OFF-GRID SOLAR MARKET TRENDS REPORT 2018

GRAPHS

February 2018

LIGHTING GLOBAL
Catalyzing markets for modern off-grid energy

AN INNOVATION OF
WORLD BANK GROUP
THE WORLD BANK
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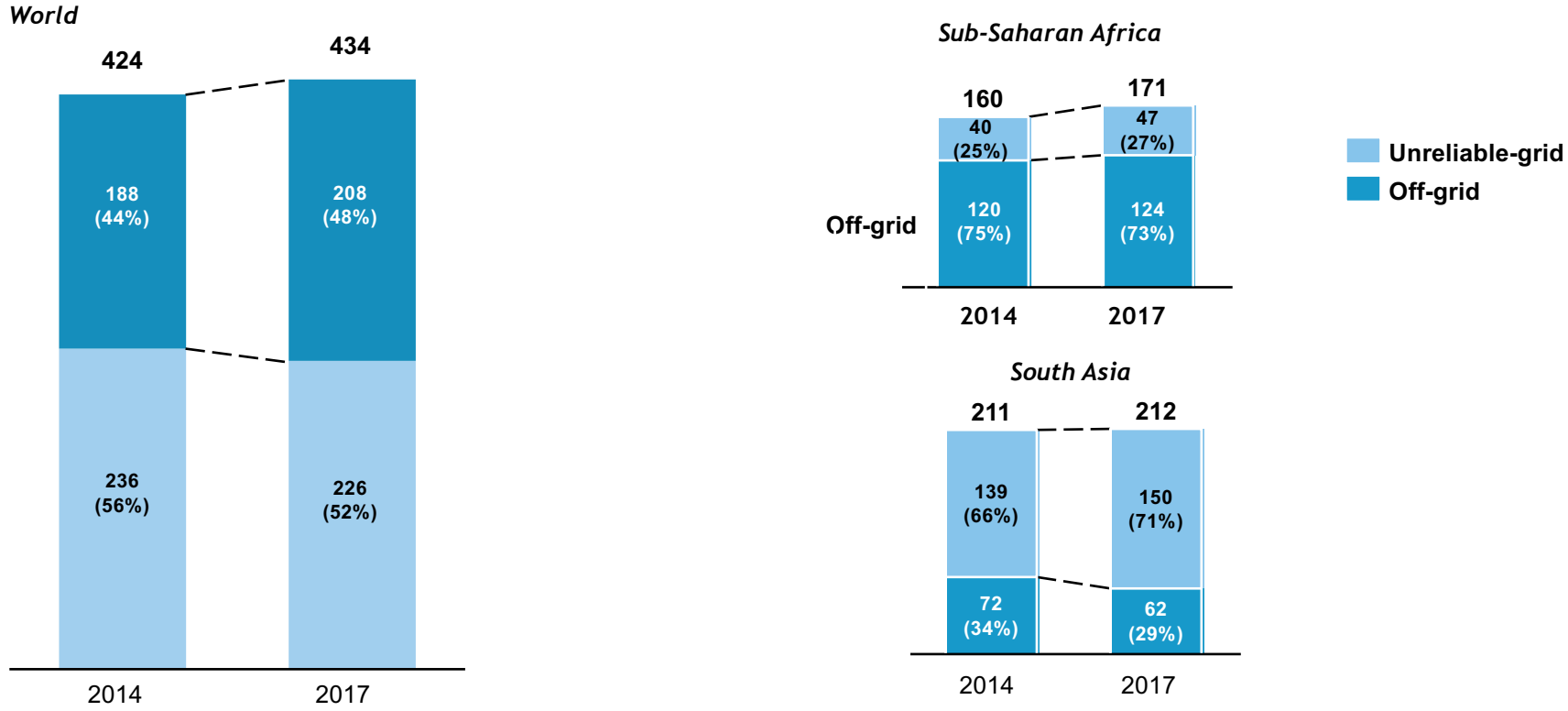
IFC International Finance Corporation

1A: Market Fundamentals

Despite a decline in the off-grid population, the potential OGS market has increased since 2014 driven by the rising unreliable-grid population

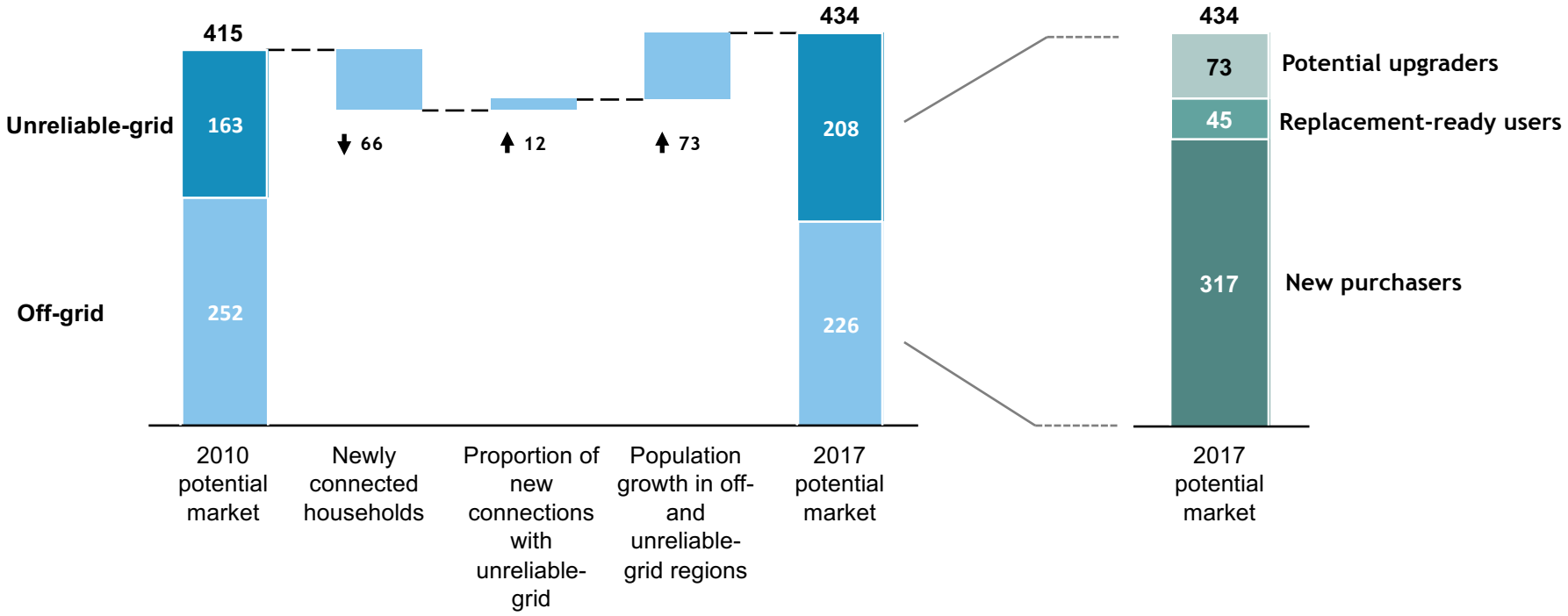
Global potential market
Million households (2014-17 est.)



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 25 in full report. Source: (International Energy Agency, 2016); (International Energy Agency, 2017a); Dalberg market model and analysis

The potential market increased by 20 million since 2010 as population growth offsets electrification efforts, 70%+ of market will be first time buyers

Change in potential market
Million households (2010-17 est.)

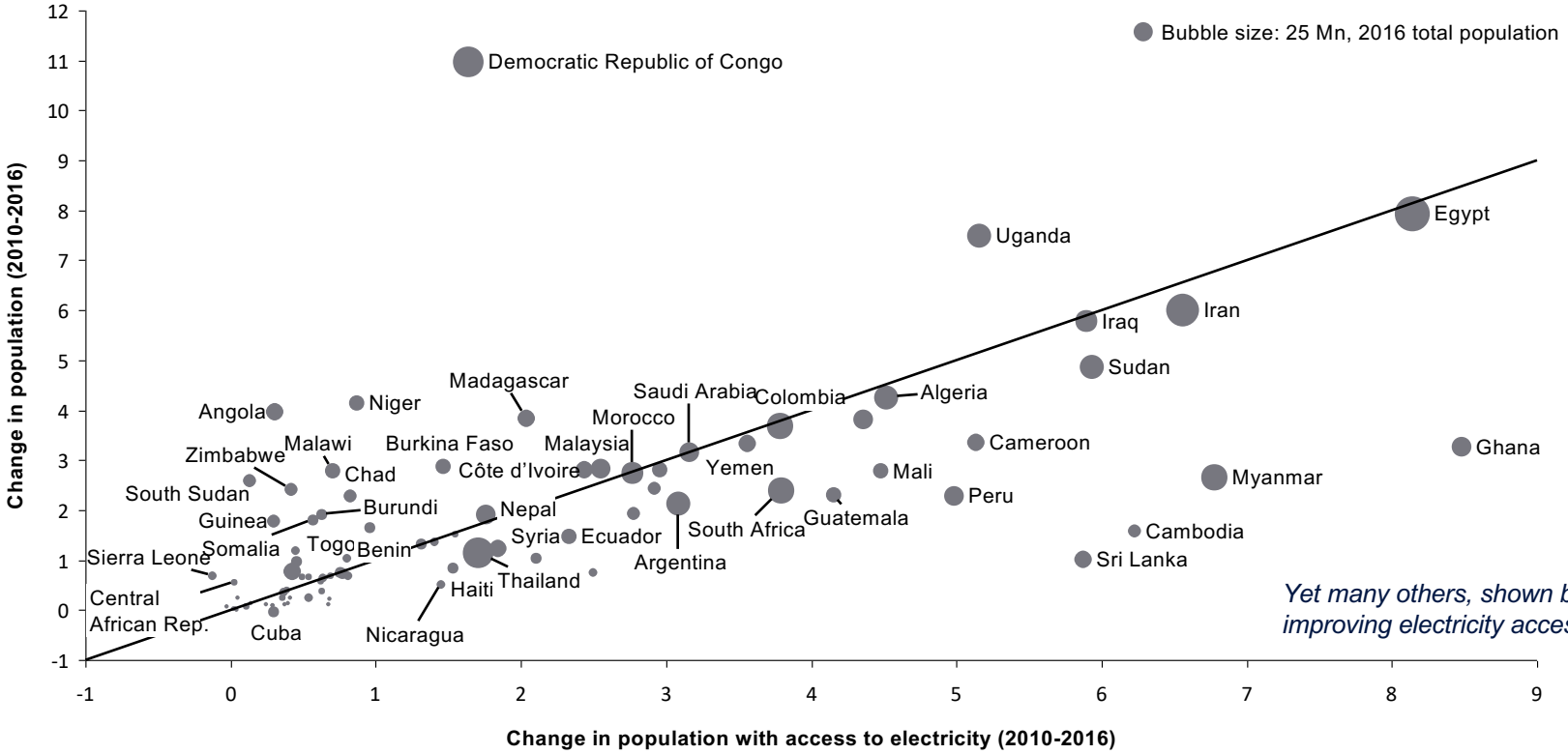


Note: An estimated 317 million households have not yet purchased an OGS device. 45 million purchased a device between 2010-2014 that is now expiring, based on an assumed three-year product lifetime. 72 million households have purchased an OGS device within the past three years, but could be targeted for upgrades. 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 24 of full report. For total sales estimation methodology, see Section 1B of full report. Source: (International Energy Agency, 2016); (International Energy Agency, 2017); (United Nations, 2014); Lighting Global/GOGLA sales data; Dalberg market model and analysis

The impact of population growth on the electrified population generally follows a correlated trend, but some countries have been exceptional

Population growth and growth in population with electricity
Million people (2010-16)

In countries above the line, population growth has inhibited progress in electrification

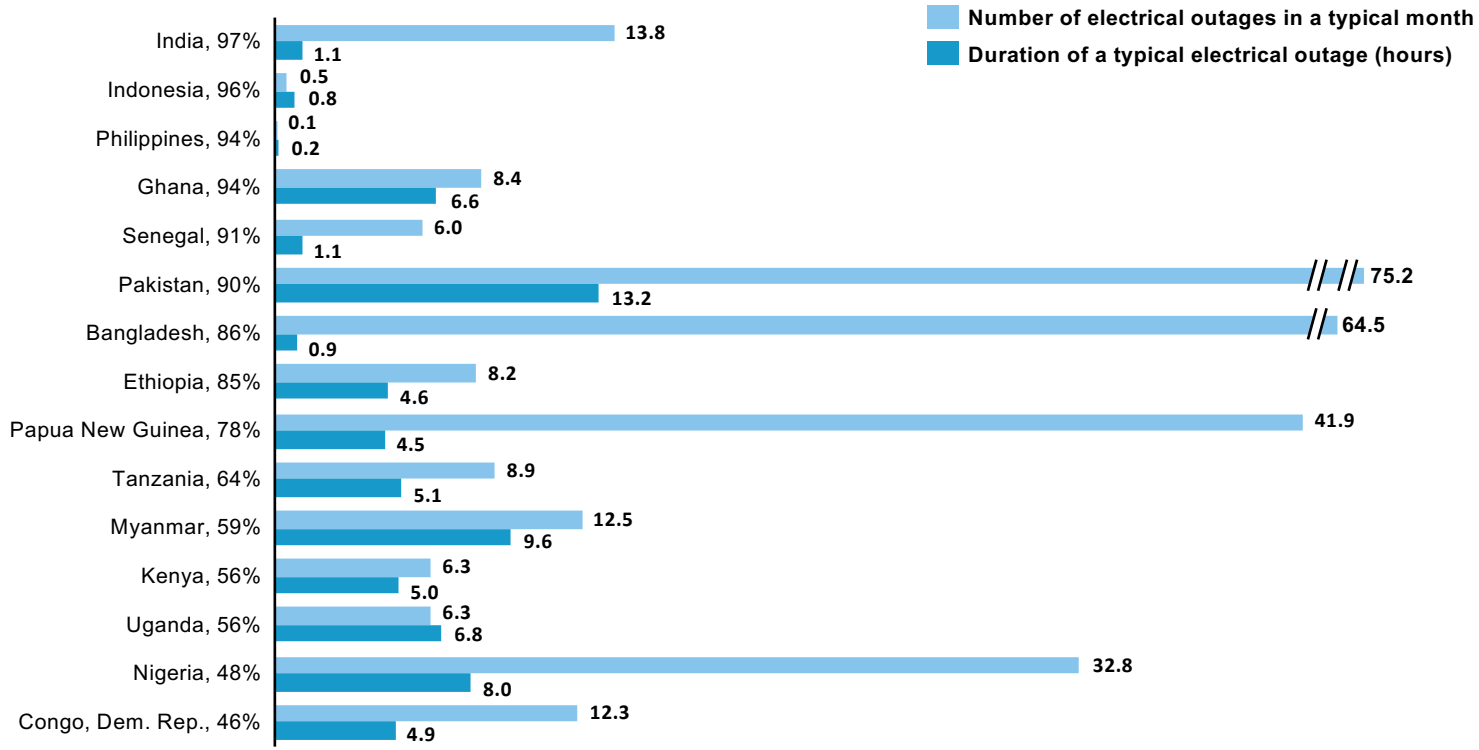


Yet many others, shown below the line, have succeeded in improving electricity access despite demographic pressures

Lack of reliable grid power is an issue across Asian and African markets, regardless of gris electrification rates

Urban grid reliability

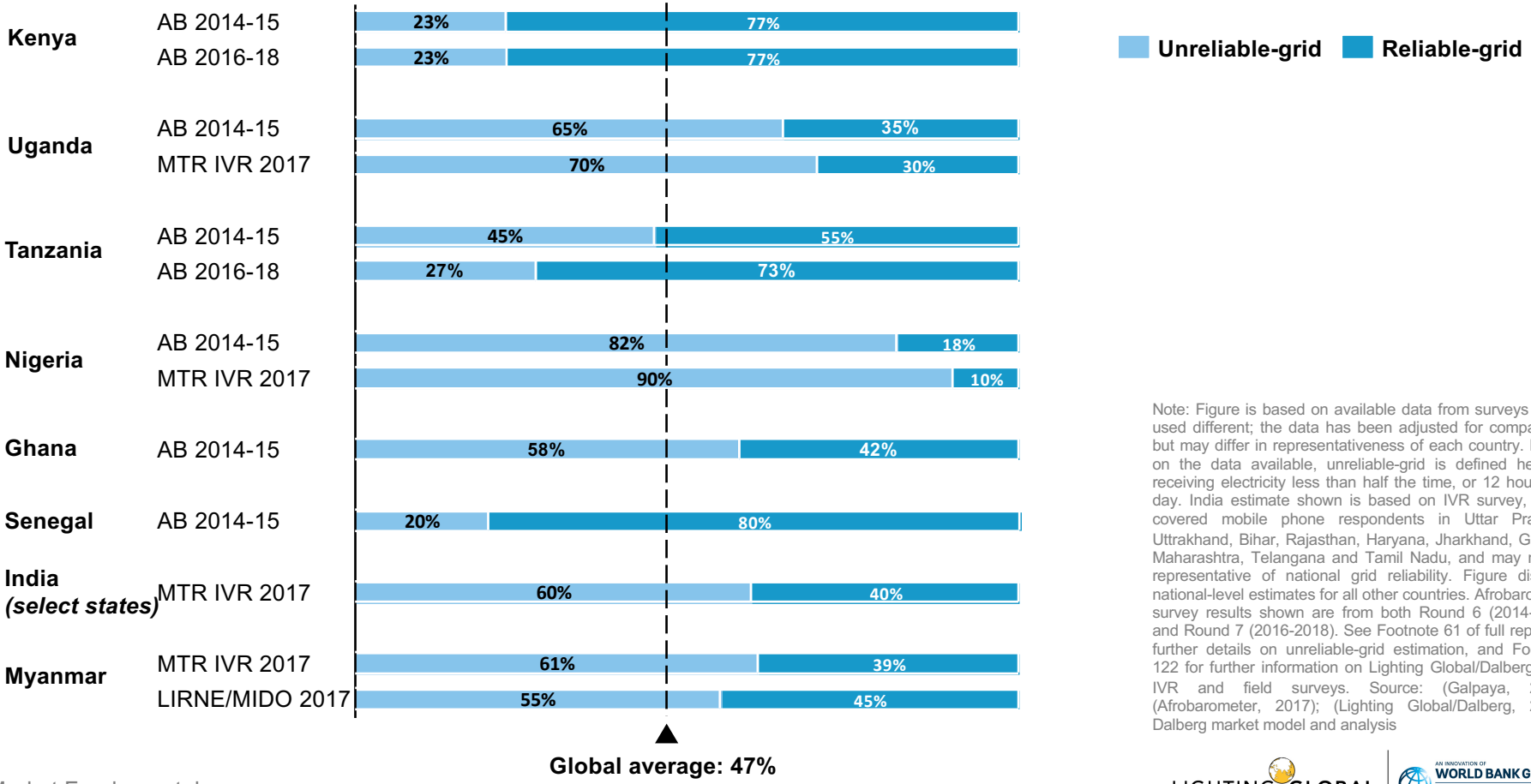
% urban grid access; select countries (2013-15)



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

An estimated 47% of the on-grid population has unreliable-grid across the major OGS markets

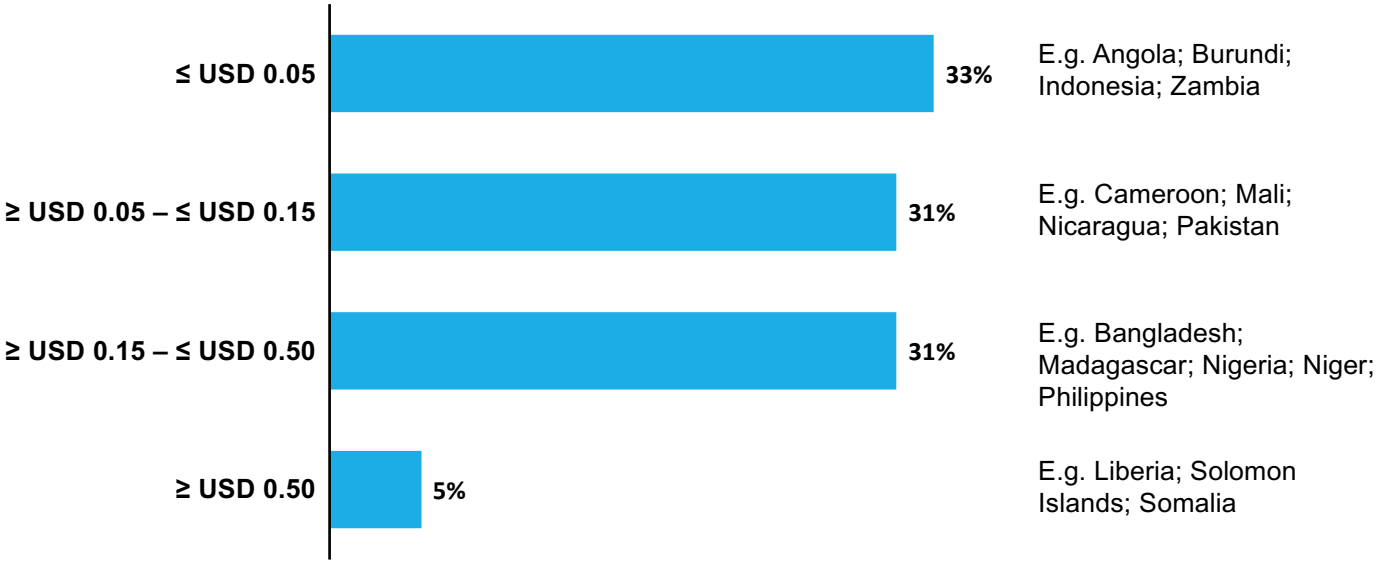
Electricity availability among households with grid access
% of on-grid households; select countries (2014-17)



Note: Figure is based on available data from surveys which used different; 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 IVR survey, which covered mobile phone respondents in Uttar Pradesh, Uttrakhand, 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 61 of full report for further details on unreliable-grid estimation, and Footnote 122 for further information on Lighting Global/Dalberg MTR IVR and field surveys. Source: (Galpaya, 2016); (Afrobarometer, 2017); (Lighting Global/Dalberg, 2017); Dalberg market model and analysis

Those who have grid access often face high tariffs for electricity

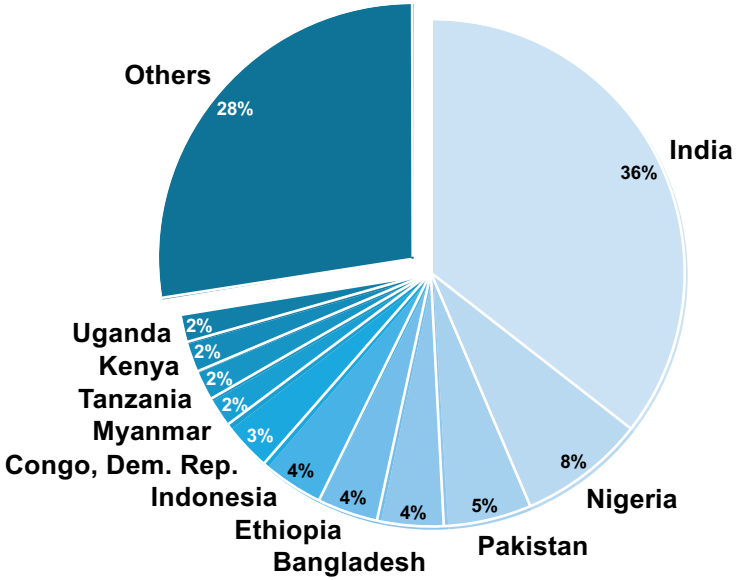
Cost of subsistence electricity consumption across 55 energy-access deficit countries
USD/kWh for 30 kWh monthly consumption



Source: World Bank RISE 2016

India, Nigeria, and Pakistan comprise nearly half, and 11 countries combine for nearly three quarters of the total OGS potential market

Countries with largest potential markets
Million off- and unreliable-grid households (2017 est.)

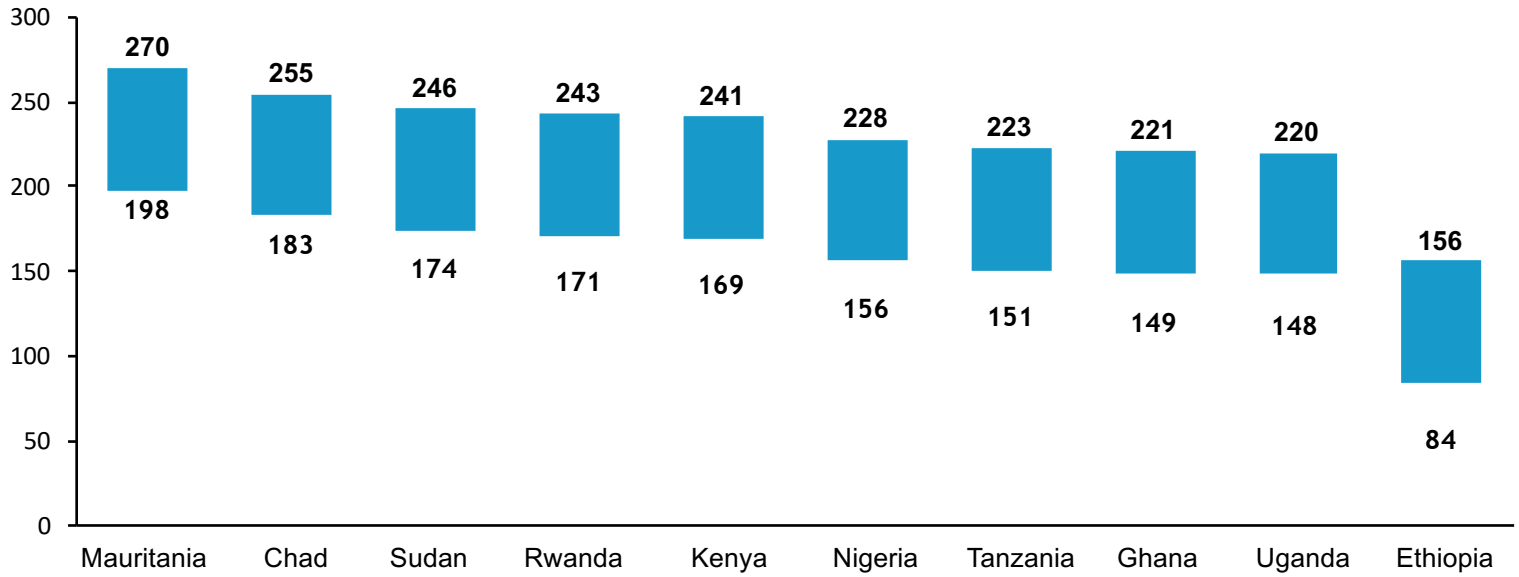


Total global potential market of 434 million households

Note: For unreliable-grid estimation methodology, see Footnote 24 of full report . Source: (International Energy Agency, 2016); (International Energy Agency, 2017); Dalberg market model and analysis

Across Sub-Saharan Africa, the potential households saving arising from using OGS products are considerable

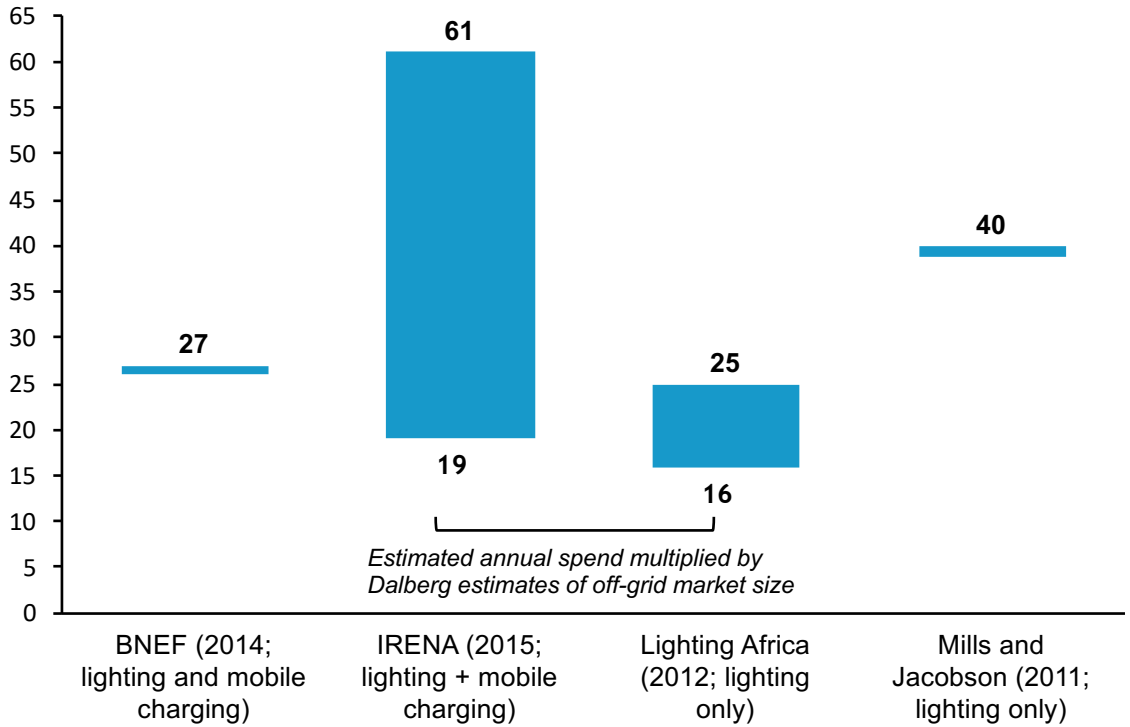
Annual off-grid household expenditure on traditional lighting sources and mobile phone charging
USD; (2015)



Source: (IRENA, 2016b); Dalberg analysis

Multiple estimates point to a potential market, of between UDS16 – 61 billion dollars, for OGS products which replace lighting and mobile charging

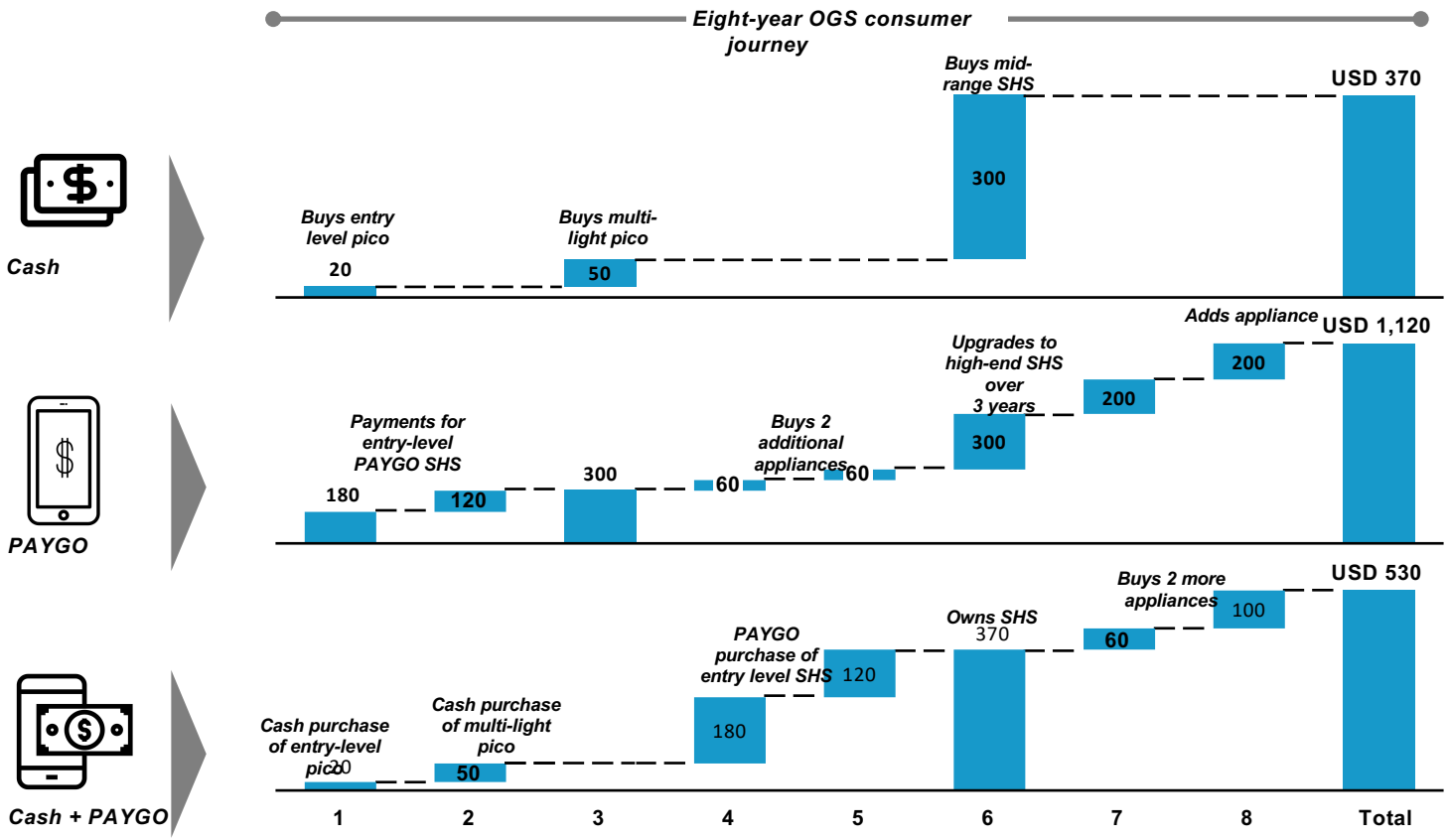
Estimated annual spend on lighting and mobile phone charging by off-grid households
USD billions



Source: (IRENA, 2016b); (Mills & Jacobson, From carbon to light: a new framework for estimating greenhouse gas emissions reductions from replacing fuel-based lighting with LED systems, 2011); Lighting Africa (2012) referenced in (Acumen, 2017c); Dalberg analysiss

Using PAYGO can nearly triple the lifetime value of a consumer relationship when compared to straight forward cash sales businesses

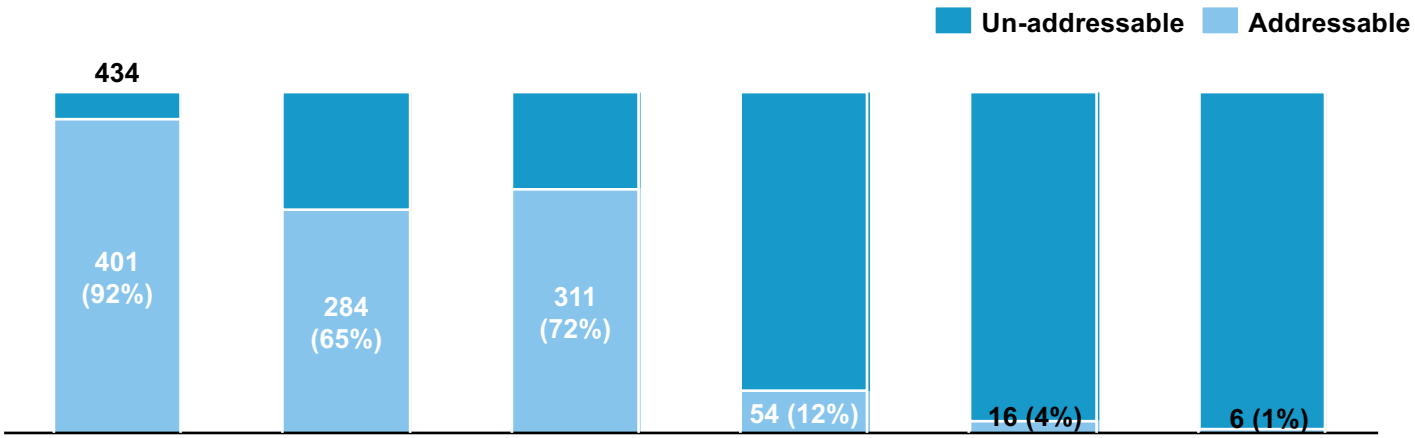
Lifetime value of potential off-grid solar consumers – illustrative



Note: Icons sourced from The Noun Project

3 – 10 watt OGS systems represent the largest potential market as PAYGO financing driven affordability allows these products to reach a wide market

Estimated global addressable market based on affordability
Millions, households (2017)

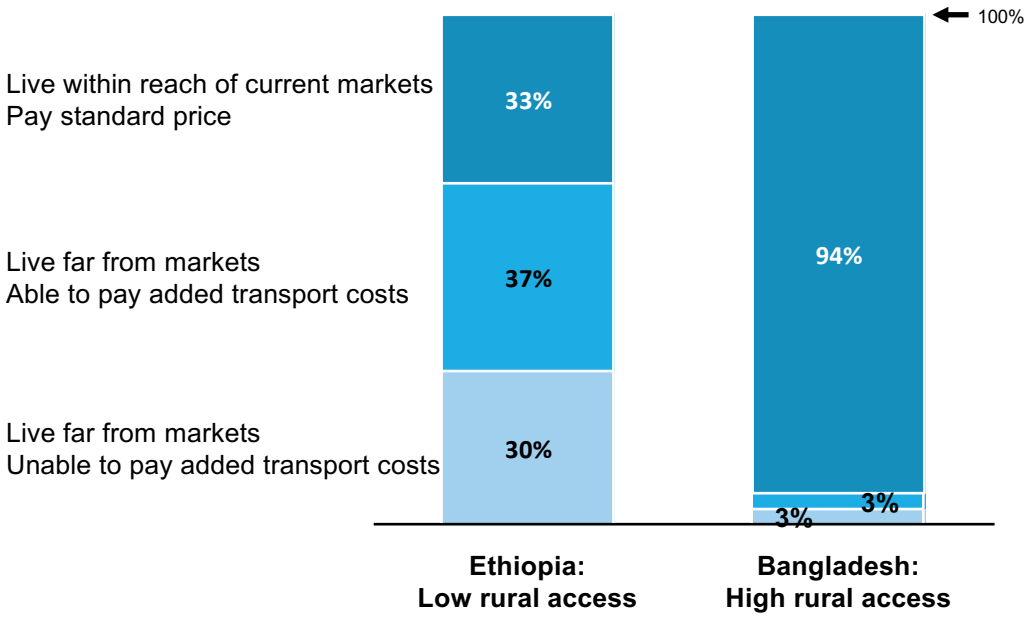


	Single light (~0-1.5 Wp), CASH	Single light + mobile charger (~1.5-3 Wp) CASH	Multi light + mobile charger (~3-10 Wp), PAYGO	11-20 Wp (Entry-level SHS), PAYGO	21-49 Wp (Basic SHS), PAYGO	50-100 Wp (Medium SHS), PAYGO
Price (USD)	5	25	20 (deposit)	36 (deposit)	53 (deposit)	102 (deposit)
Market size (USD, Bn)	0.7	2.3	18.9	5.7	3	1.8

Note: Estimated annual market size based on average total cost of ownership (assuming a 3-year product lifespan), 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 $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. Source: Dalberg market model and analysis (see sources and methodology in Table 3 of full report).

Regional pricing reflect transportation costs shrinking the country-wide addressable markets by between 3 – 30%

Reachable market for single light + charger pico
% of addressable market for ~1.5-3Wp pico at a USD 25 standard price



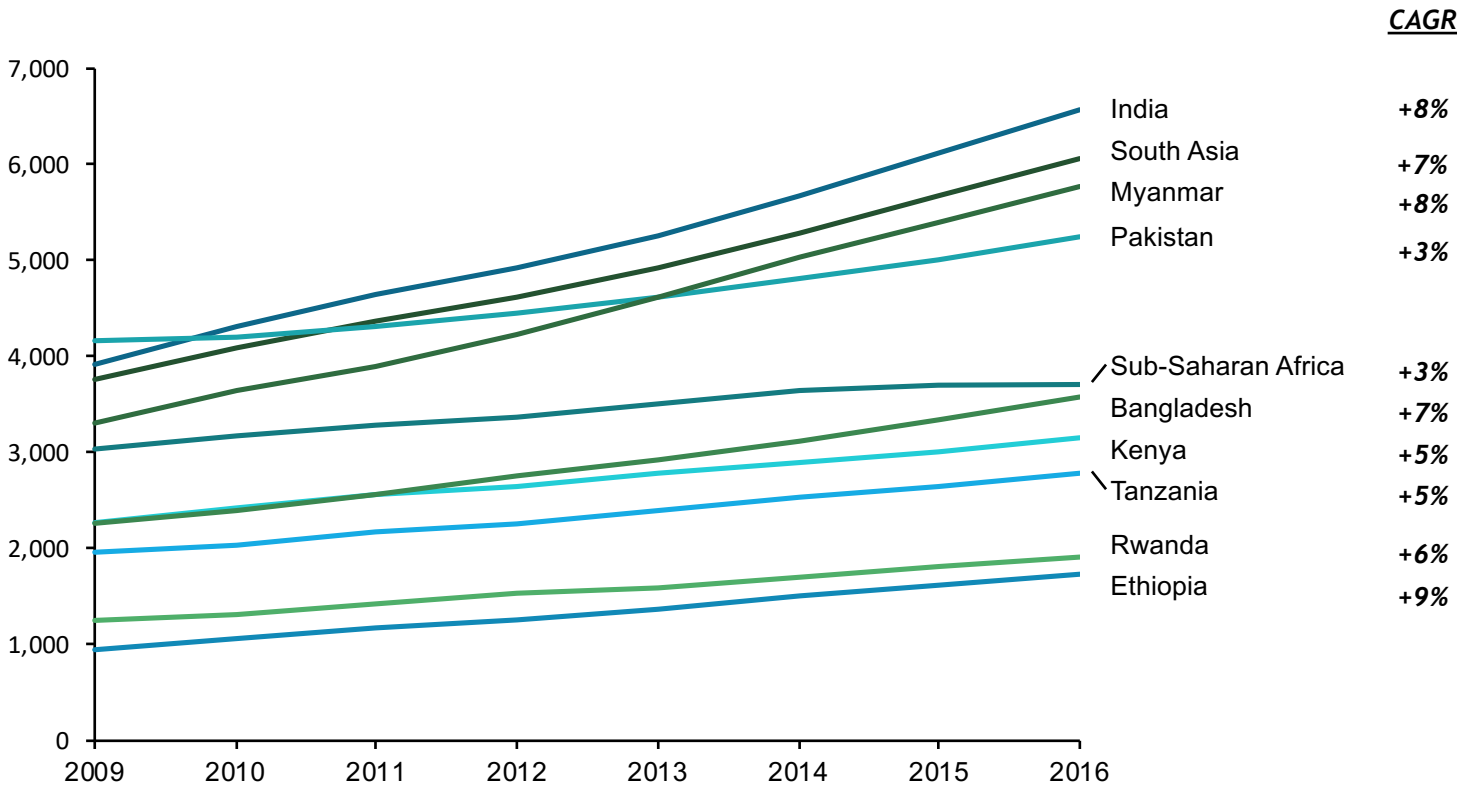
Ethiopia and Bangladesh represent extremes in rural access.

Most countries' reduction in the addressable market will fall between 3% and 30%.

Source: Dalberg market model and analysis (see Table 3 of full report for full methodology and sources)

The Asian addressable markets are larger, in part reflecting higher GDP/capita than SSA markets, which have not been catching up over the past decade

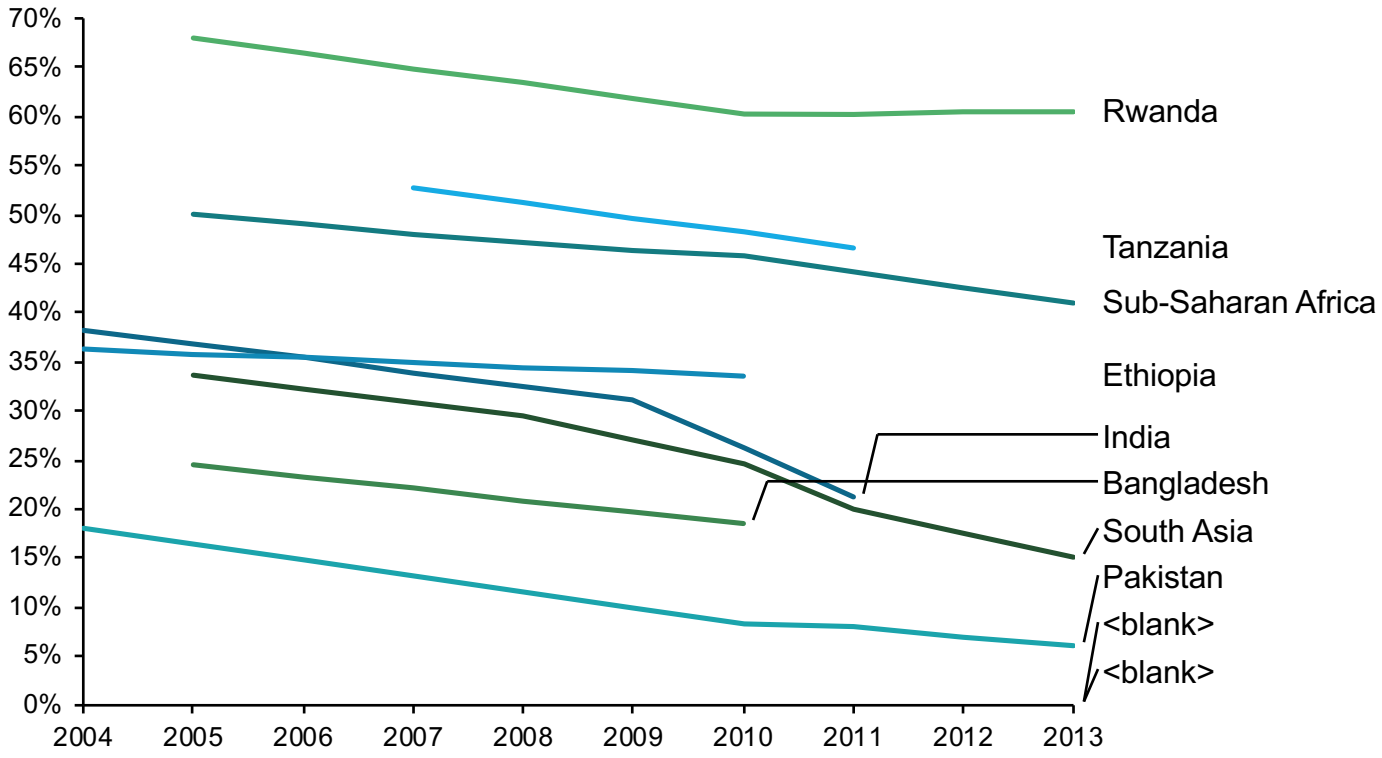
GDP per capita
2011 PPP (current international $); select countries (2009-2016)



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

Poverty headcount has fallen in all markets increasing the size of the addressable market

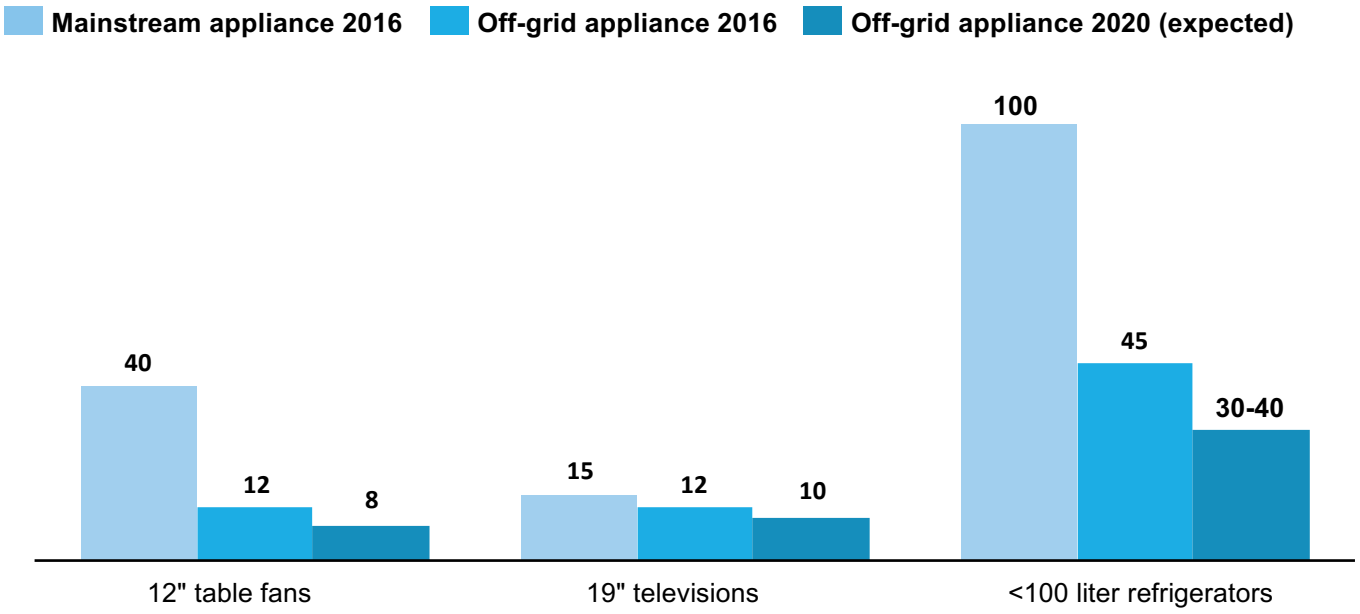
Poverty headcount ratio at USD 1.90 a day
2011 PPP; percentage of population; 2004-2013;



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

Power usage efficiency is expected to improve across all major off grid appliances

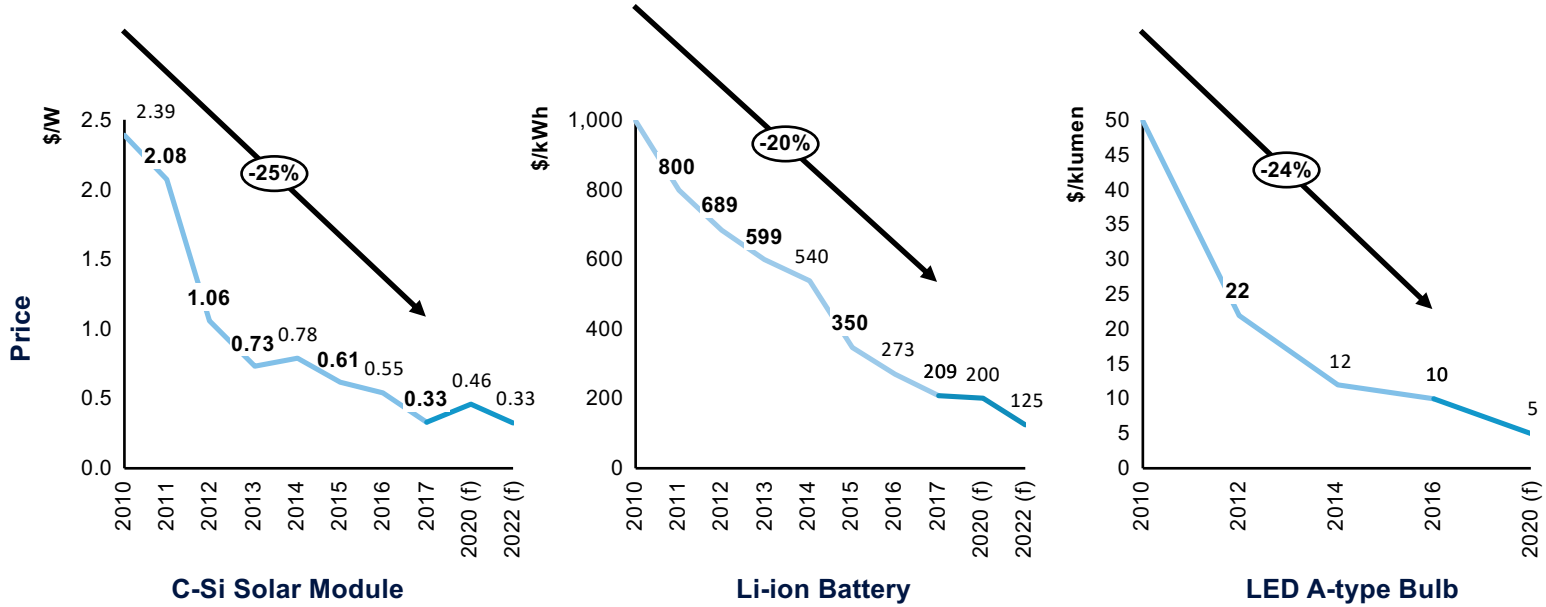
Estimated power rating for off-grid appliances
Watt (2016-20)



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, "State of the Off-Grid Appliance Market," 2015

Unit costs for OGS component have declined since 2010 by 20 – 25%, some component costs have stabilized, but other remains in sharp decline

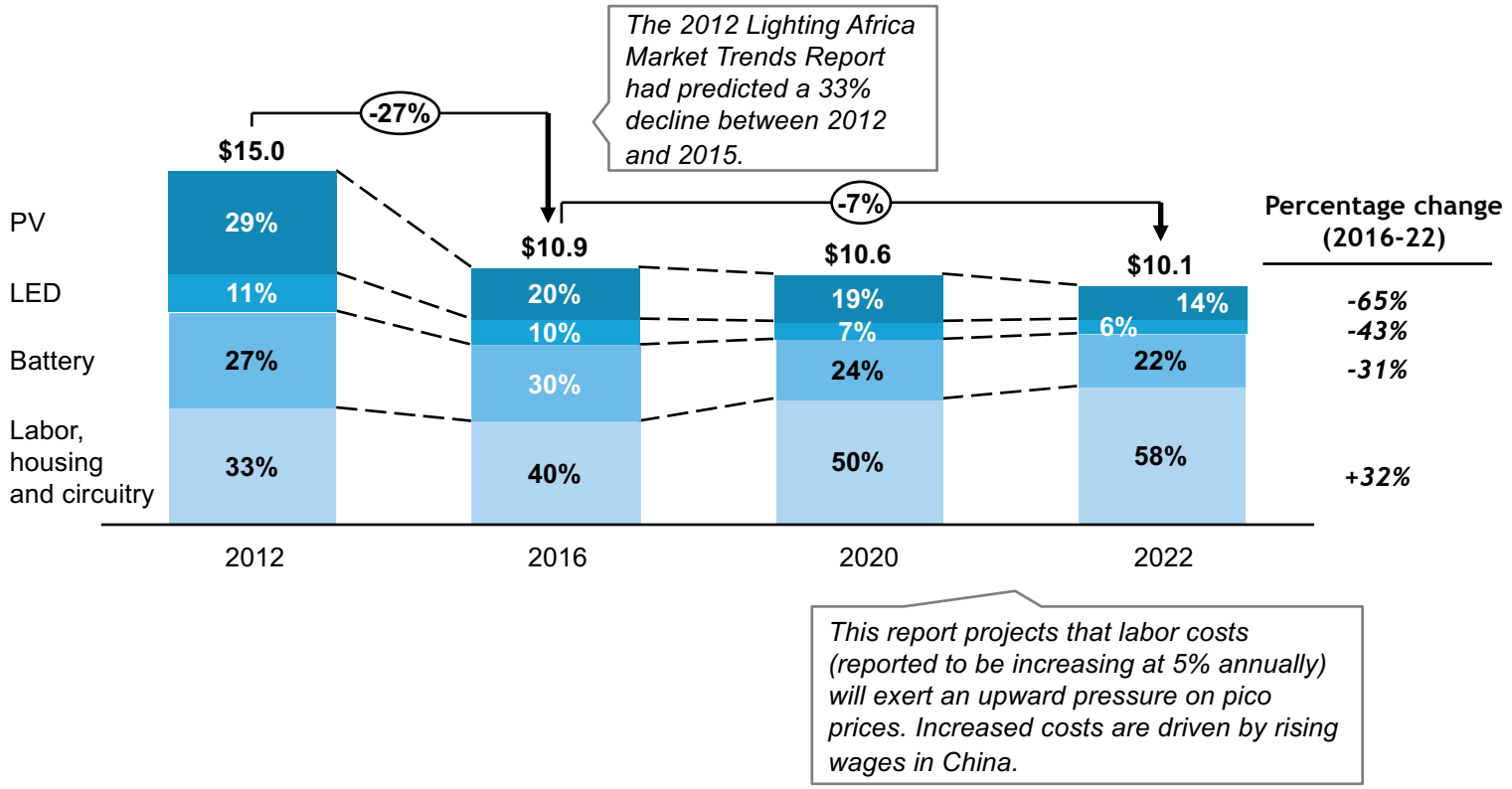
Evolution of price for OGS components
Multiple units, 2010-22



Source: I. C.SI: 1) 2010-2015 data for both is from IRENA (2016) for January of the year; 2016 (c-Si) is Q4 estimates from GTM Research (2016) 2016 (a-Si) is Dec 2015 price from IRENA, 2017 (for both) is June spot price on PV Insights; 2020 (c-Si) is an average of GlobalData (2017) and GTM Research (2016); II. Li-ion: (1) 2010-2016 data from BNEF, 2016, Forecast estimates: GTM Research; McKinsey analysis, Björn Nykvist & Måns Nilsson. "Rapidly falling costs of battery packs for electric vehicles" Nature Climate Change (2015); LED: 2010-2016 prices are from U.S. DOE (2016)

Historical rate of unit cost decline will slow as higher labor and BOS costs offset decreasing component costs in the coming years

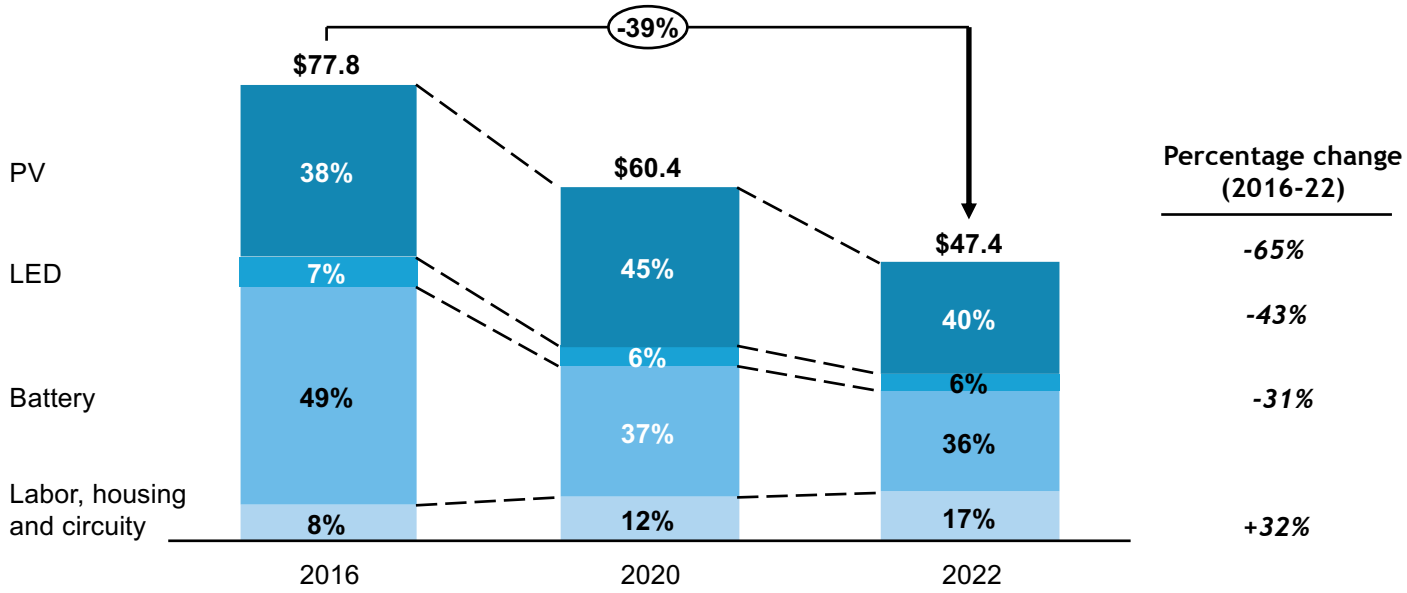
Decomposition and forecast of the median PLS component cost
USD (2012-2020)



Note: 1) Based on product with ~3W PV and ~50-100 lumens 2) 2012 costs from Lighting Africa 2012 Report 3) 2016 manufacturing cost extracted from Lighting Global data for a product with specs listed in note 1) and adjusted for inflation 4) Share of components as part of total cost in 2016 based on interviews 5) Projections to 2020 and 2022 based on CAGR of components (from different sources) 6) Labor rate changes taken as +5% based on interviews 7) In 2016, labor accounts for ~10% of costs and housing and circuitry for ~30%; Source: Dalberg Research and Analysis

Based on the above trends, the manufactured cost of the median pico device fell by 43% between 2012 and 2016

Decomposition and forecast of small SHS costs
USD (2016-2022)

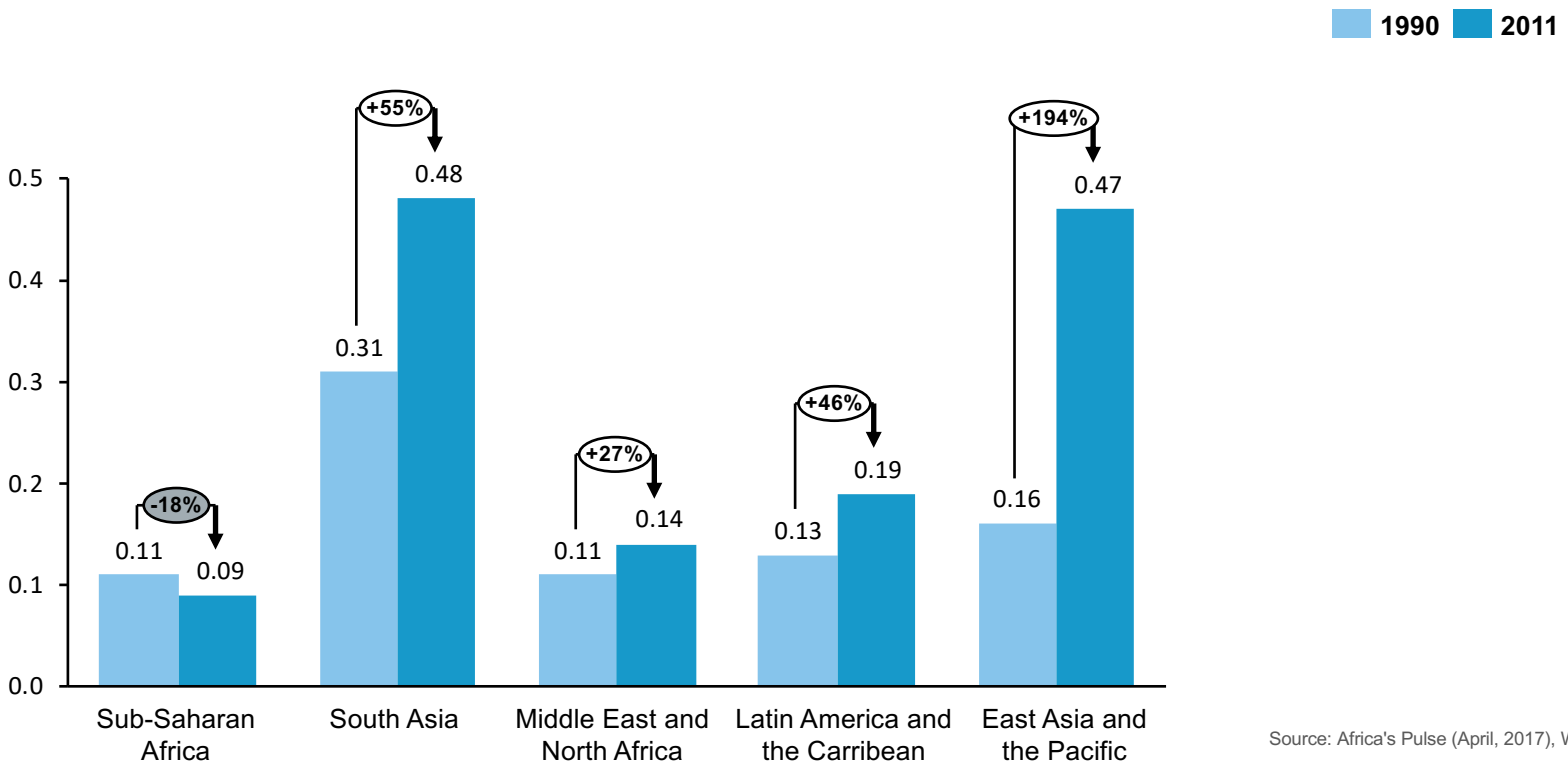


Please note that the Dalberg title does not correspond to the graph

1) Based on product with ~3W PV and ~50-100 lumens 2) 2012 costs from Lighting Africa 2012 Report 3) 2016 manufacturing cost extracted from Lighting Global data for a product with specs listed in note 1) and adjusted for inflation 4) Share of components as part of total cost in 2016 based on interviews 5) Projections to 2020 and 2022 based on CAGR of components (from different sources) 6) Labor rate changes taken as +5% based on interviews 7) In 2016, labor accounts for ~10% of costs and housing and circuitry for ~30%; Source: Dalberg Research and Analysis

From 1990 to 2011, road transport infrastructure quality declined in Sub-Saharan Africa, despite improvements globally

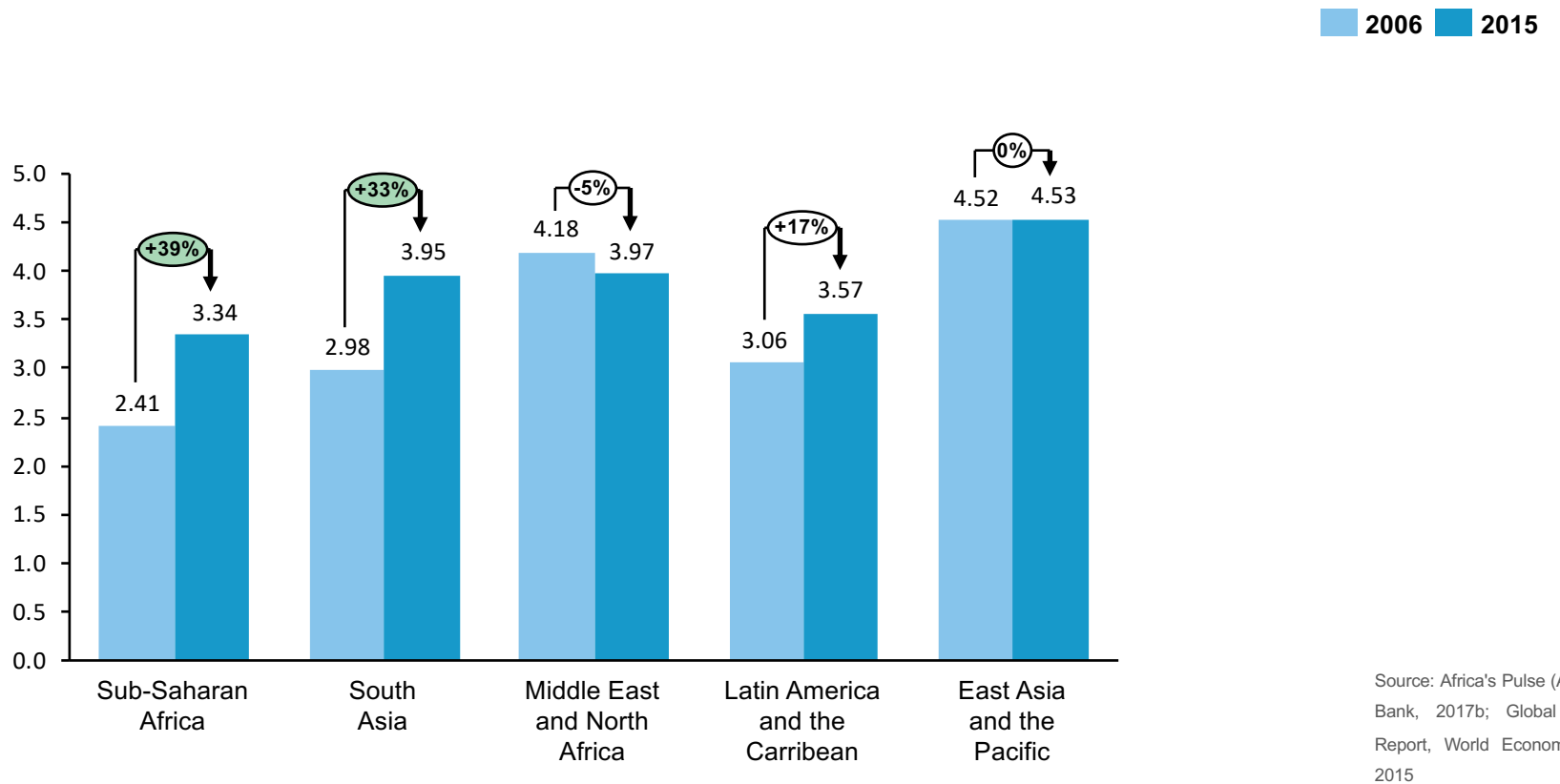
Quantity of road transport infrastructure
Km of road per km² of land area (median); (1991-2011)



Source: Africa's Pulse (April, 2017), World Bank, 2017

Sub-Saharan Africa and South Asia have shown the greatest recent improvement in the perception of road quality

World Economic Forum perception of road quality
Score (0 – worst; 7 – best); (2006-2015)

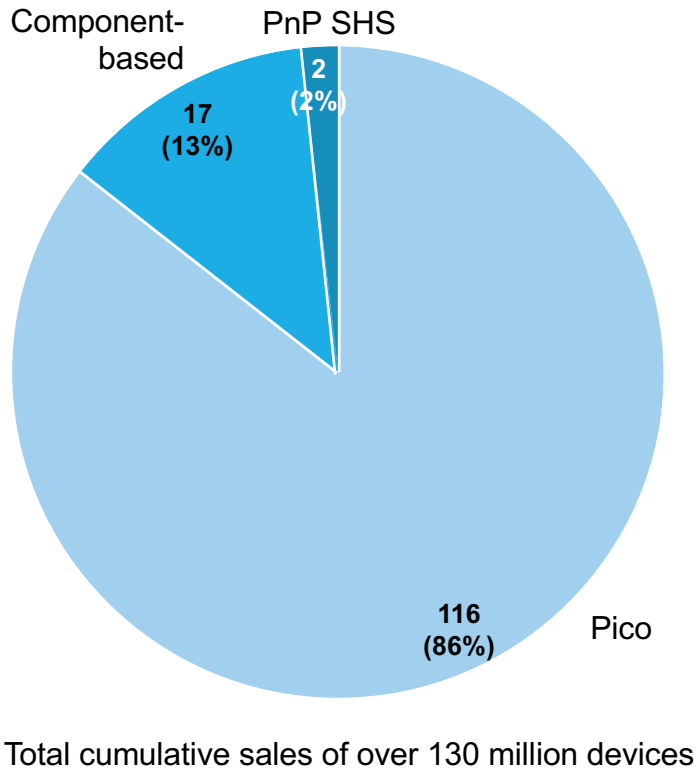


Source: Africa's Pulse (April, 2017), World Bank, 2017b; Global Competitiveness Report, World Economic Forum, 2006; 2015

1B: Sales

Pico lanterns are the vast majority of units sold, representing 86% of cumulative units sold

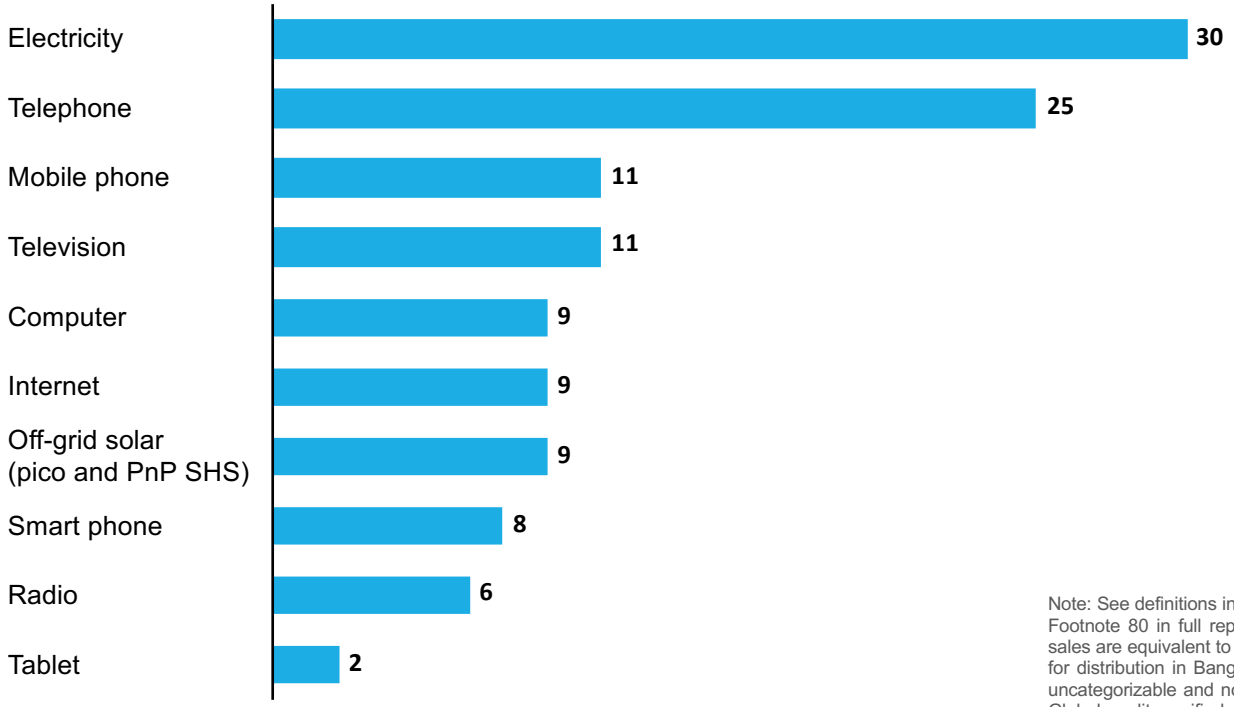
Cumulative OGS distributed to date
Million units (2010-17 est.)



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 5 of full report. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

Speed of penetration of OGS systems is inline with rates seen during the introduction of other innovative technologies

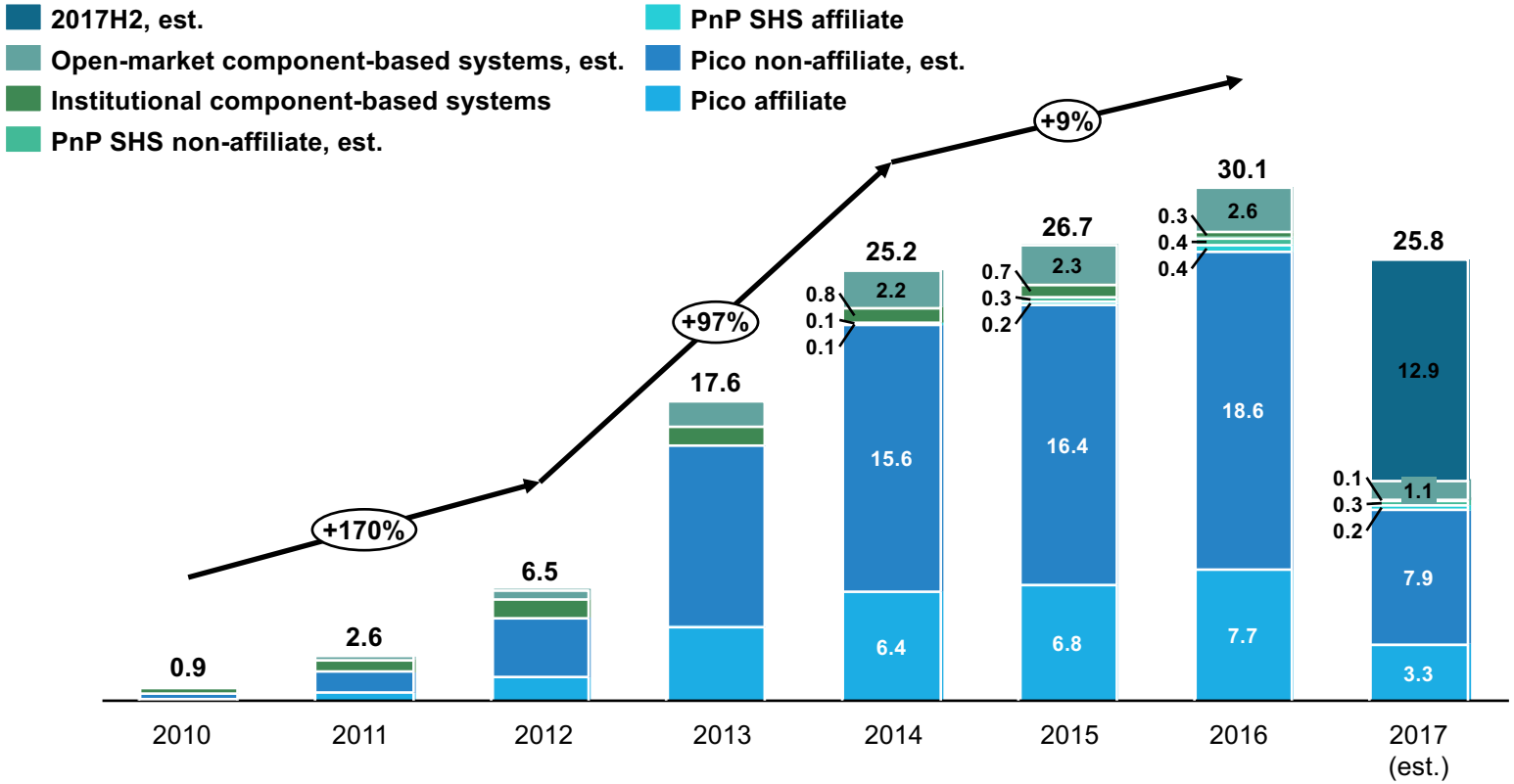
Time from consumer availability to 10% penetration
Years



Note: See definitions in Table 5 of full report and non-affiliate estimation methodology described in Footnote 80 in full report and throughout the following section. 2017 H2 estimate assumes H2 sales are equivalent to H1 sales. Institutional/government component based systems only account for distribution in Bangladesh, India, and Myanmar. 8000 LG/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. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

Industry wide growth rates have slowed over time and are projected to decline in 2017

Annual sales of OGS devices, across categories
Million units; (2010-17 est.)

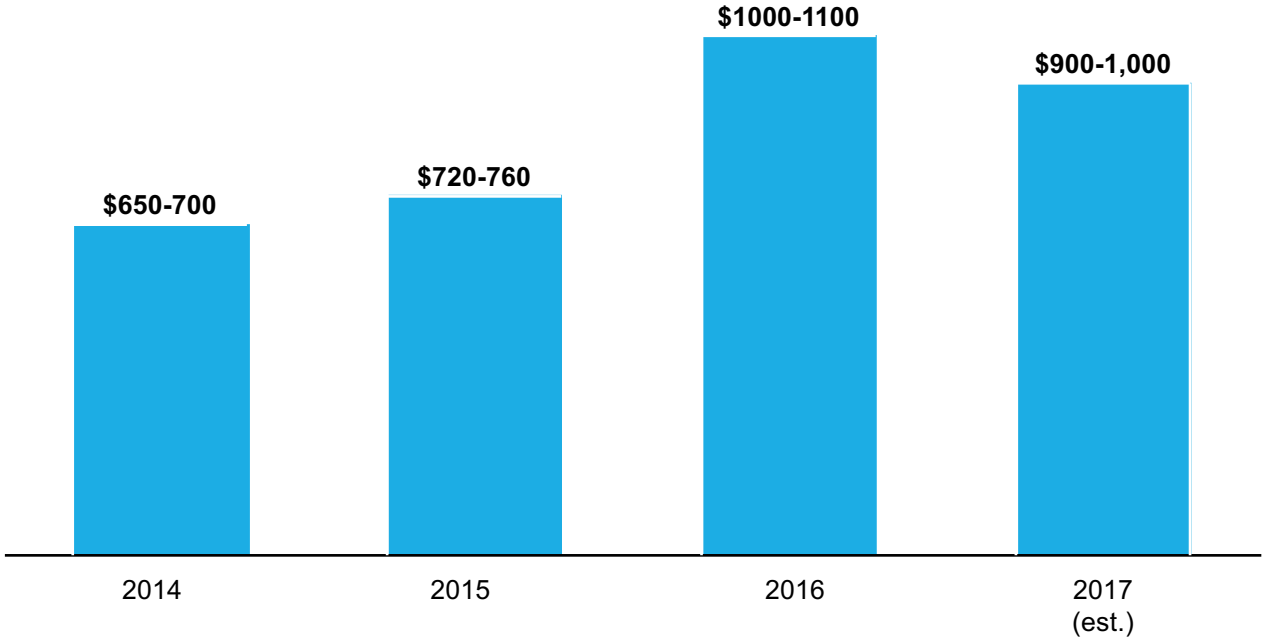


Note: See definitions in Table 4 and non-affiliate estimation methodology described in Footnote 79 in full report and throughout the following section. 2017 H2 estimate assumes H2 sales are equivalent to H1 sales. Institutional/government component based systems only account for distribution in Bangladesh, India, and Myanmar. 8000 LG/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. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

Sales

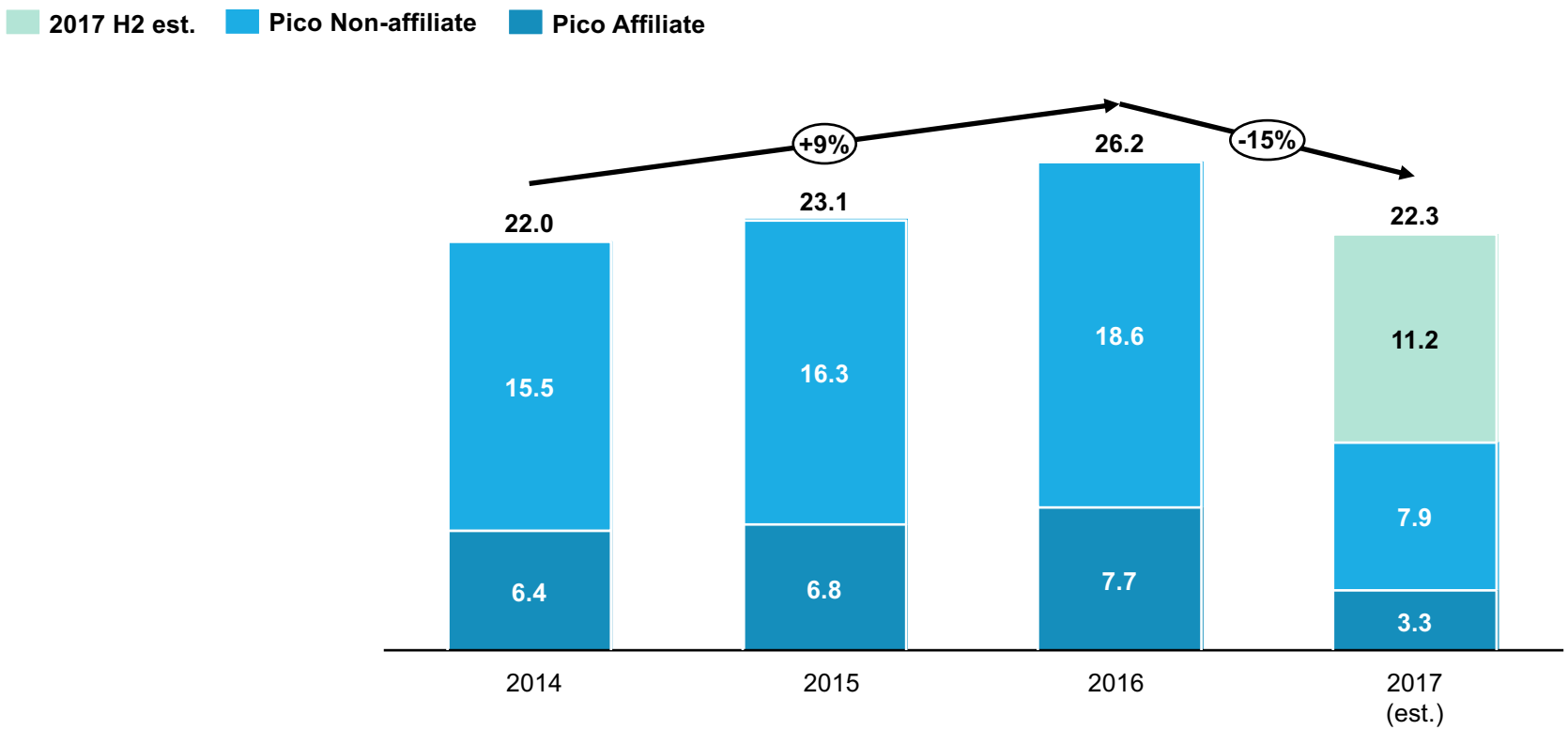
Overall revenues were affected by the 2016-17 sales dip, but continuing growth from the PnP SHS segment has reduced the effect of the slowdown

Estimated annual OGS revenues
USD millions (2014-17 est.)



Note: Figure includes estimates of affiliate and non-affiliate pico and PnP SHS as well as open-market component based systems.

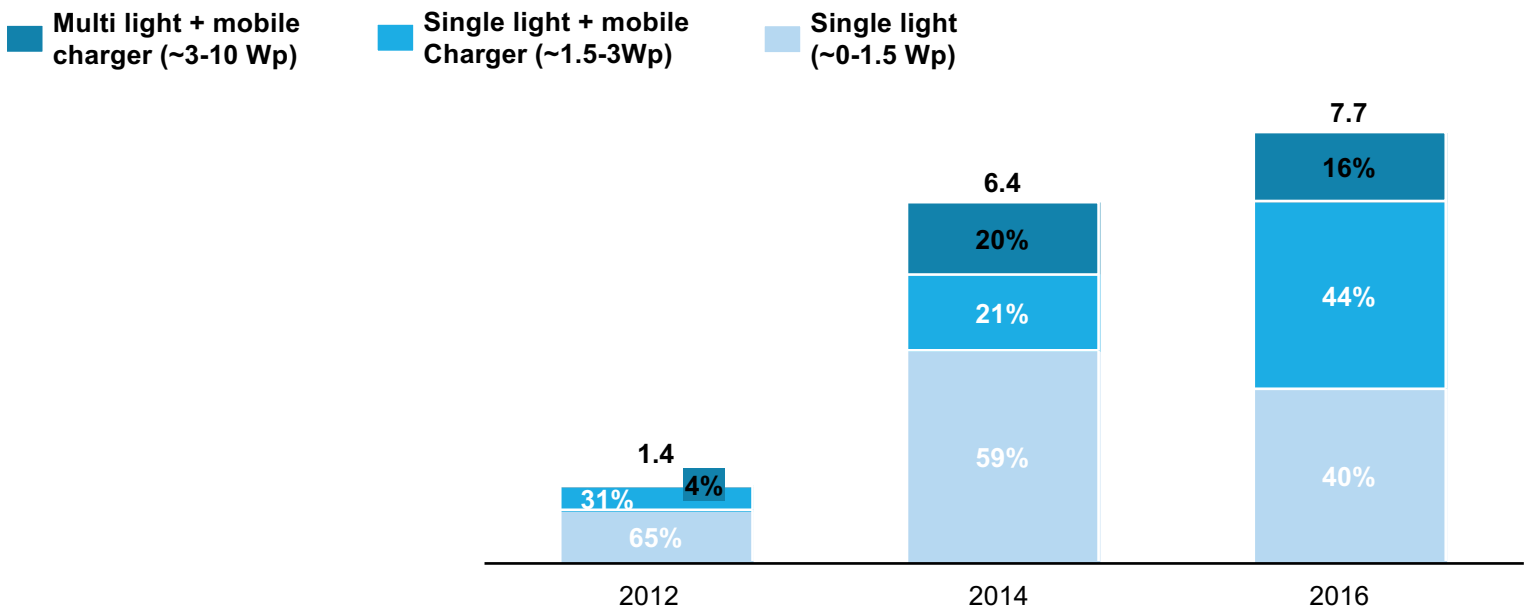
Units sold of pico lanterns grew by 9%from 2014 to 2016 but are expected to decline by 15% between 2016 and 2017



Note: See Table 5 and Footnote 79 in full report for details on non-affiliate estimation. 2017 H2 estimate assumes H2 sales are equivalent to H1 sales. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

For pico devices during 2014 – 16 , 1.5-3w units sales growth outpaced other product segments despite exhibiting the slowest growth in 2012 -14

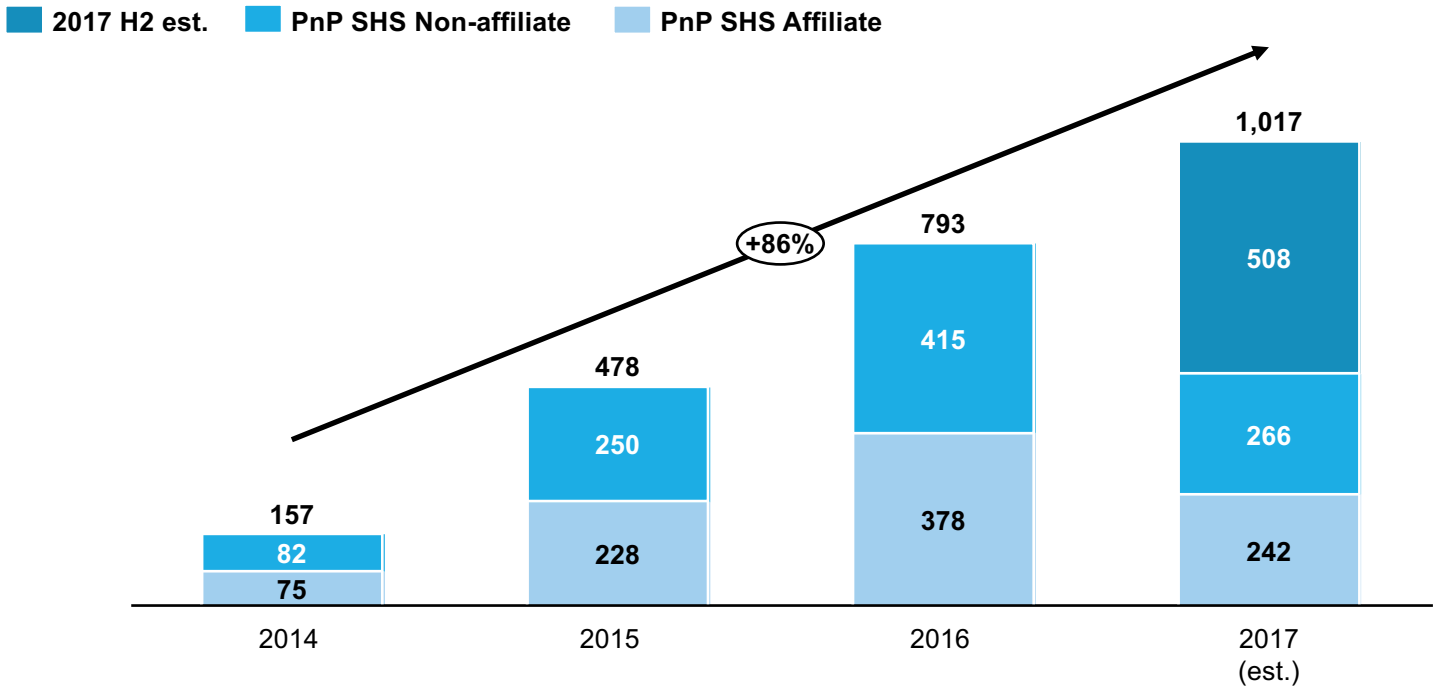
Annual global sales of affiliate pico devices by size
Million units; <11W categories (2012-17 est.)



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

SHS unit sales trends matched historical pico sales growth rates, and sales continued to climb despite 2016-17 slowdown for pico

Estimated annual plug-and-play SHS sales
Thousand units (2014-17 est.)

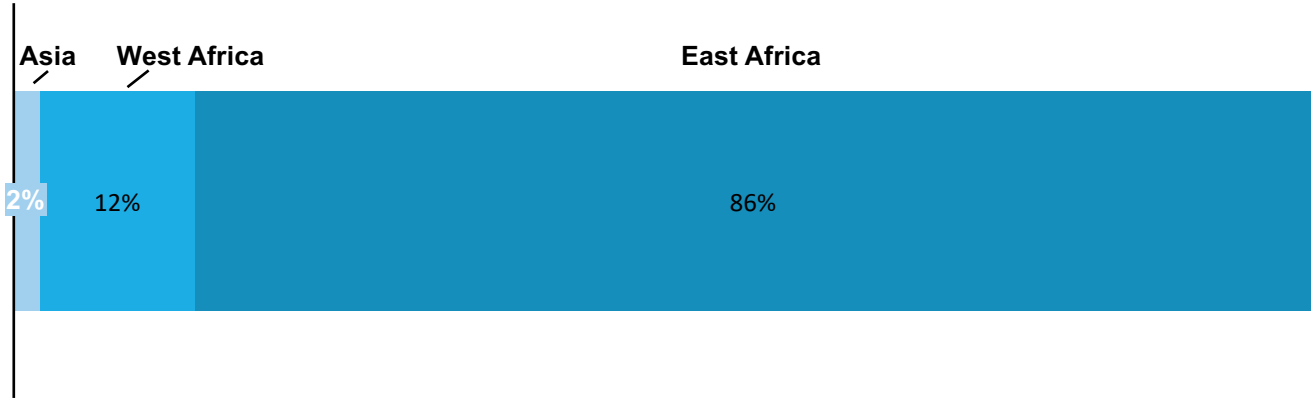


Note: See Footnote 79 in full report for details on non-affiliate estimation. 2017 H2 estimate assumes H2 sales are equivalent to H1 sales. Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

East Africa is the center of the PAYGO market with 86% of cumulative PAYGO sales

Geographic share of the PAYGO market[1]

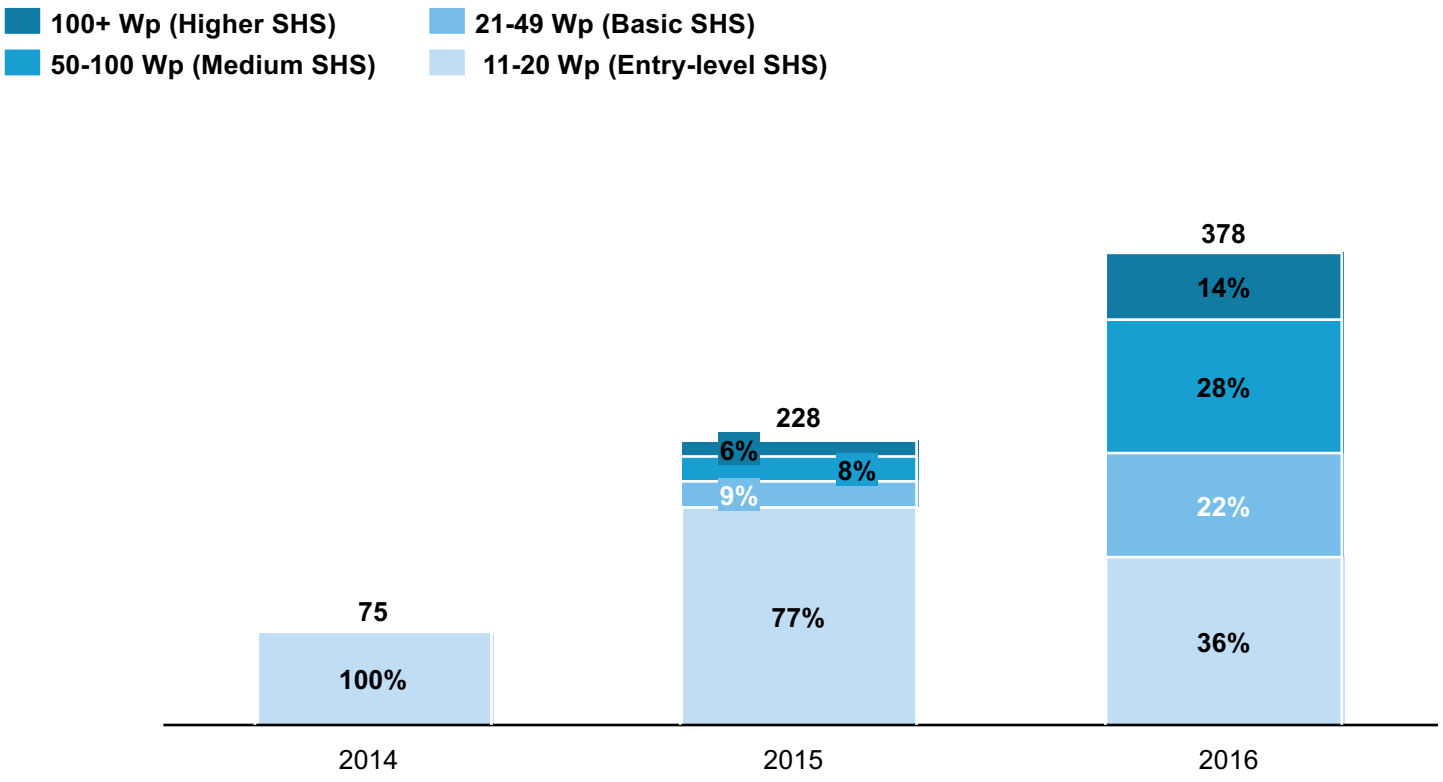
N=11 players; Share of cumulative unit sales (2013-2017)



(1) Cumulative sales of 11 PAYG 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

Sales in PnP solar home systems have moved to increasingly larger systems over time

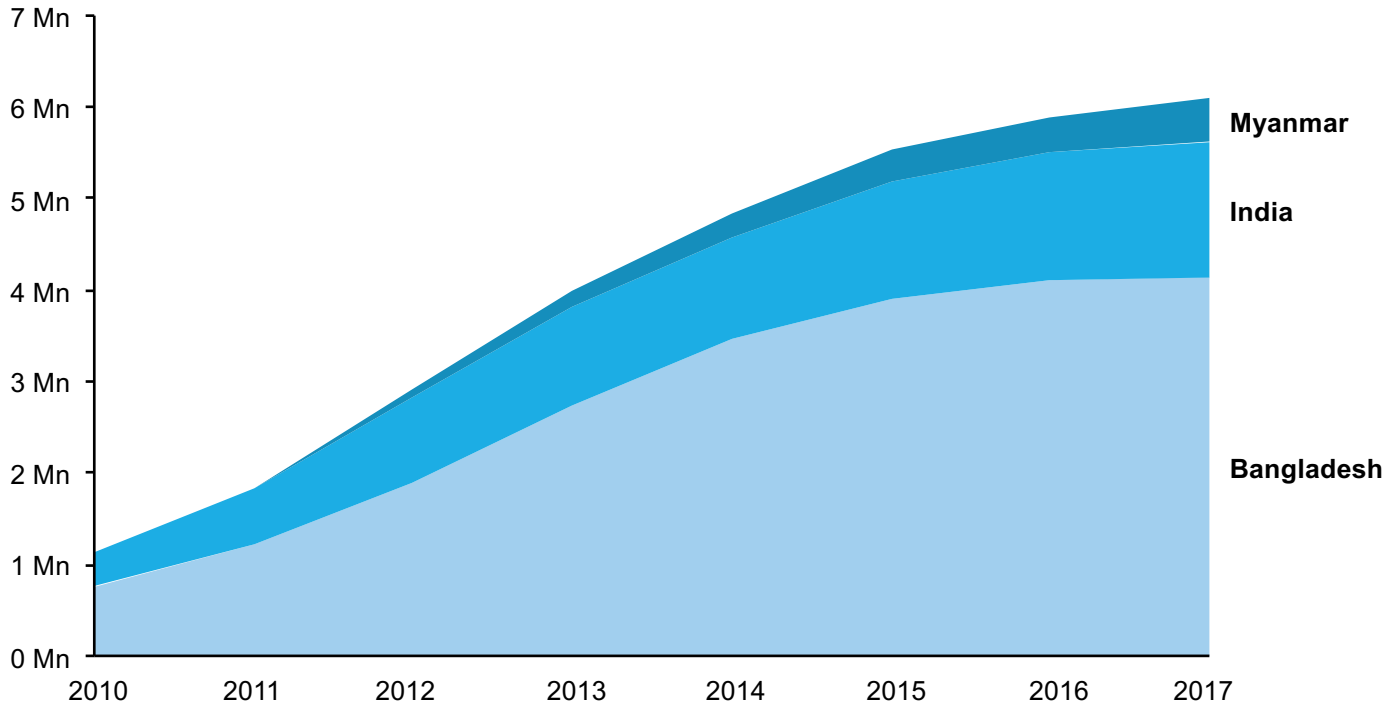
Annual global sales of affiliate PnP SHS devices by size
Thousand units; >11Wp categories; (2014-17 est.)



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

Components-based systems have developed in India and Myanmar; but Bangladesh remains the largest with 68% of units sold across the countries

Cumulative institutional distribution of component-based systems
Million units; select countries *(2010-17 est.)*

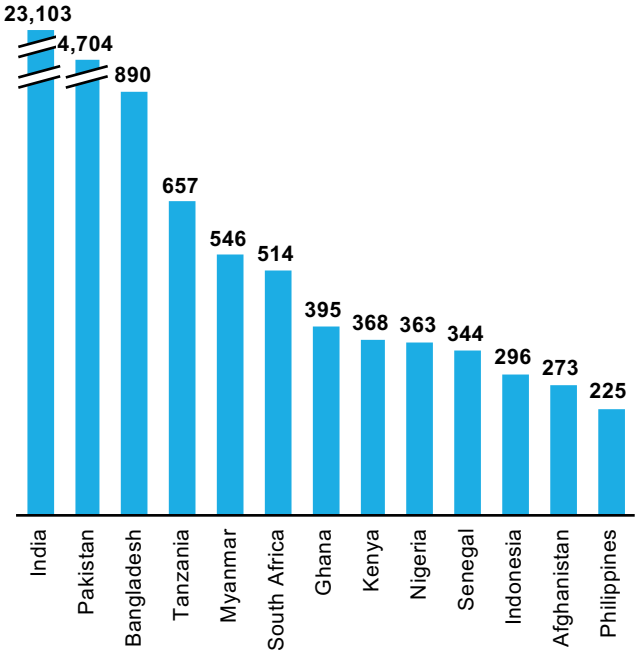


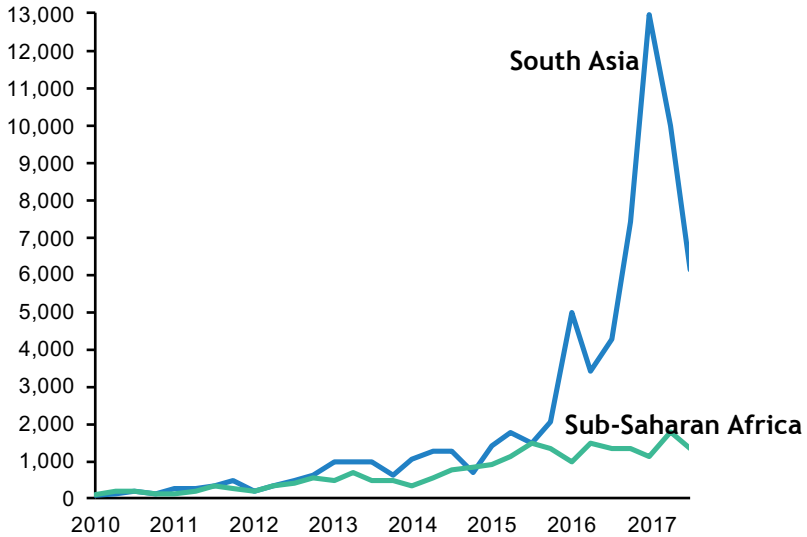
Source: India, Bangladesh and Myanmar government materials; (Hystra Hybrid Strategies Consulting, 2017); Dalberg market model and analysis

Sales

Chinese solar panel exports are larger to South Asia than to Sub-Saharan Africa

Solar panel exports from China - Directional proxy for component-based sales
Thousand units; (left: 2016Q4 – 2017Q3; right: 2010Q1-2017Q3)

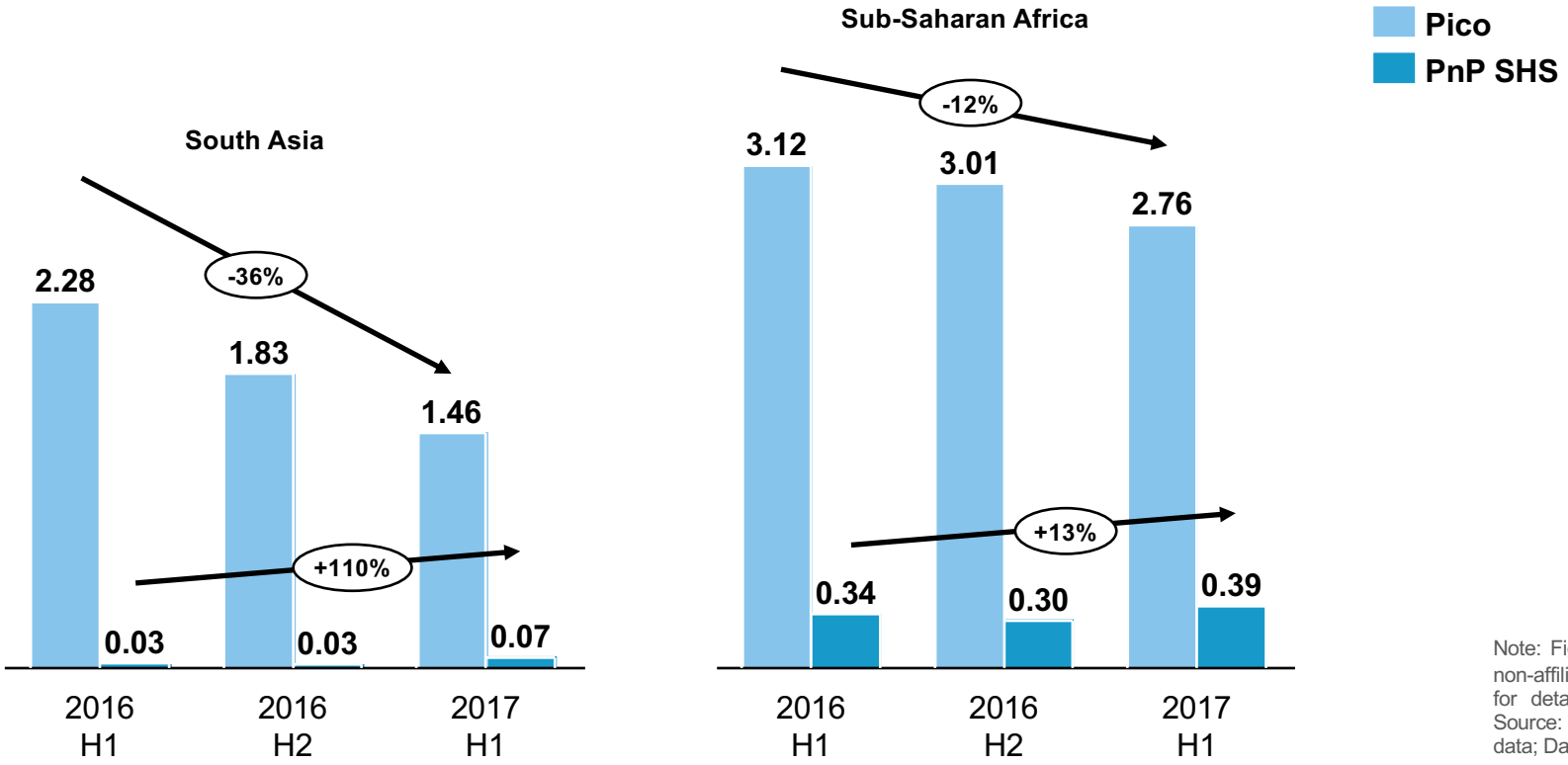




Note: Figure displays exports from China of HS code 85414020, "Solar cells" to countries in Sub-Saharan Africa, South Asia, and select countries in East Asia and Pacific. Exports with unit value below $10 and greater than $150 not included, to filter out small parts and large PV panels unlikely to be 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)

YoY sales were steadier in Sub-Saharan Africa than South Asia, where demonetization and a low-based of PnP SHS have led to steeper shifts

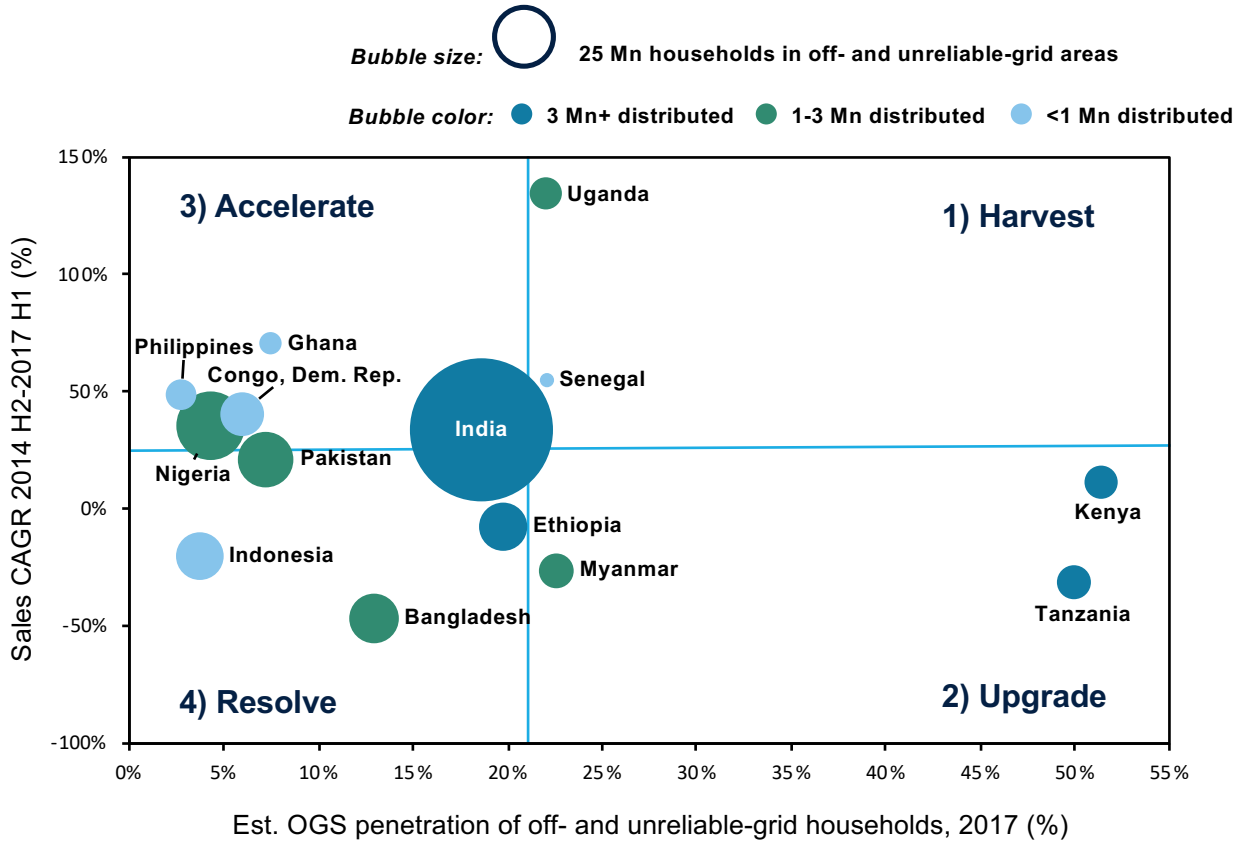
Regional sales trends, by product category
Million units (2016 H1- 2017 H1)



Note: Figure includes affiliate sales and non-affiliate estimates (see Footnote 123 for details on non-affiliate estimation). Source: Lighting Global/GOGLA sales data; Dalberg market model and analysis

Most markets are underpenetrated and nearly ready for rapid scaling up

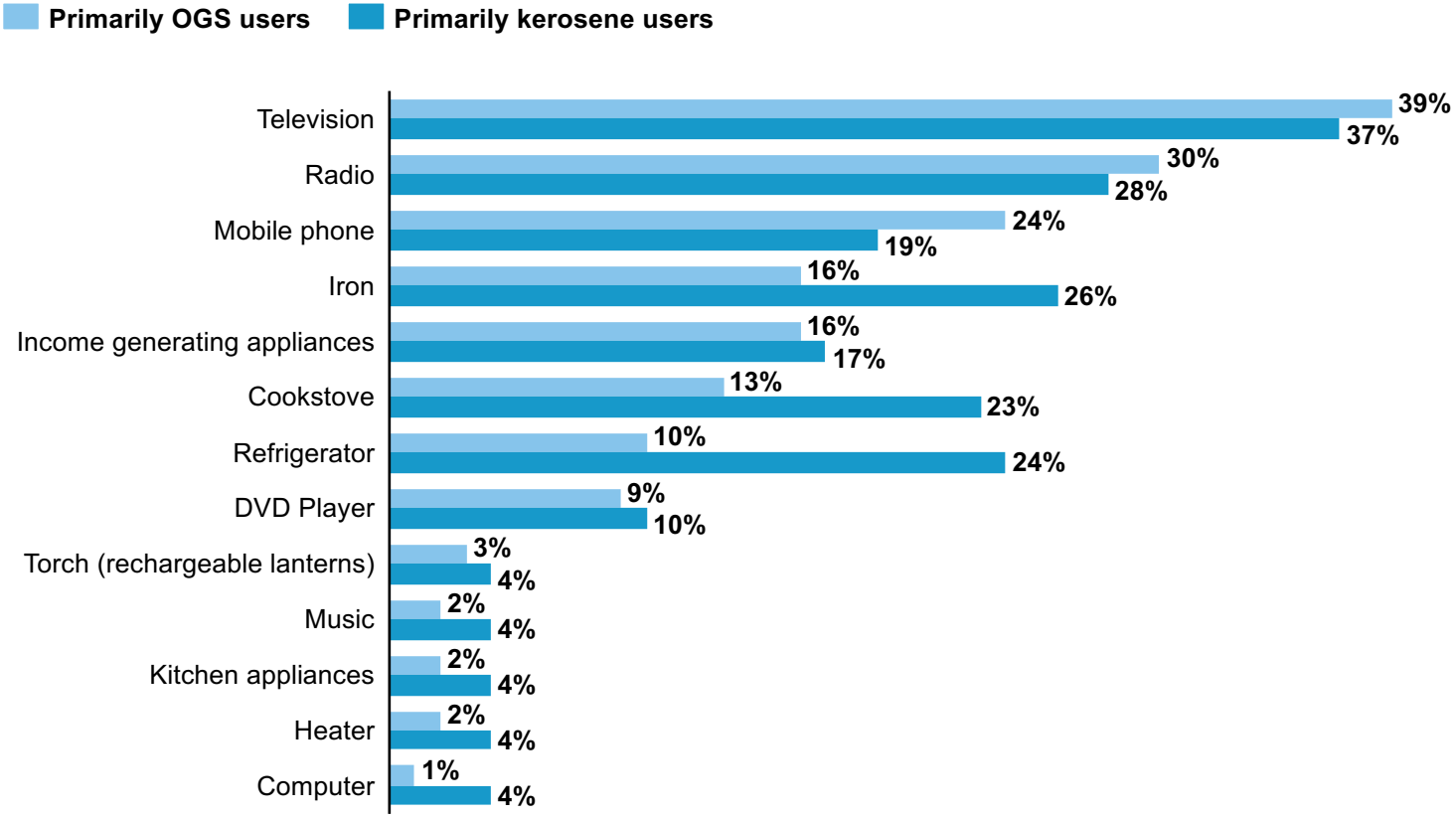
Estimated sales and penetration of OGS devices in select markets
% change (2014H2-2017H1)



Note: Estimate includes both affiliate and non-affiliate sales 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 assumes a 3-year product lifespan (GOGLA, 2016a). Source: Lighting Global/GOGLA sales data; Industry interviews; Dalberg market model and analysis

Televisions and radios are the most desired appliances amongst Kenyan households

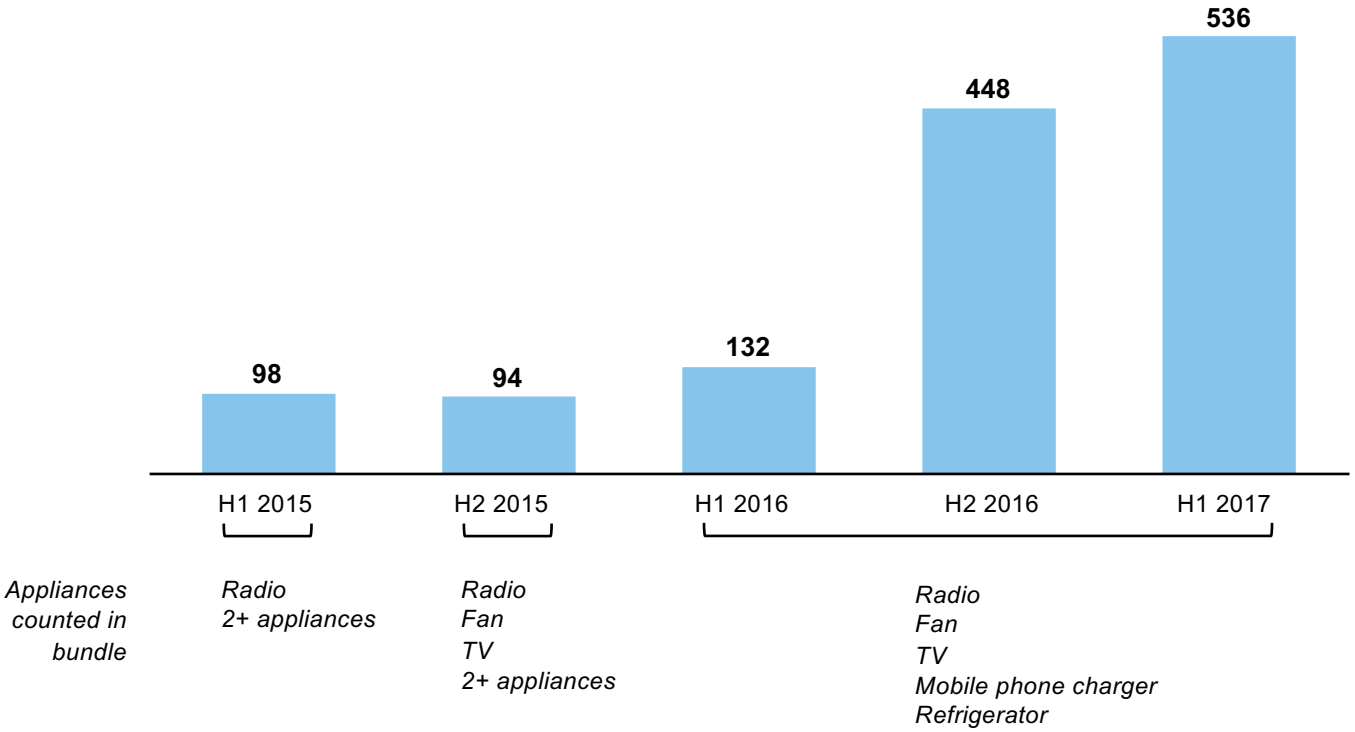
Desire for appliances among OGS and kerosene users, rural Kenyan households
% of households; 2015



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: Appliance Ownership among Electric Grid and Home Solar Households in Rural Kenya, University of Berkeley and NBER Working Paper

Bundling of appliances with OGS devices appeared as a trend in the later half of 2016 and continued into 2017

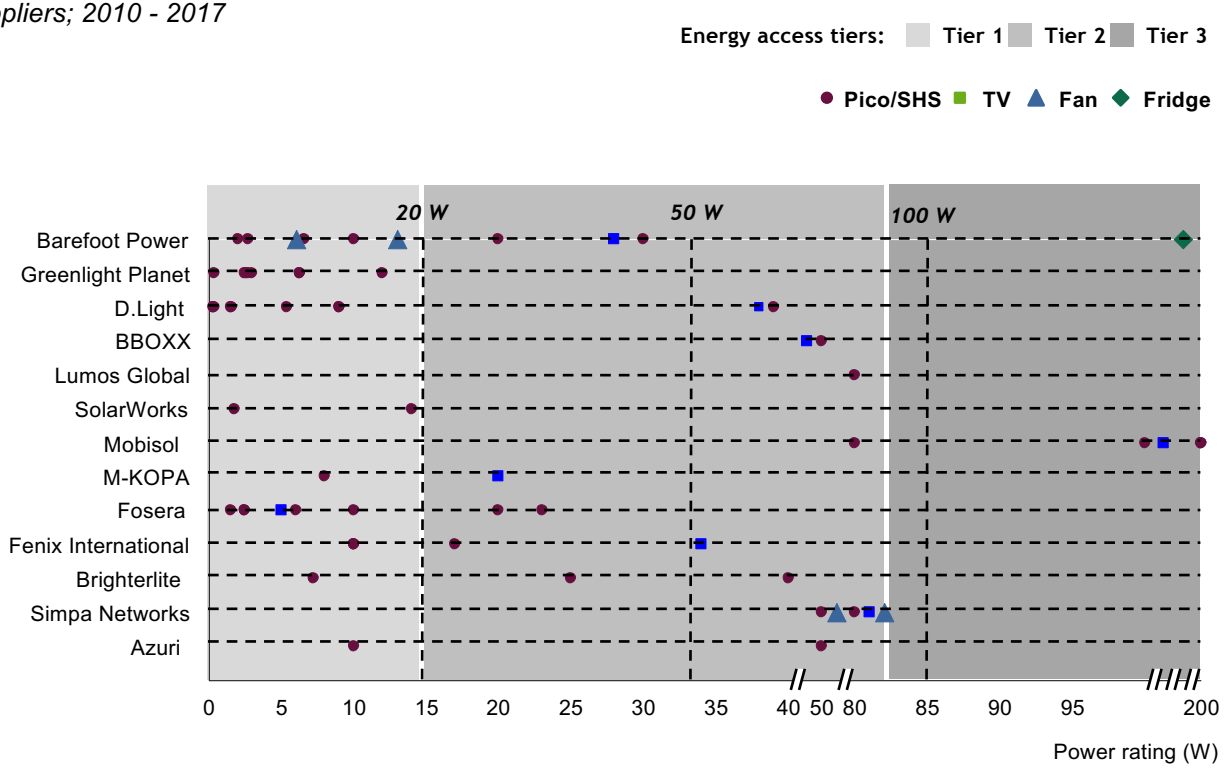
Sales of OGS devices bundled with appliances by LG/GOGLA affiliates
Thousand units (2015 H1-2017 H1)



Source: Lighting Global/GOGLA sales data

A variety of OGS appliances exist across multiple energy access tiers

Product base of selected OGS players
n= 12 suppliers; 2010 - 2017

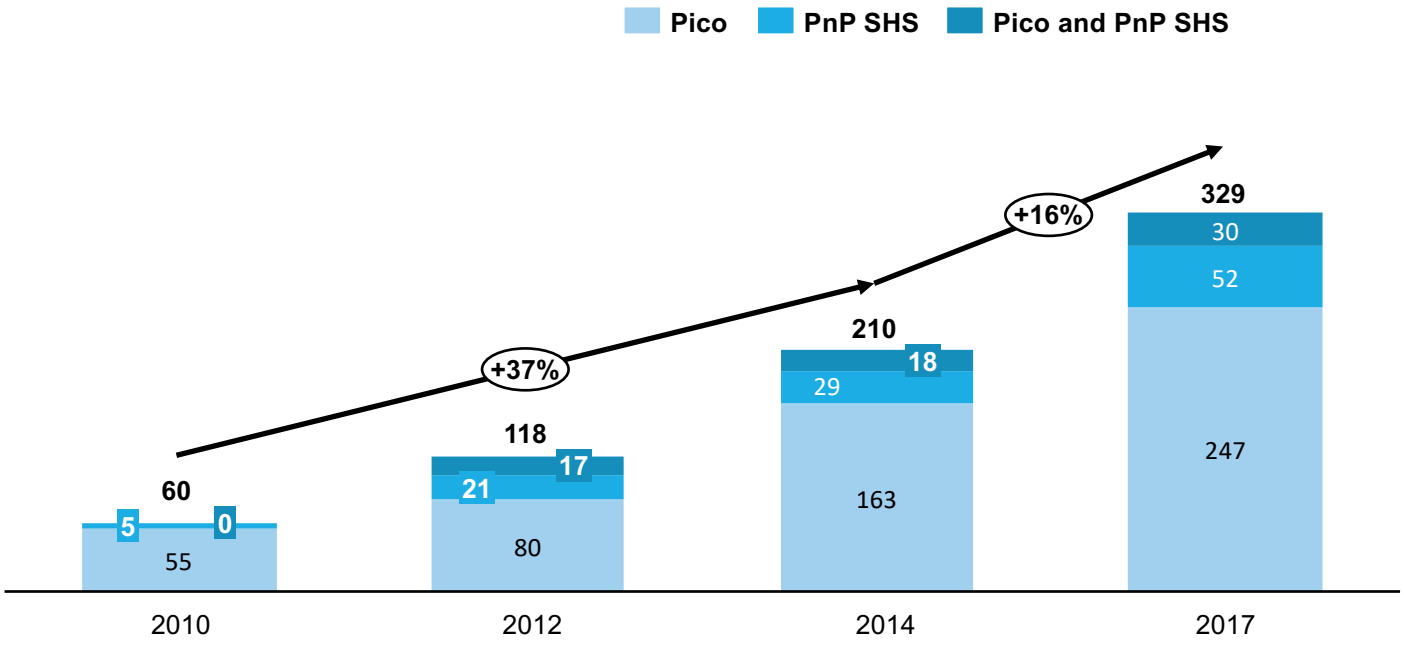


1) Greenlight Planet is to introduce a TV into the market; wattage is indicative at this point of time; (2) Tier 1 includes a minimum of: 3W (peak power), 12Wh (consumption); Tier 2 includes a minimum of: 50W (peak power), 200Wh; Tier 3 includes a minimum of: 200W (peak power), 1kWh (consumption). Source: ESMAP/ SE4All; 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 the analysis. (3) The list of products is not exhaustive but is representative. Source: Lighting Global database, Sendea catalog, Hystra Case Studies, Dalberg research and analysis

1C: Competitive Landscape

The OGS market continues to attract new entrants, albeit recent rates of new entrants have slowed

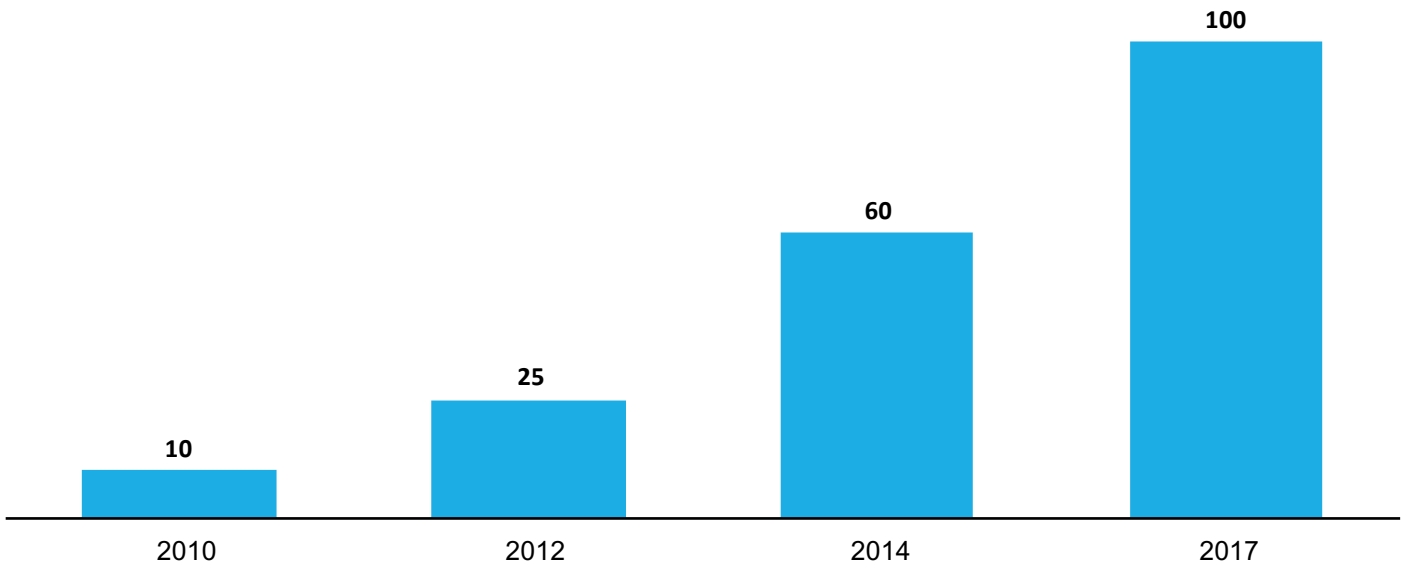
OGS competitive landscape – manufacturers and distrbutors[1,2]
Number of companies (best estimates, not exhaustive), 2010-2017



Note: (1) 2010: No. of pico suppliers Lighting Africa 2010 report (2) 2012: Number of pico suppliers based on 2012 Lighting Africa report, SHS and "both" numbers based on secondary research and include only companies that are still operational today (3) 2014: BNEF and secondary research (4) 2016: Based on secondary research in 2016 (5) These numbers are not exhaustive but represent a large number of suppliers in the market

The geographical scope of the OGS market has increased over time, reaching 100 countries in 2017

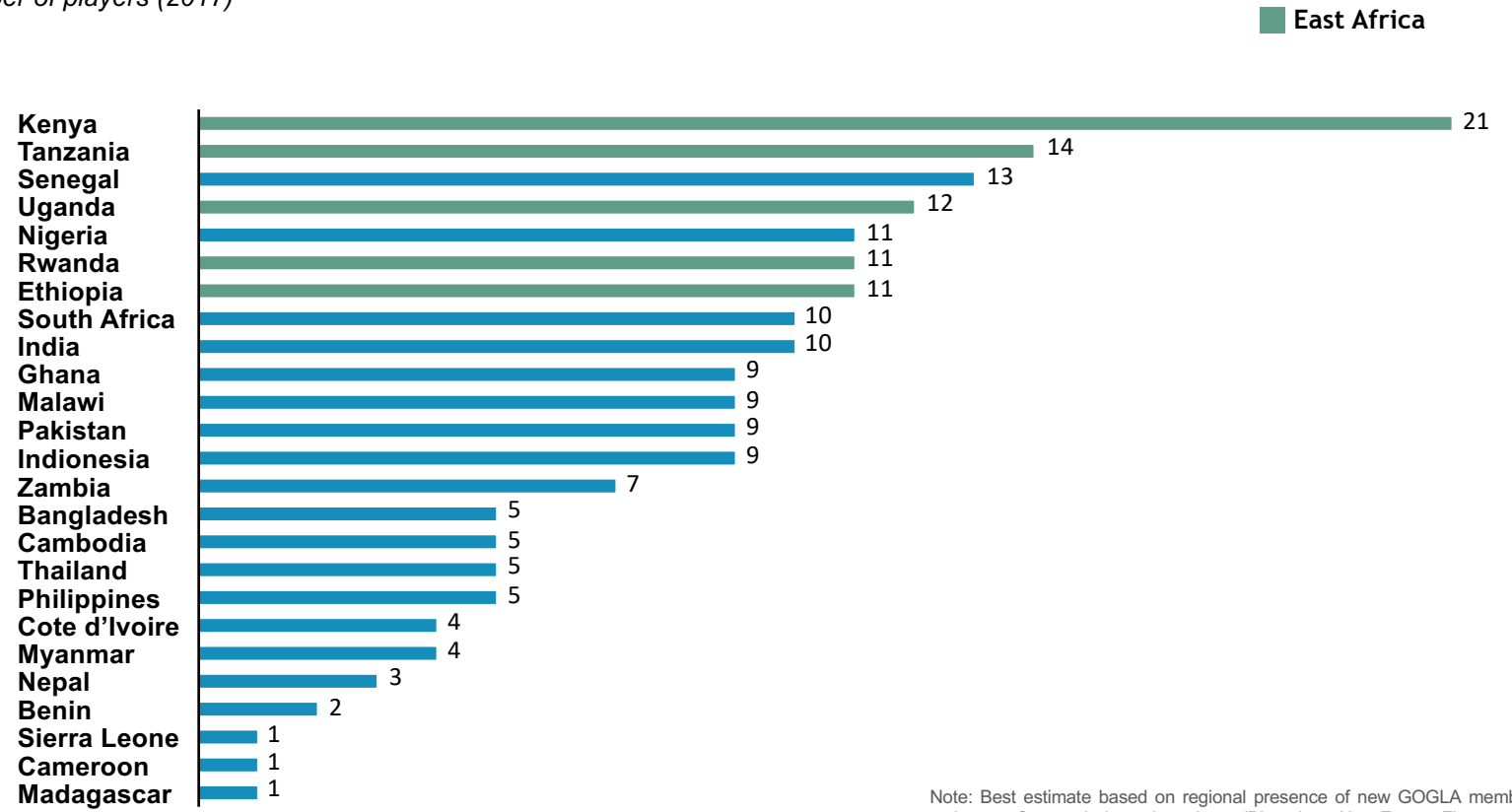
Number of countries with a sales presence (over time)
Number of countries (2010-2017)



Source: Previous Lighting Africa and Global reports and data; Dalberg analysis

Quality verified products are concentrated in East Africa

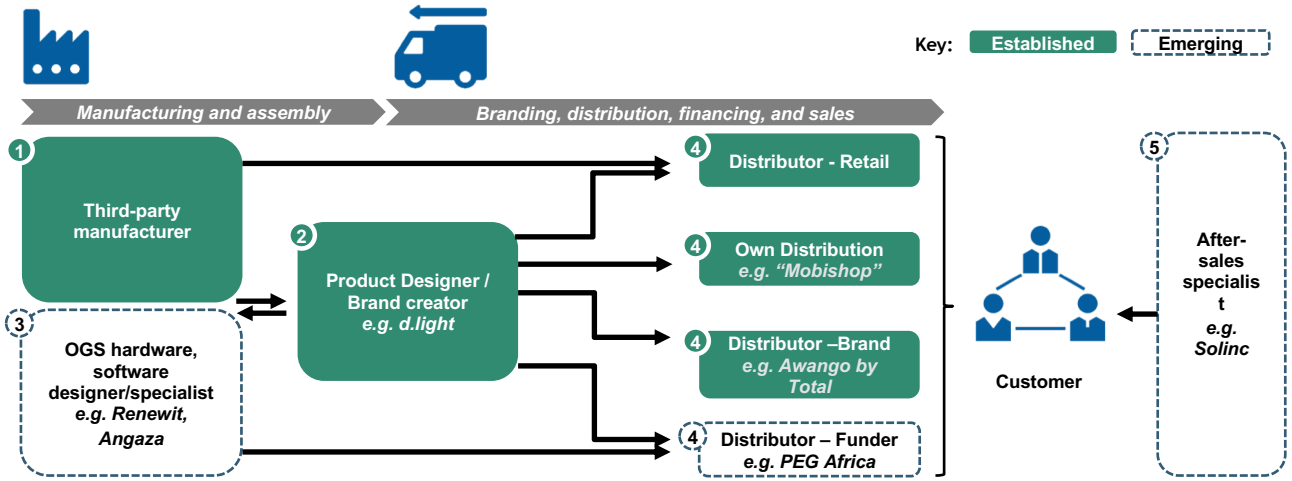
GOGLA members sales presence in individual countries
Number of players (2017)



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

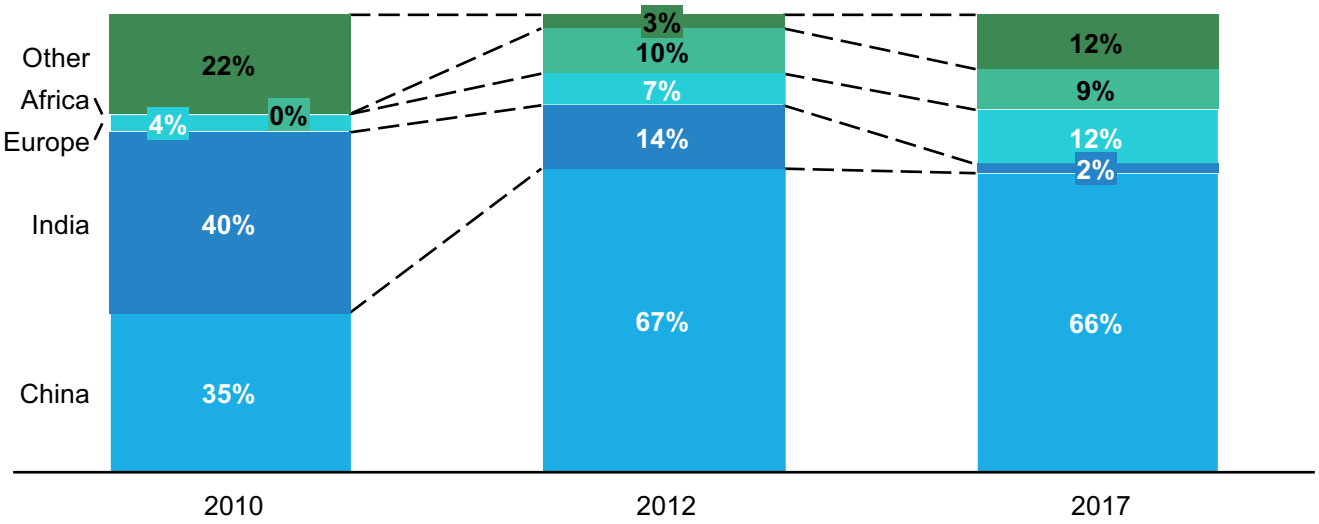
Specialized companies, focusing on specific niches in the value chain, are emerging

OGS industry high-level industry structure and composition



Since 2010, supplier's headquarters moved away from India, towards China & Europe; two thirds are now headquartered in China

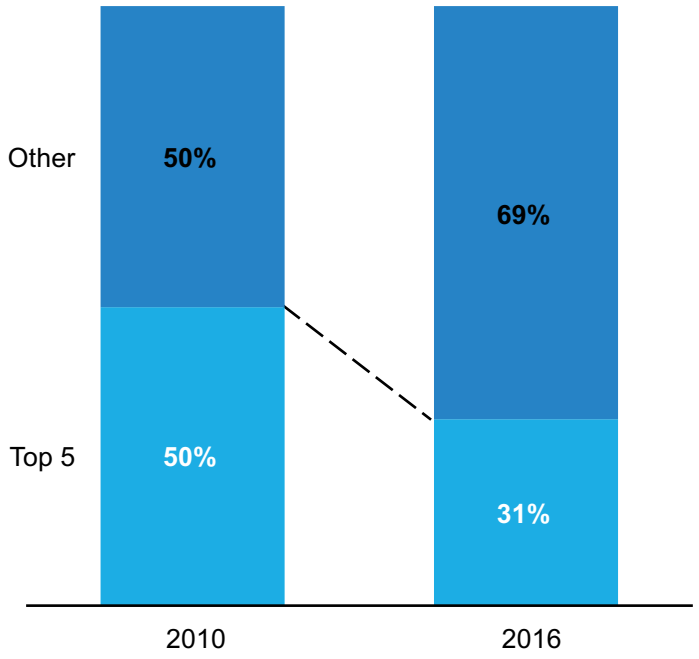
Suppliers by headquarter location
% of suppliers (2010-17)



Source: 2010: (Dalberg, 2010); 2012: Dalberg analysis for Lighting Africa 2012 Market Trends Report (Dalberg, 2012); 2016: Company websites, LinkedIn, Dalberg Research and Analysis

The pico segment has become increasingly competitive

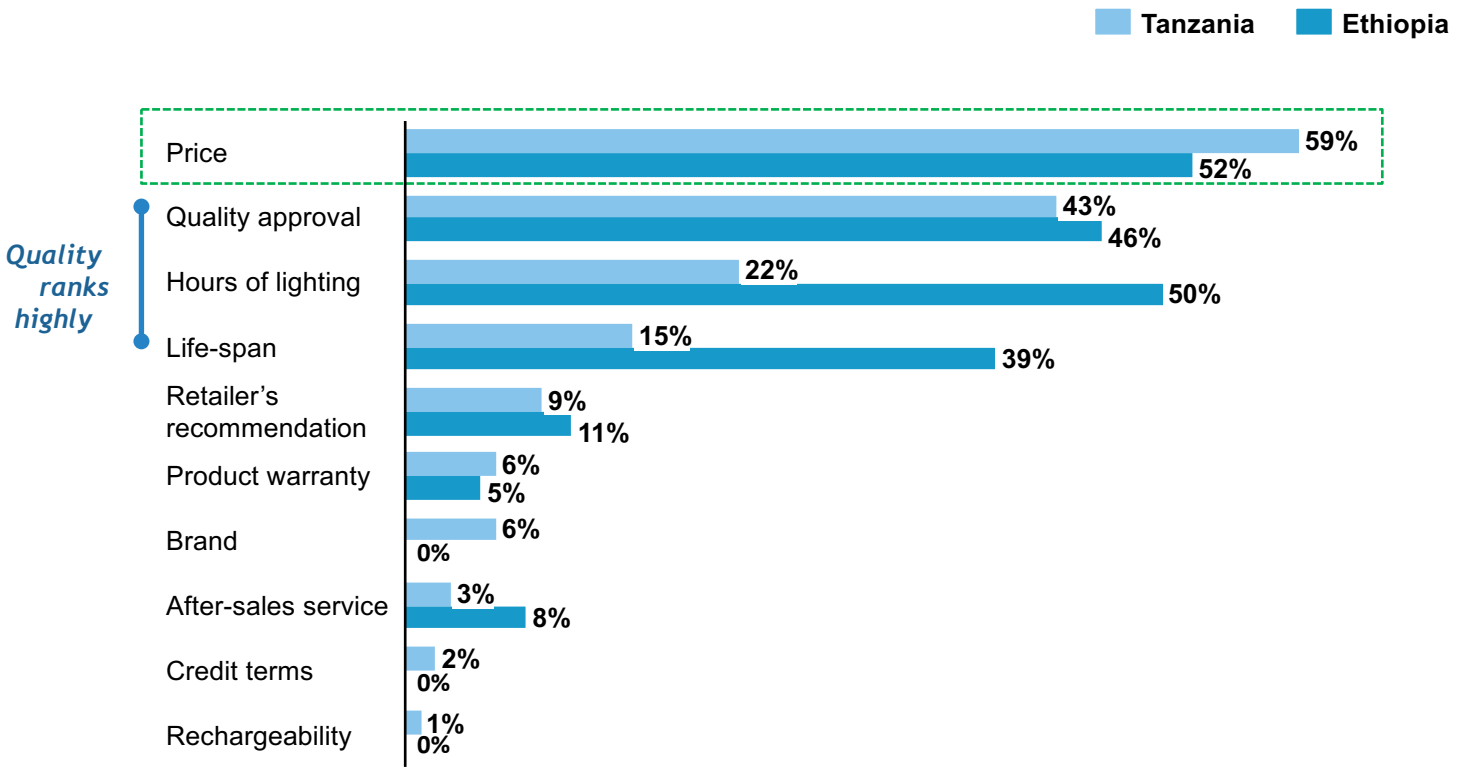
Market concentration of pico affiliates and non-affiliates
% of total annual unit sales (2016)



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. Sources: Industry interviews; Dalberg research and analysis

More than half of consumers cite pricing as the primary concern when purchasing lanterns, metric on quality are the next considerations

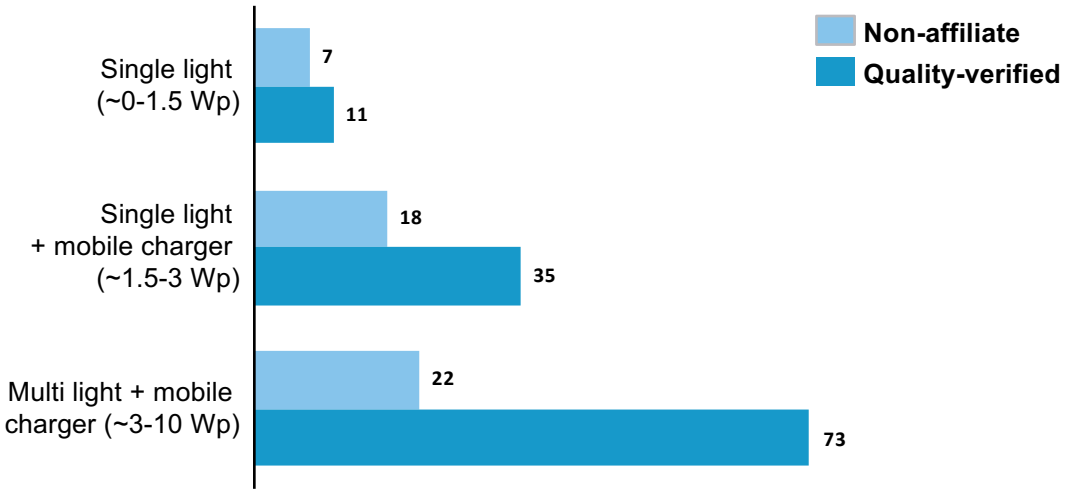
Retailer Survey Results: "What do your customers ask for when they are considering which lantern to buy?"
Tanzania, n=644 retailers (2017); Ethiopia, n=887 (2016)



Source: Off-Grid Market Study – Ethiopia (Ipsos, 2016b); Off-Grid Market Study - Tanzania (Ipsos, 2017)

Quality verified are priced higher than similar non-affiliated products, the premium for verified products increases as units get more powerful

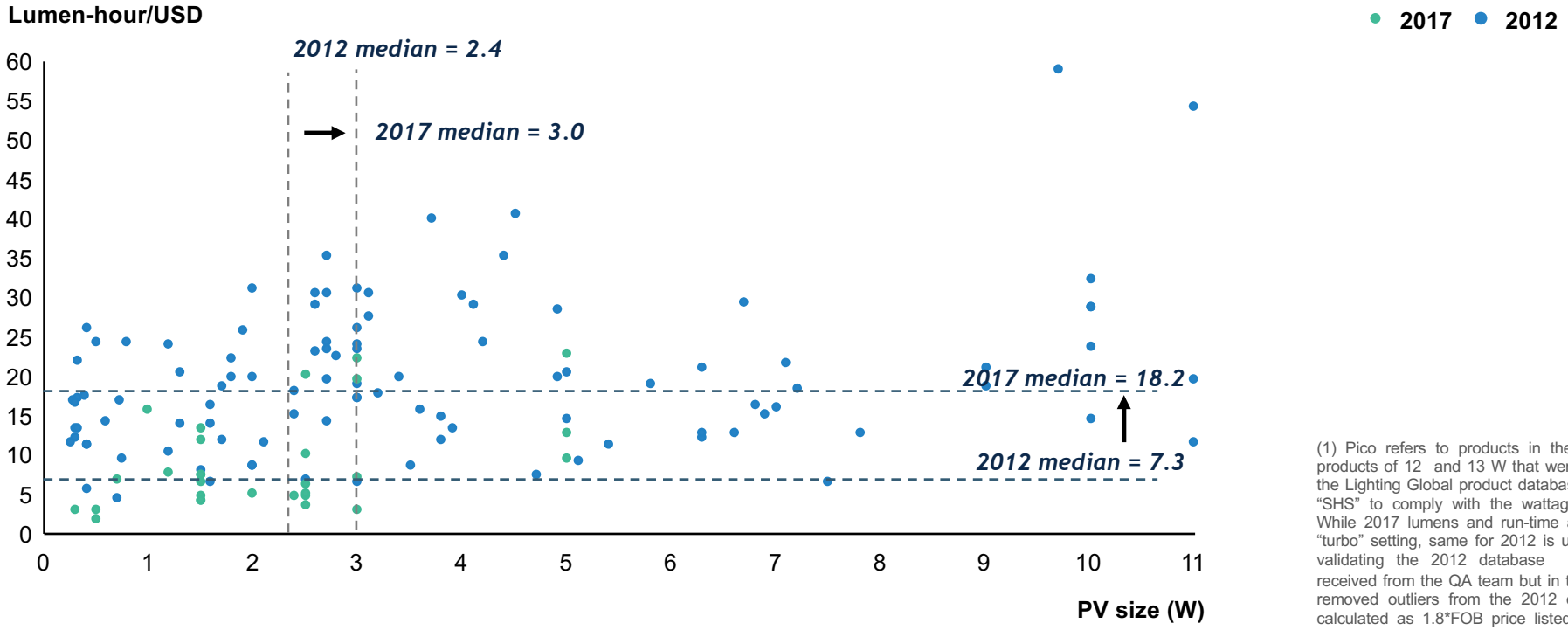
Price range of products for a given size
N=127 products, generic and verified, USD, 2017



Source; Unlocking an Energy Revolution in Ethiopia With Lessons From the Black Market Greentech Media, 2017), Industry Interview

The OGS market continues to attract new entrants, albeit recent rates of new entrants have slowed

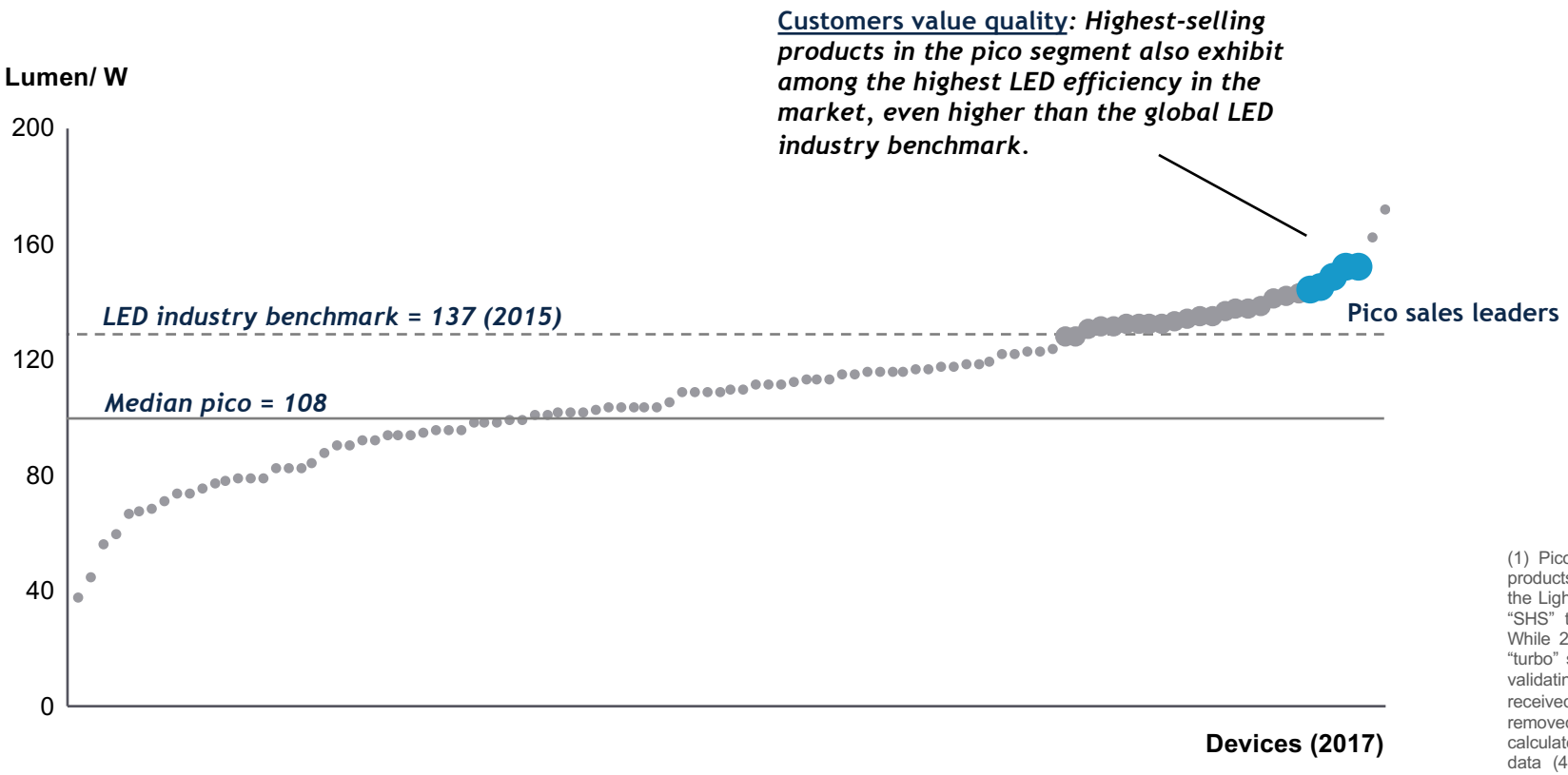
Evolution of value proposition (lm-hr/$) for the pico product universe
Lighting Global quality verified pico products; n=29 (2012); n=104 (2017)



(1) Pico refers to products in the 0-11 W range, 4 products of 12 and 13 W that were listed as "pico" in the Lighting Global product database were changed to "SHS" to comply with the wattage classification. (2) While 2017 lumens and run-time are for products on "turbo" setting, same for 2012 is unclear – we will be validating the 2012 database with specs sheets received from the QA team but in the meanwhile have removed outliers from the 2012 database. (3) Price calculated as 1.8*FOB price listed in Lighting Global data (4) 2017 prices adjusted for inflation; Source: Lighting Global data 2012 and 2017, Dalberg Analysis

Products from pico sales leaders have market leading lighting efficiency, which is even above the LED industry benchmark

Lighting efficacy industry performance
Lumen/ Watt; n=107; select affiliates and non-affiliates (2017)

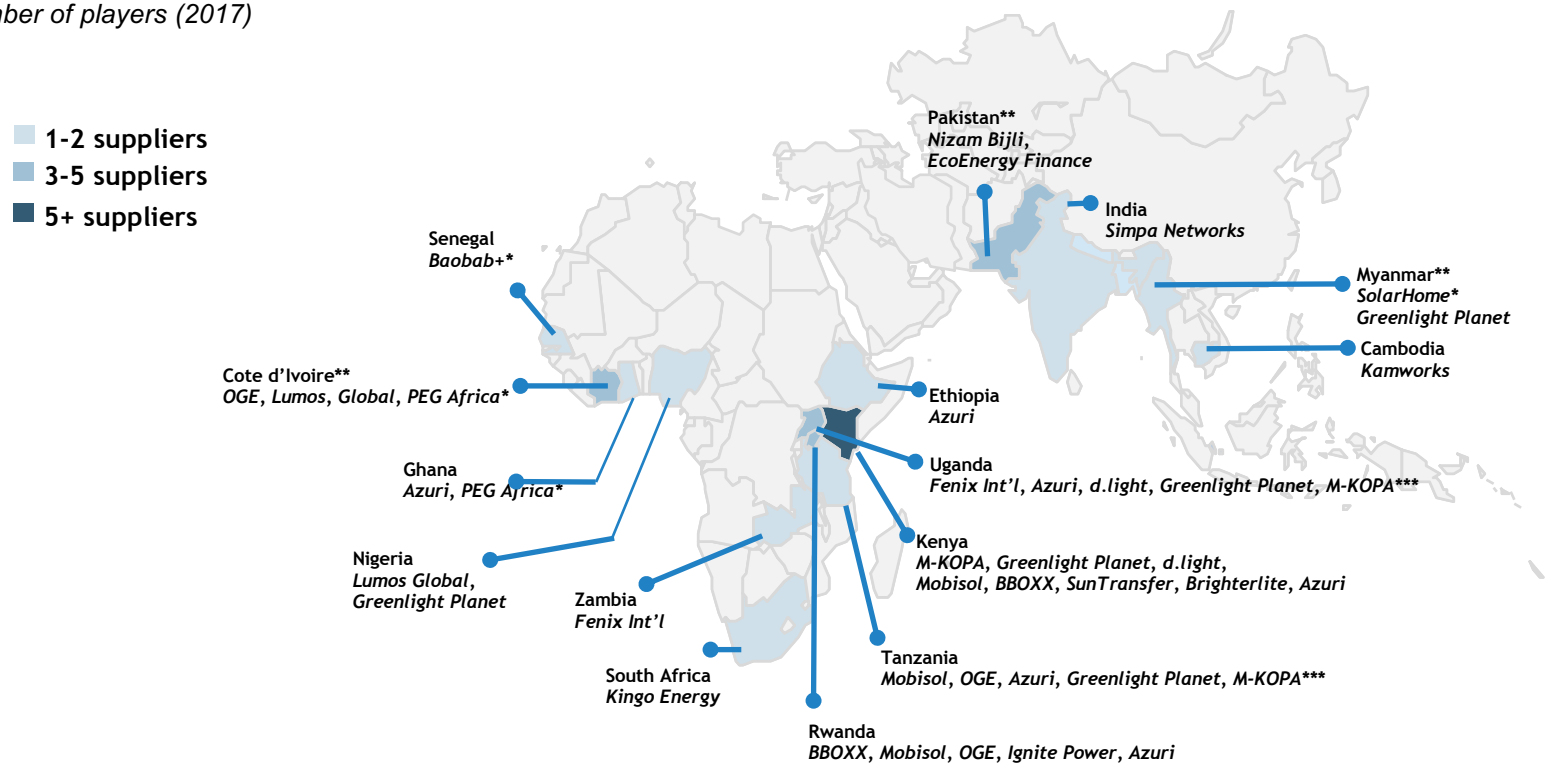


(1) Pico refers to products in the 0-11 W range, 4 products of 12 and 13 W that were listed as "pico" in the Lighting Global product database were changed to "SHS" to comply with the wattage classification. (2) While 2017 lumens and run-time are for products on "turbo" setting, same for 2012 is unclear – we will be validating the 2012 database with specs sheets received from the QA team but in the meanwhile have removed outliers from the 2012 database. (3) Price calculated as 1.8*FOB price listed in Lighting Global data (4) 2017 prices adjusted for inflation; Source: Lighting Global data 2012 and 2017, Dalberg Analysis

East Africa has become a global hub for PAYGO, although like in the pico segment, expansion into West Africa has gathered substantial steam

Presence of PAYGO players by country

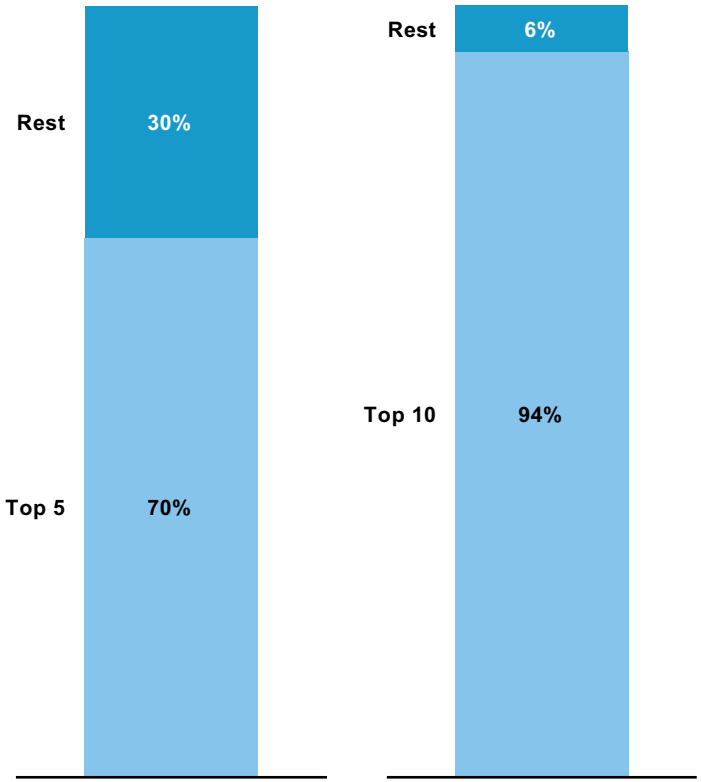
Number of players (2017)



(Note: Does not consider pilots, only well-established sales presence; The data is not exhaustive, but is representative; (*) 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

The SHS/PAYGO market is marked by a top-heavy landscape, in which the top five companies generate 70% of sales annually

Market Concentration in the PnP SHS segement[1,2]
% of annual unit sales (2016)

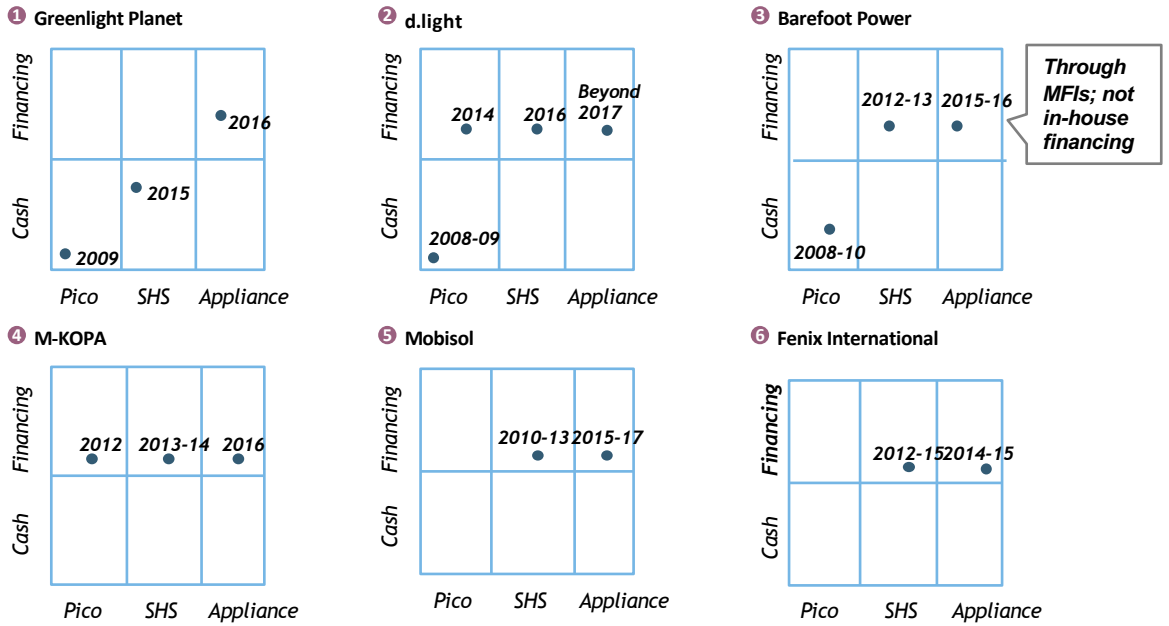


Note: (1) Number of suppliers in 2010 from Lighting Africa, 2010 report (2) Number of suppliers in 2017 collated using the GOGLA and Lighting Global websites, Alibaba and desk research (3) For HQ 2010 share, Europe was split out of "US, Canada, Australia, Japan" assuming all 5 regions had equal share listed. The other 4 regions were clubbed in with "Others" (4) Data unavailable for 12 suppliers listed in 2017; Source: Lighting Africa 2010 and 2012, Dalberg research and analysis

Products from pico sales leaders have market leading lighting efficiency, which is even above the LED industry benchmark

Product and business model evolution for select OGS players

Product launch dates (2009 – 2017)

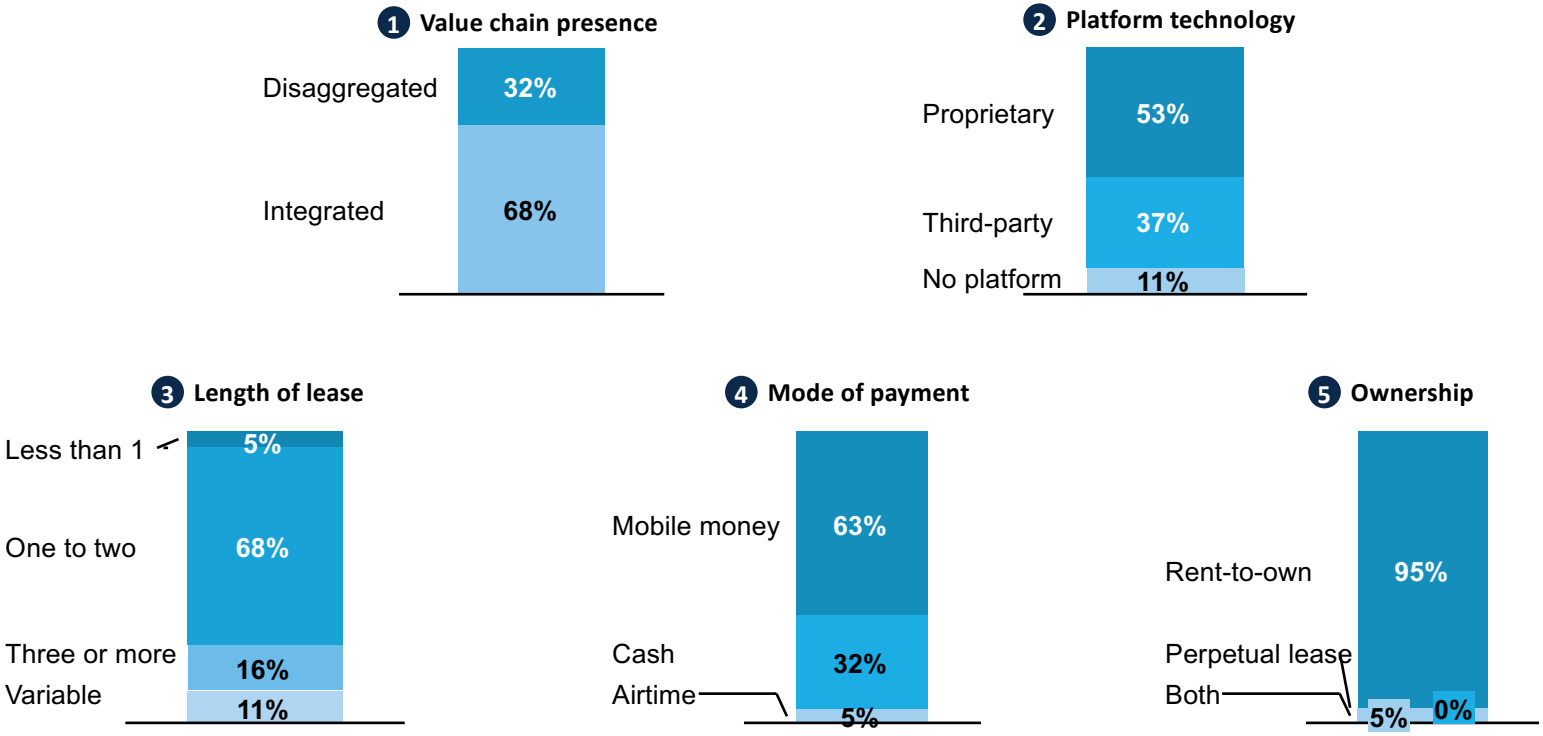


Note: Date of product launch is an approximation based on news reports and company websites and includes a pilot period. Source: Dalberg research and analysis

Products from pico sales leaders have market leading lighting efficiency, which is even above the LED industry benchmark

PAYGO business model specification landscape

% of PAYGO players interviewed (2017)



Note: Based on the business model specifications of 19 PAYGO operators. While this number is not exhaustive, it is chosen to represent diversity of business models and geographies.

Suppliers offer a range of DC powered appliances which include both household and productive uses

DC-powered appliances and their manufacturers *(Illustrative)*

Household

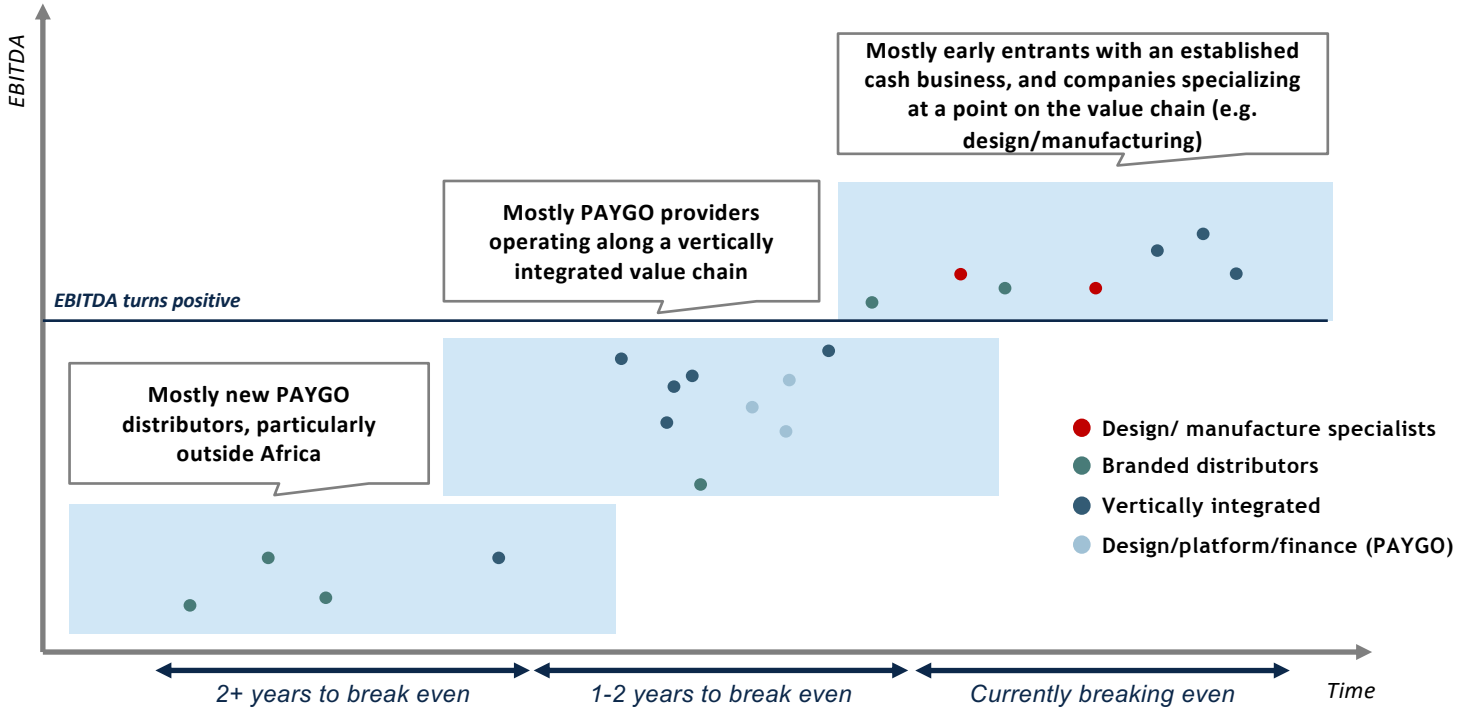
Productive Use

	Appliance Type	Supplier
1	Fan	*Barefoot Power, ECCO, NIWA, All Solar Lights, MAKS, BBOXX, Yingli Solar, SuperStar Group, Onergy Solar, Phaesun, Fosera*
2	TV	*Barefoot Power, NIWA, Onergy Solar, MAKS,SELCO, BBOXX, D.Light, NIWA, Mobisol, Alphatronics, Samsung**
3	Rice cooker	*Roadpro, MAKS*
4	Iron	*Ningbo Jiming*
5	Kettle	*Ningbo Jiming*
6	Washing machine	*Unique*
7	Refrigerator	*Barefoot Power, Phocos, Rigor, Unique, Vestfrost Solutions, SolarNow, Nova Kool, SunDazer, Haier**
8	Freezer	*Dulas Solar, Phocos, SunDazer*
9	Hair clipper	*Off-Grid Electric, Ecoboxx*
10	Sewing machine	*SELCO, Onergy Solar*
11	Egg incubator	*Lifeway Solar, Engokho Kuku Farmer*
12	Milking machine	*Lifeway Solar, Wenzhou Marice Animal Husbandry Machine*
13	Solar pump	*Futurepump*
14	Grain mill	*AgriSol*
15	Huller/thresher/grater	*AgriSol*

Note: (*) Commercial supplier 1) 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; Please note that the data is not comprehensive or representative. Sources: GIZ, "Productive Use Appliance Catalogue," 2016; Sendea Product Catalog, Dalberg analysis.

Established cash sales businesses and specialized firms have turned profitable, but breakeven for SHS/PAYGO players remain elusive

Overview of company profitability
N= 20 companies, EBITDA (2017)

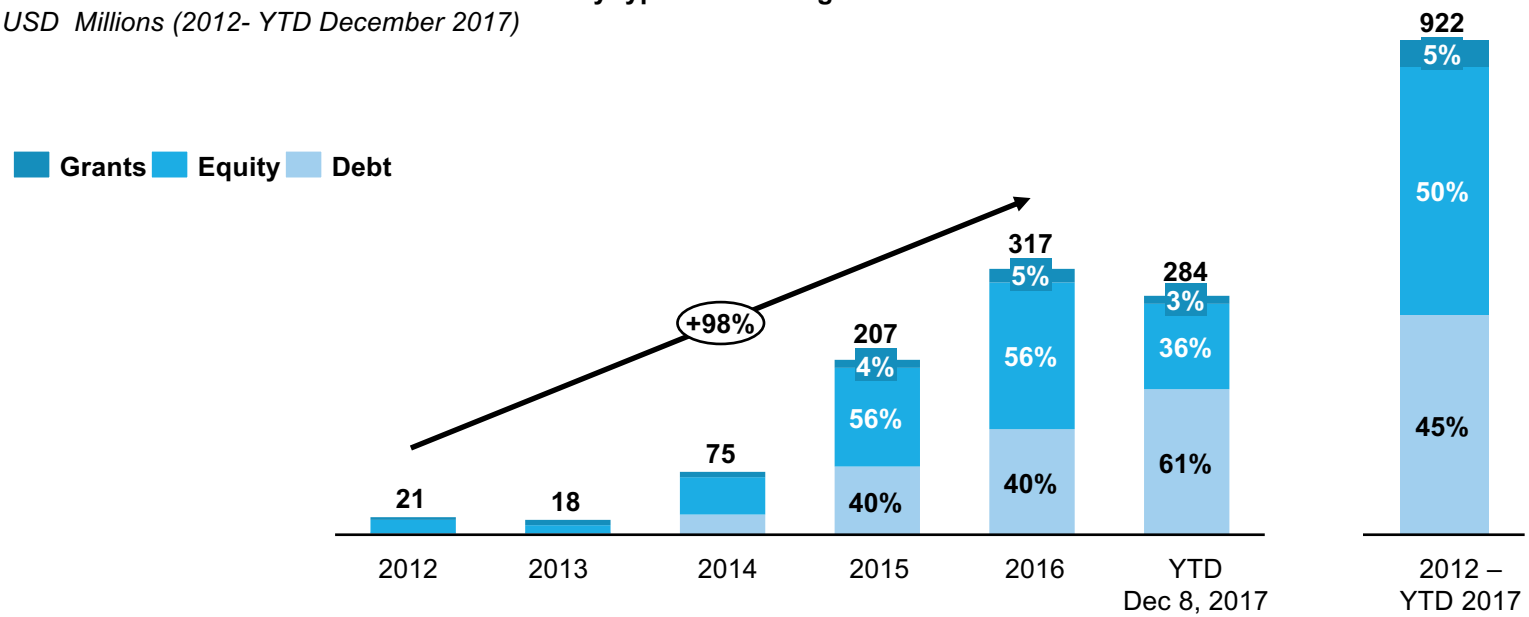


(1) Mapping is relative and not exact (2) Estimates based on indicators self-reported by suppliers Source: Dalberg Interviews, Dalberg Analysis

1D: Access to Finance

From 2012 - 16, annual funding increased by 98% annually, but 2017 investments lagged previous year due to a lack of equity funding

Annual investment in OGS sector over time by type of financing
USD Millions (2012- YTD December 2017)

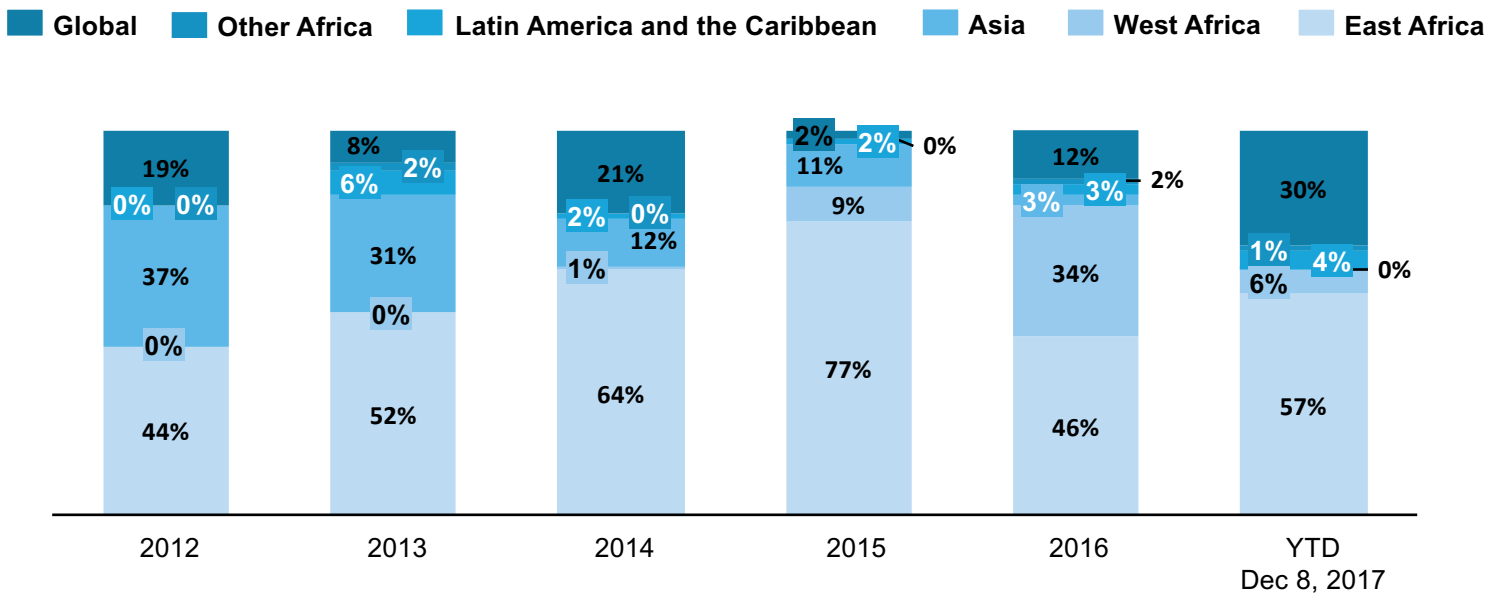


	2012	2013	2014	2015	2016	YTD Dec 8, 2017
Avg. size of top 5 transactions	2.8	2.4	9.8	21.3	31.7	25.4
Avg. size of overall transactions	1.4	1.0	3.1	5.6	4.0	5.0
Number of transactions	15	18	24	37	79	57

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

Investments historically flowed to East Africa, but concentration is decreasing; West Africa has emerged as an important destination for funding

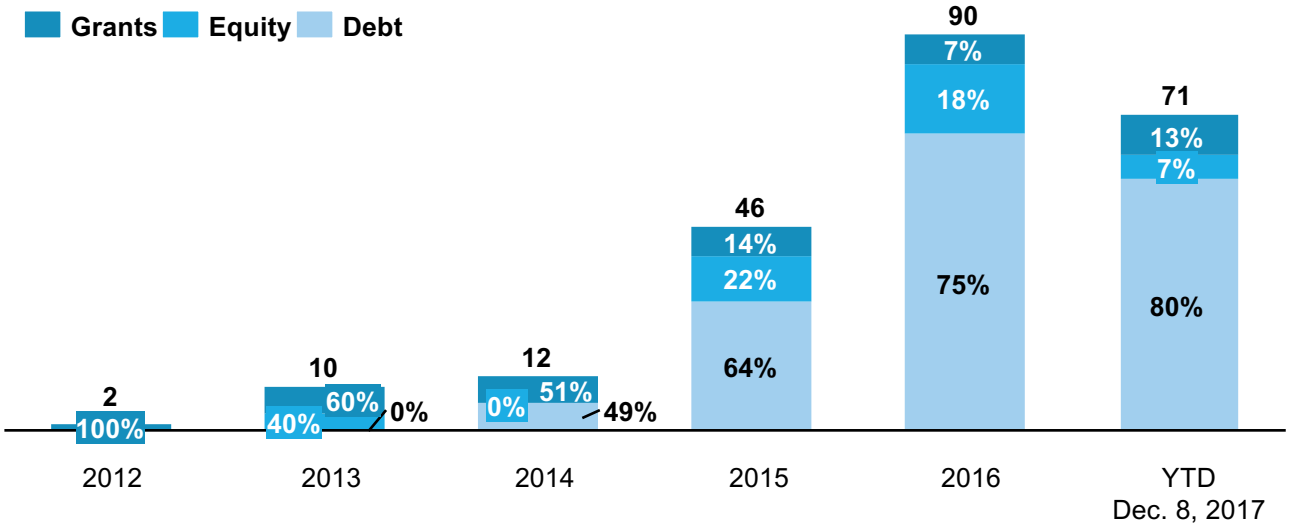
Breakdown of total investment in OGS sector by geographical dispersion
% of total, (2012- YTD October 2017)



Note: Which geography was assigned to a specific investment was based on the primary geography where the investment would be made. 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 include estimated 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

DFIs have been key funders since the inception of the sector and continue to be key suppliers of grants and debt financing

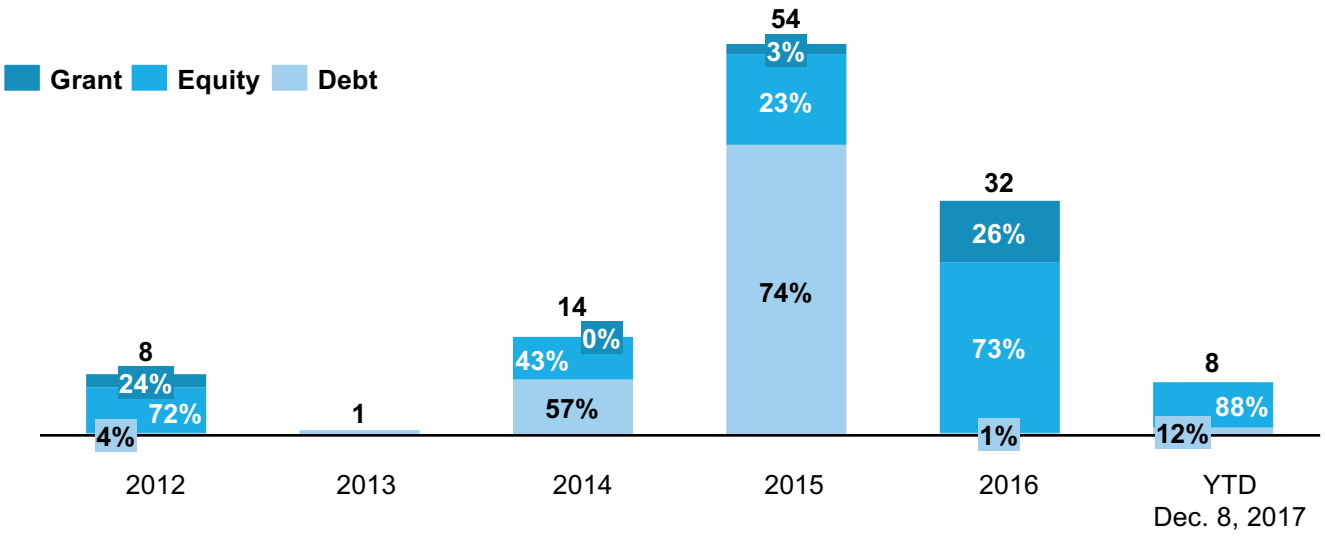
DFI funding over time
Millions USD (2012- YTD December 2017)



Source: GOGLA 2018 Deals Database

Foundations have made flexible investments that are specific to company needs

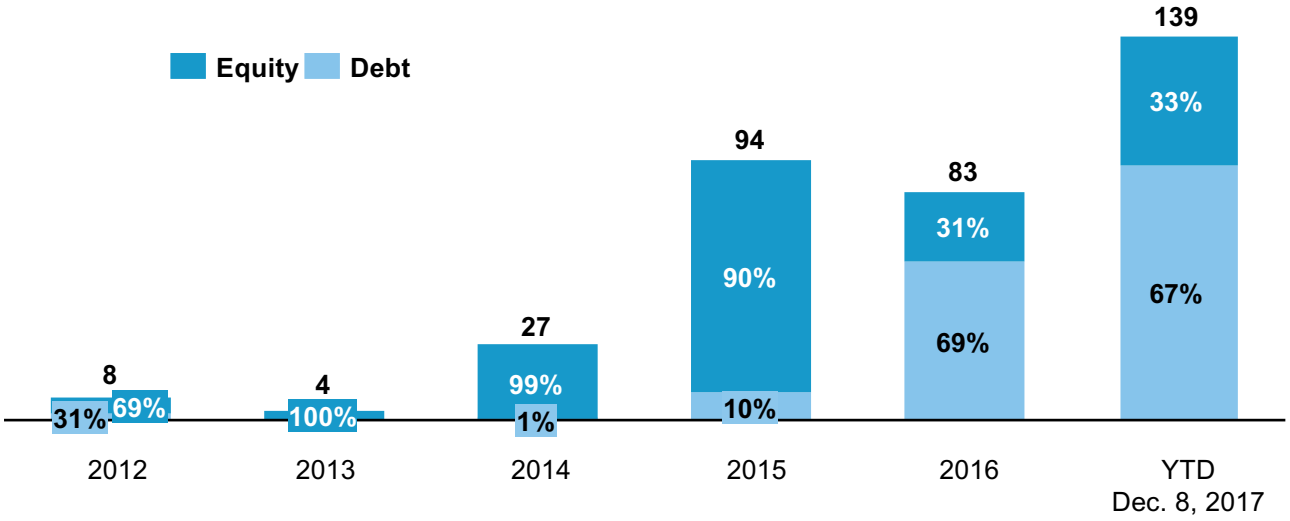
Funding from foundations over time
USD Millions (2012- YTD December 2017)



Source: GOGLA 2018 Deals Database

Impact Investors have been a primary source of equity funding; lately their focus has shifted to debt investments

Investments by impact investors over time
Millions USD (2012- YTD October 2017)

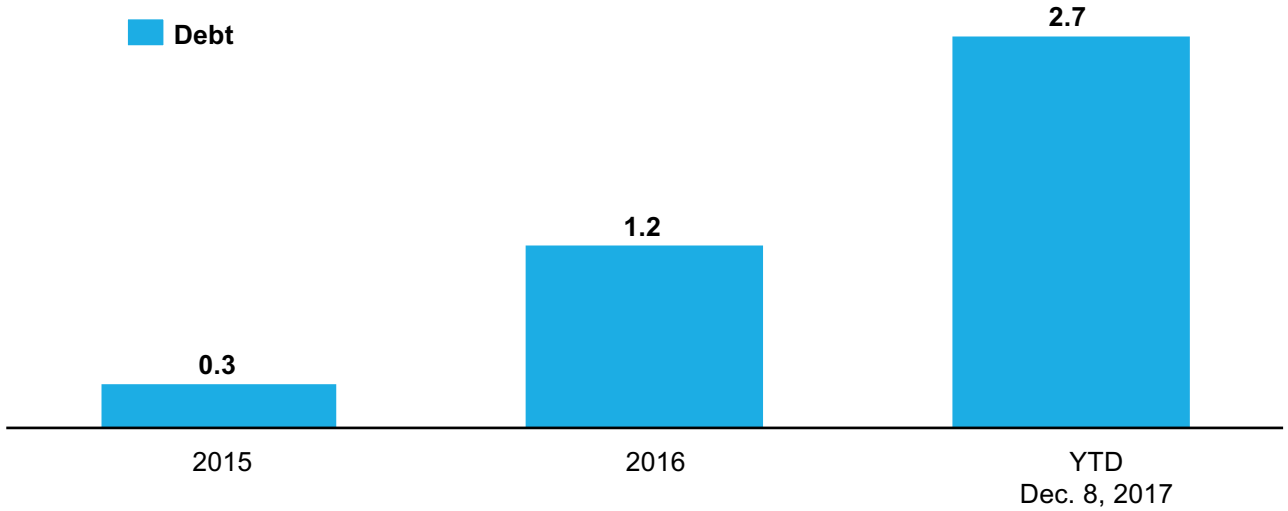


Source: GOGLA 2018 Deals Database

OGS focused crowdfunders have recently emerged, uptake has been quick as funding has been in high demand

Crowdfunding raised over time

Millions USD (2015- YTD December 2017)

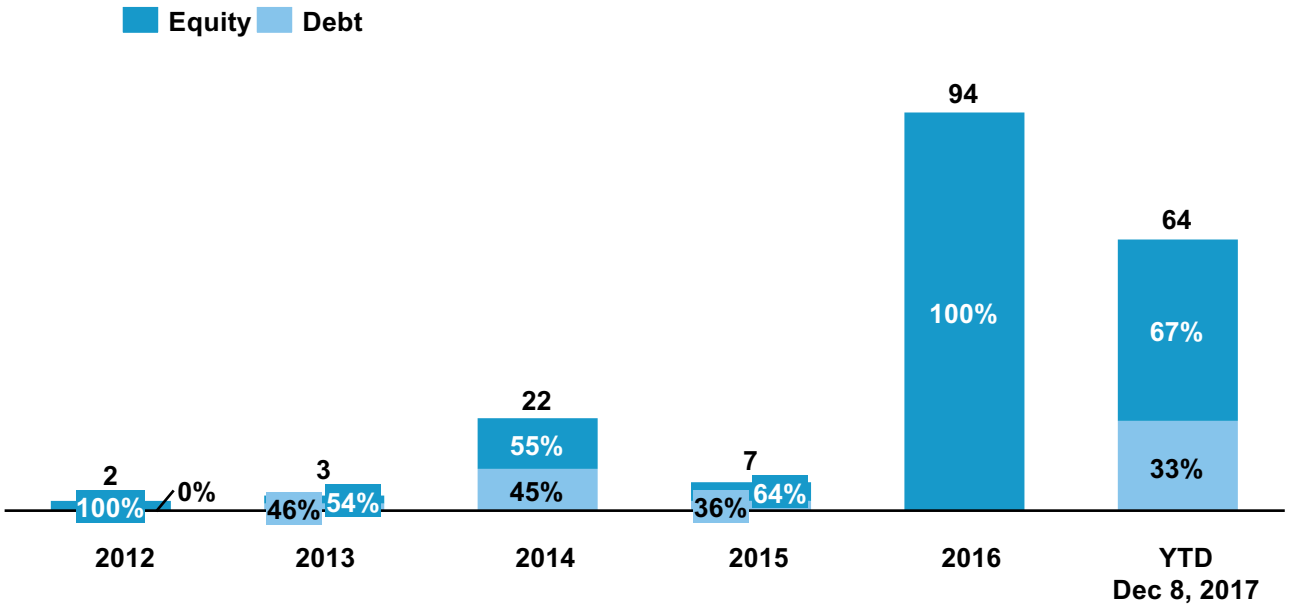


Source: Only those projects that funded OGS directly (e.g. pico and SHS companies). Source: GOGLA 2018 Deals Database

Commercial funders have entered the market, but funding has been inconsistent and opportunistic

Commercial capital raised over time

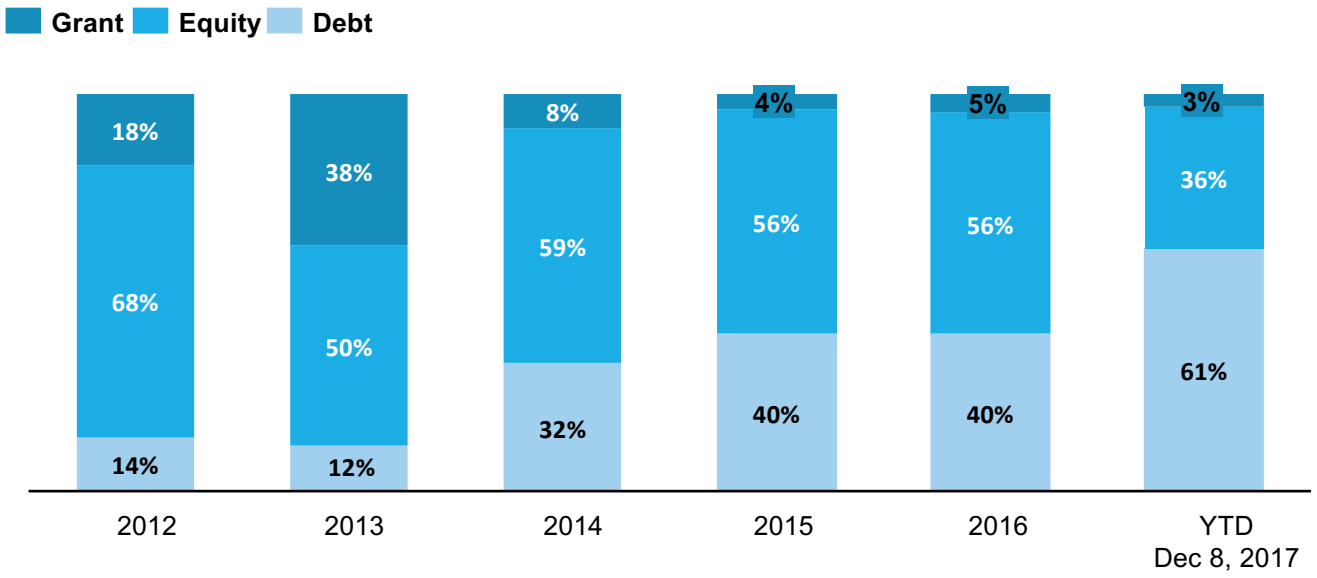
Millions USD (2012- YTD October 2017)



Source: 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

Industry wide investments have shifted towards debt over time

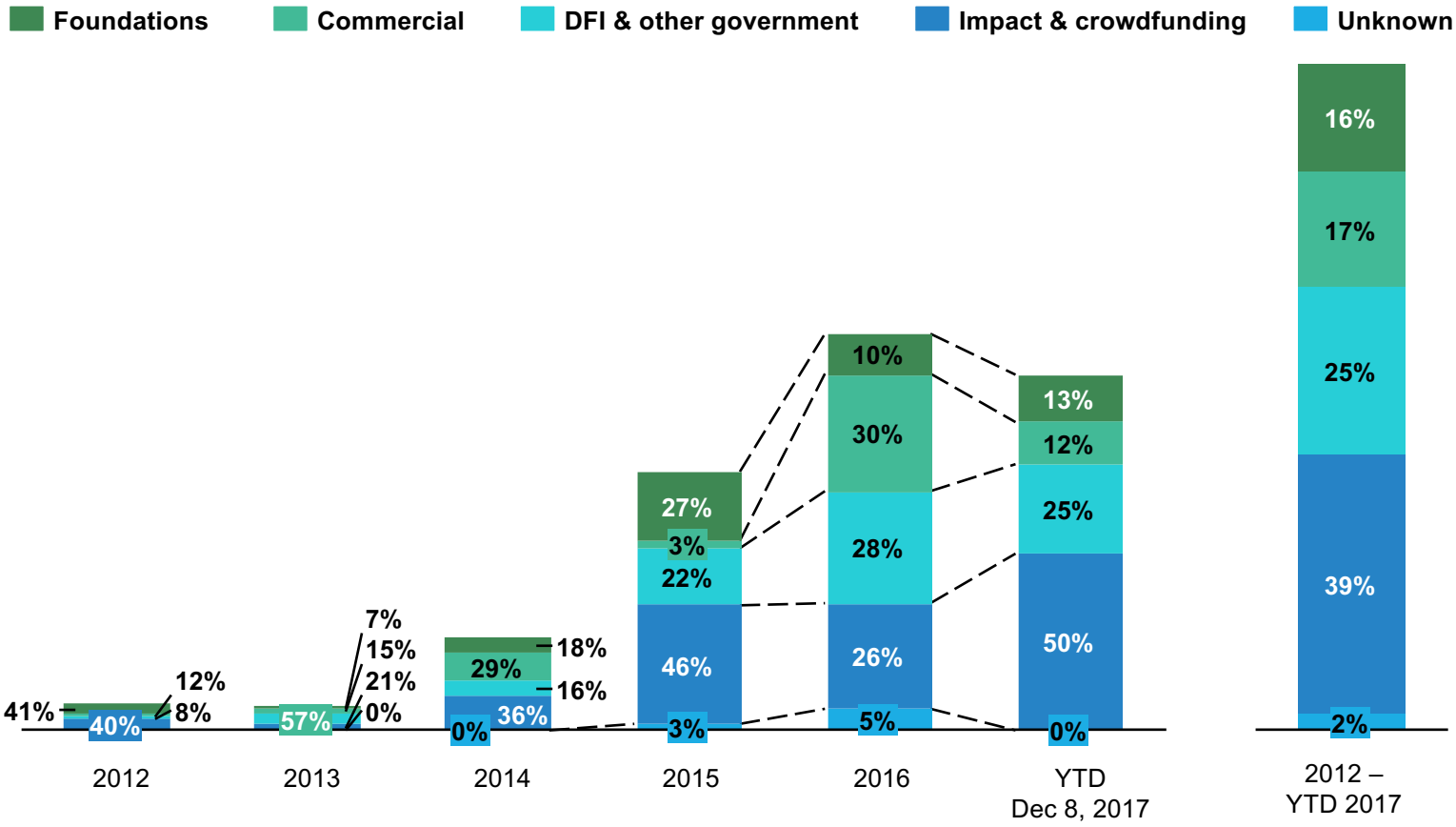
Breakdown of fund raised by instrument
% of total funds raised (2012- YTD December 8, 2017)



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 Source: GOGLA 2018 Deals Database

Impact investors and DFIs are the primary funders of the OGS industry, but for-profit funding has emerged as a force in the past two years

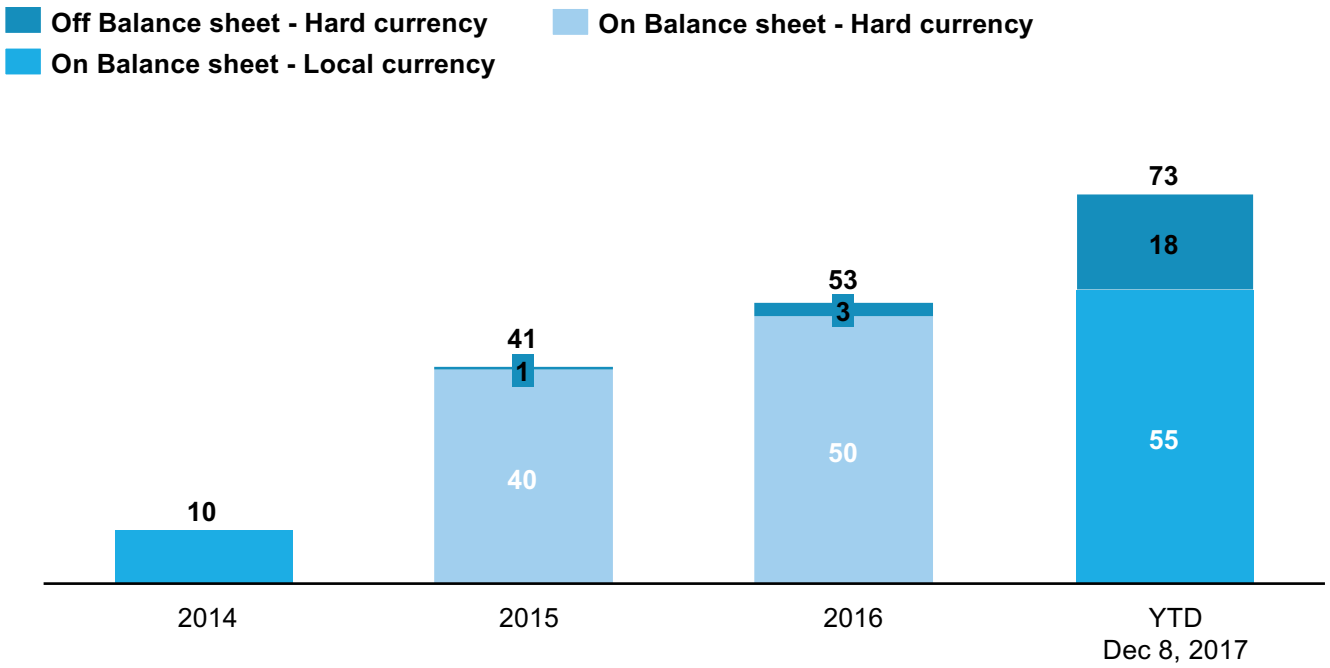
Investments by investor type
% of total funds raised (2012- YTD October 2017)



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
Source: GOGLA 2018 Deals Database

Leveraging the value of consumer receivables to support lending will be an important source of debt funding

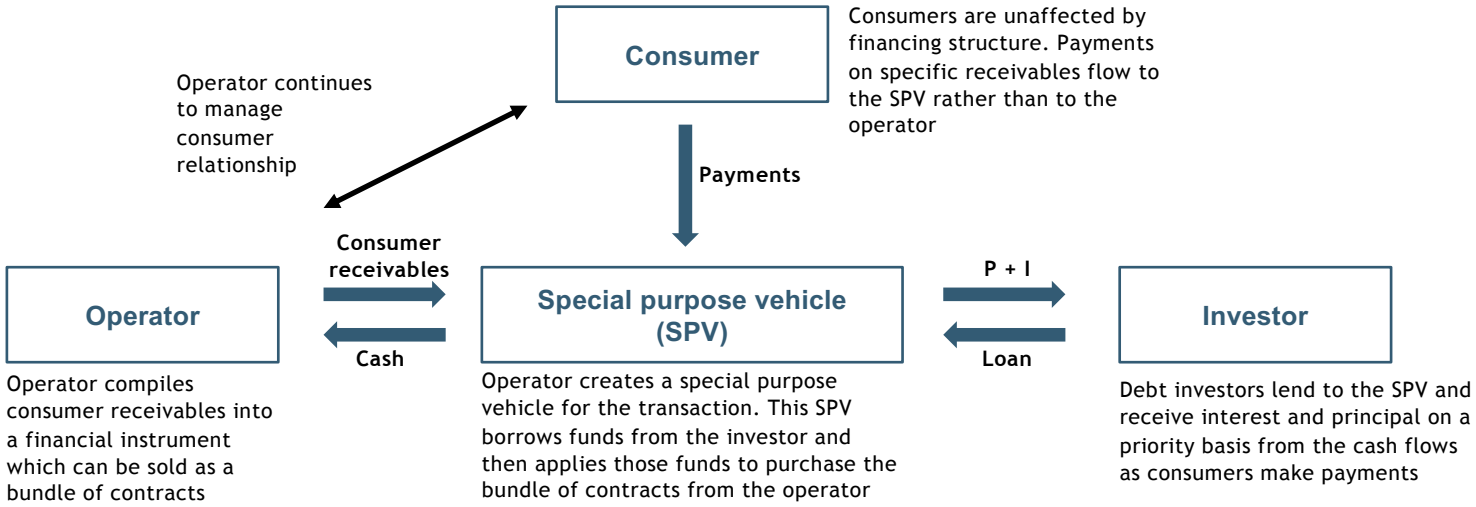
Funding which leverages asset values to support lending, over time
Millions USD (2014 – YTD October 2017)



Source: GOGLA 2018 Deals Database

Off balance sheet structures provide a way to raise capital by leveraging the strength of the PAYGO consumer receivables

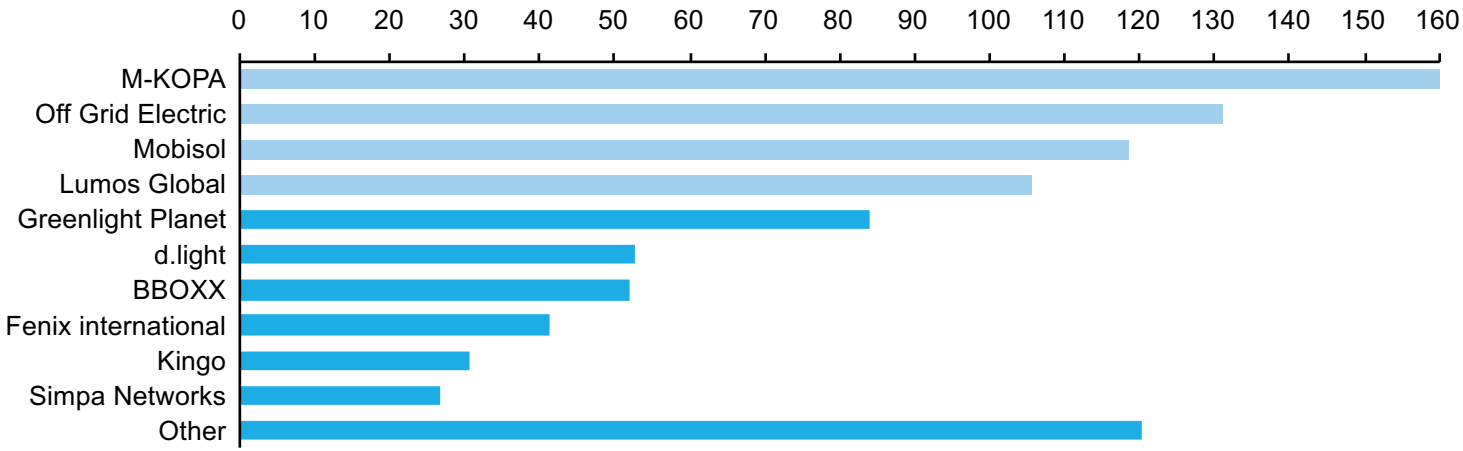
Structure of an off-balance sheet transaction (Illustrative)



Note: While 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

Flow of funding has been highly concentrated with 60% of funding flowing to the top 4 suppliers

Companies receiving funds
Millions USD (2012- YTD December 2017)

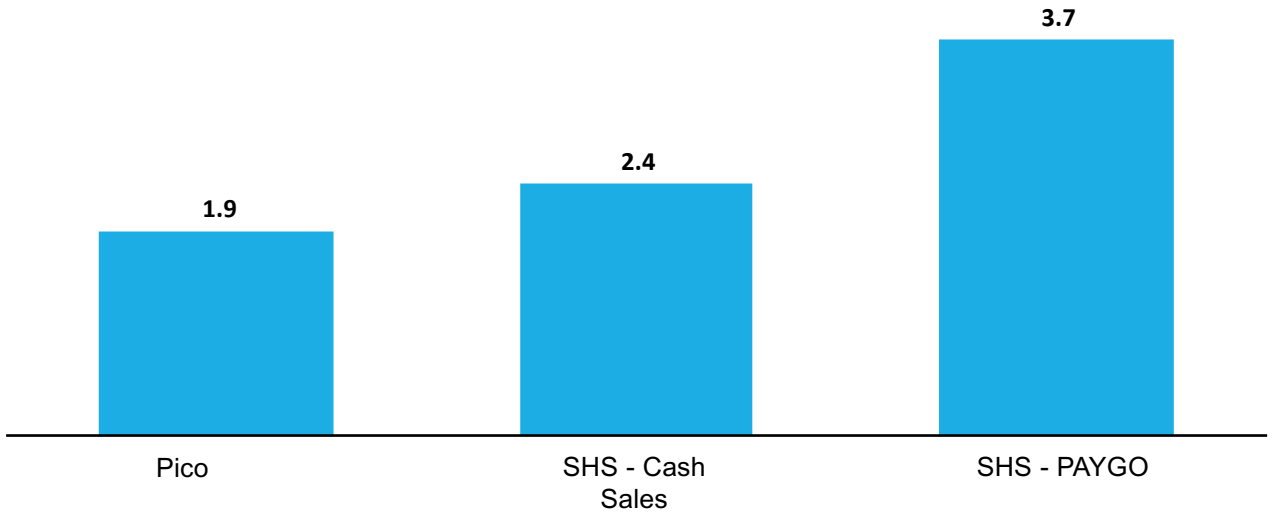


Note: 2017 figures include estimates of the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study has not been able to verify the size of these transactions, and estimates that they collectively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

SHS/PAYGO businesses face an easier fundraising environment that other business models

Relative ease of fundraising in the current market, by business models

Average score from poll of fund providers, Score out of 5 (1 is difficult to fundraise, 5 is easiest), n=18, ,(2017)

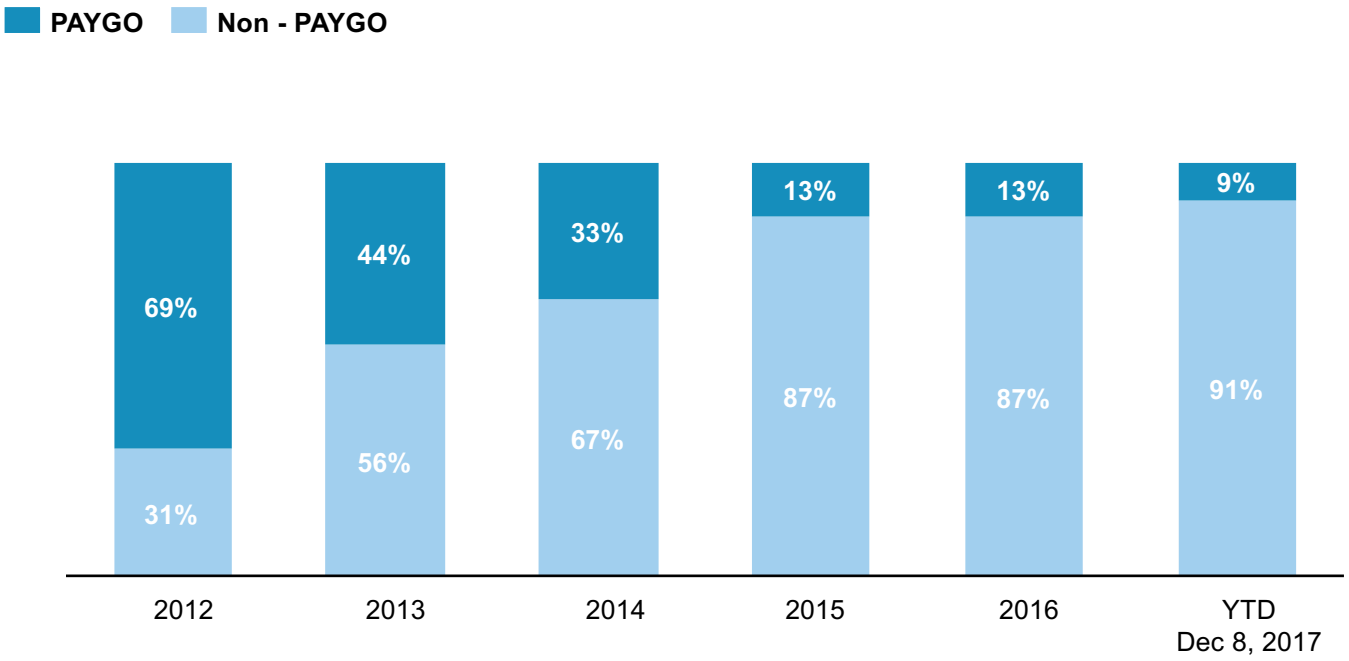


Source: Industry interviews

Funds raised have gone to companies which use the PAYGO business model, in recent 3 years more than 85% of funding has gone to such companies

Funding flows by business model

% of total funding raised (2012- YTD October 2017)

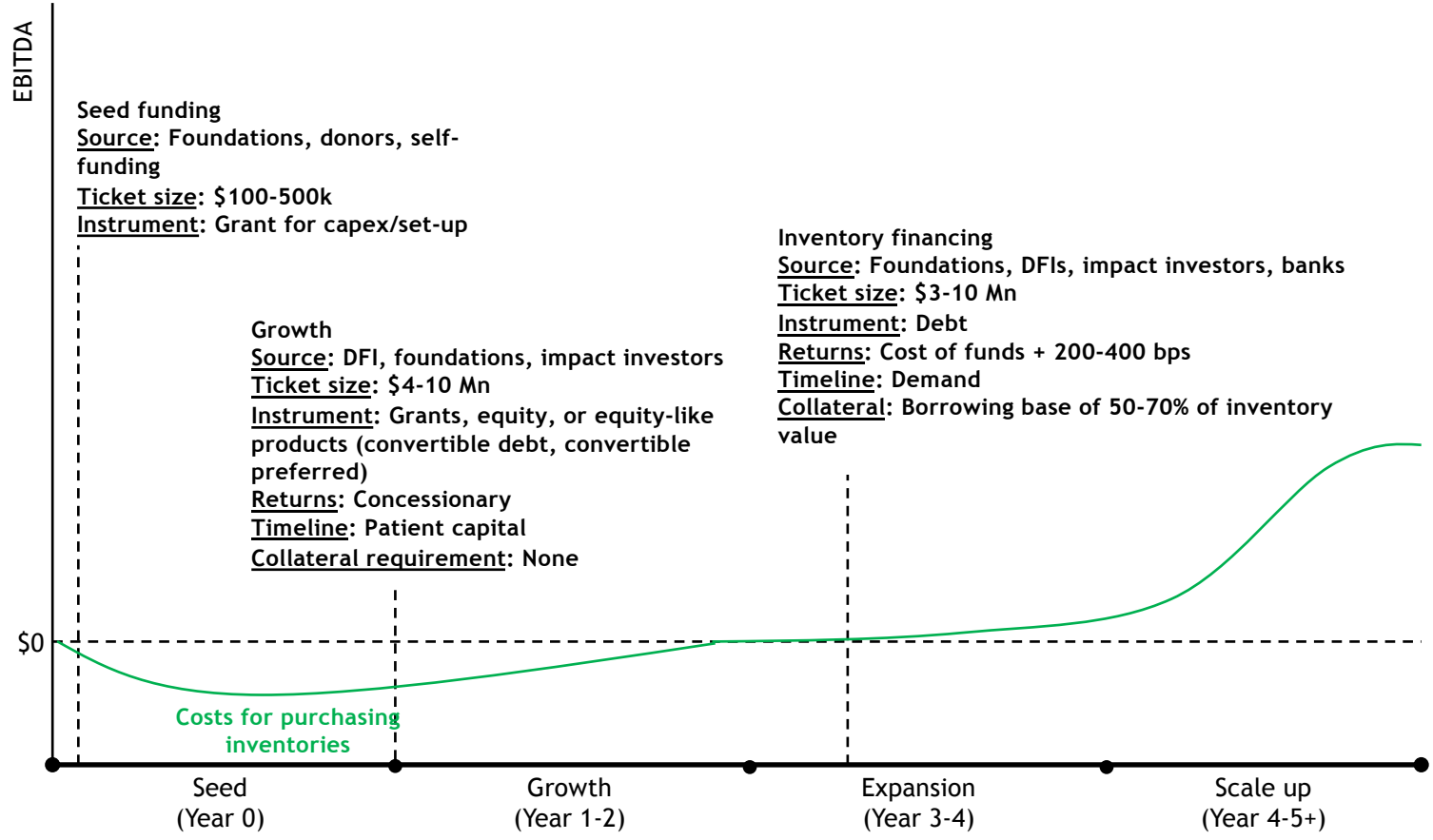


Note: 2017 figures include estimates on the acquisition of Fenix International by Engie and a follow-on investment from a consortium of investors led by Investec Asset Management into Mobisol. This study has not been able to verify the size of these transactions, and estimates that they collectively 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

Total funding raising, in the first five years, for a successful indicative cash sales business is under USD 10 million dollars

Indicative historical funding cycle for company following a cash sales model

ILLUSTRATIVE



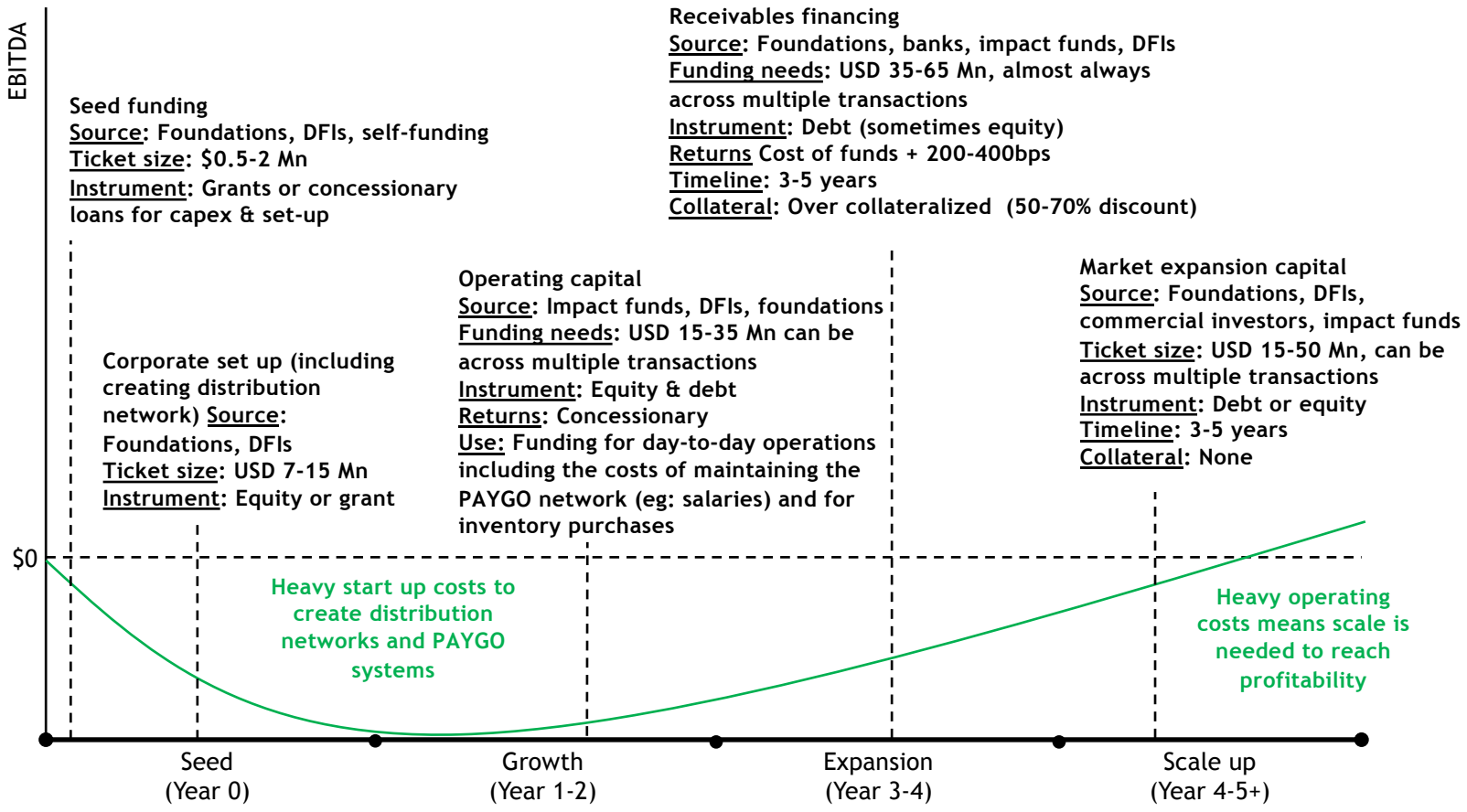
Note: Years are indicative and based on typically growth in OGS lantern market based on industry interviews ; EBTDA curve is indicative.

Source: Dalberg Interviews, Dalberg research

Total funding needs, for the first five years, for a successful indicative PAYGO business can range from 70 to 150 Million

Figure 82: Indicative historical funding cycle for company following a PAYGO sales model

ILLUSTRATIVE



Note: Years are indicative and based on typically growth in the SHS PAYGO market ; EBTIDA curve is indicative.

Source: Dalberg Interviews, Dalberg research

Better understanding of consumers risk allows for the leveraging of PAYGO technologies to offer consumers new financing opportunities

Evolution of the proprietary consumer risk model

Built off standard models: Standard risk rating models often used by banks or other financial institutions serve as templates

Modified to reflect the on-the-ground realities: Behavioral finance measures are often added to risk models reflecting the cultural habits and the financial situation of consumers

Further refined with data: Models are updated based on actual consumer data, allowing for radical improvements

Seasoning is needed to gain institutional support: Models need to be back-tested after experiencing market stressors and an economic downturn (yet to occur)

New financing opportunities

Loans: Companies such as Fenix International have expanded their offering to include education and agriculture loans, which are in high demand

Insurance (and other 3rd party financial products): Credit ratings can be leveraged by third parties over the PAYGO platform to provide financial products to consumers

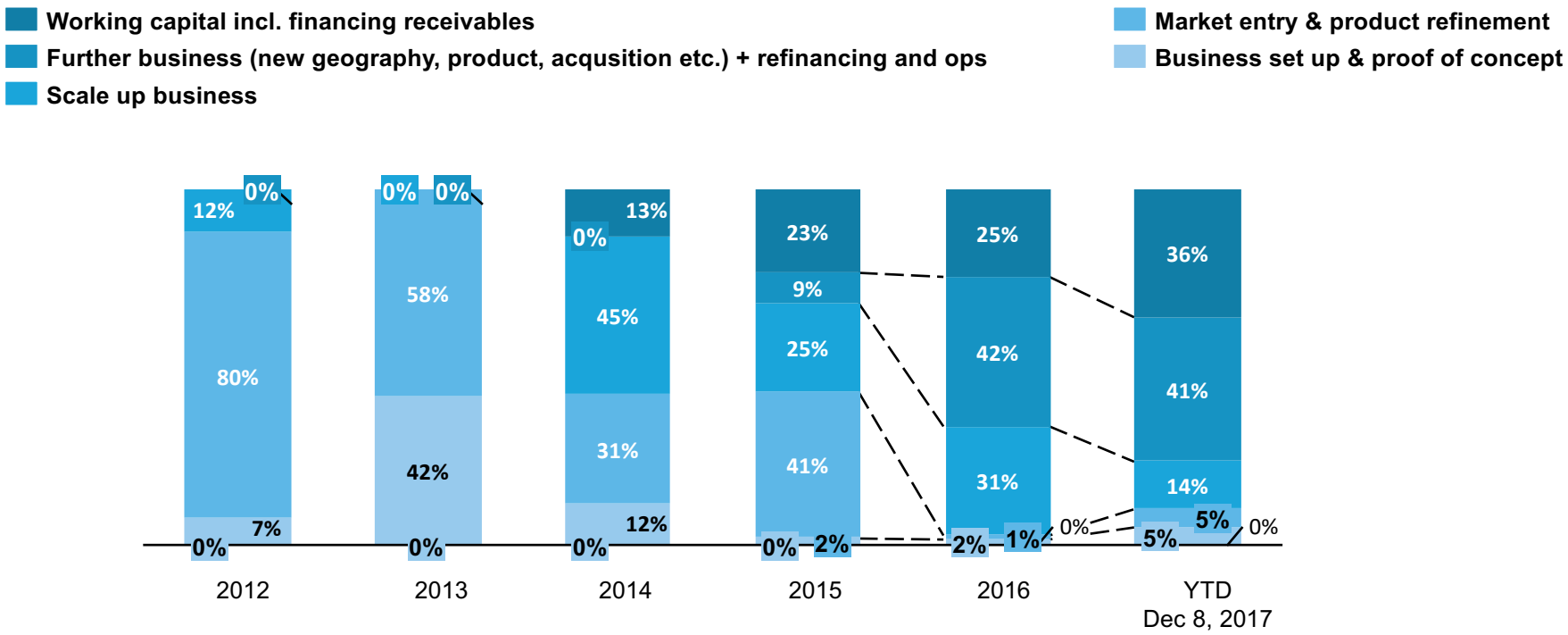
Consumer products: There is growing interest among consumer product suppliers to leverage PAYGO platforms to provide financing for other consumer products

Funding for businesses: A strong credit history with a solar home system provides the basis for purchasing larger commercially focused SHS

Source: Dalberg Interview , Dalberg Analysis

Stated use of use of funds has evolved over time reflecting maturity in the market, especially for PAYGO businesses which have large funding needs

Use of funds over time
Percentage of total funds raised (2012- YTD October 2017)

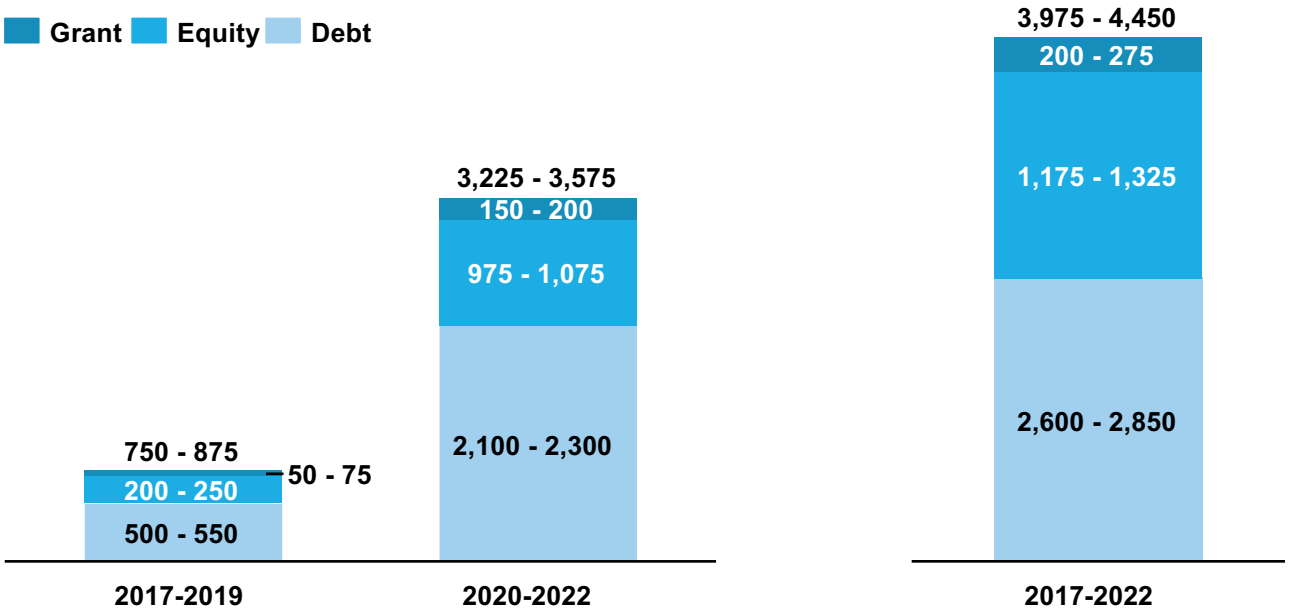


Note: Use of funds was determined either through interview or by reviewing the publicly announced stated use of funds at the time of fund raising through corporate news releases or other publicly available news sources. 2017 figures include estimated on the acquisition of Fenix International by Engie 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

Amount of external funding needed till 2022 is more than 4 billion dollars of which 2.7 billion will be debt financing

Forecasted external financing need for top OGS affiliate companies

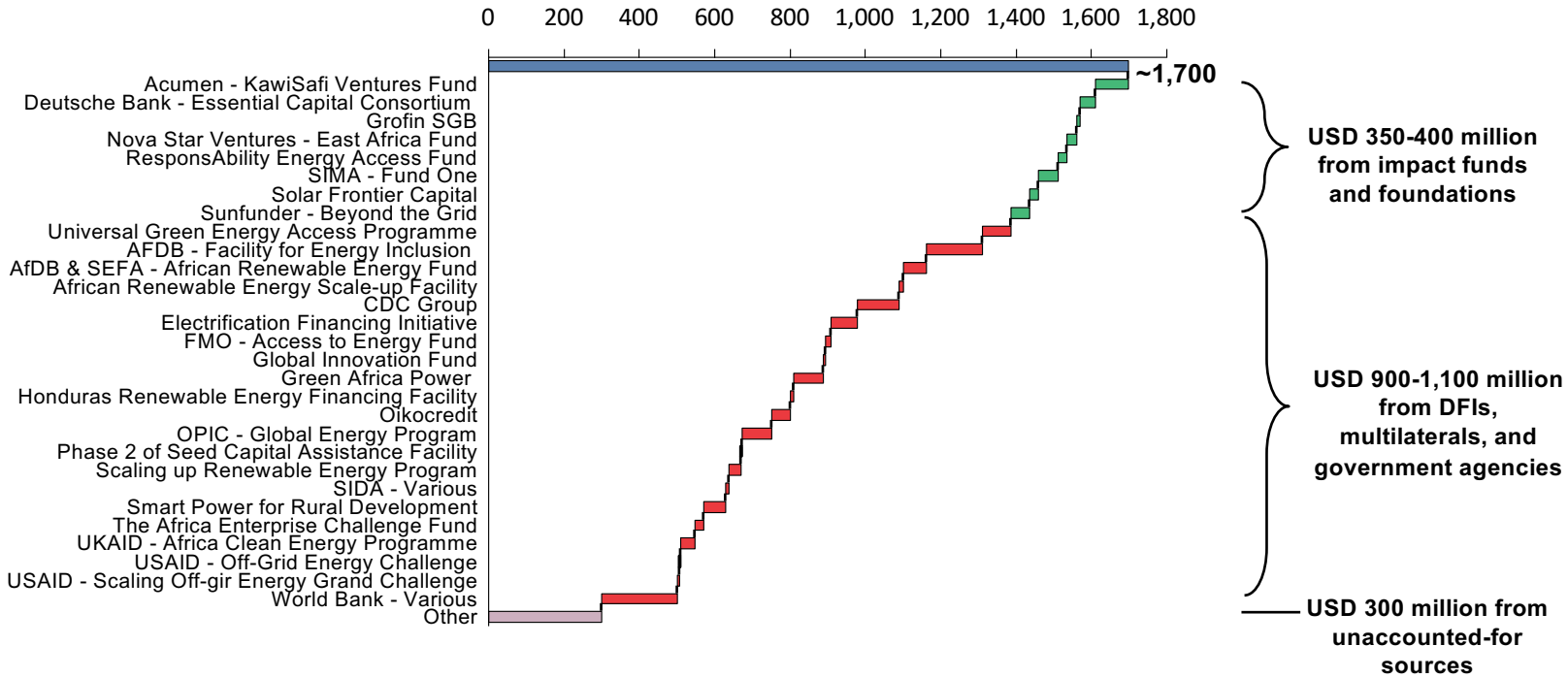
Millions USD (2017-2022)



Source: Dalberg OGS 2017 – 20122 financing needs forecast model; Dalberg analysis

A number of funds have publicly committed to support the OGS sectors, we believe that they will provide roughly USD 1.7 billion in funding

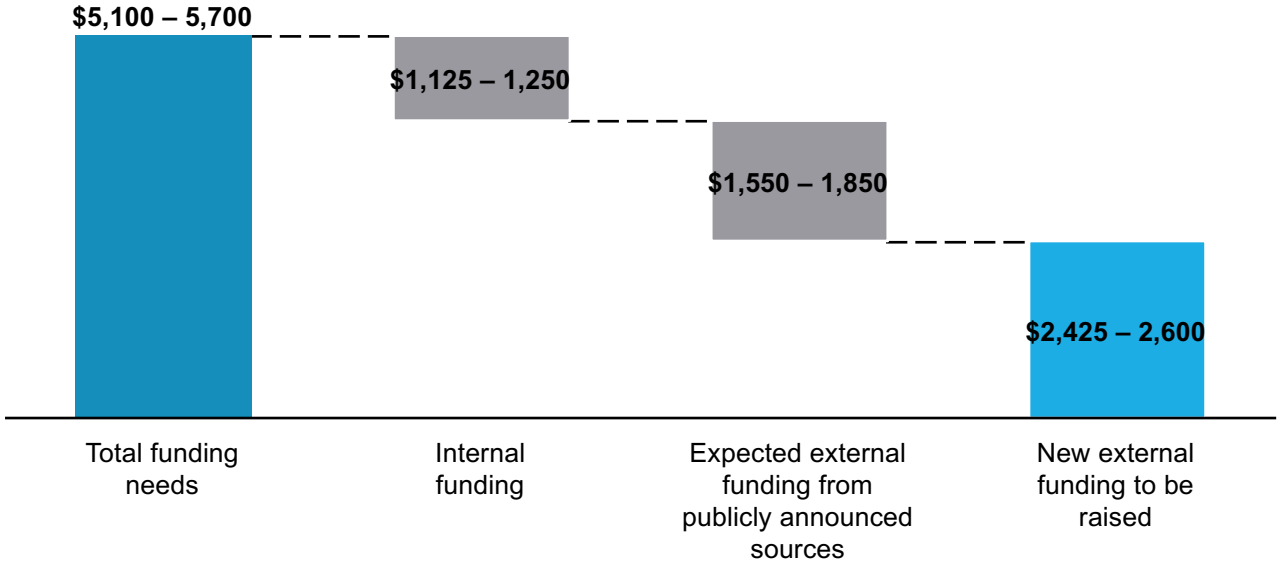
Breakdown of expected capital to be invested in the OGS sector by fund
Millions USD (2017-22)



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 previously public announcements. To account for the few funds which may overspend expectations and to reflect commitments made by funds unknown to us, the authors have added a further USD 300 million to the estimate, which is approximately equal to increasing to a 20% increase on the expected funding documented in this analysis.

Roughly USD 2.48 Billion in funding will need to be raised from currently unknown sources to meet funding needs of the OGS community

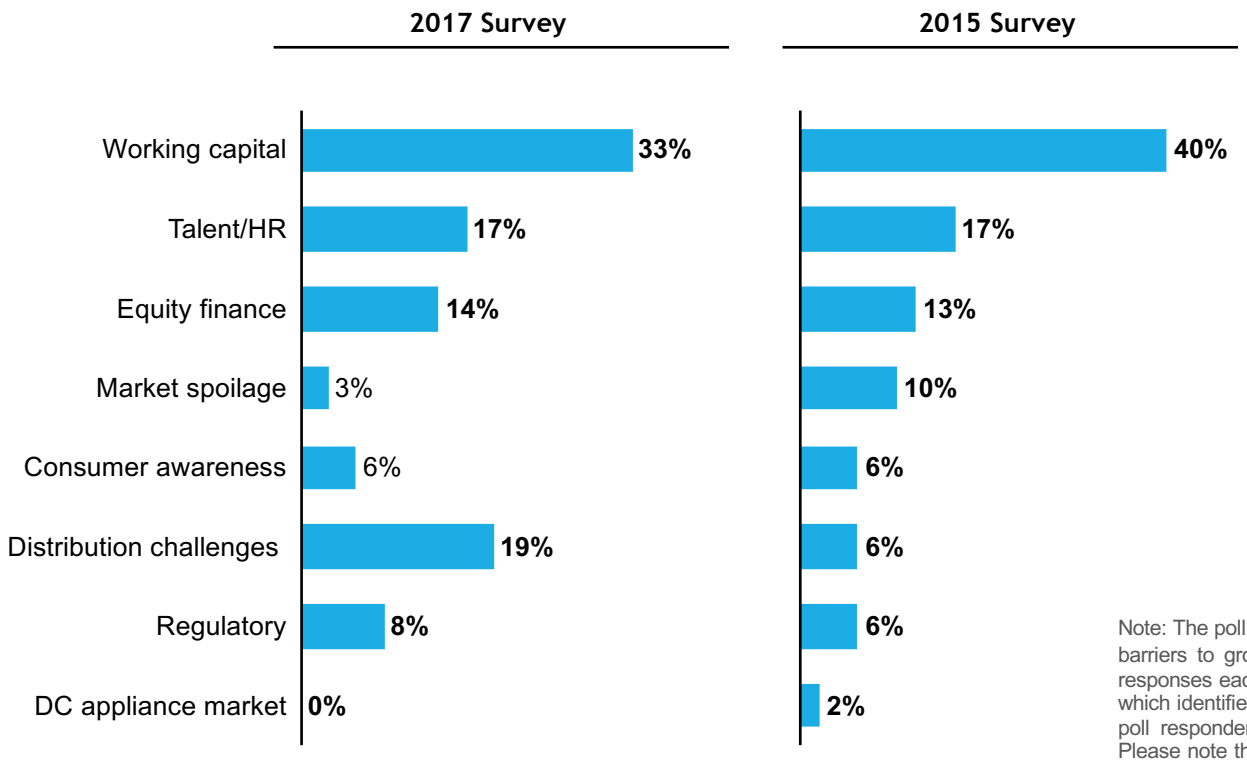
Funding gaps
Millions USD (2017-2022)



Source: Dalberg OGS 2017-2022 financing needs forecast model; Dalberg analysis

Working capital remains the key barrier to growth for businesses, but distribution challenges have also appeared as a key challenge

Investor poll results on key barriers to growth for companies
For 2017 survey: Number of poll respondents that rank each in top 3, n=17 (2017)
For 2015 survey: Top three answers of polled respondents, n=26 (2015)



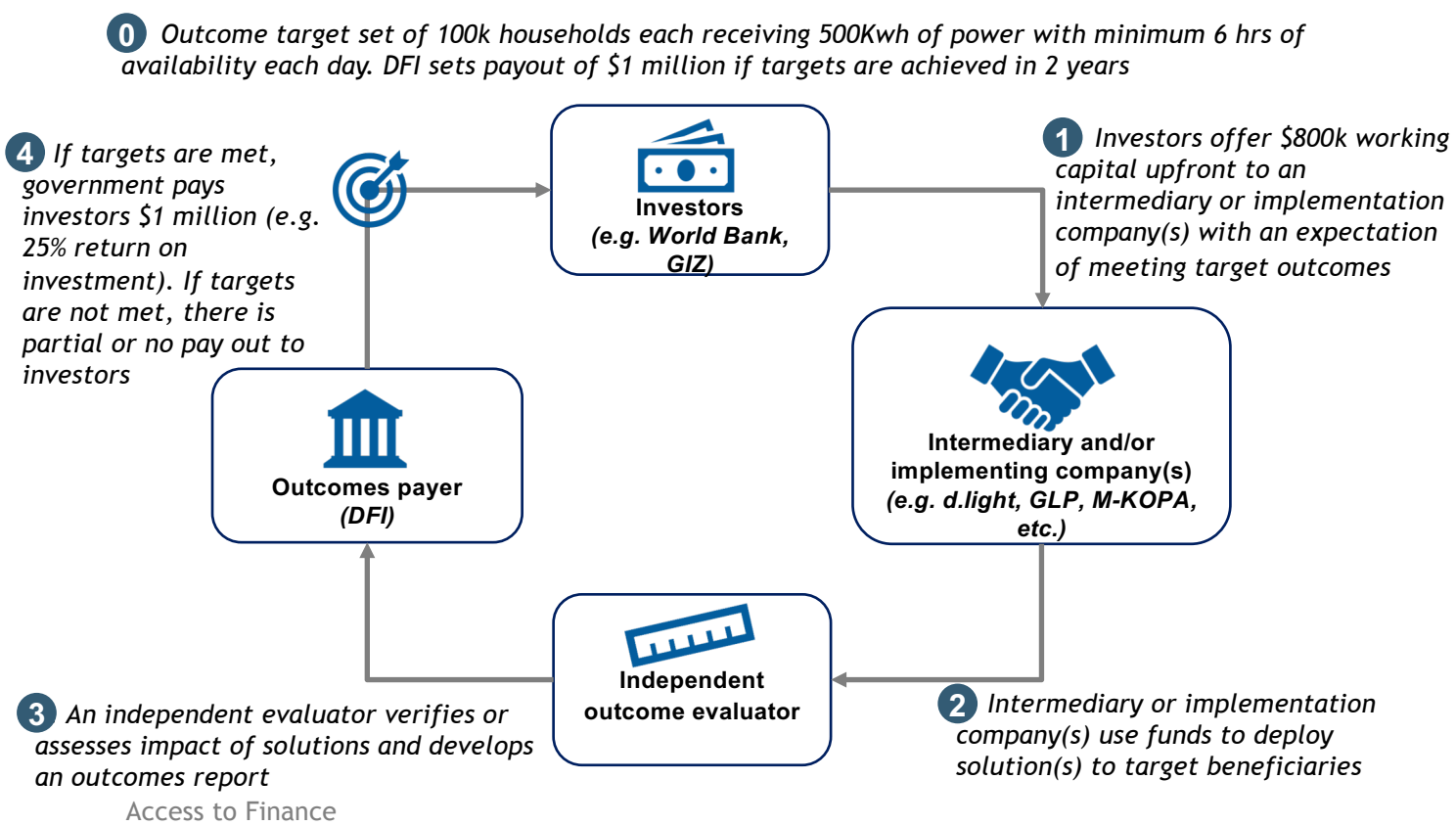
Note: The poll asked funding organizations to identify their top three issues which currently are barriers to growth in the OGS industry. The figures in the graph represent the number of responses each category received and does not represent the number of polling respondents which identified any specific 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. Please note that not all respondents identified three issues when completing the poll. Source: Industry interviews; (Bloomberg New Energy Finance, 2016)

An energy impact bond can be an effective instrument to meet policy agendas and finance solutions that create desired outcomes

ILLUSTRATIVE

Example structure of a Development Impact Bond, an emerging RBF vehicle

An energy DIB in Rwanda could be used to finance access to electricity for rural population in off-grid areas



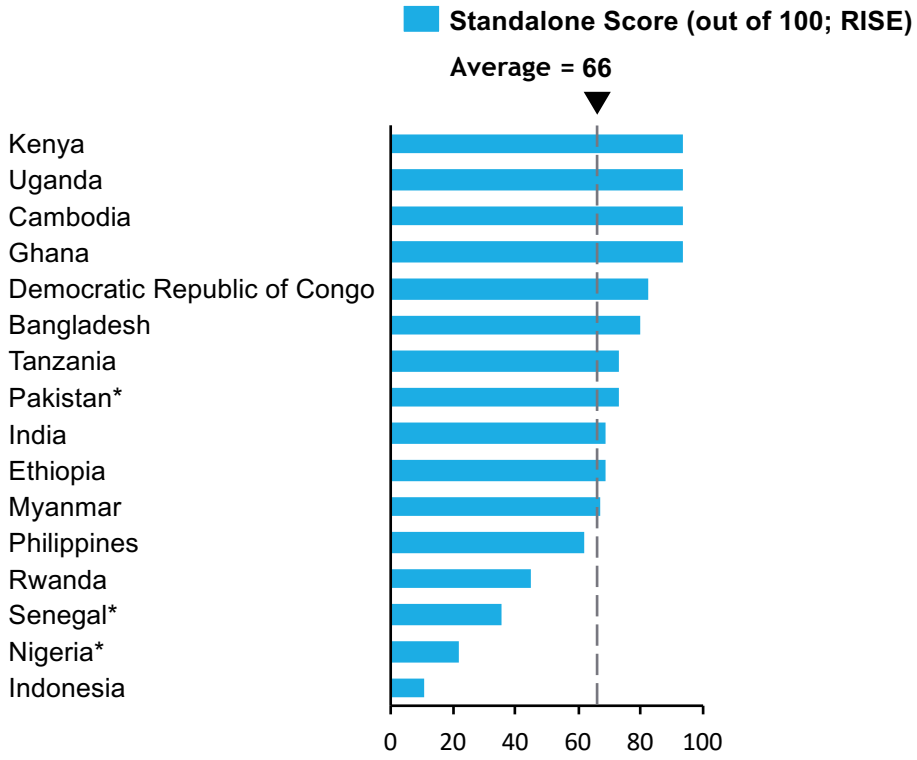
Source: Dalberg analysis

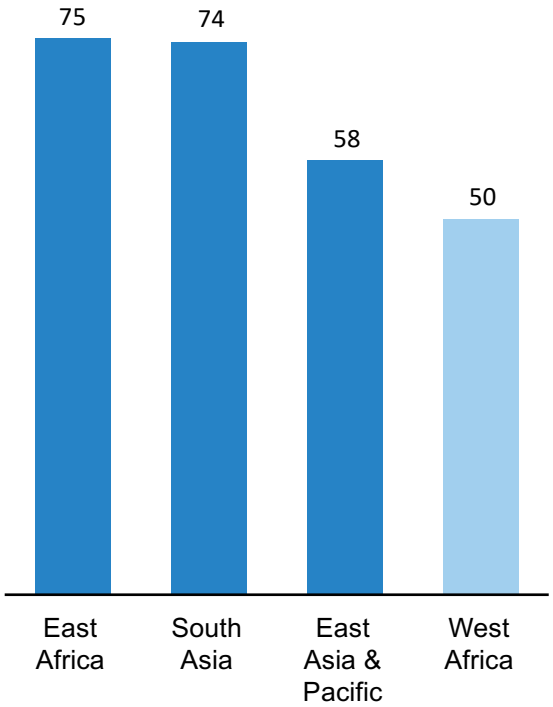
1E: Enabling Environment

East Africa and South Asia provides a fertile regulatory environment; despite recent sales and investment growth West Africa lags behind

Regulatory environment for 'stand-alone' systems – countries and regions

Scores (/100) on the Regulatory Indicators for Sustainable Energy Index (World Bank ESMAP; 2016)[1]





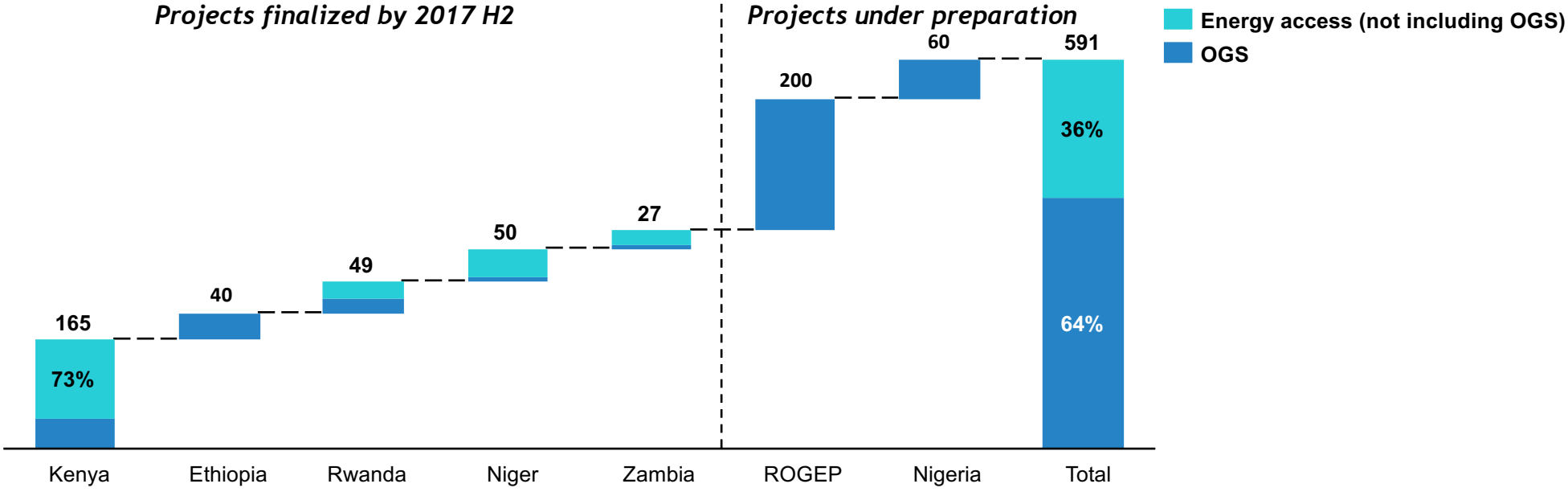
(1)RISE is a set of indicators to help compare national policy and regulatory frameworks for sustainable energy. It assesses countries' policy and regulatory support for each of the three pillars of sustainable energy—access to modern energy, energy efficiency, and renewable energy.

* Countries without integrated national programs

Source: http://rise.esmap.org; World Bank; Dalberg analysis

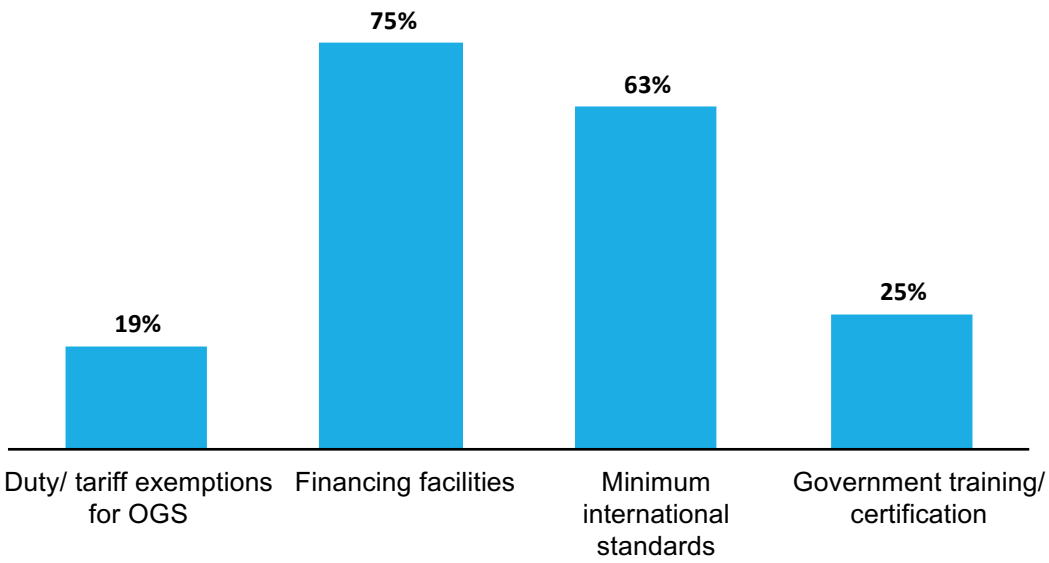
Kenya remains the center of energy access investment, drawing the greatest attention from the world bank's PPP programs

World Bank PPPs with Sub-Saharan governments for energy access, including OGS
USD millions



Countries are likely to focus on financing support when adopting enabling policies, duty exemptions and government training are often overlooked

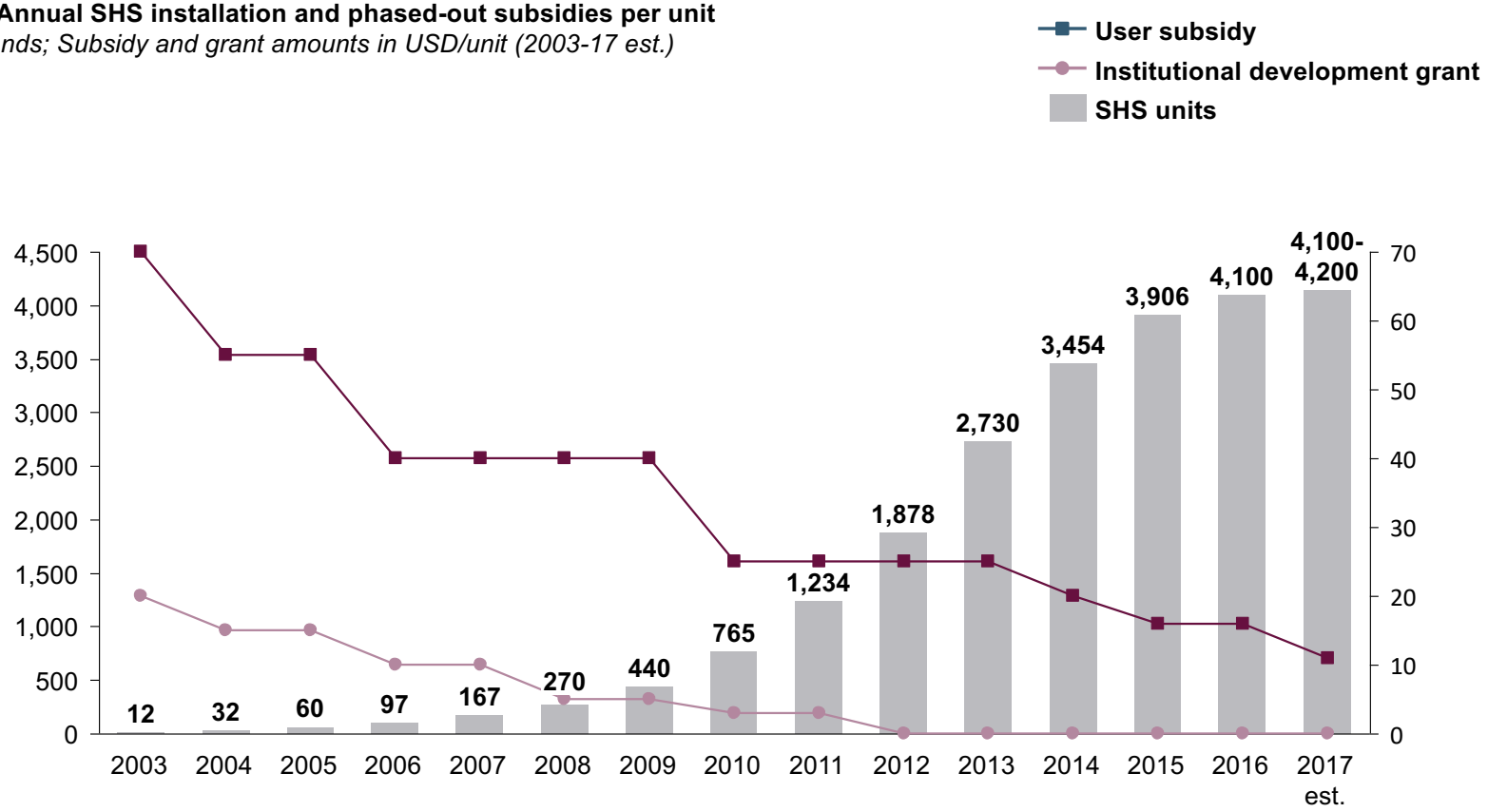
Share of the priority countries adopting enabling policies for stand-alone systems
% of top 15 electricity-poor countries (2016)



Source: http://rise.esmap.org/countries (World Bank/ ESMAP); Dalberg analysis

Products from pico sales leaders have market leading lighting efficiency, which is even above the LED industry benchmark

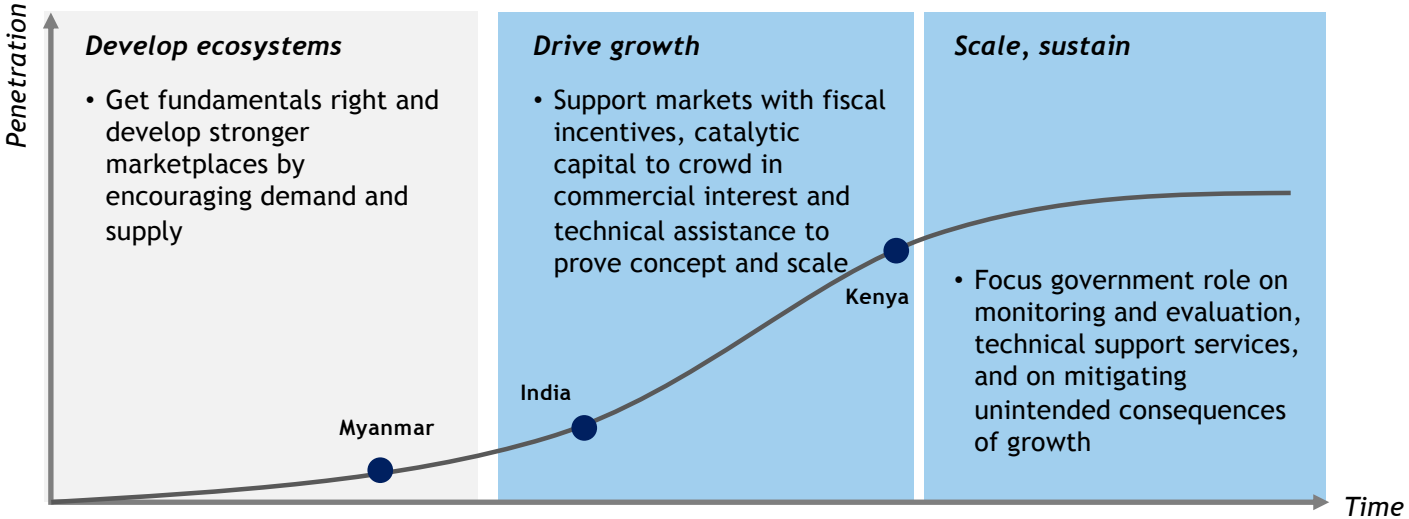
IDCOL Program – Annual SHS installation and phased-out subsidies per unit
SHS units in thousands; Subsidy and grant amounts in USD/unit (2003-17 est.)



Source: IDCOL; *Making renewable energy a success in Bangladesh: getting the business model right*, ADB South Asia Working Paper Series (December 2015)

Government support differs depending on the level of penetration in the market, most markets currently need policy to drive growth

Long term evolution of policy and regulatory support for OGS markets - Illustrative



Enabling policies/ activities

- Engage all stakeholders, especially private sector
- Design/establish integrated national energy strategies
- Engage and increase awareness among consumers
- Reduce subsidies on other fuels (e.g. kerosene)
- Introduce VAT and import tariff exemptions

- Facilitate access to finance for consumers and enterprises, including RBF for last-mile communities
- Train and build local capacity in the supply chain
- Adopt/enforce quality standards/certification
- Develop/institutionalize data collection/monitoring/testing platforms and capacity

- Strengthen enforcement and monitoring, especially of quality assurance programs
- Develop norms for efficient/safe disposal of OGS
- Establish consumer protection and grievance response mechanisms, including data/privacy norms
- Strengthen/maintain private-sector collaboration
- Develop/provide incentives to reach more remote and poorer consumers

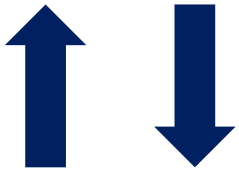
Source: Dalberg Analysis

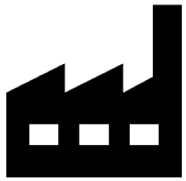
Collective action by governments and suppliers can effectively tackle the e-waste challenge of the OGS sector

Key actions policymakers and companies can take on safe disposal of e-waste

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

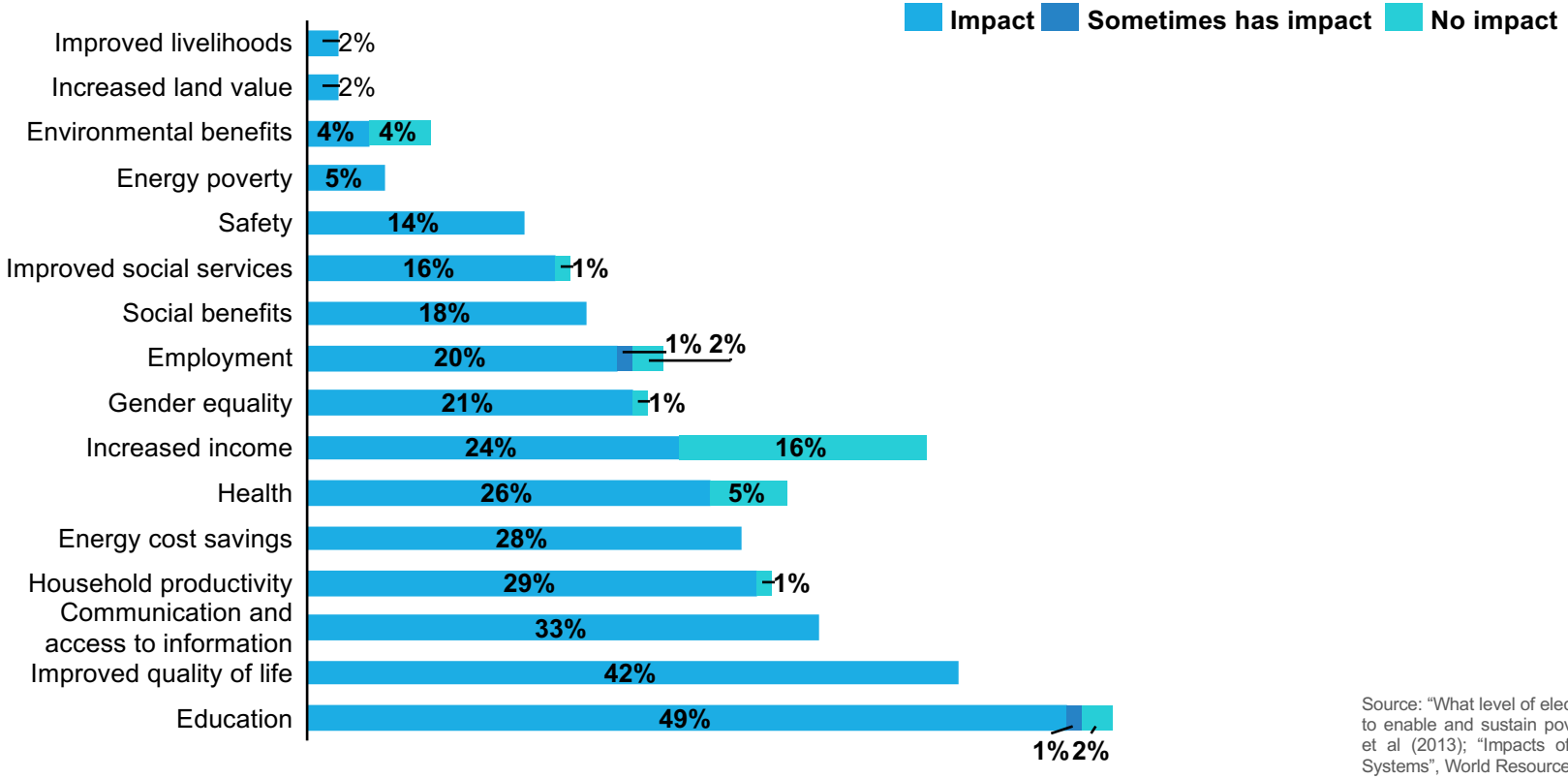
- **Form partnerships with other sectors and industries, for example, partnerships with OEMs, telecom operators, software majors, etc. in order to share cost of proper collection and disposal, awareness creation, and data collection.**
- **Engage in partnerships along the supply chain with local distributors 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.**

Source: (GOGLA, 2017), (Department for International Development, 2016)

1F: Impact

Electrification positively impacts households across a range of criteria; the largest improvement is in education

Reported impacts of electricity consumption for households in literature
% of households (2013)



Source: "What level of electricity access is required to enable and sustain poverty reduction?", Pueya et al (2013); "Impacts of Small-Scale Electricity Systems", World Resources Institute (2016)

Multi-tier Matrix for Measuring Access to Household Electricity Supply

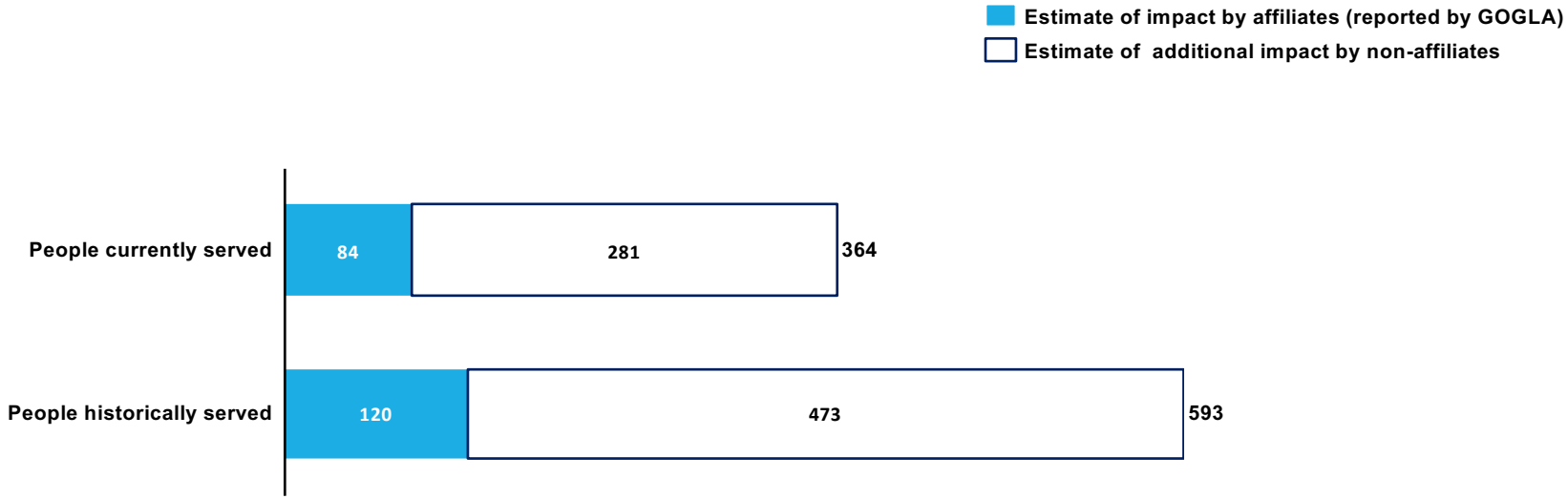
Multi-tier Matrix for Measuring Access to Household Electricity Supply

		Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
1. Peak Capacity	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
2. Availability (Duration)	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
3. Reliability						Max 14 disruptions/ week	Max 3 disruptions per week of total duration <2 hrs
4. Quality						Voltage problems do not affect the desired use of appliances	
4. Affordability					Cost of a standard consumption package of 365 kWh/year < 5% of household income		
6. Legality						Bill is paid to the utility, prepaid card seller, or authorized representative	
7. Heath and Safety						Absence of past accidents and perception of high risk in the future	

Source: Bhatia, M. and N. Angelou. 2015. Beyond Connections: Energy Access Redefined. ESMAP Technical Report 008/15. Washington: World Bank.

OGS devices have provided improved energy access to 593 million people

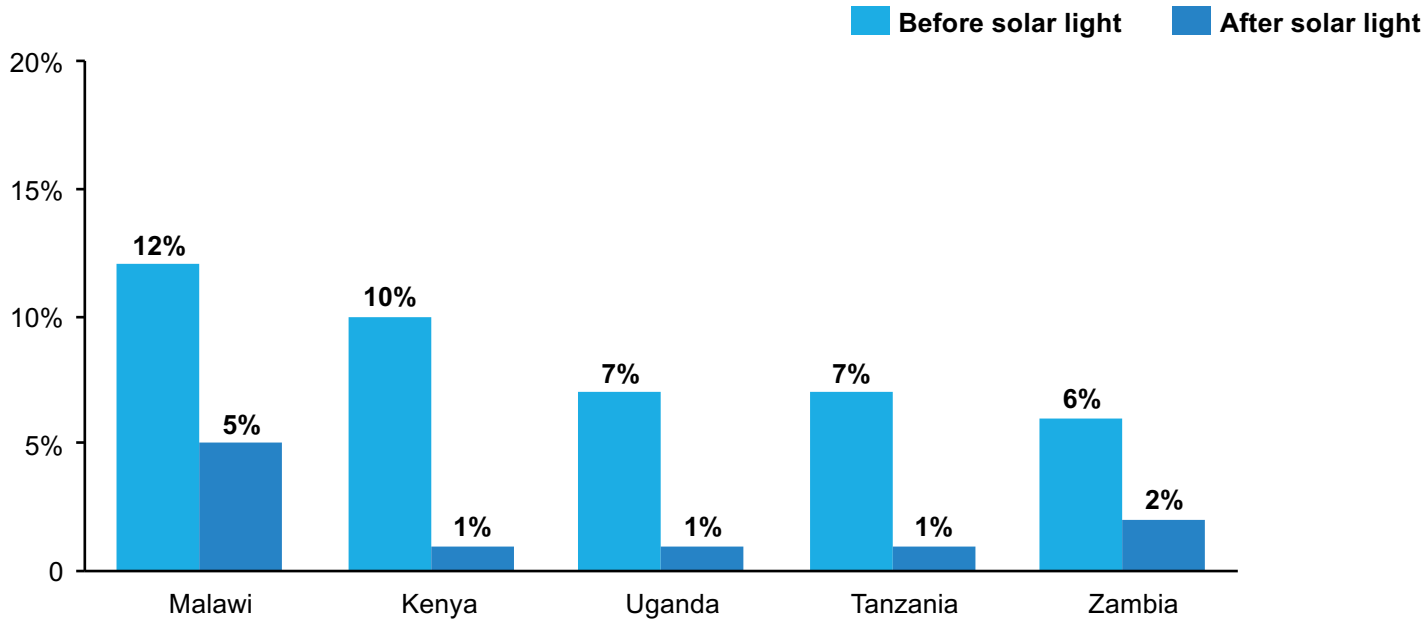
Improved energy access
*No. of people in millions; 2017**



* GOGLA estimates cover devices sold till H1 2017; Non-affiliate estimates also include devices sold in H2 2017

The purchase of a solar lights reduces spending by households on lighting by 58% to 90%

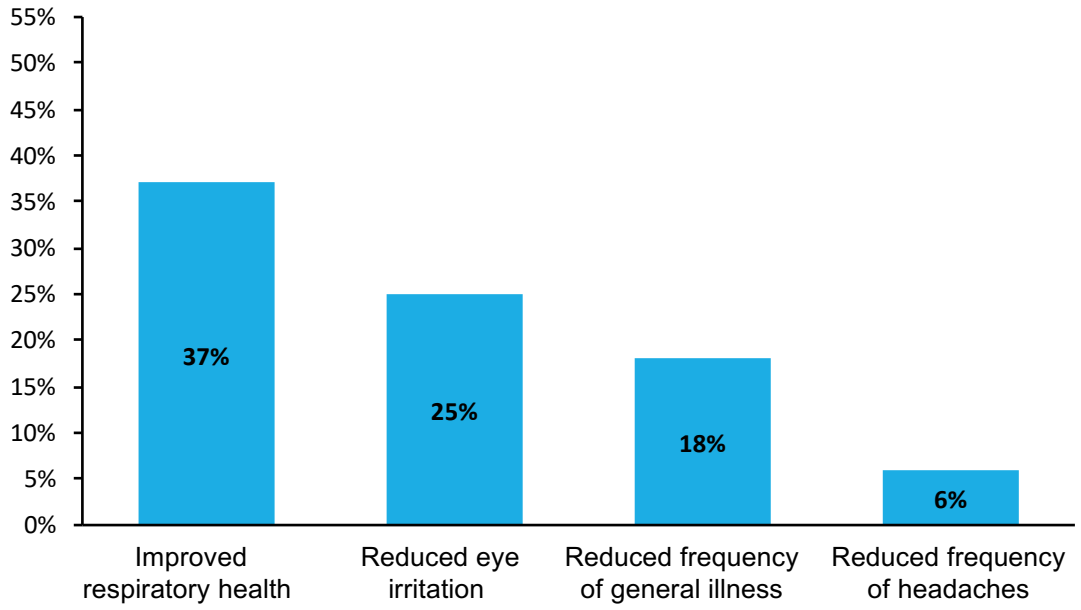
Proportion of household income spent on lighting
% of total household income; select African countries (2012-15; annual)



Source: Energy Lean Data (Acumen, 2017a)

Replacing indoor kerosene use with solar lighting improves respiratory and other health related issued by 6% to 37%

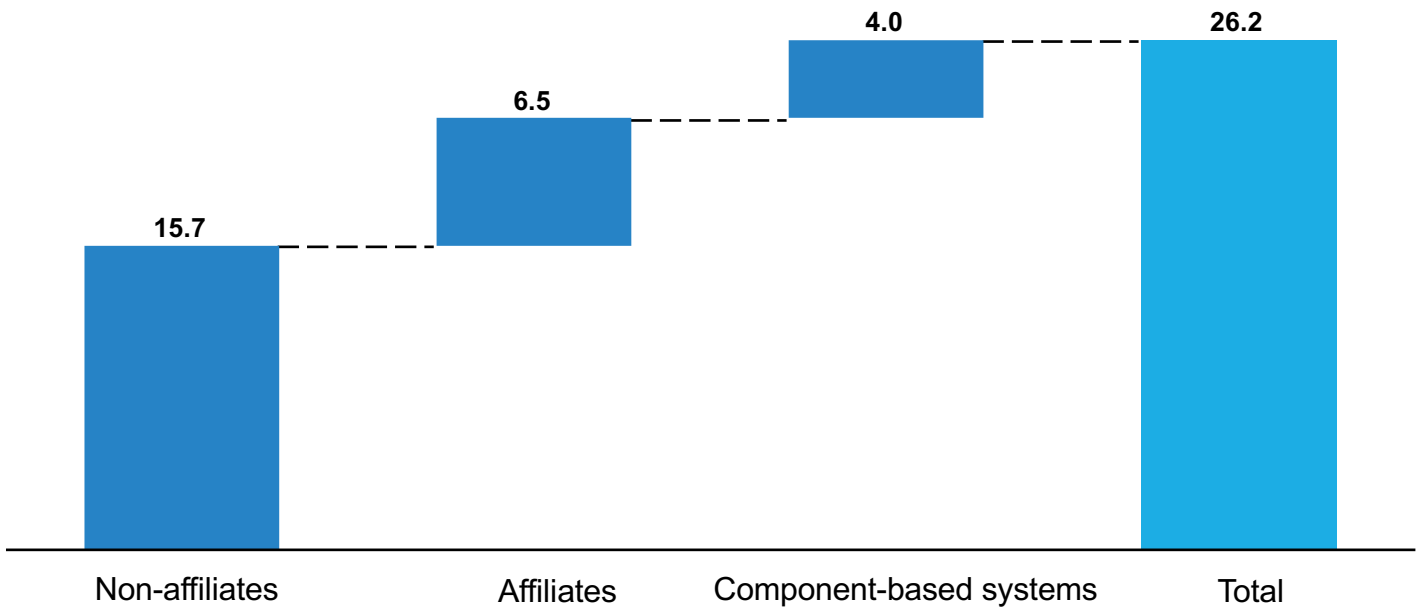
Improved health among households who used kerosene prior to buying a solar light
% of households with reductions in health issues; select countries in Sub-Saharan Africa (2012-15)



Source: (Harrison, Scott, & Hogarth, Accelerating access to electricity in Africa with off-grid solar - The impact of solar household solutions, 2016)

Concerns could arise about e-waste from the estimated 26.2 million off grid solar devices which have been discarded

Potentially discarded post-warranty OGS devices
Millions; 2009-2014; Global

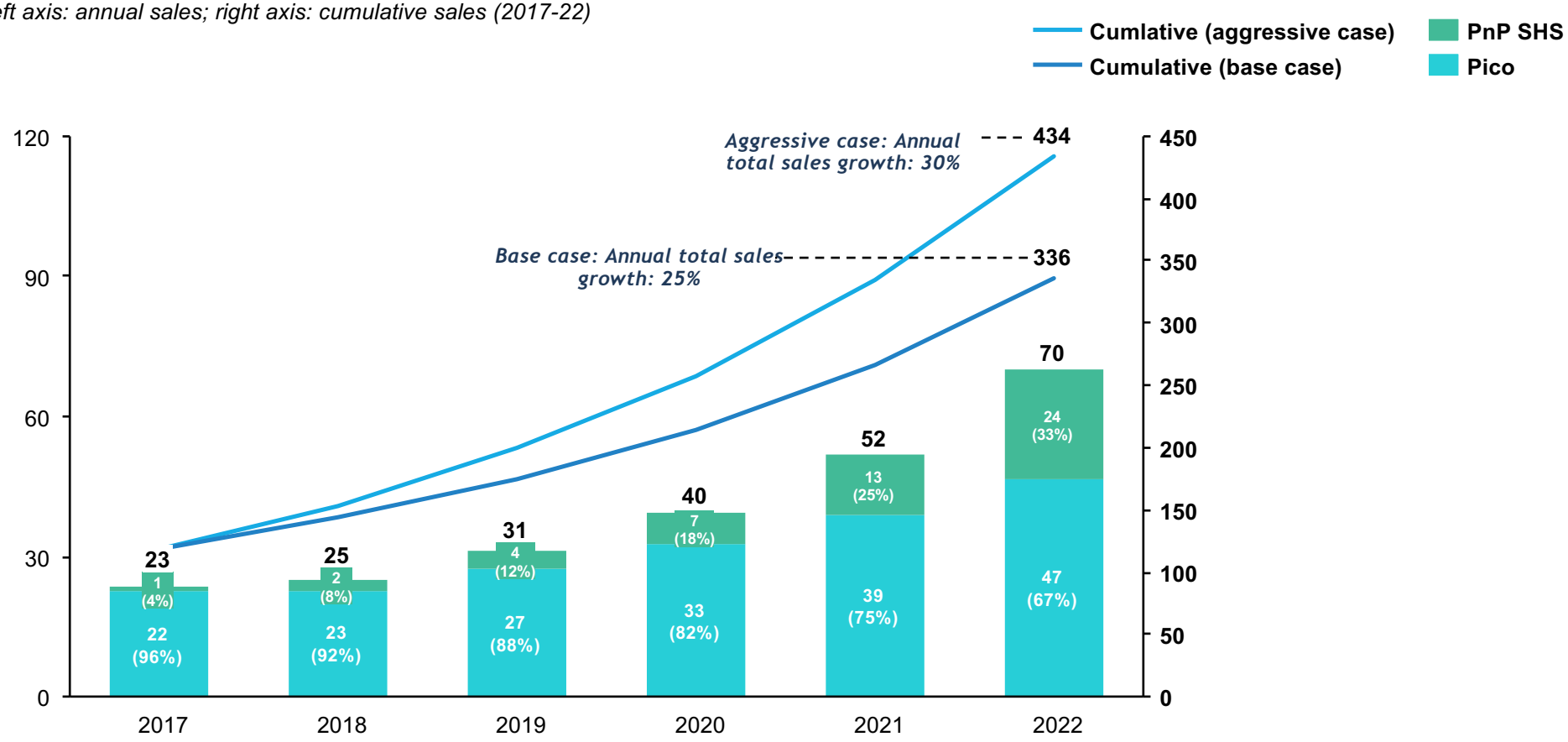


2: The Market in 2022

OGS sales are expected to grow by 25% annually, reaching a projected 70 million units sold in 2022

OGS market forecast for pico and PnP SHS

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



Source: Dalberg market model and analysis (see Table 10 of full report for full methodology and sources)

Analyzing a cross section of nearly 100 people from Kenya and India, we identified five financial personas that capture key behavioral patterns.

Path Follower

Strong bonds with community and traditional norms grounds financial behavior

Leveraged Opportunist

Takes risks and experiments with new ways to earn and manage money

Systematic Builder

Works to interlink financial endeavors to balance growth with risk

Ladder Climber

Grows income through career progression, while securing financial future through investments

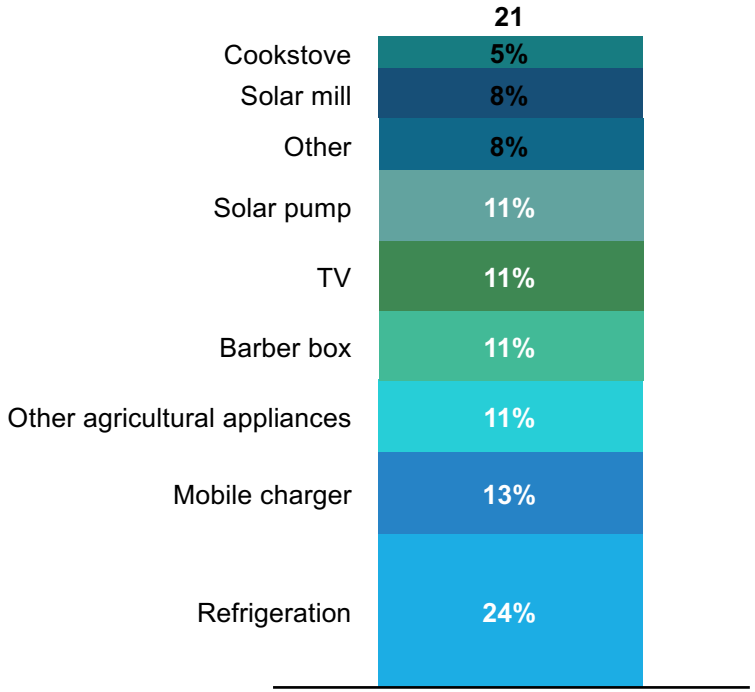
Stressed Survivor

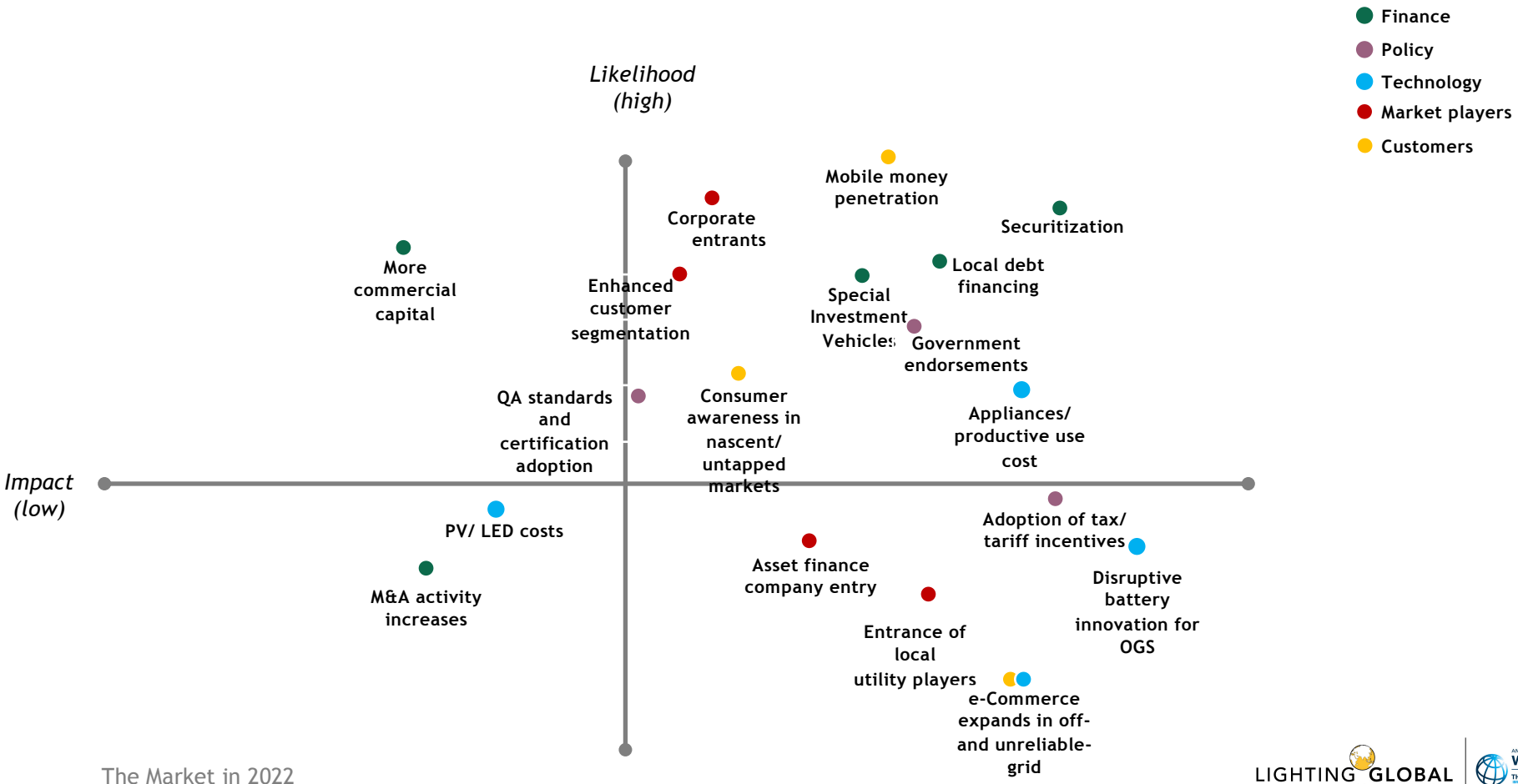
Struggles to meet basic needs, making it extremely difficult to improve finances

Source: Dalberg Analysis

Refrigeration identified as the high productive use appliance by nearly a quarter of surveyed companies

Results of a survey of OGS companies on highest potential productive use appliances



Innovations in finance and consumer capabilities show the greatest probability of high impact

Relative ranking of game changers for the OGS industry