been driven by a higher initial income base in South Asia, which, in terms of GDP per capita, has grown at an average of 7% annually; this is substantially faster than Sub-Saharan Africa's 3% growth from a much lower base.

Figure 27: GDP per capita, South Asia and Sub-Saharan Africa[112]

2011 PPP (current international USD); select countries (2009-16)



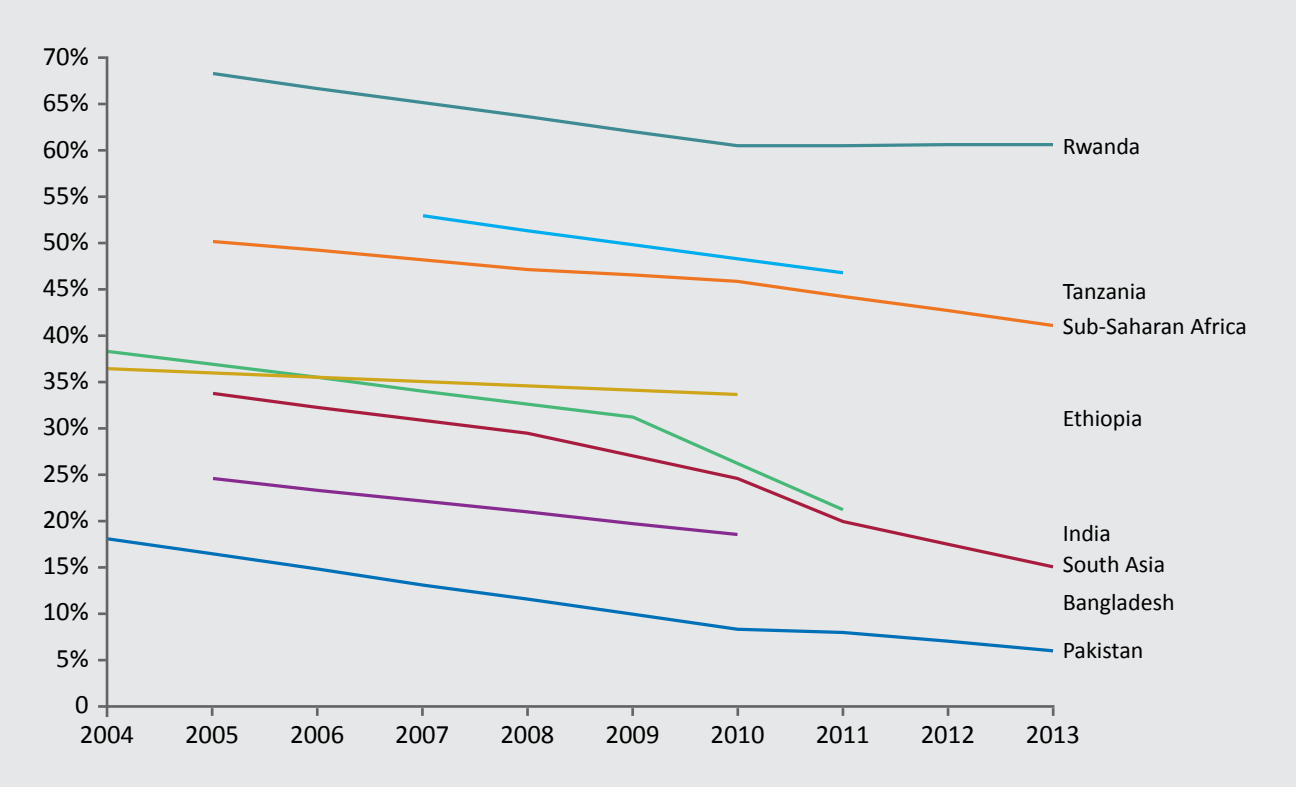
[111] *Source: (Sunny Money, n.d.)*

[112] *Source: World Bank World Development Indicators: NY.GDP.PCAP.PP.CD (2009-2016)*

The story at the national level has been a lot more varied (Figure 27). South Asian markets, such as India and Bangladesh have grown either at the regional average, or faster. In Sub-Saharan Africa, key markets today such as Kenya, Rwanda, Tanzania and Ethiopia have all clocked above average growth. While GDP per capita does not account for changes in the distribution of income, several of these countries have seen sharp reductions in poverty over the last decade, implying some movement up income segments. As a whole, South Asia has seen its population living below the poverty line (at USD 1.90 a day) go from ~34% in 2005 to ~15% in 2013; while Sub-Saharan Africa has seen a shift from ~50% to ~41% in the same period (Figure 28).

Figure 28: Poverty headcount ratio at USD 1.90 a day[113]

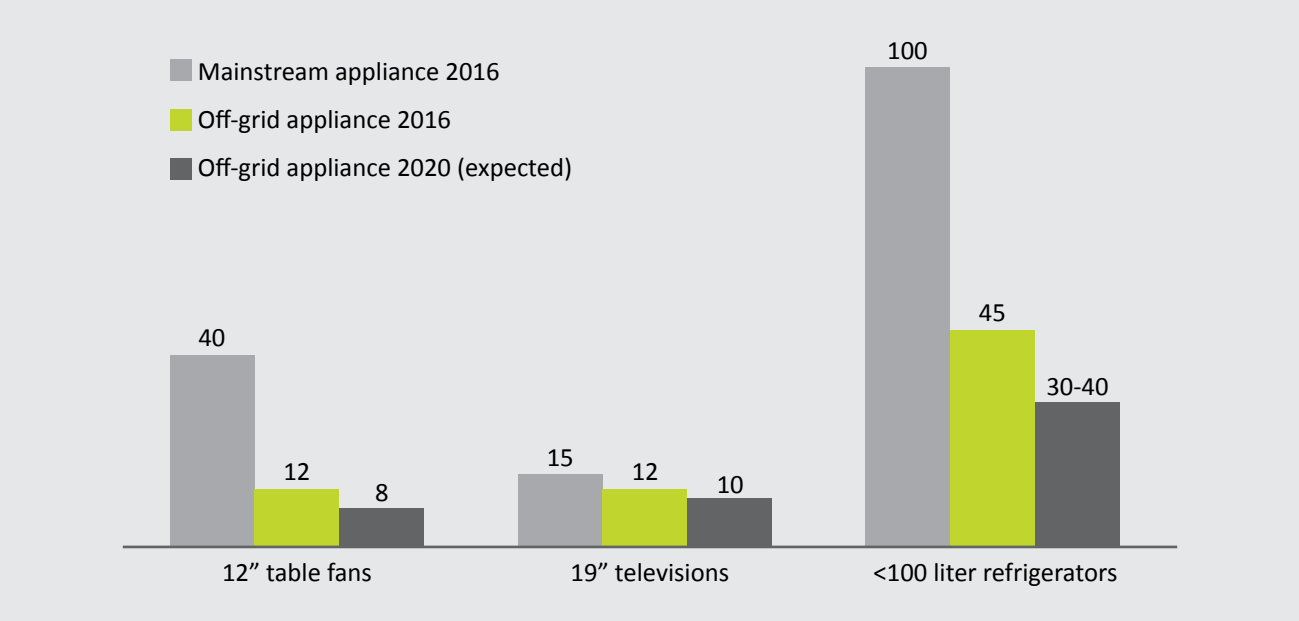
2011 PPP (current international USD); % of population (2004-13)



2. **Product economics and efficiency: Component and appliance efficiencies continue to improve, and costs are likely to continue falling, but at a slower pace.** The trend of falling costs and rising efficiency—which has allowed for steady reductions in the price of OGS devices—is likely to continue going forward, although at a slower pace. DC appliance efficiency is improving rapidly and is playing an increasingly important role in improving the economics and service capacity of SHS. The main drivers of declining OGS device prices have been improvements in the efficiency and economics of the three main components – PV panels (predominantly C-Si), LED lights, and batteries (Li-ion) – prices for which have dropped by 79%, 80% and 73% respectively between 2010 and 2016. Market positioning for each of these is reviewed below:

[113]*Source: World Bank, World Development Indicators: SI.POV.DDAY (2004-2013)*

Figure 29: Estimated power rating for off-grid appliances[114]
Watts (2016-20)

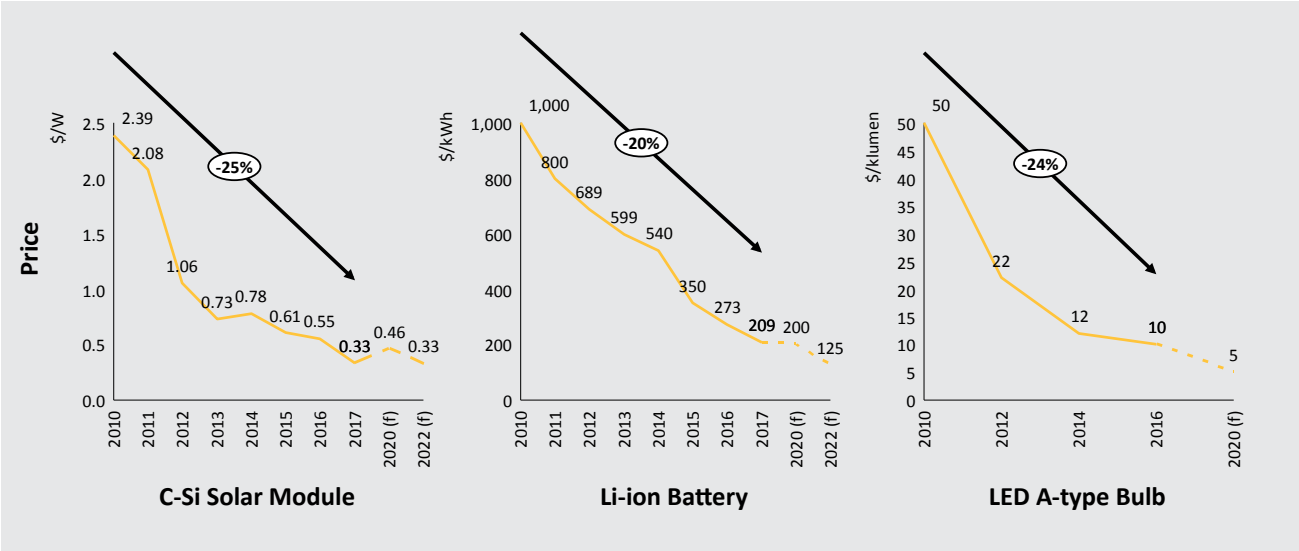


- *Appliances: Step changes in efficiency continue to improve end-user access.* The most powerful driver in improving the affordability of solar services—beyond lighting alone—is the jump in appliance efficiency. As described in Section 1B.4, a plethora of DC appliances, such as pumps, refrigerators, TVs and fans have experienced rapid improvements in wattage requirements, enabling them to run on lower capacity SHS, and thereby increasing affordability for end users. Key innovations include improved brushless DC permanent magnet motors and blade design for fans; improved LEDs, efficient optical films, and panel designs that require less lighting for TVs; and improved insulation materials and brushless, variable DC compressors for refrigerators. Global appliance sales outside of the OGS sector are expected to continue to drive costs down.
- *Panels: Falling panel prices are likely to stabilize.* The price of PV panels (C-Si) dropped steeply between 2010 and 2012, driven by a 70% increase in global module production capacity between 2010 and 2011, and a drop in the price of polysilicon (from USD 80/kg to USD 30/kg) in 2011. This was followed by a period of strong demand from 2013 to 2016, exemplified by China doubling its installed capacity of solar in 2012 and 2013; in this period, prices fell, but not as precipitously as in preceding years. In 2017-18, there is likely to be a dip in prices again as leading manufacturers increase their installed capacity (over 60 GW of module production capacity was added in 2016) leading to over-supply in the market. As the market stabilizes, however, through the exit of some manufacturers as well as efforts by others to stabilize their margins, prices will be pushed up and will stabilize.

[114]Note: Mainstream appliance 2016: TV - Samsung's 19" Class F4000 LED TV; Fan - Benross 12" desk fan. Off-grid appliance 2016: Based on TV and fan 2016 ratings from the winners of GLOBAL LEAP competitions. Off-grid appliance 2020: Projections based on CLASP "State of the Off-Grid Appliances Market" report, 2015. Assumptions: Performance and range of uses are held constant. Specifically, lighting at 300 lumens, 1 phone charger, a 19-inch TV, <100L refrigerator, and a 12-inch fan. Performance/size of associated appliances held constant at 300 lumens, 12" fan, 19" TV and <100L fridge. Source: (CLASP & Dalberg, 2015); CLASP Global LEAP competitions (2016)

Figure 30: Evolution of price of OGS components[115]

Multiple units (2010-22)



- *LED Lights: Reports show an increase in efficiency.* Research from 2015 identifies the cost and efficacy of LEDs as primary cost drivers for pico solar products.[116] The price of A-type LED bulbs fell by 80% between 2010 and 2016, driven by falling LED chip prices, better thermal management, and falling packaging costs. Increases in efficiency (in lumen/Watt) also exert downward pressure on pico device costs. These efficiency improvements and price declines have led to the mainstreaming of modern LEDs in new devices, allowing manufacturers to reduce the PV panel size while maintaining performance constant. The pace of decline has been projected to slow down going forward, however, from a CAGR of 24% to a CAGR of 16%.[117]
- *Batteries: Lithium-ion dominates the industry and raises the bar for other technologies.* The price of a Li-ion battery pack has declined at a CAGR of 20% between 2010 and 2017; industry forecasts suggest that this could accelerate to a 32% annual drop up to 2022. This is driven by an increase in global manufacturing capacity and scale (as the mega-factories of large producers such as Samsung, LG Chem, Panasonic and Tesla begin production), sustained demand across industries, and heavy investment into R&D from multiple industries. Investment into batteries has flowed in primarily from the following sectors in recent years: IT (USD 4.5 billion), electrical equipment (USD 3.6 billion), renewable energy (USD 1.9 billion) and the automotive industry (USD 1.8 billion).[118] As a result of these cost declines and efficiency gains, Li-ion technology has been firmly established as the battery of choice for the bulk of Lighting Global/GOGLA-affiliated suppliers. As of 2017, 95% of certified pico devices now use Li-ion batteries, compared to 5% in 2010.[119] Sealed Lead Acid (SLA) batteries, however, remain common for component-based OGS devices, as well as systems above 150-200W, where they sometimes offer better economics. Going forward, lithium-ion is likely to continue its dominance in this industry for at least the next few years due to the absence of suitable, developed alternatives with comparable

[115]Source: C-Si prices: (IRENA, 2016a); (Munsell, 2016); (Vorrath, 2016); (GlobalData, 2017). L-ion prices: (Hensley, Newman, & Rogers, 2012); (Lacey, 2016); (Randall, 2017); (U.S. Department of Energy, 2017); (Driscoll, 2017); (Chediak, 2017). LED prices: (U.S. Department of Energy, 2016)

[116]Source: (Phadke, et al., 2015)

[117]Source: (U.S. Department of Energy, 2016)

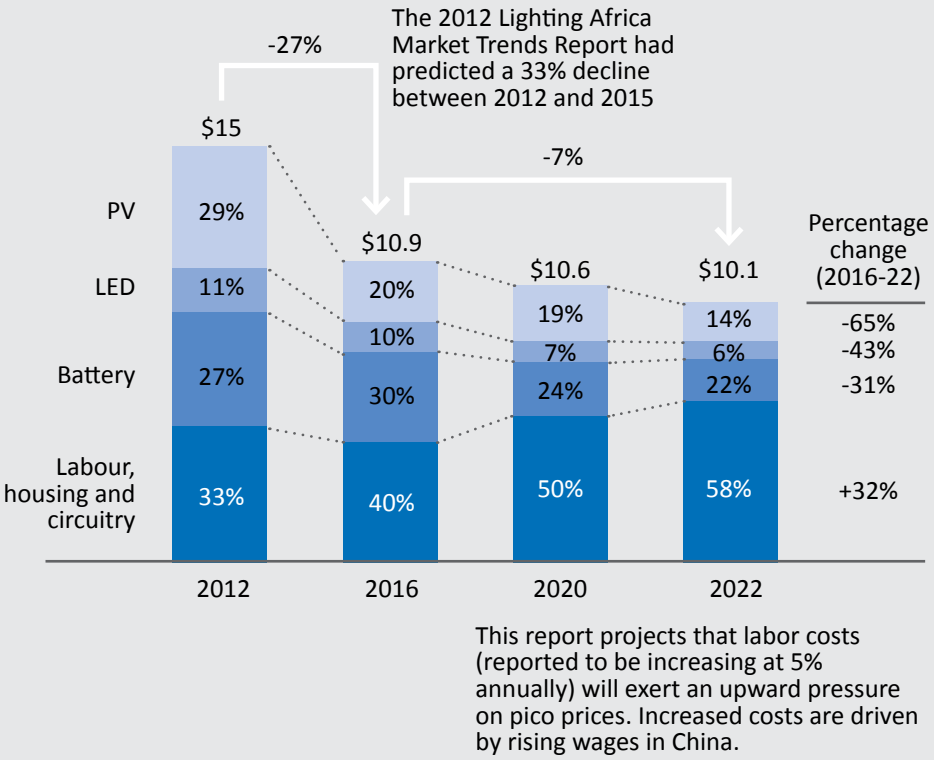
[118]Source: (Dansie, 2015); (Lacey, 2016)

[119]Note: Based on analysis of pico products (0-10W, with a few exceptions in the 10-15W range), with a sample of the total cumulative products in a given year (N-107). Source: Lighting Global; Dalberg analysis

energy density. Much of the investment in energy storage has been funneled into Li-ion technology, leaving little room for innovation in alternative technologies. For example, next generation batteries received only USD 40 million over the past eight years. Whereas, the investment in Tesla's Gigafactory, which will produce Li-ion batteries, alone reaches USD 5 billion. Furthermore, as Li-ion technology becomes cheaper and more efficient (due to this investment), the bar for other technologies to be more cost-effective than Lithium-ion will keep rising.[120]

Overall, the manufacturing costs of pico devices is expected to stabilize. Based on these trends, the manufactured cost of the median pico device fell by 43% between 2012 and 2016; in the long term, plateauing component costs and rising labor costs will stabilize it at an approximately 10% decrease.

Figure 31: Decomposition and forecast of the median pico component cost[121]
USD (2012-22)

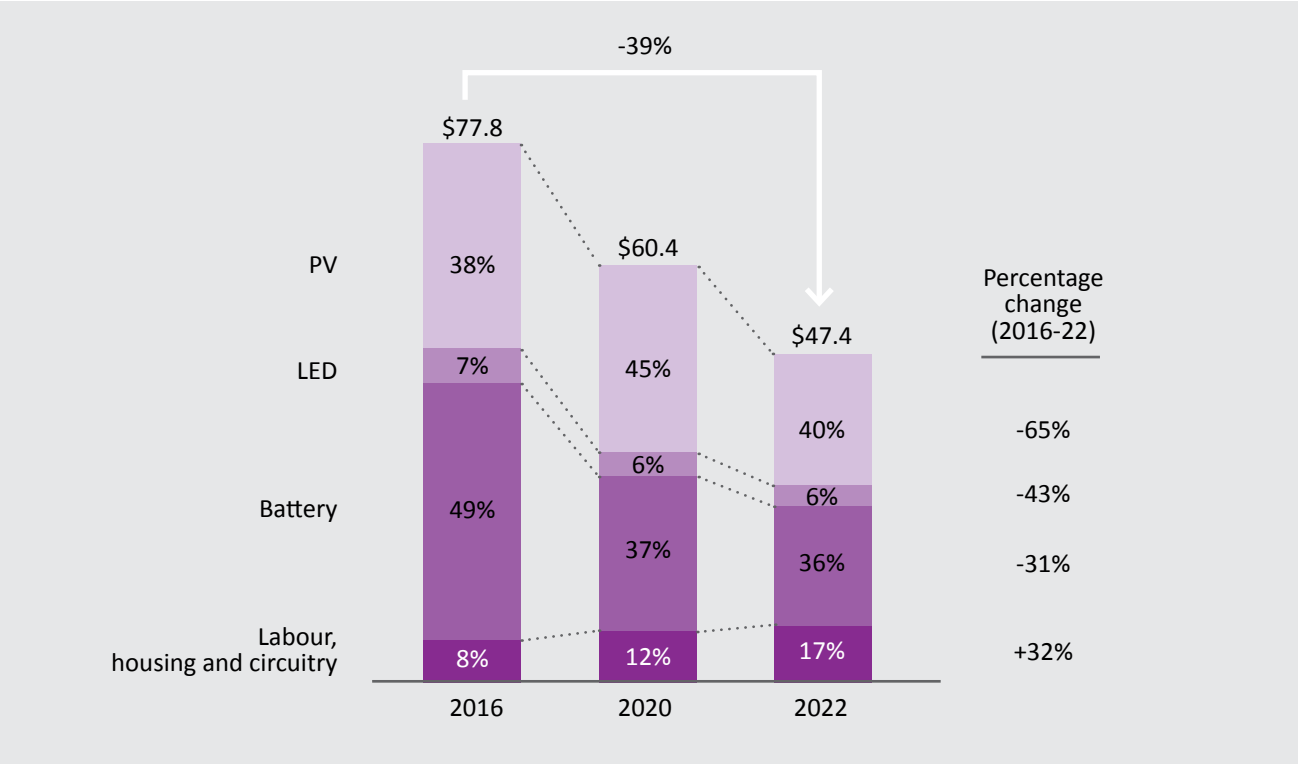


The impact of these trends will be more pronounced for SHS as the decline in battery costs, which contribute almost half of the total cost today, will have a larger impact on the overall cost of the system. The effect on end-consumer prices may be somewhat subdued, however, due to the other components and add-ons that add to the cost of today's plug-and-play systems, such as appliances.

[120] *Source: (Martin, 2016)*
[121] *Note: Holding performance constant for a PV of 3W, light output of 75 lumens and battery size of 14 Wh. Source: Dalberg research and analysis*

Figure 32: Decomposition and forecast for small SHS component costs[122]

(USD, 2016-2022)



3. **Rural connectivity: Improvements, with regional variations, are underway.** Better rural connectivity results in greater accessibility to affordable devices, and lower distribution costs. Moreover, it is also linked to greater productivity, economic growth and thus increasing incomes. Telecoms infrastructure and mobile money growth are a boon to PAYGO suppliers, seen especially in East Africa to date (see Sections 1B and 1C), where it has compensated for poorer transport infrastructure compared to Asia by reducing the cost of making payments.[123] In addition, transport infrastructure is especially key for product distribution. In South Asia, this has improved significantly in the past two decades (Figure 33). For example, in India, the Pradhan Mantri Gramin Sadak Yojana (PMGSY) – a government scheme that aims to provide all-weather road connectivity to all rural habitations across the country with a population of 500 or more (or in the case of hill states, tribal districts and desert areas, 250 or more) – has led to a host of benefits. These range from increased access to markets and a rise in incomes in the state of Himachal Pradesh, to market access benefits for dairy farmers in the state of Rajasthan; this is after meeting 64% of the overall target.[124] Since 2012, Bangladesh has rehabilitated or newly built 3,060 kilometers of 5,248 kilometers of tertiary roads to promote rural connectivity.[125]

[122]Note: Figures may not add to 100% due to rounding. This analysis holds performance constant for a PV size of 35 W, light output of 500 lumens, and battery size of 136 Wh. The analysis does not factor in the cost of appliances. Source: Dalberg research and analysis

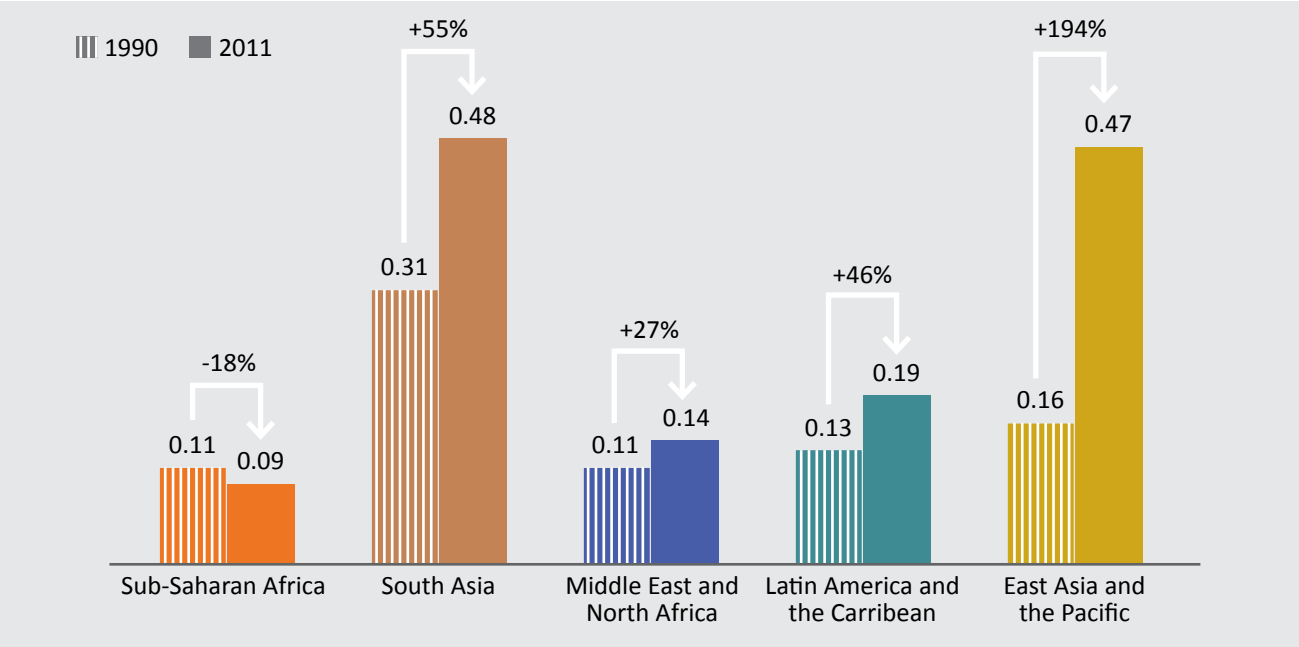
[123]Source: Industry interviews

[124]Source: (Hindustan Times Mint, 2017)

[125]Source: (World Bank, 2016d)

Figure 33: Quantity of road transport infrastructure[126]

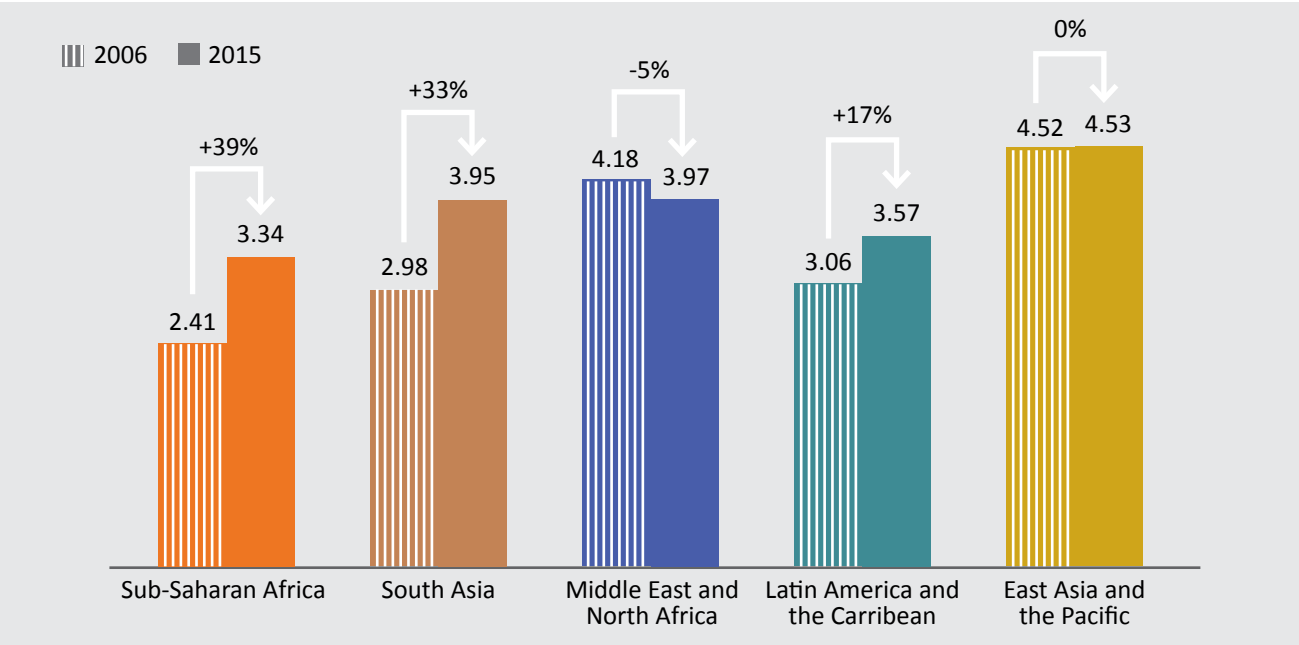
Km of road per km² of land area, median (1991-2011)



Sub-Saharan Africa, however, has lagged behind. According to the World Bank, it is the only developing region (among SSA, SA, MENA, LAC, and EAP) where road density has declined (by 18%) over the past two decades (Figure 33). Within the region, there is a large gap in road density for lower-income and lower-middle-income countries, compared to upper-middle-income countries.

Figure 34: World Economic Forum perception of road quality[127]

Score: 0 = Worst, 7 = Best (2006-15)



[126] *Source: (World Bank, 2017b)*

[127] *Source: (World Bank, 2017b); (World Economic Forum, 2006; 2015)*

However, recent years may be showing an improvement. The perception of road quality in Sub-Saharan Africa, as well as in other developing regions, shows an improving trend between 2006 and 2015 (Figure 34).[128]

In conclusion, the OGS sector is buoyed by a vast and diverse potential market.

The preceding sections have summarized the limited data available today about the off- and unreliable-grid populations that make up the potential market for the OGS sector. As discussed, the size of this dynamic market remains relatively stable despite underlying shifts due to population growth in off-and unreliable-grid areas (especially high in rural and low-income areas) and rising prevalence of unreliable-grid even as off-grid populations decrease in some regions.

Describing these populations only by population size, energy access, and economic terms, however, reduces them to a monolithic market. But in fact, although data on these populations is limited, they represent a vast and diverse set of markets comprised of heterogeneous consumers.

The challenges in connecting with these potential consumers, particularly as the market solidifies, suggest that a one-size-fits-all approach is impossible. If one looks to the experience gathered from other electronic goods and FMCG companies, one can see that deeper segmentation of these markets, including a focus on consumer behavior, has paved the way for market expansion and maturation. Compilation of rapid insights from Lean Data techniques,[129] investment in human-centered design, and use of personalized consumer data gathered from the PAYGO industry will help grow the OGS industry to best serve the future. Such an approach can help all players develop product design, communications, and offerings for the dynamic potential market in a more sophisticated manner.

[128] *Source: (World Bank, 2017b)*
[129] *Source: (Acumen, 2017b)*

1B. SALES

KEY MESSAGES

- OGS MARKET: Overall OGS penetration is growing. The pico segment saw slowing sales, while plug-and-play SHS have seen rapid growth from a small base, driven by PAYGO. Component-based systems are no longer a point of industry focus in most regions.
- REGIONAL TRENDS: Since 2016, pico sales by affiliates have fallen more sharply in South Asia than in Sub-Saharan Africa.
- COUNTRY TRENDS: Volume and relative market share of product sales are a function of local factors, including the policy and macroeconomic enabling environment, demand from the potential market, supply and distribution, and the maturity of the market.
- APPLIANCES: Consumers exhibit strong desire for appliances, with regional diversity in preferences. PnP SHS bundled with appliances—mostly radios, fans, and TVs—sell rapidly, and the universe of energy efficient appliances is expanding.

> “Sales in this market are just going to grow and grow. Off-grid solar is becoming more trusted and more affordable, and performance is continuing to rise—we can produce products today that weren’t possible even 18 months ago.”
>
> **- Richard Atwal, Renewit**

Overall OGS market: Growing penetration, with variation across segments.

The OGS market has evolved over time into three broad product segments: (1) pico, (2) plug-and-play SHS, and (3) component-based systems (institutional and open-market). There is much variation within these segments – in terms of business models, competitive dynamics, and target customers. In addition, more is known about companies affiliated with Lighting Global and GOGLA than the "non-affiliate" companies whose products comprise the remainder of the market, which makes some observations less definitive. Table 7 provides an insight into the constitution of these segments, and contains definitions of key terms used throughout this report.

Over 130 million OGS devices have been sold to date, in a market that is now generating approximately USD 1 billion in revenues annually, or about USD 3.9 billion to date.[130]

Table 7: Definitions of segments[131]

Segment	Definiton	Sub-segment	Definition
Pico	Lanterns and simple multi-light systems (which may enable mobile charging) of 0-10.999 Wp. These enable partial or full Tier 1 electricity access to a person or household.	Affiliate	Pico products of companies that are Lighting Global Program Associates, companies with products that are Lighting Global quality verified, or companies that are GOGLA members.
		Non-affiliate	Pico products of companies that are not affiliated to Lighting Global or GOGLA in any way, and whose products are either branded or generic (comprising no-names, copycats and counterfeits).[132]
Plug-and-play SHS	All-in-one packaged SHS kits of 11+ Wp, typically powering several lights as well as appliances, and enabling full Tier 1 or higher electricity access for a household.	Affiliate	PnP SHS products of companies that are Lighting Global Program Associates, companies with products that are Lighting Global quality verified, or companies that are GOGLA members.
		Non-affiliate	PnP SHS products of companies that are not affiliated to Lighting Global or GOGLA in any way, and whose products are either branded or generic (comprising no-names, copycats and counterfeits).

[130]Note: Revenue estimates include all product categories except institutional distribution of component-based systems, as these are typically not fully market-based. Estimates for non-affiliates are based on affiliate product category mix, and assume 30% lower prices among non-affiliates. Affiliate revenues based on GOGLA data (cash only) and on price estimates based on supplier interviews and the Lighting Global and Sendea/Mangoo databases; Estimate uses cash prices to estimate all sales due to limited reliable data on PAYGO revenues. Source: Lighting Global/GOGLA sales data; (Lighting Global); (GOGLA, 2016b); (Sendea, n.d.); Dalberg market model and analysis

[131]Note: Although some suppliers refer to multilight devices <11Wp as SHS, this report utilizes the pico and SHS product category definitions according to GOGLA and Lighting Global (GOGLA, 2017)

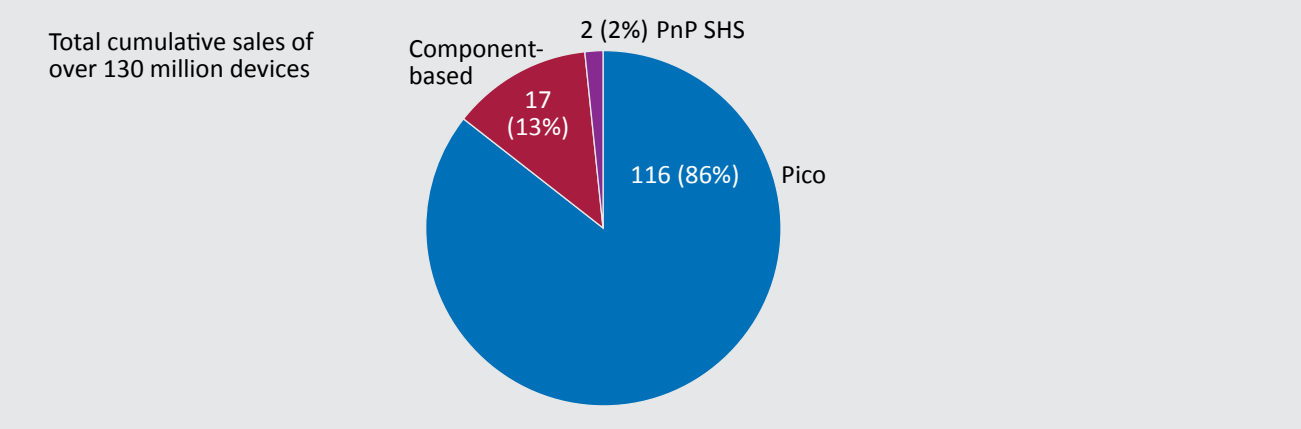
[132]Note: Generic terminology adopted from prior Market Trends Report. Source: (Bloomberg New Energy Finance, 2016)

Component-based systems	Devices in which components (i.e. PV module, battery, lights, inverter, wiring, etc.) are compiled independently. These devices are typically SHS (11+ Wp), but can be smaller.	Open-market	SHS devices in which customers purchase components from local markets and assemble themselves or via a retailer.
		Institutional/ govt. sales (non-affiliate)	SHS devices that are assembled from and distributed with the support of institutional subsidy programs such as Bangladesh's IDCOL or India's National Solar Mission.

A quick look at the market share between these segments reveals: (1) Pico devices retain the majority market share, as expected, comprising 85% of cumulative sales, or 116 million units to date. This reflects their low pricing and longer market presence vis-à-vis PnP SHS. (2) PnP SHS, which were practically non-existent as a product segment for BoP markets in 2010, have emerged strongly in the past three to four years. They account for around 2% of total OGS sales to date, or 2.5 million units to date. (3) Component-based system sales account for 13% of cumulative OGS sales. While initially driven by institutional and government distribution, they are now dominated by open-market sales, which first took off in the 1990s.

Figure 35: Cumulative OGS distributed to date[133]

Million units (2010-17 est.)



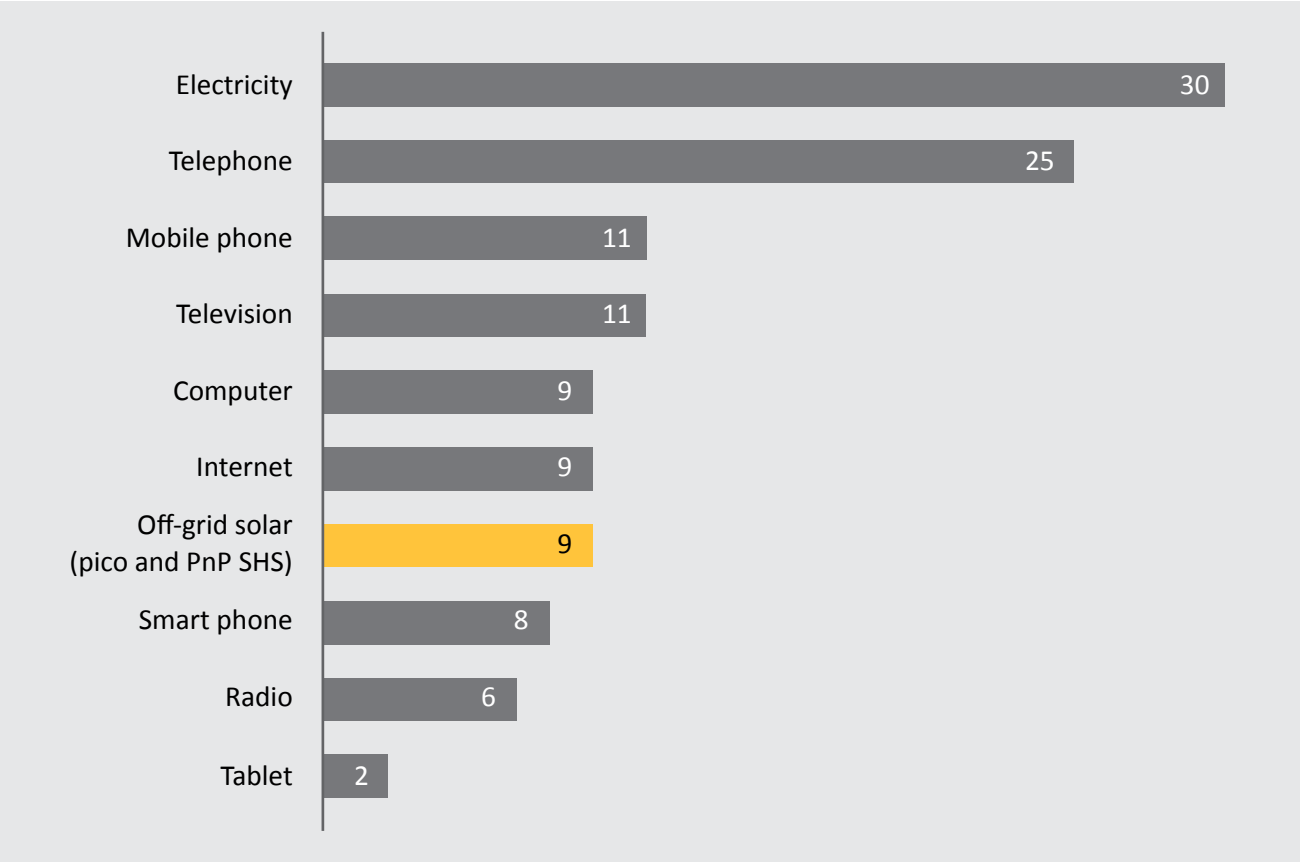
Taken together, OGS devices have penetrated 15-20% of the global potential market.[134] Their long-term growth rates are comparable to other FMCG industries in the US, such as smart phones and computers (see Figure 36). Packaged OGS device sales globally were estimated to have penetrated 10% of the global off- and unreliable-grid population by 2015.[135] Unlike penetration timelines for other industries depicted (which are based on US penetration data), OGS penetration has been achieved in an environment of low consumer awareness, coupled with distribution and affordability challenges endemic to the low-income countries that form the majority of the OGS market. Timelines to further penetration are likely to be even shorter given that 15-20% of the global off- and unreliable-grid population has already been penetrated as of 2017.

[133]Note: Figures may not add to 100% due to rounding. Cumulative sales refers to all devices sold to date, including those that have lapsed their warranties or have been discarded. Estimate includes affiliate and non-affiliate pico and PnP SHS, as well as component-based systems via institutional/government distribution and open-market sales. See definitions in Table 7. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

[134]Note: Penetration calculation discounts sales to assume 10% sales to repeat customers and 3% loss of devices sold, and assumes a 3-4 year product lifetime (GOGLA, 2016a)

[135]Note: Figure is based on affiliate and non-affiliate sales of pico and PnP SHS devices. It does not incorporate component-based systems distributed via institutional programs or the open-market, given that these are not market based or are based on penetration of component industries, which differ from OGS-specific applications

Figure 36: Time from consumer availability to 10% penetration[136]
Years



1B.2 SEGMENT-WISE TRENDS

In the past several years, sales trends have diverged across the pico, PnP SHS and component-based product segments. This section describes trends for each segment that are common across most geographies. Section 1B.3 then reviews context-specific trends on a regional and country basis.


Photo credit: GOGLA

[136]*Note: OGS years of penetration were calculated using Lighting Africa's founding year (2007) as proxy for the launch of the pico and PnP SHS industry (earlier introduction of costlier and less functional component-based SHS since the 1980s may have nonetheless provided onramps for consumer awareness and distribution. Estimate incorporates pico and PnP SHS sales using the methodology described in Footnote 134, and does not include penetration of component-based SHS. Penetration figures for other products based on US penetration rates. Source: Lighting Global/GOGLA sales data; (DeGusta, 2012); (International Energy Agency, 2017b); Dalberg market model and analysis*

Figure 37: Annual sales of OGS devices, across categories[137]

Million units (2010-17 est.)

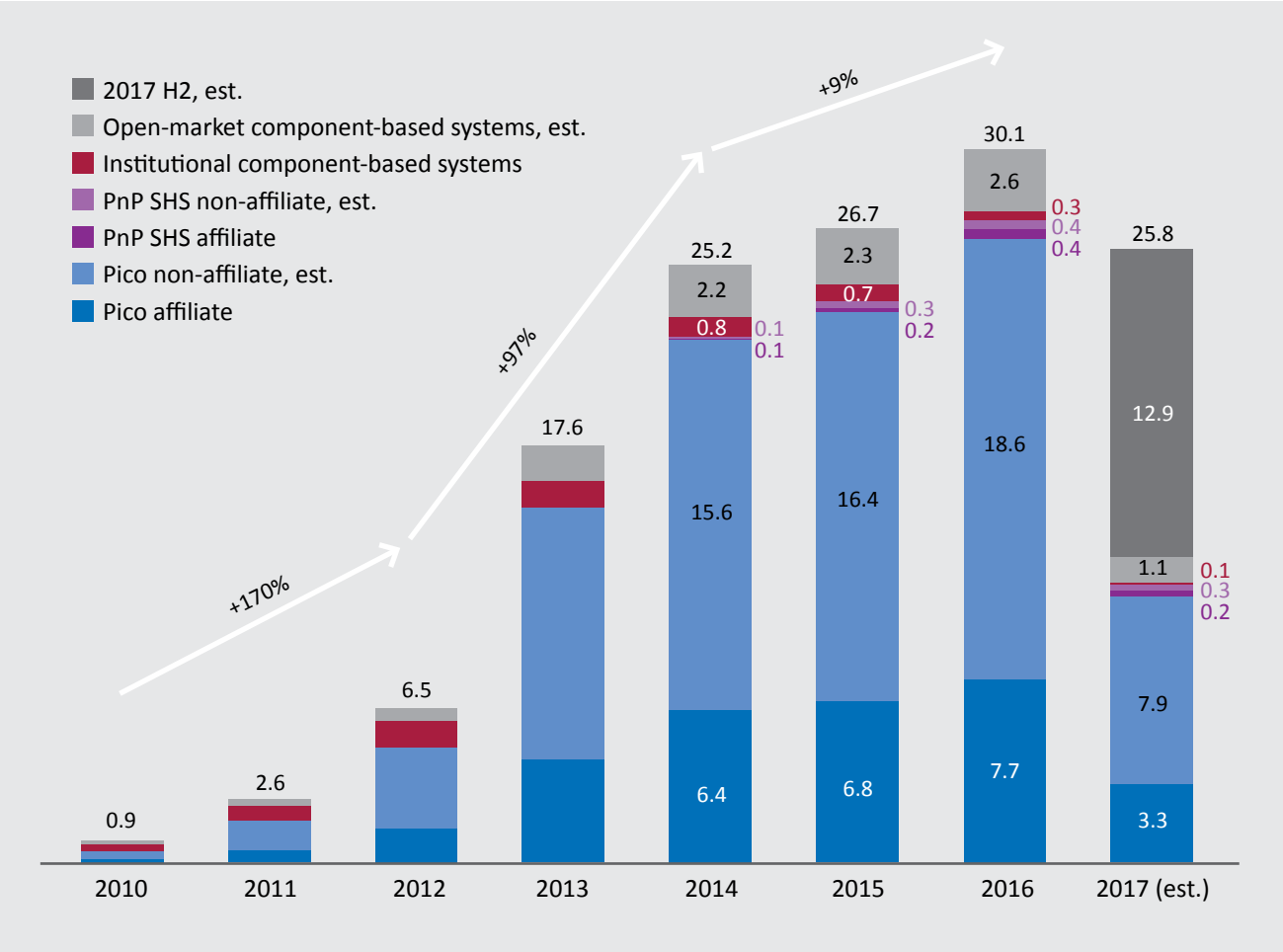


Figure 37 showcases estimated sales for all segments of devices and inclusive of both affiliate and non-affiliate suppliers. As shown, initial explosive growth has slowed since 2014, and is now expected to contract for the first time in 2017 based on data from the first half of the year. This is also reflected in overall industry revenues (see Figure 38), which are also expected to contract slightly in 2017. This contraction is reflective of the growing base of existing OGS customers as well as segment and geography specific trends explored in the remainder of this section and in Section 1B.3.

[137]Note: See definitions in Table 7 and non-affiliate estimation methodology described in Footnote 149 and throughout the following section. 2017 H2 estimate assumes H2 sales are equivalent to H1 sales, and comprises estimates across all product categories. Institutional/government component-based systems only account for distribution in Bangladesh, India, and Myanmar. 8000 Lighting Global/GOGLA affiliate sales in 2015 are uncategorizable and not shown. Lighting Global commenced data collection on sales of Lighting Global quality verified products in 2009, covering 25 countries by 2014. Since 2014, GOGLA has also collected sales data from its members, reporting member sales jointly with Lighting Global. Given this, affiliate data prior to 2014 represents a smaller base of products. Non-affiliate sales and open-market component-based sales are represented as constant ratios in this constants in this report due to lack of data and given to the relatively short duration of the industry, but this likely overestimates non-affiliate sales and underestimate open-market component-based sales in the industry's early years. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

Figure 38: Estimated annual OGS revenues[138]

USD millions (2014-17 est.)

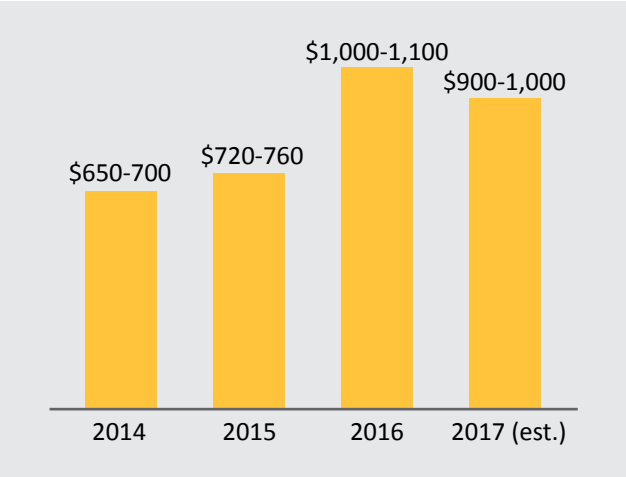
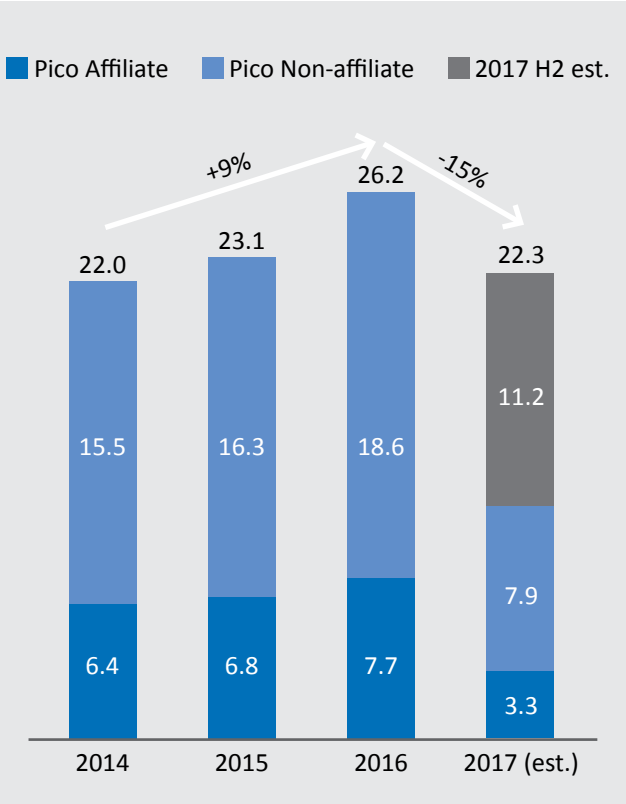


Figure 39: Estimated annual pico sales[140]

Million units (2014-17 est.)



Pico: Slowing sales in recent years. Larger systems selling better.

Sales growth in the pico segment has dropped sharply in the past two years across both affiliate and non-affiliate suppliers. Sales growth in this segment had tracked aggressive projections from earlier in the decade with 102% annual growth between 2012-14 (albeit from a small base), but decreased to 9% growth during 2014-16. While slowing growth rates is natural for a sector that, as of 2016, had a base of over 90 million cumulative devices sold (including close to 30 million affiliate devices), the sharp decline was still surprising.

Early numbers from 2017 indicate a year-on-year decline in absolute terms, unless the market picks up in the second half of the year; this trend is also reflected in pico revenues, which had been growing until the 2017 drop in sales. Cumulative sales of pico devices have reached an estimated 100 million units, around a third of which are affiliate sales, and have generated approximately USD 2 billion in revenues since 2014.[139]

Why the slowdown in the pico segment? Localized shocks in several key markets, as well as structural trends in the OGS market globally are responsible:

Localized shocks in several key markets explain a large part of the current slowdown. In India, demonetization (the sudden removal of INR 500 and 1,000 bills amounting to 86% of currency in circulation, in November 2016) caused a rural cash crunch in the world's largest pico market. A major drought in Kenya and Tanzania constrained consumer incomes in the region. And Nigeria's economic crisis devalued the naira, which inhibited customers purchasing power and led to lower access to foreign

[138]Note: Revenue estimates include all product categories except institutional distribution of component-based systems, as these are typically not fully market-based. Estimates for non-affiliates are based on affiliate product category mix, and assume 30% lower prices among non-affiliates. Affiliate revenues based on GOGLA data (cash only) and on price estimates based on supplier interviews and the Lighting Global and Sendea/Mangoo databases; Estimate uses cash prices to estimate all sales due to limited reliable data on PAYGO revenues. Source: Lighting Global/GOGLA sales data; (Lighting Global); (GOGLA, 2016b); (Sendea, n.d.); Dalberg market model and analysis

[139]Note: See Footnote 138 for estimation details. Source: Lighting Global/GOGLA sales and revenue data; (Sendea, n.d.); Dalberg market model and analysis

[140]Note: See Table 8 and Footnote 149 for details on non-affiliate estimation. 2017 H2 estimate assumes H2 sales are equivalent to H1 sales and comprises both affiliate sales and non-affiliate estimates. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

exchange for OGS suppliers. OGS sales volumes remain relatively geographically concentrated, and these four countries represented over two-thirds of global affiliate pico sales in 2016. Each recorded a sharp slide in affiliate pico sales between 2016 H1 and 2017 H1; sales are approximately 35% lower in Kenya and India, 40% lower in Nigeria, and 60% lower in Tanzania. It should be noted that these localized shocks broadly affected sales of consumer and/or FMCG products in these countries, and not just OGS products, and many sectors have revived since. For example, in India the sales of FMCG goods (including biscuits, salty snacks, soaps, shampoos, and washing powders, among others) fell by 20-40% post November 2016.[141]

In some cases, the effects of localized shocks were limited to OGS devices. For example, in Ethiopia, mandated local testing of every product (including systems passing Lighting Global quality verification standards) in an environment with low testing capacity led to already-quality verified products being held in customs, while multiple non-affiliate products bypassed authorities and went directly to customers. This led to an immediate, rapid decline in affiliate sales in 2016, though this has since been resolved.

> "The drought in Sub-Saharan Africa has affected us, since 80% of OGS consumers derive some income from farming, but this has mostly been for small systems. The dip in sales has not affected larger systems very much."
> **- Affiliate supplier**

Further discrete country-level factors (including how affiliate and non-affiliate segments interact within countries) are explored in depth in Section 1B.3.

Structural trends across the OGS market globally:

- *Exhaustion of the low-hanging fruit in major markets.* Due to the difficulty of large scale distribution to remote markets, most companies have focused on relatively easier commercial options. These include targeting customers that are closer to cities, have higher spending power, and are often already connected to some level of electricity. Even relatively mature markets see affiliate pico products concentrated in denser urban and peri-urban areas. In Kenya, suppliers struggle to reach lower density areas in the North and East; sales in Tanzania are concentrated in densely populated areas around Arusha, Dar es Salaam, Highlands, and Lake Zone.[142] This implies that there are yet untapped areas in these markets. The industry cannot maintain previous growth rates if it continues to focus on easy-to reach markets, and innovations and investment in business models and distribution will be required to expand to last-mile areas. Currently, reaching customers in remote (and sometimes less secure) rural regions is estimated to add 20-50% to distribution costs, which is often unviable for consumers in lower-income remote regions.[143]
- *Uneven real income growth.* Past forecasts relied partly on strong real income growth, however, while average incomes have risen, many of the gains have not gone to those that typically consume OGS products (for example, in India, the share of the country's wealth held by the top 1% grew from 40% in 2010 to 58% in 2016).[144]

[141] *Source: (First Post, 2017)*
[142] *Source: (Hystra Hybrid Strategies Consulting, 2017a)*
[143] *Note: See Figure 26 for further detail on rural distribution costs. Source: Industry interviews*
[144] *Source: (Jha, 2017)*

- *Cannibalization at the upper end of the pico market from PnP SHS.* PnP SHS products (especially lower-wattage devices) now have product economics that resemble those of pico due to the emergence of PAYGO financing models. Yet these products deliver a higher value proposition—a boon for consumers. At the same time as sales in pico have slowed and recently dipped, affiliate PAYGO sales grew at a CAGR of 141% in the last three years.
- *Increasingly commoditized pico market,* where differentiation among players is substantially based on price. In the early days, companies affiliated with Lighting Global and GOGLA represented cutting edge design and quality. Yet as the industry matures, that product advantage has diminished. In this environment, affiliates have lost some market share to non-affiliates, who typically have greater flexibility on pricing and margins. It may also imply that affiliate sales have fallen faster than non-affiliate sales in markets experiencing a slowdown in 2017. Due to increased competition, the market has also started to see market exits, where before it only saw the entrance of new players.

  While previous estimates put the non-affiliate sales market share at 66%,[145] recent data suggests it averages 71% globally, based on a weighted average of 16 countries for which estimates were developed.[146] While sales data for non-affiliate devices is not collected and/or reported systematically, this study has estimated country-level non-affiliate market share based on: (1) interviews with suppliers and other industry experts; (2) interviews with Lighting Africa and Lighting Asia country/regional teams; (3) MTR 2018 interactive voice response (IVR) and field surveys conducted across Uganda, Nigeria, India and Myanmar (see Appendix A for further details);[147] and (4) desk research, including Lighting Global market research conducted by Ipsos.

  Outliers include 35% non-affiliate market share in countries like Kenya where affiliate brand investment is high, and 90%+ estimated in markets like Bangladesh, Pakistan, and Myanmar where affiliate investment remains low and proximity to Chinese exporters boosts wholesaler supply chains.[148] Table 8 highlights the wide range of estimates that exist across countries.

Table 8: Variation in market share estimates of non-affiliate pico devices by source[149]

Segment	BNEF (2016)	Interviews and desk research	Lighting Global/ Ipsos (2016-2017)	MTR 2018 Field Survey	Final estimates for MTR 2018
Global	66%				71%[150]
Kenya		30-55%	35%		35%
Tanzania		67-90%	72%		72%
Ethiopia		40-65%	57%		57%
Uganda		60-70%		49%	55%
Nigeria		80-85%		67%	70%
India		70-80%		75%	75%
Myanmar		90%		100%	90%

[145]*Source: (Bloomberg New Energy Finance, 2016)*

[146]*Note: Based on weighted average of final estimates from 16 countries. See Table 8 for additional details.*

[147]*Source: (Lighting Global/Dalberg, 2017)*

[148]*Note: Industry interviews also suggest that within countries, non-affiliate market share is often higher in port cities and border towns, where wholesale shipments of non-affiliate goods are able to easily flood local markets*

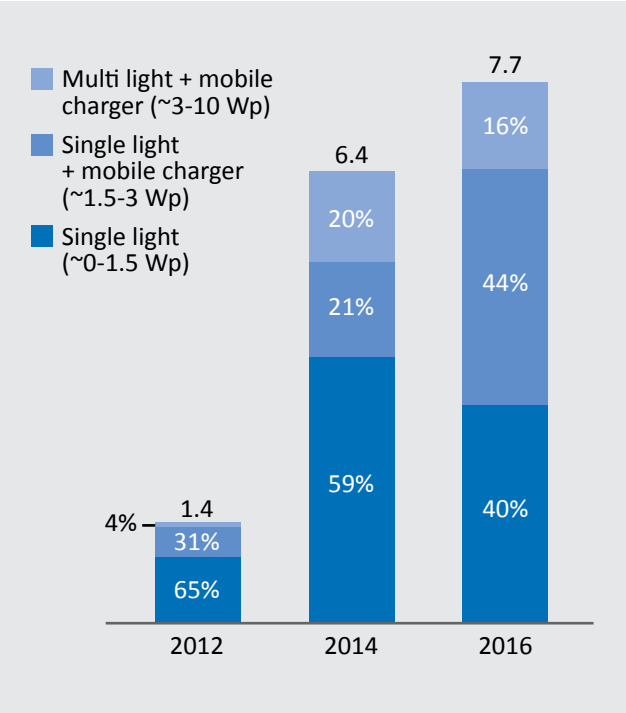
[149]*Note: The use of ratios to estimate data-poor non-affiliate sales as shown in Table 8 may over or under-estimate total sales where drivers of affiliate and non-affiliate sales diverge. These ratios are employed as constants in this report given to the relatively short duration of the industry, but likely overestimate non-affiliate sales in the industry's early years. All country level figures that include non-affiliates (including penetration calculations) use country-specific non-affiliate market share estimates. Source: (Bloomberg New Energy Finance, 2016); (Ipsos, 2016a); (Ipsos, 2016b); (Ipsos, 2017); (Lighting Global/Dalberg, 2017); Dalberg market model and analysis*

[150]*Note: Based on weighted average of final non-affiliate estimates from 16 countries. See Footnote 149 for further detail*

Demand for larger multi-light systems is growing faster than other segments. Among affiliates, recent sales have seen the share of single-light pico decrease relative to devices with higher power and service levels. It is expected that this trend will intensify, especially in the multi-light + mobile category, which has a high concentration of PAYGO. It is important to note, however, that the product-category trends noted in Figure 40 reflect a changing menu of products available for consumer uptake. These include increased higher-power product offerings in recent years, as well as changes in the subset of companies affiliated with Lighting Global and GOGLA.

Figure 40: Annual global sales of affiliate pico devices by size[151]

Million units; <11Wp categories (2012-16)

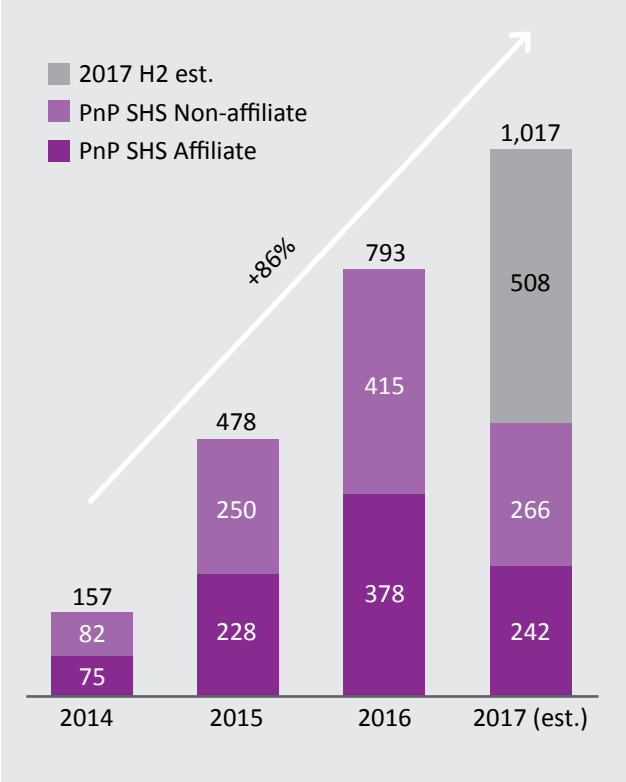


Plug-and-play SHS: Rapid growth from a small base, driven by PAYGO.

Plug-and-play SHS sales have grown rapidly from a small base since 2013-14. The segment accounts for less than 5% of total annual OGS distribution, yet makes up 20-30% of annual revenues. Cumulative sales of PnP SHS kits have grown to an estimated two million units, of which 1.2 million are affiliate sales. Since 2014, the segment has generated USD 400-500 million in revenues.[152]

Figure 41: Estimated annual plug-and-play SHS sales[153]

Thousand units (2014-17 est.)



[151]Note: Figure reflects sales data of active Lighting Global and GOGLA affiliates in each year and may not be representative of the total pico market. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

[152]Note: Estimate uses cash prices to estimate all sales due to limited reliable data on PAYGO revenues. See Footnote 138 for other estimation details. Source: Lighting Global/GOGLA sales data; (Lighting Global); (GOGLA, 2016b); (Sendea, n.d.); Dalberg analysis

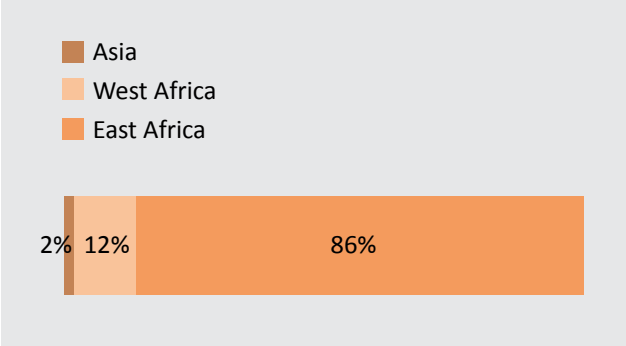
[153]Note: See Footnote 149 for details on non-affiliate estimation. 2017 H2 estimate assumes H2 sales are equivalent to H1 sales and comprises both affiliate sales and non-affiliate estimates. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

The standout OGS growth story of the last three years has been PAYGO-based PnP systems. They made up over 80% of systems sold by Lighting Global and GOGLA affiliates in 2016.[154] PAYGO-based PnP systems (most of which are SHS, but some are pico) SHS grew at an average rate of ~140% (2013-2016); if projected sales provided by companies interviewed for this report in mid to late 2017 are realized, cumulative PAYGO sales will have exceeded 2 to 2.5 million by the end of 2017.[155] While still small in overall numbers, the segment's revenues are expected to overtake total pico revenues in the next three to five years. This is due to strong growth, a much higher average unit price compared to pico prices, as well as the opportunity to upgrade customers to higher services levels as well as appliances. Most suppliers in the industry believe that nearly all future SHS growth will be driven by PAYGO systems, barring markets such as India where PAYGO growth is likely to be contingent upon mobile money and other digital forms of payment taking off.

Thus far, growth has been limited to countries with strong mobile money ecosystems, with particular crowding-in in East Africa. This signals both high growth potential in the future, but also the challenges of operating successfully in different regulatory environments (see Figure 42, as well as Figure 61 in Section 1C). Several countries in West and Central Africa (especially Nigeria and the Democratic Republic of the Congo) are already showing healthy mobile money growth.[156] India, the largest OGS market in the world, currently has very low PAYGO penetration corresponding largely to its minimal mobile money market and relatively low uptake of PnP SHS to date. It is, however, poised for significant growth in mobile and digital transactions over the next five years. Mobile money has proved the most streamlined mechanism of payment for PAYGO operators, but as PAYGO technology and business models mature and diversify, digital money may be less of a constraint.

Figure 42: Geographic share of the PAYGO market[157]

% cumulative unit sales; n=11 players (2013-17)



Affiliate PnP SHS surpass those of non-affiliates in most but not all markets. The PnP SHS segment differs significantly from the pico segment in that the bulk of market share belongs to affiliate suppliers in most geographies. Insights from interviewees suggest that non-affiliates represent a minority of PnP SHS sales in most countries, with just 20-40% market share in nearly all markets. The main exceptions are Tanzania, Myanmar, and India, where non-affiliate PnP SHS suppliers (such as Pro-Solar in Tanzania, and SELCO in India) are estimated to have captured large chunks of market share, 57%, 75% and 71%, respectively.[158]

Affiliates have been able to retain market share for several reasons:

- *Greater barriers to entry.* While the pico segment has become commoditized in key markets, typical PnP SHS production requires investments in PAYGO integration, especially for intelligent semi-conductors (for PAYGO-enabling); this poses an entry barrier for smaller players. Beyond technology, the main barriers are larger working capital requirements (for inventories and financing consumer receivables), establishing and maintaining distribution and after-sales service networks,

[154] *Source: Industry interviews; Dalberg analysis*

[155] *Note: This figure includes PAYGO products under 10.999 Wp and classified as pico in this report per the Lighting Global/GOGLA product categories*

[156] *Source: (Patterson, 2016)*

[157] *Note: Cumulative sales of 11 PAYGO players across geographies. While the numbers may change by adding in sales of more suppliers, these estimates are directionally accurate. Source: Industry interviews; company websites; Dalberg research and analysis*

[158] *Note: Key non-affiliate PnP SHS brands in these countries include Pro-Solar (Tanzania); GD Lite, Hong Xing, and Makasen (Myanmar); and SELCO (India). Source: Industry interviews; (Lighting Global/Dalberg, 2017); (SELCO India, n.d.); (Ipsos, 2016b) (Ipsos, 2016a); (Ipsos, 2017); (Lighting Myanmar, 2016)*

and establishing credit-risk management and data collection mechanisms. By and large, these capability requirements have tended to favor specialized (and often vertically integrated) players, as opposed to the commoditized manufacturers that typically dominate the non-affiliate pico segment.

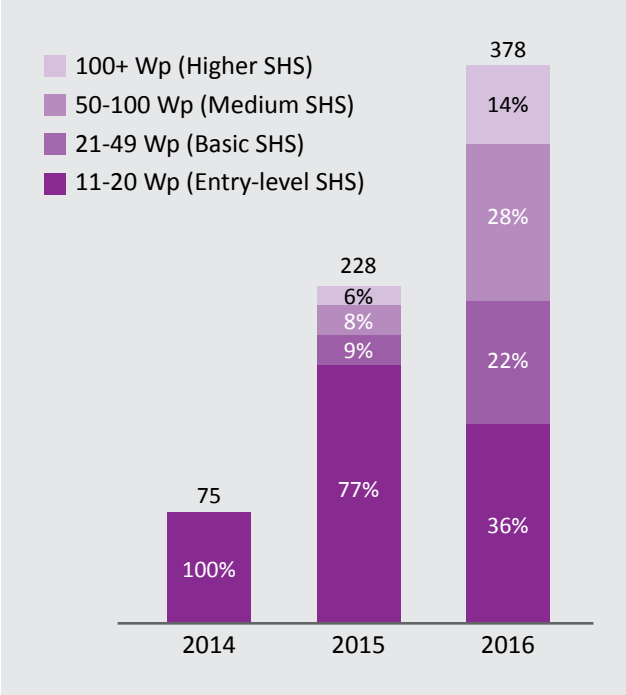
- *More quality-conscious customer-base.* As customers move up the energy (and price) ladder, they become more conscious of product quality. Customers of higher level products also rely more heavily on installation and after-sales services, which most non-affiliates are unable to provide.
- *Provision of consumer financing.* PAYGO and MFI-driven financing is typically only available on affiliate products.[159] The availability of consumer financing is one of the biggest drivers of SHS sales, enabling customers to purchase systems retailing anywhere between USD 125 and USD 800 that they would not have been able to afford previously. MFIs are keenly aware of the non-payment risk involved in supplying any kind of products. As such, MFIs typically partner exclusively with well-known brands, most of which are affiliates whose manufacturer's warranty can equal or exceed the credit period, and whose company is credible enough to cover system failures and other such issues.

At the same time, as discussed in Section 1B.3, there are some markets, such as Myanmar, where affiliates face a high degree of competition from component-based systems that are delivered via institutional programs or assembled on the open-market.

There is an emerging preference for higher-wattage PnP systems, driven by a desire for appliances. Consumers increasingly display preferences for systems that have the capacity to offer a higher level of service than lighting. This trend is reflected not only in the shift in affiliate sales segments shown in Figure 43, but also in emerging findings from the UNCDF CleanStart research in Nepal, which found marked preference for devices that can power appliances (see Section 1B.4 for further discussion on appliances).[160]

Figure 43: Annual global sales of affiliate PnP SHS devices by size[161]

Thousand units; >11W category (2014-16)



Component-based systems: No longer an industry focus in most regions, and quality remains highly variable.

Component-based systems represent a third category of OGS products, alongside pico and PnP SHS products (see Table 7 for definitions). They may be introduced through government and institutional programs, or acquired in the open-market by consumers themselves.

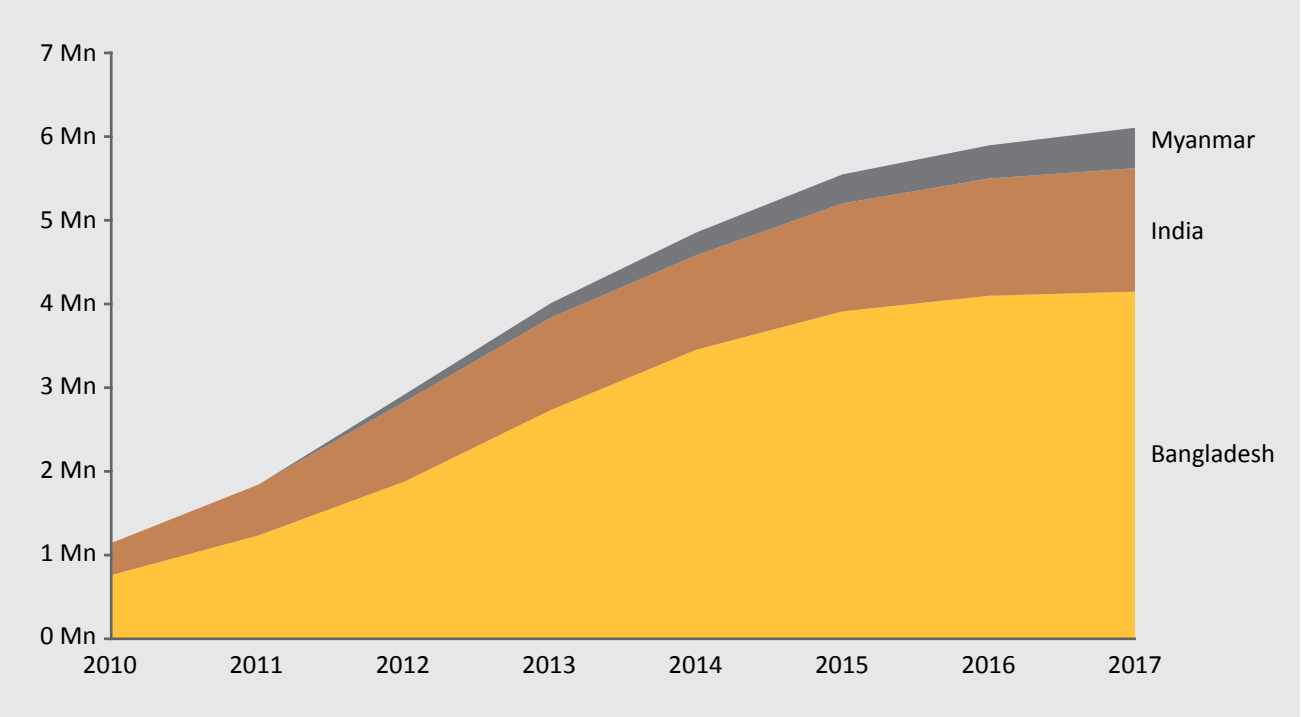
[159] *Note: A notable exception includes SELCO, a non-affiliate branded supplier which has sold 200,000 SHS in India to date, compared to less than half as many sold in India by affiliate suppliers. SELCO's business model has leveraged partnerships with a range of banks, NGOs and cooperative to finance solar systems for poor households*

[160] *Source: (UNCDF, 2017)*

[161] *Note: Figure reflects sales data of active Lighting Global and GOGLA affiliates in each year, and may not be representative of the total pico market. No affiliate PnP SHS sales were recorded prior to 2014. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis*

For over two decades, large institutional and government programs have distributed approximately seven million component-based systems either for free or at variously subsidized rates.[162] The largest active programs today include Bangladesh's IDCOL program, India's National Solar Mission, and Myanmar's National Electrification Program (see Figure 44). These programs follow a long history of smaller national and state level programs in these and other countries in Asia, Sub-Saharan Africa, and Latin America.

Figure 44: Cumulative institutional distribution of component-based systems[163]
Million units; select countries (2010-17 est.)



In parallel, consumers in these and other markets are independently assembling SHS using PV modules, batteries, lights, and other components from the open-market. To date, data on these "open-market" component-based system sales has remained opaque, given the decentralized and often informal nature of component sales.

Open-market sales of component-based systems may be larger than previously believed, and are especially ubiquitous in Asia. New estimates suggest the open-market segment may represent as much as 9% of all OGS system sales globally to date.[164] Little is known about the changing share of open-market component-based systems over time. It is clear, however, that market share varies significantly by country, from as much as 60% of all OGS devices in Myanmar, where such systems are the norm, to less than 5% in most of East Africa

[162]Note: The subsidies provided in institutional programs vary widely, and are typically phased down over time in long term programs. Myanmar's National Electrification Program represents a higher range, offering an 85-90% subsidy in Round 1 (2016) of Myanmar's National Electrification Program, projected to drop to 80% by Year 5 of the program; Bangladesh's IDCOL program represents a more lightly subsidized program, which offered 25% subsidies in 2004, dropping to 10% by 2012 and then shifting to a semi-commercial consumer financing scheme. Source: (ADB, 2015); (Lighting Myanmar, 2016); industry interviews

[163]Source: India, Bangladesh and Myanmar government materials; (Hystra Hybrid Strategies Consulting, 2017a); Dalberg market model and analysis

[164]Note: Figure is calculated on a base of all affiliate and non-affiliate pico and PnP SHS, as well as institutional and open-market component-based systems. It is calculated as a weighted average of 16 markets for which directional estimates exist. Estimates are included in this report as a constant over time due to limited information on annual sales in the past five years, however findings from the MTR IVR and field surveys suggest that sales remain significant. Source: (Hansen, Pedersen, & Nygaard, Review of Solar PV Market Development in East Africa, 2014); (Hansen, Pedersen, & Nygaard, Review of solar PV policies, interventions and diffusion in East Africa, 2015); (Ipsos, 2016a); (Ipsos, 2017); (Lighting Global/Dalberg, 2017); (Galpaya, 2016); (Government of Myanmar, 2014); (Government of India, 2011); (Jain, 2017); (IRENA, 2016b); industry interviews; Dalberg analysis

(where plug-and-play devices dominate) and other markets where institutional distribution programs have not primed the market. Lighting Global teams in Papua New Guinea and Myanmar have indicated that proximity to China and port cities is a key driver of the informal component trade; as a result, significant variation in the penetration of open-market component-based systems likely exists within countries as well.

Outside of Bangladesh and India—which have had continuous institutional distribution programs for more than a decade—the spread of component-based systems has largely been driven by direct consumer demand. Aligned with the low incomes of most off-grid consumers, many of the open-market systems identified in the MTR 2018 field surveys appear to be of very small size, often resembling multi-light pico devices sold by Lighting Global/GOGLA affiliates.[165]

Figure 45: Solar panel exports from China: An indicator of trends related to component-based sales[166]

Thousand units (left: Q4-2016 - Q3-2017; right: Q1-2010 - Q3-2017)

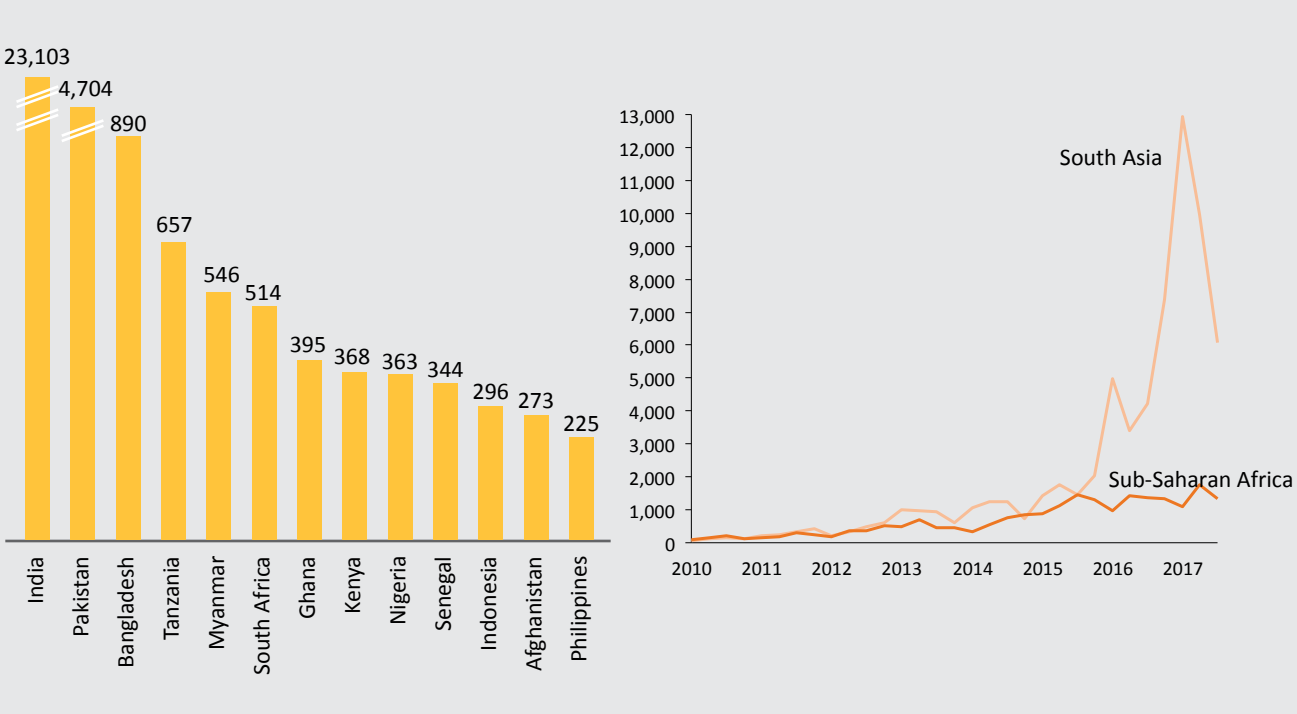


Figure 45 displays all PV panels exports from China for unit prices between USD 10-150, the majority of which are likely used for non-OGS applications (such as street lights, water pumps and industrial applications). However, even at an indicative level, this data suggests two insights. First, component-based sales (based on exports of loose PV panels) are likely much more significant in South Asia than in Sub-Saharan African countries, with particular divergence occurring in the past two years. This supports anecdotal evidence collected during interviews that identified Bangladesh, India, Myanmar, Pakistan, and Papua New Guinea as having large component-based sales. Second, component-based sales have also been affected by the general slowdown the OGS sector experienced in 2016-2017. As with the OGS sector, however, the overall trajectory for loose panel exports remains positive.

[165] *Source: (Lighting Global/Dalberg, 2017)*

[166] *Note: Figure displays exports from China of HS code 85414020, "Solar cells" to countries in Sub-Saharan Africa, South Asia, and select countries in East Asia and Pacific. Exports with unit value below USD 10 and greater than USD 150 not included, to filter out small parts and large PV panels unlikely to be used for SHS. These exports include panels exported for all purposes, including streetlights, solar pumps, industrial uses, etc.), and are not representative of the SHS market alone. Source: (Descartes Datamyne, 2017)*

Open-market sales lack quality-control processes and consumer financing. While some major institutional programs distributing component-based systems like Bangladesh's IDCOL and India's National Solar Mission vet suppliers and technicians to ensure quality, open-market sales have no such protections. For example, although some of the open-market systems identified in the MTR 2018 field studies included high-quality branded components, a significant portion comprised poor quality and counterfeit components (especially in countries with highly fluid trade with China like Myanmar and Papua New Guinea).[167] Consumers also often compile systems themselves with components of mismatched power, or do not include a control box when compiling their systems, leading to rapid battery failure as well as serious safety risks.[168] Due to the fundamental complexity of these systems, which requires significant technician training for safe installation and maintenance, many donors have shifted their attention from component-based systems toward the PnP SHS described earlier in this section.

Similarly, institutional programs have typically distributed component-based systems for free, or at subsidized and/or financed rates, but there is no consistent formal financing available for open-market system purchases. Some respondents to the MTR 2018 field studies reported using ad hoc retailer credit, and industry interviews suggests some customers stagger their component purchases as a form of self-financing, saving for each component piece-by-piece.[169]

However, open-market component-based systems also present several distinct advantages. First, components are often less expensive on a per watt basis than quality PnP SHS of similar power, though—as discussed above—they typically do not enjoy the consumer benefits of servicing, warranty protection and financing. Second, piece-meal purchases are inherently flexible and can be tailor-made to changing household needs. For example, Lighting Global experience in Myanmar suggests some households start by purchasing a battery to charge on a neighbor's solar panel or generator, and upgrade to their own panel when household needs grow or when income is available. Finally, this market segment leverages local technician and repair networks to install and maintain the systems, triggering job creation.[170]

There are opportunities to increase quality and availability of financing for users accustomed to component-based systems. Given the technical complexity and quality concerns described above, few industry watchers today regard the open-market component-based approach as a plausible pathway to scaling electricity access. The question for those approaching OGS, in all its forms, from an impact lens is whether opportunities exist to increase quality, safety, and financing within the open-market segment while maintaining the above advantages. Some concerns include:

- Can local technicians be more effectively trained to install and maintain quality systems, and to counsel consumers toward higher quality components, as was undertaken in Kenya?[171]
- Can high cost components such as solar panels and batteries be financed?
- Can consumers be supported to identify higher and lower quality components?
- What are the opportunities for PnP players to engage with component-based customers looking for modular upgrades (e.g. replacing shorter lifetime components such as batteries more often than PV panels)?

[167]Source: (Lighting Global/Dalberg, 2017); industry interviews

[168]Source: Industry interviews

[169]Source: (Lighting Global/Dalberg, 2017); industry interviews

[170]Note: Repair networks support the longevity of products in all categories, including plug-and-play systems. However, experience from Myanmar suggests that given growing familiarity with solar, most open-market systems are installed by consumers themselves, often without proper wiring

[171]Note: Kenya's energy regulations, in place in 2012, require solar PV technicians and vendors to undergo a licensing process based on a national training curriculum offered through 15-20 training institutions across Kenya. Licensing is offered at three levels of complexity, and at least 300 trained technicians had undergone the training by late 2015. Source: (Da Silva, Geoffrey, Nalubega, & Njogu, 2015)

Given the high prevalence of open-market component-based systems in markets like Myanmar and Papua New Guinea, OGS suppliers will need to adapt their marketing to the norms of customers accustomed to piece-meal purchasing. Kenya provides a useful case study for the future of this segment, showing a shift from a primarily component-based SHS market to a thriving pre-packaged PnP SHS market: In 2010, component-based systems represented an estimated 70-80% of the country's total OGS market. Yet today, following intensive investment to build the market for quality-verified and easy-to-use pre-packaged pico and PnP SHS, open-market component-based systems are believed to represent just 1-4% of annual OGS sales.[172] Kenya's shift, from a component-centric market to one in which pre-packaged devices are nearly ubiquitous, suggests that component-based systems will have an uphill challenge in an increasingly sophisticated product market that values quality.

There is little hard data available about the share of component-based systems over time and outlook for the coming years. Institutional distribution is subject to changing programmatic priorities: industry watchers suggest that such programs could become more numerous as OGS becomes increasingly recognized and integrated into national energy strategies, although many governments and donors are trending toward funding financing instruments rather than product distribution.[173] Component-based systems sold on the open-market are likely to remain present as exposure to solar PV in all its forms grows among consumers globally, but the experience of Kenya, noted above, suggests that the mass-market appeal and ease of use of PnP SHS may eclipse open-market component-based systems over time.

Photo credit: Lighting Ethiopia

[172]*Source: (Hansen, Pedersen, & Nygaard, Review of Solar PV Market Development in East Africa, 2014); (Hansen, Pedersen, & Nygaard, Review of solar PV policies, interventions and diffusion in East Africa, 2015); (KEREA, 2014); (Ipsos, 2016a); Dalberg analysis*

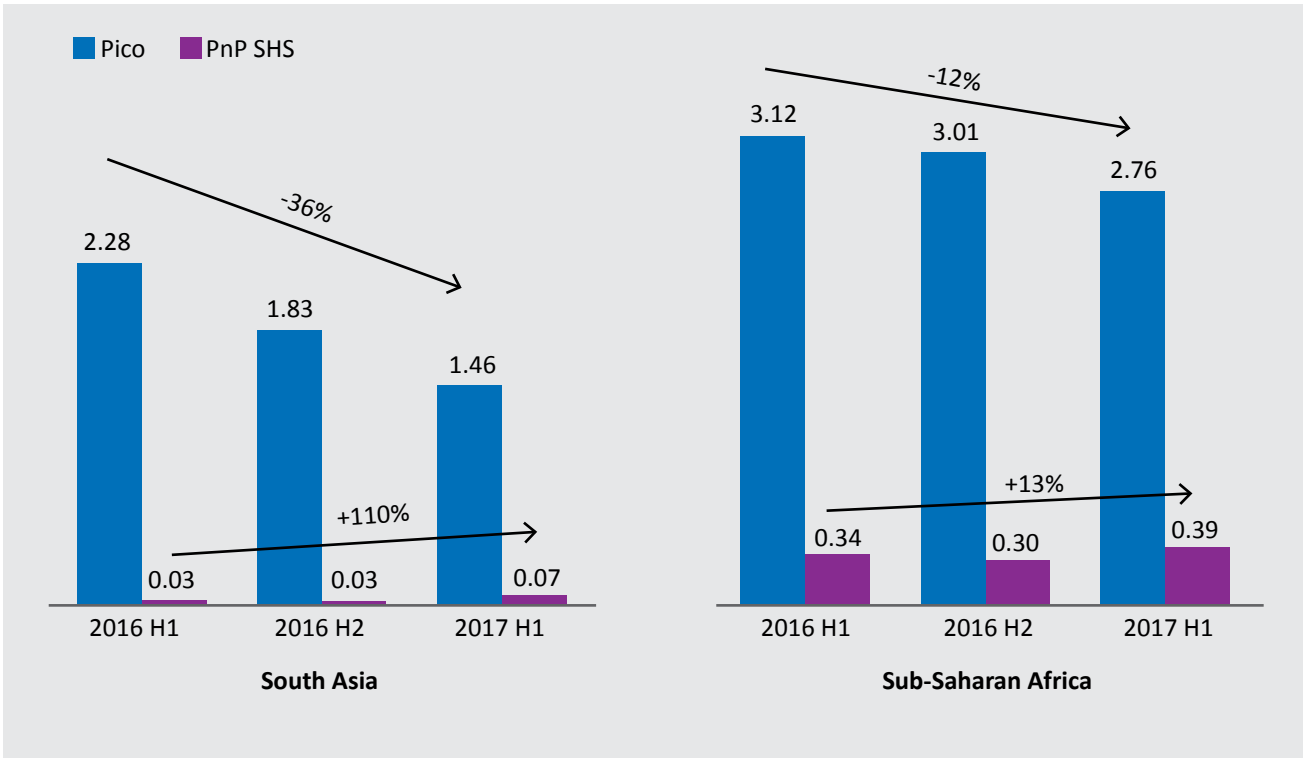
[173]*Source: Industry interviews*

Regional growth: Since 2016, pico sales by affiliates have fallen more sharply in South Asia than in Sub-Saharan Africa.

At a regional level, the 2016-2017 pico slowdown was felt most sharply in South Asia, where sales dropped by over a third from 2016 H1-2017 H2. As discussed in Section 1B.2, this was predominantly driven by exogeneous shocks in the Indian market. In Sub-Saharan Africa, the dip in pico sales was felt relatively less sharply (-12%). PnP SHS grew at close to 200% in both regions from 2015-2016, from a small base globally. Between 2016 H1 and 2017 H1, PnP SHS sales continued to jump in South Asia (110%) and West Africa (170%) albeit from a small base in both regions, but a small contraction in East Africa kept total Sub-Saharan African PnP SHS growth at 13%.

Figure 46: Regional sales trends, by product category[174]

Million units (2016 H1 - 2017 H1)



The interaction and trajectories of the segments discussed in Section 1B.2 usually plays out at the more granular country-level. The volume and relative market shares are a function of the enabling environment (local policies and regulations, as well as macroeconomic factors), demand (potential market), supply (distribution ecosystem and infrastructure), and the maturity of the market.

Figure 47 outlines the trajectories of select countries based on their market penetration and sales growth over the past several years. While each country's trajectory depends on context-specific factors, these indicators provide directional insight into the historical and future robustness of each market.

[174]Note: Figure includes affiliate sales and non-affiliate estimates (see Footnote 149 for details on non-affiliate estimation). Source: Lighting Global/ GOGLA sales data; Dalberg market model and analysis

Figure 47: Estimated sales and penetration of OGS devices in select markets[175]
% (2014 H2 - 2017 H1)

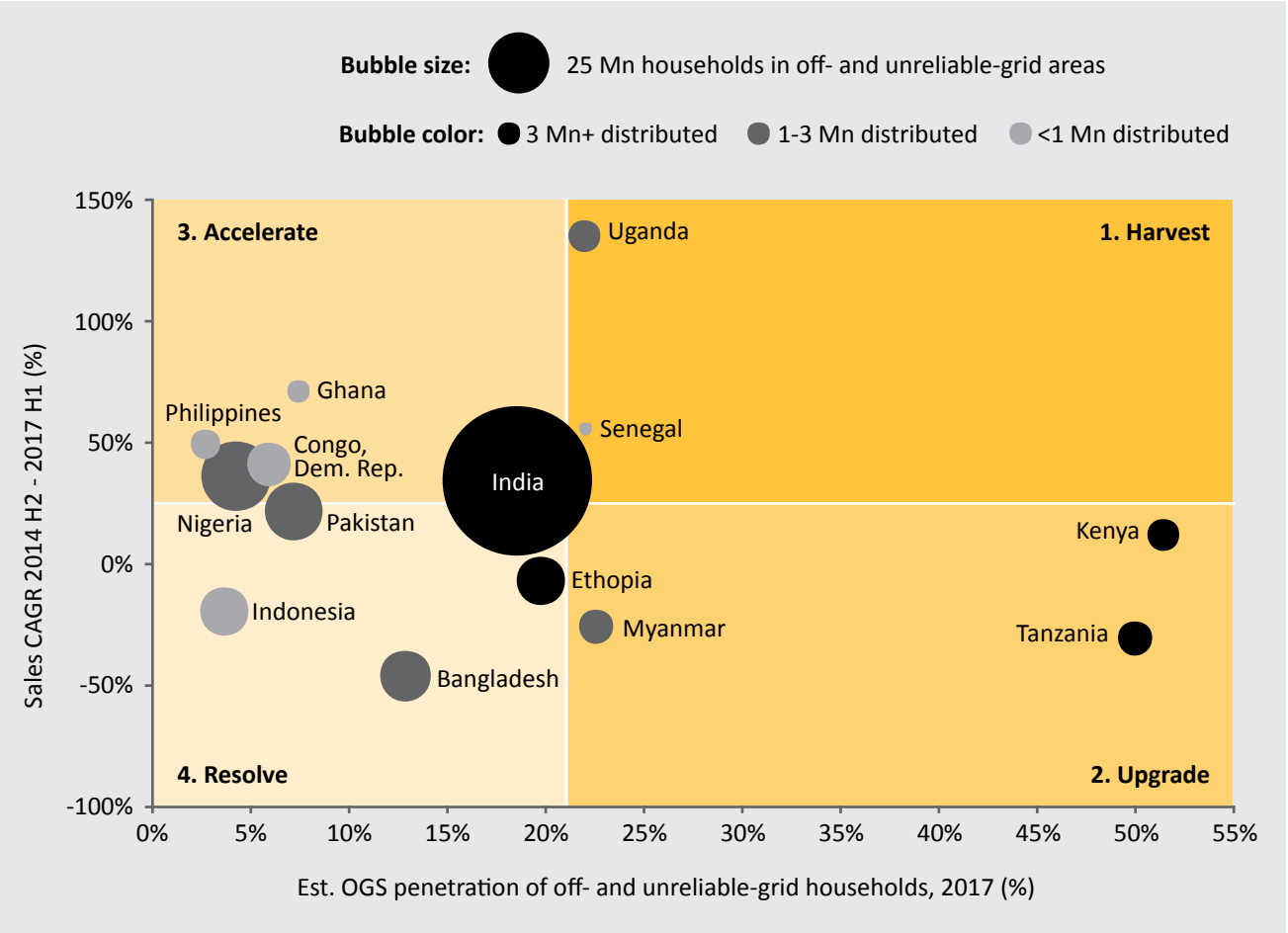


Figure 47 identifies these key markets' trajectories based on four quadrants: harvest, upgrade, accelerate, and resolve. These provide a framework to understand market potential, and possible strategies to follow based on their starting points:

1. *Harvest:* While no countries are squarely located in this quadrant, sales in Uganda continue to rise despite relatively high penetration, suggesting that suppliers can continue to harvest revenues from this active market.
2. *Upgrade:* Highly penetrated maturing markets including Kenya and Tanzania have seen sales rates fall, suggesting suppliers may consider upgrading existing customers to higher quality technologies and service levels, and should seek innovative distribution partnerships to penetrate the harder to reach customers. In Myanmar, pico and PnP SHS supplier interest has been low, but they can innovate to upgrade consumers from component-based systems, which are the norm, to safer, and easier to distribute and use pre-packaged OGS products.

[175]Note: Estimate includes both affiliate sales and non-affiliate sales estimates of pico and PnP SHS, as well as institutional component-based (India, Myanmar and Bangladesh) and open-market component-based devices. Sales are discounted to assume 10% sales to repeat customers and 3% loss of devices sold, and assume a 3-4 year product lifetime (GOGLA, 2016a). Source: Lighting Global/GOGLA sales data; industry interviews; Dalberg market model and analysis

3. *Accelerate:* Up-and-coming markets in Asia and West and Central Africa show promising growth, where suppliers can continue to scale operations to take advantage of large unpenetrated populations.
4. *Resolve:* Several under-penetrated markets have seen sales fall, and would need concentrated supplier investment to resolve context-specific issues, such as challenges in quality standards implementation in Ethiopia, and low supplier interest in Bangladesh and Indonesia.

This section takes a deeper look at select countries in each of these quadrants to understand the dynamics at play in different country markets.[176]

Upgrade

Kenya

OGS devices[177]

Three-year cumulative sales: 4.9 Mn
Total sales (2016): 2.1 Mn
Annual growth (2014-16): 11%
2017 penetration: 51%

Affiliate pico

Avg. annual sales (2014-16): 940,000
Annual growth (2014-16): 20%
Est. affiliate share of total: 65%

Affiliate PnP SHS[178]

Avg. annual sales (2015-16): 30,000
Annual growth (2015-16): 722%[179]
Est. affiliate share of total: 61%

- Commerce has slowed across the economy, affecting all OGS segments, due to impact of the drought in East Africa and the political impasse and uncertainty surrounding the 2017 election, especially in high-demand regions in Nyanza and Western provinces.
- Affiliate pico sales dipped after the 2015 exit of SunnyMoney, a major supplier, but rebounded on the strength of distributor partnerships. A large existing customer base presents a strong opportunity for upgrades; untapped markets in the northeast present an opportunity for expanding distribution networks.
- PnP SHS sales have dampened in the past year, particularly due to shipment delays at customs (stemming from a lack of clarity on tax exemptions for appliances). At the same time, the removal of exemptions increased prices (by 5-25%), which further impacted sales. PAYGO SHS sales have been increasing sharply, but from a very small base.
- **Affiliates sales 2017 H1 vs. 2016 H1:** -26%
- **Outlook:** (1) Penetration of untapped segments is imminent; (2) increases in revenues from existing customer base expected via upgrades; (3) rapid grid extension and reliability improvements could pose competition; and (4) as customers move up energy

[176]*Note: Country-level trends, provided in unit sales, are based on Lighting Global/GOGLA sales data; data provided by companies directly to Dalberg, industry interviews and desk research, as well as Dalberg analysis. Affiliate country-level product-category sales figures are provided on an average basis due to company confidentiality and Lighting Global and GOGLA's three-data-point rule, which requires at least three companies to have reported data for any single data point. Source: Dalberg market model and analysis*

[177]*Note: Figures in OGS device section of each table include affiliate and non-affiliate pico and PnP SHS, as well as component-based systems distributed via institutional and open-market channels*

[178]*Note: PnP SHS figures are shown for 2015-2016 due to lack of sales data prior to 2015*

[179]*Note: From a small base, <10,000*

ladder, challenge from non-affiliate products is expected to diminish for affiliate players.

"Although our sales have dampened in the last year, there continues to be an enduring need in the Kenyan market." – Affiliate company

"In Kenya, one of the main drivers of the market's growth since 2010 has been the favorable tax regime (Duty/ VAT free) on solar products and accessories. This made this market very attractive from the very onset." –Nana Nuamoah Asamoah-Manu, Lighting Global Kenya

Tanzania

OGS devices

Three-year cumulative sales: 5.0 Mn
Total sales (2016): 1.2 Mn
Annual growth (2014-16): -31%
2017 penetration: 50%

Affiliate pico

Avg. annual sales (2014-16): 530,000
Annual growth (2014-16): -67%
Est. affiliate share of total: 28%

Affiliate PnP SHS

Avg. annual sales (2015-16): 90,000
Annual growth (2015-16): 63%
Est. affiliate share of total: 43%

- Sales have recently dipped across segments due to cross-cutting issues such as the recent drought in East Africa, working capital challenges, and delays in VAT refunds from the government.
- Affiliate pico sales have been steadily falling since 2014, with the market dominated by non-affiliate products; contributing factors include a large presence of counterfeit products, and a further vacuum in supply created by SunnyMoney's exit (itself motivated by the high competition from non-affiliates). Market share among low-quality suppliers is expected to decline going forward due to standards adoption by the government.
- Multiple PnP SHS suppliers have reported rising sales and are confident about the market's future outlook. However, 2017 H1 sales underperformed expectations. Key issues include taxation on bundled appliances.
- **Affiliates sales 2017 H1 vs. 2016 H1:** -63%
- **Outlook:** (1) Affiliate pico products to expand via SACCOs and other institutional partnerships; (2) affiliate market share to increase on the back of upgrades (from affiliate and non-affiliate alike); (3) growth of affiliate pico segment dependent upon marketing and implementation of standards; and (4) policy and regulatory uncertainty will pose a risk to future investment.

"Reliance on the SunnyMoney model in Tanzania and not having a strong distribution partner created a vacuum that generics could come in and fill…a large part of it is due to the robust pull created by market leaders, and the generic suppliers' ability to scale through regular wholesale channels." – Ned Tozun, d.light

Myanmar

OGS devices

Three-year cumulative sales: 2.2 Mn
Total sales (2016): 760,000
Annual growth (2014-16): -26%
2017 penetration: 23%

Affiliate pico

Avg. annual sales (2014-16): 20,000
Annual growth (2014-16): -23%
Est. affiliate share of total: 10%

Affiliate PnP SHS

Avg. annual sales (2015-16): No public data
Annual growth (2015-16): No public data
Est. affiliate share of total: 25%

- The pico segment is relatively small, with small LED torches and lanterns common; 1-2 affiliate suppliers have a nascent presence, however, their products are three to five times more expensive than non-affiliate products.
- The SHS segment is dominated by component-based systems provided at an 80% subsidy (initially free) by the Department of Rural Development and the National Electrification Program (in partnership with World Bank), as well as those purchased on the open-market; there are 1-2 affiliate PnP SHS suppliers in the market.
- Consumers prefer larger systems (100W – 300W) that can power appliances. AC appliances used with an inverter (e.g. 220W TVs) are common.
- The enabling environment poses challenges – government distribution of 450,000 systems over the next five years (largely in remote areas), a lack of transparency around import taxes and tariffs, and low mobile money penetration.
- **Affiliates sales 2017 H1 vs. 2016 H1:** 32%
- **Outlook:** (1) Consumer interest in component-based systems appears to continue steadily, and is the main competition for PAYGO SHS; (2) despite ambitious projections, grid roll-out faces delays; (3) entry of energy-efficient DC appliances can be a game-changer; (4) PAYGO SHS uptake likely to be based on manual payment collection due to lack of mobile money; and (5) transition to higher quality and plug-and-play products contingent on entry of affiliate suppliers, as well as expansion of existing players' presence.

"Certain areas are probably saturated with solar, but it's largely privately-bought, poor quality component-based systems […] We expect a transition toward better quality and larger products." – Bill Gallery, Lighting Global Myanmar

Harvest

Uganda

OGS devices

Three-year cumulative sales: 2.0 Mn
Total sales (2016): 840,000
Annual growth (2014-16): 135%
2017 penetration: 22%

Affiliate pico

Avg. annual sales (2014-16): 200,000
Annual growth (2014-16): 503%[180]
Est. affiliate share of total: 45%

Affiliate PnP SHS

Avg. annual sales (2015-16): 20,000
Annual growth (2015-16): -8%
Est. affiliate share of total: 60%

- Pico sales have been rising rapidly, albeit from a small base; this is attributed to high demand coupled with a favorable policy environment. Suppliers have been increasing their efforts, and view it as high potential going forward. Early movers still hold the bulk of market share, but recent reports suggest that non-affiliate market share has risen sharply due to price point competition, leading to rising penetration.
- The PnP SHS market, particularly PAYGO, has been buoyed for a handful of companies raising local currency debt financing facilities. Relatively steady sales, including in 2017 H1, have been attributed to distribution partnerships, high mobile money penetration, high willingness to pay and large potential market.
- **Affiliates sales 2017 H1 vs. 2016 H1:** 26%
- **Outlook:** (1) Growth in distribution footprint for pico and PnP SHS alike; (2) local factors (mobile money penetration, policy environment, potential market size) hold potential for Kenya-like trajectory over next five years; and (3) early customers to move up energy ladder.

"We expect to hit profitability in fall 2017, driven by a high volume of customers, and customer accounts coming full-circle." – Affiliate company

"Generics penetration has become really noticeable in the past two years. We've talked to agents who have stopped buying our lights, as they can't compete with generics price points." – Affiliate distributor

[180] *Note: From a small base, <70,000*

Scale/Accelerate

Ghana

OGS devices

Three-year cumulative sales: 320,000
Total sales (2016): 170,000
Annual growth (2014-16): 71%
2017 penetration: 7%

Affiliate pico

Avg. annual sales (2014-16): 20,000
Annual growth (2014-16): 552%[182]
Est. affiliate share of total: 30%

Affiliate PnP SHS

Avg. annual sales (2015-16): No public data
Annual growth (2015-16): No public data
Est. affiliate share of total: 70%

- The affiliate pico segment is small but growing quickly, with a large untapped last-mile market; non-affiliate penetration is believed to be high.
- A handful of PAYGO SHS companies report fast-growing sales; one has also been able to raise local currency debt. However, they have had to invest significantly in pushing mobile money adoption, and adjusting to local usage patterns.
- Affiliate sales have been affected by issues surrounding the harmonization of taxes across ECOWAS, which led to solar lights being taxed at the same rate as other lights.[181]
- **Affiliates sales 2017 H1 vs. 2016 H1:** 106%
- **Outlook:** (1) Rapid growth to continue for pico on the back of deepening distribution across channels; (2) rapid growth of PAYGO SHS to continue due to small base, however, penetration likely to depend on mobile money adoption and contextualization for local preferences by companies.

"If we can learn how to make this work here, with low mobile money, then the technology can spread more broadly globally to everyone who needs it. Moreover, usage patterns here are different. In Kenya, customers carry a balance on mobile money that has nothing to do with PAYGO. However, in West Africa, people load money for a particular transaction, send it, and then have zero balance again. This is challenging for people in villages, who only go to a place that sells mobile money on market day." – Nate Heller, PEG Africa

[181] *Source: (Agyepong, 2016); industry interviews*
[182] *Note: Note: From a small base, <10,000*

Nigeria

OGS devices

Three-year cumulative sales: 1.7 Mn
Total sales (2016): 820,000
Annual growth (2014-16): 36%
2017 penetration: 4%

Affiliate pico

Avg. annual sales (2014-16): 160,000
Annual growth (2014-16): 48%
Est. affiliate share of total: 30%

Affiliate PnP SHS

Avg. annual sales (2015-16): 30,000
Annual growth (2015-16): No public data
Est. affiliate share of total: 70%

- The overall market, although nascent, has grown, driven by a large off- and unreliable-grid population across a spectrum of income levels, including many with high ability to pay.
- The trend toward growth has fluctuated due to drought as well as well as the economic crisis, which led to a foreign exchange shortage, devaluation of the naira and inhibited purchasing power; this crisis has waned in 2017 H2.
- Non-affiliates have a relatively small share of the market, attributed to the nascence of the solar market; major competition for affiliate companies includes traditional staples like torches and diesel or gas generators, used by rich and poor alike.
- Affiliate PnP SHS companies have reported fast-growing sales driven by effective distribution partnerships, and a high-concentration of customers that are used to having a high-powered energy system at home via generators. Challenges include fluctuating currency, and the lack of a mobile-money ecosystem.
- **Affiliates sales 2017 H1 vs. 2016 H1:** -16%
- **Outlook:** (1) Distribution footprint for pico and PnP SHS to expand beyond urban/peri-urban areas; (2) Increasing penetration by PAYGO SHS within sections of the market using diesel generators; and (3) uptake of PAYGO SHS to be influenced by contextual factors such as a reluctance to take on debt, and preference for asset ownership.

"Our number one competitor here is a diesel generator, but we're offering much cleaner and safer value at a better cost." – Ron Margalit, Lumos Global

"We expect the Nigerian market to explode; this could be the next revolution after mobile phones. There is so much appetite, and sales have taken off despite the economic crisis." – Allwell Okechukwu Nwankwo, Lighting Global Nigeria

India

OGS devices

Three-year cumulative sales: 32.8 Mn
Total sales (2016): 12.5 Mn
Annual growth (2014-16): 34%
2017 penetration: 19%

Affiliate pico

Avg. annual sales (2014-16): 2.44 Mn
Annual growth (2014-16): 74%
Est. affiliate share of total: 25%

Affiliate PnP SHS

Avg. annual sales (2015-16): 30,000
Annual growth (2015-16): 185%
Est. affiliate share of total: 29%

- The pico segment (affiliate and non-affiliate) has grown rapidly between 2014 and 2016. Non-affiliates dominate traditional retail channels, while most affiliate sales come from MFIs and other institutional channels.
- Demonetization of 86% of currency (in November 2016), followed by the implementation of a unified goods and services tax (in June 2017) have provided large shocks to sales through depressed purchasing power and a working capital shortage among distributors.
- The SHS segment is relatively small, with affiliate PnP products a small share of a market dominated by component-based systems (both via institutional distribution and open-market sales).
- Affiliate PnP SHS sales are growing, with new products coming into the market since 2016; there is significant customer demand for higher-wattage systems as well as a large pico customer base that has begun to migrate upwards.
- PAYGO SHS are yet to fully take root, which is largely due to low penetration of digital payments; if penetration deepens, sales could grow rapidly.
- **Affiliates sales 2017 H1 vs. 2016 H1:** -37%
- **Outlook:** (1) Affiliate pico sales growth contingent on innovation in distribution; (2) SHS sales to continue to grow via open-market component-based system sales, as well as MFI sales of affiliate products with appliances; (3) PAYGO uptake will be contingent on greater adoption of digital finance.

"The market is in transition… players have realized that it is moving toward newer products with higher capacity; MFIs have also started asking for newer, bigger ticket products." – Affiliate company

"Demonetization really brought everyone's business to a halt…we've still not recovered fully." – Gaurav Himkar, d.light

Resolve

Bangladesh

OGS devices

Three-year cumulative sales: 2.7 Mn
Total sales (2016): 830,000
Annual growth (2014-16): -47%
2017 penetration: 13%

Affiliate pico

Avg. annual sales (2014-16): 10,000
Annual growth (2014-16): 104%
Est. affiliate share of total: 5%

Affiliate PnP SHS

Avg. annual sales (2015-16): No public data
Annual growth (2015-16): No public data
Est. affiliate share of total: 75%

- The pico segment is relatively small, and dominated by non-affiliate companies selling low-wattage devices via traditional retail channels. Affiliate suppliers are relatively new to the market and lack a comprehensive presence via distribution partners.
- The SHS segment is dominated by component-based systems distributed through the IDCOL program, for whom sales are declining. This is primarily due to market saturation, and increased competition from both grid extension (leading to reduced repayment rates, and shrinking base of new customers) as well as open-market sales of component-based systems.
- The presence of affiliates with PnP SHS is minimal due to competition from IDCOL-subsidized devices, as well as high import taxes on SHS (26%).
- **Affiliates sales 2017 H1 vs. 2016 H1:** 187%
- **Outlook:** (1) Affiliate pico sales growth contingent on expansion of distribution via partnerships; (2) SHS sales to grow at slower rate due to declining sales via the IDCOL program; (3) unreliable-grid households to form large market for SHS; (4) existing SHS customer base of over four million customers to form large market for standalone energy-efficient appliances.

"Customers are moving up the energy ladder, but their drive to invest is hampered by the government's free giveaways, and promises of grid connectivity. Suppliers could be more active and develop deeper partnerships." – Development partner

"We're finding that a lot of customers who are grid connected want an SHS for back-up. While all our customers were originally off-grid, 50% of them are now on-grid." – Development partner

Ethiopia

OGS devices

Three-year cumulative sales: 4.0 Mn
Total sales (2016): 1.14 Mn
Annual growth (2014-16): -8%
2017 penetration: 20%

Affiliate pico

Avg. annual sales (2014-16): 520,000
Annual growth (2014-16): -18%
Est. affiliate share of total: 43%

Affiliate PnP SHS

Avg. annual sales (2015-16): No public data
Annual growth (2015-16): 89%
Est. affiliate share of total: 79%

- Overall, sales have dipped slightly due to drought in East Africa in 2017. The share of non-affiliates increased in the past several years due to issues in the implementation of quality standards (for products <15 W). As opposed to referring to the list of Lighting Global quality verified products, all products were mandatorily tested at customs, leading to long delays. At the same time, many non-affiliate systems were able to bypass customs which led to an immediate shift in the relative market share, estimated as high as 65% in 2016.[183] It is expected that affiliate companies will regain market share following resolution of standards implementation issues.
- Ethiopia is still viewed as a high potential market for over five large suppliers (pico and PnP SHS) that are seriously considering entry; some of these are developing pilots.
- Key challenges include FOREX risks and working capital for suppliers, and availability of financing for consumers.
- **Affiliates sales 2017 H1 vs. 2016 H1:** -9%
- **Outlook:** (1) Affiliate sales to regain market share, with a move toward higher wattage; (2) overall penetration to increase on the back of awareness campaigns and increased MFI participation; (3) PAYGO uptake contingent on mobile money penetration and supportive finance policy.

"The local testing of solar products <15W was not properly implemented [at the local level] nor communicated to inspectors at customs and this coupled with a provision that allowed all imports to enter the country unimpeded in an attempt to rectify the situation […] caused low-quality products to gain a significant foothold in 2016."
– Development partner

[183] *Source: (Anand, 2017)*

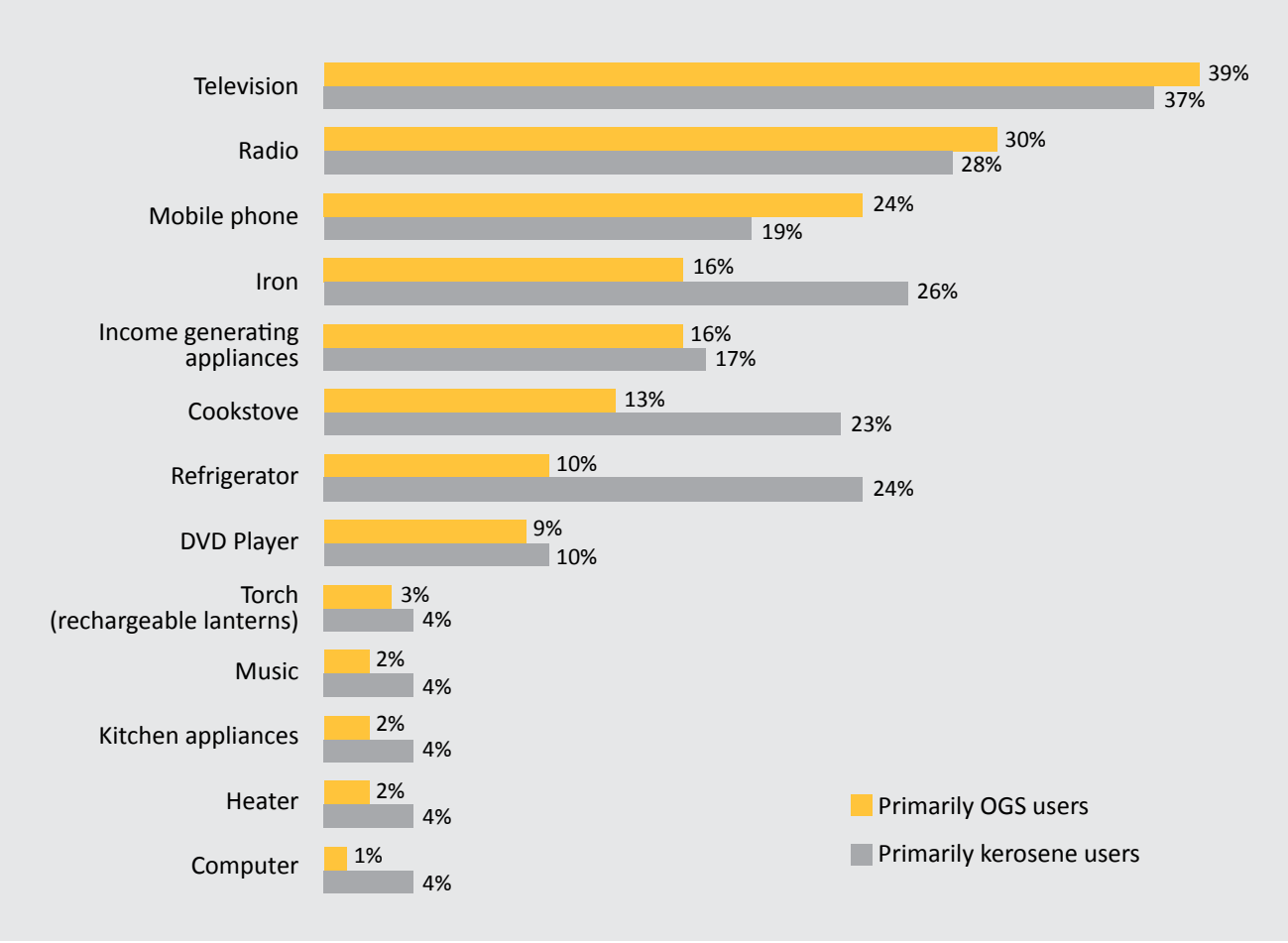
1B.4 APPLIANCE-RELATED TRENDS

Appliance-related trends have a large degree of influence on the trajectory of the OGS sector. This section describes emerging trends as DC appliances increase in number and diversity.

Consumers exhibit strong desire for appliances. As illustrated in Figure 48, there exists strong impetus among consumers in the potential market to gain grid-like service levels. In rural Kenya, the desire for appliances such as TVs, radios, mobile phones, and income generating appliances is consistent between households that primarily use OGS devices and those that use kerosene. The demand for appliances has been observed in relatively nascent markets as well. For example, suppliers in Pakistan, where few energy efficient appliances are available, are confident that greater availability of quality efficient DC appliances (especially fans in the summer) would boost SHS sales in the country.[184] The estimated annual potential spend on off-grid televisions, fans and refrigerators is projected to reach USD 4.7 billion by 2020.[185]

Figure 48: Desire for appliances among OGS and kerosene users, rural Kenya[186]

% of households (2015)



[184] *Source: Industry interviews*

[185] *Source: (CLASP & Dalberg, 2015)*

[186] *Note: Music refers to stereo systems and electronic musical instruments; Kitchen appliances include blenders, kettles, microwaves, toasters, water coolers, and food processors; Income generating appliances include posho mills, welding machines, blowdryers and shavers, water pumps, and battery chargers. Source: (University of Berkeley and NBER, 2016); Dalberg analysis*

Appliances such as TVs are common in Myanmar among users of component-based systems, and there is large potential for the efficiency gains that come with PnP SHS. For example, the bulk of TVs purchased are 220W AC TVs that require an inverter as well as a 300W solar panel to power them; a PnP SHS packaged with an efficient TV can offer the same level of service powered by a 20-50Wp panel.

It should be noted that most R&D, sales, and marketing efforts around appliances have focused on household consumers to date. Yet as the capacity of systems to power appliances improves, an additional market of MSME consumers is emerging, increasing the size of the potential and addressable market, especially for higher-powered SHS. The status, future potential, and challenges associated with appliances catering to income generating activities, termed as "productive use" appliances, are discussed in detail in Sections 1C.3, 1F.1, and Section 2.

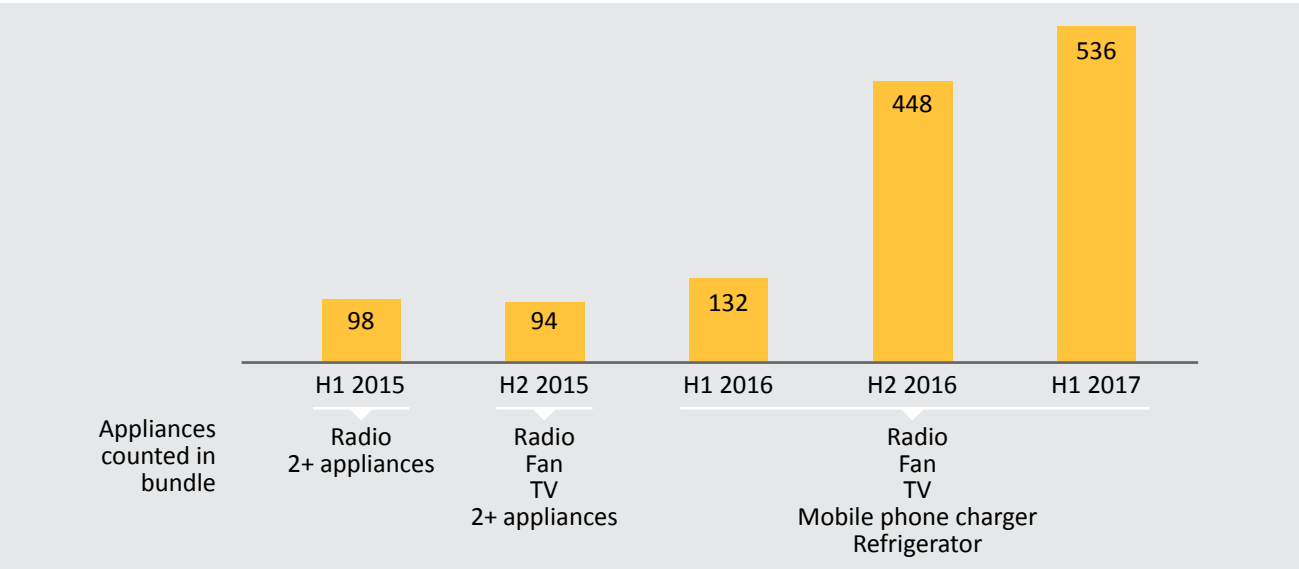
There is regional diversity in preferences. While consumer demand for radios and televisions is fairly consistent across geographies, fans, for example, are particularly relevant in hot countries. There is region-specific demand for select appliances as well. For example, rice-cookers are in high demand in Myanmar and are being prototyped by PnP SHS suppliers. Hair-clippers are common in several African markets.

> "The ability of a home system to power productive use appliances is a game changer. There is a concerted push toward selling larger products and moving up the energy value chain into things like power tools, agriculture products, and other productive use opportunities."
> **- Affiliate supplier**

OGS devices bundled with appliances have been selling rapidly. Consumer demand for appliances has prompted sales of appliance-bundled PnP SHS, which are increasing rapidly for affiliate companies. OGS companies have responded by expanding their product portfolios to include appliances, as well as enabling their products to support them.

Figure 49: Sales of OGS devices bundled with appliances[187]

Thousand units (2015 H1-2017 H1)

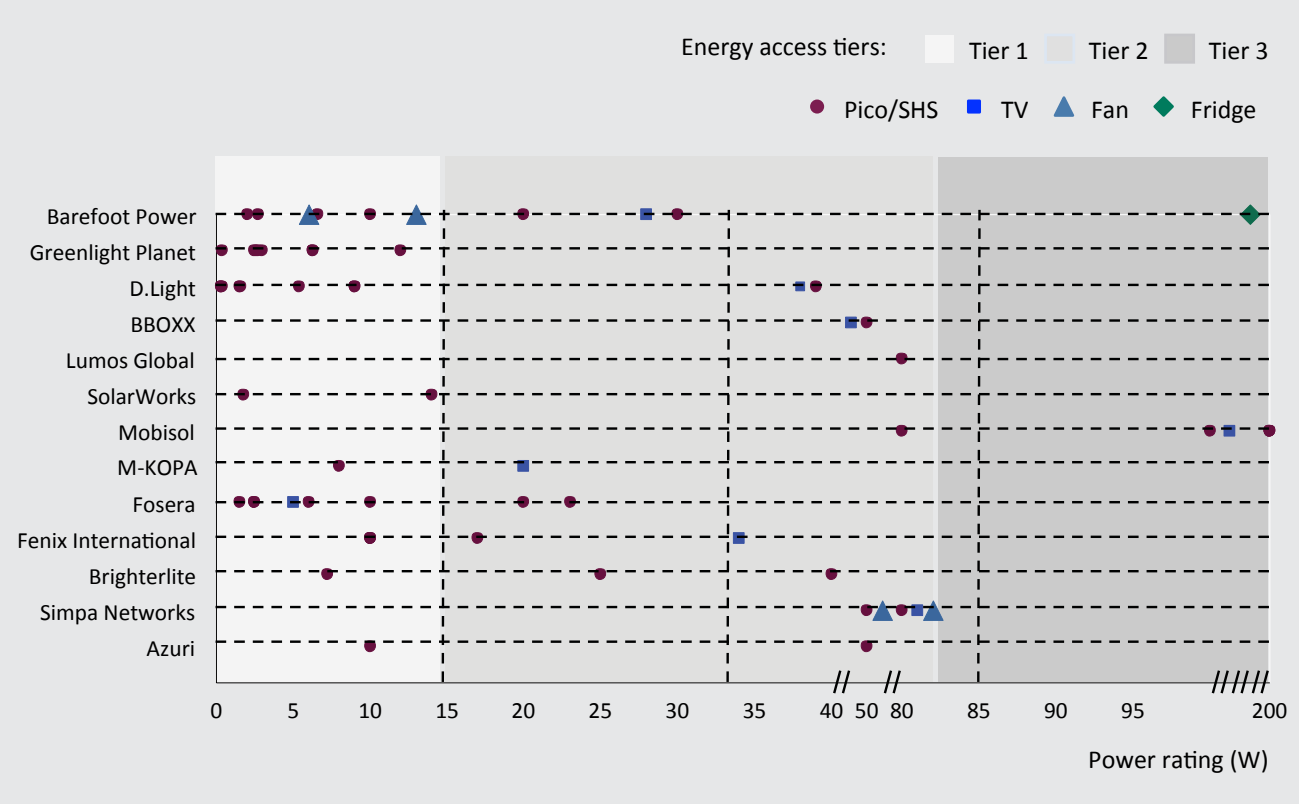


[187] *Source: Lighting Global/GOGLA sales data*

As shown in Figure 50, companies that existed and led the market since its early days, like Barefoot Power, Greenlight Planet and d.light, have upgraded and expanded their portfolios. Newer affiliates, like Mobisol and M-KOPA, have deployed a multi-product portfolio from the get-go; Lumos Global sells DC-AC converters to enable consumers to plug standard, off-the-shelf appliances into their PnP SHS.[188] As discussed in Section 1C, several of players are developing their own appliances in order to quickly establish market share.

Figure 50: Product portfolios of select OGS companies[189]

n=13 suppliers (2017)



The universe of energy efficient appliances has expanded, but is not fully represented in OGS product portfolios yet. The inclusion of appliances into product portfolios has been enabled by an increasing number and diversity of appliances available in the market today, which is in turn driven by innovation enabling higher efficiencies (and thus lower prices) as well as increased compatibility across devices and technologies. Although the universe of efficient DC appliances now ranges from egg incubators to washing machines,[190] only a handful of appliances are featured as a part of standard PnP SHS packages. These include top-selling consumer electronics such as radios, fans, and televisions. Continued institutional market building will support the mainstreaming of additional appliances: since 2015, the Global LEAP Awards have identified and provided cash prizes to incentivize innovation in off-grid TVs and fan development, and is expected to announce winners of the first Off-Grid Refrigerator Competition in early 2018.[191]

[188] *Source: (Hystra Hybrid Strategies Consulting, 2017a)*

[189] *Note: 1) Greenlight Planet is to introduce a TV into the market; wattage is indicative at this point of time; (2) Tier 1 includes a minimum of: 3W (peak power), 12Wh (consumption); Tier 2 includes a minimum of: 50W (peak power), 200Wh; Tier 3 includes a minimum of: 200W (peak power), 1kWh (consumption). Source: ESMAP/SEforALL; The Lighting Global and GOGLA teams have also developed an index to broadly map pico/SHS functionality and size to the MTF categories. These have been used for this analysis. (3) The list of products is not exhaustive but is representative. Source: (Lighting Global); (Sendea, n.d.); (Hystra Hybrid Strategies Consulting, 2017b); Dalberg research and analysis*

[190] *Source: (GIZ, 2016)*

[191] *Source: (Global LEAP, 2017)*

1C. COMPETITIVE LANDSCAPE

KEY MESSAGES

- SCOPE OF THE COMPETITIVE LANDSCAPE: The OGS marketplace has continued to attract new entrants, while its footprint has expanded to include all major off-grid regions. Product ranges now cater to a wide set of consumer value propositions.
- PICO SEGMENT: Competition has risen, although affiliate companies remain concentrated. Price is the key differentiator, though quality, distribution and branding are increasingly important.
- PLUG-AND-PLAY SHS SEGMENT: Leading companies dominate market share. Suppliers demonstrate clear convergence toward PAYGO, as well as toward moving customers up the energy ladder and providing stronger customer service. Few companies have achieved profitability, and the multiple sub-businesses inherent in PAYGO are often unwieldy for suppliers.

> "There will likely be a variety of business models that can succeed. But, we need time for the right business models to emerge: Which geographies, customer sets, and technologies [will create a profitable and sustainable business model]?"
>
> **- Greg Neichin, Ceniarth, LLC**

The OGS sector has come a long way from its inception as a small group of regionally-concentrated, single-product firms compelled to address challenges in all parts of the value chain. By 2017, the off-grid solar marketplace has expanded to encompass a broad range of players, stakeholders, geographies, products, and business models (especially PAYGO). This offers opportunities for operators in the market to distinguish themselves through specialization, and to attract a better share of market revenue. It also improves consumer choice and offerings over the long term.

This section provides commentary on trends relevant to the overall OGS market, and then illustrates dynamics for the pico segment and PnP SHS segment. Component-based SHS are not reviewed, as the competitive landscape differs for each component in relation to non-OGS uses, and is out of scope for this report.

1C.1 OVERALL MARKET

Scope: The OGS marketplace has continued to attract new entrants.

From a base of about 60 companies focused on the OGS market in 2010, the landscape has grown to about 330 companies today.[192] Of these, about 75% (~250 companies) operate only in the pico segment, with about 15% (~50 companies) exclusively in the PnP SHS segment. Less than 10% of the companies (~30) operate across both segments. This split reflects the historical trajectory of the sector, with PnP SHS emerging as a significant segment only since 2013, and on the back of the PAYGO revolution.

This universe of 330 players reflects OGS-focused companies (their focus manifested either through their involvement with industry associations or through a product portfolio in which OGS devices are among the primary products) and includes both affiliate and non-affiliate suppliers (see Table 7). While this report endeavors to describe the full breadth of the OGS market, many of the findings presented here are based on insights from affiliate suppliers, and may not fully reflect trends among non-affiliate suppliers.

Photo credit: Lighting Pakistan

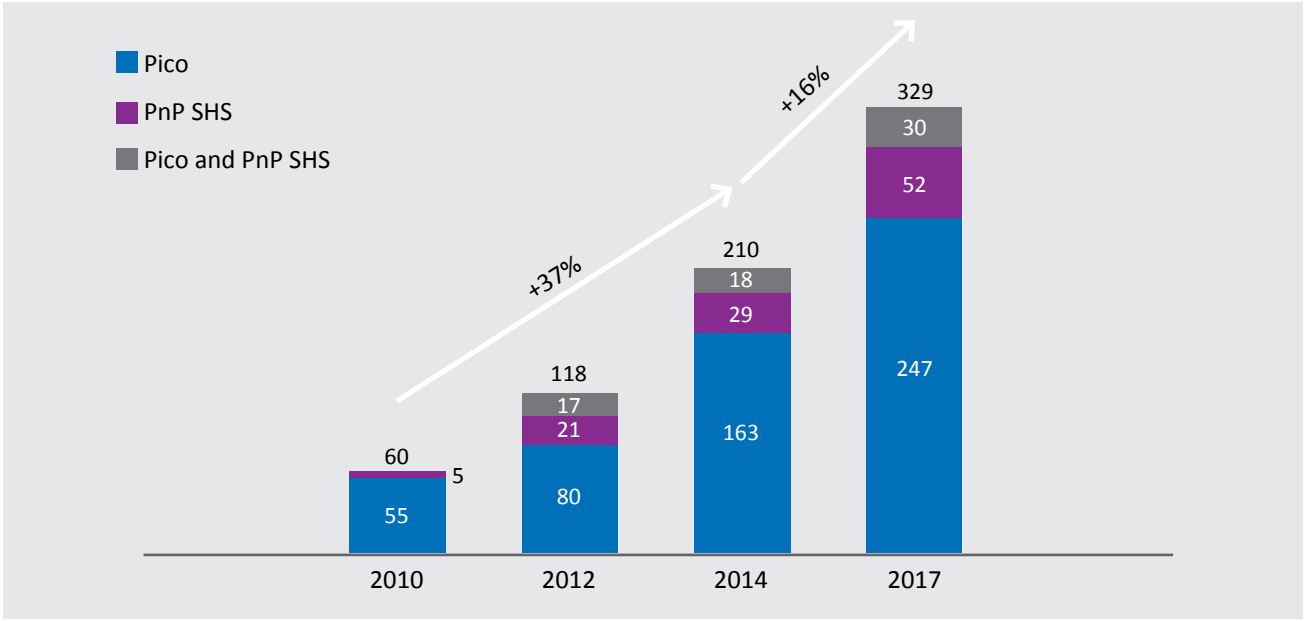
Beyond the companies described above, there is an additional universe of lighting companies whose involvement in the OGS space is more peripheral, typically producing solar portable lights as a small part of a broader consumer electronics portfolio. At best estimates, they number over 600 and are mostly based out of China.[193] Given their tangential involvement in the OGS space, these companies have been considered out of the scope for this report.

[192] *Note: OGS "focused" players are defined here as those whose main products are pico devices or solar home systems. Excludes players whose primary business line is large solar or consumer electronics*

[193] *Note: Based on searches on Alibaba.com*

Figure 51: Manufacturers and distributors focused on the OGS sector[194]

Number of companies; non-exhaustive best estimates (2010-17)



The number of companies in the industry has grown rapidly, by about 30% year-on-year since 2010. In fact, in the four years preceding 2014, the number grew at close to 40% annually, mirroring the super-charged growth of unit sales, especially in East Africa. Not surprisingly, the pace of market entry has slowed to about 15% year-on-year across segments since 2014 as the industry has matured, reflecting a natural evolution given today's large existing base of players. These trends are consistent with the slowing sales in the pico segment in past two years. On the other hand, the number of companies in the PnP SHS segment, which is still at an earlier stage in its maturity cycle, has grown at about 35% per year in the same period, driven in part by the PAYGO revolution.[195]

In terms of the number of companies, the pico supplier landscape is skewed toward non-affiliates, but affiliates dominate market share in the more quality-conscious PnP SHS segment.

Footprint: The geographic reach of OGS has grown to encompass all major off-grid regions globally.

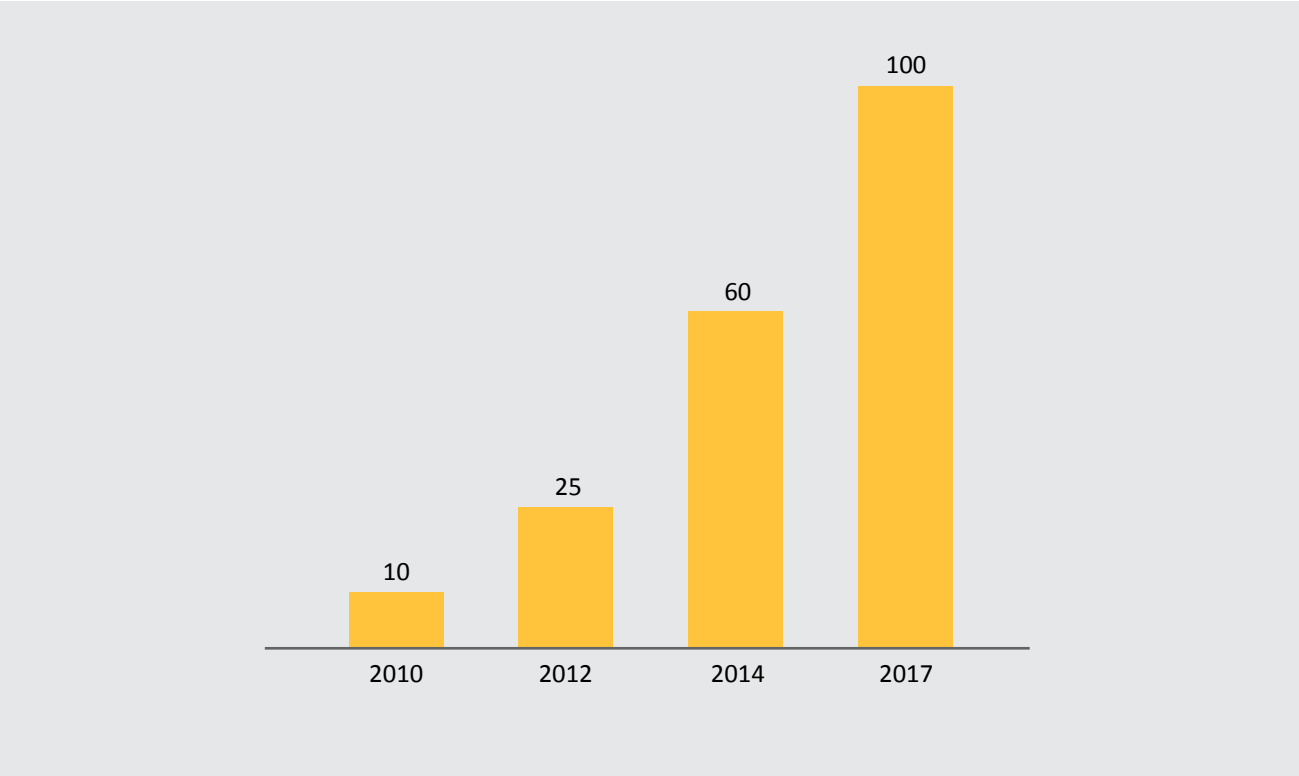
OGS products are currently distributed in over 100 countries, growing from a base of about 10 countries in 2010. In its infancy, the OGS market was confined to largely to India and East Africa. Starting from 2012 onward, the industry's geographic footprint expanded significantly to include the majority of the world's most electricity-poor countries. While natural market incentives drove most of the expansion, it is also clear that the market is especially concentrated in geographies where enablers such as the World Bank Group's Lighting Global program have historically focused.

[194]Note: (1) 2010: Number of pico suppliers: (Dalberg, 2010). PnP SHS suppliers include those who are active today and were established prior to 2010, based on secondary research (does not include distributors as it is difficult to gauge if their product portfolios included PnP SHS in 2010. (2) 2012: Number of pico suppliers: (Dalberg, 2012). PnP SHS and "both" numbers are based on secondary research and include only companies that are still operational today. (3) 2014: Number of pico suppliers from for 2015: (Bloomberg New Energy Finance, 2016). Includes both affiliates and non-affiliates, PnP SHS numbers and "both" numbers include companies that were established prior to 2014. (4) 2017: Based on secondary research in 2017. (5) These numbers are not exhaustive but represent a significant proportion of suppliers in the market. Source: Company websites; industry interviews; interviews with Lighting Global and GOGLA teams; Dalberg analysis

[195]Note: Includes both pure-play distributors as well as product designers and distributors, except for in 2010 (see Footnote 194)

Figure 52: Number of countries with an OGS sales presence over time[196]

Number of countries (2010-17)



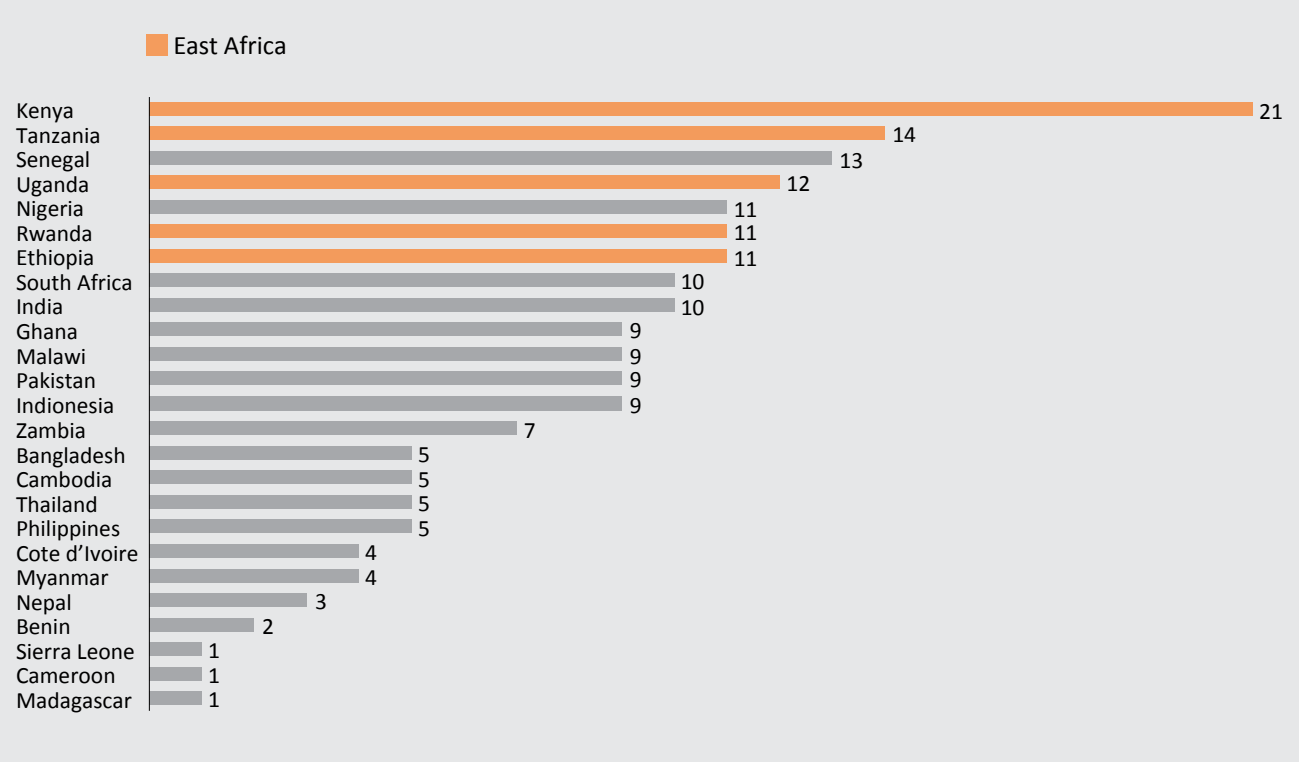
Even today, East African markets are home to the highest density of suppliers (see Figure 53). Kenya, Tanzania, Uganda, Rwanda, and Ethiopia all have 10 or more GOGLA members operating, not accounting for a significant presence of non-affiliates. Overall, South Asia is under-represented relative to Sub-Saharan Africa.[197] India, the world's largest off-grid market, is served by 10 companies (not accounting for several non-affiliate companies that design and sell products tailor-made for the extensive government-subsidized distribution programs); Pakistan and Bangladesh have even fewer (see Figure 53). While these figures pertain to affiliate suppliers, this trend also broadly pertains to the market as a whole. In fact, several markets have historically been entered first by affiliates, who typically invest significantly in market building via consumer education, after which non-affiliate suppliers followed.


Photo credit: d.light

[196] *Source: Industry interviews; Lighting Global/GOGLA data; Dalberg analysis*

[197] *Source: Industry interviews; Interviews with regional Lighting Global teams*

Figure 53: GOGLA members' sales presence in individual countries[198]
Number of members (2017)



Three factors likely drive this geographic trend. First, Asian countries have invested more heavily and effectively in their respective centralized grids than most African countries, as discussed in Section 1A. This will continue and intensify over the next three to five years. This could lead to a quicker transition of unreliable-grid households toward reliable electricity and shrink the potential market in Asia, while it remains stable or expands in Sub-Saharan Africa. Second, donor focus and funding has historically skewed toward Sub-Saharan Africa given the poor prospects of grid electrification in the region. Initiatives like the Lighting Africa program initially helped kick-start the OGS market and accelerate its momentum in the early days of the sector. Lighting Global programs led by IFC now encompass ten countries, with six in Asia, and the World Bank Group also continues to support the development of new frontier countries through partnerships. Third, increased penetration in Sub-Saharan Africa of mobile money platforms and technology, which can be leveraged for PAYGO business models, has also helped crowd-in more players into the region.

Product offerings: Companies have expanded their product sets to cater to a wide range of customer value propositions.

In the first phase of market evolution, OGS products were primarily positioned as modern lighting solutions meant to replace kerosene in under-electrified communities. Portability and price were the most crucial factors driving customer acquisition, pushing manufacturers to cheaper, smaller solutions. However, from 2014 onward, the gravitational center has definitively moved toward higher-wattage products. As exposure to OGS has increased, customer aspirations have also evolved to more comprehensive lighting needs, and more

[198]Note: Best estimate based on regional presence of new GOGLA members added in 2016 and 2017 in addition to BNEF estimates. Source: (Bloomberg New Energy Finance, 2016); GOGLA website, 2017; World Bank data; industry interviews

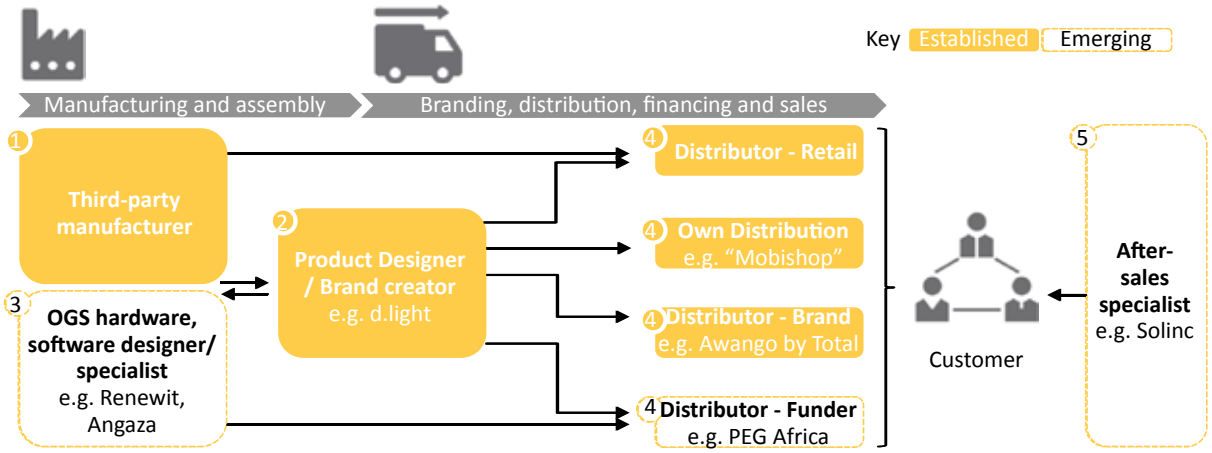
recently, beyond lighting into other applications enabled by appliances. This has dovetailed with suppliers' motivations to develop and sell higher-margin products, and to leverage existing customers for additional value in order to stabilize and grow their businesses sustainably.

Many suppliers now see smaller-sized products as a necessary first step in a long-term consumer journey that would periodically graduate users to larger, more lucrative, multi-application systems.[199] For many companies, in particular non-affiliates, pico products remain a core focus and ongoing driver of volumes. Even players who have been jostling for share and control of the PnP SHS segment indicated during interviews that smaller products remained firmly within their purview and long-term strategy.[200] Additionally, many expressed concerns about failing to deliver energy access for the lowest-income populations (if the market focuses exclusively on PAYGO-enabled SHS) as motivation for maintaining their pico presence.[201]

This has resulted in increased options for consumers. Not only can customers choose from a wide range of product types and applications (especially in more mature markets), but they also have access to multiple price-points and brands in any given product type or application. This is reflected in data collected from Kenyan and Tanzanian retail outlets: Kenyan retailers stock about 150 pico and 60 PnP SHS products/brands in retail outlets across the country; similarly, in Tanzania, there are 148 pico and 70 PnP SHS products/brands available.[202]

The structure of the industry remains familiar and comparable to what it was in the past. For the most part, the OGS sector continues to resemble Original Equipment Manufacturer (OEM)-driven industries such as the mobile-phone, computer and IT industries.

Figure 54: High-level OGS industry structure and composition[203]



[199] *Source: Industry interviews*

[200] *Source: Industry interviews*

[201] *Source: Industry interviews*

[202] *Note: Includes products/brands sold by affiliates as well as non-affiliates. Data are not available for the average number of products/brands stocked at an individual retail outlet. Source: (Ipsos, 2016a); (Ipsos, 2017); Dalberg analysis*

[203] *Source: Industry interviews; Dalberg research and analysis*

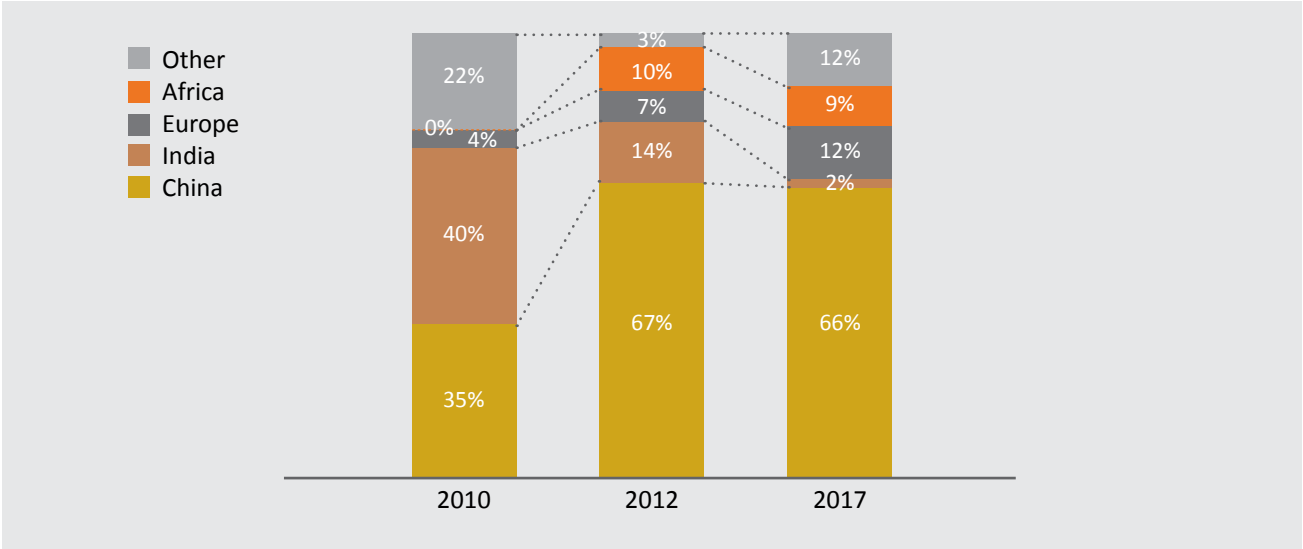
The primary modus operandi remains broadly unchanged, with OEMs or manufacturing brands retaining control over large parts of their value chains, including product design (in most cases), branding, quality control (including certification) warranty, support, and licensing of the product. Recent years, however, have seen new business models and areas of specialization emerge as the industry matures. These shifts largely pertain to the PAYGO segment, and are expected to significantly change players' modes of engagement in the value chain going forward (as discussed in Section 1C.3).

> "We started as a vertically integrated company, which is important to learn the nitty gritty of a market. During our most recent expansion, we decided to partner with local companies rather than carry the heavy cost of distribution and last mile support all by ourselves. Our operations are much leaner and all our financial KPIs are stronger as a result."
>
> **- Affiliate supplier**

The landscape now encompasses stakeholders with a broadened range of interests and includes more opportunities to specialize. In 2010, the segment was primarily comprised of impact-driven NGOs and social enterprises that focused solely on OGS products, typically headquartered in OECD countries. Today, while the impact-driven players continue to exist, the marketplace has pivoted toward companies with fully commercial business models (like Pro Solar), and includes companies with multiple product lines and services, including FMCGs, electronics and large-solar manufacturers that sense an opportunity to expand their product portfolios (like Hubei WisdomSolar). Since 2014, PAYGO business models have emerged on the landscape and have also been accompanied by the development of specialized, horizontally integrated businesses (such as Angaza), which cater to the needs of other businesses in the space. As discussed in detail in Section 2, these specialized service providers can reduce the need for vertical integration seen in the early days of the sector, and thus lessen the "time to market" for new entrants going forward. This rapid diversification has also been accompanied by a shift in the "brains" base (company headquarters location) of the segment toward Asia and Africa.

Figure 55: Suppliers by headquarter location[204]

% of suppliers (2010-17)



[204] *Source: 2010: (Dalberg, 2010). 2012: Dalberg analysis for Lighting Africa 2012 Market Trends Report (Dalberg, 2012). 2016: Company websites; LinkedIn; Dalberg research and analysis*

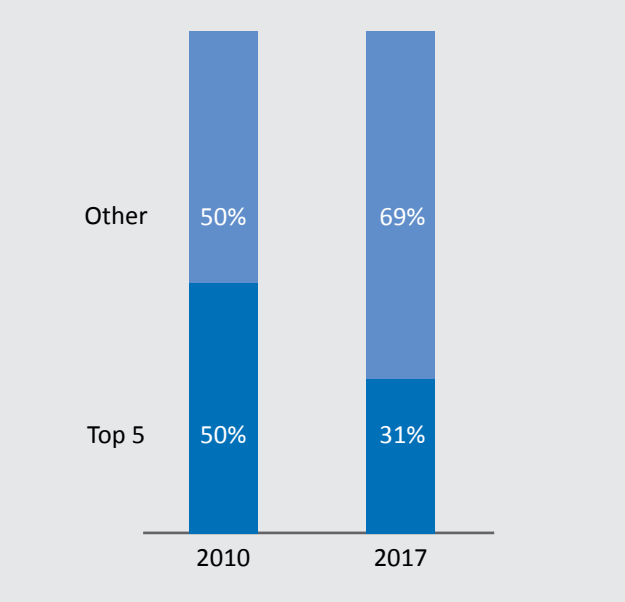
Market concentration: As a whole, the pico segment sees more competition today than in the past, but the affiliate sub-segment remains concentrated.

Market concentration among the leading companies in the pico segment has fallen progressively since 2010, when the top five companies accounted for 50% of the market. Today, this share has reduced to 30%, when considering the full universe of affiliates and non-affiliates. Within the affiliate pico universe, however, the pico segment is fairly concentrated, with the top five players commanding a little over 85% of the market. The Herfindahl-Hirschman index (HHI), a measure of market concentration, has also fallen for the pico segment since 2014-15, indicating growing competitiveness in the last two years.[205]

The first-mover advantage that early entrants (mostly quality-verified affiliates) established has gradually dissipated, and barriers to entry such as consumer awareness, technological and supply-chain challenges, access to distribution networks, and financing (to a certain extent) have decreased, particularly in maturing regions like East Africa. Consequently, the pico segment overall has witnessed a flood of products and players and—in parallel—a fall in margins, as players battled for sales and market share among price-sensitive customers.

Figure 56: Market concentration of pico affiliates and non-affiliates[206]

% of total annual unit sales (2010-17)



While by and large this trend holds across markets, individual countries may see variations according to country-level factors. Unsurprisingly, countries that have a larger share of Lighting Global and GOGLA affiliates tend to be more concentrated. In Kenya, for example, where non-affiliates likely account for less than 40% of sales in the pico segment, it is estimated that the top three players (including at least one non-affiliate) comprise over 60% of the total share of sales.[207] In Tanzania, on the other hand, non-affiliates have a significant presence, and non-affiliate products dominate their affiliate counterparts in terms of penetration of retail channels.[208] While the affiliate segment remains fairly concentrated in Tanzania (two companies are estimated to control at least 60% of the affiliate pico market), concentration across the full pico segment is likely to be closer to the global average. Similarly, in India, the top three to five players are likely to currently comprise about 25-35% of pico segment sales.[209]

[205] *Note: The HHI is a measure of market concentration. Within the affiliate universe, the HHI has reduced from 2,853 to 2,220, whereas in the universe encompassing both affiliates and non-affiliates, it has reduced from 762 to 289. HHI numbers between 2014-15 and 2016 may not be an apples-to-apples comparison given potentially different methodologies and assumptions employed by BNEF and Dalberg. Directionally, however, these numbers are accurate in representing a segment that is moving toward increased competition. Source: 2014-15 estimates: (Bloomberg New Energy Finance, 2016). 2016 estimates: Dalberg analysis*

[206] *Note: Individual market shares have not been shown to protect confidentiality. The number of suppliers in 2016 is collated using the GOGLA and Lighting Global websites, Alibaba and desk research. Source: Industry interviews; Dalberg research and analysis*

[207] *Note: Estimated using anecdotal data points collected in interviews and desk research. See also Table 8. Source: (Ipsos, 2016a); Dalberg analysis*

[208] *Source: (Ipsos, 2017)*

[209] *Source: Industry interviews; desk research; Dalberg analysis*

Mergers and acquisitions were expected in the pico segment among market leaders but have not materialized, with major investor and operator focus tending toward the PnP SHS segment instead. As opportunities for organic sales growth decreased, the pico segment was expected to enter a stage of consolidation through mergers and acquisitions, as is usually the case in most nascent or maturing industries facing increased competition.[210] Instead, the rise of the PnP SHS segment on the back of PAYGO technology has re-oriented many companies—especially quality-verified market leaders in the pico segment—back toward chasing new customers in untapped geographies. This does not mean that the pico segment is in decline, only that the focus of major players (not to mention investors) has shifted strongly to the PnP SHS segment with prospects of higher, more sustainable profits.

In the next three to five years, players in the pico segment are likely to continue to jostle for customers, especially in newly-opened PnP SHS markets, where new sets of customers will be exposed to off-grid solar. Concentration is unlikely to change significantly, and may even further decline over time. More companies, including non-affiliates, are likely to move up into the PnP SHS segment. Some from the PnP SHS segment may move down to smaller device types, as pico products will increasingly be utilized as a pathway to acquire customers for the more lucrative PnP SHS segment. Indeed, emerging findings from UNDCF's Energy Ladder Research in Uganda suggests that consumers buying PAYGO PnP SHS were of similar income levels as those buying entry-level pico lights, but that their PAYGO purchase enabled them to build up their systems with modular upgrades, thereby increasing the service levels they enjoyed as well as revenues for the supplier.[211]

As discussed further in Section 1D, mergers and acquisitions activity has only recently begun to pick up, and is predominantly concentrated in the PAYGO SHS space. 2017 saw the first two significant M&A transactions in the off-grid solar space, with Mobisol's acquisition of Lumeter and Engie's acquisition of Fenix International.

Price points: Retail price is the key differentiator for companies in the pico segment.

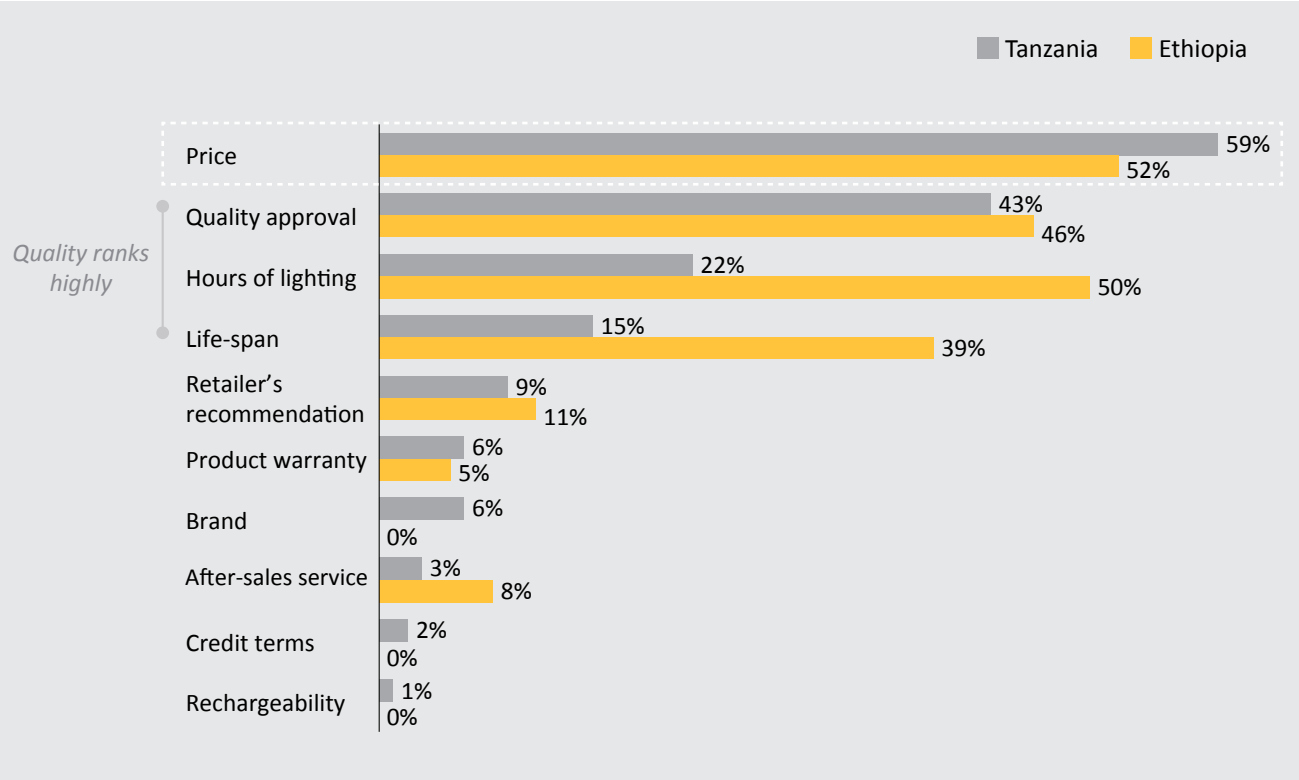
> "A lot of non-quality verified products are good enough to build the market, and at the same time, customers have different expectations of cheaper, non-quality verified products (especially in terms of lifetime) versus a more expensive product. The truly junk devices are becoming less common."
> **- Donor**

In Ethiopia and Tanzania, pico retailer surveys conducted by Ipsos found that more than half of customers in each market ask about the price of the product, whereas only 6% ask for a specific brand.[212] Pico products show wide variability in performance (see Figure 60); however, anecdotal evidence from development partners suggests that customers are well-aware of product performance risks and still choose to purchase products because of the costs savings they offer. For example, even in mature markets like Kenya, low-income customers often choose the cheapest pico devices even when they are aware of higher quality devices in the market. This occurs less as they travel up the energy ladder. In new markets, though, where consumers are less exposed to off-grid solar devices, low-quality products pose the risk of spoiling the market.

[210] *Source: (Deans, Kroeger, & Zeisel, 2002)*
[211] *Source: (UNCDF, 2017); industry interviews*
[212] *Source: (Ipsos, 2016b); (Ipsos, 2017)*

Figure 57: Pico retailer survey results: "What do customers ask for when they consider which lantern to buy?"[213]

Tanzania, n=644 retailers (2017); Ethiopia, n=887 (2016)



Quality: Affiliate products are typically more expensive, and more likely to guarantee quality and longevity.

Affiliate products tend to be more expensive; however, their products tend to score higher on lumen output, longevity and consumer protection. Non-affiliate products may or may not guarantee such features or service levels; as a result, customers may not always know what they are getting.[214]

Lighting Global/GOGLA affiliates, on average, tend to sell at higher prices than non-affiliates. Depending on the market and product functionality, the price differential can range from 20-200% (see Figure 58).[215] This gulf in price between affiliates and non-affiliates and the overall competitiveness of the pico segment has exerted a downward pressure on the gross margins of affiliate suppliers; the industry average gross margin is now around 10%. Some affiliates continue to command a higher price, and subsequently higher margins; these prices are maintained via differentiation and distribution via multiple channels.

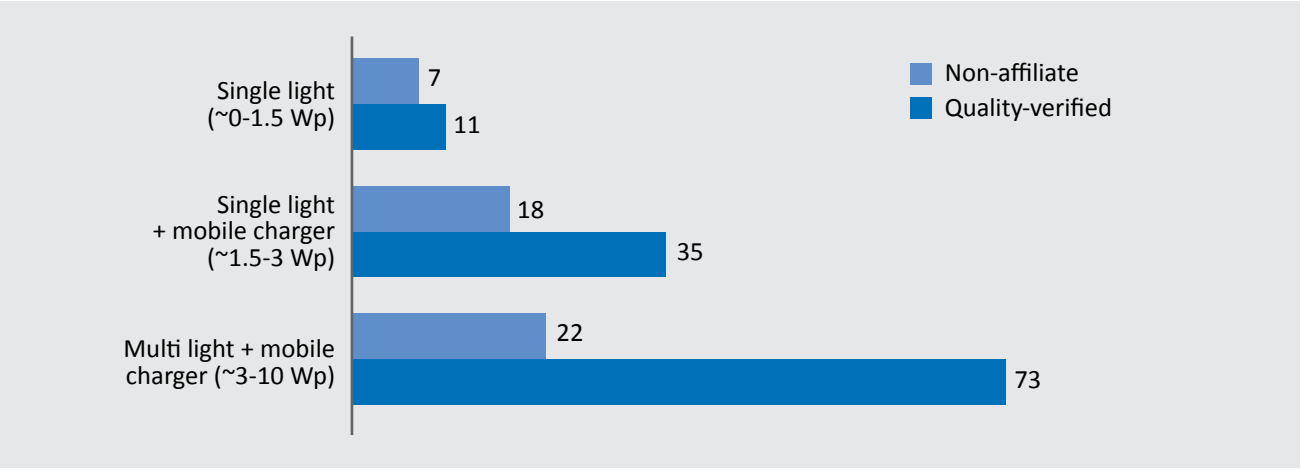
[213] *Source: (Ipsos, 2016b); (Ipsos, 2017)*

[214] *Note: Findings on the range of quality levels among non-affiliate products are expected in early 2018 from new research by the Lighting Global quality verification team*

[215] *Source: (Anand, 2017); industry interviews*

Figure 58: Price range of products for a given size *(Indicative)*[216]

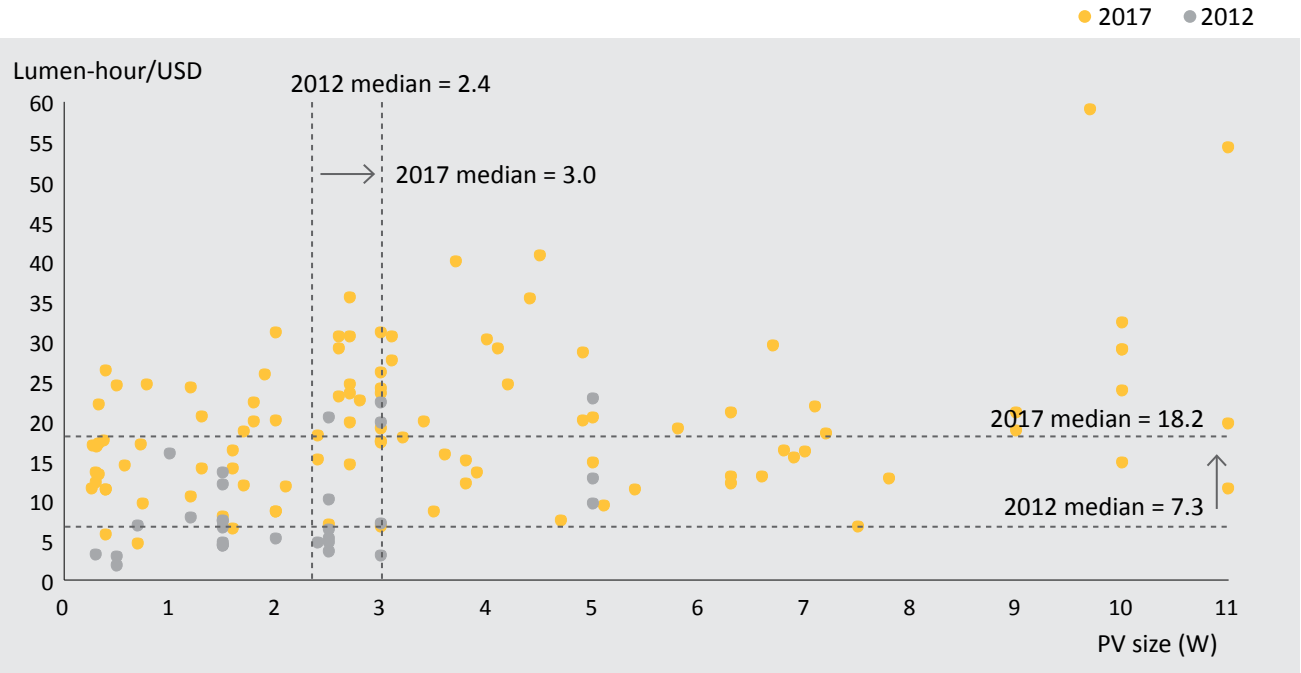
Select Lighting Global quality verified and non-affiliate products; USD (2017)



Industry players have innovated pico products rapidly to keep performance up-to-date with advances in the underlying technologies, including in PV panels and LEDs. The value proposition of products in the pico segment has steadily improved especially with respect to lighting. As measured in lumen-hours per dollar, the value proposition of the median pico product has increased from 7.3 units in 2012 to 18.2 units in 2017, a gain of almost 150%.[217]

Figure 59: Evolution of value proposition (lm-hr/$) for the pico product universe[218]

Lighting Global quality verified pico products; n=29 (2012); n=104 (2017)



[216]*Source: Lighting Global; company websites; Alibaba*

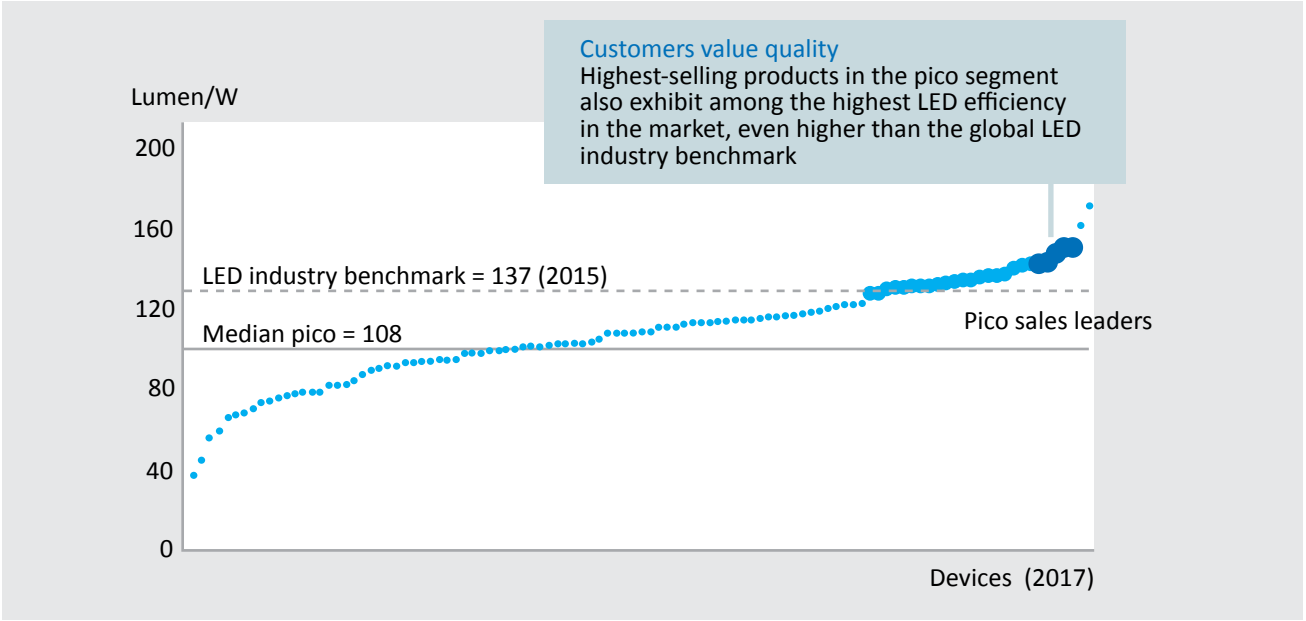
[217]*Note: Performance measured as lumens at highest setting * solar run time at highest setting. This is then divided by retail price to arrive at per unit performance. Retail prices are calculated as 1.8 * FOB price listed in the Lighting Global products database. 2017 prices are adjusted for inflation*

[218]*Note: (1) Pico refers to products in the 0-11 W range according to the Lighting Global/GOGLA product categories (GOGLA, 2017). Four products of 12 and 13 W that were listed as "pico" in the Lighting Global product database were changed to "SHS" to comply with this wattage classification. (2) While 2017 lumens and run-time are for products on "turbo" setting, the setting used in the 2012 data shown is unclear and hence outliers have been removed. (3) Retail prices are calculated as 1.8 * FOB price listed in the Lighting Global products database. (4) 2017 prices adjusted for inflation. Source: Lighting Global data 2012 and 2017; Dalberg analysis*

Some companies, including (but not limited to) market-leading affiliates, are differentiating by providing lighting efficiencies that are not only well above the industry average, but also out-perform benchmarks for the larger LED industry (see Figure 60). Although quality remains unmeasured for non-affiliates, industry experts report that many non-affiliates have sought a competitive edge by using LEDs that are much brighter than typical affiliate brands, which encourages customer uptake when comparing products in a retail setting.

Figure 60: Lighting efficacy industry performance[219]

Lumen/Watt; n=107; select affiliates and non-affiliates (2017)



Affiliates in the pico segment further differentiate from non-affiliates by building products that last longer. Interviews suggest that quality-verified products typically have longer warranty periods than products from non-affiliates, which may or may not have any warranty attached. In addition, retailers in several East African countries report that quality-verified products tend to outlast their warranty periods.[220] The lifetime of other products, especially non-quality verified devices, are highly variable – ranging from a few weeks to years.[221]

Distribution and branding: Key differentiators for affiliate products.

Early investments in distribution by affiliate pico suppliers established strong relationships with branded distributors and built brand equity; this enabled successful companies to keep a competitive edge. Successful companies typically followed a two- to three-pronged approach when setting up distribution networks: (1) building an on-the-ground, door-to-door sales network that focused on educating customers on the advantages of solar, particularly in remote areas; (2) establishing proprietary partnerships with well-regarded brands (both inside and outside the OGS industry) to expand their sales networks and reach "low-hanging" customers in newer markets; (3) entering partnerships with MFIs and other institutional partners (a highly successful model in India for affiliate companies, but less so in some African markets).[222]

[219] Note: Industry benchmark based on stated average efficacy of commercial A-type LED bulbs as per U.S. Dept. of Energy. Source: Lighting Global data; U.S. DoE; Dalberg research and analysis

[220] Source: (Ipsos, 2016b); (Ipsos, 2016a); (Ipsos, 2017)

[221] Source: Industry interviews

[222] Note: Some suppliers have suggested that partnerships with MFIs and cooperatives take a higher share of margins given higher costs associated with training their sales force and the large potential customer base that they bring to the table, and also entail strict procurement guidelines, which sometimes deters partnerships

These early efforts to create consumer awareness and trust have been instrumental in pulling new suppliers into the market. Consumer awareness and trust created by affiliates lowered the costs of consumer acquisition significantly and attracted new affiliates as well as non-affiliates in such numbers that pico products have become commodified in certain markets. Despite this growing competitiveness, affiliates have retained a competitive edge in maintaining partnerships with large-scale and institutional distribution channels that require proof of quality or rely on long-term relationships.

Some companies successfully established customer relationships and repeat sales over time through marketing and branding strategies. Top brands find that customers clearly associate the product with either the company name, the name of the product, or both. The experience of most companies in the pico segment shows that while marketing and branding savvy is not necessary to make a large volume of initial sales, it is a driver of repeat sales and upgrades. Beyond the top five brands, however, only a handful of companies have managed to establish clear brand equity. A few patterns and best practices have emerged, based on conversations with some leading pico brands.

- *Direct customer education and word-of-mouth remain the most powerful marketing tools.* For example, Greenlight Planet found success in the pico market via their village entrepreneur network. In the early days of the market, community ambassadors were effective in gaining trust for the brand. Emerging findings from UNCDF's Energy Ladder research in Uganda suggests that direct marketing by suppliers, demonstration by peers, and referrals by community leaders are the most influential sources of information driving end-user uptake.[223]
- *Incentives for retailers tend to work extremely well, especially in rural locations.* Providing incentives to retailers who remain the first/only touchpoint for customers, especially in remote areas, helps build a brand when retailers advocate for it. Some companies, particularly non-affiliates, provide a commission or sell their products on consignment to retailers, incentivizing them to refer their products to customers and keep them in stock.
- *Piggybacking on other trusted brands in associated sectors could increase credibility and trust in a product.* For example, d.light partnered with BPCL and HPCL in India, trusting the state-owned cooking gas distributors (with significant rural reach and visibility) to retail their solar products. Several brands have also partnered with Total to distribute products through its extensive global network of petrol stations. However, this strategy may not always succeed. Finding partners that are compatible and have complementary revenue streams is crucial, according to industry players.[224] Some partners may also need incentives and capacity building to be able to effectively promote pico products.

1C.3 PLUG-AND-PLAY SHS SEGMENT

Market concentration: The PnP SHS market is marked by a top-heavy landscape, with leading companies dominating market share.

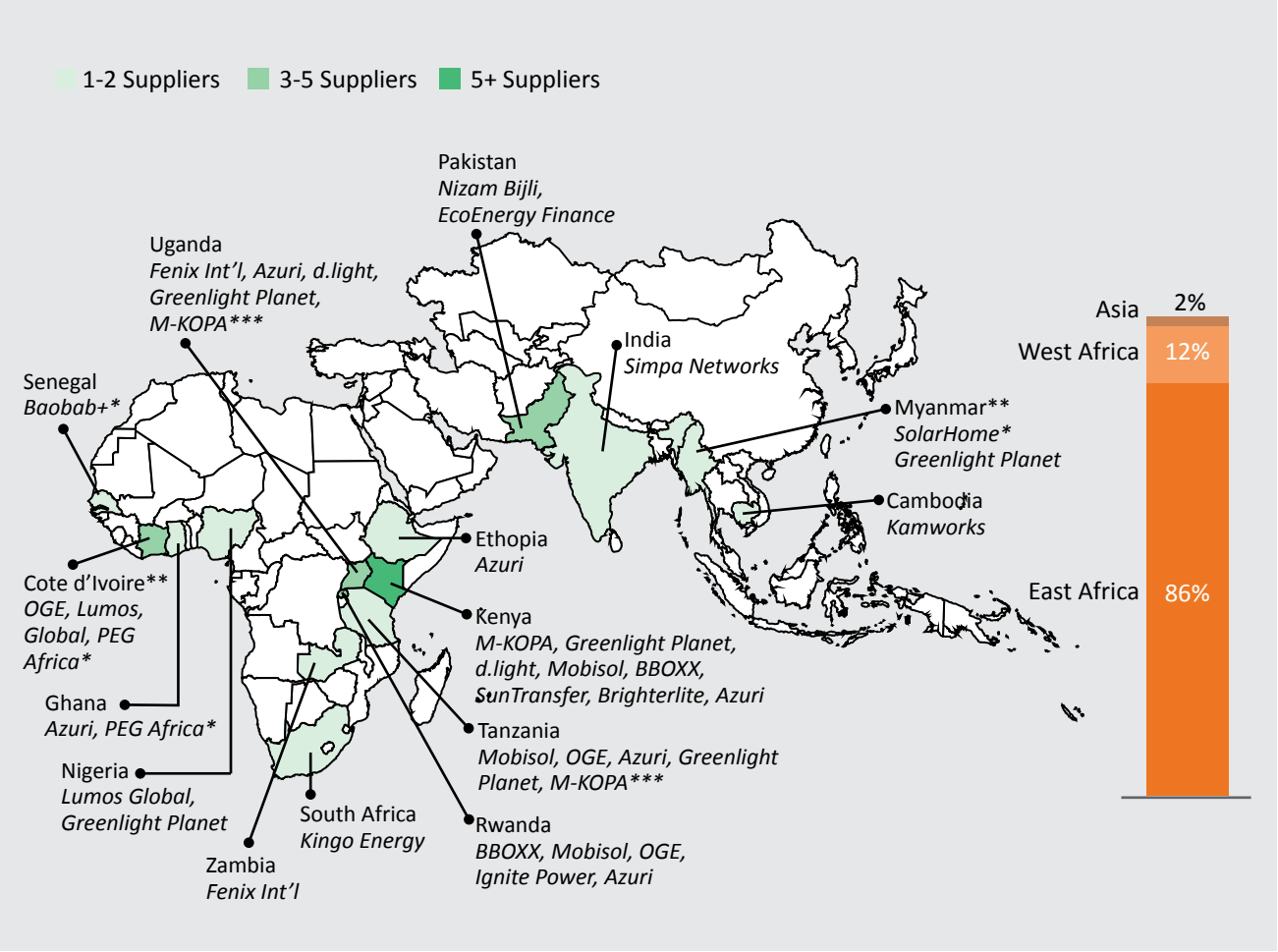
Though a few companies entered this market as early as 2010, the still-nascent PnP SHS segment has only taken off in the past three to four years and is evolving at a quick pace. Business models are in flux, and significant value remains on the table in terms of opportunities for organic sales growth (e.g. customer acquisition and up-selling) and high product margins ranging from 50-80%.[225] These opportunities exist both for vertically-

[223] *Source: (Goyal, Jacobson, & Gravesteijn, 2017); (UNCDF, 2017)*
[224] *Source: Industry interviews*
[225] *Source: Industry interviews*

integrated companies undertaking consumer-facing functions as well for horizontally-integrated companies that provide solutions at specific points on the value chain. Competition is light within the affiliate PnP SHS segment, especially among PAYGO players; most companies are first or second movers in their respective country markets, and have been able to convert that advantage into near monopolistic and/or oligopolistic positions. For example, the first movers in the PnP SHS segment in Kenya, Uganda and Nigeria occupy approximately 60%, 70% and 30% of market share in their respective markets.

Figure 61 illustrates the high geographic concentration of PAYGO players.

Figure 61: Presence of PAYGO players by country[226]
Number of players (2017)



This market concentration is further reinforced by the barriers posed by high capital needs, which limit competition in the short term (see Figure 62).

[226]*Note: Figure does not consider pilots, only companies with an established sales presence in a country. The data are not exhaustive, but are representative. Key: (*) Distributor (**) New entrants (2015-2017) with low overall in-country sales; (***) M-KOPA has presence but bulk of their sales come from Kenya. Source: Dalberg research and analysis*

Figure 62: Cost-related barriers to entry to the PAYGO SHS segment

Investments in technology: Typically, suppliers have invested between USD 1-10 million in developing proprietary software to manage payments and gather usage data.

High customer acquisition costs: PAYGO SHS sales require a trained sales force to educate consumers on navigating and maintaining the technology, and on payment terms and procedures. Most suppliers invest in and maintain large, commissioned sales teams.

High transaction costs: Suppliers often maintain a secondary team to recoup payments (through follow-ups/repossessions).

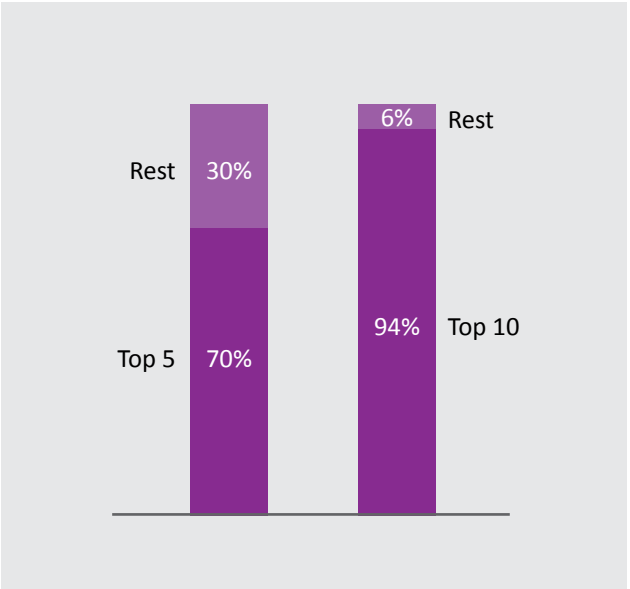
High after-sales costs: Often, a third, localized team is required to undertake post-sales servicing. Unlike smaller products that can be sent to a central service center for repair or replacement, servicing larger products necessitates a decentralized team. Major suppliers typically invest in a call-center and a local repair laboratory.

High corporate costs: Given the upfront investments and long-payment periods, suppliers that can sell consumer-receivables can access more working capital, reduce credit risk, and scale faster. This leads many suppliers to invest in skilled corporate teams to raise such debt.

While the PnP SHS segment has certain structures that would support monopolistic or oligopolistic behavior in the long term, the evidence suggests that the high market concentration—almost 70% for the top five players, and over 90% for the top 10, shown in Figure 63—reflects the newness of the PnP SHS segment at this stage, rather than the companies themselves having "won" the market. What's more, as discussed in Section 1B.2, the PnP SHS segment itself faces competition from component-based systems, including institutional distribution programs as well as open-market sales. While the degree of competition itself varies across markets, some countries such as Bangladesh and Myanmar are dominated by these component-based systems.

Figure 63: Market concentration in the PnP SHS segment[227]

% of annual unit sales (2016)



[227] *Note: Excludes the sales of M-KOPA IV and Azuri Quad in order to align with Lighting Global/GOGLA's categorization of SHS products having a wattage of 11Wp+ (GOGLA, 2017). Market share estimates may change marginally with the inclusion of these products, but market concentration figures remain directionally accurate. Source: Dalberg research and analysis*

Consequently, market concentration in the PnP SHS segment is expected to dilute over the next few years as new players enter, enticed by higher margins and untapped customers. The increasing competition in the sector will be supported by falling entry barriers, eventually leading to lower margins and profitability.

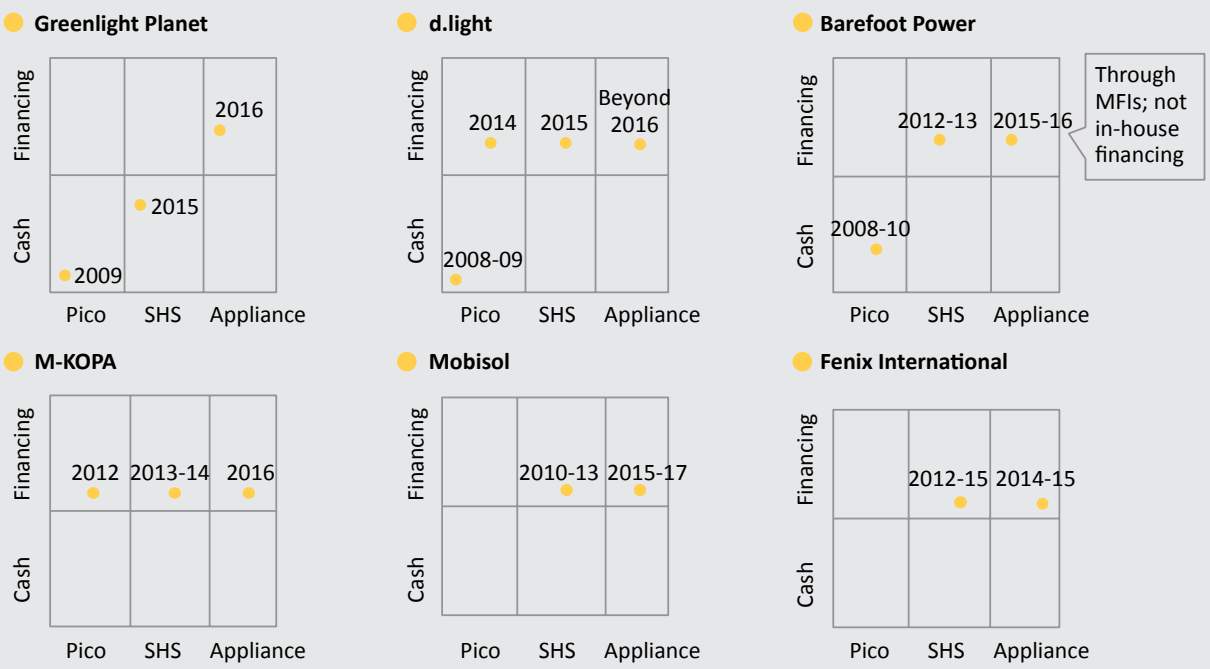
Consumer financing: Clear business model convergence toward PAYGO.

Business models have shifted to accommodate consumer financing. There is strong convergence toward PAYGO-based models, which have become mainstream in countries home to an enabling ecosystem of mobile money and conducive regulation.

Since the initial experiments with PAYGO in the first half of the decade, a handful of companies in the pico segment (such as d.light, Greenlight Planet and SunnyMoney) and nearly all PnP SHS companies are now deploying it as their preferred consumer financing option.[228] In Sub-Saharan Africa, only a few major operators (e.g. Barefoot Power) continue to experiment with other consumer financing models such as MFI-based product loans, though MFIs remain significant to business models in India. Industry stakeholders have indicated that almost all PnP SHS products, including smaller products in the 11-20W PV size range, will offer PAYGO financing going forward. This trend, however, is contingent on PAYGO taking off in markets such as India, where digital finance penetration is very low and where consumer financing remains reliant upon MFIs.

Figure 64: Product and business model expansion for select pico OGS companies *(Illustrative)*[229]

Product launch dates (2009-17)



[228]*Note: Estimates indicate that of all pico sales, less than 5% were conducted via PAYGO. The high transaction costs of PAYGO distribution and aftersales are a barrier to their deployment in the pico sector, as deploying PAYGO infrastructure becomes unviable for products that are less than USD 20-30. Those companies that do provide pico products via PAYGO are able to maintain viable unit economics by supplying a basket of products, including higher-wattage products, which help distribute PAYGO costs over a larger revenue stream. For the most part, however, the pico segment is expected to continue to focus on cash sales. Source: Industry interviews; Dalberg analysis*

[229]*Note: Date of product launch is an approximation based on media reports and company websites and includes a pilot period. Source: Dalberg research and analysis*

Figure 64 illustrates how business models in this space are converging even as the core DNA of organizations differs. Interviews suggest that early entrants that built large scale cash sales distribution businesses have shown greater focus on the core product itself. Alternatively, players who rely on selling the product through some form of financing (most often PAYGO) have typically differentiated themselves on the back of their business models and sale processes.

East Africa has become a global hub for PAYGO but expansion into West Africa has gathered substantial steam. Thus far, PAYGO has failed to gain a significant foothold in Asian markets, with just 2% share of sales to date (see Figure 42 in Section 1B.2). East Africa is particularly fertile ground for PAYGO given the high penetration of mobile money in the region. While mobile money is not necessary for PAYGO, it has the potential to enable and accelerate its uptake significantly by providing a ready platform to use for payments, collections, monitoring usage, and even assessing risk.

Business models: PAYGO companies have multiple sub-businesses, often making them unwieldy.

The PAYGO business is essentially four businesses—product design/assembly, distribution, platform technology, and banking—rolled into one. As it is difficult to excel across all four, the business model and customer offering is shaped by operators' choices on a range of core questions and dimensions. These questions include what position to ideally take in the value chain, whether to develop a PAYGO platform in-house or purchase technology from a third party, and what mode(s) of payment to support. Choices are often driven by geographical limitations—for example, mobile-based payments are restricted to geographies that have mobile money infrastructure and penetration.

At the same time, most operators across geographies are streamlined toward certain choices (see Figure 65), suggesting that a few dominant business models are emerging. These choices impact a company's ability to scale and maintain the quality of their portfolio, and are explored in detail below.

- *Value chain focus:* Currently the majority (68%) of known PAYGO operators are vertically integrated, while less than a third have chosen to outsource parts of the value chain. Examples of integrated players include M-KOPA in Kenya and Mobisol and Off Grid Electric in Tanzania. Azuri Technology, on the other hand, outsources distribution to local partners while retaining control over product design and development. At this early stage of the industry, vertical integration is driven by: (1) the need to control customer experience across the value chain, given that quality long-term customer relationships, which drive payment recovery and upselling, are crucial to the business model, and (2) the unavailability of suitable in-country distribution partners.

  Companies that had operated on an integrated value chain in their first market have often chosen to take a partnership approach when entering new geographies. For example, when entering the Kenyan market in 2016, Mobisol partnered with Chloride Exide for distribution, and Off Grid Electric partnered with Total for distribution when entering Cote d'Ivoire. This trend is likely to continue as companies look to scale while optimizing costs.

- *Platform technology:* More than half of PAYGO players have built their own PAYGO platforms for customer relationship management and to "unlock" the device on payment. A platform may allow "unlocking" one of three ways: (a) on-network, via GSM or other communications infrastructure, (b) off-network, via periodic connection to an agent's device, or (c) off-network, via manually entered codes sent to customers via SMS.[230] The type of connectivity chosen impacts whether the product can

[230] *Note: This report has sought to align its characterizations of PAYGO models with the forthcoming taxonomy of business models being used by off-grid energy companies, under development by the World Bank Group and GOGLA*

be deployed outside its first market. For example, a GSM-based unlocking mechanism may struggle in markets outside Kenya that have poor GSM coverage.

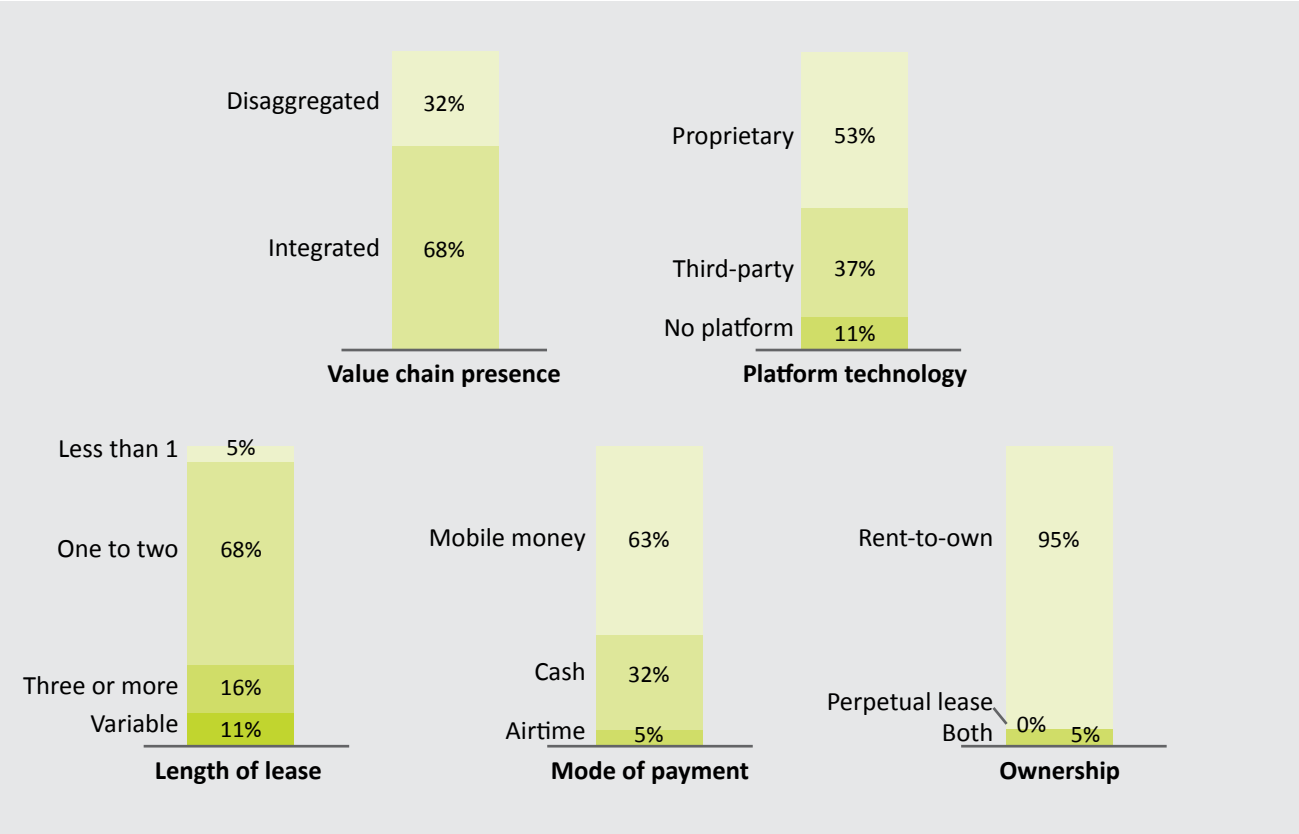
In-house PAYGO software developers are typically early entrants in this segment who—much like early entrants in the pico segment—invested heavily in design and ultimately provided a blueprint/prototype for the rest of the industry. An industry player called this investment the "first mover disadvantage," as specialists such as Angaza, Lumeter (acquired by Mobisol), and Solaris Offgrid have since gained significant market share, allowing other PAYGO providers to license software from them to avoid in-house software development costs. Outside of East Africa, in regions that lack mobile money or remote payment options, a few PAYGO companies rely on manual payment recovery.

- *Financing model:* A majority of industry players are coalescing around a lease-to-own financing model with a payment period of less than two years. Transfer of ownership acts as an incentive for customers to complete payments; many off-grid customers are not used to the idea of paying for energy as a service (as in a perpetual lease model) and require this incentive. The incentive is often most effective when the prospective timeline to ownership is short, thus reducing the risk of defaults. Striking a balance between affordable monthly installments and short lease lengths is more complicated for larger systems (above 50W) given their higher overall cost of ownership, leading their payments to be typically spread over more than two years.
- *Payment process:* In East Africa, almost all PAYGO providers rely on mobile money. Outside East Africa, however, this mode of payment is complicated by lower penetration of mobile money and many customers' unfamiliarity with using it even when it is available (often leading to the building up of arrears). In the first case, some players have innovated their technology to accommodate payments through mobile airtime. While this innovation lends itself to scalability, going forward, it may run into regulatory challenges. Others rely on cash-payments that customers hand over to repayment agents. This method leads to high costs—accrued from agent commissions, transportation, security, and administrative costs for tracking payments—which increase as operations move to less dense areas. Companies are innovating to address these challenges, and their efforts may hold lessons for the uptake of PAYGO outside East Africa. For example, PEG Africa has started a "Good Payers' Club," in Ghana which gives free health insurance for a month to those customers who are up-to date on their arrears or pay off their systems early. The share of PEG Africa's customers in this club has been rising.

Photo credit: Fenix International (Jjumba Martin)

Figure 65: PAYGO business model specification landscape[231]

% of PAYGO players interviewed (2017)



The choices that players make along the dimensions mentioned above point to the major business models that are emerging. Some combinations of these choices, framed here as typologies, are likely to scale and dominate the sector in the coming years; those typologies are further described for the entire OGS market in Section 3. Typologies pertaining to the PAYGO sector today include:

- *Vertically-integrated, energy service provider:* This typology is similar to many business models today in which the company acts as a utility provider and controls most aspects of the value chain, from product design to payment collection. Examples include both companies that have entered the PAYGO space directly as well as established pico players moving into the PAYGO SHS space. During the nascent stages of the PAYGO industry, most new entrants chose to invest heavily in all parts of the value chain to compensate for the lack of suitable partners and to control the customer experience as they innovated to find an optimal business model. Pico players moving into this segment leveraged their product design expertise and existing distribution channels. Going forward, in maturing markets, companies may shift away from vertical integration as the emergence of suitable partners allows them the opportunity to save costs. In new markets, however, where OGS devices are less ubiquitous, companies may still need to establish their own networks to acquire and sustain customers.
- *Banker:* In this typology, a company focuses on the customer-facing functions of the value chain, including sales, credit assessment, payment recoupment and after-sales service. PEG Africa and

[231] *Note: Figure is based on the business model specifications of 19 PAYGO operators. While this analysis is not exhaustive, it represents the diversity of business models and geographies among PAYGO players*

SolarHome exemplify this typology, procuring products from established OGS players and then investing in infrastructure to support customer acquisition and management. Going forward, the market may see increasing emergence of such models driven both by existing, vertically-integrated players shifting focus to the downstream value chain, and new entrants drawn into the market by the excitement surrounding PAYGO and looking to shorten their time to market by procuring existing products.

- *Value chain specialist:* Companies operating in this typology typically focus on one part of the value-chain (usually upstream) and are horizontally integrated. Examples include Angaza, which specializes in PAYGO technology for a range of energy products, and Renewit, which focuses on product design and manufacturing of solar products ranging from lanterns to solar kiosks. The range of products integrated in this model may extend beyond OGS and solar. For example, Mobisol is licensing its hardware-agnostic software to enable up-selling of other consumer electronics and products sold with consumer financing.[232] Going forward, this model would be most attractive to players that are looking to leverage an existing capability (such as software design or manufacturing ecosystems) to enter the OGS market.

> "PEG Africa was the first to pursue a [banker] model, whereby we licensed hardware and software rather than developing it ourselves. Quality hardware and software existed in the market already, so we saw no value in investing to reinvent the wheel. We have raised USD 21 million over the last three years, and we are the largest licensor of PAYGO technology in Africa. We have shown this model can work, and now there are many companies adopting this approach."
>
> **- Hugh Whalan, PEG Africa**

Energy ladder: There is increasing emphasis among operators on moving customers to higher service levels.

Market leaders have placed increasing emphasis on transitioning their customers upward through the energy tiers, especially by providing access to DC-powered appliances. As discussed in Section 1B, customers have expressed significant latent demand for these higher-order energy services. OGS companies have invested across a wide range of applications, from household to productive uses (see Figure 66). Several leaders have already developed high-performance, self-branded appliances in order to quickly establish market share. Examples include Mobisol (32," 24," and 22" TVs), BBOXX (24" TV), SolarNow (24" TV), M-KOPA (19" TV) and d.light (19" TV), all of which were high-achievers at the Global LEAP awards for efficient off-grid appliances in 2016.[233]

[232] *Source: (Mobisol, 2017)*
[233] *Source: (Power Africa, 2017)*

Figure 66: DC-powered appliances and their manufacturers *(Illustrative)*[234]

Players are also differentiating themselves by targeting "productive use appliances." Off Grid Electric, for example, features a "business in a box" in its product portfolio targeted at rural entrepreneurs.[235] Mobisol is piloting an 800W product in combination with a welding machine targeted at SMEs. Barefoot Power has piloted a DC refrigerator and is looking to develop productive use appliances in the future. While companies cite productive use appliance sales as an important emerging trend, there exist several challenges to its mainstream adoption (see Section 2).

Currently there are few, if any, major commercial consumer electronics giants investing seriously in the off-grid appliance space. Only Samsung (TVs) and Haier (refrigerators) have shown initial interest. This suggests that these "mainstream" players remain unclear as to the prospects and potential of the OGS sector, and how to engage with it effectively; stakeholders have suggested that market volumes are yet to become material from their perspective. Their greater involvement going forward has the potential to accelerate the momentum and maturity of the off-grid appliance universe.

[234] *Note: (*) Commercial supplier. Product list is NOT exhaustive but covers most products listed in the two sources below accessed through MIT D-Lab's Off-Grid Energy Resources. The data shown are not comprehensive or representative. Source: (GIZ, 2016); (Sendea, n.d.); Dalberg analysis*

[235] *Source: (Shapshak, 2016)*

Customer service culture: Companies are investing in a more personalized sales experience.

Some leading companies have noted the importance of providing a personalized sales experience in driving sales and keeping customers happy in the PAYGO SHS space. This investment can take several forms. One way for companies to differentiate is via their sales and distribution channels. Companies typically choose to deploy multiple channels to cover different customer segments across geographies, such as dedicated sales agents, retailers, distribution partners, and institutional sales. However, most have a dominant channel in each country of operation.[236] Several leading PAYGO operators are beginning to converge toward developing and deploying proprietary distribution networks. According to them, building a dedicated sales force leads to higher operating expenses, but facilitates in-depth customer relationships, usage data, and loyalty.[237] Other companies—particularly those with experience in the pico segment—often choose to leverage their existing relationships with retail and company networks to maximize scale and reach.

Beyond the point of sale, companies are investing significantly in building customer satisfaction to drive both word-of-mouth marketing as well as future sales and upgrades. This investment takes several forms. While most suppliers offer free repairs or replacements within a warranty period and technical support via SMS or a call center, others—especially in newer PAYGO markets—pro-actively reach out to customers immediately after installation and every few months to ensure adequate performance of the product. Other methods of customer engagement include leveraging call-centers to inform customers of rewards available on completion of payment, as well as referral programs which can provide existing customers with incentives such as rebates on existing loans.

Price points: The market is still price-sensitive.

While PAYGO increases the affordability of the product, customers are still sensitive to the overall cost of ownership. Players that have the highest sales in the PnP SHS segment are also associated with some of the lowest costs of ownership. Anecdotal evidence suggests that in markets where a new entrant offers a lower price for products with similar wattage and functionalities, customers often do switch between companies. Achieving a low cost of ownership in this segment can be challenging due to high entry costs. There are certain factors, however, that can drive down the price. These include leveraging economies of scale in distribution accrued from related products (e.g. by using the same distribution channel for multiple products), highly efficient product design and procurement procedures, and an established customer base to whom a company may sell larger products after selling an entry-level lighting product.

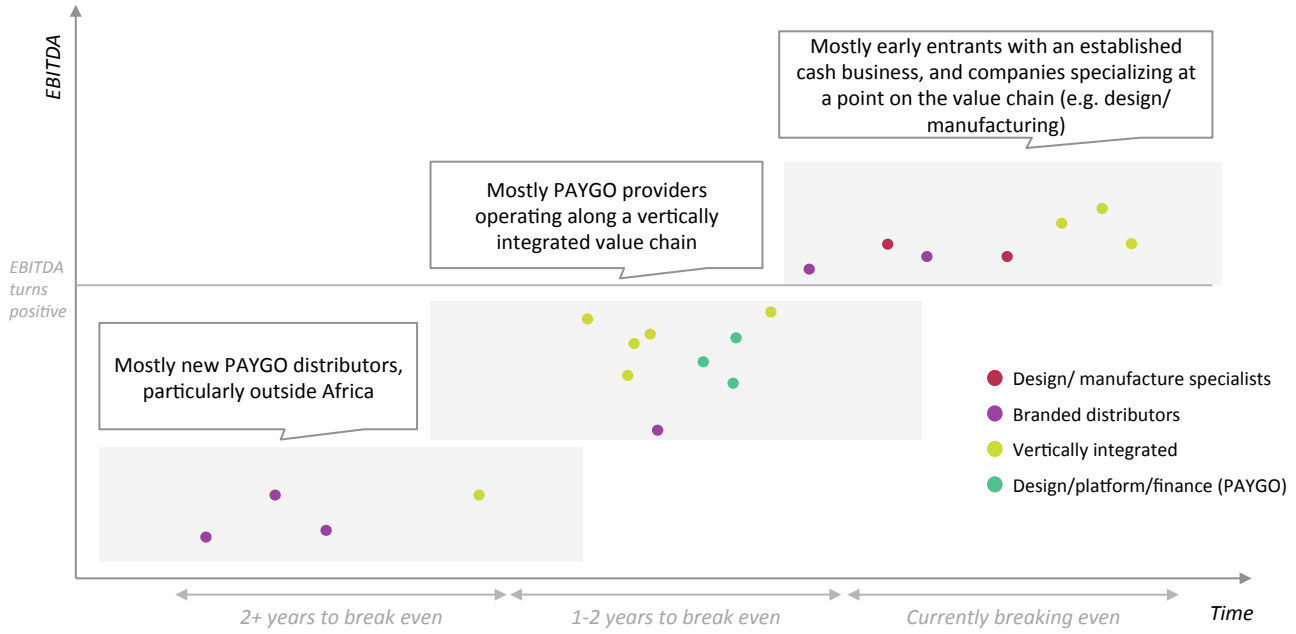
Profitability: Few companies have achieved profitability, although some consider themselves close.

Only a few companies in the OGS sector have been able to achieve net-profitability (see Figure 67). These are either early entrants in the market with an established pico cash business (with interest and/or presence in the SHS segment), or horizontally-integrated specialists in the OGS supply chain, e.g. white-label manufacturers or B2B technology providers.

[236] *Source: Industry interviews*
[237] *Source: (PowerforAll.org, 2016); industry interviews; Dalberg analysis*

Figure 67: Overview of company profitability[238]

n=20 companies; indicative EBITDA (2017)



Companies that have entered the PAYGO SHS segment have yet to achieve profitability, though some claim to be en route to becoming EBIDTA-positive by 2018 or 2019. While gross margins per unit are high in the sector, operating costs related to serving PAYGO customers are also high, depressing EBITDA. Given this, profitability for this segment has thus far been closely tied to companies' ability to rapidly acquire customers and achieve scale. This is reflected in the fact that a substantial proportion of funds raised in the last 2-3 years are based on aggressive projections (see Section 1D); it is yet to be seen if companies can meet them. To date, a large part of the sector has been following a "scale, then sustain" strategy, like Amazon or Uber, seeking to be first-movers in key markets and thereby capturing market share. A few companies have begun to reverse toward a "sustain, then scale" approach, establishing deep and long-term relationships with customers to drive portfolio quality and eventual profitability.

Reaching scale is complicated by a few factors for this segment. First, scale needs to be balanced with high portfolio quality. To achieve both at the same time, companies need highly sophisticated credit assessment systems, as well as highly efficient follow-up and payment recovery operations. Most companies are still innovating on both fronts (explored in detail in Section 1D). This requires time and investment in corporate teams to raise necessary levels of debt. Second, proof of concept has yet to occur beyond most PAYGO SHS companies' first market. Once low-hanging customers in urban and peri-urban areas have been tapped, companies will need to move deeper into less dense rural areas, or move into other new markets. Companies and investors interviewed suggest that this has proven challenging and comes at the cost of a deteriorating collections scenario. Some companies have reduced costs through partnerships, however, such as with a software provider (to save on technology R&D costs), or with a telco partner for distribution. As more such partnerships emerge, the timeline to profitability may shorten.

[238]Note: Placement of dots is indicative. Estimates are based on indicators self-reported by suppliers. Breakeven timelines are based on interviewee-reported estimates of when their companies' EBITDA will turn positive. Source: Interviews; Dalberg analysis

1D. FINANCE

KEY MESSAGES

- CAPITAL FLOWS: The OGS sector has seen a dramatic increase in funding. East Africa has been the primary recipient of funds, although West Africa and globally-oriented businesses have also gained traction.
- SOURCES OF CAPITAL: Debt has gained prominence. Commercially focused funders and crowdfunding have emerged, while local capital remains limited; social investors may refocus to maximize impact.
- RECIPIENTS OF FUNDING: Capital has largely flowed to a handful of relatively established companies; most of them use PAYGO models.
- USES OF CAPITAL: While industry-wide use of funds has diversified quickly as companies mature, investors have raised concerns that some companies' funding strategies may not align with the speed of their corporate development.
- FUTURE NEEDS AND GAPS: External funding requirements are expected to grow substantially, and a large gap remains. The marketplace will require new sources of capital, including commercial finance (both debt and equity).

> "We are at a crossroads where companies are struggling to figure out how they will be profitable, how they manage investors, and how they will operate through this first piece of adversity."
>
> **- DFI**

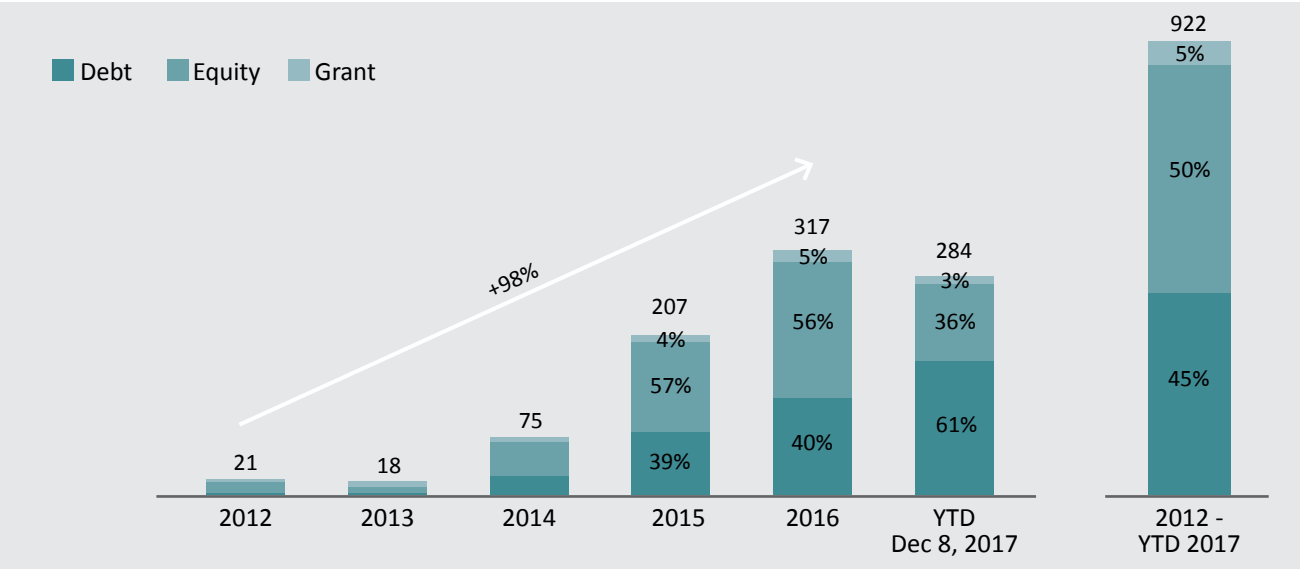
This section analyzes funding flows to private OGS companies from non-governmental sources. While financial support from governments remains important for the OGS sector, especially for creating an enabling environment (see Section 1E), direct investments or loans from government entities to OGS companies have been negligible.

Funding flows analyzed in this study are primarily based on publicly announced transactions and are thus likely to understate total investments (once unpublicized capital flows are included). They also naturally lean toward affiliate companies, as non-affiliate companies have historically raised funds from informal external sources or funded themselves through internal cash flows. While there are limitations to focusing primarily on affiliate companies, recent trends in the OGS sector (including the rise of PAYGO models) have been driven largely by affiliates; this section seeks to provide a view of these developments.

Investment growth: The OGS sector has seen a dramatic increase in funding.

Fundraising in the OGS sector has doubled annually between 2012 and 2016, with annual investments touching USD 317 million in 2016. However, the sales slowdown in 2016-2017 (see Figure 37) may have caused some investors to take pause. Cumulatively, USD 922 million has been raised since 2012.

Figure 68: Annual investment in the OGS sector over time, by financing instrument[239]
Millions USD (2012-17)



	2012	2013	2014	2015	2016	YTD Dec 8, 2017
Avg. size of top 5 transactions	2.8	2.4	9.8	21.3	31.7	25.4
Avg. size of overall transactions	1.4	1.0	3.1	5.6	4.0	5.0
Number of transactions	15	18	24	37	79	57

[239]*Note: Figures may not add to 100% due to rounding. 2017 figures include estimates regarding the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study has not been able to verify the size of these transactions, and estimates that they collectively fall in the range of USD 30-45 million. Source: GOGLA 2018 Deals Database*

GOGLA 2018 Deals Database

As part of this report, a database was compiled of investments in the PnP SHS and pico industries from January 1st, 2012 to December 8th, 2017 to enable analysis of investment flows over time. This database was funded by GOGLA and the Africa-EU Renewable Energy Cooperation Programme.

In this database:

Transaction dates are recorded as of the date that the transaction was publicly announced, and deal sizes are converted to USD equivalents based on the average foreign exchange rate for that year, where applicable.

Information for this database was collected from a combination of primary and secondary sources including company press releases, news reports, funder annual reports, research reports, and industry association reports. Deal information for 2016 and 2017 was verified, where possible, via interviews with suppliers and investors as a part of the 2017 GOGLA Investment Survey.

Historical funding patterns have reflected growing enterprise financing needs, as well as increasing investor confidence in the sector. As shown in Figure 68, the number of transactions per year increased from 15 to 79 between 2012 and 2016 (a rise of over ~50% year-on-year), demonstrating the growing appetite of the funding market. Average transaction size has also broadly increased, reflecting growing needs as well as investor preferences for larger deal sizes which reduce transaction costs—such as legal fees and due-diligence costs—on a per dollar raised basis.

Total funds raised in 2017 were slightly below expectations, considering historical growth rates. Barring unexpected announcements in the final few days of December 2017, the industry will have raised less funding during this year compared with previous year for the first time since 2013. This decline is reflective of a recent decrease in overall industry revenues (discussed in Section 1B.2) in combination with a pullback by some equity investors (possibly due to perceived high valuations, as discussed at the end of this section). At the same time, the average transaction size remains similar to two years prior and has increased year-on-year, showing that the decline in total fundraising can be attributed to lower overall financing activity in the market.

This year-on-year decline in funds raised should be understood in context. While the depth and breadth of the funding market has improved (see Section 1D.4), the investor base remains small in absolute terms, making investment trend analysis difficult as 1-2 large deals can skew the landscape. This occurred in 2016 where two transactions boosted investments in Q4-2016 (a short delay would have pushed these investments into 2017). As such, at least a portion of the year-on-year change in fundraising volumes should be attributed to the noisy funding and data collection environment.

The long-term fundraising environment, on balance, remains positive. While some company projections (on which valuations were based) were aggressive, and while it is apparent that not all projections will be met, market fundamentals remain sound and deserving of support. The decline in funds raised is expected to be temporary, as the financing demands of companies using PAYGO models are expected to resume once growth

recommences. However, funding is expected to continue to skew toward debt. Based on industry interviews for this study, an estimated 74% of interviewees were optimistic about the industry's long-term prospects and indicated that they would likely increase their funding during the following year.[240]

> "Off-grid solar is a run-away train that can't be stopped. The market may experience some blips along the way, but there's no reason it won't continue to follow a positive, secular growth trend."
> **- U.S.-based impact investor**

Some interviewees have indicated that the slowdown in 2017 may be a blessing in disguise, as it organically slowed the hype felt in 2014-2016 surrounding corporate valuations before it could become a systemic problem.[241] This draws a parallel with industries such as microfinance, which fell from initial hype in the 1990s to rebound stronger, with more self-aware companies seasoned by adversity.

Furthermore, the needs of the largest companies have reached a size where traditional equity investors are seeking to make co-investments. This process of bringing together investors with different priorities can be time consuming and expensive, slowing the provision of funding. Until commercial investors (who are more comfortable with larger investments) begin to invest in earnest, this joint investing is likely to continue. Fortunately, there is evidence that commercial investors are beginning to take active interest (see Figure 74) now that a level of industry maturity has been achieved. In the interim, interview evidence suggests that companies themselves are taking active steps to bring together different funders as financing needs increase for the largest firms.

> "We had not jumped in earlier as there were few companies that could absorb a deal of this size"
> **- Private equity fund**

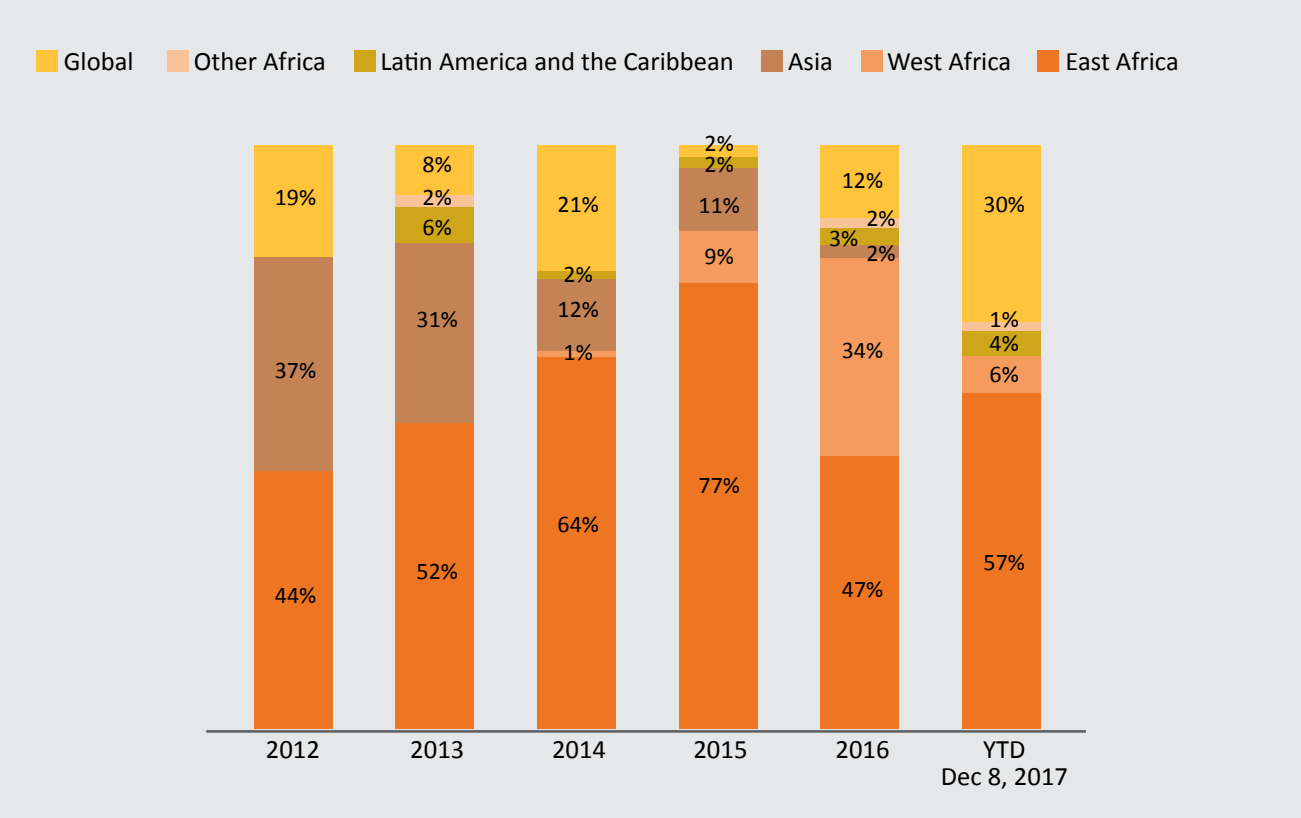
Photo credit: SOLARKIOSK

[240] *Source: Industry interviews*
[241] *Source: Industry interviews*

Investments spreading geographically: East Africa has been the primary recipient of funds, although West Africa and globally-oriented businesses have also gained traction.

Figure 69: Geographic split of funding over time[242]

% of total funds raised (2012-17)



As the historical engine for the OGS sector, it is unsurprising that East Africa has received the bulk of funding. More broadly, East Africa represents a fertile environment for commerce, with relatively high ease-of-doing-business, a strong payments ecosystem, an enabling regulatory environment, and a well-educated and digitally-connected customer base. These macroeconomic factors were important in attracting investors during the early days of the sector.

Capital inflows into West Africa accounted for 34% of investments in 2016, tracking the movement and expansion of pico and PnP SHS companies into the region. For example, PEG Africa leveraged a grant from GSMA Mobile for Development Utilities in 2014 to build its business in West Africa and subsequently raised more than USD 21 million in line with growth. However, much of West Africa-focused fundraising in 2016 was driven by Lumos Global, which raised USD 105 million in 2015-2016.[243] Even without Lumos Global's efforts, inflows increased from USD 3.3 to 18 million from 2015 in 2017, demonstrating broad interest and confidence in the region.

[242]*Note: Figures may not add to 100% due to rounding. The geography assigned to each specific investment was based on the primary geography where the investment would be channeled. For example, an investment to expand a company's operation into West Africa would be classified as West African. In circumstances where specific project details were unavailable, the geographical focus of the investee's operations was assigned to the investors. In instances where a company's operations spanned multiple geographies, a global geography was applied. 2017 figures included two transactions related to the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study was not able to verify the sizes of these transactions prior to publication, and has thus included estimates, which in total fall in the range of USD 30 – 45 million. 2017 YTD total also includes investment in Asia representing less than 1% of the global total which thus does not appear on the graph. Source: GOGLA 2018 Deals Database*

[243]*Source: GOGLA 2018 Deals Database*

Latin American & Caribbean OGS markets increased capital inflows yearly since 2013, with USD 12.5 million invested for the year to date December 2017. These investments were outpaced by financing entering East Africa, resulting in a declining share of total global investments. Likewise, investments into Asia have increased annually for three years until 2016, when investments dipped by ~60%. According to interviewees, possible reasons for slowing investment in Asia include uncertainty around grid expansion, lower overall OGS uptake in the region (highlighted in Section 1B), and to a lesser extent exogenous shocks in India (e.g. demonetization). As of December 2017, Asian investments have not recovered.

A few players, primarily leading pico suppliers such as d.light and Greenlight Planet, have raised funds for their global businesses. This was reflected in 2017 where Greenlight Planet raised USD 60 million, boosting the proportion of funds raised by globally-oriented companies to 30%. This trend has been accelerated by these large pico companies expanding their product offering to include PAYGO SHS.

> "(We) have found SHS uptake in Pakistan and India has been either slower or unpredictable and (we) are actively trying to understand those markets better."
> **- Leslie Labruto, Acumen**

Going forward, investors and suppliers alike expect the geographical diversity displayed in 2016 and 2017 to continue to expand. The initial growth in investment outside of East Africa will be driven by West Africa, as discussed above. For Asian markets, growth will be country-specific. It should be noted that development finance institutions and impact investors are working to understand Asian markets better, implying that there is a willingness to invest in those markets.[244]

Photo credit: Mobisol

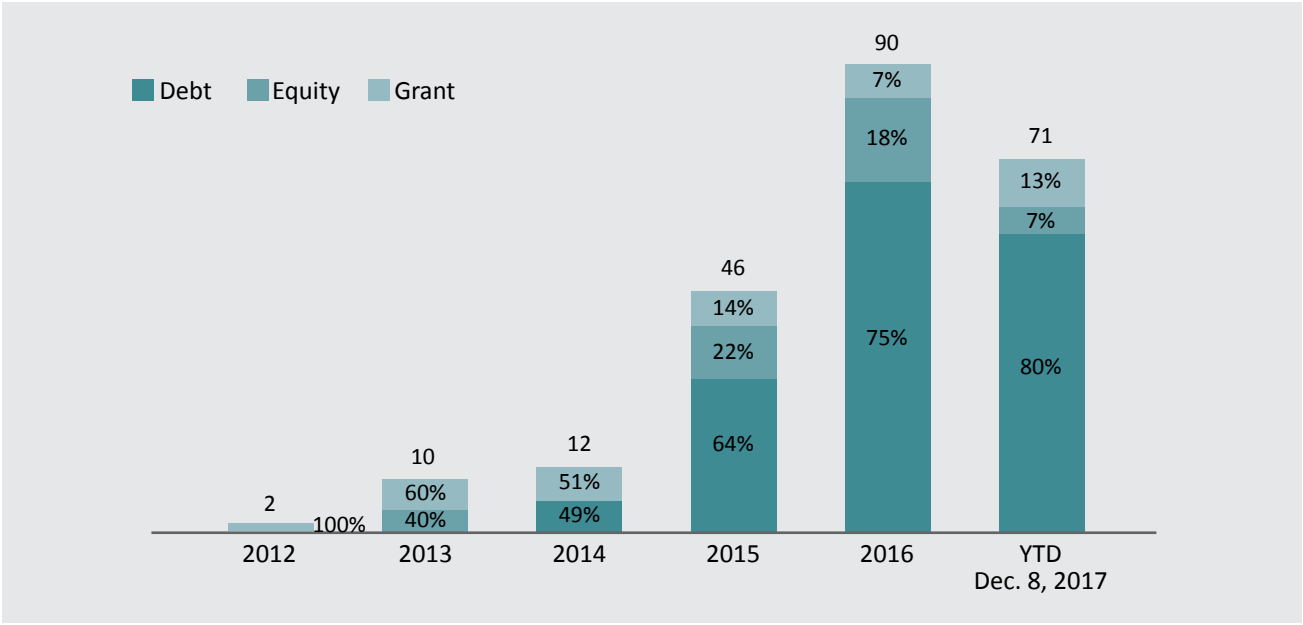
[244] *Source: Industry interviews*

1D.2 SOURCES OF CAPITAL

This section takes a detailed look at sources of capital in the sector, as well as the preferences and profiles of funding sources. This is followed by a review of emerging trends underlying their involvement.

Development finance institutions (and other similar government-funded institutions)

Figure 70: Funding from DFIs over time[245]
Millions USD (2012-17)



DFIs have provided a cumulative share of ~25% of total funding since 2012. They are driven primarily by their search for additionality, a term that in this case pertains to providing financing where other funders are not willing to venture. Within this context, DFIs have provided capital to all types of firms; their participation extends from pico to PnP SHS companies, including PAYGO, and funds committed have grown at 172% per annum between 2012 and 2016, albeit from a low base. Debt has been an important part of DFI funding, particularly as equity investments can be cumbersome for government-backed institutions (as DFIs may not want the appearance that a foreign government is operating companies in other countries). DFIs have historically supported early stage PnP SHS companies, often providing financing at concessionary terms.[246] DFIs have since worked with each other and other investors to crowd-in capital and meet the industry's growing need for larger ticket sizes.

> "DFIs shouldn't be doing what the markets can do already. The idea is that DFIs make themselves redundant by helping companies develop and improve such that commercial funders can follow and take over. Ideally that moment is reached within 5-7 years."
> **- Frederik van den Bosch, EDFIMC**

[245] *Source: GOGLA 2018 Deals Database*

[246] *Note: Encouraged by the perceived ability to bring high impact, early debt from DFIs often included concessionary terms such as interest free periods and forgiveness of repayment when certain metrics were met*

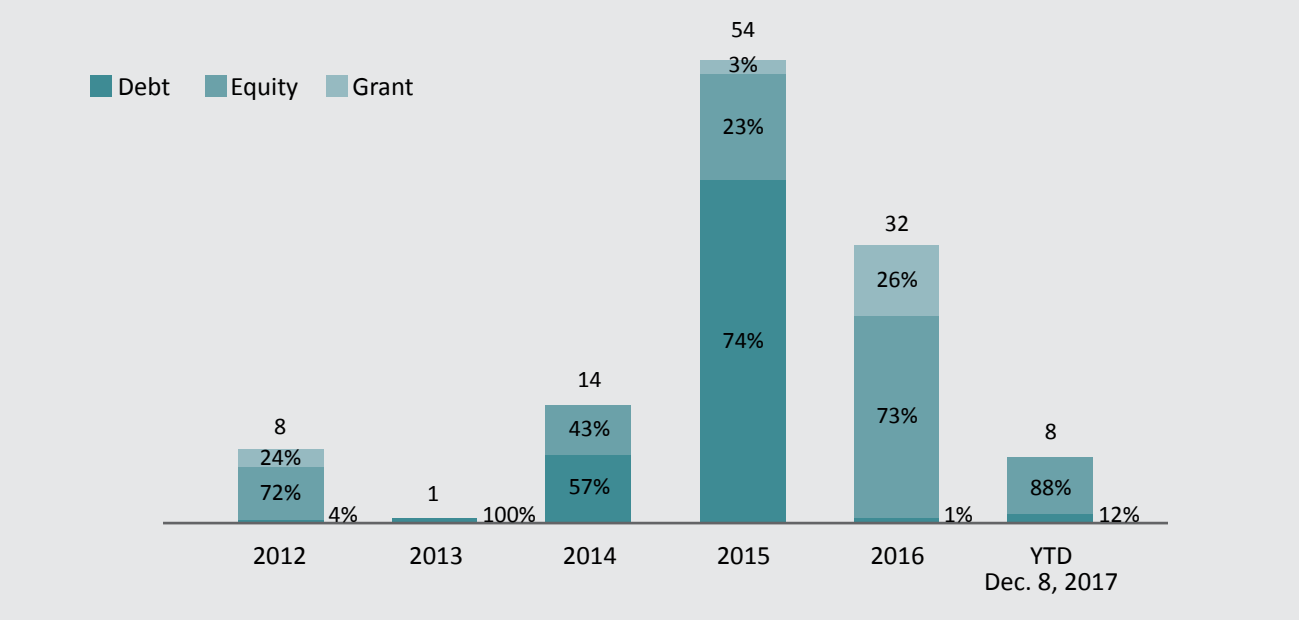
DFIs: Investment profiles, preferences, and requirements

Risk appetite	Medium to high
Type of investee	Companies with a social focus and the ability to rapidly expand
Instruments	Grants, equity, and increasingly, debt (including local currency financing)
Average ticket size	Increased from ~USD 1.3 million in 2013-14 to ~USD 4.2 million during 2015-16, and rising to ~USD 8.9 million in 2017
Return profile	Concessionary, with a recent trend toward commercial rates (high risk local currency pools have reported interest rates of ~20-25%) with 2-3-year terms
Conditions	Generally uncollateralized with standard liquidity & leverage ratios. Conditions, while present, are often waived if funds are concessionary
Example	A large part of Mobisol's funding has come from DFIs, including KfW (grants, equity, and debt totaling EUR 11.2 million), FinFund (debt totaling EUR 17.5 million), IFC (equity totaling EUR 5.42 million), and FMO (equity totaling EUR 9.2 million)

Corporate foundations and family offices

Figure 71: Funding from foundations and family offices over time[247]

Millions USD (2012-17)



> "Our orientation is 'impact first', we seek to solve problems relating to rural livelihoods. Once we identify the intervention, we analyze the commerciality and impact, and that determines the type of capital we deploy."
>
> **- Greg Neichin, Ceniarth, LLC**

[247] *Source: GOGLA 2018 Deals Database*

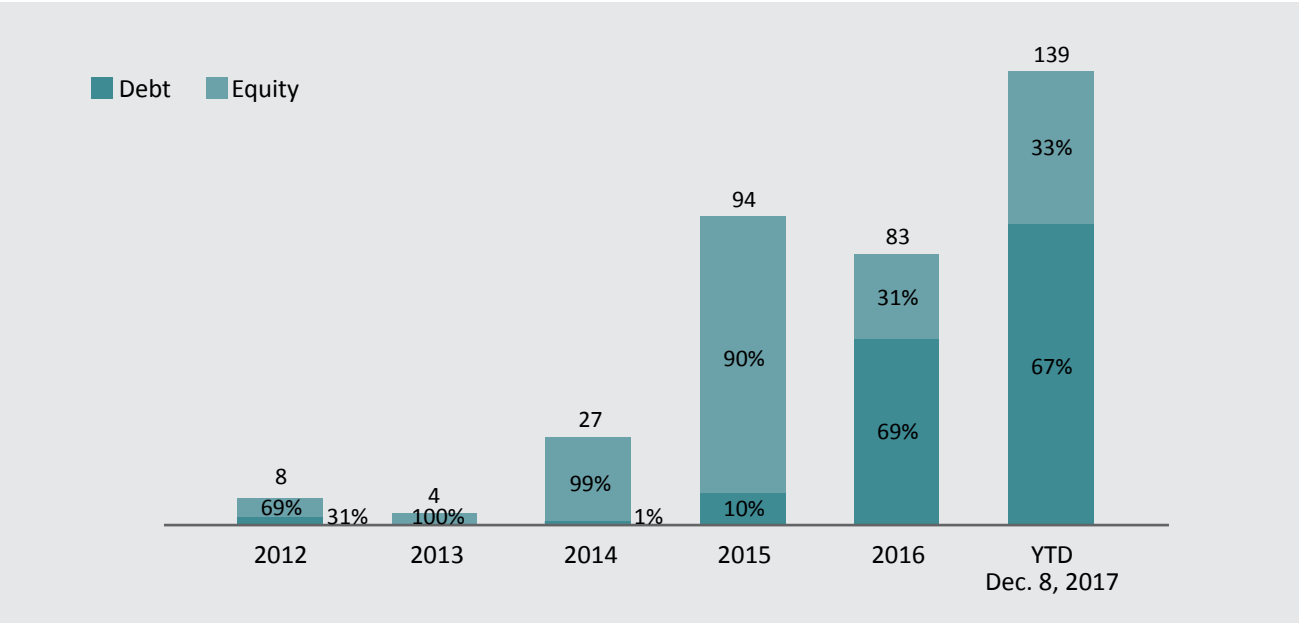
Foundations: Investment profiles, preferences, and requirements

Risk appetite	Medium to high
Type of investee	Flexible in preference
Instruments	Willing to deploy all instruments as well as innovative structures depending on need
Average ticket size	Ranges from small grants to very large transactions (e.g. USD 30+ million loans). Some foundations and family offices have no specific restrictions with regards to ticket sizes, matching the size of the investment or loan to project needs. Observed average ticket size has increased over time
Return profile	Return profiles are flexible and can range from commercial rates, to concessionary terms, and even grants when the situation warrants. Returns can also be determined after an investment or project is decided upon, and investment return hurdles, if any, are determined by internal metrics rather than based on meeting investor needs (as would be the case in a fund). Terms are similarly flexible, but often fall between 1-5 years
Conditions	Standard liquidity & leverage ratios
Example	Shell Foundation has had a relationship with d.light since 2009, and its support has ranged from a USD 2 million trade financing facility in Africa (in partnership with OFID) to a USD 5 million grant in 2016 (in partnership with USAID-DIV and UNCDF) as part of a Series D round to expand SHS sales and bring higher-powered products to market[248]

Impact investors

Figure 72: Funding from impact investors over time[249]

Millions USD (2012-17)



[248]*Source: (Energy Access Practitioner Network, 2016); (Shell Foundation, n.d.)*

[249]*Source: GOGLA 2018 Deals Database*

Impact investors provide between a quarter and a half of total funding annually. Impact investors, as defined for this report, invest and lend through funds, which they use to raise capital from their own investors. Given that they fundraise from multiple sources, they have access to a large pool of investable funds and can raise capital quickly if needed. These funds have defined objectives and targets. For example, most funds have an end date before which they must deploy their capital; this can lead impact investors to seek investments in larger companies as their larger needs offer a consistent way to deploy capital. Other times, limitations on transaction sizes might mean that the impact investor needs to raise a completely new fund in order to make a larger transaction. More practically, impact investors have worked with other impact funds, DFIs, and funders to make joint investments that can meet larger deal size requirements. Within these deal structures, impact investors often act as a focal point, bringing together funding sources and assuming the role of deal arranger.

> "We look for financial returns, but are firmly targeted on reaching the poor. We have passed on deals where the customer base is too upmarket."
> **- Leslie Labruto, Acumen**

Impact investors: Investment profiles, preferences, and requirements

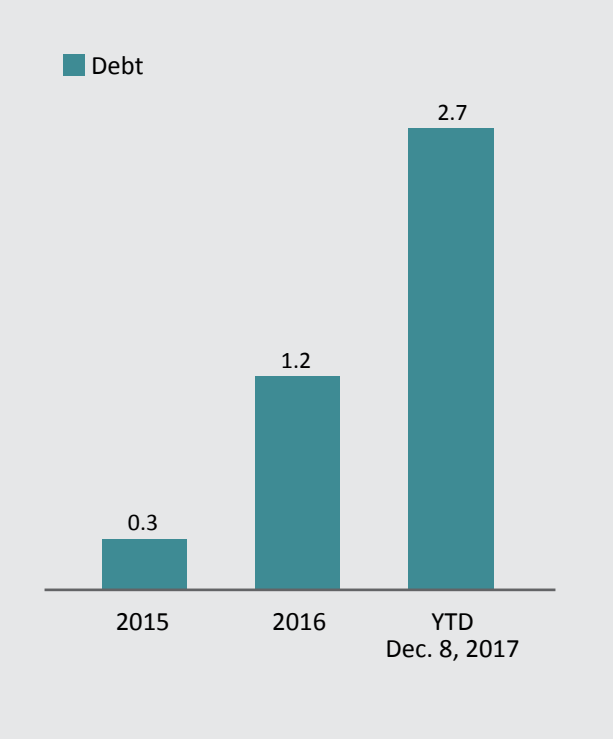
Risk appetite	Low to medium
Type of investee	Market leading companies
Instruments	Generally, equity (both common and preferred), with a recent trend toward debt
Average ticket size	Increased from ~USD 3.1 million in 2012-14 to ~USD 4.0 million during 2015-16 and rising to ~USD 8.2 million in 2017
Return profile	Investments are required to meet both financial and social hurdles. At times there are tradeoffs between the two; as a result, return profiles can span from purely commercial to highly concessionary. Generally, return profiles are guided by the conditions established when the investment fund was raised. There are usually minimum and/or target returns on the funds. Observed returns for debt were in the mid-high teens, with equity returns a few points higher. Social returns are measured by metrics such as greenhouse gas emissions avoided and households electrified
Conditions	• Common equity with few or no additional conditions. Preferred equity shares have low non-cumulative dividends with conversion to common equity shares at exit without liquidity preferences • Debt follows standard liquidity & leverage ratios. Portfolio quality is tracked using standard metrics (e.g. PAR 30) and/or company specific metrics
Example	In Q4-2016, d.light secured USD 15 million in equity financing from a consortium of impact investors including KawiSafi Ventures Fund, Energy Access Ventures, Omidyar Network, and NewQuest Capital Partners to finance its PAYGO business globally[250]

[250] *Source: (Energy Access Practitioner Network, 2016)*

OGS-focused crowdfunders

Figure 73: Funding from OGS focused crowdfunders over time[251]

Millions USD (2012-17)



Crowdfunding platforms connect OGS companies with socially conscious individual investors that may be looking to invest in impactful projects. Given the social focus of these investors, they accept lower returns than would be expected from similarly sized commercial loans. There are now several platforms that specialize in OGS-focused crowdfunding, acting as an important bridge between initial seed capital and larger funding rounds with DFIs, impact investors, and/or commercial investors. As these platforms are relatively new, their fit into the longer-term industry landscape is likely to evolve over time.

> "Crowdfunders appear eager to provide working capital to companies at Series A and B stages—a time when working capital is scarce for a company."
> **- Christopher Aidun, Persistent Energy Capital**

Crowdfunders: Investment profiles, preferences, and requirements

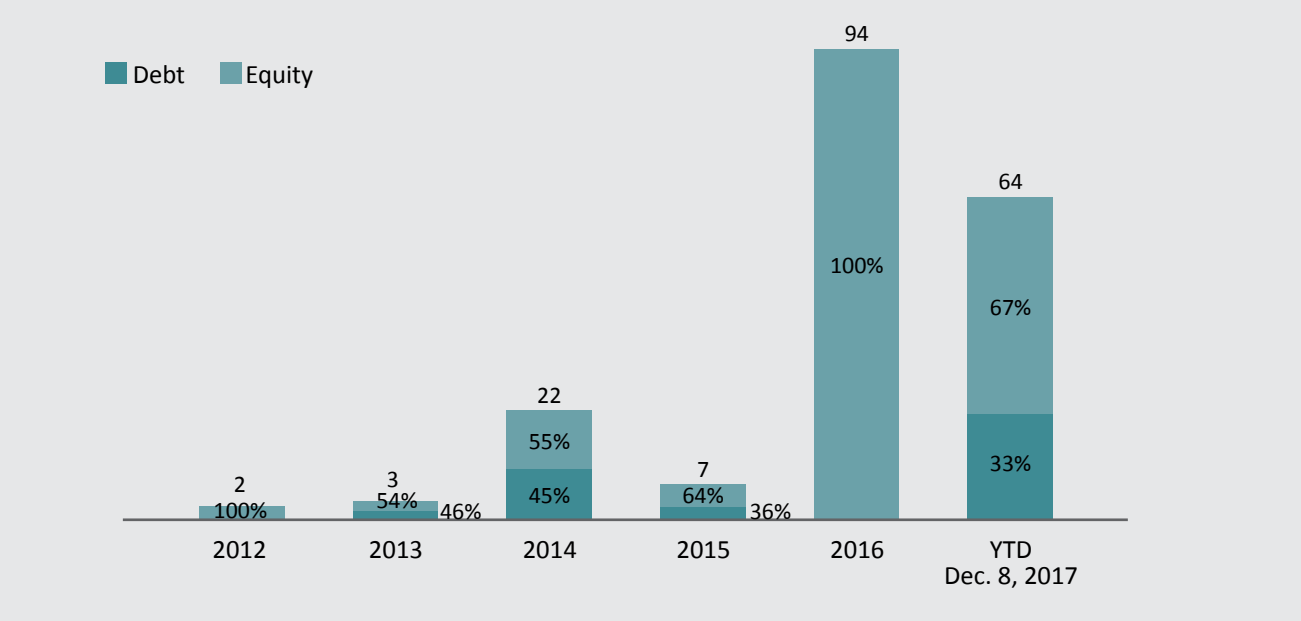
Risk appetite	Medium
Type of investee	Companies beyond the start-up stage looking to scale up operations
Instruments	Generally debt, but equity may be on the horizon
Average ticket size	Varies by firm. Industrywide, the projected amount of funds raised for each company can range from USD 50,000 to USD 1.5 million, with the expectation that the company will raise funds three to five times annually
Return profile	Often below commercial rates due to social focus of investors. Observed rates have ranged between 5% and 12%, with an additional fee paid on closing and/or loan repayment. Term is project specific, and usually 24-36 months
Conditions	The funder will complete standard credit due diligence, and will track standard leverage and liquidity metrics. PAYGO companies can also expect portfolio quality to be tracked
Example	From 2016 to 2017, Raj Ushanga House successfully completed at least four crowdfunding campaigns using both the Lendable and Trine crowdlending platform. Funds from each campaign were used to purchase inventory from Azuri Technologies; each fundraise ranged between EUR 150,000 and 300,000

[251]*Note: Only includes those projects that funded OGS directly (e.g. pico and SHS companies). Source: GOGLA 2018 Deals Database*

Commercial equity

Figure 74: Commercial debt and equity raised over time[252]

Millions USD (2012-17)



Rapid growth has attracted commercial equity investors to PAYGO SHS companies with proven business models and clear pathways to profitability. Generally, these investors place a premium on strategies designed to own customer relationships and create intellectual property. Their involvement to date has been sporadic and limited to a few large investments; this can be partly explained by the fact that few companies have the size and platform to appeal to commercial equity investors.

> "We want to invest in a growing company whose track record shows that their business plan is working... The key is to invest in technology that allows for sustained competitive advantage."
>
> **- Private equity investor**

[252] *Note: 2017 figures include estimates regarding the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study has not been able to verify the size of these transactions, and estimates that they collectively fall in the range of USD 30-45 million. Source: GOGLA 2018 Deals Database*

Commercial equity: Investment profiles, preferences, and requirements	
Risk appetite	Medium to high
Type of investee	Larger, established companies looking for expansion capital and long-term partnership
Average ticket size	Ticket sizes can range from single large investments of up to USD 40 million to smaller initial investments of around USD 5-10 million (which may be followed by larger investments)
Return profile	Early stage investors target venture-type return profiles. Investments in more mature companies expect long-term returns greater than debt capital investments
Conditions	Investors with a sizeable investment are likely to expect a seat on the board, as well as a management team receptive to outside advice
Example	In Q4-2016, Pembani Remgro Infrastructure Fund, an African infrastructure investor, led a consortium of funders, including Very Long-term Capital Management and Israel Cleantech Ventures, in a USD 40 million equity investment into Lumos Global[253]

Commercial debt

Commercial debt funders largely consist of local banks, and local branches/subsidiaries of international banks. Other participants could include investors buying into public debt offerings such as a bond or a securitization transaction (although public debt offerings have yet to develop as the industry still remains young). To date, banks have proved hesitant to extend loans, although recent lending points to 2017 being a possible tipping point where they begin to provide debt funding. This initial hesitancy can be attributed to:

- **General uncertainty with a new industry:** Banks have been conservative in lending to the OGS sector due to the absence of a track record of successful operations. In addition, a traditional focus on project financing has left banks ill-prepared to understand the nuances (including risks) of lending to OGS companies. Some lenders, however, have sought to differentiate themselves by making the sector a strategic focus and by building up internal capabilities.
- **Conservative lending culture:** African and Indian banks have historically been conservative lenders, often having large collateral requirements for relatively new players or industries they are unfamiliar with.

> “Developing innovative funding solutions to enhance and unlock the evolving off-grid sector as part of the energy revolution remains an important strategic focus for Standard Bank. Understanding the sector and leading the financial offering across various product options, as well as partnering with DFIs and other financiers, will remain critical in supporting the value proposition.”
>
> **- Standard Bank**

[253] *Source: (Lumos Global, 2016)*

> Local banks are ready to finance infrastructure, but they are reluctant to finance consumer sales business models. The off-grid industry is closer to a sales business model than to an infrastructure one.
>
> **- Impact investor**

Commercial debt: Investment profiles, preferences, and requirements

Risk appetite	Low
Type of investee	Established companies focused on funding working capital
Average ticket size	~USD 2 million for standalone loans. When part of a larger syndicate of lenders (often with DFIs), the proportion of the syndicated loan from commercial lenders can reach USD 7-10 million
Return profile	Cost of funds plus 400 to 600 bps over 3- to 4-year terms
Conditions	• Working capital facilities are typically governed by a borrowing base; advance rates of 50-70% of receivables value • Standard due diligence requirements and monitoring of leverage and liquidity metrics • May require credit enhancements (such as upstream guarantees, ring-fencing of assets, cash sweeps, and access to electronic payment platforms)
Example	In Q4-2017, Stanbic Bank, as the lead syndicate, led a USD 55 million local currency equivalent debt facility of which they committed USD 9 million. Other lenders included the CDC Group (USD 20 million), FMO (USD 13 million) and Norfund (USD 13 million)[254]

Changing profile: The role and prominence of the different types of investors described above has varied over time. Key trends related to these sources of capital include the growing prominence of debt funding, the entry of commercially-focused funders, a continued lack of local capital, a potential shift in the focus of social investors back towards impact, and the emergence of crowdfunding as an important source of funding. These are described in detail below.

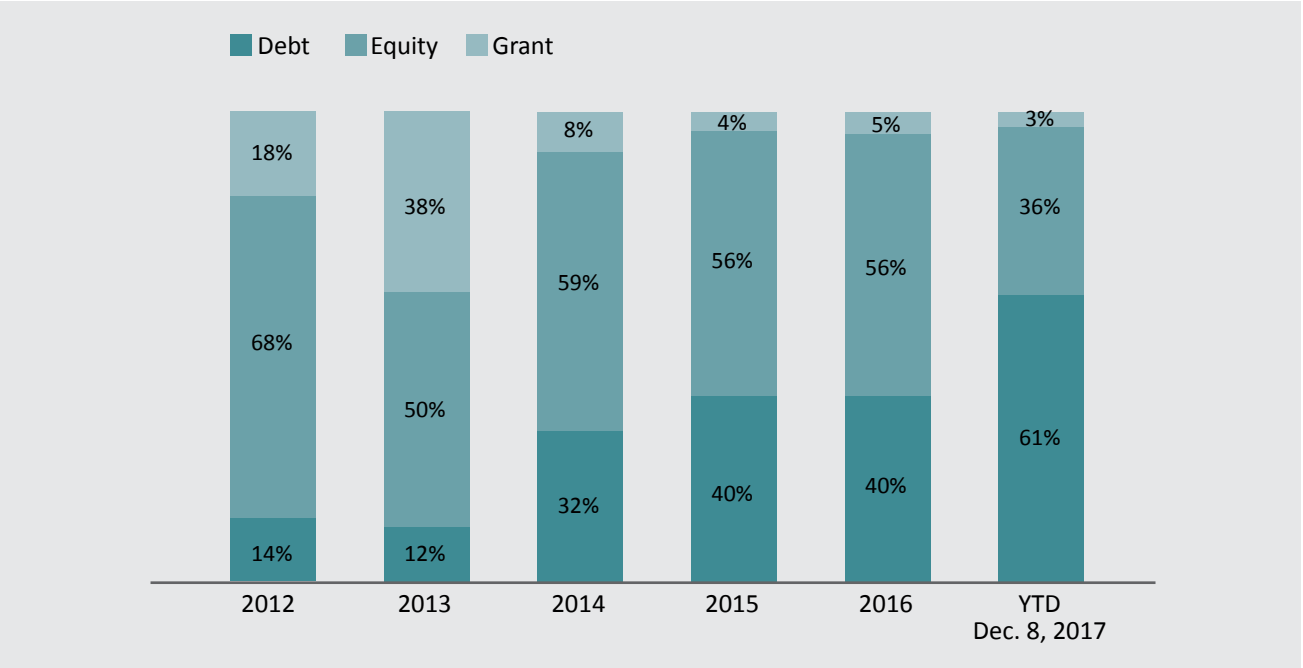
1. As the industry matures, funding has shifted toward debt.

The proportion of debt as a percentage of total investment has increased annually since 2013, reflecting the changing needs of maturing PAYGO companies. These needs have shifted toward financing working capital, which is better suited for debt. To illustrate, the largest debt deals in the last two years have been with PAYGO players, such as Lumos Global's USD 50 million fundraise from OPIC during Q4-2016.

[254] *Source: (M-KOPA, 2017b)*

Figure 75: Breakdown of total funding by type[255]

% of total funds raised (2012-17)



Equity investments have recently declined, and may reflect a perceived overvaluation in the market. Impact investors, as well as some foundations, have expressed concern that the market may be overvalued, and view the recent dip in equity investments as a period of reflection for investors. These concerns, as well as the different viewpoints surrounding them, are explored in detail in Section 1D.4.

The share of grant funding has declined, but remains important for long-term growth of the industry. Grant funding comprised 15-40% of total funding in 2012 and 2013, reflecting an immature sector in need of patient capital. As the industry grew, the sector shifted toward standard equity and debt investments. Reflecting the industry's changing needs, the use of grants has recently diversified to include funding for R&D and geographic expansion, often in conjunction with a broader investment package. Grants are now made across a company's lifecycle and in a range of sizes, from tens of thousands of dollars for start-up capital (such as USADF's grant of USD 100,000 to OneLamp Uganda), to millions of dollars for later stage companies (such as Shell Foundation and Beyond the Grid's USD 5.5 million grant to d.light).[256] In absolute terms, the total size of grants has increased annually since 2012 (despite a falling share compared to debt and equity), reflecting the fact that the industry, while maturing, still requires support for last-mile reach, innovation, and new market entry.

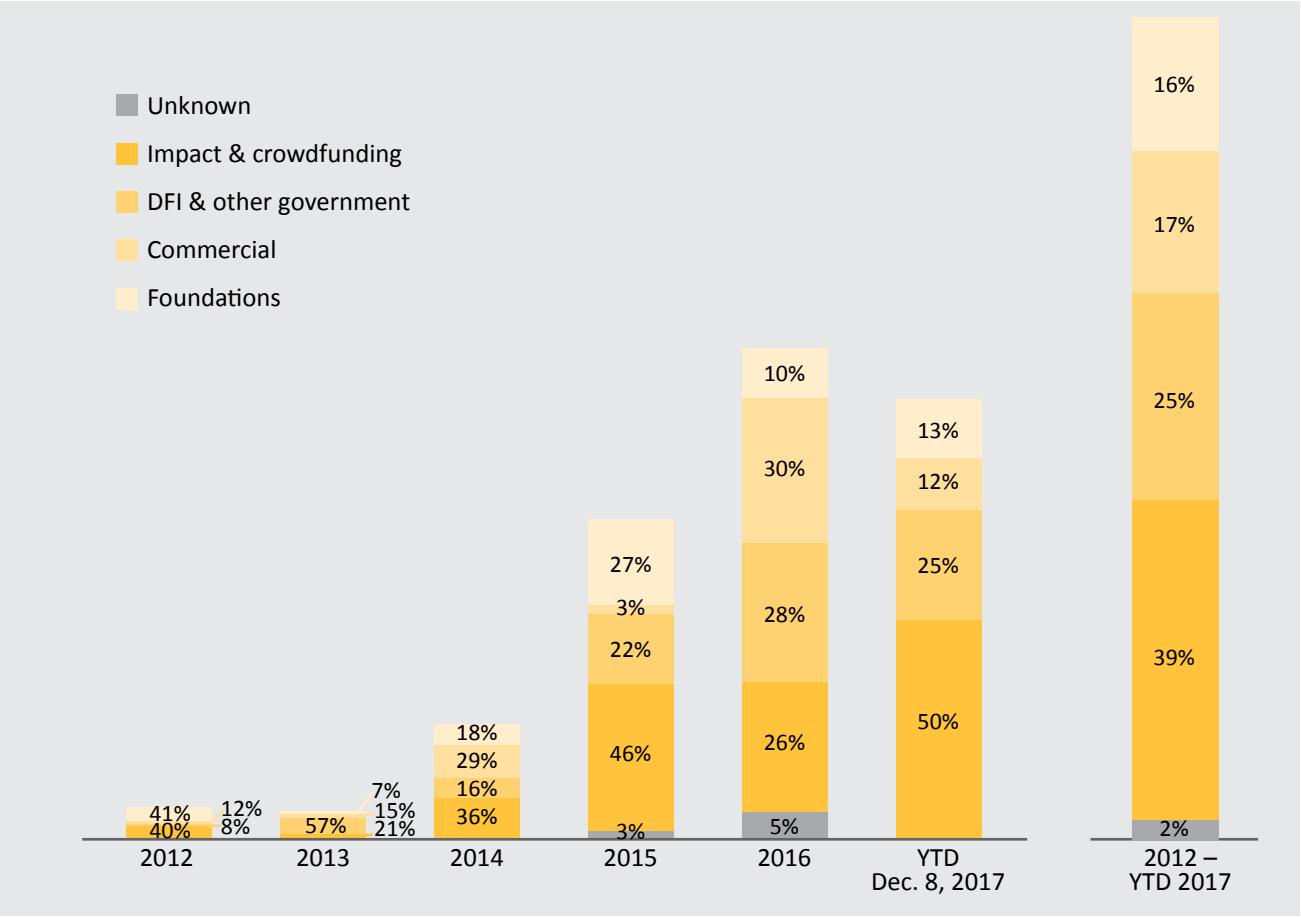
[255]Note: Figures may not sum 100% due to rounding. 2017 figures include estimates regarding the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study has not been able to verify the size of these transactions, and estimates that they collectively fall in the range of USD 30-45 million. Source: GOGLA 2018 Deals Database

[256]Source: (Beltran, 2017); (US Embassy in Uganda, 2016)

2. Commercially-focused funders are entering a sector historically dominated by impact investors, DFIs and foundations.

Figure 76: Shift in types of funders over time[257]

% of total funds raised (2012-17)



In line with the increasing financial viability of the sector, there has been a shift toward commercial funding sources. This includes funding from investors with a profit-driven priority as well as increasingly commercial terms from current investors (which reflects a change in attitude). This trend is not immediately evident in Figure 76, as many commercial investments are supported by DFIs and other social investors. For example, M-KOPA raised a USD 80 million loan from a syndicate of lenders of which commercial capital (USD 9 million) represented 11% of the total commitment. While the need for support from DFIs and impact investors is likely to continue in the near team, commercial capital is expected to gain importance as a funding source as the market continues to mature.

> "Commercial funding for OGS projects remains limited, but the OGS market is maturing quickly which should allow for the adoption of commercial funding within the next 2 years. The most mature players, primarily companies that adopted PAYGO business models, are more likely to receive financing."
>
> **- DFI**

Commercial equity funders have made opportunistic investments, and are active partners in driving value. There were three significant equity transactions in 2016, all valued above USD 10 million. This was followed in 2017 by the acquisition of Fenix International by

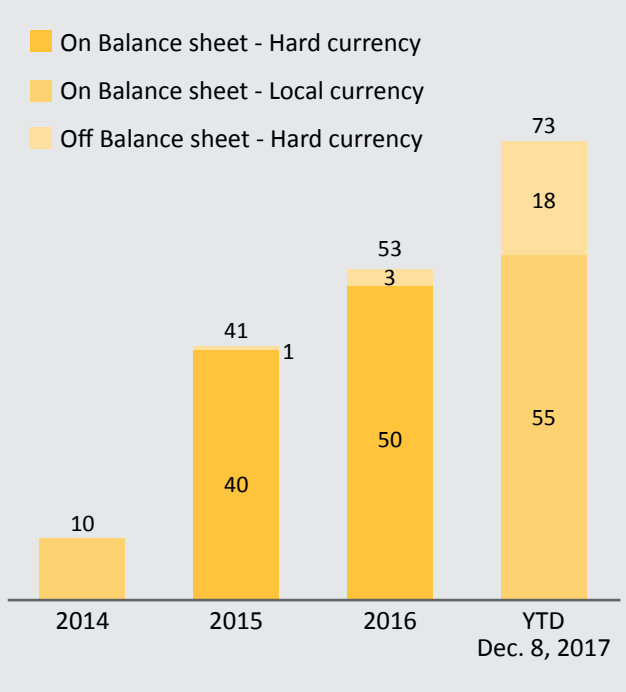
[257] *Note: Figures may not add to 100% due to rounding. Source: GOGLA 2018 Deals Database*

Engie and a follow-on investment by a consortium of investors led by Investec Asset Management into Mobisol. These investments were large, with investors often taking a significant cut of the investee's equity to ensure that they have a say in how the company is run, with the understanding that their equity may be diluted in subsequent fundraises. Such funding often comes with enhanced reporting requirements and sometimes seats on the board of directors. Investors may also be active in supporting the business by providing technical assistance, assisting in compiling or selling business plans, and helping hire top talent.

It should be noted that the addition of a significant equity investor can upset internal corporate power dynamics in both positive and negative ways.[258] As a result, entrepreneurs and boards have been careful in accepting equity investments to ensure that they add the right partner to their team. This, coupled with the large size of equity deals, contributes to the sporadic and contextual nature of equity investments when compared with debt financing (which is consistently required to fund operations).

Figure 77: Debt supported by leveraging asset values[259]

Millions USD (2014-17)



Commercial lending has gradually increased, signaling a step in the maturation of the industry. To date, most commercial lending has leveraged the value of assets on the balance sheet (such as receivables) to underpin the loans rather than lending against the company's operating cash flows. In such loans, the loan size is limited by the value of assets pledged as collateral. For example, a loan size may be capped at 70% of the value of inventories. Loans of this type have increased every year since 2014, reaching USD 73 million in 2017, equal to 42% of the value debt commitments for the year. Such lending has been driven by:

- *Improved perception of asset values:* Historically, lenders were uncertain of the value of OGS assets, and thus limited in their willingness to use them as collateral; this understanding is improving. Lenders are assigning higher value to SHS because they are: (1) larger in size (making recovery more worthwhile), (2) have a longer useful life (making recovered assets more valuable), and (3) have proven to provide consumer benefit (making resale more likely). Furthermore, lenders' understanding of the value of consumer receivables has improved. Many PnP SHS companies have risk rating models (explored later in this sub-section) which can be shared with banks to help them understand the portfolio risk.
- *Ability of banks to electronically monitor cash flows, building trust:* Some companies have obtained funding from commercial banks by ring-fencing certain receivables from the operating company. Under this arrangement, the ring-fenced consumer loan receivables payments must be made through mobile payment applications and routed directly to loan repayment. The bank would then be granted access to the appropriate mobile money accounts to track the payments. This removes management discretion

[258] *Note: For example, a knowledgeable and savvy investor can provide commercial support that may have been difficult or expensive to obtain through other means, while an investor that clashes with management can use up management resources*

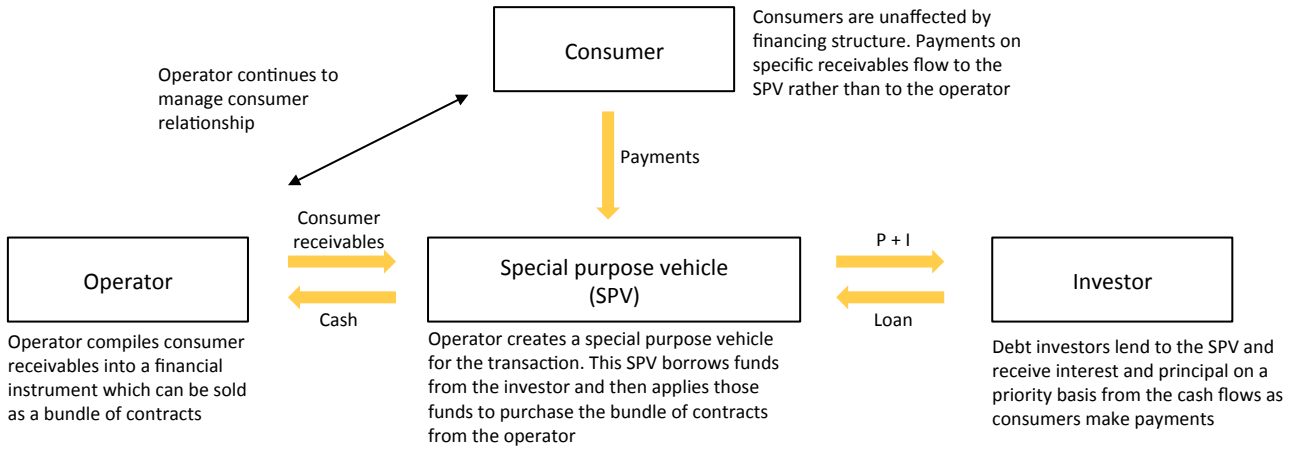
[259] *Source: GOGLA 2018 Deals Database*

around when and how the loans are repaid while providing the bank with oversight on loan repayments, thereby building trust.

- *Emergence of innovative instruments (such as off-balance-sheet transactions) that simplify lending at scale:* Some companies have raised capital by selling their receivables to an off-balance-sheet entity (at a discount), which then leverages the value of those assets to create a loan (illustrated in Figure 78). Several companies have raised funds in this manner, including a transaction of over USD 10 million by Mobisol in Q4-2017, and a USD 6 million transaction in Q4-2017 by SolarNow (which is its second off-balance-sheet transaction).[260]

  While commercial investors have yet to lend to these special purpose vehicles (investors have included impact investors and DFIs), their emergence is noteworthy as they simplify lending. For example, they remove the need to negotiate inter-creditor agreements as these loans will not affect corporate balance sheets. As standalone instruments, they are scalable, making them particularly beneficial to supporting the growth of PAYGO companies, which consistently generate consumers loans that need financing. Investments in off-balance-sheet vehicles are expected to be an important future source of commercial capital (as detailed in Section 1D.5).

Figure 78: Structure of an off-balance-sheet transaction *(Illustrative)*[261]



3. A continued lack of local capital leaves the sector reliant on riskier foreign funding.

Cultivating local sources of capital will be integral to the market's long-term development. Local funders can better monitor their investments and have a stronger grasp of local market risk and trends (as discussed in Section 1D.5). Nonetheless, current funding from local institutions is insufficient to support industry growth given the size of the sector's needs. Foreign investments are needed to maintain the market's unabated growth.

To date, most funding to the sector has come from international sources, exposing companies to currency risks. The bulk of OGS companies operate in markets with currency volatility and are thus vulnerable to fluctuations. One such exposure is through purchasing inventory denominated in US dollars (the normal practice, even with Chinese manufacturers). A rise in the value of the US dollar against the local currency can

[260] *Note: SolarNow raised USD 2.6 million in an off-balance-sheet structure funded by Sunfunder in early 2016*

[261] *Note: This illustrative transaction cannot be considered a true securitization as the debt is not tranched (including no equity tranche) or sold down. Nevertheless, the transaction provides a useful template on the types of off-balance-sheet structured asset transactions that are being used in the off-grid solar space*

> Most of the debt funding is made in hard currency, exposing the borrower to forex risk. To prevent forex risks, it would be preferable for local commercial banks to provide local currency funding, and the international financing companies could provide guarantees.
>
> **- Loic Perret, Proparco**

increase purchasing costs, reducing margins. In fact, in interviews, distributors highlighted that forex volatility has a strong impact on net margins.

Another exposure comes through the hard currency loans that international funders often provide.[262] Volatility can lead to a mismatch between the currency earned and the currency of loan repayment; if the local currency depreciates against the hard currency, repayments become increasingly expensive. PAYGO companies, given their need to finance receivables via debt, are particularly vulnerable as the risk can accumulate on balance sheets as they grow. Maintaining sufficient equity to absorb possible forex losses while dynamically managing currency risk will be important to the long-term viability of the PAYGO sector. Ways in which this risk can be mitigated, namely local currency funding, forex hedges, and off-balance-sheet financing, are explored later Section 1D.5, as well as in Section 2.

4. Social investors may refocus toward investments that maximize impact.

Historically, social investors in the OGS sector (including DFIs and impact investors) filled the role of early stage investors due to the shallow pool of local venture funds. This arrangement reflected a point in time when the OGS market was seen as particularly innovative, with the possibility of addressing a social need through profitable and financially sustainable business models. Given the social focus of these funders, financial terms were often concessionary.

This support continued, and these funders helped the first-generation companies scale up. This doesn't imply that social investors were unwilling to make high-risk investments, rather than their local deal sourcing capabilities and internal constraints made it relatively difficult to unearth further early stage "diamonds in the rough." Moreover, the companies which already received support continued to demonstrate impact as they scaled up and developed quickly.

DFIs and impact investors were important in helping the first-generation of PAYGO SHS companies become commercial entities. Investment from impact investors and DFIs was consistently above 50% of total funding from 2013-2016. During this period, PAYGO SHS companies experienced significant sales growth, resulting in

> We are starting to see demand for BoP and last-mile focused ventures, but the shift is slow. It's a bit like a pendulum – we started out as CSR and grant-funded initiatives, shifted to a commercial, scale-oriented mindset, and now there is a push to move back to the BoP.
>
> **- DFI**

[262] *Note: Hard currencies are national currencies from countries with strong economic and political environment. They are expected to remain stable through a short period of time and to be highly liquid in the foreign exchange market. Example of hard currencies include the United States dollar, European euro, Japanese yen, British pound, Canadian dollar, Swiss Franc and Australian dollar*

their adoption of commercially-focused business plans. This was reflected in some companies directing their efforts toward acquiring relatively well-off customers, given that they may be better credit risks and easier to reach.[263]

Recognizing the increasingly commercial focus of some portfolio companies, social investors may re-focus their investments toward seeking additionality.[264] Some DFIs and impact investors may shift focus toward the last-mile market segments that have always been the intended beneficiaries, or towards smaller and early stage companies which have not received the same attention over the past few years. This should be especially helpful to pico companies which are often better suited to helping consumers at the base of the pyramid (BoP). This support could take the form of direct investment, as well as indirect support such as de-risking investments for other funders, providing technical assistance to companies, and building industry capacity.

5. Crowdfunding has emerged as a particularly relevant source of funding for early stage companies and new entrants.

Interviewees have suggested that new entrants have found it relatively difficult to raise funds when compared with the first-generation of companies in the space (further explored in Section 1D.3). Specialized OGS-focused crowdfunders have provided capital to companies across the industry lifecycle, and have been especially helpful in funding companies in search of inventory financing after receiving an initial injection of early stage funding.[265]

> “Crowdfunding might be a helpful method to pave the way for commercial lending—for companies to test out the market first.”
> **- Debt provider**

Crowdfunding has long been a source of capital for improving energy access. Until recently, however, crowdfunding campaigns were too small to be used as a primary source of capital.[266] New platforms have emerged to provide useful levels of capital especially when multiple financing rounds are considered.[267] Characteristics of fundraising through crowdfunders include:

- **Provision of capital at a project level, allowing companies to raise funds in smaller chunks to avoid sticker shock.** Once due diligence is completed, it is relatively easy for companies to put new projects onto the crowdfunding platform, streamlining the funding process. In fact, the expectation is that companies will use the platform multiple times, allowing the lender to spread out the cost of the initial review. Some borrowers also have an agreement with platforms to raise a certain amount spread out over a number of months or even years.

[263] *Note: This refers to the top 20% of the BoP category, not rich individuals/households in absolute or global terms*

[264] *Note: Additionality refers to the desire to provide funding where commercial sources may not reach, and thus such funding is “in addition” to market-based financing*

[265] *Note: As these crowdfunding platforms are relatively new, how they best fit into the longer-term industry landscape is likely to evolve over time. Currently, each platform focuses its operations on a specific stage of a company’s development. For example, Trine typically supports smaller companies and may help a company raise USD 100,000 for purchasing inventory, while Lendahand usually supports companies that require funding for a specific project goal and may help a company to raise USD 500,000+ (over several transactions)*

[266] *Note: For example, in 2015, GVEP International estimated that there were approximately 2,000 energy access crowdfunding campaigns but with an average campaign size of only USD 1,725. Source: (Cogan & Collings, 2016)*

[267] *Note: While SunFunder started out as a crowdfunding platform, it has not crowd-sourced capital for several years, instead preferring to raise capital through the issuance of notes and via institutional investors*

- **Flexibility across instruments.** Crowdfunding has shown its ability to raise equity and grants in addition to debt. While raising equity via crowdfunding in the OGS sector is in its early days, adjacent industries have done so successfully, and the scope of crowdfunding platforms will likely expand similarly in due course.[268]
- **Signal to the market.** Being featured on a crowdfunding platform and being successful in raising funds can act as a signal that a company is a good business risk. Such companies can use a series of crowdfunding campaigns as evidence of strong business operations, allowing the company to scale up while simultaneously gaining the attention of traditional international investors. This is especially true for companies that are also planning to raise equity.

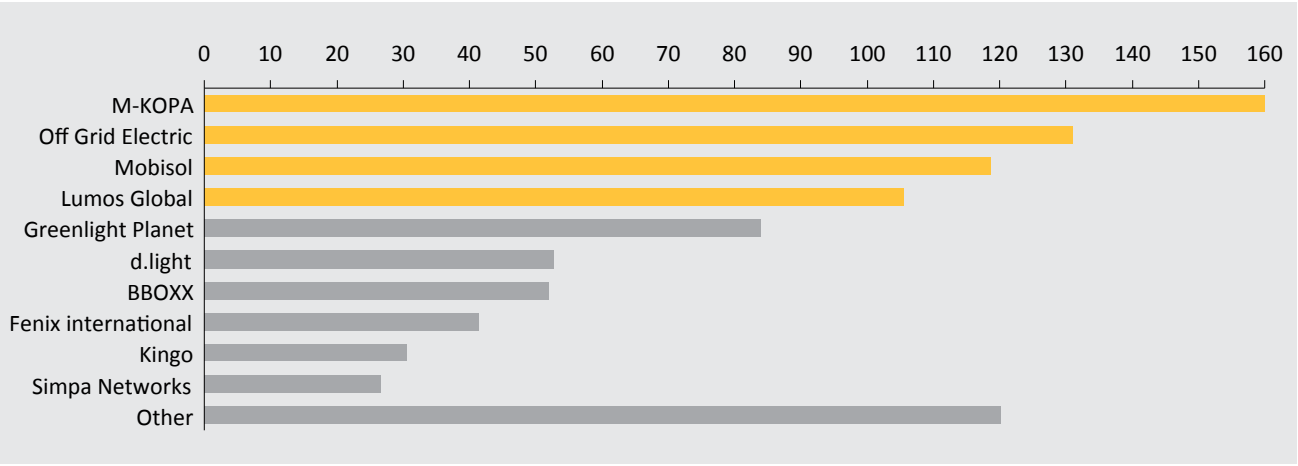
> "A major unseen benefit is that crowdfunding allows the company to build a reputation and build credibility, especially with international funders."
> **- Tobias Grinwis, Lendahand**

1D.3 RECIPIENTS OF FUNDING

Funding concentrated: Capital has largely flowed to a handful of relatively established companies.

To date, investments have been concentrated in market leading companies, with ~56% of the sector's cumulative funding raised by only four companies; the top ten companies received ~87% (see Figure 79).[269]

Figure 79: Companies receiving funds[270]
Millions USD (2012-17)



[268]Note: Buffalo Grid, a company providing solar power phone charging stations in India and Uganda, raised USD 750,000 in equity, while Renovagen raised USD 1.5 million in equity for a portable solar power plant which can be used in emergencies
[269]Source: Industry interviews
[270]Note: 2017 figures include estimates of the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study has not been able to verify the size of these transactions, and estimates that they collectively fall in the range of USD 30-45 million. Source: GOGLA 2018 Deals Database

A focus by some funders on helping market leaders scale up may have crowded out funding for new companies.

Underlying factors include:

- *Tendency of funders to support portfolio companies:* In an environment with high capital needs, it is easy to make impactful investments even with larger companies. As such, it can be tempting for investors to continue funding existing portfolio companies due to a combination of factors, including investment inertia and wanting to boost the effectiveness of previous investments.
- *A potential lack of differentiation between first- and second-generation companies:* Many impact investors and DFIs have a strong focus on driving innovation. While this is helpful in dispersing new ideas, many second-generation firms emulate the success of the first-generation companies while bringing incremental improvements and addressing slightly different target markets, often through the identification of a specific commercially viable business idea. These companies bring competition and new energy to an industry, but may not necessarily be distinctly innovative and as a result may be overlooked.

> "The so-called 'Gen 2' didn't really have any competitive advantage to the 'Gen 1' companies. Most of them were just more of the same, and investors preferred to just invest in the market leader as the business models were essentially the same."
> **- Industry association**

There are several emerging trends that could reduce this concentration of funding and help newer companies scale. As discussed in Section 1D.2, new funding sources such as crowdfunding are emerging as an avenue for smaller companies to fundraise. Greater specialization is likely to provide better opportunities for companies to differentiate and attract funding. Finally, newer companies may also follow a less capital-intensive pathway compared to the market leaders of today, due to greater availability of specialist partners.

Furthermore, there may be a natural industry correction. There is reason to believe that the current concentration in funding is reflective of a market which is in transition. Over time, as market risks stabilize, funding should become more balanced and distributed across market players.

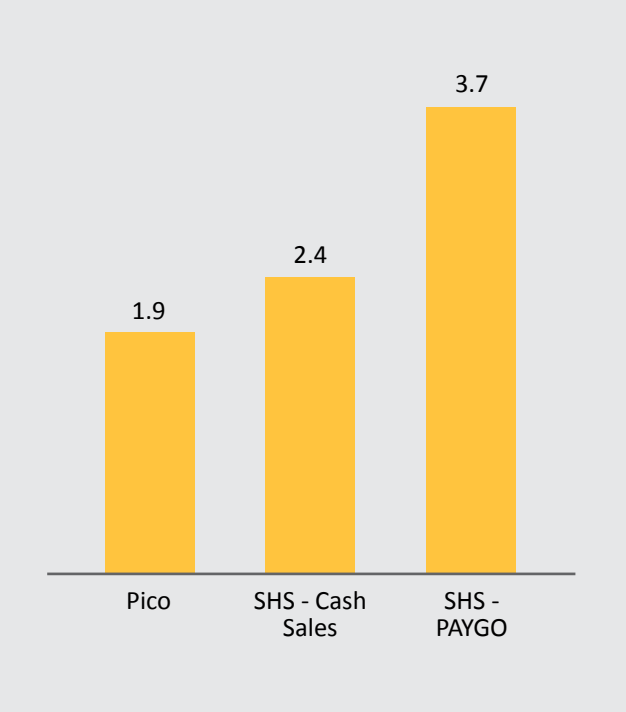
> "Investors like to see companies doing one thing well. A lot of early stage companies are starting fresh with new SHS products, and that's just not necessary anymore."
> **- Leslie Labruto, Acumen**

PAYGO magnet: Companies adopting PAYGO models have received the lion's share of capital.

Funders are more willing to support PAYGO SHS business models. The PnP SHS segment has attracted the bulk of financing due to its higher growth rates (see Table 3) and large funding needs, as PnP SHS companies increasingly adopt PAYGO financing models.

Figure 80: Relative ease of fundraising in the current market by business models[271]

Average score from poll of funders; score out of 5 (1=Difficult, 5=Easiest to fundraise for a company operating under a specific business model); n=11 (2017)



At the same time, investments into pure-play pico companies became relatively slower—especially when compared to the fast growing PAYGO companies, many of which are PnP SHS—as the segment's sales are projected to slow going forward. Greater competition (especially from non-affiliate firms) has depressed margins, making pico companies less attractive to investors (see Figure 80). While some incumbents have upgraded customers to PnP SHS devices and have raised funds in support of this new business line, others with strong brands focused on capturing the relatively upmarket segment of the pico market. Without an existing customer base or a strong brand, newer pico entrants find it difficult to raise external capital.

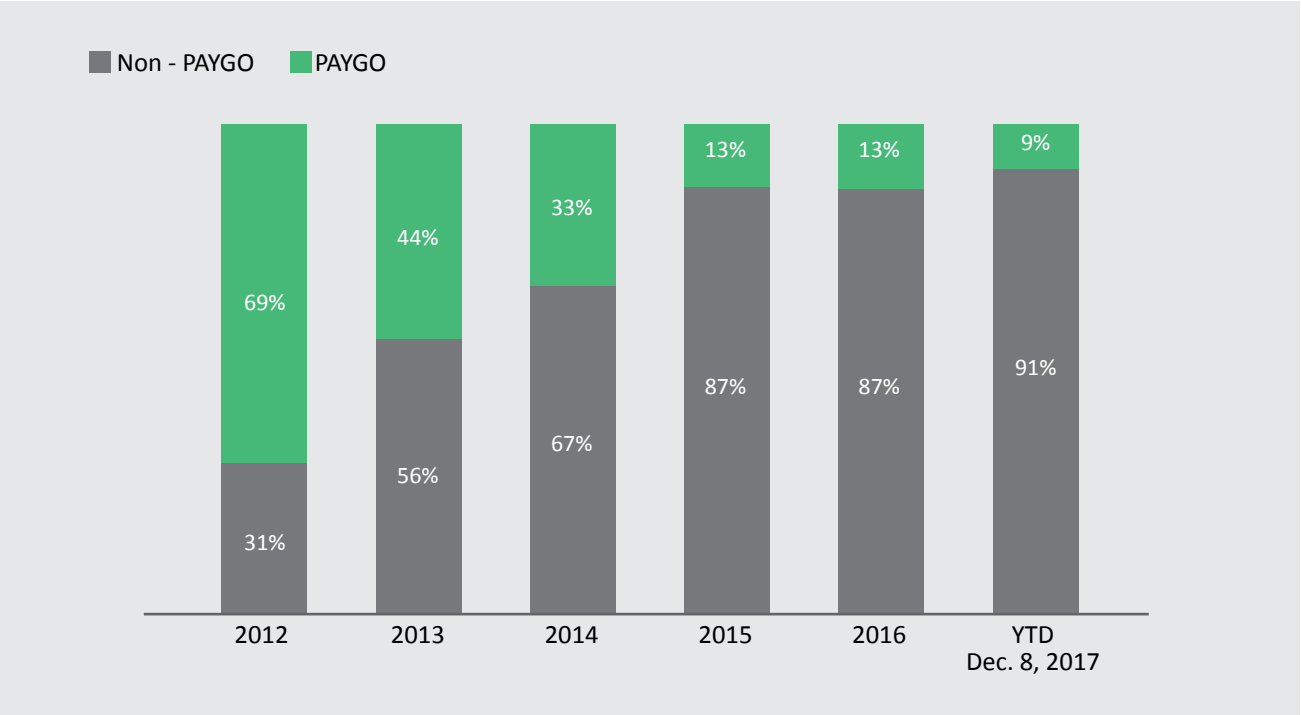
It should be noted that this study may not effectively capture funding towards the pico segment due to the increasing share of non-affiliate companies within it. There is little information available on funds raised by these companies; many of these company's fund operations through a combination of informal funding sources, internal cash flows, and cross-subsidization from other products sold.

The relative share of funds going to PAYGO companies has increased rapidly. In 2012, PAYGO companies accounted for 31% of total funds raised; this crossed 90% by 2017. Overall from 2012 to 2017, PAYGO businesses raised USD 773 million, equal to ~85% of all funds raised.

[271] *Source: Industry interviews*

Figure 81: Funding flows by business model[272]

% of total funding raised (2012-17)



Several reasons underline this investor preference for PAYGO business models:

1. Consumer preference for financing drives sales growth

Consumers prefer businesses that offer financing. For example, a study in Bangladesh found that 90% of customers chose financing when given a choice between financing and upfront payment.[273] In another study, 53% of customers of one SHS company said that a driving reason to select a company was the mode of payment; only 3% cited price as the main reason.[274]

Beyond making a product more affordable, financing can reduce risk for customers buying a new technology or from a new brand, as it allows them time to test the product before handing over full payment. For example, during SunnyMoney's PAYGO trial in Kenya, of the 80% of households who completed their repayments, 15% made a full repayment in the initial 30 days following the deposit despite the original term being six months. This implies that consumers used the initial payment period to develop trust in the product before paying the full price.[275]

2. PAYGO companies have inherently high financing needs, particularly due to the creation of consumer loan receivables

PAYGO models have historically required multiple rounds of financing for upfront investments and working capital. As a result, the investment needs for a PAYGO company can be up to eight times that of a cash sale-based company.

[272]Note: 2017 figures include estimates on the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study has not been able to verify the size of these transactions, and estimates that they collectively fall in the range of USD 30-45 million. Funds raised to support a new PAYGO SHS business by companies which have historically sold pico products have been allocated to PAYGO. Source: GOGLA 2018 Deals Database; Dalberg analysis

[273]Source: (Brossman, 2013)

[274]Source: (Acumen, 2017c)

[275]Source: (Alstone, Gershenson, Turman-Bryant, Kammen, & Jacobsen, 2015)

These needs include:

- *Setting up distribution networks and technology platforms:* Vertically integrated PAYGO companies required early financing to create extensive distribution networks, and to develop the software platforms and technologies that enable PAYGO financing and allow companies to shut down devices in case of non-payment of installments.
- *Financing embedded consumer loans:* The PAYGO business creates affordability by extending a consumer loan which needs to be financed. This need to fund receivables can range from USD 35-65 million per company or even higher, as some recent transactions have shown. In comparison, a supplier dealing in cash sales may require USD 3-10 million for funding inventories.

Figure 82: PAYGO companies act as financial intermediaries[276]

PAYGO companies collect an upfront deposit, and then receive payments on a regular basis for the balance of the loan term. As there is a time lag between paying the manufacturer and collecting the full value of the receivables from end users, most PAYGO companies are expected to rely on short-term working capital facilities to finance customer purchases. Hence, PAYGO companies act as financial intermediaries, providing consumer loans to encourage sales.

Besides default and collection risks, financing customers is challenging because PAYGO companies do not accept deposits like a commercial bank, and are therefore dependent on funding from investors, lenders, and internal cash reserves to finance the consumer loans. The larger the value of a loan and the lengthier its term, the more working capital is needed to fill the negative cash flow gap that is generated during the normal course of business. As a result, working capital is necessary for a PAYGO business to scale up, and the lack of it will restrict growth.

Financing needs for receivables are closely tied to the rate of revenue growth, and thus PAYGO companies will not remain reliant on external capital indefinitely. They will be able to finance the majority of their operations from internal cash flows once they reach scale and their growth rates slow; however, this will take several years. Bardouille, Shepherd, and Vanzulli estimate that companies which are growing rapidly may continue to rely on external sources for financing for 8-15 years before financing needs level off. The more aggressive the company's growth, the greater the need for external funds due to the corresponding cash crunch.

- *Expanding into new markets and developing new products:* PAYGO companies' expansions have historically been capital intensive due to the need to create new distribution networks in expansion markets. Similarly, capital expenditures (particularly on R&D) have been significant as product lines have expanded to include appliances.

[276] *Source: (Bardouille, Shepherd, & Vanzulli, 2017)*

Figure 83: Historical external funding cycle for company following a cash sales model *(Indicative)*

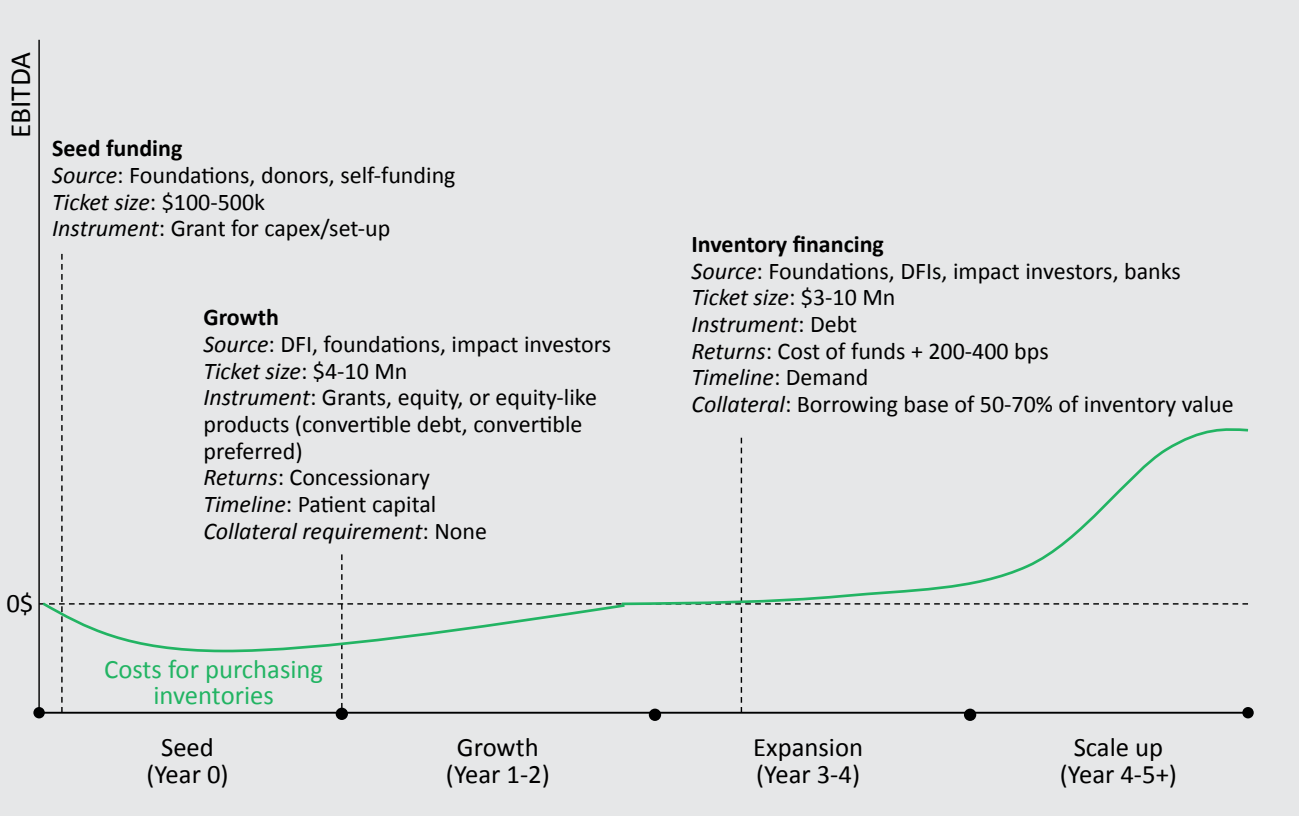
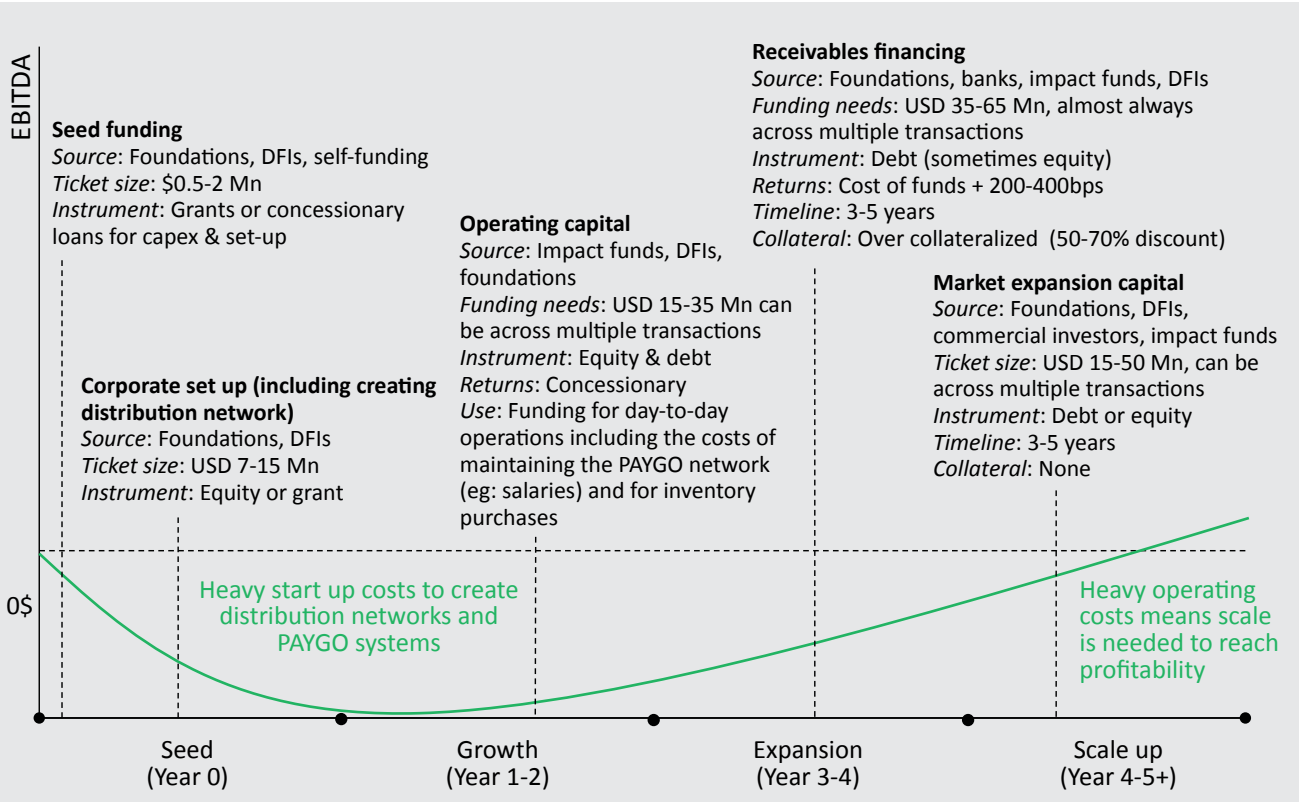


Figure 84: Historical external funding cycle for company following a PAYGO sales model *(Indicative)*



While PAYGO models have supported rapid growth, they risk placing a heavy debt burden on consumers. Some funders are concerned that because PAYGO business models push much of the consumer's financial burden to the future, the impact of extending these consumer loans (such as possible defaults) may not be felt for many months or years. If consumers are over extended and unable or unwilling to make the full loan repayments, investors are not funding working capital but rather subsidizing future losses due to defaults. Such defaults may arise either when the burden of loan repayment is too high, pushing consumers into bankruptcy, or because consumers become unwilling to continue to make payments. This second default scenario is particularly relevant for companies that extend the PAYGO payment period too far in an attempt to engineer affordability, or for those whose products become obsolete before the PAYGO term is complete.

3. Sales from PAYGO companies may be more profitable in the long-term compared to sales via other business models

Devices sold under a PAYGO financing plan have higher gross margins than sales of similar cash-sales devices. This is balanced by the fact that a PAYGO business is more complicated, with higher operating costs, than a cash-sales based business; this complexity makes net margins more difficult to obtain quickly. The higher gross margins from PAYGO sales are due to additional margin for providing financing on top of margins from product sales. Coupled with high growth rates and significant scope for future organic growth, this demonstrates a pathway to scale and profitability, and promises the possibility of robust returns to investors.

4. PAYGO provides data-driven insights on a new consumer segment

For many PAYGO customers, the acquisition of a solar home system is their first major durable consumer product purchase. Through the PAYGO function, the company develops long-term relationships with its customers, collects valuable data, and gains an understanding of their credit risk (see Figure 85). In the future, this data can provide a unique understanding of an entirely new class of consumers.

Data-driven insights are helping develop new ways for companies to manage portfolio risks. Due to the relative nascence of PAYGO models, the industry has little experience in quantifying the risks of the business, especially through a full business cycle. Monitoring the quality of the consumer loan portfolio is important to understanding this risk and is typically managed through standard metrics, often borrowed from other financial institutions, such as PAR 30.[277] However, there may not be sufficient data to inform funders on what level of PAR 30 is an unacceptable risk or whether another metric may be a better measure of long-term risks. For example, consumers that are late on payments because of the seasonality of their income may not be a high credit risk.

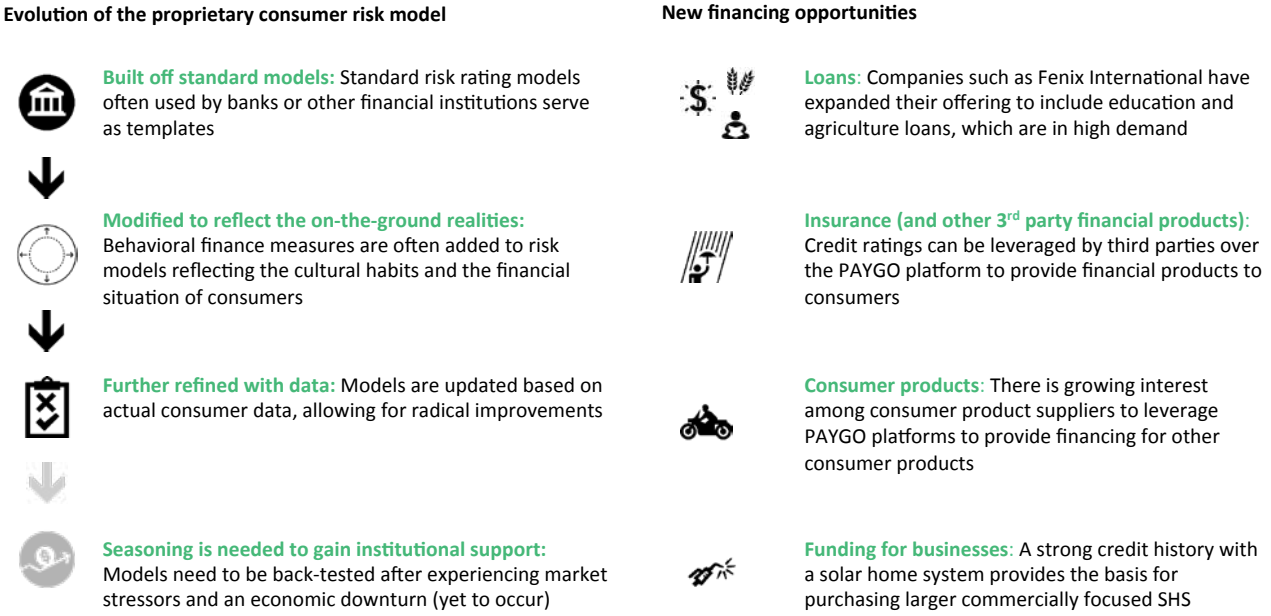
Entrepreneurial funders are experimenting with different ways to monitor portfolio risks. These include proprietary metrics developed by companies that add behavioral finance measures to better reflect a consumer's financial situation and cultural habits; such metrics are continuously refined as more consumer data is collected. However, at this point the use of such bespoke models is an exception rather than the norm; lenders have noted that while proprietary models are useful in provide a fuller picture of the portfolio risk, they are still a long way from being trustworthy on a standalone basis as they are yet to be tested in a recessionary cycle. Some lenders have also expressed hesitance in adopting non-standard risk rating metrics as it makes comparison of portfolios across companies difficult, increasing uncertainty and due diligence costs.

Knowledge of consumer behavior can help build a pathway to sell consumer goods to customers. A consumer that is deemed a good credit risk can be offered follow-on purchases on improved payment terms; this can extend to an entirely different subset of products (see Figure 85). Some companies have already begun to sell

[277] *Note: PAR 30 is the Portfolio-at-risk 30, which is calculated as the value of accounts in arrears for more than 30 days divided by the total size of the portfolio*

non-OGS products to consumers. For example, Fenix International offers eligible customers system upgrades (such as appliances on improved payment terms) as well as financing for non-energy products, such as education loans.

Figure 85: PAYGO businesses have adopted new credit risk models[278]



Data collection creates new challenges. The collection of consumer data raises issues of privacy, as customer details are often collected without the customers' full acknowledgement. PAYGO companies require their customers to sign contracts when registering for credit and there is some evidence that some customers either don't understand the full nature and value of the information collected, or on occasion do not provide their consent. According to data collected by Acumen, 27% of PAYGO SHS customers felt that the agent did not explain the contract to them adequately during the sign-up procedure, and 13% said that parts of the payment plan were unclear.[279] Such data collection can create unbalanced power dynamics where individual customers may be denied services based on a rating system that they do not understand.

Another concern arises from the subsequent usage of customer data. For example, PAYGO players spoke of the ability to tell if a wedding was coming up in a village based on electricity usage patterns alone, which could prompt advertisements for a wedding loan (to make the wedding grander). Some investors would see this as a measure of progress, potentially replacing loan sharks, while others would consider it irresponsible.

[278] *Source: Industry interviews; Dalberg analysis*
[279] *Source: (Acumen, 2017c)*

Alignment concerns: While industry-wide use of funds has diversified quickly as companies mature, investors have raised concerns that some companies' funding strategies may not align with the speed of their corporate development.

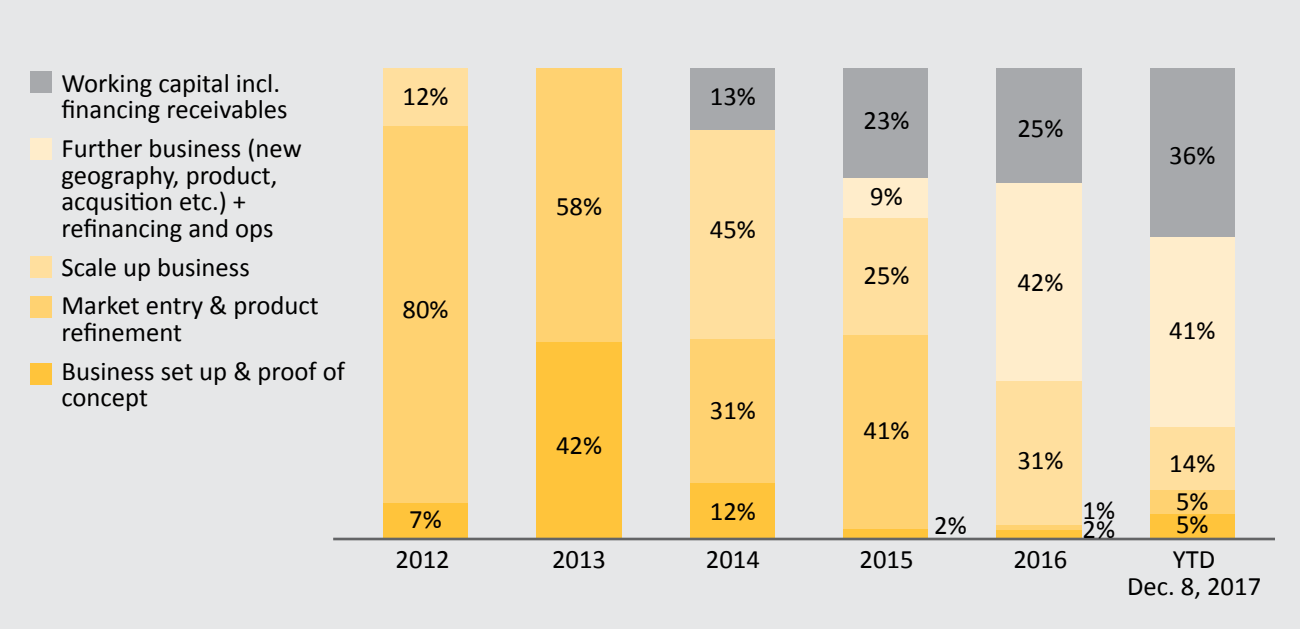
Companies across industries typically develop by establishing operations, scaling up, and then seeking expansion opportunities. When fundraising for each successive stage of development, there is an assumed de-risking that leads to the company being able to access better terms. Thus, at times, some investors may offer funding later in a company's development despite being unwilling to commit in early stages. As companies in the OGS sector are now raising funds across multiple lifecycle stages, this has attracted a variety of funders with different risk profiles.

> "More and more investors are hearing about the sector and taking interest…the investor base is widening."
> **- Nico Tyabji, Sunfunder**

OGS companies have matured quickly, moving from a collection of newly incorporated companies to a group of stable startup-type companies (as self-reported) in a span of a few years. As a result, the distribution of funding allocations within companies in the OGS sector has changed dramatically. As shown in Figure 86, the period between 2012-2017 saw funding transition from being primarily used for market entry and business set up, to being used for working capital, scale-up, and expansion.

Figure 86: Use of funds[280]

% of total funds raised (2012-17)



[280]*Note: Figures may not add to 100% due to rounding. Use of funds was determined either through interviews or by reviewing the publicly announced stated use of funds at the time of fundraising through corporate news releases or other publicly available news sources. 2017 figures include estimates on the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study has not been able to verify the size of these transactions, and estimates them to collectively fall in the range of USD 30-45 million. Source: GOGLA 2018 Deals Database*

However, there is a perception among some investors that certain companies have progressed through development stages too rapidly. If true, this would suggest that market hype had allowed companies to raise capital earmarked for the next stage of their development (applying this to working capital) without first meeting the milestones for their current funding stage. This may have led to overvaluations, as fundraising for a later round would imply a level of de-risking and a higher valuation (see View 1 below).

Funders' opinions are divided around concerns of overvaluation. Some funders have raised concerns that PAYGO companies are overvalued, given the valuations observed during 2014-2016 (which have been priced at mid-single digit multiples of trailing revenues).[281] Others, pointing to industry-wide macro trends, are less worried and view these valuations as justified. In any case, most investors point to 2017 as a time when equity funders began to temper their hype from previous years.

> "It does seem like there has been a period of reflection. Maybe this is part of the natural cycle of some companies having big forecasts and needing to reassess a bit."
> **- Greg Neichin, Ceniarth, LLC**

These two views of the investment community can be summarized as follows:

View 1: The market may be overvalued due to aggressive equity fundraising

There may be a structural reason for high valuations that does not relate to the true value of PAYGO companies. The large working capital needs of PAYGO companies are most efficiently funded by debt. As discussed in Section 1D.2, debt has been difficult for these companies to obtain, resulting in the use of equity to fund growth. However, raising multiple equity rounds is difficult without increasing valuations in each subsequent round.[282] As a result, the need for equity to finance working capital became the driving force behind increased valuations.

The momentum for this equity fundraising was encouraged by market exuberance that fed the belief that companies were maturing quickly (and thus perceived to be readily able to meet aggressive forecasts) and were therefore prepared for the next "round" of equity financing. In reality, some companies may have been fundraising before reaching normal corporate development milestones.

A rapidly growing industry was able to sustain aggressive valuations. However, the industry-wide sales slowdown in the latter half of 2016 and into 2017 led to some companies missing their targets. This tempered the exuberance, and caused some investors to reassess their fundraising positions (due to companies pushing out timelines for meeting forecasts). These investors became reluctant to put in more equity in this environment. As a result, companies may have shifted to using debt to maintain

> "Finding new debt sources of working capital would significantly lower the equity-intensiveness of scaling for PAYGO solar home system companies."
> **- Impact investor**

[280] *Note: Based on interviews responses with industry participants on expected industry-wide valuation metrics; not specific to any transaction*

[282] *Note: Higher valuations were needed to justify the efficacy of previous funds raised and to avoid excessive dilution. This may have been exacerbated by early investors with clauses in their investment restricting the company from raising capital at lower valuations without receiving specific waivers*

growth, with the view of growing into their valuations. There is some evidence that this has happened in 2017. Debt accounted for 61% of total funding, up from 40% the prior year (see Figure 75).

If debt funding remains insufficient, there is a risk that companies may be forced to accept down equity rounds to raise capital, possibly catalyzed by external factors such as increased competition.

View 2: Greater optimism and high valuations are justified, considering the potential long-term value of a customer relationship and the large potential market

> "Companies are not overvalued. We simply don't know how to value them."
> **- Christopher Aidun, Persistent Energy Capital**

For some investors, the view that OGS companies are overvalued may be too simplistic given the nascence of the business model and the lack of historical data and understanding of consumers. As a result, investors may be divided on how to properly value companies under current market conditions.

According to this view, the industry's forward progression could have a range of outcomes, ranging from a situation where companies find it difficult to expand beyond their current base, to one where companies will tap into new sources of growth and valuations will multiply manifold. Some investors believe that the latter outcome is likely. This view stems from a combination of factors:

1. *The value of a customer relationship may be larger than is being accounted for.* Current valuations are often based on multiples of projected cash flows. This method may not fully consider the value of some cashflow streams which are still developing, such as the full lifetime value of a customer relationship that leverages PAYGO to sell non-OGS products (as detailed in Figure 85). When such further revenue streams are accounted for, the value of the consumer relationship may be greater than current projections predict.
2. *The broader potential market contains a lot of value if the expansion challenge can be overcome.* While some question the replicability of PAYGO business models across geographies, cultures, and political landscapes, the size of the potential market is indisputable (as detailed in Section 1A). Companies continue to experiment with different models for expansion and there have been promising advances using mobile technology, electronic payment methods, and partnerships with specialized distributors. The success of these initial steps toward solving the expansion challenge would go a long way in addressing concerns around replicability.

Investors who ascribe to this view point to large equity investments in 2016 as evidence that equity investors are prepared to support the industry. The slowing of equity investment in 2017 indicates a wait-and-see pattern, given the decelerating industry sales in 2017, as well as an overall shift toward debt financing. Once the market returns to a positive trend of sales growth, these investors expect that equity investment will likewise rebound quickly.

Valuations remain difficult to determine due to the nascence of the industry

In common with both views is that valuations in the OGS market are difficult to determine, as a wide range of outcomes are possible. Despite some companies having been successful at raising funds, a dominant and profitable business model has not yet emerged. Business models used in the OGS market remain in flux as

the industry seeks to expand profitably. In all likelihood, multiple successful business models will emerge, reflecting the needs of specific market segments (see Section 3).

> "There will likely be a variety of business models that can succeed. But, we need time for the right business models to emerge: Which geographies, customer sets, and technologies [will create a profitable and sustainable business model]?"
>
> **- Greg Neichin, Ceniarth, LLC**

1D.5 FUTURE NEEDS AND GAPS

Financing needs: External requirements are expected to grow substantially, driven by PAYGO.

This study estimates total financing needs to amount to between USD 5.1 and USD 5.7 billion between 2017-2022 (assuming sales growth rates commensurate to the baseline forecast scenario in Section 2). It should be noted that these needs pertain to the growth of companies operating in this sector (including potentially new entrants) and not the quantum of funds needed to develop the enabling environment in which the market operates, nor to fully meet the needs of the total potential market. It is also important to note that this estimate does not reflect an aggressive or pessimistic scenario, but a range due to the uncertainty of individual variables within the underlying forecast model (as detailed in Table 9).

Of the total financing needs, about 75-80%, or about ~USD 4.0-4.5 billion, will need to be funded externally, and the balance funded by companies' internally generated cash flows (see Table 10). These forecasts suggest that industry will need to raise a combined USD 750-875 million externally in 2017-2019. This will grow three-fold between 2020-2022 (see Figure 87).

Photo credit: Lighting Pakistan

Figure 87: Forecasted external financing need by top OGS affiliate companies[283]

USD millions (2017-22)

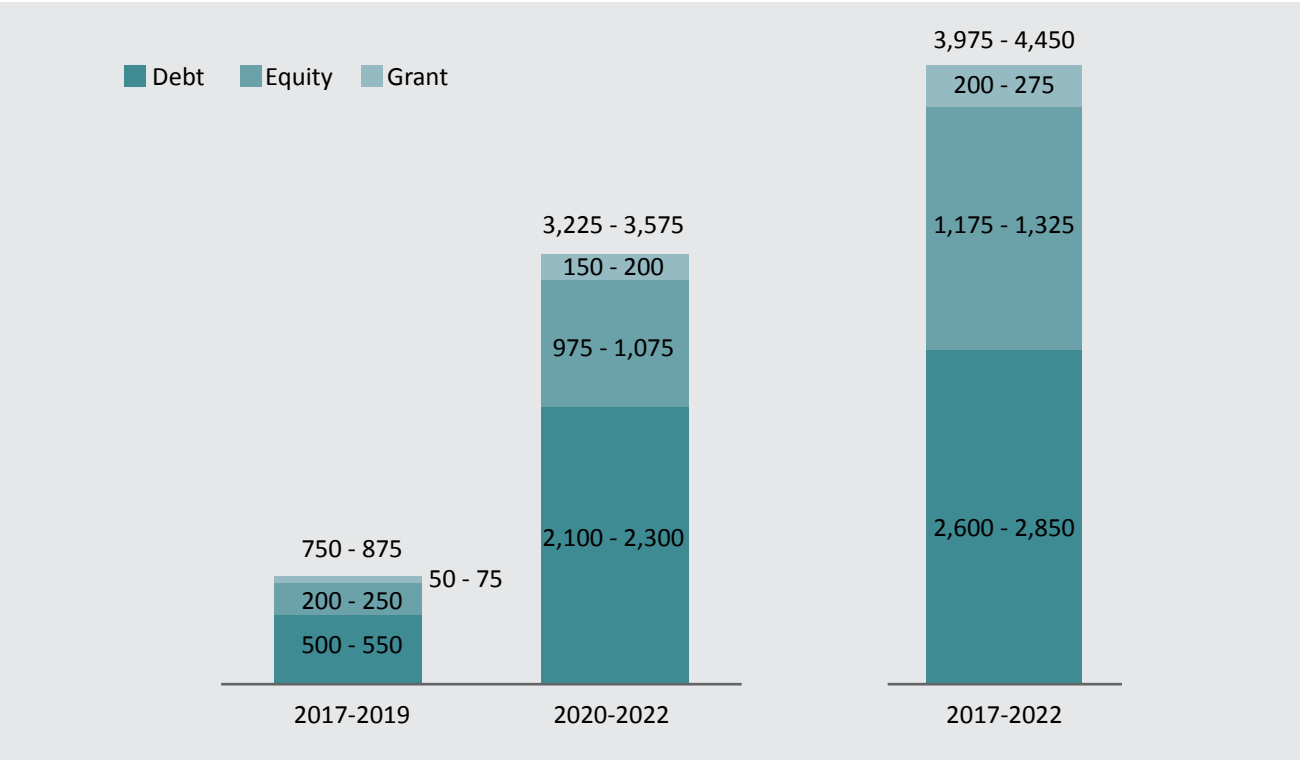


Table 9: Methodology underlying financing needs model

Approach

The model uses a bottom-up approach to determine the financing needs of the industry. Individual estimates on the financing outlook for 10 market-leading companies were forecasted, which were then combined with high-level estimates on the financial outlook for 10 additional non-specific affiliate PAYGO SHS companies and 40 non-specific affiliate pico companies to create an overall view of the industry. This study assumes that the material proportion of the fundraising environment is captured here, as smaller companies, especially non-affiliates, will likely not have material external financing needs.

Companies included in the model

For the sake of individual company analysis, this study projects the financial details for the seven largest PnP SHS companies and the three largest pico companies. These companies were chosen based on estimates of their current size, expected growth rates, and geographical completeness.

[283]*Source: Dalberg OGS 2017-2022 financing needs forecast model; Dalberg analysis*

Table 9, continued

Structure of the model

- *Working capital accounts:* The model uses 2015 and 2016 sales figures to extrapolate best estimates on an opening balance for standard working capital accounts. These figures were then projected outwards until 2022 to determine the additional financing needs to fund growth.
- *Capital expenditures:* Maintenance and growth capital expenditures were estimated based on historical capital expenditure for existing companies and capital expenditures for companies in similar industries. These estimates then accounted for projections on how such expenditures would be more efficient in the future, as well as future expansion patterns.
- *Cash flow from operations:* These were approximated based on an estimate of individual company gross margins, and an evaluation of projected standard operating costs for the major business models.
- *Total needs, split by instrument:* Assuming there is minimal leakage of cash from dividends, external financing needs were calculated as the sum of working capital needs and capital expenditures less internally generated cash flows. The external financing needs amount was then split between debt, equity, and grants based on estimates of an expected split.[284]

Sources of data

- *Company level data:* Company level data, including selling prices and units sold, was gathered from secondary sources such as industry reports and publications. These were verified via interviews (where possible, or where data was available) with the companies that were included in the model.
- *Industry-wide estimates:* Industry estimates, including growth rates, came from this study's market forecast model (see Table 12).
- *Industry assumptions:* Industry assumptions were made, where necessary, based on desk research of similar industries going through similar stages of the industry life cycle, including expectations on the level of competition.

Funding consumer receivables from PAYGO businesses will be the main driver of financing needs. 60-70% of funding, or approximately USD 3.4-3.7 billion, will be used to finance the consumer receivables generated by PAYGO companies. Financing of inventories will assume a further ~20-30% of funds raised, and the remainder of the funds will be applied to capital expenditures. Table 10 summarizes the forecasted sources and uses of capital for the OGS industry.

[284] *Note: Debt-equity-grant ratios reflect a combination of secondary research and interview data. Expected debt ratios ranged between 65% and 90% with a standard response settling in the 70-75% range. This study has chosen to reflect debt needs at the low end of this spectrum as meeting the total debt needs will be difficult without a material increase in commercial lending, such as from off-balance-sheet transactions. However, this type of transaction remains in the early stages of its development path and the success of such an instrument in raising larger amounts is untested*

Table 10: Sources and uses of capital – Forecasted total financing needs by top OGS affiliate companies[285]

USD millions (2017-22)

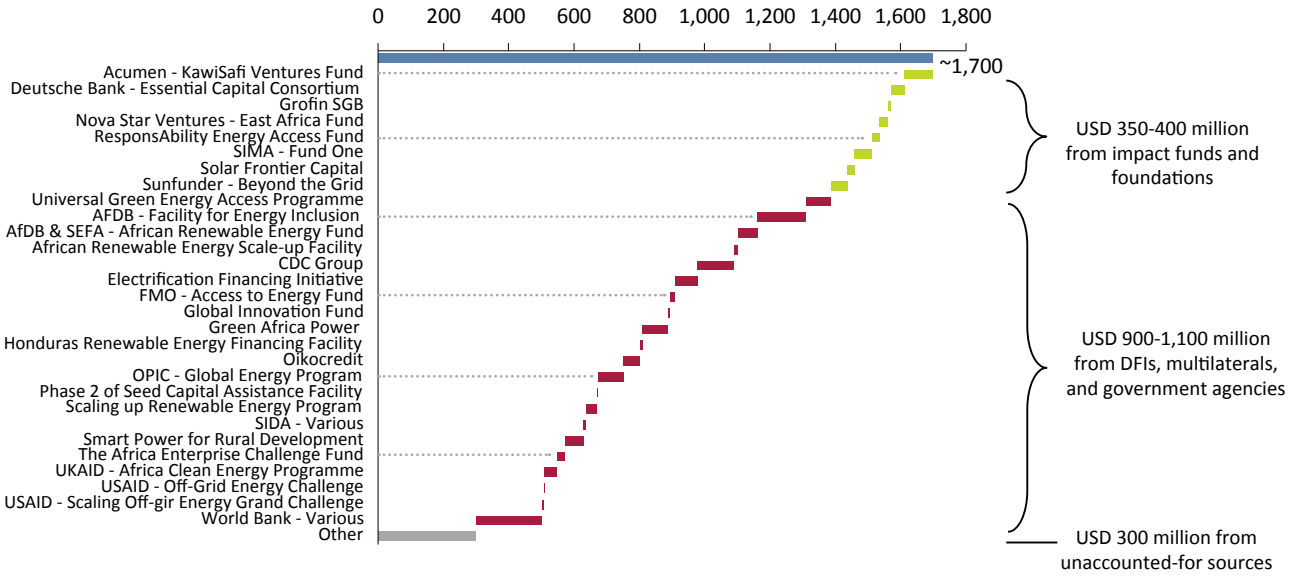
Uses of capital		Sources of capital	
Funding receivables	3,350 – 3,725	Operating cash	900 – 1,000
Funding inventories	1,275 – 1,425	Change in payables	225 – 250
Capex	475 – 550	External (Debt)	2,600 – 2,850
		External (Equity)	1,175 – 1,325
		External (Grants)	200 – 275
Total	**5,100 – 5,700**	**Total**	**5,100 – 5,700**

As working capital is forecasted to be the primary use of funds, a lack of working capital financing will slow sales growth, and thus the growth of the industry as a whole. This sentiment was reflected by some funders and companies who have suggested that a lack of working capital is a key barrier to further industry growth (see Figure 90).

Financing gap: While over USD 1.5 billion in funding has been announced, a large gap remains.

Figure 88: Expected amount of funding from committed sources by funder[286]

Breakdown of expected funding (2017-22)



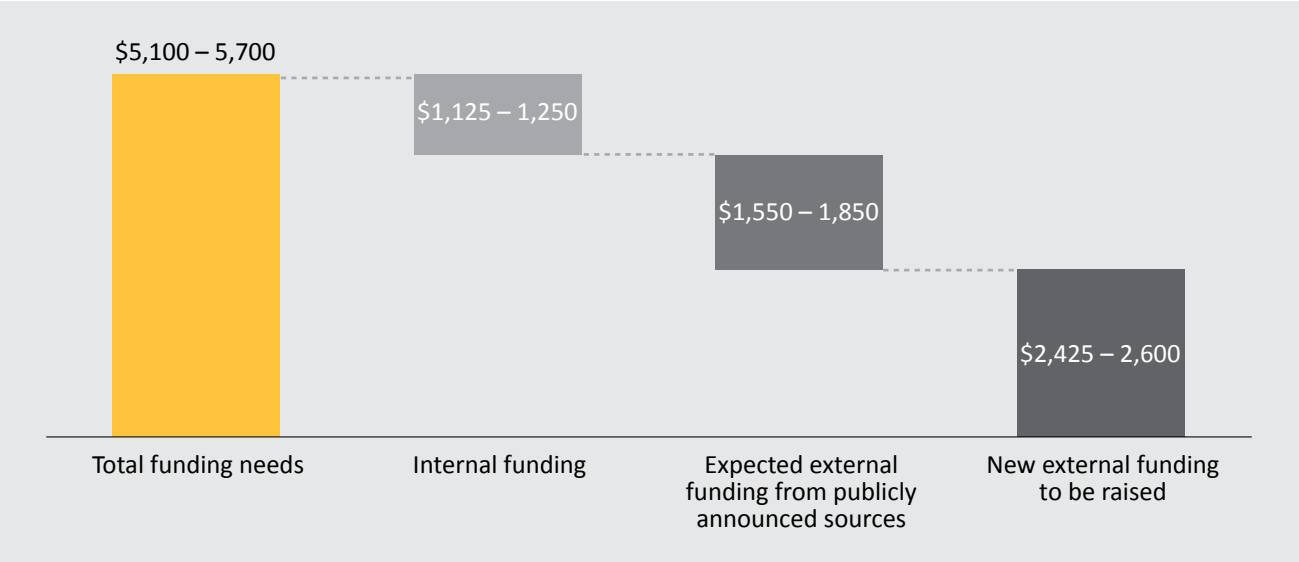
[285]*Source: Dalberg OGS 2017-2022 financing needs forecast model; Dalberg analysis*

[286]*Note: This reflects the expected value of investments from funds which have made public commitments to support the off-grid solar space from 2017-2022. Note that this amount of financing provided by each fund/organization does not reflect a summation of the size of each fund. Rather, it is the authors' expectation on the quantum of financing the fund will provide to the off-grid solar sector based on: (1) the size of the fund, (2) expected term of the fund, (3) the fund's objectives, (4) amount of funding already allocated to projects or otherwise dispersed, (5) timing of fund launch, and (6) a qualitative view of the investor's interest in the off-grid solar space. Further, this analysis assumes that the investment funds listed in the graph represent approximately 80% of the financing that will come from funds which have made previous public announcements. To account for the few funds which may overspend expectations and to reflect commitments made by funds unknown to this study, the authors have added a further USD 300 million to the estimate, which is approximately equal to a 20% increase on the expected funding documented in this analysis*

To meet projected financing needs for the following five years, this study estimates that USD 1.55 – 1.85 billion of funding will come from various sources that have expressed public support for the OGS space (see Figure 88). In addition, companies will meet ~USD 1.1 – 1.3 billion of the forecasted funding requirement through internal sources. After accounting for supportive public and internal sources, the industry will still need to raise approximately USD 2.45 – 2.60 billion in additional external funding. The fact that the sources of this funding are currently unknown does not imply that there will be a deficit of funds available to companies. Rather, new sources of capital will need to bubble up to meet industry needs.

Figure 89: New external funding to be raised[287]

Projected funding sources (2017-22)



New funding: The marketplace will require new sources of capital, including commercial finance.

Funding needs may exceed what traditional funders can comfortably provide based on historical funding patterns (see Figure 70, Figure 71, and Figure 72). While these funders will continue to support the sector, and are likely to increase their ticket sizes to reflect industry needs, new sources of capital are needed to meet the forecasted funding gap. A large part of this is likely to come from commercial sources. While the sources may differ for debt and equity, cross-cutting implications of greater commercial capital include:

1. *Greater focus on financial performance by companies:* Improved financial performance will be required to generate the profits needed to attract new commercial funders; this financial pressure will likely lead to greater professionalization of corporate leadership teams to meet the needs of the funders, bankers, and investors. This may eventually be a driving force behind the faster adoption of industry standards, such as common credit metrics or standardized methods to shut down devices.
2. *Altered cost structure and terms:* At first glance, commercial finance is expected to raise the cost of borrowing as it is generally more expensive than development finance. However, this does not necessarily translate into higher net costs to companies. Concessionary finance is often provided in hard currencies (which has a hidden cost of managing forex risks), and can come with lengthy and costly application processes. Commercial finance sources have a more streamlined due diligence process and

[287] *Source: Dalberg OGS 2017-2022 financing needs forecast model; Dalberg analysis*

greater resources to complete transactions quickly. In some instances, these lower soft costs can provide benefits that offset some of the higher financial costs. [288]

3. *Potential to free up concessionary finance for redeployment:* If commercial funders support the money-making aspects of the OGS market, this can free up resources for concessionary financiers to redeploy into marginalized areas.

Over the next 5-6 years, it is likely that commercial funders will continue to gain familiarity with the sector via blended finance transactions that serve as a stepping stone to greater commercial financing.[289] Interviews suggests that when concessionary sources co-invest with a commercial funder to spread out risks, the commercial funders may be willing to pursue investments that are larger than what they would ordinarily be willing to invest given their inexperience in the sector.

The participation of commercial funders could be further catalyzed by the development of ecosystem-wide, standardized metrics. As a new asset class, there is limited information around market size, effective policy incentives, business model dynamics, or the financial and operational performance of PAYGO companies. Both investors and companies agree that increased availability of data and reporting standards could help increase transparency and manage perceptions of risk. To this end, increased data reporting capacity and standardization would be of great benefit for the sector.

> "For the time being, you'll likely find a hybrid financing structure where DFIs invest alongside commercial investors until there is enough of a track record in place."
> **- Local commercial lender**

Standardized metrics can form the basis for the development of financial vehicles, operational tool-kits, and policy programs that are critical for the sector's growth. Once implemented, the industry will have a common set of metrics to (1) quantify risk factors, and (2) provide industry participants with a common language, increasing the effectiveness of data collection and industry analysis. This is important for financiers assessing investment opportunities.

The World Bank and IFC, together with the Global Off-Grid Lighting Association (GOGLA) Secretariat and its members, have developed a Key Performance Indicator framework for the PAYGO solar off-grid sector, which provides a good starting point for setting an industry standard.[290]

Potential equity sources: Strategic investors and investors from adjacent industries could play important roles.

Commercial equity investors span a wider range of risk tolerance, and have greater financial resources at their disposal when compared to the traditional sources of capital in the OGS sector. As a result, they will be important in both early stage financing, as well as for larger ticket investments. In some instances, private

[288] *Source: (Tremolet, Leveraging commercial finance for water: Will it hurt the poor?, 2017)*
[289] *Note: There are many definitions of blended finance, but it can broadly be understood to mean the deployment of philanthropic, concessionary, and development finance (often alongside commercial funding) for the strategic purpose of mobilizing additional commercial finance into frontier and developing markets*
[290] *Note: A guide for this framework is available here: https://www.lightingglobal.org/resource/technical-guide-for-the-kpi-framework/*

capital can be joined with government finances to bring OGS solutions to markets which may not have been reached independently by either private or public funding (as discussed in Section 1A.2). At the same time, there is a large role that direct equity investments can play. Sources of such investments are explored below:

1. **Multinational companies increasingly see energy access companies as an investment opportunity.** These strategic investors may invest in the OGS market to acquire technologies and business know-how, or simply to better understand emerging trends. To make investments, energy companies may leverage knowledge gained through philanthropic or impact investing. This would echo Engie SA's acquisition of Fenix International. ENGIE Rassembleurs d'Energies initiative, Engie's fund aimed at supporting energy access, made investments in Fenix in 2015 and 2016, before Engie Africa completed its acquisition in 2017.[291] Similarly, Total has been an active player in the OGS market via the distribution of pico products in its service stations through Awango, an internal startup. This familiarity with the sector may have helped provide a foundation for follow-on investments in the off-grid space, including an equity investment in Off-Grid Electric in 2016 through Total Energy Ventures (a venture capital fund). The prospects and implications of greater involvement by multinational companies is discussed further in Section 2.
2. **Investors from adjacent industries may look for synergies between OGS and their core industry.** As OGS devices are used in adjacent industries, companies will be exposed to new investors with a secondary interest in off-grid solar. For example, solar systems that can be used for productive uses in agriculture (e.g. powering water pumps for irrigation) may find interested investors in agriculture-focused investment vehicles. Similarly, as PAYGO companies embrace their position as financial intermediaries (see Figure 82), they may benefit from financial sector-focused investments.

Photo credit: MPOWERD (Bhushan Dahal)

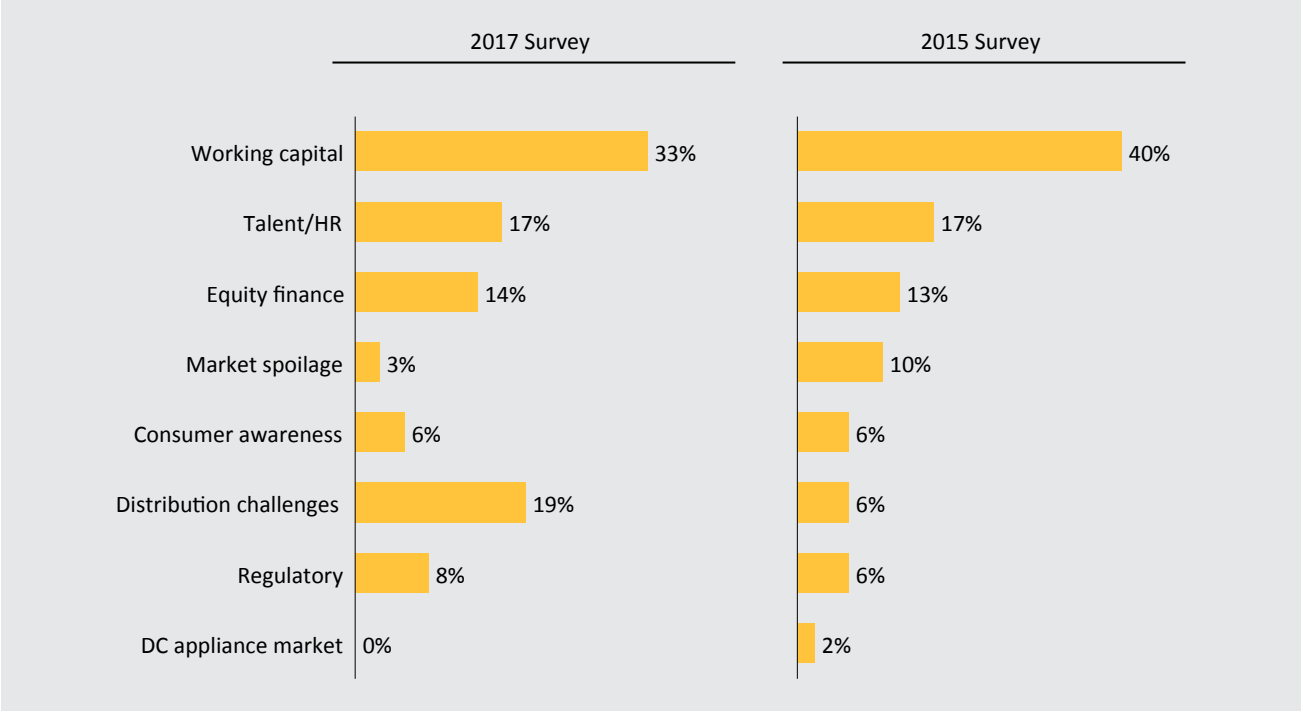
[291] *Source: (Engie, 2017)*

Future debt sources: Especially important for working capital, debt is expected to come from increased local and off-balance-sheet financing.

The total debt need from 2017-2022 will be between USD 2.6-2.9 billion. While significant new financing sources are coming online (see Figure 88), the need is so large that further debt sources will be required to meet funding needs. This will be an important factor in meeting the large working capital needs of companies (which constitute the majority of future debt funding needs). A lack of working capital has been consistently cited as a significant barrier to growth (see Figure 90).

Figure 90: Poll results on the relative importance of key barriers to growth in the OGS industry

2017 survey: Number of responses in each category when asked about top 3 barriers, n=19 (2017)[292]
2015 survey: Top three answers of polled respondents, n=26 (2015)[293]



Key drivers of additional debt funding will include:

1. An increase in off-balance-sheet, structured asset financing (such as securitization). 2017 has seen accelerated uptake and development of such instruments. This is important as asset financing could make up 70-80% of the capital needs of some of the largest companies.[294]

Most off-balance-sheet structures to date have been funded by DFIs and impact investors with a higher willingness than typical lenders to experiment with new financial structures. However, as more structured

[292]*Note: The poll asked funding organizations to identify the top three issues which currently are barriers to growth in the OGS industry. The figures in the graph represent the number of responses each category received and does not represent the number of polling respondents which identified any specific topic. For example, working capital was identified by 12 of the 19 poll respondents as a top three issues but represented 33% of total responses received. Not all respondents identified three issues when completing the poll. Source: Industry interviews*
[293]*Source: (Bloomberg New Energy Finance, 2016)*
[294]*Note: Not indicative of any one company's fundraising needs, this range is based on estimates provided in interviews. Source: Dalberg interview*

transactions are completed (providing a history of successful use) and as companies improve their portfolio management and risk assessment capabilities, uptake is likely to increase. An investor's ability to understand and track the credit risk of a receivables portfolio will be key to the success of off-balance-sheet funding as industry-wide defaults rates vary widely, suggesting that off-balance-sheet structures will be easier to access for some companies over others.

> "The risk remains that lenders do not know yet if their portfolio of securitized assets could still be operated in case a DESCO [distributed energy services company] goes into bankruptcy. The securitization structure is off-balance-sheet, so in theory it should be bankruptcy remote, but is it really?"
> **- David ten Kroode, Oikocredit**

As these structures prove their effectiveness, segmentation of customers into risk pools and the emergence of standardized risk analysis will allow for increased participation by new investors in the OGS asset financing market, possibly unlocking international capital. However, the OGS industry offers a complex environment for such financing, and legal and administrative hurdles will need to be resolved before these structures can deliver to their true potential. Of particular note is the risk to an investor that off-balance-sheet loans will still be affected by the financial health of the operating company (e.g. if the operating company went bankrupt), despite the assets having moved off-balance-sheet. This would eliminate one important benefit of the off-balance-sheet structure.[295] Until a third party can show that the consumers loans can be profitably unwound without the support of the operating company, such loans continue to carry a risk premium.

2. An increase in local institution and local currency financing. The recent past has seen an increased willingness by local banks to lend to the OGS industry. For example, in 2017, BBOXX completed a local currency working capital deal with Banque Populaire du Rwanda and Stanbic Bank (in syndication with a group of DFIs and impact investors) which provided an USD 80 million equivalent loan, of which USD 55 million could be drawn in Ugandan and Kenyan shillings.[296] An increase in local debt is vital to the development of the sector for the following reasons:

- *Local banks are well positioned to provide revolving loans:* While the majority of loans will be extended to PAYGO companies to finance consumer loan receivables, the ability of local banks to finance inventory should not be overlooked, especially in their support of local companies selling pico products. Single light pico companies have lower financing needs compared to their PAYGO counterparts and a more easily understood path to profitability. As such, they are well suited for straightforward inventory financing on revolving terms from banks.[297] Local banks are better able than foreign funders to provide revolving loans due to the need for ongoing monitoring and communications between the lender and the borrower.

[295] *Note: This implies that the value of the receivables is tied to the ongoing operations of the company that supplied the PnP SHS given that they continue to service the systems and are the primary point of contact with the customer. In an ideal scenario, the consumer loans could be taken over by a third party and full value for those loans could be realized regardless of the health of the operating company. Until better and more standard procedures are established, it remains possible that financial difficulties with the operation company may affect the value of the structured loan*

[296] *Source: (M-KOPA, 2017c); Dalberg research*

[297] *Note: Similar to a credit card, revolving loans allow companies to use the money up to an agreed credit limit whenever they need it. Once they repay the amount owed, the credit becomes available to draw on again*

- *Local debt providers offer on-the-ground knowledge of transactions:* Frequent and frank communication between company management and debt providers is important, especially for young companies. On-the-ground lenders are well placed to communicate frequently, avoiding miscommunication, gaining comfort with an unfamiliar industry, and staying abreast of developments. The benefits of on-the-ground access were recently highlighted in the first trilateral deal, where Essential Capital Consortium provided the financing for BBOXX but the loan itself will be managed by Banque Populaire du Rwanda.[298]
- *Local funding may be less sensitive to global financial factors:* Foreign investors can be influenced by the political and economic climate of their home markets. This may result in uncertain availability of funding from these sources. Furthermore, global capital can be fleeting whereas local capital is typically committed to the local economy; several interviewees noted a specific risk of flight by foreign investors in the event of a large public default by any one market leader. Finally, foreign funding denominated in hard currency opens companies up to forex risks.

> "The original thinking was that the banks were too risk averse and unwilling to jump into this market. We quickly found out that some of the banks were willing to take the risk. But, they had other reasons for not investing, including not being knowledgeable about the companies and sector, collateral requirements, and regulatory limits."
> **- Geoffrey Manley, CDC Group**

- *Local financing helps to develop sectoral expertise, which may encourage future investments and lending:* A lack of understanding of industry risk is an important reason that local financial institutions are hesitant to provide funds. The diligence process required to make a loan is an important part of the process of building up this knowledge. For example, Stanbic Bank worked with M-KOPA for a year putting together the transaction before it culminated in Q3-2017.[299] This learning is integral to developing a base of knowledge in the market which can be the foundation of future transactions.
- *Local funders support indigenous businesses in ways that foreign capital may not be able to:* Historically, leading companies were led by entrepreneurs from OECD countries who secured grants and funding from the DFI and impact investing community. In countries with large electricity access deficits, local entrepreneurs unfamiliar with this community may find it difficult to raise funds in similar ways, limiting growth prospects. Creating a local ecosystem of funders that know the local economy, language, and business needs is vital to encouraging the development of businesses run by local entrepreneurs.

3. The replication of currency risk-hedging mechanisms used by the MFI industry. As identified in Section 1D.2, loans in hard currency present a forex risk to OGS firms. Adopting hedging instruments which have been deployed by DFIs and microfinance investment vehicles (MIVs) into the OGS sector may provide a solution. There has been an impetus to replicate these tools for PAYGO companies. For example, Sunfunder has partnered with MFX Solutions to create a new facility which includes a currency hedge.[300] The first of these transactions was completed in a USD 13.5 million debt and equity fundraise by PEG Africa, where the debt portion was structured to reduce foreign exchange risk.

> "We want to fund local entrepreneurs in this space but don't know how to reach them, as they regularly don't speak English or have the same networks as others have. Local intermediaries are needed."
> **- Saskia Werther, DOEN Foundation**

[298] *Source: (BBOXX, 2017)*
[299] *Source: (Prabhu, n.d.)*
[300] *Source: (SunFunder, 2017)*

Grants and concessionary capital: These will continue to be required from historical sources to fund uncertain projects, as well as to reach the last mile.

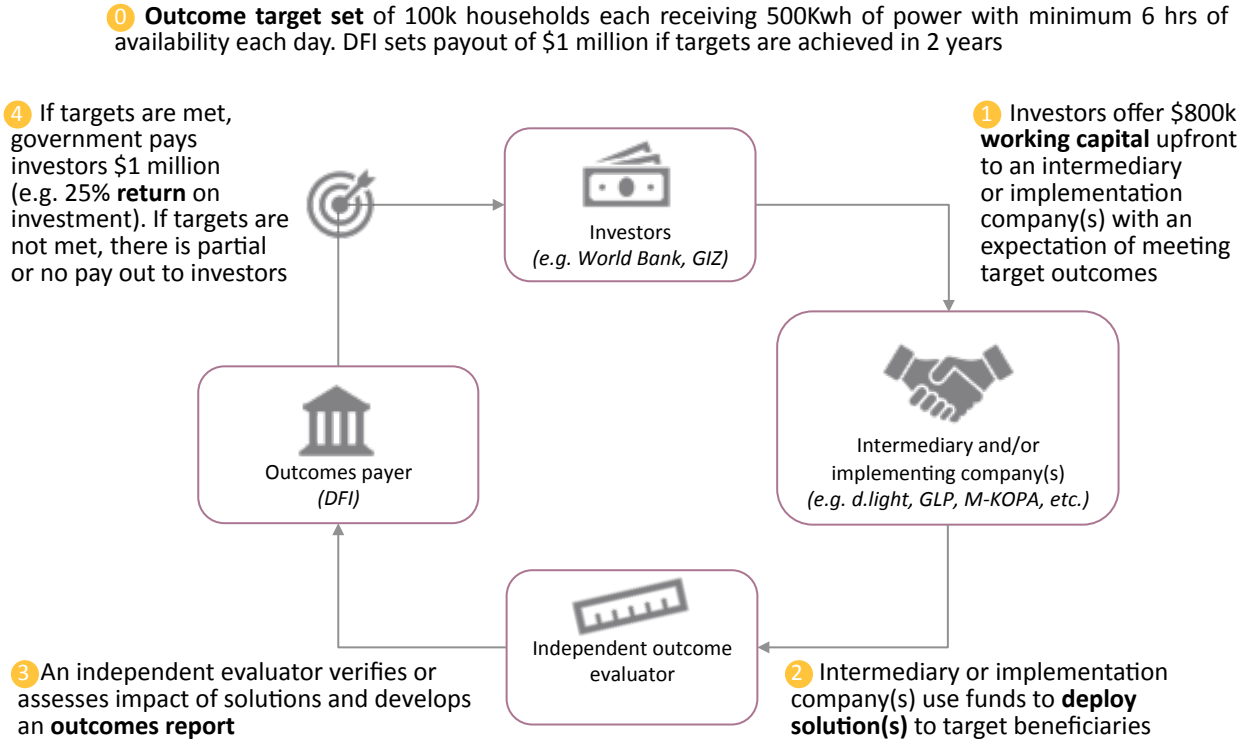
The industry continues to be unable to readily raise funds to finance the riskier parts of its businesses. Grants and concessionary capital are important to bridge these gaps and spur industry development. Multinational organizations, DFIs, family and corporate foundations, and government bodies can play an important role in the following ways:

1. **Funding start-up ventures.** The market for commercial early stage financing in countries where the OGS industry has developed is relatively shallow. However, grants and concessionary finance are key to ensuring that there is a robust bench of second-generation companies joining the market. Several funding organizations have a stated goal of supporting early stage companies. For example, USAID aims to help "early, growth-stage start-ups overcome the challenge of raising capital."[301] However, the on-the-ground reality from interview data suggests that capital for early stage companies is lacking. Further refocusing by some social investors away from the larger companies and back toward smaller and local companies would be a welcome development in this regard.
2. **Driving industry innovation.** Targeted grants to fund product research, geographic expansion, and ecosystem development have brought long-term corporate and industry-wide development that supports the entire OGS sector. For example, the Bill and Melinda Gates Foundation provided grants to support M-KOPA's research and development on new products, and expansion to new geographic areas.[302] Similarly, USAID's grant helped Mobisol to launch SolarHub, a software platform to streamline operations, payments, and logistics. Such grants will continue to help push the industry forward by, for example, de-risking market entry into new or challenging geographies, supporting the product innovation required to explore productive use appliances, or supporting innovation in lending via the use of guarantees.
3. **Making investments targeted toward last-mile segments.** As highlighted in Figure 90, several companies have found distribution to be increasingly challenging as they develop away from their core base of peri-urban communities. Addressing these distribution challenges will be fundamental to reaching last-mile consumers in remote geographies. Grant funding to subsidize the cost of distribution and/or invest in new distribution will be important to reaching these consumers.

   Innovative financing instruments such as results-based financing (RBF) also provide a means to incentivize last-mile reach. RBF mechanisms focus on the effective allocation of risks across outcome payers (e.g. DFIs, development partners, multilateral agencies), investors (including impact investors, DFIs), and service providers (the implementing organizations), and incentivize highly-efficient service delivery. Organizations such as EnDev are already experimenting with raising capital using RBF mechanisms, including through development impact bonds (see Figure 91).

[301] *Source: (Burger, n.d.)*
[302] *Source: (Price, 2016)*

Figure 91: Illustrative structure of a Development Impact Bond, an emerging RBF vehicle



In interviews, several DFIs were enthusiastic about exploring the prospects of results-based financing to incentivize deeper penetration of last-mile customers. Energy access is well suited for the use of RBFs as outcomes are easily verified (e.g. availability of power to a household, of a certain wattage, for a certain period of time). Additionally, the benefits of providing access to energy are well understood and the organizations that can carry out the electrification projects are readily available.

Aggregators bring efficiency: Financial aggregators, whose impact cuts across instruments, will make it easier to raise large sums of capital.

Aggregation is the pooling together of finance, company track record information, and project data into a bundle that reaches a scale attractive to large investors. Financial aggregators such as Sunfunder have been facilitating this process by acting as central coordinators, combining small ticket investors into an investment portfolio that offers scale, lower costs, and—depending on the investment made—diversified risk. Beyond simply bringing together investors, such aggregators develop the bespoke knowledge needed to make smart investments in an industry that is still maturing and which operates in a high-credit risk environment. Through these shared platforms, industry standards can be developed, building transparency across the industry and further encouraging investment.

The emergence, and expected development, of such aggregators is similar to the rise of specialized investment vehicles (SIVs) in the early days of the microfinance industry.[303] At that time, the microfinance industry faced a challenge similar to PAYGO companies in finding appropriate capital providers. SIVs called microfinance investment vehicles (MIVs), which developed specialized expertise in microfinance, were created to provide MFIs with capital ranging from debt to venture capital funding. Currently, MIVs collectively manage over USD 10 billion in capital.[304]

Similar facilities could play a significant role in financing the future development of PAYGO businesses. In fact, there are likely to be opportunities for MIVs to directly invest in PAYGO solar companies as they look for new growth opportunities.[305] This opportunity to pool microfinance investments into the PAYGO sector was noted by a prominent impact investment fund, stating, "We have built strong renewable energy capabilities, which led us to raise our energy access fund two years ago, and we're excited about the opportunities we see in this sector. At the same time, some PAYGO solar companies have similar characteristics as asset-backed financing companies, and those investments could fit into our MFI portfolios as well."[306]

Support beyond funding: Companies will require capacity building to absorb ever-increasing sums of capital.

The ability of companies to effectively absorb the ever-increasing sums of capital is uncertain. Insufficient capabilities would lead to raised funds remaining on the balance sheet unused, or mismanaged. Factors that can help increase the industry's absorptive capacity include:

- *Strong finance teams:* PAYGO companies will need strong finance departments to monitor the quality and risks of their receivables portfolio. As hiring and training of financial expertise can be difficult due to human capital constraints, technical assistance from DFIs could provide important support to companies.
- *A bench of technical managers:* As companies grow, capital deployment will be in the hands of regional managers with allocated budgets. Skilled managers will be vital to the proper use of funds. Interview commentary has pointed to experienced managers being competitively recruited away from existing firms, as businesses have already begun to place a premium on talent.

> "When doing an honest assessment of where there was a greatest need, we landed on providing technical assistance. Many of companies have inexperienced management and would benefit from support to expand their operations."
>
> **- DFI**

[303] *Source: (Sotiriou, Bardouille, Waldron, & Vanzulli, 2018 (forthcoming))*
[304] *Source: (Sotiriou, CGAP, 2017)*
[305] *Source: (Sotiriou, Bardouille, Waldron, & Vanzulli, 2018 (forthcoming))*
[306] *Source: (Sotiriou, Bardouille, Waldron, & Vanzulli, 2018 (forthcoming))*

1E. ENABLING ENVIRONMENT

KEY MESSAGES

- CURRENT LANDSCAPE: The rise in government engagement and pioneering efforts of the global development community are mobilizing OGS to a faster trajectory.
- DRIVERS: Exposure to thriving OGS markets and strong leadership in the international development community has facilitated the rapid integration of OGS into electrification policy.
- CHALLENGES: Not all countries have policies conducive to OGS advancement, and gaps exist at both the regulatory and implementation level.
- EMERGING BEST PRACTICES AND RISKS IN PUBLIC POLICY: The way forward includes integrating OGS into national planning, tax/tariff exemptions, minimal and careful use of subsidies, quality standards, and coordination with the private sector.
- OUTLOOK: Evolving areas for future engagement include consumer protection frameworks, environmental regulation on e-waste, and funding for efficient appliances.

> "Public actors over the last five to eight years have dramatically changed their views on off-grid solar. Today, many countries have put down some clear marker or target for off-grid as a component of government electrification policies."
>
> **- Arthur Itotia Njagi, Lighting Global**

Government engagement in the OGS sector has come a long way in recent years. Awareness of OGS has increased and grid extension is not considered the only path to better energy access. Momentum in this sector is no longer entirely driven by DFI and private sector efforts. This steady rise in government engagement has encouraged the development of sector-enabling policies and regulations, and encouraged DFIs to accelerate the pace of establishing government partnerships and committing funds to OGS. Unfortunately, policy gaps, a lack of coordination between the private and public sectors, and uneven implementation across different markets continue to hold the OGS sector back. The following analysis of key issues and addressable challenges in this emergent industry points the way ahead.

Current landscape: The rise in government engagement and pioneering efforts of the global development community are mobilizing the OGS industry to a faster trajectory.

Significantly, policymakers have shown greater urgency to incorporate OGS into their energy access strategies as a complement to grid and mini-grid approaches. A survey of the Regulatory Indicators for Sustainable Energy (RISE) index provides cross-cutting evidence of this growing government interest. According to RISE, about half of the world's 55 most electricity-deficient countries have by now implemented a national program aimed at supporting OGS.[307] The picture improves if one restricts analysis to 16 "focus" countries (constituting about 70% of the world's off-grid population):[308] 13 of these countries have integrated OGS into their national electrification programs. Pakistan, Nigeria and Senegal are the only focus countries that currently do not have integrated electrification strategies, although Nigeria and Senegal are in the process of exploring these in partnership with the World Bank Group.[309]

Photo credit: Sunna Design

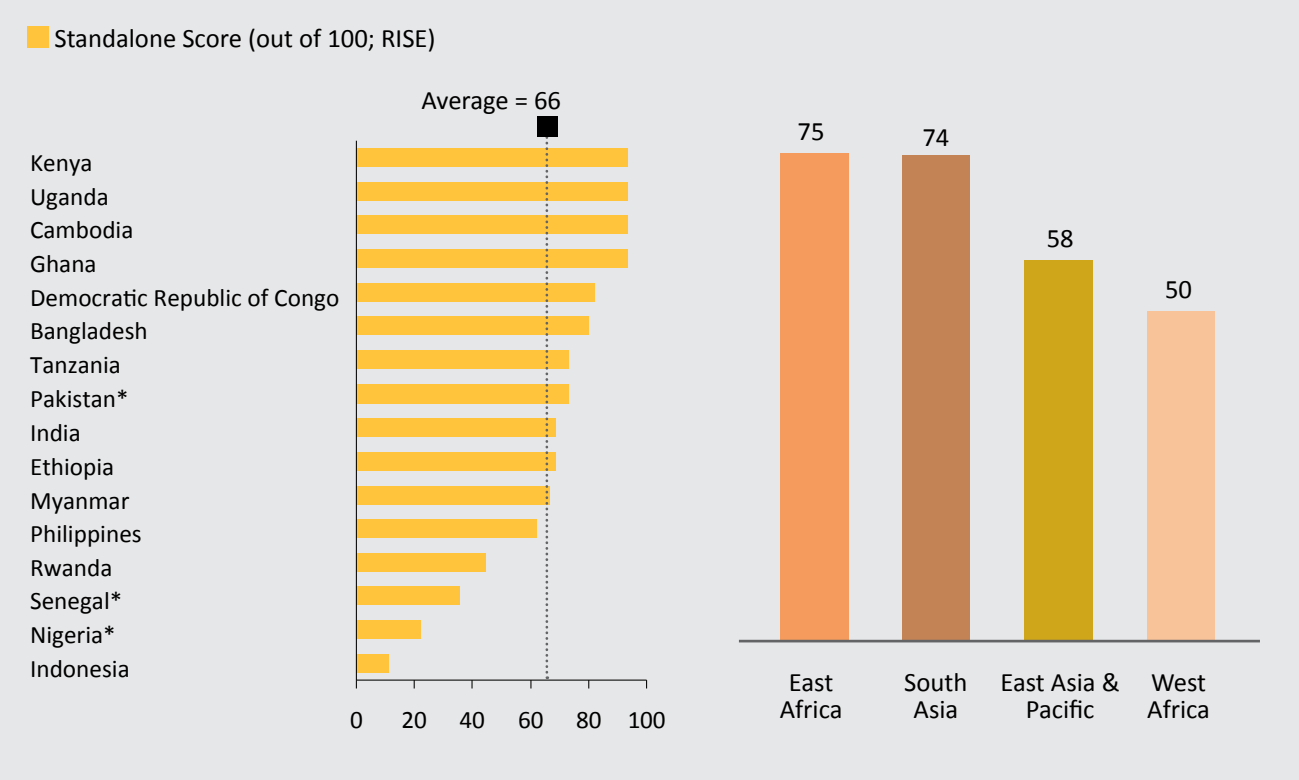
[307]*Note: Based on data collection and benchmarking conducted by the World Bank Group's RISE scores. RISE is a set of indicators to help compare national policy and regulatory frameworks for sustainable energy. It assesses countries' policy and regulatory support for each of the three pillars of sustainable energy: access to modern energy, energy efficiency, and renewable energy. The enabling environment for standalone devices includes the following parameters: (1) the existence of a national program; (2) financial incentives; (3) standards and quality. Source: (ESMAP, 2016); Dalberg analysis*

[308]*Note: Given their weight in terms of unserved populations, these 16 countries together provide a reasonable overview of the global enabling environment for OGS. The 16 countries also represent important existing and emerging OGS markets across Sub-Saharan Africa, South Asia and East Asia. They form the basis of the Dalberg market model forecast in Section 2 of this report. Source: (International Energy Agency, 2017a)*

[309]*Note: Nigeria and Senegal have entered into a partnership with the World Bank Group (via the Regional Off-Grid Electrification Project (ROGEP)), which aims to establish programs and financing in support of OGS. ROGEP was announced in October 2017 and is expected to come online in the next few months*

Figure 92: Assessment of enabling environment for "stand-alone" systems in priority off-grid countries[310]

Regulatory Indicators for Sustainable Energy (RISE) Index scores on environment for "stand-alone" systems (2016)



The increase in government activity has also accelerated the development of a common set of regulations and policies that will prove fundamental to the growth of OGS markets. These building blocks include the following measures, which are in line with the RISE approach:

- An integrated electrification framework with a clear role for OGS (alongside grid and mini-grid approaches), with related plans and targets;
- Fiscal support, preferably in the form of tax exemptions;
- Public financing support for consumers and enterprises;
- Quality standards and certification to promote and scale the use of stand-alone home systems;[311]
- Training, capacity building, and consumer awareness programs.

That being said, the OGS industry is made up of many heterogeneous markets with localized challenges, and policies will be adopted and implemented differently across countries. The manner in which this may pan out is explored in further detail later in this section.

[310] *Note: Countries without integrated national programs marked with (*). Source: (ESMAP, 2016); Dalberg analysis*

[311] *Source: (ESMAP, 2016)*

Drivers: Exposure to thriving OGS markets and strong leadership in the international development community has facilitated the rapid integration of OGS into electrification policy.

Growing exposure to OGS markets has helped stimulate this shift in governments' perspectives. Governments (especially in Sub-Saharan Africa) have seen OGS markets operate successfully within their borders and in neighboring countries and deliver energy access to millions. This has deepened policymaker awareness that OGS markets offer a cheaper, more efficient alternative to grid-based electricity for many, and also lower the burden on limited public resources.

Crucially, these market developments have dovetailed with strong convergence and leadership in the international development community on energy access broadly. Initially, the launch of the Sustainable Energy for All (SEforALL) initiative by the United Nations in 2011 served as a rallying cry for energy access efforts, including government and private sector initiatives globally.[312] Later, a unifying mission was achieved with the endorsement of the Sustainable Development Goals (SDG), including SDG 7 on ensuring "access to affordable, reliable, sustainable and modern energy for all,"[313] and the establishment of the MTF in 2015, which provided a framework to design, implement and track these efforts (see Table 4 for details). These initiatives have not only put developing country governments under pressure to deliver universal access to electricity, but also emphasized that the only way to do so quickly and cost-effectively is to adopt grid and off-grid approaches simultaneously.

Within the broader energy-access agenda, the emphasis on affordability and sustainability has brought the promise of market-driven OGS into sharp focus. This adds impetus and immediacy to the work of initiatives like the World Bank Group's Lighting Global Program, DfID's Energy Africa campaign, USAID's Power Africa Beyond the Grid program, and GIZ's EnDev Program.[314]

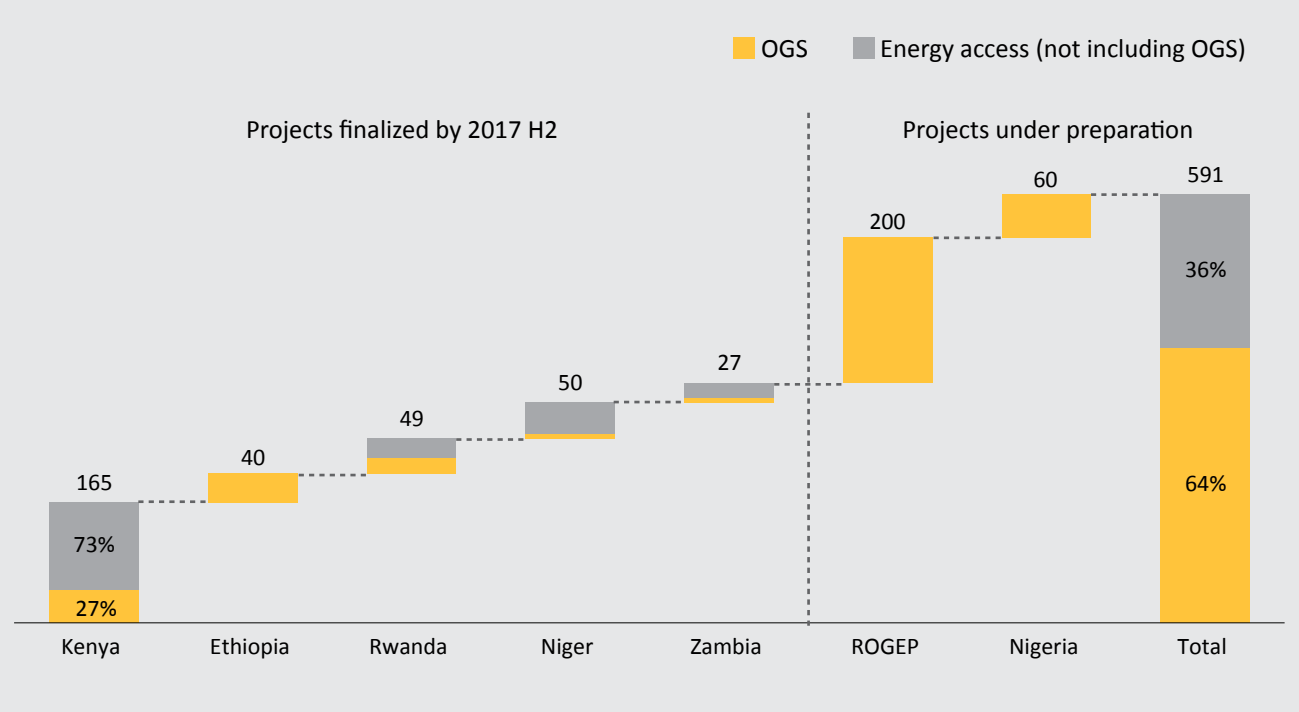
Recently, the combination of these factors and the resulting government interest reached a tipping point, which is reflected in the public financing landscape. More than 25 countries are now engaged in partnerships to build capacity and deploy funding to incentivize the OGS sector. The majority of these comprise bilateral and multilateral funding agreements for broader energy access (inclusive of off-grid solar, mini-grid and grid approaches) between the World Bank and mostly Sub-Saharan African countries. Together these investments total about USD 590 million, with at least 50% available to the standalone or OGS sector, primarily for the local currency needs of OGS companies (some of these funds and programs are already functional whereas others are still in their set-up phase). Given the well-established and growing need for local working capital, these efforts are expected to mobilize the sector back to a faster trajectory.

Figure 93 demonstrates how this USD 590 million is distributed across countries and regions. The USD 200 million earmarked for the Regional Off-Grid Electrification Project (ROGEP) is especially noteworthy because it focuses on West African countries that have previously lagged behind their East African counterparts in terms of conduciveness for OGS.

[312] *Source: (SEforAll, 2017a)*
[313] *Source: (UNDP, 2016)*
[314] *Source: Interviews with program staff*

Figure 93: World Bank projects with Sub-Saharan governments for energy access, including OGS[315]

USD millions (2017 onwards)



Challenges: Not all countries have policies conducive to OGS advancement, and gaps exist at both the regulatory and implementation level.

While policy-related progress has been encouraging, as seen in the growth of the sector and the increase in government involvement, there remains much room for improvement.

1. The framing and prioritization of the OGS sector needs further definition and clarification in most countries. As noted earlier in this section, at least half of the world's most energy deficient countries are yet to commit to integrating OGS into their electrification strategies and planning. Those with large off-grid populations include Nigeria and Pakistan. The goal of universal access will not be achieved in the foreseeable future until OGS policy coverage is extended to all off-grid regions and countries.

Other country governments have not adequately prioritized the sector. Most countries with OGS-enabling policies continue to almost solely focus on the grid. Many consider OGS only as a last-mile channel, to be applied where the grid cannot reach over the long-term. In some cases, they are reluctant to provide support that could help OGS operators in areas near the existing grid and unreliable-grid areas, thus confining them to segments that are not commercially viable or scalable. Interviews with sector stakeholders (companies, investors and relevant DFIs) in India and Tanzania, for example, have indicated that government funding and capacity in both countries are earmarked almost entirely for grid-based capacity development and improvement of the grid's transmission and distribution network. In India, the Jawaharlal Nehru National Solar Mission (JNNSM), which was established to promote adoption of solar energy in India, has been criticized "for being skewed toward

[315]Note: ROGEP stands for the Regional Off Grid Electrification Project to support Off Grid Electrification in West Africa. The OGS specific amount for Rwanda has been estimated based on a total figure of USD 49 million, of which USD 44 million has been allocated to mini-grids and OGS devices. It has been assumed that 50% of the allocation for mini-grids and OGS is for OGS support. Source: World Bank

grid-connected, large-scale solar energy applications; underrating the potential of small applications, scale and method of allocation of funds."[316] Only 7% of the total program budget was allocated toward off-grid solar applications.[317] Similarly, in Tanzania, 90% of the USD 1.3 billion funding for the National Rural Electrification Program (NREP 2013-2022), is reserved for on-grid investments.

At a global level, SEforALL estimates that of the USD 19.4 billion committed on average annually in 2013-2014 for electrification in the 20 largest off-grid markets, only one percent, or about USD 200 million, was dedicated to support decentralized solutions including OGS and mini-grids.[318] SEforALL notes that this is concerning, given the sector's "enormous promise to provide basic electricity services quickly and at significantly lower costs."[319]

Moreover, the off-grid and mini-grid sectors are often clubbed together in the minds of government actors when they are quite different, especially in the type of regulatory support they require.[320] Mini-grid operators resemble large-scale utility players, and as such may need direct subsidies to be able to scale. OGS companies, on the other hand, are best served by mechanisms that allow markets to take off and scale, such as import tariff and tax exemptions on products, consumer awareness support, and adoption of quality standards. This bundled view may hinder efficient implementation of policies. Often, the same governing agency is put in charge of both sectors, despite differing needs. However, as interest and activity in the sector grows, it will be important to disentangle the two sectors for planning and execution purposes.

2. The policy and regulatory landscape lacks uniformity. Certain countries are lagging and key policy gaps exist across countries. Table 11 reveals the uneven regulatory environment across focus countries. Five countries, including Kenya, Uganda, Ghana, DRC and the Philippines, have most of the basic OGS-enabling policies in place. All other countries lack at least two or more basic enabling policies. Countries from East Africa score particularly well, with Ethiopia being the outlier. South Asian countries lag, which is a concern given the region's large share of the potential market. Nigeria has the most underdeveloped OGS-enabling environment among the focus countries, reflecting its status as a relatively nascent OGS market. Positively, however, the Nigerian government has recognized the potential of OGS and solar mini-grids. It is in partnership with multilateral development agencies—notably GIZ and the World Bank Group—and it is in the process of developing support frameworks, certifications, and skills-building programs that could accelerate markets.[321]

Photo credit: NIWA (Ti el Attar)

[316]*Source: (Sravanthi, 2013)*

[317]*Source: (Sravanthi, 2013)*

[318]*Note: Since 2013-2014, when data on the USD 200 million in OGS investments was collected, investments in OGS have picked up considerably (see Section 1D). However, they remain marginal relative to investments in on-grid infrastructure. Source: (SEforALL, 2017c)*

[319]*Source: (SEforALL, 2017c)*

[320]*Source: Industry interviews*

[321]*Source: (Mama, 2017)*

Table 11: Summary of key policy indicators for off-grid solar across priority energy-poor countries[322]

Countries[323]	National program promoting pico/ SHS	Duty/tariff exemptions (whole system)	Minimum standards[324]	Government training/ certification	Overall[325]
Kenya	Yes	No	Yes*	Yes	
Uganda	Yes	No	Yes	Yes	
Ghana	Yes	No	Yes	Yes	
DRC	Yes	Yes	Yes	No	
Philippines	Yes	Yes	Yes	No	
Tanzania	Yes	No	Yes*	Yes	
Cambodia	Yes	No	Yes	No	
Ethiopia	Yes	No	Yes*	No	
Bangladesh	Yes	No[326]	Yes	No	
India	Yes	No	Yes	No	
Rwanda	Yes	No	Yes*	No	
Senegal	No	Yes	No	No	
Myanmar	Yes	No	No	No	
Pakistan	No	No	Yes	No	
Indonesia	Yes	No	No	No	
Nigeria	No	No	No	No	

3. Important policies are lacking across several priority energy-poor countries, as shown in Figure 94. Governments are doing better in areas related to establishing financing mechanisms and adopting international standards. However, at least 80% currently do not have duty and tariff exemptions.[327]

About 75% of the focus countries lack relevant training and capacity-building programs on OGS. Only four countries (Kenya, Uganda, Tanzania and Ghana) have established these. In Kenya for example, the Energy Regulatory Commission (ERC), in conjunction with the National Industrial Training Authority, instituted the Solar Photovoltaics Systems Regulations (since 2012), which mandated relevant training and certification for all persons designing and installing solar PV systems (from pico to utility scale). The project, which was co-funded by USAID, helped train close to 2,000 technicians as of 2016 H2.

[322]Source: (ESMAP, 2016); Dalberg analysis

[323] Note: Figure includes top 10 potential markets and select other countries. Source: (International Energy Agency, 2016)

[324]Note: Starred countries (*) have harmonized national standards with Lighting Global Quality Standards for pico-solar products based on testing to IEC Technical Specification 62257-9-5. In addition, there are at least three countries in Africa and Asia that are in the process of adopting standards that are harmonized with Lighting Global Quality Standards. Source: IFC staff interviews

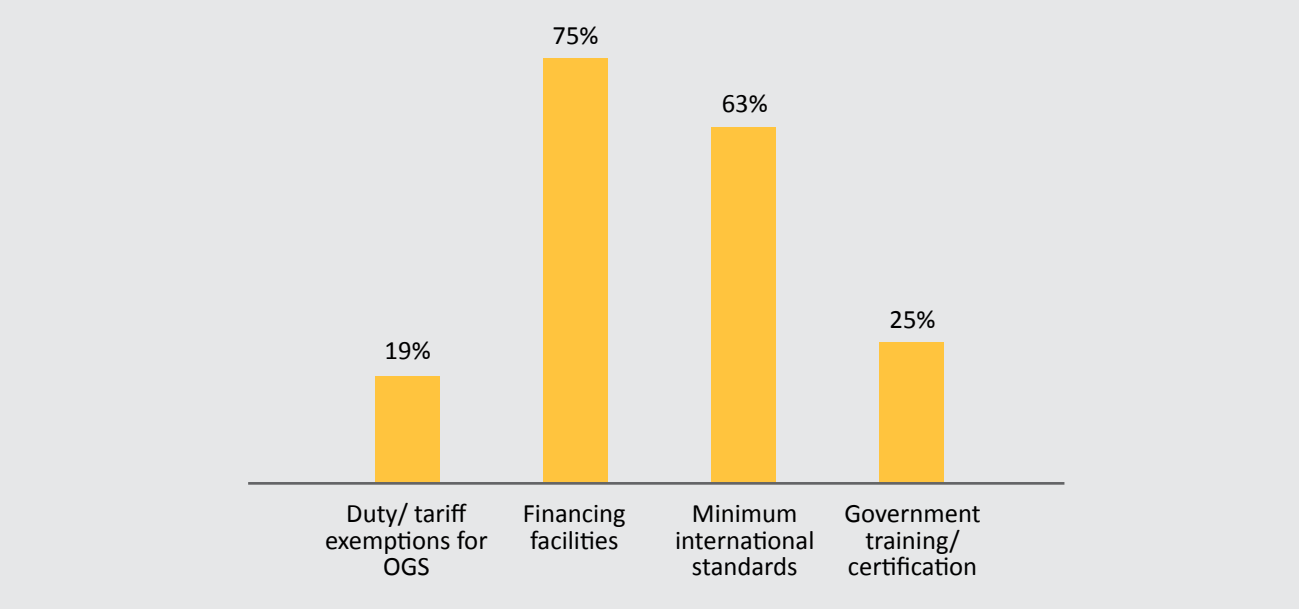
[325]Note: Rating synthesized on the basis of the presence of the four key OGS enabling policies as shown in the table

[326]Note: The Government of Bangladesh is considering the imposition of import taxes on SHS and PVs of 26% and 35% respectively; however, these have been put on hold currently, and the favorable tax regime is expected to continue for the next 12 to 18 months or more. Source: Industry interviews

[327]Note: See Figure 94. Source (ESMAP, 2016); Dalberg analysis

Figure 94: Share of the priority countries adopting enabling policies for stand-alone systems[328]

% of top 15 electricity-poor countries (2016)



4. Limited enforcement capacity and/or poor enforcement have impeded progress, even in countries that have conducive policies for OGS. Key enforcement-related obstacles have come up repeatedly in the past several years. These include a lack of clarity and transparency on plans and targets (including grid-electrification plans), poor state- or district-level coordination and enforcement, and the lack of robust data-collection and reporting on OGS sales and usage to inform decision-making. As such, it is not surprising that these challenges would impact OGS market growth adversely.

In Ethiopia, in spite of active government encouragement of OGS, the lack of coordinated policy and poor planning and enforcement resulted in significant and avoidable failures. The Ethiopian government actively promotes a private-sector based approach to off-grid solar through its Electricity Network Reinforcement and Expansion Project (ENREP), a World Bank-funded, USD 40 million working-capacity facility.[329] The government also implements a national quality certification program for OGS products, with support and technical assistance from Lighting Africa. The Ethiopian Standards Agency (ESA) mandated the development of independent quality standards for OGS products, which was both unnecessary and inefficient given that established standards already existed (e.g. International Electrotechnical Commission Technical Specification 62257-9-5).[330] At the same time, these standards were imposed without adequate investment in product-testing capacity and coordination between national and local administrators.[331] This caused significant delays for companies seeking quality approvals, while a large number of sub-standard products (especially in higher-wattage categories) entered the country.[332] This is reflected in the most recent market research from the country, which indicates

[328]*Source: (ESMAP, 2016); Dalberg analysis*

[329]*Source: (World Bank, 2016b)*

[330]*Source: Ethiopian Standards Agency (2017); industry interviews*

[331]*Source: Interviews with Lighting Africa.*

[332]*Source: Industry interviews*

that non-quality verified products accounted for 57% of pico volumes.[333] It should be noted that the Lighting Global program and Ethiopian government partners have recognized this issue and have taken active steps to mitigate it. These include organizing training and capacity building workshops with officials, and strengthening monitoring and evaluation channels.[334]

In Tanzania, there are regulations on solar energy standards, as well as mandated pre-verification of solar shipments. However, these apply to traditional home solar arrays and often prove ineffective for pico devices and plug-and-play SHS.[335] In some cases, due to poor coordination capacity, shipments of quality products were stopped, while low quality products entered the country. Evidence from Lighting Africa market surveys demonstrates the ensuing effects on a national scale: non-quality verified products accounted for 72% of pico and 57% of PnP SHS products being sold across the country in 2017.[336] One interviewee raised concerns that local enforcement has proven to be the biggest bottleneck.[337]

Emerging best practices and risks: The way forward for public policy in the OGS industry.

As governments become more active stakeholders in developing OGS markets, an improved understanding has emerged regarding the most appropriate ways for them to engage as well as the conditions needed for success. Key public policy influences to spur OGS growth include the following:

1. Integrating OGS into national electrification plans and targets is crucial. Having a defined view on the right mix of grid, mini-grid, and off-grid solutions needed to achieve universal electrification is a critical step. In addition, efforts to integrate off-grid solar into electrification plans should consider the changing role and capacity of grid and off-grid technologies over time to reach under-served populations, e.g. potentially viewing off-grid solutions as a form of pre-electrification, even for households that may eventually be reached by the grid. This kind of planning can serve as the basis for establishing targets and developing other support mechanisms that do not leave any sector behind. Clear guidance and regulations will help push private-sector engagement by providing a strong license to operate, and by creating confidence about the governments' intentions and commitments.[338]

Establishing targets is not enough. Each approach to electrification will require customized policy and regulatory support to flourish. For the OGS industry, this is likely to include several measures. Some, such as national programs, fiscal incentives, training and recruitment programs, quality and environmental standards and certification, are discussed earlier in this section. Others, such as allowing companies freedom and flexibility to determine price-points, consumer awareness campaigns, and financing mechanisms for firms and consumers are also relevant.[339]

Establishing and incorporating robust monitoring and evaluation approaches is essential to integrated electrification policies and planning. This can feed into several key processes including setting baselines and targets, tracking progress toward energy access targets, and informing further decision-making. Governments can now adapt and use the World Bank's/SEforALL's MTF for this purpose.[340]

[333]*Source: (Ipsos, 2016b)*
[334]*Source: Industry interviews*
[335]*Source: Industry interview; desk research.*
[336]*Source: (Ipsos, 2017)*
[337]*Source: Industry interviews*
[338]*Source: (GOGLA, 2017); industry interviews*
[339]*Note: These are based on and aligned with recommendations developed by RISE, and a comprehensive OGS policy review conducted by GOGLA in 2017*
[340]*Source: (GOGLA, 2017); industry interviews*

Finally, coordinating across other sectors will help identify opportunities for off-grid electrification, such as the need for electrification of village schools, or the use of solar water pumps in agriculture. This can help widen the public funding pool, and ensure that redundancies and overlaps across programs are minimized.[341]

2. Tax and tariff exemptions have proven to be effective instruments to encourage market growth. Governments should acknowledge that, as noted by GOGLA, "temporary or permanent removal of VAT and tariffs – covering the entire product, including any appliances – is one of the most effective ways for governments to support the growth of the standalone solar market, improving affordability, boosting uptake and accelerating energy access." Exemptions increase the competitiveness of OGS companies as savings—which can be as high as 40% of the FOB price[342]—are in turn, passed on to consumers to drive affordability and sales. To demonstrate that prices matter, a study in Kenya found that reducing the price of a solar lamp from USD 7 to USD 4 increased household uptake from 37% to 69%.[343] As touched upon earlier in this section, in the past, tax and tariff exemptions have been especially successful in East African countries, including Kenya, Tanzania, Uganda and Rwanda, in driving significant market growth.[344]

Beyond driving sales within a country, tax and tariff exemptions may also have a long-term positive effect on public finances, although more detailed research is needed on this front. One study in Mozambique found that standalone solar market growth would increase business taxes over a ten-year period. It would enable businesses to stay open longer, increase productivity as a result of improved health, and create jobs in the supply chain.[345]

3. End-user subsidies should be minimized and, if necessary, applied carefully so as not to distort pricing signals. These subsidies may enable governments to scale distribution in the short term; unfortunately, they are burdensome to government finances due to their complexity (even when the subsidy levels themselves are low) and they generally distort the market. More than half of the focus countries currently include whole-system subsidies as part of their OGS support programs. These range from free or highly subsidized systems in countries like Myanmar to smaller subsidy rates in countries like Bangladesh and India. These products are often distributed in areas where OGS companies would operate, which dampens demand and spoils the market. As is noted by GOGLA in their guidance to governments, "While there may be short-term benefit for selected users, longer-term adoption of stand-alone solar is likely to be reduced, and could be reversed, if market distortion is not carefully minimized."[346] Ironically, end-user subsidies could have an opposite effect than intended, elongating the timeline for achieving energy access and increasing costs.

There is no denying that special assistance is likely to be needed in most countries to extend energy access to remote and/or low-income populations. Yet, it is important to design the assistance in a self-sustaining way that prioritizes market-based delivery.[347] There are three easily defined ways for governments to accomplish this.

- *Proper identification and targeting of in-need segments:* Using a combination of geospatial analysis and the MTF framework, governments can now segment and map their populations effectively according to their energy access needs.[348] In addition, governments can also leverage existing social programs that already pre-identify the "poor" to target subsidies, e.g. in the form of vouchers or cash

[341]*Source: (SEforALL, 2017c)*
[342]*Source: (GOGLA, 2017)*
[343]*Source: (GOGLA, 2017); (Rom, Gunther, & Harrison, 2017)*
[344]*Source: (GOGLA, 2017)*
[345]*Source: (GOGLA, 2017)*
[346]*Source: (GOGLA, 2017)*
[347]*Source: (USAID Power For All, 2016)*
[348]*Note: The Tanzania Energy Access Maps developed by the World Resource Institute provides an apt example of this, layering geospatial data on electrification and socioeconomic indicators to inform investment in off-grid solutions. Source: (World Resources Institute, 2017b)*

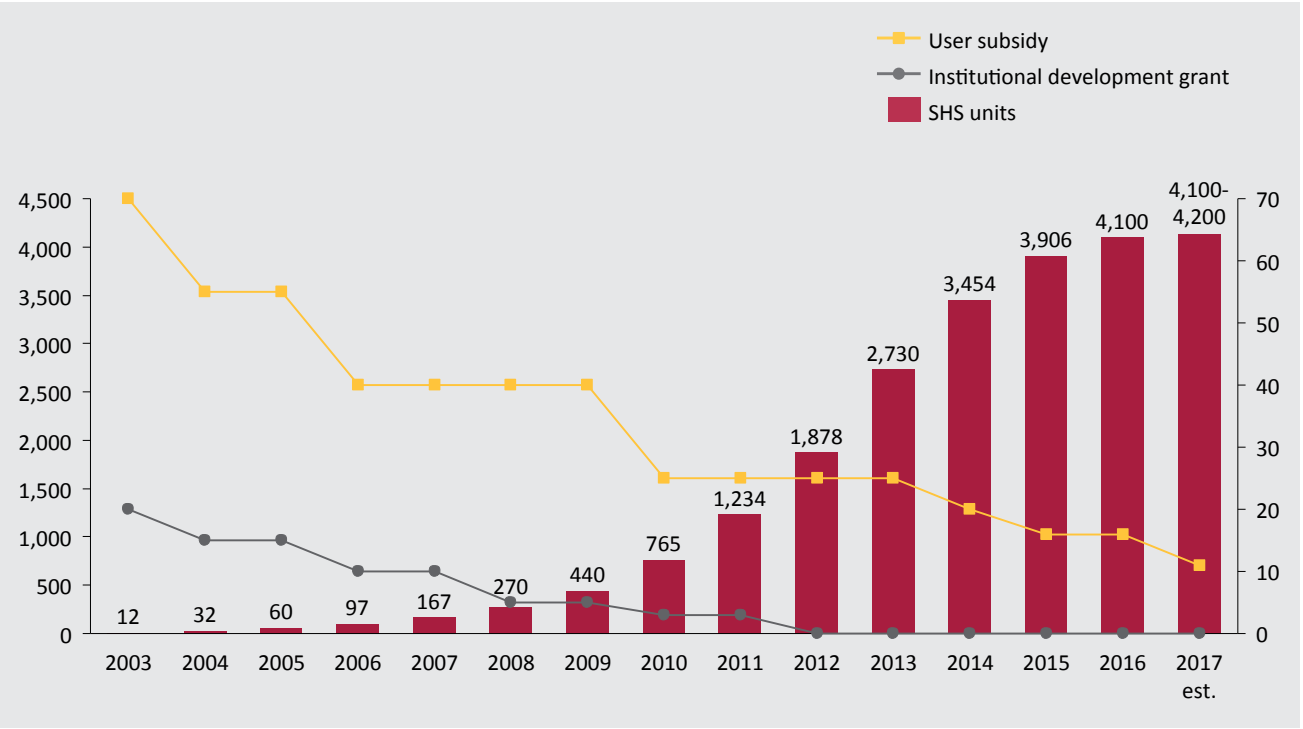
transfers. Investments in monitoring and evaluation, as EnDev has done, are also important to ensure accountability.

- *Design principles should champion the least distortion to OGS markets* and define a clear exit strategy for the government in a way that does not shock the commercial market. This can be done in a variety of ways, including designing a system of cascading subsidies so that over the long-term market prices prevail. Alternatively, innovative approaches can be employed, such as results-based-financing mechanisms (e.g. development impact bonds) that focus on incentivizing the private sector to service last mile segments.
- *Program design and delivery should coordinate* with the private sector: Scale will only be reached if private companies are successful. As noted above, governments are increasingly recognizing this reality and engaging private companies as their vehicle for achieving the policy objective of energy access. Therefore, any government engagement should be undertaken in consultation with the companies.

Successful government assistance programs have used a combination of these practices to achieve their goals. For example, the Kenyan government consulted extensively with the private sector before designing the Kenya Off-Grid Solar Access Project for Underserved Counties (K-OSAP) program. The K-OSAP program provides debt and results-based financing to companies that agree to enter specific, under-served regions of the country.[349]

Bangladesh took a different route in its IDCOL program, which has successfully distributed more than four million SHS since 2003. IDCOL deployed a set of progressive subsidies whereby smaller systems that are more affordable to the poorest populations received a higher subsidy relative to larger systems. In addition, to encourage a transition toward a commercially oriented SHS market in the country, the subsidy elements and the concessional rates of IDCOL's refinancing program have gradually been reduced.

Figure 95: Annual IDCOL SHS installation and phased-out subsidies per unit[350]
Left axis: SHS units, thousands; Right axis: grants and subsidies, USD/unit (2003-17)



[349]*Source: : (GOGLA, 2017)*
[350]*Source: (ADB, 2015); (Quddus, 2015); industry interviews; Dalberg analysis*

However, it should be noted that the IDCOL program has recently faced a slew of challenges due to market spoilage and competition from another government distribution program, "Kabhika," which provides free SHS. The lack of coordination between IDCOL and Kabhika meant that free SHS were distributed in areas under IDCOL coverage, which inevitably had a negative impact on both repayments from existing IDCOL customers, as well as new sales.[351] This is a prime example of how good intentions and best practices can quickly be rendered ineffective due to poor enforcement and coordination.

4. Quality standards must be applied in a consistent and coordinated manner, and be supported by capacity-building and training to be effective. As shown in the example from Ethiopia above, by creating a distinct local standard rather than adopting established international standards (e.g. the Lighting Global standards), and by requiring local testing rather than accepting testing and verification conducted by other countries/ organizations, the government created substantial additional costs for itself. In addition, since local testing capacity itself was under-developed, companies that sought to play by the rules were hurt, while poor-quality products flew under the radar, which in turn damaged consumer perceptions.

Governments should collaborate and coordinate with relevant international efforts and other governments to leverage existing testing norms, testing capacity, and platforms before expending scarce resources on developing and implementing independent standards. Instead, as noted by GOGLA, "it is cheaper and more efficient to conduct testing through [accredited] test laboratories around the world."[352] Further, governments can also incrementally build capacity by staggering the adoption of quality standards by incorporating them into sector support programs, including private-sector financing initiatives and consumer awareness drives.[353] Development partners and the private sector can provide important support to governments in this regard.

5. Indirect subsidies should be used to provide public goods that can help stimulate markets in a non-distortionary manner. These may include building awareness among consumers, providing key market intelligence and data to investors and companies, supporting enabling platforms such as industry associations. Especially in the early stages of market creation and development, targeted government support to build and establish consumer awareness and trust in the OGS product category would be welcome to private-sector entities, who rarely have the resources to do so independently. When combined with a strong view on quality and standards, these programs also help achieve the twin objective of protecting consumers from poor-quality products. As noted by GOGLA, "government support can ensure consumers are educated about the benefits of solar, how to use it, and where to buy quality products. Similarly, they can reach out to retailers and distributors, educating them about the benefits of working with quality products."[354] For example, Kenya, which is the most mature market in Africa for OGS products today, benefitted significantly from early consumer awareness campaigns first implemented by Lighting Africa and SunnyMoney. Lighting Africa's campaign methods ranged from roadshows and product demonstrations to mass media campaigns which included quality-verified products embedded into TV programs, radio talk shows, and a Christmas campaign across print and TV that reached over 29 million Kenyans.

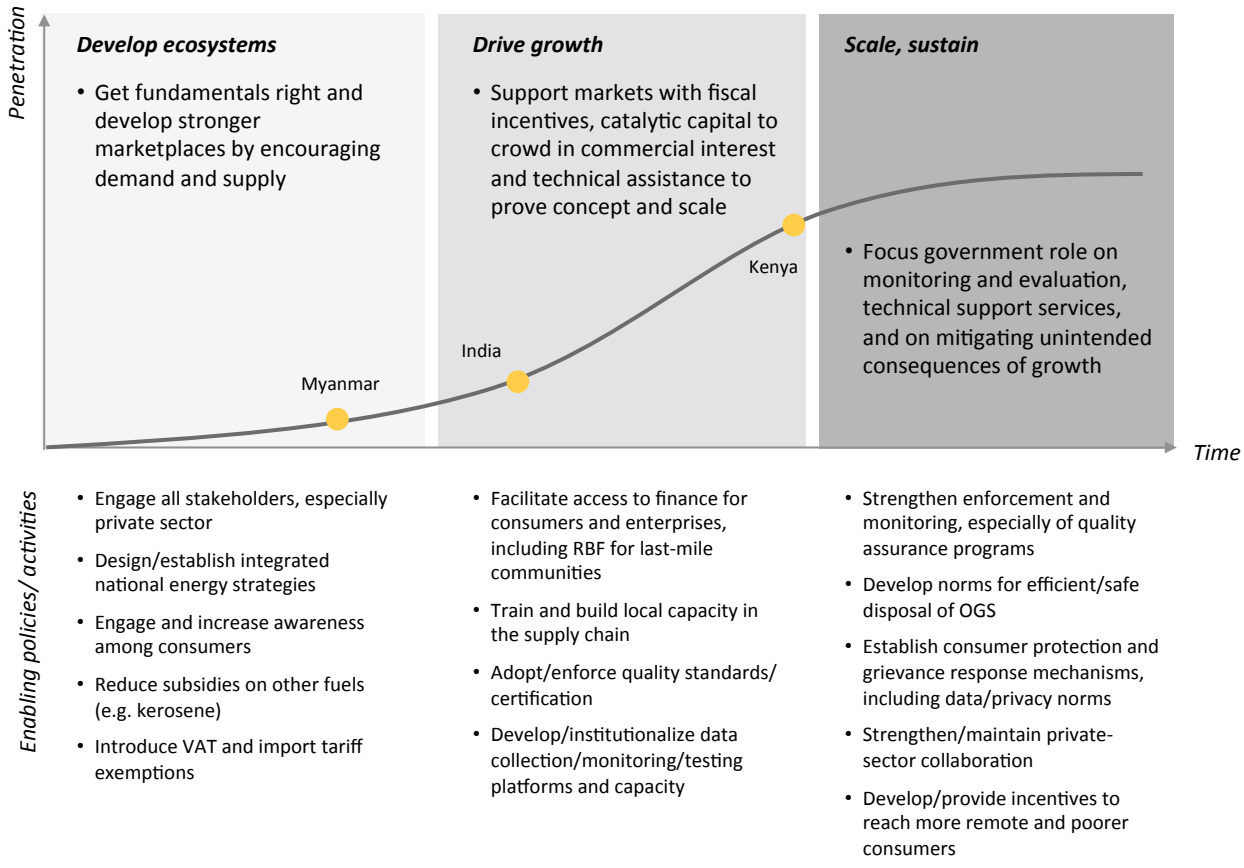
These "public goods" also carry low risk of market distortion; according to GOGLA, they focus on reducing "upstream" risks and costs for businesses without undermining "downstream" consumer price expectations and willingness to pay in the way that end-user subsidies might do so in a commercial market.[355]

[351] *Source: Interviews with IDCOL and GOGLA*
[352] *Source: (GOGLA, 2017)*
[353] *Source: (GOGLA, 2017)*
[354] *Source: (GOGLA, 2017)*
[355] *Source: (GOGLA, 2017)*

6. Coordination and communication with the private sector must be maintained. This is necessary to design and properly implement a sustainable enabling environment for OGS. The lessons discussed above demonstrate that public sector efforts to develop OGS market capacity and create energy access impact have the most chance of succeeding when they "grow in a natural way in conjunction with the market."[356] Thus, governments need private sector inputs on the design and potential impact of upcoming policies and to collect key market intelligence and data. At the same time, companies can use the platform to discuss their challenges, as well as make a case for the support they need at various stages of market growth.[357]

There is no definitive and universal checklist that governments can follow yet. However, the past 8-10 years have provided an illustration of the evolving nature of public support that has allowed OGS to develop in certain markets. These are encapsulated in Figure 96.

Figure 96: Long term evolution of policy and regulatory support for OGS markets *(Illustrative)*



[356] *Source: (UNEP and GOGLA, 2015)*
[357] *Source: (GOGLA, 2017)*

It is important to note that most market players highlight policy uncertainty as worse for the market than a lack of sector-enabling policies. While businesses can operate, and sometimes even flourish, in a policy vacuum (especially if a market is in its initial stages), companies are reluctant to engage and invest in a country if the policy environment is constantly in flux and if they perceive that enforcement is lacking. The relative stability of the policy and business environment in place in East Africa was the region's main point of attraction for private sector players and helped catalyze later market growth. Unfortunately, the recent changes in the import duty regime has led to policy volatility, especially in Tanzania: taxation levels vary from county to county and from consignment to consignment, undermining predictability and companies' ability to plan significantly.

Outlook: Evolving areas for future engagement include linkages with other sectors, consumer protection frameworks, environmental regulation on e-waste, and funding for efficient appliances.

Alongside these lessons, newer areas of government engagement and regulation are emerging as the sector grows.

- **Linkages across sectors should be built.** As discussed in Section 1C.3, the PAYGO SHS segment by nature spans beyond energy access, touching upon telecom, finance, and agriculture (through productive use appliances). Many countries today are missing the enabling environment that existed in East Africa and allowed PAYGO to thrive. Governments today need to think not only of their energy policies, but enabling policies in their telecom sector (to boost mobile money or similar platforms) and finance sector (to enable and regulate the leasing aspects of PAYGO), as these aspects are key determinants for where the market may move next.
- **Consumer protection frameworks should be developed.** As OGS markets grow, consumer protection frameworks and laws need to be established and adopted in order to protect customers from misleading marketing and poor-quality goods, and to hold OGS providers accountable. These will include a combination of quality standards and performance testing mechanisms, as well as ways to test and report "truth-in-advertising" and marketing. Some governments, particularly in East Africa (e.g. Kenya, Uganda and Ethiopia) have led the way by adopting Lighting Global's proposed framework and methods for quality testing that includes five dimensions, including truth-in-advertising, durability, system quality, lumen maintenance, and warranty.[358] Ensuring compliance will require private sector partnerships, especially with local supply-chain actors, as well as a direct line of communication with end users.

  Given the nascent state of the business model, several policy implications of PAYGO operations remain unclear. Three potential scenarios that could lead to bad consumer experience include PAYGO providers not offering appropriate after-sales services, a company going bankrupt before the customer finalizes payments, or customer data not treated responsibly. As of now, the interests of leading companies and their investors provide sufficient incentives to address this risk adequately within the industry. As this sector evolves, the industry will need to establish best practices and guidelines to ensure consumer protection when the sector scales. Policymakers and industry associations should keep an eye on how the sector is developing to identify potential consumer protection risks early on, and jointly find ways to address these while avoiding heavy-handed regulation. Any policy measure directed at PAYGO should recognize the range of unique business models employed by PAYGO providers.

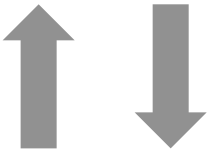
[358] *Source: (GOGLA, 2017)*

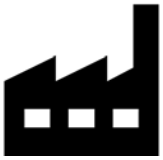
- **Establishing environmental regulations and standards for disposal will become important.** Even among the focus countries, about two-thirds are yet to develop necessary environmental regulations and standards for the sustainable disposal of off-grid solar devices (Bangladesh, Democratic Republic of Congo, Tanzania, and Kenya are the exceptions). It should be noted that even in aggregate, the industry's current e-waste contribution is minuscule: a DFID study noted in 2016 that "standalone solar makes an 'almost negligible' contribution to e-waste as a whole, providing less than 0.5% of total volumes generated."[359] As volumes increase between 2016 and 2020, however, e-waste generated by off-grid solar products is expected to double.[360] Thus, it will be important for government and industry players to pro-actively collaborate to share data, develop frameworks, build monitoring capacity, and provide relevant support to ensure effective disposal systems.

Figure 97: Areas for government and private sector efforts and partnerships regarding OGS device disposal[361]

Governments

- **Enact clear policies and regulations that are coordinated with multiple ministries,** for example between the energy, telecoms and environment departments.
- **Create local level implementation mechanisms,** enabling local authorities to enact bylaws ensuring that e-waste is separated from general solid waste at the point of collection.
- **Upgrade local collection recycling efforts** through technical assistance and investment promotion; in particular not only focusing on collection and dismantling activities, but also developing local markets for other actions.





Suppliers

- **Form partnerships with other sectors and industries,** for example, partnerships with OEMs, telecom operators, software majors, etc. in order to share cost of proper collection and disposal, awareness creation, and data collection.
- **Engage in partnerships along the supply chain** with local distributors of solar products and other channel partners to coordinate the setup of collections and take-back logistics, so that consumers can benefit from easier access to convenient disposal options.
- **Build consumer awareness** and continue consumer engagement to encourage consumers to properly dispose of OGS products by introducing incentives, like exchange offers and upgrades.

- **Funding for efficient DC appliances is needed to unleash latent demand.** To date, significant funding has gone into the research for commonly-used and desired appliances such as fans and TVs. As a result, these appliances have seen efficiency levels climb, facilitating their deployment and use with SHS devices. TVs, in particular, are expected to be fairly universally deployed alongside SHS in the coming years (discussed further in Section 2).

  However, there remains a significant need for further research and development (R&D) funding for a range of applications that are more energy intensive, pertaining to higher-order household needs such as refrigeration, heating and cooling, as well as productive (income-generating) uses including agriculture, food-processing, and small-scale engineering. Currently, these applications consume too much power to be

[359] *Source: (GOGLA, 2017)*
[360] *Source: (Department for International Development, 2016)*
[361] *Source: (GOGLA, 2017), (Department for International Development, 2016)*

bundled with PnP SHS in a cost-effective and affordable manner. While larger systems (with larger panels) are expected to reduce in price by 2020, performance improvements and price reductions will be required to enable large appliances' use with the smaller panels and batteries of PnP SHS.[362] What complicates the issue is that while demand for fans and TVs is fairly ubiquitous across regions and countries, the higher-order energy needs tend to vary based on local conditions, customs and preferences. For example, a sewing machine may be popular in Myanmar, but not in some African countries. Even within a country, a cassava grinder may be popular in one region but not in another. As a result, customized research will be necessary, and government leadership in defining and supporting such research will be imperative.

While the international development community has spearheaded efforts to help the emergent OGS sector reach its potential of promising energy access to all, the space has been transformed by the steady increase in government involvement. As this vast and diverse market evolves, it has become necessary to develop strong, unified frameworks and cooperative partnerships. Mapping out the features of this market, and addressing them through well-defined, coordinated, and uniformly implemented policies is the most urgent challenge for governments, and they can also substantially support private sector initiatives in this area. What's more, robust, well-integrated guidelines must be in place to allow governments to manage the risks that emerge with newer technologies, as well as to pass on the benefits to the population at large.

[362] *Source: (GOGLA, 2017)*

1F. IMPACT

KEY MESSAGES

- WIDESPREAD IMPACT: The OGS industry has had profound impact on energy access globally, as well as on economic, health, and social outcomes.
- UNTAPPED OPPORTUNITY: The proliferation of e-waste presents an opportunity for the industry to amplify its positive environmental impact through investing in proper waste disposal.
- METRICS OUTLOOK: Going forward, impact on OGS-related metrics will increase, but further research is required to develop a framework that fully captures the breadth of impact at an industry-level.

> “If you’d told me that solar would be more in use than kerosene, or that kerosene hurricane lamps would be phased out, I would have told you you’re crazy. But it’s happening.”
>
> **- Donor**

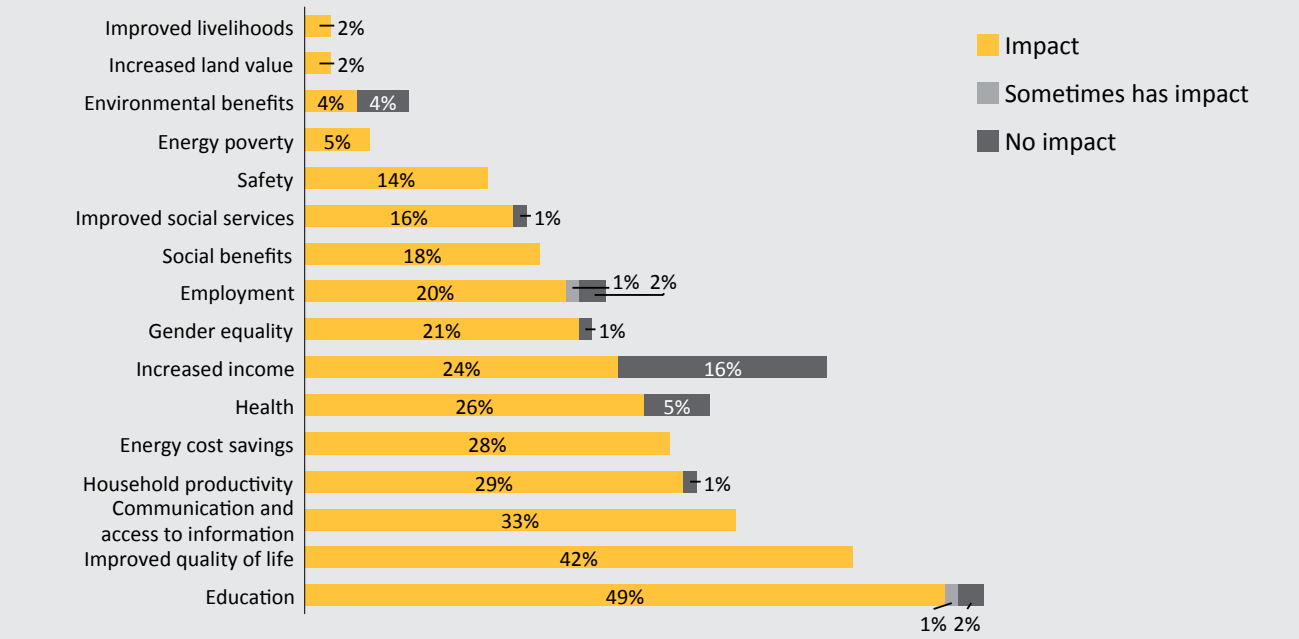
1F.1 OVERVIEW AND METHODOLOGY

This section lays out the breadth and depth of the impact created by OGS devices. Most directly, OGS products improve energy access at a household level. This service, in turn, impacts the economic, educational, physical, social and environmental well-bring of the household as well as of the local community and economy. At the same time, it is important to note that some benefits are yet to be fully established (such as on health, economic outcomes, and education) due to either a lack of existing research, or the research showing mixed results. Moreover, in some cases (such as education), outcomes are indirect, and affected by many other factors, with access to lighting just being one.

This section draws broadly from three sources. First, it draws from a review of the literature on the impact of OGS devices, and—in cases with scant OGS-specific data—on the impact of electrification more broadly.[363] Second, this section also relies on metrics and estimates created by GOGLA that use company-level operational data to estimate the impact created by affiliate products. These supplement regional, context-specific impact studies to provide aggregated industry-wide numbers. These estimates rely on data from affiliate companies only. Third, select estimates were developed for this study to gauge the impact of the broader industry that includes non-affiliate devices and component-based systems. These analyses estimate improved energy access provided, aggregate savings on energy related expenditures,[364] torch casings displaced, and the number of potentially out-of-use OGS devices. Given the paucity of underlying data on the performance of non-affiliate devices, these estimates should be treated as purely directional.

Figure 98: Impacts of electricity consumption for households, as reported in the literature[365]

% of literature reviewed (2013)



[363]*Note: The literature reviewed was identified via desk research, as well as the literature covered by ODI's study Accelerating Access to Electricity in Africa with Off-grid Solar. While this report endeavors to use the most up-to-date findings, given the scarcity of resources on certain topics, a few older studies are also cited. The date of publication of these studies range from 2013-2017, with a few older studies lying outside this range*

[364]*Note: These two metrics have been developed by GOGLA for estimating the impact of affiliate products (with known performance). These analyses rely on GOGLA's methodology and extrapolate it to the broader industry. Given the unknown performance of non-affiliates and open-market component-based systems, however, these estimates should be treated as purely directional*

[365] *Note: Percent of papers reviewed which did not analyze each issue is equal to the remainder of each 100% sum, and is not shown in graph. Source: (Pueyo & Hanna, 2013); (World Resources Institute, 2016)*

It should be noted that given the relative nascence of the industry, aggregable, industry-wide estimates are scarce. Most impact studies specific to the OGS sector rely on regional or company-specific data. A few initiatives are striving to plug these gaps. As introduced in Table 4 and illustrated in Figure 99 below, which is adapted from SEforAll's flagship Beyond Connections report, the MTF is an effort to build global, aggregable metrics and a database for measuring energy access in a non-binary fashion. While the MTF is applicable to sources beyond off-grid solar, GOGLA's impact metrics are a step in the direction of creating a cohesive framework within which the OGS industry can report impact. In addition, studies such as those undertaken by SolarAid and Acumen are invaluable in providing OGS-specific data within regional contexts and business models. The Acumen Lean Data initiative provides recent insights based on impact data collected from 5,500 customers across 11 countries served by 21 companies providing energy services (from solar lamps to micro-grid connections).[366]

Figure 99: Multi-tier matrix for measuring access to household electricity supply

		Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Peak Capacity 1	Power capacity ratings (in W or daily Wh)		Min 3 W or 12 Wh	Min 50 W or 200 Wh	Min 200 W or 1 kWh	Min 800 W or 3.4 kWh	Min 2 kW or 8.2 kWh
Availability (Duration) 2	Hours per day/ hours per evening		Min 4 hrs/ 1 hr	Min 4 hrs/ 2 hrs	Min 8 hrs/ 3 hrs	Min 16 hrs/ 4 hrs	Min 23 hrs/ 4 hrs
Reliability 3						Max 14 disruptions/ week	Max 3 disruptions per week of total duration <2 hrs
Quality 4							Voltage problems do not affect the desired use of appliances
Affordability 5							Cost of a standard consumption package of 365 kWh/ year < 5% of household income
Legality 6							Bill is paid to the utility, prepaid card seller, or authorized representative
Heath and Safety 7							Absence of past accidents and perception of high risk in the future

[366]*Note: Acumen launched its Lean Data initiative in 2014. It is a customer-centric, technology-based approach to impact measurement. The Energy Lean Data series cuts across 38 Lean Data projects, 21 companies, 11 countries, and 7,500 interviews representing 5,500 customers (end-users) of energy products/services from mini-grids, to solar home systems, to solar lanterns, to solar water irrigation pumps, to improved cookstoves – including over 750,000 data points on energy access impact from end-users*

Widespread impact: The OGS industry has had profound impact on energy access globally, as well as on economic, health, and social outcomes.

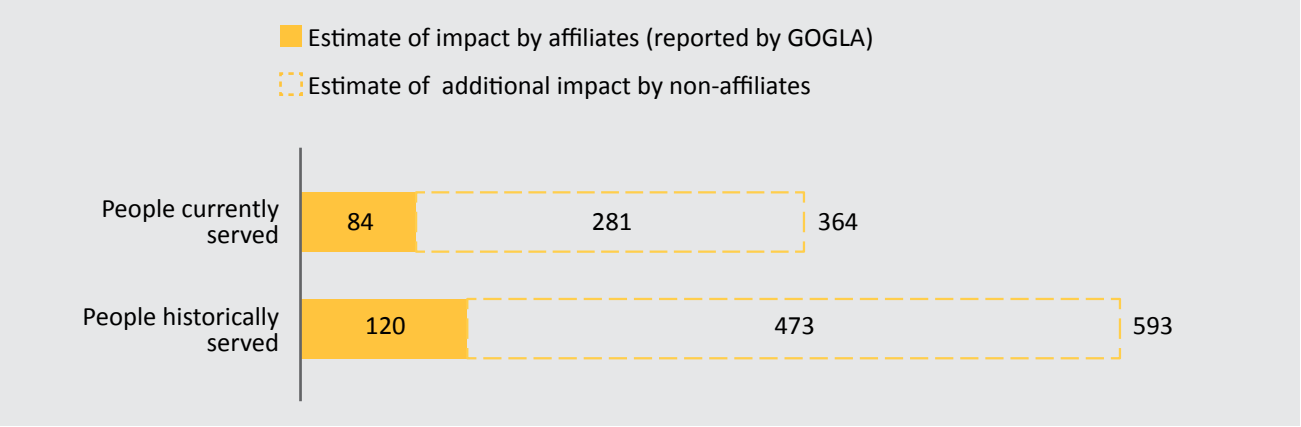
Energy access

Historically, GOGLA estimates that affiliate OGS devices to date have provided improved energy access to 120.3 million people. About 83.7 million continue to enjoy access today.[367] Of these, 39.7 million people have access to Tier 1 energy, with at least four hours of lighting and charging in the day and one hour in the evening. An additional 1.8 million people have access to Tier 2 energy, receiving at least four hours of lighting in the day and two hours in the evening along with the option of powering small to medium devices such as fans and TVs.[368]

These numbers correspond to the services provided only by affiliate products and may be higher when the universe of non-affiliate and component-based products is brought into the scope of these metrics. This study estimates that in addition, over 470 million people may have been served by non-affiliate and component-based products historically, with ~280 million people currently being served.[369]

Figure 100: Improved energy access[370]

Millions of people (2017)



Economic impact

Economic impact is manifested in three ways: as a change in household expenditure, as a change in income generation, and through increased employment. Additionally, there are indirect long-term benefits that could accrue at the household level if savings are diverted to activities that lead to better health and educational outcomes. Few studies explore this link directly, but it is a potential area for further exploration.

[367]*Note: Dalberg's calculations use the "improved energy access, current" metric of the GOGLA impact metrics. Source: (GOGLA, 2016a); (GOGLA, 2017)*

[368]*Note: Does not include non-affiliate products. Source: (GOGLA, 2017)*

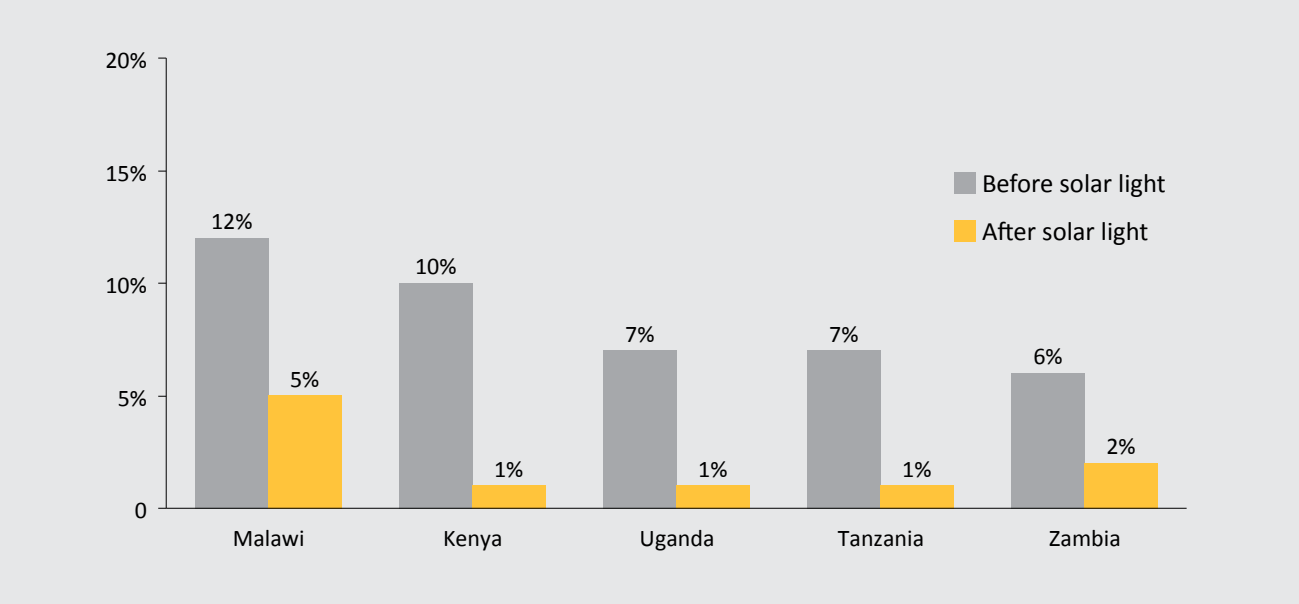
[369]*Note: See also Footnote 364. These estimates are based on calculations using the "improved energy access, current" metric of the GOGLA impact metrics. Source: (GOGLA, 2016a)*

[370]*Note: GOGLA estimates account for devices sold till 2017 H1 whereas the non-affiliate and component-based system estimates extend to 2017 H2*

While small OGS devices lead to household savings through reduced spending on kerosene (and sometimes mobile charging), larger OGS devices have been found to increase spending on energy. SolarAid's primary research across Kenya, Malawi, Tanzania, Uganda and Zambia (2012-2015) found that 71% of families reduced their lighting spend after purchasing an individual solar light, and 69% eliminated kerosene use.[371] Figure 101 illustrates reported decrease in household spend on lighting in these countries after the purchase of a solar light.

Figure 101: Proportion of household income spent on lighting[372]

Average % of total annual household income; select African countries (2012-15)



Similarly, insights from Acumen's Lean Data work found that 79% of families using solar lights and solar home systems reduced their spending on alternative sources of power (such as kerosene and candles). At the same time, however, 80% of them—particularly those purchasing larger models— increased their expenditure on energy as a whole. Data from Acumen's research found that, across a range of OGS technologies, households spend USD 72 a year on average, implying a willingness to pay more for a higher level of energy service.[373] In another study, two SHS companies in East Africa found that the amount their customers spent on energy during the repayment period increased by 59% and 100% respectively.[374]

Overall, GOGLA estimates that households have seen about USD 5.2 billion in economic savings[375] as they switch from kerosene and/or other conventional fuels to affiliate OGS devices. When considering the entire universe of OGS devices, which includes non-affiliate products and component-based systems, total savings could be more than double.[376]

[371] *Source: (Harrison & Adams, An evidence review: How affordable is off-grid energy access in Africa?, 2017)*
[372] *Source: (Harrison, Scott, & Hogarth, Accelerating access to electricity in Africa with off-grid solar - The impact of solar household solutions, 2016)*
[373] *Source: (Acumen, 2017a)*
[374] *Source: (Harrison & Adams, An evidence review: How affordable is off-grid energy access in Africa?, 2017)*
[375] *Source: (GOGLA, 2017)*
[376] *Note: Refer to Footnote 364*

Customers use their OGS devices for income-generating activities. GOGLA estimates that the OGS industry has supported the income-generating activities of 1.9 million people to date.[377] Recent Lean Data work by Acumen found that 17% of one company's PAYGO SHS customers in East Africa use their systems for income generating activities; three-quarters said the extended business hours enabled by this led to an average income increase of 60%.[378] In general, however, it is difficult to ascertain whether extended hours necessarily translate into a direct increase in sales.[379] For example, the average income of solar-electrified enterprises was found to be 82% higher than non-electrified enterprises in Ghana, but it was difficult to establish causality.[380] Similarly, while 21% of a PAYGO SHS company's customers used a PAYGO SHS for their business in Southeast Asia, only 17% said that they saw an increase in income due to it.[381]

OGS devices also lead to an increase in the time spent on productive work at the household level; however, there is limited data on how, and if, this is linked to increases in income. For example, research in Kenya found evidence that fathers increased their time spent doing paid work by 13% daily after being given a solar light. However, a positive impact on overall income was not seen within the timeline of the research, and researchers therefore advised additional research to learn whether this type of change will have a positive effect on income in the longer term.[382]

The solar lighting industry creates jobs. Early findings suggest that the solar lighting industry is leading to increased employment. A survey of product developers, distributors, and retailers in seven countries showed that about 17,000 workers per million lanterns are introduced into the market annually across the entire production-to-sales process.[383] Applying this metric, the same study estimates the potential creation of two million new jobs to serve off-grid households.[384] Direct jobs captured range across the value chain—manufacturing and assembly, importation, marketing, distribution, retail, after-sales service, financing, market research, and monitoring and evaluation. The study did not estimate indirect job creation such as production of raw materials and components, contract employees, entities involved in shipping and customs, and third-party entities involved in financing; factoring these in would likely showcase a larger impact of the industry on job creation.

At the country level, a study in Bangladesh estimates that 114,000 jobs were created as a result of local solar assembly between 2006 and 2016.[385] Another study that focused on the economic benefits of solar coverage, primarily due to increased hours of operation, found that an increase of 1% in solar coverage increased direct employment in the local economy by 0.02%.[386]

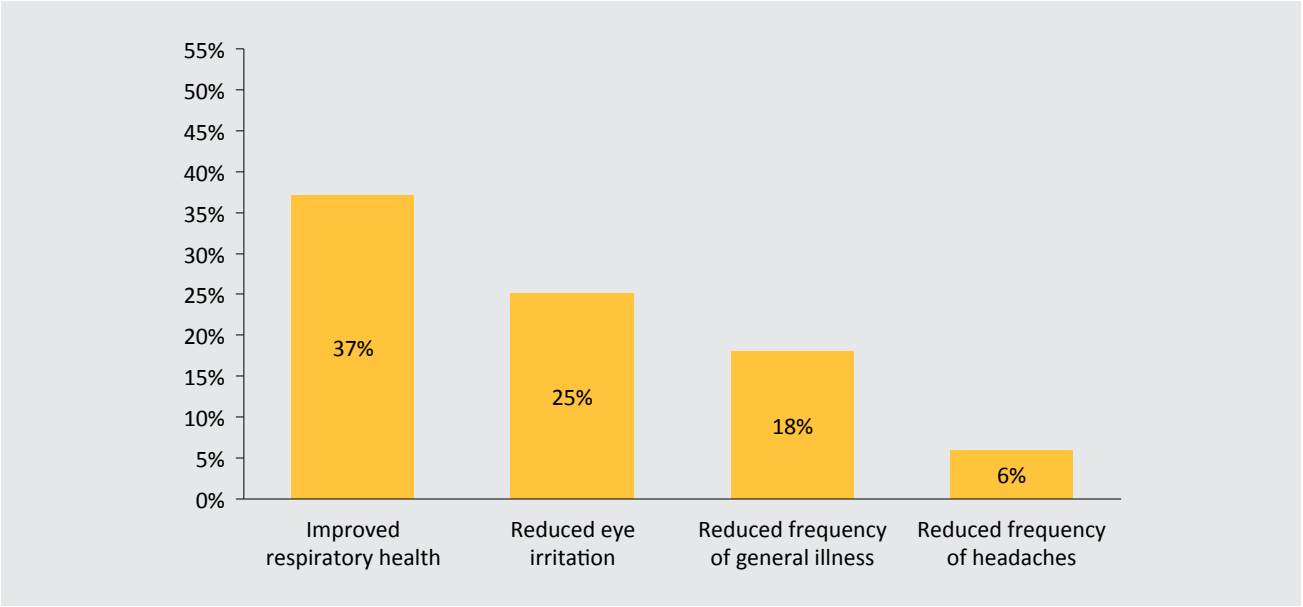
Health impact

Health benefits of OGS devices may accrue in one of three ways: (a) through reduced kerosene use for lighting, (b) through electrification of health care centers, and (c) through a reduction in expenditure that can lead to increased spending on food, and through it, to better nutritional outcomes. This sub-section focuses on the first pathway and provides anecdotal examples of the second. The third is not covered in this study given the paucity of data.

[377] *Source: (GOGLA, 2017)*
[378] *Source: (Acumen, 2017a)*
[379] *Source: (Azimoh, Klintenberg, Wallin, & Karlsson, 2015)*
[380] *Source: (Obeng & Evers, 2010)*
[381] *Source: (Acumen, 2017a)*
[382] *Source: (Hassan & Lucchino, 2014)*
[383] *Source: (Mills E. , 2016)*
[384] *Source: (Mills E. , 2016)*
[385] *Source: (Africa Progress Panel, 2015)*
[386] *Source: (Harsdorff & Bamanyaki, 2009)*

Figure 102: Improved health among households who used kerosene prior to buying a solar light[387]

% of households with reductions in health issues; select countries in Sub-Saharan Africa (2012-15)



In households, the use of kerosene lanterns leads to indoor air pollution via suspended particulate matter and other noxious gases (such as carbon monoxide and sulphur dioxide), which create health hazards. A study by SolarAid found that 40% of solar light owners reported suffering from kerosene related health issues.[388] In the same study, 63% of solar light users who previously used kerosene lamps experienced an improvement in their health (Figure 102 details improvements in specific symptoms). Similarly, results from Acumen's Lean Data project saw many OGS customers (45% of those who used kerosene before OGS devices) notice improved health; in particular, a reduction in coughing, chest problems, respiratory issues, and eye strain/irritation was commonplace.[389] These results are echoed in the findings of a small-scale study in Busia county in Kenya. The survey found that $PM_{2.5}$ levels, a measure of airborne particulate matter, decreased drastically within the home, by 79% in the child's study area and 61% in the main living room.[390] In addition, residents no longer experienced respiratory and eye irritation symptoms once a household switched to solar lights.[391]

The use of kerosene or other open-flame lighting sources (such as candles) also leads to high instances of accidents, including burns, fires and poisoning (as kerosene is sold in soda bottles, people, particularly children, may ingest it accidentally).[392] SolarAid found that 19% of respondents in Uganda had faced such accidents; 14% of families using kerosene in the Lean Data baseline study had also experienced accidents.[393] The use of solar lights reduces such incidents. An impact study undertaken by d.light similarly found that only 0.9% and 0.4% of households with a d.light product experienced burns and fires, respectively, compared to 6% of the comparison households that relied on open-flame lighting and experienced burns and fires.[394]

[387]*Source: (Harrison, Scott, & Hogarth, Accelerating access to electricity in Africa with off-grid solar - The impact of solar household solutions, 2016)*
[388]*Source: (Harrison, Scott, & Hogarth, Accelerating access to electricity in Africa with off-grid solar - The impact of solar household solutions, 2016)*
[389]*Source: (Acumen, 2017a)*
[390]*Note: Measurements in the kitchen are not included to isolate pollution due to lighting from pollution due to cookstoves*
[391]*Source: (Lam, et al., 2017)*
[392]*Source: (Harrison, Scott, & Hogarth, Accelerating access to electricity in Africa with off-grid solar - The impact of solar household solutions, 2016)*
[393]*Source: (Acumen, 2017a)*
[394]*Source: (IDinsight, 2017)*

The lack of electricity access is felt not only in households but also in communal places such as healthcare facilities. 30% of health facilities in Sub-Saharan Africa, which collectively cater to 255 million people, lack access to electricity.[395] Even those which do have access do not have a steady supply. A survey of 11 countries in Sub-Saharan Africa found that among health facilities that had an electricity supply, only 28% received it regularly.[396] Innovative off-grid products can and have provided some relief in such situations. We Care Solar, for example, developed and are distributing a "Solar Suitcase" that supports health workers, primarily related to obstetrics, working in conditions challenged by lack of electricity access.[397] The company's estimates suggest that they have served 1.5 million mothers and newborns through their product.[398]

Impact on education

Studies on the impact of OGS devices on education yield mixed results. While access to OGS devices increases the time that students spend on school-work, this increase does not always translate into higher academic performance. This is not surprising as many other factors affect academic performance, such as motivation, quality of teaching, and access to materials.

For example, the use of solar home systems has seen a small increase in the amount of time spent studying in the evening in Bangladesh[399] and Bolivia.[400] Acumen's Lean Data project recorded an increase in study time from 2 hours to 2.7 hours per night.[401] Evidence from Rwanda[402] and Kenya[403] found that while the overall total study time of male students went up, for female students it merely shifted from the daytime to evening.

The link between lighting from OGS devices and improved student outcomes has not been established in the literature. A pilot study in Uganda found that while pico devices increased study time by 30 minutes, test results unexpectedly declined.[404] Another study in Bangladesh found that increased study hours and initial improvement in school attendance did not translate into improved academic performance.[405] Both suggest an insignificant effect of pico devices on educational attainment. An impact evaluation of the installation of solar systems in eight primary schools in Uganda by BBOXX suggests otherwise, finding an increase in the number of students attaining top marks in their Primary Leaving Exams.[406] Additionally, a large RCT exploring impacts on education in Kenya found that students in homes with solar lights increased their math grades by an average of 4%.[407] Given that educational outcomes are determined by a range of diverse factors, it is not entirely surprising that the link between OGS devices and education is mixed.

[395]Source: (Harrison, Scott, & Hogarth, Accelerating access to electricity in Africa with off-grid solar - The impact of solar household solutions, 2016)
[396]Source: (Harrison, Scott, & Hogarth, Accelerating access to electricity in Africa with off-grid solar - The impact of solar household solutions, 2016)
[397]Note: Includes two 20-watt solar panels, a 14 amp-hour lithium ferrous phosphate battery, a 15A charge controller, two rechargeable LED headlamps, and a phone charger. The Basic Plus Solar Suitcase offers a AA/AAA battery charger with batteries, and a fetal doppler
[398]Source: (We Care Solar, n.d.)
[399]Source: (Samad, Khandker, Asaduzzaman, & Yunus, 2013)
[400]Source: (World Bank, 2017a)
[401]Note: This may be affected by school year as the Lean Data project was conducted at different times in the year. Source: (Acumen, 2017a)
[402]Source: (Grimm, Munyehirwe, Peters, & Sievert, 2016)
[403]Source: (Rom, Gunther, & Harrison, 2017)
[404]Source: (Furukawa, 2014)
[405]Source: (Kudo, Shonchoy, & Takahashi, 2016)
[406]Source: (Achilla, 2014)
[407]Source: (Hassan & Lucchino)

Gender-related impact

The gender-related impacts of off-grid solar are one of the areas with the most limited data. Consequently, this sub-section relies heavily on the broader literature for energy-related impact on women and girls. The literature available classifies four broad sources of benefits:

Reduced exposure to household air pollution, which has a disproportionate impact on women: According to Oxfam, 60% of all premature deaths due to indoor air pollution occur in women and children. This is one of the largest health-related risks for women in Sub-Saharan Africa, associated with afflictions such as pneumonia, strokes and lung-cancer.[408] While unclean cooking fuels contribute to this indoor air pollution, kerosene also disproportionately impacts women as they use lighting indoors while cooking, and thus may be exposed to it longer or at a closer range. Consequently, reducing exposure to this pollution by using clean energy sources such as solar reduces negative health outcomes for women.

Increased education and time for income generating activities: According to the UNDP, lighting at home directly impacts women's literacy. Brazil census data shows that girls in rural areas with access to electricity are 59% more likely to complete their primary education by the time they are 18 than those who do not have lighting at home.[409] However, this may also be correlated to factors such as the initial income of the household. While access to lighting and energy may lead to time-savings for women, the impact of this time on income-generation is ambiguous. While evidence from South Africa, Guatemala, and Nicaragua suggest that electrification is strongly related to increased employment for women, a study by Pachauri and Rao argues that these findings are highly context-specific and the impact of energy on women's income and employment is unclear.[410]

Increased access to information through appliances powered by solar home systems: Access to increased communication, in turn, abets facets of empowerment. A survey by M-KOPA found that 47% of customers bought a TV to access the news or educational material and 70% felt more informed and politically aware after using the TV.[411] While the survey does not disaggregate responses by gender, it provides a good indication of the impact of TVs (or other mass communication devices) on household members. A study in rural India showed that women who had access to cable TV had lower tolerance for spousal abuse, lower son preference, more autonomy, and greater likelihood of sending young girls to school.[412]

Increased safety: Lighting devices may improve the physical safety of women, however, there is little empirical evidence establishing this link. Anecdotal evidence reports that women are at higher risk of sexual violence when collecting cooking fuel after dark, which may be mitigated by having a steady source of lighting at home. With portable lights, women may also be able to carry a lighting device with them, extending the hours in which they feel safe to leave home. Results from Acumen's Lean Data show that 67% of customers purchasing a solar lantern or home system reported feeling safer since buying or using their product. While this result did not change much when disaggregated by gender, men and women think of safety in different ways: men refer to improvements in the security of the home, and women talk about safety of the family in terms of health and accidents.[413]

[408] *Source: (Rewald, 2017)*
[409] *Source: (Rewald, 2017)*
[410] *Source: (Pachauri & Rao, 2013)*
[411] *Source: (M-KOPA, 2017d)*
[412] *Source: (Rewald, 2017)*
[413] *Source: (Acumen, 2017a)*

Not all impact that relates to women, however, is positive. A recent study by CGAP and BFA across 138 households in four countries – Cote d'Ivoire, Ghana, Kenya, and Tanzania – found that the decision to purchase solar was primarily made by men, often against initial protests by their wives. Households often met payments by reducing women's budgets and purchasing power in the day-to-day household budget.[414] Similarly, the Lean Data project found that for 51% of customers, the male head made the decision to purchase alone, with the female head making the decision alone in 23% of customers; 26% of households saw the male and female making a joint decision.[415] Should husbands continue to acquire more assets through the solar provider, this could be a persistent issue with broader implications.

Untapped opportunity: The proliferation of e-waste presents an opportunity for the industry to amplify its positive environmental impact through investing in proper waste disposal.

Impact on the environment

While OGS product sales have had a positive environmental impact in terms of avoiding greenhouse gas emissions and displacing electronic waste in the form of discarded torches, poor recycling of discarded solar devices may pose a challenge in the future. Moreover, until solar products meet all household needs, households are expected to continue stacking lighting sources, which will continue to have a harmful impact on the environment. For example, in some cases households continue to use kerosene while owning a solar product (although the usage is reduced).

GOGLA estimates that the use of Lighting Global/GOGLA-affiliated solar devices has avoided 28.6 million tons of greenhouse gas emissions.[416] When considering the entire universe of OGS devices, emissions avoided are likely to be substantially higher.

GOGLA's estimates of avoided emissions include carbon dioxide as well as black carbon, a by-product of burning kerosene that has a high capacity for trapping heat in the atmosphere. One study estimates the amount of black carbon generated from the use of kerosene lamps worldwide to be 270,000 tons per year – a quantity that has the climate warming capacity of 240 million tons of carbon dioxide.[417]

In addition to displacing kerosene, a substantial proportion of solar devices displace dry-cell battery torches as the main form of lighting within a household. These torches, which typically have a short life-span and require frequent battery changes, accrue considerable electronic waste in the form of discarded casing and batteries. According to research by SolarAid and Acumen across Kenya, Malawi, Senegal, Uganda, and Zambia, an average of ~30% of pico-solar light customers, and ~20% of SHS and mini-grid customers used torches as their main source of lighting prior to purchasing an OGS product. This study estimates that since 2009, OGS devices may have displaced up to 20.6 million torch casings.[418] These estimates are indicative, as consumers may tend to retain torches in the household even if their use was discontinued or reduced due to the purchase of a solar light. This displacement, indirectly, leads to environmental benefits in the form of reduced space

[414]Source: (Zollmann, Waldron, & Sotirio, 2017)

[415]Source: (Acumen, 2017a)

[416]Note: These estimates, however, do not account for the greenhouse gas emissions released in the manufacturing and distribution of solar devices. Source: (GOGLA, 2017)

[417]Source: (Harrison, Scott, & Hogarth, Accelerating access to electricity in Africa with off-grid solar - The impact of solar household solutions, 2016)

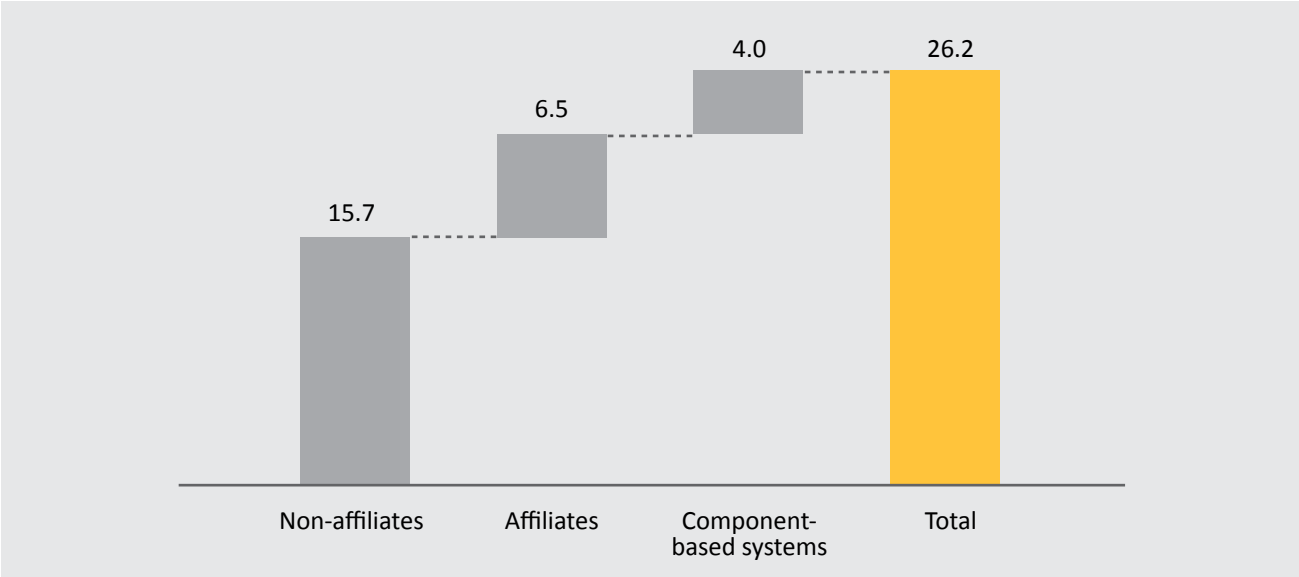
[418]Note: This estimate uses Acumen and SolarAid's findings on household sources of lighting prior to purchasing a solar device and industry sales data since 2009 to estimate the number of torches that are likely to have been displaced by solar lights and home systems. The total displacement figure is based on a weighted average of pico and SHS devices sold since 2009. As there is a lack of data around the quality of non-affiliate and component-based systems, this study assumes a lower rate of displacement of torches for these versus affiliate systems. Source: (Acumen, 2017c)

occupied, leaching, and toxicity at landfill sites. It should be noted, however, that consumer behavior may also lead to the products being littered within their homes.

This positive impact of offsetting torches might be muted by the proliferation of e-waste as solar devices reach the end of their lives. Assuming half of devices are discarded after their 3-4 year lifetime, this study estimates that up to 26.2 million OGS devices could be out of use by 2017 (see Figure 103).[419] If improperly disposed, these could have an adverse impact on the local environment. Not only does this create large amounts of plastic waste, it also leads to issues of toxicity from improper disposal of components, particularly lithium-ion batteries.

Figure 103: Estimate of potentially out-of-use OGS devices[420]

Million devices (2017)



A hazard assessment study at the University of California, Irvine, found that discarded Li-ion batteries should be classified as hazardous according to U.S. federal regulation due to their high lead content.[421] Copper, cobalt and leached chromium and thallium also create toxic hazards.[422] In addition to toxicity, the improper disposal of rechargeable lithium-ion batteries creates a fire hazard – pressure or heat can cause improperly disposed batteries to spark and ignite dry materials around them. According to American Disposal Services, they are one of the leading causes of fires in recycling trucks.[423]

Unlike lead-acid batteries that have uniform composition and thus a recycling process that can be standardized, lithium-ion batteries can have a variety of chemistries and component combinations. This variation makes recycling of lithium-ion a much more complicated process, and consequentially, the provision of recycling facilities remains nascent. This gap, globally, could be an opportunity for the OGS sector to amplify its impact.

[419]Note: This estimate is based on cumulative product sales between 2009 and 2014 for affiliate, non-affiliate, and open-market component-based systems, and cumulative sales between 2009 and 2013 for institutionally-distributed component-based systems (it assumes a lifetime of 3 years for all devices, except for institutionally-distributed component-based systems, for which a 4-year lifetime is assumed). Additionally, it conservatively assumes that 50% of devices are discarded post-warranty period. As there is little data on the longevity of non-affiliate devices and open-market component-based systems, this estimate should be treated as purely directional

[420]Refer to Footnote 419

[421]Source: (Kang, Chen, & Ogunseitan, 2013)

[422]Source: (Kang, Chen, & Ogunseitan, 2013)

[423]Source: (American Disposal Services, n.d.)

A few initiatives to manage e-waste are already afoot in the sector. For example, SolarAid's "Solar Waste" project—a collaboration with a doctoral candidate at the University of Edinburgh—studies consumer behavior and waste economies in Kenya and will recommend viable solutions to effectively and sustainable discard solar waste.[424]

Metrics outlook: Going forward, impact on OGS-related metrics will increase, but further research is required to develop a framework that fully captures the breadth of impact at an industry-level.

The market has had strong impact to date across several metrics, although some areas such as health require further research. Looking ahead, based on further sales and diffusion alone, this impact is expected to increase. It could also be bolstered further via emerging trends that showcase opportunities for impact beyond clean lighting. These include:

1. *Productive use appliances.* The new generation of plug-and-play systems are increasingly paired with capabilities or appliances that can be used for income-generating activities. The most common productive use of SHS devices cited in interviews includes setting up mobile-phone charging businesses; these can earn monthly revenues of up to USD 100 in a country such as Tanzania. Beyond household appliances, however, there is an emerging trend towards producing appliances and systems specifically targeted at businesses and agricultural applications (as discussed in Section 1C.3). For example, an OGS player supplying PAYGO-enabled water pumps in Tanzania has already engaged with 2,000 farmers in the country.[425] As technology evolves and companies innovate on business models, such appliances are expected to become increasingly available in the market.
2. *Increased mobile money adoption.* Devices sold through PAYGO can drive the adoption of mobile money in certain markets. A study by Acumen found that 2% of SHS customers in Kenya were new to mobile money. In other regions (likely with lower rates of mobile money penetration), this proportion was as high as 15%.[426]
3. *Uptake of financial services.* Some OGS players are beginning to provide financial services to their OGS customers upon meeting certain criteria. PEG Africa, for example, provides a month of free health insurance to customers with low or no defaults. Fenix International provides customers the option to take out agricultural or educational loans once they complete the payment on their OGS device.

While these trends are promising, their impact remains anecdotal at this stage. Further research is required to create a framework to measure impact at an industry-level across multiple dimensions and to collect corresponding data to shed light on the full welfare implications of the industry.

[424]*Source: (Solar Aid, 2016)*
[425]*Source: Industry interviews*
[426]*Source: (Acumen, 2017a)*

SECTION 2:

THE MARKET IN 2022

The overall trajectory of the OGS market remains on sound footing. The market will achieve healthy growth rates based on sound fundamentals, as well as on the continued momentum of key drivers from the past few years (especially the expansion of PAYGO, and continued engagement from governments). The OGS market can accelerate faster if certain cross-cutting initiatives are explored, as described in the following sections.

Forecasts for 2017-2022: Stable, strong growth ahead. PnP SHS expected to drive revenues.

The OGS market will grow across segments at an annual rate of 25% in the next five years. Between 240-250 million units are expected to be sold between 2017-2022, with annual sales expected to reach approximately 70 million devices in 2022, across pico and PnP SHS, affiliates and non-affiliates. The market is expected to generate about USD 20 billion in estimated cumulative sales revenue across 2017-2022, and USD 8 billion in annual sales by 2022.[427]

- *Pico:* Pico sales will return to 2014-15 levels once the dip in 2017 is safely navigated. Annual growth rates of 15-20% are projected for 2017-2022. By 2022, the pico segment will generate annual revenue to the tune of USD 1-1.5 billion, with the value of cumulative sales from 2017-2022 expected to be about USD 4-5 billion.[428]
- *Plug-and-play SHS:* The business-as-usual scenario projects that the PnP SHS segment (overwhelmingly driven by PAYGO companies) will exhibit growth of 80-90% over the next five years, reaching 20-25 million in annual unit sales by 2022 (roughly what pico sales are today) and annual revenues of USD 6-7 billion. This segment will drive value for the entire market, given its higher price points and faster sales trajectory; it is estimated to comprise three quarters of cumulative revenue till 2022, equivalent to USD 14-15 billion.[429]

In 2022, the OGS sector could be providing improved current energy access to up to 740 million people,[430] depending on the proportion of new versus repeat sales. A rising share of these will have gained at least Tier 2 energy access, beyond simple lighting, as customers expand to higher-wattage systems.

The drivers and rationale behind the estimates are explored below, following the description of the methodology in Table 12.

> “There is still a long way to go in electrification worldwide – the need for lighting continues. The off-grid solar industry is also likely to evolve in terms of its offerings: demand for bigger units continues to rise, and we’ll see more innovation around specific needs.”
>
> **- Pauline Githugu, M-KOPA**

[427] *Note: Assumes prices and product mix at 2017 levels. Source: Industry interviews (for assumptions and estimates); Dalberg market model and analysis*

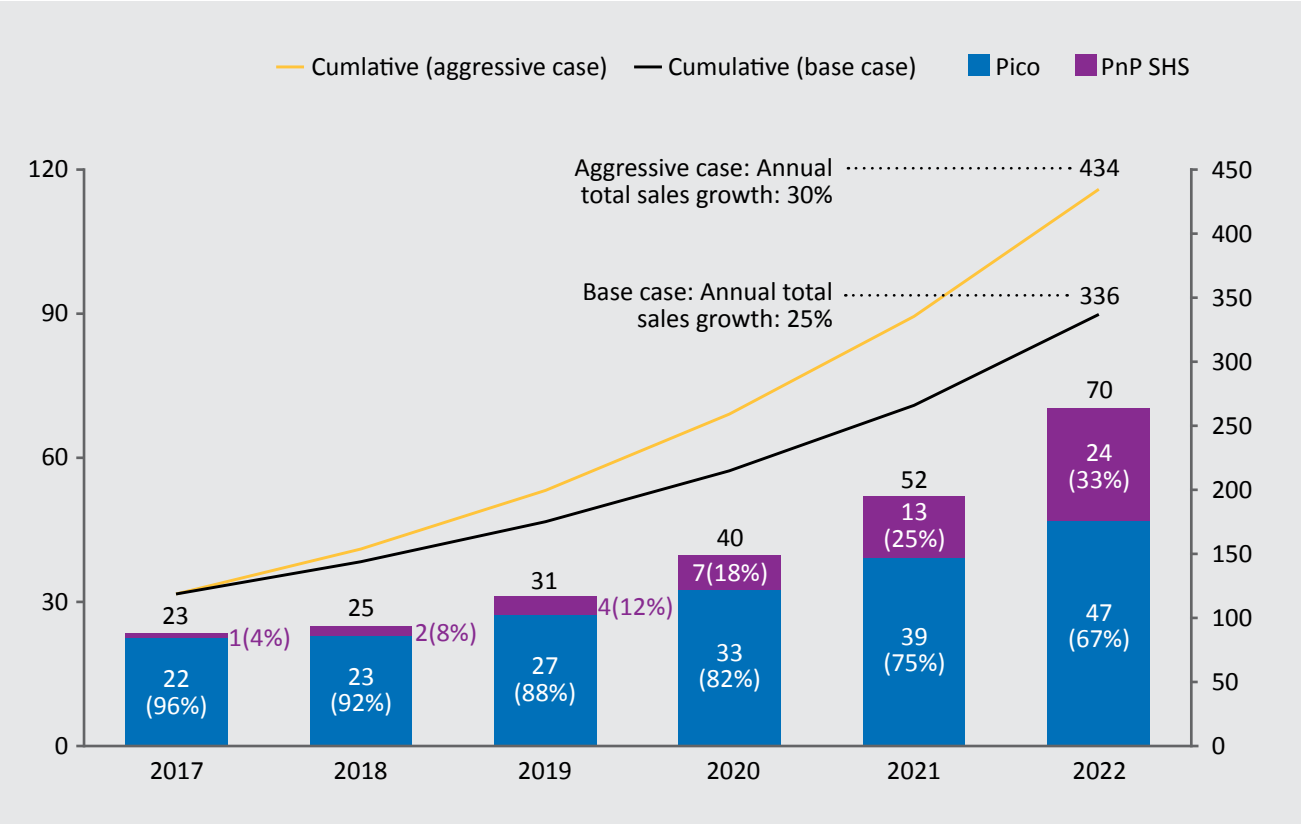
[428] *Source: Industry interviews; Dalberg market model and analysis*

[429] *Source: Industry interviews; Dalberg market model and analysis*

[430] *Note: Based on Dalberg calculations using the “improved energy access, current” metric of the GOGLA impact metrics. Source: (GOGLA, 2016a)*

Figure 104: OGS market forecast for pico and PnP SHS[431]

Million units; left axis: annual unit sales; right axis: cumulative unit sales (2017-22)

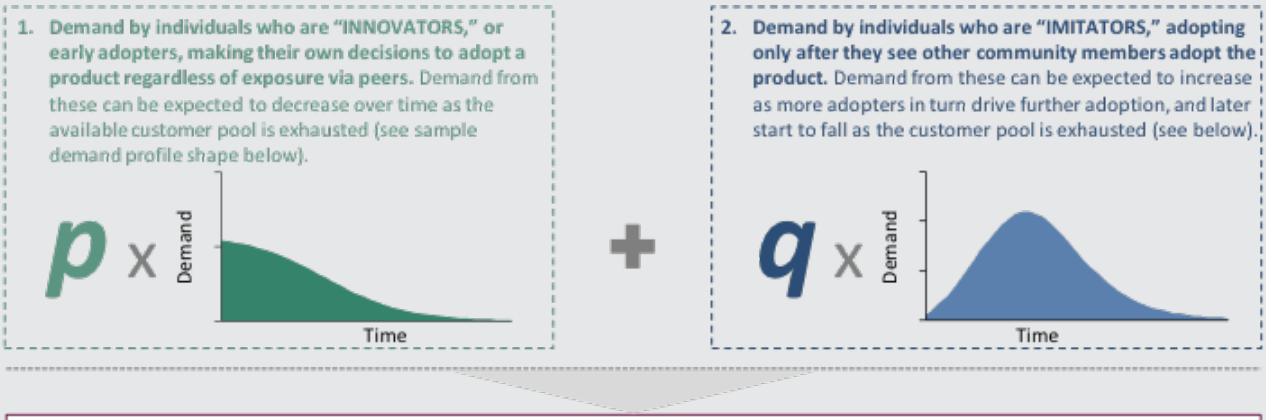


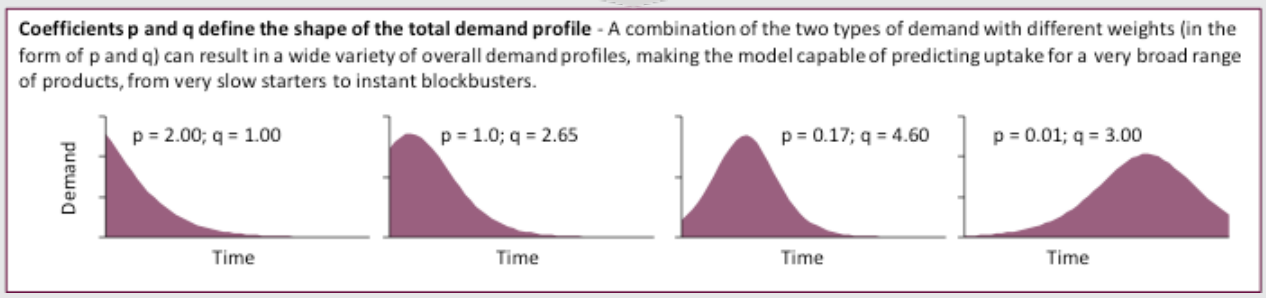
[431] *Note: Segments may not add to totals due to rounding. See Table 12 for full methodology and sources. Source: Dalberg market model and analysis*

Table 12: Methodology for the market forecast model

Base case: Bass Diffusion Model

To estimate pico and plug-and-play SHS market growth to 2022, this study employs a Bass Diffusion Model. This model posits that any new product "diffuses" into a given customer segment through demand created by two methods:





These parameters are then used to estimate the cumulative demand curve for a product, often described as an S-curve.

Applicability and limitations of the Bass Diffusion Model

- ✓ A major strength of the Bass model, and the reason it is employed in this report, is that it can be used to predict long term product uptake only using a few initial data points of product penetration, necessitated by the early stage of the plug-and-play SHS market.
- ✓ The original paper on the Bass diffusion model[432] is one of the most cited papers of all time globally. It has been successfully applied in both research and industry decision-making across a wide range of product types and in diverse markets—including low-income markets such as those where OGS products are sold.
- × One limitation of the model is that results tends to change if there are planned interventions that shift cumulative demand, such as behavior change campaigns or giveaway programs.
- × Results can vary if customer groups are highly segregated and located in disconnected regions, and can be expected to show differing behavior.

[432] *Source: (Lilien, Rangaswamy, & Van den Bulte, 1999)*

Table 12, continued

It is also important to note that the Bass Diffusion Model is based on consumer uptake and not supplier capacity to meet demand. This study assumes that current players will grow, and new entrants will emerge in tandem to meet this growth in demand. Significant supply constraints would slow the growth projected in this model.

Input and Assumptions

To calculate the diffusion of off-grid solar devices, this model estimates the annual penetration (sales ÷ adjusted potential market) of pico and PnP SHS devices in major maturing and nascent markets across Sub-Saharan Africa and Asia.

- *Adjusted potential market:* Using the annual potential market calculations described in Table 6, the analysis overlays assumptions about the maximum number of eventual adopters that "would" buy a pico or plug-and-play SHS if market economics allowed. Among base of the pyramid consumers (<USD 8.44/day), this analysis assumes up to 70% would buy a pico product and up to 40% would buy a PnP SHS. Among higher income consumers (>USD 8.44/day), the analysis assumes up to 40% would buy a pico product and 70% would buy a PnP SHS.
- *Sales:* Sales data on Lighting Global and GOGLA affiliates from 2014-2017 are augmented with assumptions about the full OGS market including non-affiliate suppliers described in Section 1B, and adjusted for repeat sales and product loss (GOGLA, 2016a). Component-based system SHS are not included in this estimate because institutional distribution is based on program targets rather than market mechanisms, and open-market component-based systems are influenced by the market dynamics of each component (e.g. diffusion trends specific to, for example, lead acid batteries, which are used in numerous other applications unrelated to OGS).

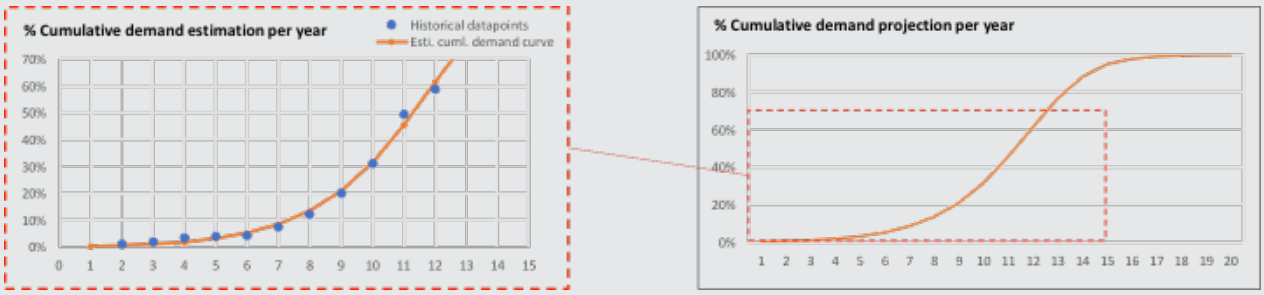
These penetration data are overlaid with unique pico and PnP SHS market duration assumptions in each country, based on desk research and supplier interviews. Penetration at each year of market duration is then averaged for pico products and PnP SHS products separately to arrive at p and q coefficients for each product.

Outputs of Bass Diffusion Model

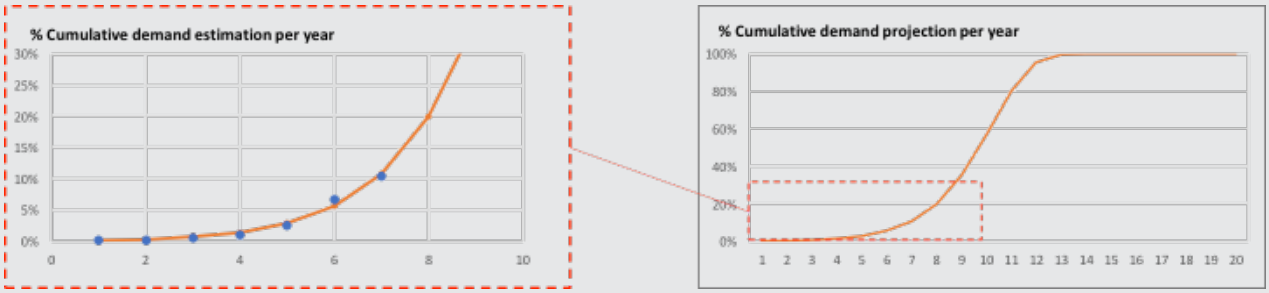
The cumulative demand curves estimated by this model suggest that while pico products have already progressed well into the spike of their global demand curve, PnP SHS devices are only beginning to ramp up.

Table 12, continued

Pico product diffusion



Plug-and-play SHS kit product diffusion



Aggressive case

The aggressive case shown in Figure 104 assumes that the three highest impact gamechangers mapped in Figure 106 come to pass:

1. **Adoption of tax/tariff incentives** in 4-5 countries, thereby dropping prices and increasing sales.[433]
2. **Disruptive battery innovation, as well as step changes in appliance efficiency and cost,** thereby dropping prices and increasing sales.
3. **An influx of financing to the sector** (including second-generation companies) through securitization or other financing channels such as special investment vehicles, thereby boosting companies' ability to scale rapidly (similar to current market leaders following the intensive investment received in recent years).

In this scenario, annual pico growth rates jump from 16% in the base case to 25%, PnP SHS growth jumps from 87% in the base case to over 100%, and the total annual growth jumps from 25% to 30%.

[433]*Source: (Rom, Gunther, & Harrison, 2017)*

Drivers and rationale for projections

The projections indicate that while past growth rates will not be repeated, the rapid slowdowns in 2016-2017 are expected to be temporary. The effects of local shocks in key geographies (e.g. India and Nigeria) will dissipate from 2018 onwards. This positive trajectory is based on a few factors:

- *The market fundamentals will remain buoyant*, with sound growth in macro-drivers that are likely to be sustained. As discussed in detail in Section 1 of this report, these include (1) a large potential market, (2) ongoing real income growth, (3) improvements in distribution infrastructure and ease-of-doing business within countries, (4) a policy environment that increasingly offers at least a basic license to operate, (5) improving technology trends (albeit slower than in the past), and (6) a maturing private sector that continues to be hungry to expand.

  In addition, a growing market for replacements and upgrades for current OGS consumers will contribute to the return to solid sales growth. Replacements and incremental sales (including upgrades to higher level devices) are expected to drive between 60-65% of cumulative sales between 2017-2022. It is only in the past 2-3 years that branded companies have partially shifted focus from rapidly acquiring new customers to deepening their relationships with existing customers. This trend has likely been intensified due to the twin effects of dampening sales in the known affiliate industry in 2016-2017, and the growth of PAYGO, and with it the prospect of elevating existing customers to higher-wattage, higher-margin PnP SHS. In Kenya, 77% of retailers surveyed by Ipsos in 2016 recieved repeat sales from their solar customers, mainly for the same type of product; they say that good customer experience with the product is critical to repeat and upgrade sales. The lower cost of customer acquisition in an increasingly price-sensitive market is also an additional factor. One OGS brand with a presence in both segments indicated in an interview that up to 50% of their PnP SHS customers were existing pico users. With a rising number of products and customers now beyond their warranty periods, suppliers—especially affiliates—have indicated that they intend to focus more sharply on upgrades and incremental sales going forward.
- *Expansion of PAYGO, including cheaper systems as well as wider appliance availability, will continue to drive growth.* Improvements in appliance performance and affordability, especially fans and TVs, will boost SHS sales, and vice versa. Industry experts have noted that these two technologies are furthest ahead in their development cycles for efficient off-grid use. Three PAYGO companies have already launched self-branded televisions in 2016-2017, with one player, M-KOPA, having sold up to 70,000 by July 2017.[434] Based on inputs from interviews and desk research, it is conservatively estimated that up to 60% of PnP SHS sold in the market over 2017-2022 could have bundled DC fans, and about half would likely include DC-powered TVs. With around 50 million PnP SHS projected to be sold cumulatively between 2017-2022, this would imply cumulative sales of about 30 million fans and TVs. This means the OGS sector will command a higher share of customers' wallets. Acceleration in consumers desire for and ability to afford higher service levels and appliances will be a main driver of SHS sales.
- *Virgin and under-penetrated markets will offer incremental growth opportunities,* including those with large off-grid populations like the Democratic Republic of Congo. As demonstrated in Section 1B.3, few countries have achieved penetration in excess of 20% of their potential markets, implying large scope for expansion into harder-to-reach areas, including in maturing markets. Moreover, there are at least 40 countries that together account for around 200 million off- and unreliable-grid households that remain largely unaddressed by OGS.

[434] *Source: (M-KOPA, 2017a)*

» *Pico:* Entry into new geographies may slow, as affiliate market leaders, usually the first entrants in any country, shift focus to improving the quality and depth of their existing customer portfolios. However, some pico players, including larger non-affiliates, will strike out into new markets as competition for customers grows. Expectedly, West Africa is a key target for many pico companies, and existing low-income markets with strong dependence on kerosene, such as the Democratic Republic of the Congo, Malawi, Mozambique, and Pakistan, also represent high potential.[435]

» *PnP SHS:* To date, PnP SHS have trailed pico products into most OGS markets. In markets like East Africa, pico products paved the runway for future PnP SHS sales. This was clearly observed in 2014-2016, when the PnP SHS segment grew emphatically, driven by PAYGO. Going forward, East Africa will continue to be a big revenue driver through upgrades and replacement sales, and will likely offer significant growth opportunities for bundled appliances.[436] Over the next 5-6 years, this study projects that companies will begin launching PnP SHS business models in countries where pico sales have been minimal or non-existent to date. Most major manufacturers and distributors express optimism about West Africa, which appears poised for rapid PAYGO entry and sales growth in the next 5-6 years. Côte d'Ivoire and Senegal were two of the likeliest candidates for focused expansion. Not only are they among the fastest-growing economies in Sub-Saharan Africa (with GDP growth rates of 6.5%+), but these countries have recently combined political stability with improving infrastructure and a focus on attracting foreign trade and capital. Beyond these two, Nigeria, given its large addressable base, was also noted as promising by almost every major company interviewed.

- *Growth or expansion of second-generation companies is expected, particularly non-vertically integrated players in the PAYGO space.* At least 10 companies beyond the top tier of current leading firms have entered the market in the last 2-3 years. The growth of these companies (and new ones, including local players) will be essential to support the projected growth of the OGS sector. Some of these companies are already growing rapidly and have successfully raised funds; for example, Senegal-based Oolu has sold over 25,000 PnP SHS in under 2 years, and recently completed a Series A round of USD 3.2 million in equity.[437]

  It is likely that that these second-generation companies will continue to increasingly focus on relatively untapped markets, as Lumos Global did in Nigeria and PEG Africa in Ghana. This will, in some cases, enable them to capture first-mover advantage and greenfield marketing opportunities, which UNCDF's research in Ghana has shown to be a key driver of consumer purchase decisions.[438] At the same time, such companies can also leverage the innovations developed by the first-generation of companies as well as by the subsequent maturation of the industry-wide ecosystem. These include (but are not limited to) a lower requirement for investment in learning about what works in OGS sales and marketing as well as product and platform technology development. These second-generation companies can then focus their efforts on operational excellence, building out their internal finance capacity and external fundraising methods, and understanding the nuances of their local target markets. However, as discussed in Section 1D.3, these companies may face obstacles in attracting the level of capital received by the first-generation given the widening pool of players, as well as an eventual reduction in truly greenfield markets.

- *Well-targeted gap funding from development and public-sector partners is available.* While investors are moving beyond their initial exuberance regarding the sector, there is a rising focus on achievement of universal sustainable electrification, as enshrined in the SDGs and the SEforALL agenda. There is also recognition that a substantial portion of potential customers are both highly remote and significantly

[435] *Source: Industry interviews*
[436] *Source: Industry interviews*
[437] *Source: (Oolu, 2017)*
[438] *Source: (Goyal, Jacobson, & Gravesteijn, 2017); industry interviews*

cash constrained. Carefully designed support mechanisms such as vouchers, targeted tax incentives, or rebates can help unlock a large part of this market. This has already led to significant DFI, government, and foundation funding that could help plug the gap between investor hurdle rates and where the market is today. For example, EnDev's results-based financing program in Tanzania provides private-sector suppliers a cash incentive based on the performance (mainly lumen-hours) of each high-quality product they sell in rural areas. Others, such as the World Bank's USD 200 million ROGEP partnership with 15 ECOWAS member countries, focus on channeling support to regions where the enabling environment for OGS has received less attention and support. Nevertheless, it is crucial to design such investments prudently to avoid undermining the commercial market.

- *Consumer awareness of the category is largely established.* By now, even in many virgin markets there is basic awareness of OGS devices. This report expects consumer loyalty toward individual brands to become the next battleground, although price will remain the overwhelming driver for pico products.
- *Policymakers will continue to recognize and buy into the energy access and impact potential of OGS as a whole and work toward providing a favorable business and trade enabling environment.* High-level government endorsement and incorporation of off-grid technologies into national electrification plans, including solar, wind and hydro, are an important signal to other players regarding the stability of the off-grid sector. It is also important to coordinate with the private sector on regulation, particularly when dealing with issues such as OGS quality standards, taxation, and e-waste. As noted by GOGLA in a guidance note to governments, "temporary or permanent removal of VAT and tariffs—covering the entire product, including any appliances—is one of the most effective ways for governments to support the growth of the standalone solar market, improving affordability, boosting uptake and accelerating energy access."[439] To demonstrate the potential impact: a study in Kenya found that reducing the price of a solar lamp from USD 7 to USD 4 increased household uptake from 37% to 69%.[440]

Game-changers

Several cross-cutting initiatives/scenarios can help supercharge the OGS sector. This report's business-as-usual scenario, as described above, would still leave approximately 300 million households without improved access to electricity.[441] There are several high potential opportunities to drive the mandate for stronger growth. Most impactful among these are:

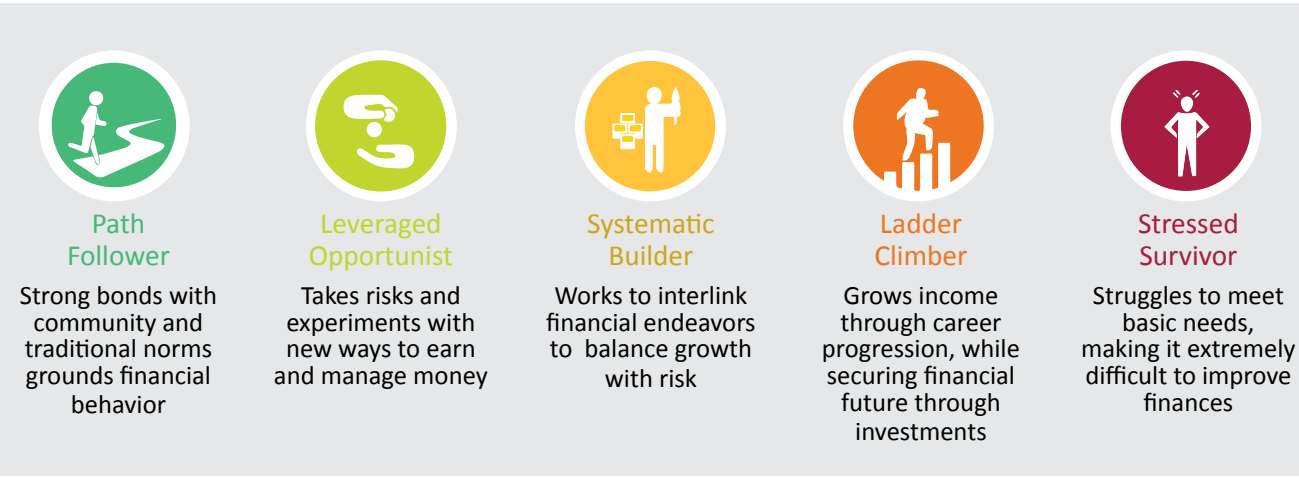
- *Defining the next level of customer segmentation.* A common refrain among OGS companies interviewed for this report is the difficulty of penetrating beyond an initial core set of users in a village, even though macro indicators of income would suggest an ability to pay. The experience of other electronic goods and FMCG companies suggests that segmentation needs to move beyond economic indicators and dig deeper into customer behavior. Greater investment in human centered design-based segmentation can help all players better target product design, communications, and offerings to the various behavioral segments present in a village.

[439] *Source: (GOGLA, 2017)*

[440] *Source: (Rom, Gunther, & Harrison, 2017)*

[441] *Note: Current improved access estimate incorporates sales of all actively-in use OGS devices. See GOGLA Impact Metrics for calculation methodology (GOGLA, 2016a). Source: (International Energy Agency, 2016); (International Energy Agency, 2017a); Dalberg market model and analysis*

Figure 105: Example of behavior segmentation: Personas of digital finance users in India, Kenya



- *Major corporations enter the segment in a substantial way.* The OGS industry has attracted interest from large multinational corporations for some time. However, this has not materialized into sustained market entry or long-term presence. Companies such as Schneider, Panasonic and Phillips that explored OGS in the past 5-8 years have limited their scope and are marginal players to the sector. Recently, two other international conglomerates, Total and Engie, formalized their interest by acquiring stakes in OGS companies: Total Energy Ventures acquired a stake in Off Grid Electric in 2016 and Engie completed its acquisition of Fenix International in 2017. Salesforce also took part in Angaza's Series B round in late 2017.

  These types of transactions are likely to build steam over the next few years as several large global utilities and/or oil and gas companies seek to build their renewable energy assets substantially (in the face of falling oil prices and long-term decline of that industry). In addition, distribution partnerships have shown success, such as Total's Awango initiative, which is among the largest sole distributors of OGS with a footprint in over 30 countries globally. The entry of additional corporate players could help existing OGS companies address key challenges by: (1) increasing access to capital (both debt and equity), (2) leveraging supply chains and economies of scale in procurement and distribution, (3) increasing access to technical skills and expertise, (4) promoting access to global and local networks including strong government contacts, and (5) helping develop higher brand equity. At the same time, it should be noted that competition from companies with far superior access to finance via their parent corporations could crowd out prospective small and medium entrants.
- *Mobile money penetration increases in key OGS markets such as India, Nigeria, and Ethiopia.* The growth and scale up of digital finance and payments (including mobile money penetration) is expected across many developing markets. This would most notably include India and Nigeria, which also have the largest potential markets for OGS in the world with a total of nearly 200 million potential household customers in off-grid and unreliable-grid locations as of 2017.[442] This, in turn, is expected to translate into an increase in end-user affordability on the demand side, and to significantly ease and facilitate the growth of PAYGO business models, at an accelerated pace for operators. Bolstering symbiotic relationships

[442] *Note: See Section 1A for estimation methodology. Source: (International Energy Agency, 2016); (International Energy Agency, 2017a); Dalberg market model and analysis*

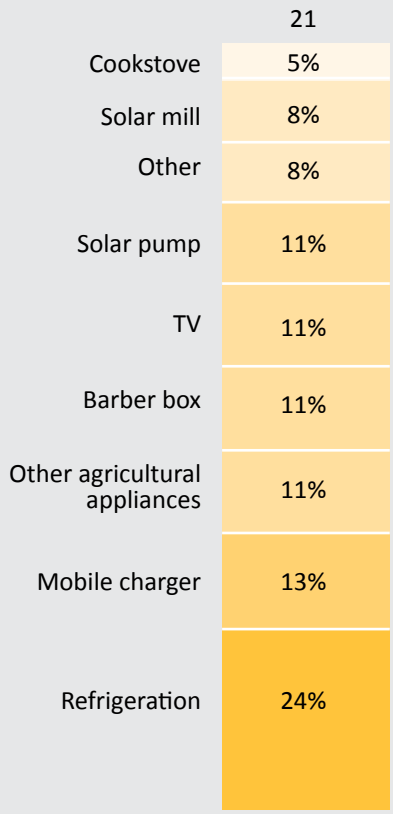
between PAYGO companies and mobile money operators could accelerate this trend. In fact, market watchers observed that first time mobile money usage is often driven by the need to make energy payments. PAYGO providers will therefore need to ensure careful communication and support to such customers to avoid some of the risks that new users of mobile money often face, such as fraud and low awareness of transaction fees.[443]

- *Growth of off-balance-sheet, structured asset financing.* One way to address the emerging funding gap (as detailed in Section 1D) is to deploy off-balance-sheet asset financing models. Investors and companies alike have pointed to the prospects of unlocking financing for PAYGO companies based on the value of their underlying receivable assets. Until recently, off-balance-sheet structures were funded by DFIs and impact investors with a higher risk tolerance than typical commercial investors. However, as companies improve their credit risk assessment capabilities, commercial uptake could increase quickly. Segmenting customers into different risk pools and raising funding accordingly is one option that could become feasible once off-balance-sheet structures prove effective in fundraising. Better data on these transactions and standardization of performance metrics will help to bring in new investors. However, the OGS industry offers a complex environment for this kind of financing. As a result, several legal and administrative hurdles will need to be resolved before these off-balance-sheet financing models can deliver their potential.
- *Local-currency financing materializes and is deployed effectively.* The last two years have seen greater prevalence of local currency financing, which will only go up courtesy of a large set of bilateral and multilateral funding agreements for energy access (inclusive of OGS, mini-grid, and grid). These agreements, primarily between the World Bank and Sub-Saharan African countries, involve investments of over USD 550 million of which at least 50% will be available to the OGS sector. Much of this funding will target the local currency needs of OGS companies and could be catalytic due to the reduced currency risk and resultant increase in local bank involvement in the space. It could improve on-the-ground understanding as well as offer a nuanced view on risk management. At the same time, it will be important for local banks to build the requisite expertise to assess the risk in the OGS sector in order to effectively lend to it.
- *Emergence of specialized investment vehicles (SIVs).* In the early days of the microfinance industry, finding appropriate debt providers was a challenge. Over time, specialized investment funds called microfinance investment vehicles (MIVs) emerged. They developed specific expertise in the industry and provided wholesale debt to MFIs. The dynamics of PAYGO business models lend themselves to similar funding opportunities. In fact, there are likely to be direct opportunities for MIVs to also invest in PAYGO solar companies as they look for new growth opportunities. Currently, MIVs collectively manage over USD 10 billion of capital and could be a significant source of future funding.
- *Increased integration of productive-use appliances with SHS.* It is clear the industry needs to help put money back in the pockets of consumers if it wants to move customers up the energy ladder. Several industry players have noted in interviews that they are likely to increase their R&D budget to develop and pilot productive use solutions such as agricultural implements and refrigerators. However, currently the collective market remains under-developed, fragmented, and in need of targeted support (see Table 13). An increase in investment levels (especially in research and development) above existing plans could catalyze the integration of productive use appliances. Importantly, significant potential exists for convergence between larger capacity solar players (mini-grids, captive plants) that are already experimenting with productive use applications, and PAYGO OGS players with know-how of product level financing and remote asset management.

[443] *Source: (Kiiti, 2012)*

Table 13: Results of a survey of OGS companies on highest potential productive use appliances[444]

n=21 companies (2017)



A survey of PnP SHS companies, which asked them to list the appliances with most productive use potential, revealed that they were most optimistic about refrigeration. Beyond this, there was no real consensus. This points to the fact that "productive use" encompasses "40 distinct categories of products, each with their own trajectory and challenges."[445] Companies also suggested that currently, demand across these categories is fragmented, and depends on local conditions – a fact that will come in the way of rapid scale moving forward. This is, in turn, drives two challenges:

- *Lack of product design research:* There is little incentive for off-grid suppliers to invest in R&D given low current demand. As mainstream appliance companies are not focused on the BoP segment, their design gains have a cost trade-off.
- *Lack of distribution channels:* Distributors are unwilling to stock small volumes of slow-moving appliances (as opposed to those with high demand such as TV). The large size of these products also makes transportation and logistics challenging and costlier.

- *Increased government endorsements and regulatory support for OGS.* Policymakers are increasingly incorporating OGS into their energy access strategies to complement grid and mini-grid approaches. It is expected that this trend will intensify in the next three to five years, as more governments become convinced of the positive impact of OGS markets as seen on millions of households in energy-poor countries. In addition, as noted earlier in this section, stronger government coordination with the private sector and the adoption of tax and tariff exemptions and incentives for OGS systems, components, and energy-efficient appliances could transform the industry as occurred in early winner markets in East Africa. These instruments are non-distortionary, increase end-user affordability (by directly reducing prices by up to 30% in certain countries), and level the playing field for enterprises. In addition, recent studies have shown that VAT and import tariff exemptions may deliver a boost to government finances in the long-run, while offering broader household and macroeconomic benefits. One model in Mozambique found that standalone solar market growth would increase business taxes by offering multiple benefits. It would enable businesses to stay open longer, increase time spent working (by improving health), and encourage job creation in the standalone solar supply chain.[446] However, as discussed in Section 1E, governments will need to be careful to ensure that support provided does not distort commercial markets (e.g. through end-user subsidies).

[444]*Source: Dalberg productive use survey of interviewees for MTR 2018*

[445]*Source: Industry interviews*

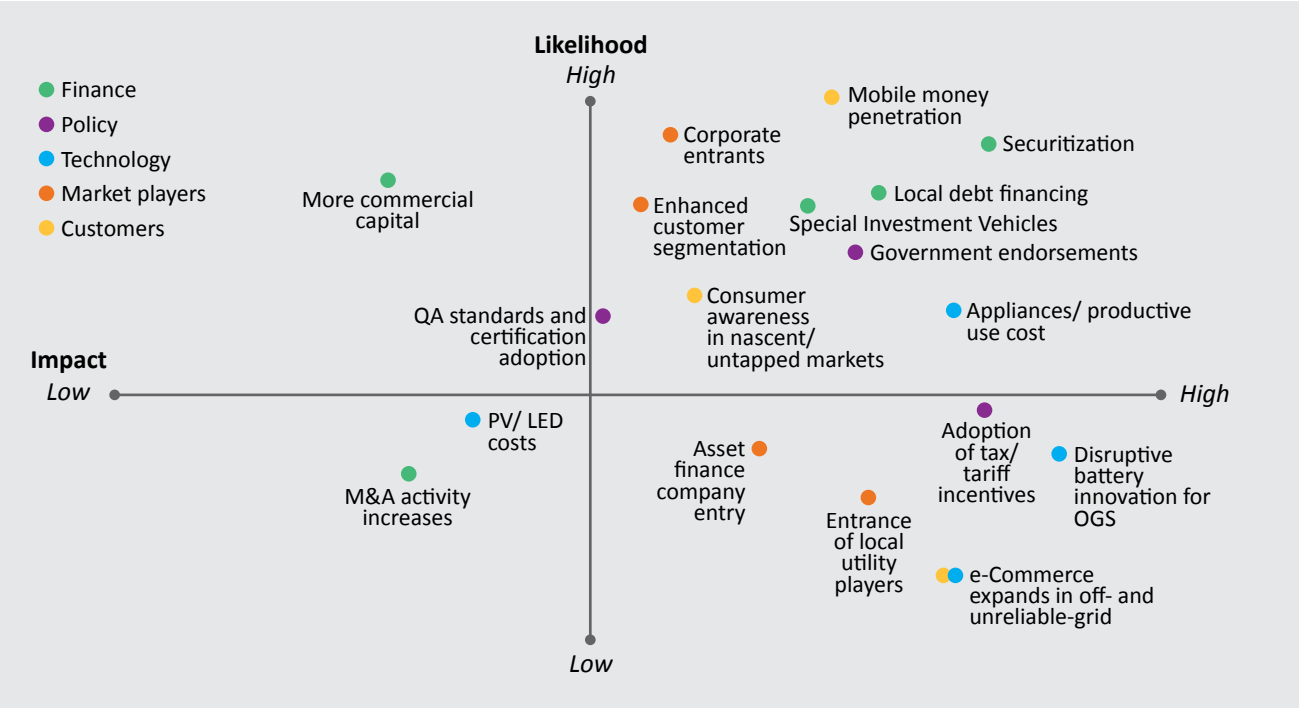
[446]*Source: (GOGLA, 2017)*

- *Accelerated adoption of universal quality assurance standards among countries.* As described in Section 1F, wide adoption of internationally agreed-upon quality assurance standards can provide a significant boost to country markets, ensuring that consumers' experience with OGS is based on quality products and increasing the likelihood that they will be repeat purchasers. However, as evidenced in the experience of Ethiopia (see Section 1E), implementation and enforcement are key to ensuring that quality standards have the desired effect. Without coordination with established international standards and testing schemes, and without building the requisite implementation capacity, customs regulations can do more harm than good by creating unnecessary costs and unproductive barriers to entry, and enabling poor quality goods provided by actors who simply avoid customs to flood the market.

These and other potential game-changers are mapped according to their potential industry impact and likelihood in Figure 106.

Figure 106: Relative ranking of game-changers for the OGS industry

Subjective ranking (5-6-year time horizon)



SECTION 3:

HOW TO WIN?

The OGS sector has established itself as a high-impact, high-growth market. Yet few OGS companies are profitable today. Competition is only rising, and sources of differentiation are falling. The long-term prize, a market worth USD 8 billion by 2022, will continue to attract entry and funding, but as in other mature home electronics markets, only a handful of companies are expected to achieve profitability in each market. For those players seeking to be the leaders in the sector and deliver outsized returns, the following common traits are expected:

- **Global in reach:** Narrow geographic focus will lose to scale economies of global competitors as this study sees only superficial geographic customization needs for most OGS products.
- **Multi-product:** Customer acquisition costs make narrowly-focused product ranges uneconomical.
- **Imported**: Despite attempts to increase local manufacturing, interviews suggest that manufacturers expect China to remain the manufacturing base for an overwhelming majority of products. Overall, the direction of regulation on import fees/taxes will only support greater levels of international trade. Larger players, however, will continue to increase their capabilities in localized servicing.
- **Privy to advantaged capital:** Given thin margins, accessing a lower cost of capital will be key to moving faster and further than competitors. The leading firms in the sector will each have found a way to access cheap capital either through blended finance of patient and commercial capital and/or government-offered instruments. Companies today continue treating this as an ad-hoc function of fundraising. They quickly need to create a professional treasury role that focuses on accessing optimal off-balance-sheet financing and managing the deployment of those funds tightly.

However, no one model will dominate. Below, four distinct models that will have a competitive advantage in the long-run are characterized. While, in reality, many hybrids may emerge, the characterizations that follow serve as a guide and reflect elements already witnessed in leading companies today.

Model 1: The Energy Ladder Companion

What?

Such companies provide a full suite of energy products from entry level pico devices to large PnP SHS with a broad range of additional energy efficient appliance offerings. They focus on creating a lifelong brand association with users through customer engagement and by helping them transition up the energy ladder. These firms are especially active in moving customers from basic single light pico to multi-light pico devices, and potentially to more expensive and higher margin PnP SHS products. This typifies the evolution of many electronics products, where the choice of entry-level device and brand loyalty has an influence on a customer's future choices (as witnessed in the mobile handset wars over the last 10-15 years).[447]

Several companies are following this model in earnest. Leading pico players such as d.light and Greenlight Planet have introduced PAYGO SHS products, and are quickly migrating their customer portfolio to higher value systems (able to power TVs and higher-level appliances). At the same time, they continue growing their sizeable pico customer base, viewing this as a key entry-level asset that will eventually be upgraded.

[447] *Note: Research finds that repurchases of mobile phones are strongly linked to past experience and brand loyalty. Source: (Petruzzellis, 2008)*

Why?

The effort required to reach, educate, and ultimately convert a customer, is significant. Returning customers buy more products over time, reduce expensive customer acquisition costs, and often introduce new customers to the product line.

As described in Section 1A.1, converting a first transaction to a lifetime relationship provides a long-term return. The cost of marketing to get a customer to upgrade is often lower than the cost of acquiring a new customer, making it easier to increase the value of an existing relationship as opposed to making a new one. According to one company, having a breadth of products reduces per unit marketing costs. In addition to having a product for each level of the energy ladder, this strategy requires ongoing customer connections as well as a strong understanding of and ability to track the lifetime value of a consumer.

Success Factors?

1. **Strong entry product** (e.g. USD 5 pico light): Since this is the first customer touchpoint, the initial product will establish brand perception and set the foundation for future interactions. While a loss leader strategy employed in other industries is unlikely to suit a BoP market, entry-level products in OGS nevertheless tend to have the thinnest margins in percentage terms.

> "When we go into new markets, we really focus on the entry-level products. They build our brand and help us achieve scale."
> **- Affiliate supplier**

2. **Brand/quality consistency:** As some customers are migrated up the energy ladder, product familiarity and brand recognition become important to developing loyal customers. To develop this loyalty, quality needs to be established at the first purchase. While customers often prioritize pricing, they ultimately encounter the full brand experience, including the quality, after-sales service, and longevity of the product. Establishing a strong brand presence is especially important in the crowded pico space where competition is fierce.
3. **Flexible business model by geography.** Companies in this model run a variety of payment (PAYGO and cash) and delivery models (own, retail, hybrid) based on the needs of the market and the product segment. This flexibility in approaches will need to be maintained over the next five years to enable a global footprint that serves the distinct needs of each geography.
4. **Customer relationship management:** Each customer needs to be a repeat customer, and thus the energy companion needs to understand how to build a relationship with their customers after the initial transaction. This requires thoughtful processes on data capture, an outreach timetable for each customer (e.g. at estimated periods for upgrades), an understanding of the lifetime value of a customer, and a focused review of consumer needs. Importantly, as companies migrate into PAYGO, these systems need to also help companies understand who not to serve.

Model 2: The Banker

What?

A PAYGO SHS player focused on deepening a loan product relationship with customers, using OGS as an entry point. The firm may use a PAYGO model to finance OGS compatible appliances but the PAYGO business can also be extended to meet other consumer needs such as loans or other consumer goods. These companies can potentially act as a customer entry point for other financial organizations such as banks and insurance companies.

As discussed in Section 1D.3, companies have been making early forays to move beyond the provision of OGS systems and compatible appliances. For example, Fenix International have expanded their offering to other loans such as for education. Within the OGS appliance universe, companies such as Mobisol are moving toward offering productive use appliances, and are even piloting an 800W system targeted at businesses that run energy-intensive appliances such as welding machines and saws. This provides a rich market for offering sizeable loan products and enhancing the value of each customer acquired.

Why?

Heavy costs in establishing initial loan relationships. The initial customer acquisition cost is significant, as are the upfront investments required to run a PAYGO business. Given the long-term monitoring of the consumer's information as part of the credit risk process, these firms have an unparalleled advantage in collecting customer data in otherwise data-poor environments. This allows them to better upsell other products and become gatekeepers to the customer for other companies. Furthermore, the loans that they offer allow for the sale of larger and higher-margin products.

Success Factors?

1. **Big data analytics:** What different PAYGO companies can do with the customer data they collect through OGS use and payments will be key for extracting long-term value from an otherwise investment-heavy model. Strong capabilities to mine this data will support both product and service sales, while helping reduce portfolio risks.

   For instance, continuous repayment data allows companies to refine their credit assessment models and build a consumer profile, allowing for the segmentation of consumers by their credit risk. This, in turn, allows companies to offer upgrades and additional services to low-risk customers. As the database of customers grows and is further refined, it turns into an asset that could provide avenues for partnership with other product manufacturers and asset-financing companies, and could also potentially be sold to third-parties. As discussed in Section 1D.3, however, due attention will need to be paid to customer privacy as well as transparency in this regard.

2. **Banking capabilities:** PAYGO products sit at the integration of loan and OGS products. Companies that know how to rate the credit worthiness of their customers effectively, run smooth collections processes, and deal with delinquency will have a more attractive loan portfolio and thus attract cheaper and higher volumes of capital. Achieving this requires companies to focus on three areas that relate to their banking functions: internal capacity building, alignment of internal incentives, and customer incentives and risk assessment.

   - *The investment in internal capacity building encompasses all levels*, from management to collections agents. At the management level, expertise is required to control and monitor cash flows. This includes incorporating best practices in portfolio management and having a specialized credit risk

department (which runs sophisticated credit scoring and risk mitigation models) and a bad debts department.

- *At the front-end, sales and collections agents need to have common incentives* that don't promote short-termism at the cost of a risky long-term customer portfolio.
- *Finally, customers need to be incentivized as well,* as this could well be their first exposure to formal credit. For example, PEG Africa offers incentives to customers that repay regularly, such as free health micro-insurance, as well as additional credit for products such as a smartphone or a cook stove.

> "There is a parallel between the PAYGO market and the microfinance industry. Both are driven by credit quality. However, MFIs have a better handle of credit scoring than the off-grid space. PAYGO SHS companies are still changing the way that they vet credit risk. There is a lot of flux and companies are not sure what works – they are still trying to find the sweet spot in this dynamic. So far, microfinance has done a better job of consistently collecting data and having real credit processes in place."
> **- Funder**

3. *Technology advantage:* Lighting is fast becoming commoditized, and the PnP SHS space faces significant competition from component-based systems in certain markets. However, there remain significant opportunities to differentiate on the design and efficiency of larger appliances like TVs and refrigerators. Excellence in this area is important as smaller products are not financed, but large appliances are almost always purchased through PAYGO financing. Appliances extend beyond those that serve household needs to productive use appliances as well. However, even with PAYGO, many such appliances will remain beyond the reach of customers unless technology helps bring efficiency to such a level that a modest-sized PnP SHS can power the appliance.
4. *Advantaged financing:* With large upfront outlays and long payback cycles, cheaper capital is key to profitability, particularly in PAYGO. As discussed above, developing stronger internal banking capabilities will help earn the trust of investors, and many top PAYGO companies see the raising of cheap capital as a central function of their leadership.

Model 3: The Fast Follower

What?

An OEM or non-affiliate manufacturer that focuses on replicating tried and tested models and markets. Such players have a low-cost manufacturing base and limited investment in design, customer education, and proprietary distribution. Instead, such companies focus on providing good, established design at highly competitive prices, be it entry-level pico or larger PnP SHS (although PAYGO has to-date been out of their purview). Importantly, fast-followers are not synonymous with large-scale generic manufacturers. While some may start there, several such manufacturers are transitioning into brands in their own right.

Why?

The fast follower is a well-established strategy in electronics. It comes into its own once enough trust in the category is established – often by the demand stimulation measures (such as marketing and consumer awareness creation) undertaken by other companies. For example, in East Africa, substantial investments into marketing and consumer education were made by early entrants and market-building programs. Once trust and awareness in OGS devices began to take root, followers began to enter with a high-volume, low-margin approach well-suited for BoP markets. Additionally, OGS companies have limited intellectual property (except with respect to customer data and platforms related to PAYGO), which makes the fast-follower model even easier to execute.

Success Factors?

1. **Scale economies across multiple products:** Fast followers tend to leverage their broader manufacturing base (often for contract manufacturing) to access scale economies in the purchase of LEDs or batteries. The fact that many such companies have a product portfolio that extends to products beyond solar lighting (such as emergency lights, torches, and broader electronics) often provides them with even greater scale economies, enabling further cost reductions.
2. **Flexible manufacturing:** Fast followers are likely to try and sell multiple products, and will need to be able to change what they are selling quickly to follow new market trends. As they typically do not direct the market, they will need to react quickly to its changes.
3. **Distributor incentives and ability to leverage informal networks:** Such companies rarely invest in establishing their own distribution network but instead rely on master distributors to carry the load of marketing. These distribution models provide Fast Followers with large volumes, low costs, and speed to market. Typically, manufacturers provide goods on a wholesale basis to master distributors, who also distribute or forward marketing materials (such as fliers). For deeper geographic penetration, master distributors outsource to retailers. Both distributors and retailers have a significant amount of flexibility around margins and price-setting, making products attractive to stock. In other instances, wholesale distribution takes place at large marketplaces in cities that have access to deep, informal distribution networks with low transaction costs, high flexibility, and wide geographic reach.[448]

Model 4: The Value Chain Specialist

What?

Companies that are opting to achieve excellence on a specific part of the OGS value chain and outsourcing/ partnering on the rest. Models are emerging in all parts of the value chain, be it technology, distribution, manufacturing, or even financing.

Why?

The market is mature enough to allow for specialization, helping increase quality and leverage. In its early days, companies had to vertically integrate to account for lack of suppliers in various parts of the value chain. The move toward specialization will clearly help parts of the sector scale faster. For example, Renewit, a Hong Kong-based manufacturer, has sold between 2.5 to 3.5 million OGS products that it designs, engineers and

[448] *Source: (Anand, 2017)*
[449] *Source: (Hystra Hybrid Strategies Consulting, 2017b); industry interviews; Dalberg analysis*

manufactures for their own brand or for other clients to market and sell.[449] They report fast-growing sales with minimal investment in marketing and distribution.

At the front-end, SolarKiosk's business model of establishing solar-powered kiosks in rural areas which retail a diverse range of products (as opposed to solely OGS devices), has enabled it to focus on refining its distribution. Solar Kiosk has scaled to over 200 outlets in East Africa today (from a pilot in 2013) while outsourcing product design and manufacturing.

PAYGO platform technology specialists such as Angaza have been able to develop multiple variants of their platforms for PAYGO OGS products, and have scaled via manufacturer and distribution partners. Thanks to these technology specialists, their clients have essentially leapfrogged into PAYGO SHS without having to go through early growing pains associated with the segment (such as investing heavily in proprietary software). At the same time, one potential exit for such players is to be bought out by a market leader, as was the case with Lumeter, a technology specialist acquired by Mobisol.

Going forward, technology specialists will be able to scale further by expanding their offering to non-OGS products. Importantly, their specialized offering will help bring down entry barriers in the PAYGO segment.

Success Factors?

1. **Land grab:** One of the key offerings a specialist can provide to other OGS clients is scale economies. Whether it's a technology platform or a network of distribution points, scale will help make specialists the de-facto standard. Leading specialists will need to sacrifice margins for scale over the next five years. This also creates a strong self-reinforcing loop where specialists are more aware of market needs due to the wide application of their products. Technology specialists in PAYGO for example are likely to spot emerging technology needs and innovations faster when they serve multiple clients across multiple geographies.
2. **Client service:** While they may have grown from specializing in distribution, manufacturing, or technology, specialists will need to adopt a client service posture. The winning firms will have sales teams who know how to forge effective partnerships with other OGS segments. This is a skill that can even make up for a mediocre product in the short term; reaching scale quickly can help a mediocre product become a strong product later, as described in the land-grab point above.

While the above models will prevail in the market as it is today, it is worth considering where the market can be taken by those who lead. The paragraphs that follow take a more crystal ball approach to imagine a potential end game for leading OGS companies.

The authors' view of a potential future: From OGS to a consumer electronics company.

As avid followers, researchers, and advisors in the OGS space, the authors of this report have consistently felt that the sector has defined itself around a critical challenge, but in addressing that challenge, leading sector players have developed impressive and broadly applicable capabilities. The future of the sector lies in going beyond the initial clean, safe, and affordable lighting challenge.

[450] *Note: According to NetBase, a leading social analytics firm, technology brands were the 4th largest category among the 100 Most Loved Brands of 2017, after social media, e-commerce and entertainment. Source: (NetBase, 2017)*

[451] *Source: (Wells, 2016)*

Today, many of the world's most loved brands are electronics companies.[450] Electronics, and phones especially, don't simply occupy a huge amount of one's time, they also have the ability to form an emotional connection because of the nature of services they provide, whether it is communication to loved ones, a dose of entertainment, or enhanced productivity. The experience is visceral. For an off-grid household, experiencing a first electric lighting product is also a visceral experience.[451] Every great entrepreneur in the OGS sector describes the delight in their customers when they experience the shift from kerosene and candles to their first solar light.

The authors believe that just like the Walkman of the 80s, iPod of the 90's, and smartphones of this decade, this first touch with the customer can be translated into a strong emotional connection as long as the product delivers on quality. And that connection can translate across categories. Add-in PAYGO models which also collect mountains of data, and you not only have emotional connection, but also a better understanding of what that connection is worth and where else it can be applied.

Hence, leading OGS players have the ability to transform themselves into broader consumer electronics companies that have a DNA for making products work in tough conditions and frontier markets. This applies not only to the integrated B2C companies, but also to specialists in the value chain (e.g. PAYGO technology specialists) who can serve additional product segments. To get there, the best B2C companies will invest in brand architecture that focuses on the emotional level rather than just the product level. They will define themselves not by the products they create, but by the problems they solve and the feelings they create for their customers. Whether it's Apple, with its design DNA, or Maglite, with its law enforcement heritage, strong brand architecture is what has made these products ubiquitous (it is worth noting that like OGS products, both companies essentially make products that are versions of batteries connected to LED lights). The best specialists will broaden their partnerships and increase the flexibility of their models.

This study, by definition, focuses on the OGS sector, but the players within it don't need to. Energy provision itself promises to be lucrative, and all signs point toward significant growth in energy demand as the more than 430 million off- and un-reliable grid households globally experience the transformative shift to dependable energy access. But in the long-run, leading companies will leverage their brand and customer relationships to serve broader electronics needs. Investors, should take note as that is potentially an even bigger prize.

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APPENDIX A:

MARKET TRENDS REPORT 2018 IVR AND FIELD SURVEYS

Rationale and survey overview

Previous market reports have found it challenging to accurately estimate a number of measures related to the off- grid solar market, as target consumers typically live in data-poor environments. Chief among these are the prevalence of unreliable-grid access, the penetration of various product types (such as non-affiliate products), purchase patterns, as well as consumer satisfaction.

To date, many analyses on these topics have been hampered by small sample sizes or have been directional at best, depending on modelled assumptions. While this report has pulled insights from the available desk research as well as anecdotal reports from targeted interviews, a compelling need remained for better, more robust estimates on these topics.

To address these gaps, Lighting Global commissioned Dalberg to lead, manage, and analyze two means of primary data collection:

1. A large-sample, **mobile-phone-based interactive voice response (IVR) survey** of off- and unreliable-grid households;
2. A small-sample, **field-survey** of off-grid households owning OGS devices in last-mile locations.

The two surveys complemented each other to ensure maximum coverage of the target population, and to provide triangulation across survey methods and desk research.

Survey focus

Both surveys targeted households living in countries with significant data gaps about energy access and the OGS sector.

OGS market type	Africa	Asia
Mature	Uganda	India
Nascent	Nigeria	Myanmar

The surveys included a short set of streamlined questions. The IVR survey included questions on electricity access and reliability, current and prior OGS product ownership, channel of purchase, product name and price, whether the product was still usable and working, and customer satisfaction.

The field survey, conducted face to face, enabled deeper probing and therefore also included questions on the respondent's income, the number of products owned, whether they purchased the product component-by-component or a in plug-and-play package, whether they paid an installation fee, how they financed the device, factors driving their purchase, and whether they are still using the device and why.

IVR and field methodologies

IVR methodology: IVR (Integrated Voice Response) technology has been used increasingly by development agencies globally to pose questions to mobile-accessible populations in local languages. It involves the use of a human voice recording to ask survey questions via a mobile phone call, to which the survey participant can respond by pressing a number on the phone dial pad or by speaking their response, which is recorded and stored in a secure database.

With the exponential rise in mobile phone penetration rates across developing countries, including in India, Myanmar, Nigeria and Uganda, IVR surveys have emerged as a cost-effective and robust methodological tool with a number of advantages. They can be useful in places with low literacy rates since the survey questions are asked in a participant's local language. Moreover, the anonymity of IVR surveys may promote higher rates of disclosure on topics that are stigmatized. IVR surveys also offer a standardized survey experience for respondents (since the survey itself is pre-recorded), reducing the possibility that different interviewers may bias survey data.

In order to access respondents, the IVR survey operator used a Random Digit Dialer (RDD) to obtain a sample of potential mobile users. In geographies where number prefixes are assigned by location, RDD attempts targeted those areas with a higher propensity of solar use, as suggested by secondary data.

Of the numbers randomly generated, between 10% and 30% corresponded to active phone numbers. Upon answering the phone, participants selected their language, received a brief overview of the survey, and were prompted to select whether they would like to participate. Respondents then answered a series of automated questions about their access to and ownership of solar products using their dial pad and voice response.

Between 1,000-19,000 respondents opted to initiate the survey in each country, though caller drop-off and disqualification based on responses (e.g. not owning an OGS device) resulted in a reduction of the sample sizes following each question, with 150-1,500 respondents answering the final question in each country.

Field survey methodology: The field survey was intended to triangulate and deepen the findings from the broad-based IVR surveys and to reach households that may not have access to mobile phones. The survey teams randomly selected off-grid villages and households meeting the criteria for the survey. Heads of each household were interviewed about their solar purchase decision, and their OGS products were photographed to enable cross-verification of brand and product type. Approximately 100 survey respondents were reached in each country.

Conclusion

Responses from these surveys provided foundational data for analyses throughout the 2018 Market Trends Report, especially regarding unreliable-grid prevalence, and to develop estimates on the presence of affiliates, non-affiliates, and component-based systems. Findings were also used as reference points on electricity access, solar device penetration, device pricing, and consumer experience themes. Lighting Global and Dalberg will seek further opportunities to leverage the survey findings for future research on the OGS market.

APPENDIX B:

INDUSTRY EXPERTS INTERVIEWED FOR MTR 2018

- Acumen, Lean Data: Kat Harrison
- Acumen, Pioneer Energy Investment Initiative: Leslie Labruto
- Acumen: Alex Healy
- Angaza: Lesley Marincola
- Arc Finance: Chikako Fujita
- Azuri Technologies: Nigel Preston
- Barefoot Power: Rick Hooper
- BBOXX: Anshul Patel
- Brighterlite: Martin Hamann (formerly of Brighterlite Myanmar)
- CDC Group: Emma Hawkins and Geoff Manley
- Ceniarth LLC: Greg Neichin
- Consultative Group to Assist the Poor (CGAP): Daniel Waldron
- Collaborative Labeling and Appliance Standards Program (CLASP): Matt Jordan
- Commercial Bank of Africa: William Muguima
- Council on Energy, Environment and Water (CEEW): Abhishek Jain
- Climate Policy Initiative (CPI) Climate Finance: Cameron Carswell and Federico Mazza
- d.light: Ned Tozun and Gaurav Himkar
- Developing World Markets: Robert Constantino
- DOEN foundation: Saskia Werther
- EcoEnergy: Shazia Khan
- Ecozoom: Ronald Van Haarten
- Electrification Financing Initiatives: Frederik van der Bosch
- EnDev/Netherlands Agency, Energy and Climate Change: Derk de Haan
- EnDev/SNV: Josh Sebastian
- ENGIE Rassembleurs d'Energies: Loic De Fontaubert
- Fenix International: Caitlin Burton
- GIZ: Caspar Priesemann
- GOGLA: Koen Peters, Johanna Diecker, Susie Wheeldon, Laura Sundblad
- Greenlight Planet: Anish Thakkar and Ben Matthews
- GSMA: Ilana Cohen
- Helios Investment Partners: Ogbemi Ofuya
- Humboldt State University, Schatz Energy Research Center: Arne Jacobsen, Meg Harper
- Hystra: Francois Lepicard
- IDCOL: Md. Monirul Islam
- IFC, Lighting Global: Russel Sturm, Arthur Itotia Njagi, Naomi Bruck, Leo Blyth, Rahim Kanani
- IFC, Lighting Bangladesh: Muhammad Taif UI Islam
- IFC, Lighting Ethiopia: Aster Mihret Zewdie
- IFC, Lighting Asia-India: Anjali Garg, Rajeev Palakshappa, and Praviin Kumar
- IFC, Lighting Kenya: Nana Nuamoah Asamoah-Manu
- IFC, Lighting Myanmar: Bill Gallery Tun Zaw Myint, Tha Nyan To
- IFC, Lighting Nigeria: Allwell Okechukwu Nwankwo

- IFC, Lighting Pakistan and Afghanistan: Marco Indelicato, Umul Awan, Efrem Ferrari, Ibrar Khattak
- IFC, Lighting Papua New Guinea: John Solok
- IFC, Lighting Tanzania: Andrew Abduel Mnzava
- Independent distributor for G.D.Lite in Kenya: Antony Mwangi
- International Energy Agency: Hannah Daly
- Kenya Ministry of Petroleum and Energy: Eric Mwangi
- Lendahand: Tobias Grinwis
- Lumos Global: Ron Margalit
- M-KOPA Solar: Pauline Guthigu
- Mobisol: Thomas Duveau
- Nadji.Bi: Julien Potron
- Off-Grid Electric: Jessica Eastling and Joshua Pierce
- Oikocredit: David ten Kroode
- Omnivoltaic Energy Solutions Co. Ltd.: Huashen Wang
- ONergy Solar: Nirmal Mohanty
- PEG Africa: Nate Heller
- Persistent Energy Capital: Chris Aidun
- Proparco: Loic Perret
- Renewit: Richard Atwal
- Responsibility Investments AG: Vivian Kotun
- Simusolar: Marianne Walpert
- SolarAid/SunnyMoney: John Keane and Jamie McCloskey
- SolarHome: Mia Bedrenets
- SolarKiosk: Thomas Rieger
- Solinc: Haijo Kuper
- Stanbic Bank: Stephen Lovell
- Sunfunder: Nico Tyabji and Isabelle de Cointet
- Sunny Irrigation: Rick Sheridan
- TIL Ventures: Erik Simanis
- Total Awango: Gregory Durand and Ted Mugisa
- Trine: Andreas Lehner
- UNCDF: Robin Gravesteijn
- USAID, Power Africa: Maria Rivera and Katrina Pirelli
- USAID, Scaling Off-Grid Energy Grand Challenge for Development: Sarah Bieber and Molly Doyle
- World Bank, Africa Energy Practice: Raihan Elahi
- World Bank, ESMAP: Dana Rysankova
- World Bank: Corinna Bordewieck, Farah Mohammadzadeh

APPENDIX C:

LIGHTING GLOBAL ASSOCIATES AND GOGLA MEMBERS

IFC Lighting Global Associates (December 2017)

Manufacturers
AEG International
All Solar Lights
All Weather Solar Technology Co
Anji Dasol Solar Energy Science Technology Co. Ltd.
Azuri Technologies Ltd.
Barefoot Power Ltd.
BBOXX
Brighterlite
d.light design
EcoZoom
fosera Group
Freeplay Energy
Greenlight Planet
Lagazel
Little Sun
Mibawa Suppliers Ltd.
M-KOPA Solar
Mobisol
MPOWERD
Nadji.Bi Group
Niwa - Next Energy Products Ltd.
Nokero
OffgridSun
Omnivoltaic Energy Solutions Co Ltd.
Orb Energy
ovSolar (Omnivoltaic Power Company Limited)
Philips Ltd
RAL Consumer Product Ltd.
Renewit Solar Limited
Shamba Technologies
Shanghai Easy Renewable Energy Co
Solarworks
Speedtech Energy
Villageboom GmbH
WakaWaka (Off-Grid Solutions)
Zhejiang Holley
Zimpertec

Distributors
Bimas
CIT
Devidayal Solar Solutions Private Limited
Dharma Life (Gajam India Pvt. Ltd.)
Digicel
EcoEnergy Solutions
Equity Bank
Ethio Addis Trading Agency
Frontier Markets
Interoil
Lydetco
Onergy (Punam Energy Pvt. Ltd.)
Origin Energy
RAFODE (Rural Agency for Development)
Rensys Engineering
Solar Development
Solar Sister
Solar Solutions
Solar Women
SolarHome
SolarKiosk
STM
SunnyMoney
Total
VEP (Visionary Empowerment Programme)
Vera International

GOGLA Members (December 2017)

Acumen Fund
AESP Green Energy
Andrew Reicher
Angaza
ARESS Sarl
Azimuth
Azuri Technologies Ltd.
Baobab+
BBOXX

Benvell HK
BioLite
Blue Haven Initiative
Bright Life by Finca
BRIGHT PRODUCTS AS
BUREA
CDC Group
CLEAN
CREEC
d.light design
Deutsche Bank
Developing World Technologies
DgridEnergy
EcoEnergy
EcoZoom Limited
Energy Access Ventures
Energy Private Developers
Engie - Rassembleurs d'Energies
Enlight
Fenix International
FMO
fosera GmbH & Co.KG aA
Fraunhofer ISE
Freeplay Energy
Frontier Markets
GAIA Impact Fund
Greenlight Planet
IFC
James Norman Bardsley
JUA Energy
Jua Solar
KEREA
Lagazel
Lendahand
Little Sun
Lumi
Lumos Global
M-Kopa
Mobisol
M-PAYG
Mwezi Limited
Nadji.Bi Group
NewLight Africa
NIWA Solar Products
Nizam Energy
Nokero International Ltd.
NOTS Impact Entrepreneur
Off Grid Electric
Omidyar Network
Omnivoltaic Energy Solutions
One Degree Solar
Oolu Solar
OPES Solution Ltd.
OSRAM AG
ovSolar
Pamoja Life
Pawame
PEG Africa
Persistent Energy
Peter Gutman
Philips Lighting B.V
Plug the Sun
Power for All
Qotto
Rahimafrooz
RAL
REAN
REAZ
REIAMA
Renewit
ResponsAbility
Shell Foundation
SIMA - Social Investment Managers and Advisors
Simpa Networks
Simusolar
Sinoware Technology
Smarter Grid International
Solar Aid
Solar Energy Development Association-Ethiopia
Solar Kiosk
Solar Way
SolarHome
Solaris OffGrid
SolarNow
SolarWorks
Sologrid
SOSAI Renewable Energies Company
Stichting DOEN
Strathmore Energy Research Centre Kenya
Sun Transfer GmbH
SunFunder
Sunlite
Sunna Design
SunStream technology
Super Star Group
TAREA
Total - Access to Solar
TRINE
UpOwa
Videre Global
Village Power
WakaWaka
Wolfgang Gregor
Zonful Enterprises

APPENDIX D:

LIGHTING GLOBAL QUALITY ASSURED PRODUCT LIST

Lighting Global Quality Verified Pico Solar Products—December 2017

AMPED INNOVATION

WOWsolar family

WOWsolar 60

ALL SOLAR LIGHTS

All Solar Lights

ALL WEATHER SOLAR TECHNOLOGY CO.

Solar Lantern

ANJI DASOL SOLAR ENERGY SCIENCE & TECHNOLOGY CO. LTD.

SSL200

AZURI TECHNOLOGIES LTD.

Indigo Duo Solar Home System

10W Quad Solar Home System

15W Quad 600

BAREFOOT POWER PTY LTD

Connect 600

Go 250 / Go 255

Go 150

BIOLITE INC.

Solar Home 620

BRIGHTERLITE

L4

BRIGHT PRODUCTS

SunBell

SunBell 2.0

CAA COMMUNICATIONS AND ACCESSORIES INT GMBH

Solar Lantern L10

D.LIGHT DESIGN

A2

S100

S2

S3

S20

S30

Solar Lantern S300B

D20/D20-g

D30

D34

D33X Family

D330/D330R

ECOZOOM

Radio Lamp

Multi Light

Single Solar Light

EcoZoom Family

FOSERA GROUP

Pico Solar Home System 3000

Pico Solar Home System 7500

Pico Solar Home Systems Family of Products

Mobile One

FREEPLAY ENERGY

Energy Hub

Radiance Solar Lantern

GREENLIGHT PLANET

Sun King Home 60 / Sun King Home 60 Easybuy

Sun King Home 120 / Sun King Home 120 Easybuy

Sun King Home Family of Products

Pro X Plus

Sun King Pro Easybuy / Sun King Pro X

Sun King Mobile

Sun King Charge / Sun King Pico 50

Sun King Eco

Sun King Pico

Sun King Pro 2

Sun King Pro All Night

Sun King Boom / Sun King Boom Easybuy

Sun King Home 40Z / Sun King Home 40Z Easybuy

JUA ENERGY

Free Light L2

Free Light L2+

Home Mate H1 / Home Mate H1G

Free Light 1

LAGAZEL

Lagazel Kalo 1500

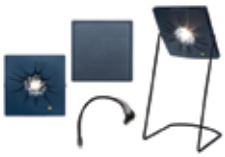
Lagazel Kalo 3000

LITTLE SUN GMBH

Charge 2200

Little Sun

Charge 4400



Little Sun Diamond

M-KOPA SOLAR

M-Kopa 4

MIBAWA SUPPLIERS LTD.

Solarpack 3

MPOWERD

Luci EMRG

Luci Original

NADJI.BI GROUP

Zebu v.1

NIWA - NEXT ENERGY PRODUCTS LTD.

Multi 300XL

Multi 100 Plus

Uno 50

Office 200 X2

MSS-Modular Solar Systems

NOKERO

Solar Light Bulb

NRS ENLIGHT FZE

Solar Smart All-in-one / Solar Shelter Kit

NURU ENERGY

NL3

OFF GRID ELECTRIC

M-Power M30

OFF-GRID SOLUTIONS BV

Waka Waka Light

OFFGRID SUN

Energy Station Plus

Energy Station Basic

OMNIVOLTAIC ENERGY SOLUTIONS CO. LTD.

ovCamp HS2-36_LB1122

ONE DEGREE SOLAR

Bright1

ORB ENERGY

Solectric 10

Solectric 15

Solectric 30

OVSOLAR (OMNIVOLTAIC POWER COMPANY LTD.)

OvBeacon MB2-090

OvBeacon MB2-200

OvBeacon MB2-290

OvBeacon MB2-380

OvBeacon MB2-160

OvPilot X

PANASONIC CORPORATION

Solar Lantern

PHILIPS

LifeLight Plus

LifeLight Home

POLY SOLAR TECHNOLOGIES CO. LTD.

3W Mini Solar Power System

10 W Solar Home System

RAL CONSUMER PRODUCTS LTD

Solar Lantern

RENEWIT SOLAR LTD.

Solar Homework Light

RENEWIT SOLAR LTD / NEWLIGHT AFRICA

Heya Happy Home / Solar Home Power Station with 2 Light Bulbs

RENEWIT SOLAR LTD / POWER EQUATION

Solar Home Power Station with 3 Light Bulbs

Solar Home Power Station with 3 Light Bulbs and Flashlight

Solar Home Power Station with 3 Light Bulbs, Radio, and Flashlight

G1 Solar Power Lantern with Phone Charger

G3 Solar Power Lantern

SCHNEIDER ELECTRIC INDUSTRIES SAS

Mobiya TS170S

Homaya Solar Home System S01

Homaya Solar Home System S02

SHAMBA TECHNOLOGIES

io Battery 100 Set

SHANGHAI EASY RENEWABLE ENERGY CO

Solar Home Light Kit

SHENZHEN SOLAR RUN ENERGY CO. LTD.

Solar Reading Lamp

SKYPOWER HOME

Skypower Home Solar Kit Radio 1-5W

Skypower Home Solar Kit Radio 2-10W

SOLARWAY

Solar Home Power System

SOLARWORKS!

Solar Power Ball

Solar Rooflight

SPEEDTECH ENERGY

Mini Solar Light Bar

TEAM PLANET

Striker United

THIRD WAVE POWER

Jungu

TRUE SOLAR USA INC

Melody

Harmony

VILLAGEBOOM GMBH

Villageboom High Power

YINGLI GREEN ENERGY EUROPE GMBH

SM100

Lighting Global Quality Verified Solar Home System Kits—December 2017

AEG INTERNATIONAL

GoSol Firefly 12

BAREFOOT POWER LTD

Connect 3050

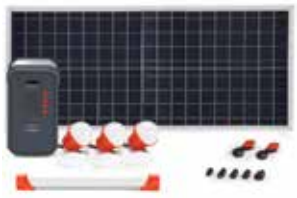
Connect Systems
Family of Products

BBOXX

BBOXX Home

D.LIGHT DESIGN

X740



X850

FOSERA GROUP

LSHS 7500

FOSERA GROUP (continued)

LSHS 10500

LSHS Family

MOBISOL

Mobisol Family
SHS–19”TV

OFF GRID ELECTRIC

M-Power M120

M-Power
Family of Products

OMNIVOLTAIC ENERGY SOLUTIONS CO. LTD.

OvCamp Solar
Home Systems
Family of Products

OvCamp HS2-
144_LB2244

ZIMPERTEC

Litio Solar Home
System Kit / LS70000-K1

Download the full report at www.lightingglobal.org

LIGHTING GLOBAL
Catalyzing markets for modern off-grid energy

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THE WORLD BANK IBRD • IDA | IFC International Finance Corporation

www.lightingglobal.org

GOGLA
The Voice of the Off-Grid Solar Energy Industry

www.gogla.org

ESMAP
Energy Sector Management Assistance Program

www.esmap.org

Dalberg Advisors

www.dalberg.com