OFF-GRID SOLAR
MARKET TRENDS REPORT 2020

March 2020

Produced by

LIGHTING GLOBAL

AN INITIATIVE OF WORLD BANK GROUP
THE WORLD BANK IFC

GOGLA

ESMAP
Energy Sector Management Assistance Program

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This report is the fifth in a series of biennial assessments of the global off-grid solar market undertaken by the World Bank Group through its Lighting Global Program. Lighting Global is the platform under which the World Bank Group supports the development of the global off-grid solar energy services market and includes a portfolio of country-based market development programs undertaken through Lighting Africa, Lighting Asia, Lighting Pacific, and Energy Sector Management Assistance Program (ESMAP).

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Dear Reader,

In 2009, the World Bank Group's Lighting Africa program launched with an audacious target: to reach 250 million people with off-grid solar products by 2030. Thanks to the vision, innovation, and commitment of a remarkable group of entrepreneurs, the off-grid solar industry surpassed the goal of 250 million in 2019—more than a decade ahead of schedule.

Today, the off-grid solar industry has been embraced globally as the critical component in the fight to eliminate energy poverty. It has become a proven reliable way to provide affordable modern electricity services in rural communities and an important complement in areas with unreliable grid electricity. Yet as this report makes clear, the Sustainable Development Goal 7 target of achieving universal electricity access by 2030 will require a steep acceleration of the off-grid solar market's development.

A decade in, the off-grid solar industry has already delivered quality energy services to hundreds of millions of people – including those that traditional electricity utilities had been unable to serve. Lighting Africa's successful pilot in Kenya has been replicated across the continent and the globe, leading to the creation of Lighting Asia and Lighting Global, which is now active in nearly 40 countries. The Global Off Grid Lighting Association (GOGLA) boasts more than 170 members, serving hundreds of millions of customers globally.

The 2020 edition of the Off-Grid Solar Market Trends Report measures the pulse of the off-grid solar market, and includes the most comprehensive sales and impact data available, in-depth analysis on current market dynamics and an outlook on the future of the industry. As in previous years, we seek to frame the varied trends of a dynamic sector, to inform the range of actors in the market, and to set strategy.

The cross-currents that characterize the evolution of the off-grid solar market are a compelling part of the story told in the Market Trends Report. Technology continues its rapid development, driving improved economics that enable more and more people to access modern electricity services, while expanding the array of services enabled by solar power.

Governments are stepping up their support to the sector, integrating off-grid solutions in their electrification plans, improving the enabling environment, and increasing financial support in order to leave no one behind. While household services, including fans and appliances and internet connectivity, have become a mainstay of the sector, the frontier of productive uses of solar is now firmly in sight, and the report looks at pathways for the market's further expansion. Business models continue to adapt and respond to customer needs, including opportunities for sustainable off-grid services for schools and health facilities.

The future of the off-grid sector heralds a second decade of innovation and impact. As the market matures, the industry's focus on volume of sales has evolved into a more refined focus on unit economics and sustained profitability. This is the lynchpin for attracting the levels of investment needed to grow the sector at scale. And that is the precondition for achieving our ultimate energy access goal: the elimination of energy poverty.

We hope you enjoy reading the story of where we are, and where we're headed.

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This report is produced by Lighting Global, GOGLA, and ESMAP, in collaboration with Vivid Economics and Open Capital Advisors.

Lighting Global is the World Bank Group's initiative to rapidly increase access to off-grid solar energy for the 840 million people worldwide living without electricity. Lighting Global - managed by the International Finance Corporation (IFC) and the World Bank - works with manufacturers, distributors, governments, and other development partners to build and grow the modern off-grid solar energy market. Lighting Global programs are funded with support from the Energy Sector Management Assistant Program (ESMAP), The Public – Private Infrastructure Advisory Facility (PPIAF), The Netherlands' Ministry of Foreign Affairs, The Italian Ministry for the Environment, Land, and Sea (IMELS), and the IKEA Foundation.

GOGLA is the global association for the off-grid solar energy industry. Established in 2012, GOGLA now represents over 170 members as a neutral, independent, not-for-profit industry association. Its mission is to help its members build sustainable markets, delivering quality, affordable products and services to as many households, businesses and communities as possible across the developing world. The products and solutions that GOGLA members sell transform lives. They improve health and education, create jobs and income opportunities and help consumers save money. To find out more, go to www.gogla.org.

ESMAP is a multi-donor trust fund administered by the World Bank, anchored in the Energy & Extractives Global Practice in Washington, DC. As a long-standing partnership between the World Bank and bilateral partners, ESMAP helps low- and middle-income countries reduce poverty and boost growth through environmentally sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank Group's country policy dialogue and lending programs in the energy sector. Through the WBG, ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7) to ensure access to affordable, reliable, sustainable and modern energy for all. It helps to shape WBG strategies and programs to achieve International Development Association (IDA) policy commitments and the WBG's Climate Change Action Plan targets.

IFC—a sister organization of the World Bank and member of the World Bank Group—is the largest global development institution focused on the private sector in emerging markets. We work with more than 2,000 businesses worldwide, using our capital, expertise, and influence to create markets and opportunities where they are needed most. In fiscal year 2019, we delivered more than $19 billion in long-term financing for developing countries, leveraging the power of the private sector to end extreme poverty and boost shared prosperity. For more information, visit www.ifc.org.

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Vivid Economics is a leading strategic economics consultancy with global reach. We strive to create lasting value for our clients, both in government and the private sector, and for society at large.

We are a premier consultant in the policy commerce interface and resource- and environment-intensive sectors, where we advise on the most critical and complex policy and commercial questions facing clients around the world. The success we bring to our clients reflects a strong partnership culture, solid foundation of skills and analytical assets, and close cooperation with a large network of contacts across key organizations.

Open Capital Advisors (OCA) is a management consulting and financial advisory firm that drives growth, enables investment, and builds markets across Africa. We help businesses, investors, development partners, and the public sector identify opportunities and deliver unique, impactful solutions. Since 2010, we have completed more than 600 engagements across 20 countries in Sub-Saharan Africa and for global clients focused on Africa. Our locally based team of over 120 offers experience from the world's top consultancies, private equity firms, investment banks, and development organizations including Boston Consulting Group, Citigroup, Credit Suisse, IFC, McKinsey, and The World Bank.

Abbreviations

Abbreviation	Definition
AC	Alternating current
AECF	Africa Enterprise Challenge Fund
AI	Artificial intelligence
B2B	Business-to-business
B2C	Business-to-consumer
BoP	Bottom of the pyramid
Br	Ethiopian Birr
CAGR	Compound annual growth rate
CO2	Carbon dioxide
COGS	Cost of goods sold
CSR	Corporate social responsibility
DC	Direct current
DFIs	Development finance institutions
EBITDA	Earnings before interest, tax, depreciation, and amortization
EOL	End of life
EPR	Extended producer responsibility
ESMAP	Energy Sector Management Assistance Program
FMCG	Fast-moving consumer goods
FX	Foreign exchange
GEP	Global Electrification Platform
GSM	Global system for mobile communication
HH	Household
HHI	Herfindahl–Hirschmann Index
ICT	Information and communications technology
IoT	Internet of things
KOSAP	Kenya Off-Grid Solar Access Project
KPIs	Key performance indicators
kWh	Kilowatt-hour
LED	Light-emitting diodes
LPWAN	Low-power wireless area networks
M&A	Mergers and acquisitions
M2M	Machine-to-machine
MCC	Milk collection centers
MFI	Microfinance institution
MNO	Mobile network operator

Abbreviation	Definition
MT	Metric tons
MTF	Multi-Tier Framework
NEP	National Electrification Plan
NES	National Electrification Strategy
NESAP	Niger Solar Electricity Access Project
NPV	Net present value
ODM	Original design manufacturer
OEM	Original equipment manufacturer
OGS	Off-grid solar
P2P	Peer-to-peer
PAYGo	Pay-as-you-go
PE	Private equity
PnP	Plug and play
PPP	Public-private partnership
PULSE	Productive Use Leveraging Solar Energy
PVoC	Pre-Verification of Conformity
R&D	Research and development
RBF	Results-based financing
RISE	Regulatory Indicators for Sustainable Energy
ROGEP	Regional Off-Grid Energy Project
RF	Rwandan Francs
SDG	Sustainable Development Goals
SHF	Smallholder farmer
SHS	Solar home systems
SL	Solar lamps
SLS	Solar lighting system
Solar PV	Solar photovoltaic
SWP	Solar water pump
USh	Ugandan Shillings
US$	United States Dollars
VAT	Value-added tax
VC	Venture capital
W	Watts
Wp	Watt-peak

Context and Key Definitions

Over the past decade, the biennial Lighting Global/GOGLA Market Trends Report has been the anchor of the Lighting Global/GOGLA franchise of market data and trends reports, which are the go-to source of sector information for investors, industry members, policymakers, and other stakeholders in the sector. The series includes semi-annual reports that track sales and impact results by country, region, and worldwide for Lighting Global Quality-Verified and other branded solar devices sold by GOGLA members. The Off-Grid Solar Market Trends Report is where we step back and dive deep into trends in the sector to deepen understanding among market players and illuminate the pathway forward. Geographically, this report covers Sub-Saharan Africa, South Asia, and South-East Asia.

This section provides an overview of key concepts and jargon that appear throughout this report.

Term	Definitions
Off-grid solar (OGS) sector product segments	Broadly, the main OGS household product segments can be classified into three major categories differentiated by price and function: pico, solar home systems (SHS), and appliances. Pico-scale solar devices have the lowest cost of entry for most rural, low-income households. Solar home systems, which can be designed pre-assembled for plug-and-play (PnP) or based on open-market components, provide multiple energy functions, such as powering appliances, at increasingly higher price points. Finally, solar-powered appliances, which are energy-efficient and powered by direct current (DC), include both household appliances (such as televisions and refrigerators) and productive-use appliances (such as water pumps and agricultural cold storage).
Pico products	Pico products include small, portable solar lanterns, flashlights, or lanterns designed to meet basic lighting needs as a direct replacement for kerosene lamps in a small household. These products are typically packaged either as a simple, one-light system with one LED light, an embedded 0.5–3.0 Watt-peak (Wp) solar panel, and an internal rechargeable lithium-ion (Li-ion) battery or as multi-light systems of up to three or four LED lights with a standalone solar panel rated up to 10 Wp and a rechargeable Li-ion battery. Some models include USB charging for mobile phones.
Solar home systems (SHS)	SHS have a solar panel rated 11 Wp and higher and include both home lighting systems and large systems which can power appliances. SHS refer to both plug-and-play and component-based systems, unless specified.
Plug-and-play (PnP)	PnP solar home systems comprise an all-in-one packaged kit. These have LED lights for multiple rooms (as many as 10, depending on size), a solar panel with power rating up to 100 Wp for small SHS and higher for large SHS, and a rechargeable battery. These systems may include assorted energy-efficient appliances, including mobile charging stations, radios, fans, televisions, and, in some higher-end systems, refrigerators.
Component-based systems	In component-based systems, individual components, such as the solar photovoltaic (PV) module, battery, lights, inverter, wiring, and appliances, are sourced and assembled independently by either a product aggregator or an individual for their own household, sometimes even piecemeal over a long period of time. Component-based SHS typically have power ratings above 11 Wp, which classifies them as SHS products, although some are smaller.
Productive use leveraging solar energy (PULSE)	Productive use leveraging solar energy (PULSE) is defined as any agricultural, commercial, or industrial activity that uses solar energy as a direct input to the production of goods or provision of services. PULSE enables or enhances income generation by households and microenterprises, often by mechanizing commercial activities that would otherwise be performed manually or by providing additional hours of lighting in which to work, that would otherwise be unavailable. These activities and lighting might also otherwise utilize non-renewable sources of energy, such as diesel generators or kerosene.[i]

Term	Definitions
Appliances	Appliances designed for the off-grid solar sector are categorized by their intended use-case: household or PULSE. Off-grid appliances unlock greater demand for energy access by allowing previously unserved populations to enjoy the full benefits of electrification.
Access to electricity: The Multi-Tier Framework (MTF)	The MTF, developed by ESMAP, represents an effort to build global, aggregable metrics and a database for evaluating electricity access in a non-binary fashion, measuring the quality of access rather than merely access to any source of electricity. Developed in the context of the Sustainable Energy for All (SE4ALL) initiative, the MTF is being used as a more nuanced measure of progress towards Sustainable Development Goal 7 (SDG7), complementary to the binary methodology captured in the Tracking SDG7 report written by major development stakeholders.[ii] The MTF redefines energy access to a multi-dimensional definition as "the ability to avail energy that is adequate, available when needed, reliable, of good quality, convenient, affordable, legal, healthy and safe for all required energy services." That is, having an electricity connection does not necessarily imply having access to electricity under the new definition, which takes into account additional aspects, such as reliability and affordability. Energy access is measured on a tiered spectrum, from Tier 0 (no access) to Tier 5 (the highest level of access).[iii] 
Unconnected households	Households that are unconnected and remote, far from and not connected to national grids. All of these households are potential customers for OGS products.
"Under-the-grid" households	Households that are near to but not connected to national grids. Even where a grid connection is nearby and a connection would be technically realistic, households may choose not to connect because of affordability constraints (either high connection costs to the grid or high tariffs to consume from the grid, or both) and poor reliability of service. All of these households are potential customers for OGS products.
Households with unreliable grid	These households face frequent or lengthy outages of grid electricity or experience voltage fluctuations that can damage electrical appliances.
Households connected to reliable grid	These households rarely or never face outages of grid electricity and do not experience voltage fluctuations that could damage electrical appliances.

i Lighting Global, The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa (Washington, DC: Lighting Global, September 2019), https://www.lightingglobal.org/resource/pulse-market-opportunity/, 12.

ii International Energy Agency et al., Tracking SDG 7: The Energy Progress Report 2019 (Washington, DC: The World Bank, May 2019), https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019.

iii Mikul Bhatia and Nicolina Angelou, Beyond Connections: Energy Access Redefined, Technical Report 008/15 (Washington, DC: ESMAP, July 2015), https://www.esmap.org/node/56715.

Term	Definitions
Potential market	The overall market of people (households and microenterprises) 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 represent a continued 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 devices against the potential market to arrive at an estimate for the addressable market.
Pay-as-you-go (PAYGo)	PAYGo business models allow users to pay for their products via technology enabled, 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 alternative methods include scratch cards, mobile airtime, and cash.
Quality-verfieid	"Quality-verified" products meet Lighting Global Quality Standards, which implement minimum requirements for off-grid lighting product quality, durability, truth-in-advertising, warranty, and lumen maintenance. Lighting Global offers Quality Standards for both pico products and SHS kits up to 350 W,, and compliance is required to participate in Lighting Global support programs. Quality Standards are one component of the Lighting Global Quality Assurance (QA) Program. The International Electrotechnical Commission (IEC) has adopted the Lighting Global testing methods as Technical Specification 62257-9-5. Lighting Global announced the launch of VeraSol, an evolved program of Lighting Global Quality Assurance, in February 2020. VeraSol maintains the strong foundation for quality assurance laid by the World Bank Group, providing quality verification services, comparable product data, and technical assistance to governments and institutions. For more information please visit VeraSol.org.
Affiliate	Affiliate companies are connected to any of the partner organizations involved in the semi-annual GOGLA sales data reporting process. This matrix of companies includes GOGLA members, companies selling products that meet Lighting Global Quality Standards, and appliance companies that participated in the Global LEAP Awards or are engaging with the Low Energy Inclusive Appliances (LEIA) program. It is important to note that not all products produced by affiliate companies meet Lighting Global Quality Standards, but stakeholders assume that all products affiliate companies produce are of reasonably good quality.
Non-affiliate	Companies that are not within the matrix of affiliate companies are considered non-affiliate companies. Products distributed by non-affiliate companies are considered non-affiliate products. These companies do not report their sales to GOGLA, and much less is known about the quality and level of Tier access their products provide.
First-Generation companies	These OGS companies were founded in the early stages of the sector and have since dominated the affiliate market in terms of sales, geographical reach, and value of investments raised. They typically offer PAYGo and are vertically integrated or participate in multiple segments of the value chain, especially distribution, retail, and finance.
Second-and Third-Generation companies	These younger OGS companies followed the First-Generation companies and often focus on specific aspects of the value chain..

Definitions of Key Household Product Segments

Example	Product Category	Definitions	Power Ranges (W)	MTF Level
 SunKing Pico Plus	Portable lanterns	Single light only	0.1.499 (indicative)	Enables Tier 0 (or partial Tier 1) Electricity Access for an individual person
		Single light & mobile charging	1.5 – 2.999 (indicative)	Enables Tier 1 Electricity Access for at least one person and contributes for a full household
 GDLITE 8006-A	Multi-light systems	Multiple light & mobile charging	3 – 10.999 (indicative)	Enables Tier 1 Electricity Access for at least one person and up to a full household
 M-KOPA 6	Entry-level SHS	three to four lights, phone charging and powering a radio	11-20.9	Enables Tier 1 Electricity Access for a household
 d.light X850	Basic-capacity SHS	As above, plus power for a television, more lights, appliances & extended capacity	21-49.9	Enables Tier 2 Electricity Access for a household when coupled with high-efficiency appliances
 Niwa Energy 50	Medium-capacity SHS	As above, but with extended capacities	50-99.9	Enables Tier 2 Electricity Access for a household even using conventional appliances
 Mobisol Bright Future	Higher-capacity SHS	As above, but with extended capac-ities	100+	Enables Tier 2 Electricity Access for a household, even using conventional appliances[iv]

iv A sufficiently large SHS and accompanying appliances are capable of providing Tier 3 access, though in practice this is almost exclusively delivered by a connection to the main grid or a mini-grid.

Definitions of Key Domestic and PULSE Appliance Segments

Product Category		Applications	Price ranges (US$)[v]
Household appliances			
 Cello Solar TV	Televisions	Television sets provide access to entertainment, educational content, and news. Most televisions sold as part of SHS kits are DC-powered, although AC-powered sets can be used with DC-AC solar inverters.	US$ 56-257
 Steca PF 166-H	Refrigerators	Off-grid refrigerators reduce the risk of food contamination and preserve perishable produce and beverages for both households and small mom-and-pop shops in rural, remote communities.	US$ 160-1,350
 SoXin QM-850	Fans	Fans improve household comfort, especially during hot seasons.	US$ 7-135
 M Luck Solar Radio B29	Other	Other, smaller appliances include radios for households and multi-port phone chargers for small businesses.	Variable
PULSE appliances			
 SunCulture Rainmaker 2	Water pumps	Solar water pumps improve irrigation and extend the growing season for rural smallholder farmers.	US$ 495-4,031[vi]

v Indicative prices; data derived from the Mangoo marketplace, GOGLA, affiliate and non-affiliate company websites, consultations with off-grid companies and Chinese manufacturers, and industry reports and Lighting Global–commissioned market research, such as Ipsos studies of Kenya, Ethiopia, and Tanzania.

vi Prices for solar water pumps include systems up to 5kW in size. In certain markets, such as India, much larger, more expensive solar-powered systems are used.

 InspiraFarms cold storage	Cold-storage solutions	Solar-powered cold-storage solutions enable larger-scale preservation of produce, meat, and dairy products, targeted mostly at small businesses.	US$ 160 or more[vii]
 Agsol Solar-Powered Hammer Mill	Agro-processing equipment	The most common agro-processing application is solar-powered grain milling, given the importance of the maize value chain in Sub-Saharan African markets.	Variable

vii Refrigeration for productive use ranges from small, household-sized refrigerators to large, walk-in refrigerators that sell for US$ 100,000 or more.

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REPORT SUMMARY

Photo credit: @ Solar Aid

HEADLINE INSIGHTS

US$ 1.75 billion market serving 420 million users

The off-grid solar sector has grown tremendously over the past 10 years into a vibrant, US$ 1.75 billion annual market, which remains on a solid growth curve.[1] The sector is currently serving 420 million users. From 2017 to 2019, revenues grew rapidly at 30 percent annually, while sales volumes grew at 10 percent annually. A shift towards higher-priced Pay-As-You-Go (PAYGo)–enabled products that provide higher levels of energy service has driven this rapid growth in sector turnover. While pico products still comprise around 83 percent of all sales since 2010, the growing reach of larger SHS products means that over half of off-grid solar customers now receive "Tier 1" access or higher to a clean, modern, and reliable source of electricity.

38 percent annual increase in PAYGo unit sales

As the sector matures, companies are increasingly focused on financial sustainability. Companies are moving into new geographies and underserved markets as established markets become more saturated. They are also accelerating the shift towards larger, higher-margin SHS sales in response to growing consumer demand for appliances and backup systems, which dovetails with their focus on financial sustainability. In addition, two new business models are solidifying: (1)"beyond energy" companies using consumer PAYGo data to offer financing for non-energy products and services and (2) next-generation off-grid utilities.

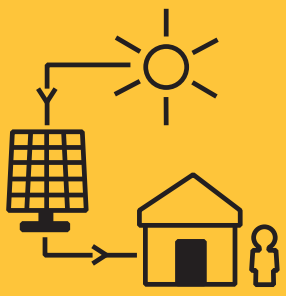
Potential market of 1.8 billion people and over 70 million farmers

The global potential OGS market remains substantial, with 840 million people without electricity access, over 1 billion connected to an unreliable grid, over 70 million farmers who could leverage OGS for productive use and a promising public institutions market. Productive Use Leveraging Solar Energy (PULSE) solutions, such as solar water pumps (SWPs), cold storage, and solar milling, and products servicing public institutions are natural expansions of the traditional OGS market, which serves households and microenterprises. Both of these markets hold tremendous potential opportunities.

1 This report follows the convention that 1 billion = 1,000 million.

US$ 1.5 billion in investment since 2012

Several signs speak to the industry's growing financial maturity, such as an increase in debt investments and larger ticket sizes. Despite this progress, funding gaps remain, particularly for Second- and Third-Generation companies, which have been unable to raise equity. Investor types are also shifting, with increased engagement from larger strategic investors, specialized debt providers, and crowdfunding, although a lack of local funding sources persists. To accelerate funding for the sector and attract investors will require innovative financing mechanisms, and companies will need to demonstrate profitability and increase transparency around operational efficiencies.



823 million users by 2030

The OGS sector remains on a strong growth trajectory; the sector is projected to serve 823 million users with OGS products by 2030. To sustain the current market growth trajectory, the sector will require an investment of US$ 1.7–2.2 billion in the next five years.

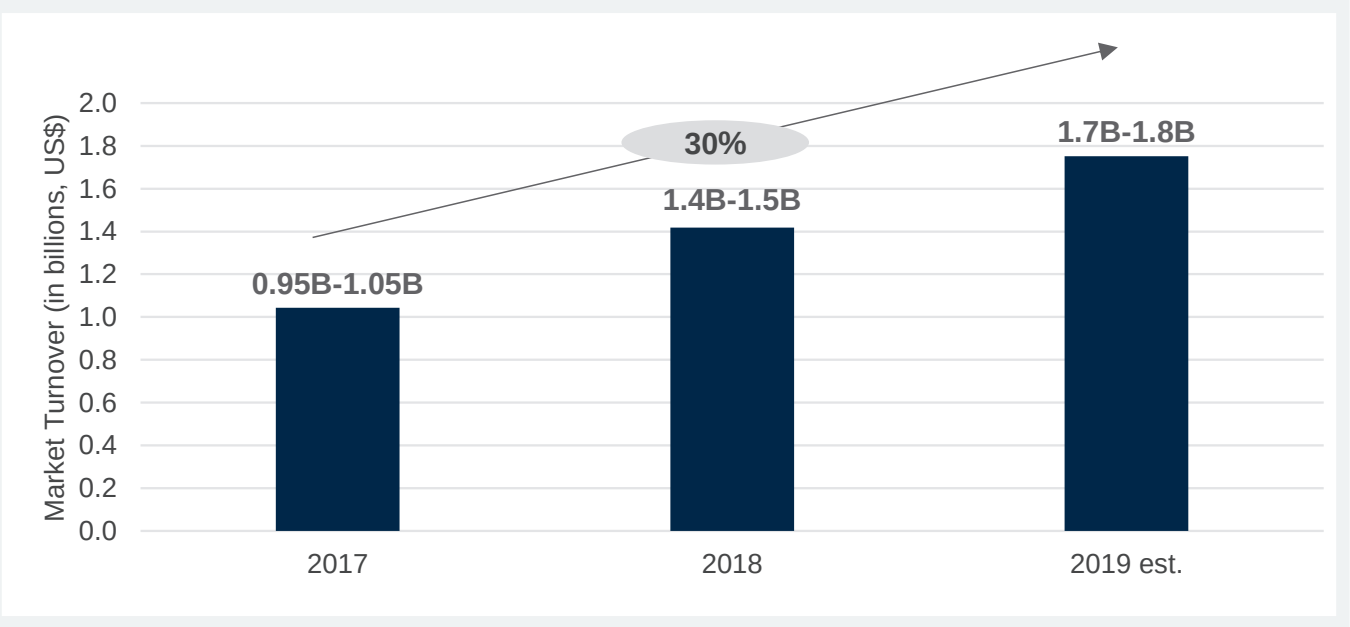
US$ 6.6–11 billion additional financing to achieve universal access

To achieve universal access, the sector would need to reach as many as 617 million people with Tier 1 OGS products as their main source of electricity; this would require US$ 6.6–11 billion in additional financing. Of this total need, US$ 6.1 to 7.7 billion comprises required external investment into OGS companies, and up to US$ 3.4 billion represents public subsidies to bridge the affordability gap. These funds will need to be raised between now and 2030 to unlock commercial opportunities, as well as to reach the poorest people.

THE OFF-GRID SOLAR SECTOR HAS GROWN INTO A VIBRANT US$ 1.75 BILLION ANNUAL MARKET CURRENTLY SERVING 420 MILLION USERS AND REMAINS ON A SOLID GROWTH CURVE.

Sales revenues are growing rapidly at 30 percent annually due to increased sales of higher-priced, PAYGo-enabled products that provide increased levels of energy service. In 2016, the industry reached a significant milestone, surpassing US$ 1 billion in annual turnover. Since then, turnover has continued to grow rapidly to reach approximately US$ 1.75 billion in 2019. This represents an annual growth rate of 30 percent over the period 2017 to 2019 (Figure RS 1). Growth in turnover is bolstered largely by increasing sales of larger systems, predominantly through PAYGo-enabled solar home systems (SHS), that provide higher service levels to customers.

Figure RS 1: Estimated OGS Annual Market Turnover (2017–2019 Estimated)



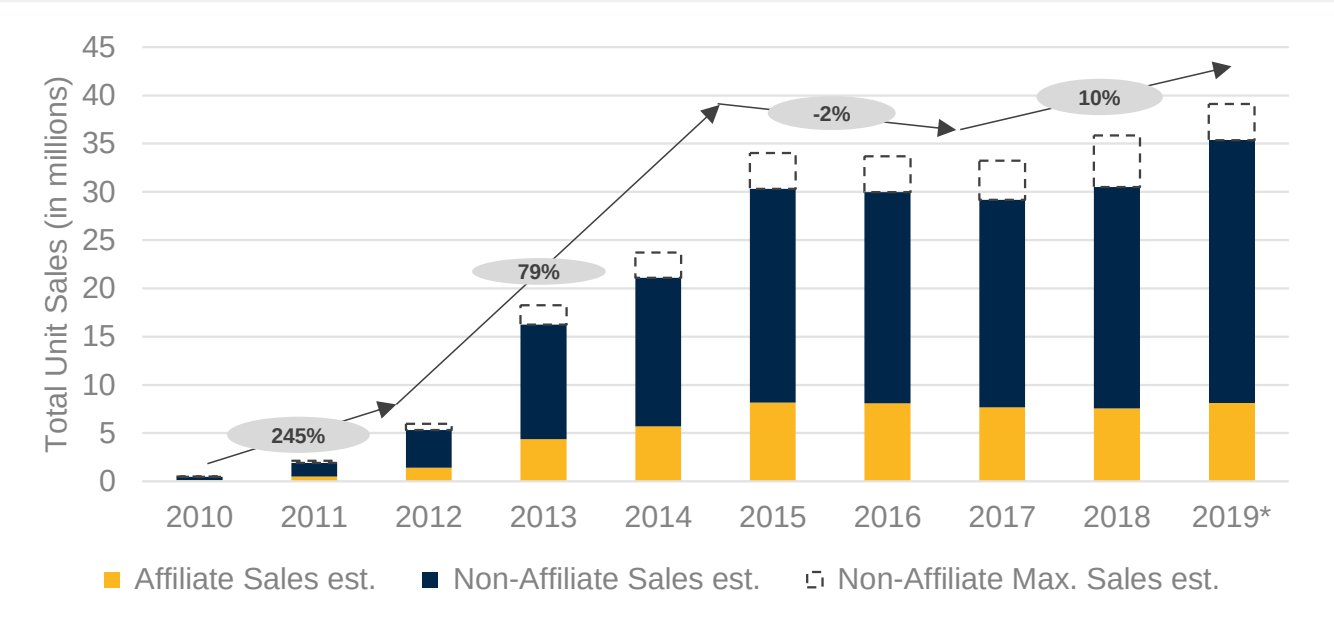
Source: Vivid Economics and Open Capital Advisors analysis of Stiftung Solarenergie. Sendea gGmbH, "Mangoo Marketplace," https://www.mangoo.org/; Aurélien Boyer et al., Pricing Quality: Cost Drivers and Value Add in the Off-Grid Solar Sector (Utrecht: GOGLA, 2019), https://www.hystra.com/reaching-scale-in-access-to-energy-2017; GOGLA data; and MTF data.

Note: Market turnover was derived by a multi-tiered approach. For cash sales, we used conservative price estimates from our pricing analyses for each wattage category, calculating a weighted average price for pico and SHS products based on these estimates. We then multiplied that average combined pico and SHS pricing by global cash sales volumes to estimate an annual market turnover for pico and SHS products bought in cash. For PAYGo, we assume a two-year repayment period, and we recognize revenue in the first year as the revenue collected from the down payment plus revenue collected from ongoing payments expected that year.

Year-on-year unit sales also continue to grow at 10 percent annually, with more than 30 million OGS units sold in 2018 and 2019 on course to exceed this figure.[2] Following the sector's rapid acceleration between 2010 and 2015, with annual growth rates of 133 percent, the industry saw a decline in sales leading up to 2017 due to localized shocks in key pico product markets and companies' adaptations to sector-wide trends. Since then, growth in annual unit sales has stabilized to 10 percent from 2017 to 2019, showing signs of a maturing market (Figure RS 2).

2 GOGLA data and MTF analysis.

Figure RS 2: Global Estimated Annual Unit Sales of OGS Products by Segment (2010–2019)



Source: Vivid Economics and Open Capital Advisors analysis of MTF data; GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H1 2018 (Utrecht: GOGLA; Washington, DC: Lighting Global, October 2018), https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2018-sales-and-impact-data; GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H2 2018 (Utrecht: GOGLA, May 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h2-2018-sales-and-impact-data; GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H1 2019 (Utrecht: GOGLA, October 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2019-sales-and-impact-data; Lighting Global., Off-Grid Solar Market Trends Report 2018 (Washington, DC: Lighting Global, January 2018), https://www.lightingglobal.org/resource/2018-global-off-grid-solar-market-trends-report; and other GOGLA sales data.

This report distinguishes between "affiliate" and "non-affiliate" products available to users. Affiliate products are sold by companies that are connected to any of the partner organizations involved in the semi-annual GOGLA sales data reporting process, including GOGLA members, companies selling products that meet Lighting Global Quality Standards, and appliance companies that participated in the Global LEAP Awards or are engaging with the Low Energy Inclusive Appliances (LEIA) program. Much less data are available on the non-affiliate portion of the market, though it contributes significantly to sales volumes (Figure RS 2).

Recently available data sources confirm that non-affiliate products account for the majority of sales volumes (72 percent).[3] Approximately 200 non-affiliate manufacturers of OGS products play an important role in an organic and competitive marketplace.[4] However, the non-affiliate market is not well understood. While non-affiliate products can represent a cheaper and sometimes quality alternative, they can also be low-quality, which can erode consumer confidence in all OGS products. This report estimates that 23 million non-affiliate products (or 72 percent of total market share) were sold in 2018, compared to 7.6 million affiliate products. While non-affiliate products dominate both the pico and combined (plug-and-play, or PnP, and component-based) SHS markets, we estimate that affiliates represent over 50 percent of the market for PnP SHS specifically. The market share of non-affiliate products varies wildly by country from, for example, 98 percent in Nepal to 3 percent in Rwanda.[5]

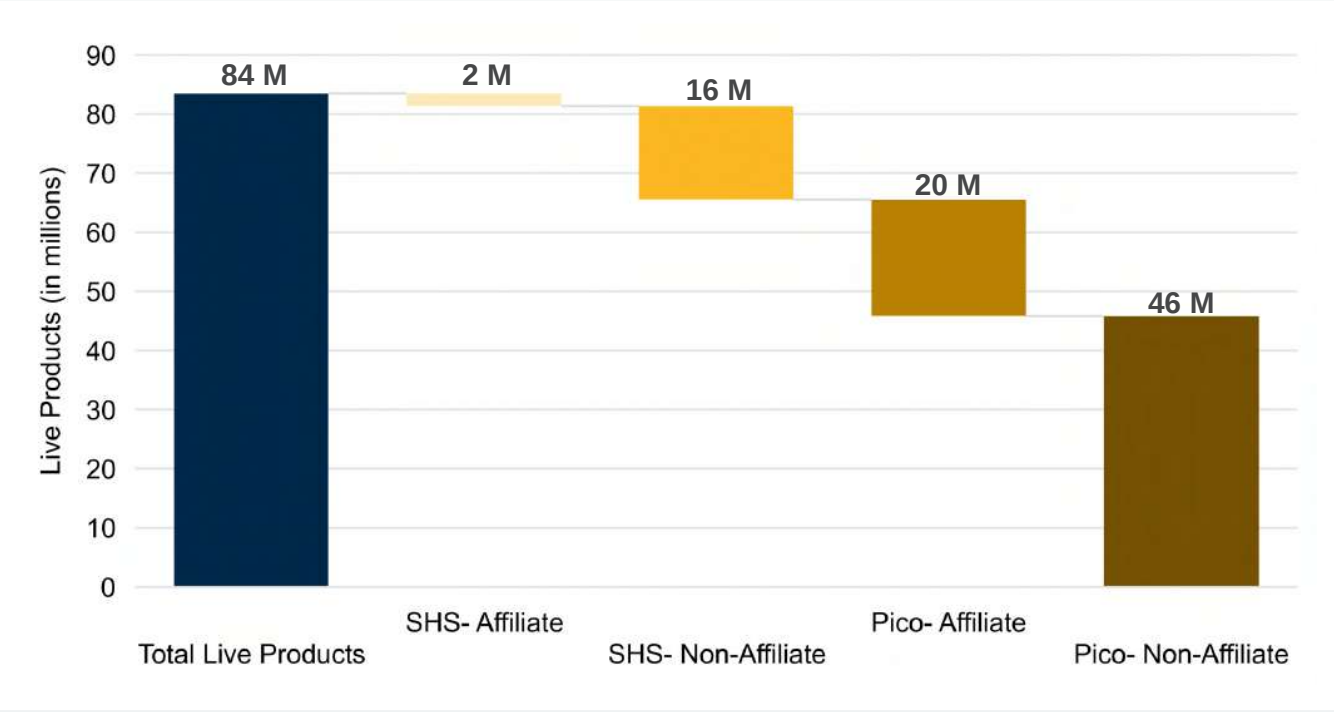
3 Non-affiliate products are those that are not sold by companies involved in the GOGLA sales data reporting process. Little data are collected on this portion of the market, but household survey data reveal the extent of their role in the market.

4 Vivid Economics and Open Capital Advisors analysis and consultations.

5 CLASP, Off-Grid Appliance Market Survey: Perceived Demand and Impact Potential of Household, Productive Use and Healthcare Technologies, 3rd ed. (London and Washington, DC: Efficiency for Access Coalition, September 2018), https://efficiencyforaccess.org/publications/off-grid-appliance-market-survey; The World Bank, Open Data, https://data.worldbank.org/; Demographic and Health Surveys, DHS Data, https://dhsprogram.com/data/; Ipsos market research commissioned by Lighting Global; MTF household survey data; GOGLA live product data; and industry interviews. Notably, the expected lifetime of high-quality affiliate products is higher than that of low-quality, non-affiliate products. Therefore, the use of live product data to calculate the non-affiliate share of sales may underestimate the number of non-affiliate products sold in the market.

In total, around 180 million OGS units have been sold worldwide since 2010, comprising 150 million pico products and 30 million SHS. Accounting for the lifecycle of these products, approximately 84 million units are "live," that is, in use today, benefiting more than 420 million people (Figure RS 3). This represents an estimated market penetration of 17 percent.

Figure RS 3: Global Estimate of Live Products by Product Segment (as of H1 2019)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA live product data and MTF data.

Today, the pico product segment is heavily commoditized and competitive, providing users with highly affordable lighting solutions. Non-affiliate manufacturers and unbranded products are firmly established in the market, representing the majority of pico sales. Non-affiliate manufacturers are also expanding their offerings to focus on designing their own brands, in some cases distributing directly to the market. This increased competition has driven down prices and made products more affordable, particularly small pico products that serve as an important entry point for many users to OGS products.

Solar home systems, which currently represent about 17 percent of unit sales, will increasingly drive growth in the years to come. The SHS segment comprises two distinct types of system: (1) PnP integrated systems, mostly using lithium battery technology and marketed by affiliate companies and (2) component-based systems offered by a wide variety of distributors, often unbranded and typically using lead-acid batteries. Affiliate unit sales of SHS have continued to grow strongly in recent years. Unit sales of larger SHS kits, particularly 21–49 Wp systems that can power televisions, increased by 73 percent annually from 2016 to 2018. SHS unit sales for products rated 11 Wp or more are increasing by 53 percent annually.[6]

The PAYGo business model used to finance both SHS and pico solar products is rapidly increasing its market share, reaching 24 percent of unit sales in H1 2019 from 20 percent in H1 2018.7 PAYGo boosts affordability, unlocking larger PnP systems that provide higher levels of energy service in addition to a wide variety of high-value, non-energy services that can be offered over PAYGo platforms. Many investors have encouraged companies to enter the PAYGo space in the face of reducing margins for cash sales of pico products. West Africa has seen the fastest increase

6 GOGLA data.

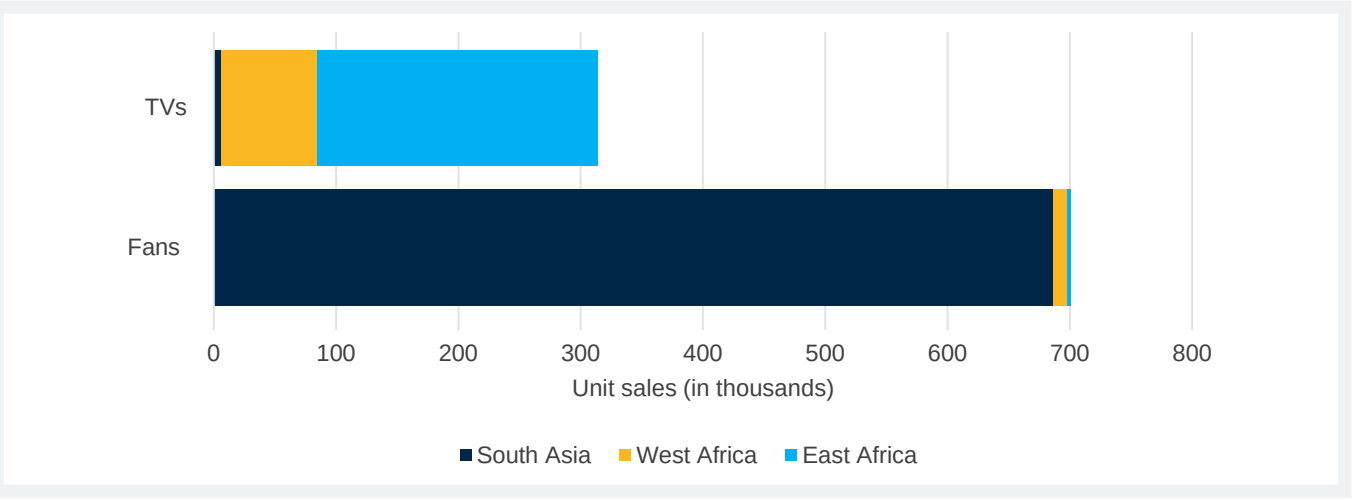
7 These figures apply only to the affiliate portion of the market.

in PAYGo unit sales in the last year, reaching 47 percent of all unit sales and 92 percent of market value in that market in H1 2019. Within the affiliate market, PAYGo comprises 76 percent of SHS unit sales and 14 percent of pico unit sales.[8]

Nonetheless, cash-based sales of pico products will remain the backbone of the industry in terms of unit sales over the next few years. More than 75 percent of affiliate products and the vast majority of non-affiliate products are sold on a cash basis.[9] Given the low incomes of target customers for off-grid products, which are generally not sold on a PAYGo basis.

The household appliance category is becoming a major driver for the sector; affiliate companies sold more than a million appliances in H2 2018 and H1 2019. High-efficiency DC appliances are contributing to the increase in PnP SHS sales. Between H2 2018 and H1 2019, appliance sales increased by 111 percent, with televisions and fans accounting for 99 percent of recorded sales.[10] Most fans are sold in South Asia, while most televisions—typically more expensive than fans—are sold in East Africa, where PAYGo financing is very prevalent (Figure RS 4). The current global addressable market for off-grid household appliances is an estimated US$ 12.6 billion and could grow to US$ 25.3 billion by 2030.[11]

Figure RS 4: PAYGo Regional Unit Sales of Televisions and Fans (Cumulative 2018 H2 and 2019 H1)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA sales data.

Productive use leveraging solar energy (PULSE) products represent an emerging opportunity for the OGS sector, although the market is still in its infancy and will continue to learn and evolve. PULSE covers a wide range of products including solar water pumps (SWPs) and cold storage for agricultural applications, as well as refrigeration and appliances for microenterprises.[12] The market for SWPs has been heavily driven by government subsidies; in India, for example, over 150,000 SWP units have been sold to date, bolstered by government subsidies.[13] The commercial opportunity for the broader PULSE market is growing due to falling costs of PULSE technology, increases in appliance efficiency, and innovations in business models. Affiliate companies sold fewer than 10,000 SWPs (all less than 3kW) between H2 2018 and H1 2019, the only periods for which sales were collected.[14] However, given the high number of non-affiliate manufacturers of solar water pumps in the market, anecdotal evidence suggests the number of units sold globally is much higher.

8 Vivid Economics and Open Capital Advisors analysis of GOGLA sales data.

9 Vivid Economics and Open Capital Advisors analysis of GOGLA sales data.

10 GOGLA and Lighting Global, Off-Grid Solar Market H2 2018; and GOGLA and Lighting Global, Off-Grid Solar Market H1 2019.

11 Dalberg, The State of the Off-Grid Appliance Market (London and Washington, DC: Eficiency for Access Coalition, October 2019), https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report, 10.

12 Lighting Global, The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa (Washington, DC: Lighting Global, September 2019), https://www.lightingglobal.org/resource/pulse-market-opportunity/, 12.

13 Dalberg, Solar Water Pump Outlook 2019: Global Trends and Market Opportunities (London and Washington, DC: Efficiency for Access Coalition, September 2019), https://clasp.ngo/publications/solar-water-pump-outlook-2019-global-trends-and-market-opportunities, 6.

14 GOGLA data.

Companies are still testing business models and a wide variety of technologies to meet large potential PULSE markets for cold storage, refrigeration, and agri-processing. Affiliate companies sold less than 10,000 off-grid refrigerators in H2 2018 and H1 2019, and only a portion of these are for productive use. Meanwhile, in addition to refrigeration, many solar milling business models and technologies are in the pilot phase and not yet commercially deployed. Beyond agri-processing, even more specialized productive use applications have emerged in specific value chains such as poultry, dairy, and coffee.[15] Though the PULSE segment remains in its infancy, the rapid expansion in market participants indicates strong potential growth, with a total addressable market of US$ 11.3 billion in 2018 for Sub-Saharan Africa alone.[16]

AS THE SECTOR MATURES, COMPANIES ARE FOCUSING ON FINANCIAL SUSTAINABILITY AND UNIT ECONOMICS BY EXPANDING TO NEW MARKETS AND SELLING LARGER SYSTEMS THAT PROVIDE HIGHER LEVELS OF SERVICE TO CUSTOMERS.

Companies are moving into new geographies and underserved markets in pursuit of scale. Several providers in East Africa have expanded into new markets, especially in West Africa, as established markets become more saturated. In Nigeria, companies are introducing new products; for example, Zola launched its Infinity backup product to serve the large unreliable grid market in that country, and Beebeejump offers an SHS product with an AC inverter, a category in which several other companies are currently testing products. Other international companies, such as RZB Lighting, are looking at Vietnam, Indonesia, and the Philippines as new core markets of interest in Asia, after achieving mixed success in more developed off-grid markets, such as India.[17] With the goal of accelerating energy access, an increasing number of government incentives are encouraging expansion to underserved regions. In Togo, both BBOXX and Soleva have entered to take advantage of the Togolese government's incentive scheme for SHS.[18]

PAYGo technology, declining manufacturing costs, and increasing appliance efficiency have fueled the shift towards larger systems. SHS manufacturing costs have declined by approximately 5–15 percent over the last two years. There are now also highly efficient DC appliances on the market, representing an increasingly cost-effective option for users. The combination of continued efficiency gains for appliances, declining manufacturing costs, and use of the PAYGo business model to increase affordability will continue to drive the SHS and appliance markets. These systems provide higher revenues and improved cashflow, important for companies that began to face investor pressure to generate profits two or three years ago.[19]

These larger PAYGo-enabled systems are providing customers with energy access levels of Tier 1 and greater, crucial for achieving energy access targets. More than half of people currently using an OGS product have at least Tier 1 access, the minimum that counts as electricity access against globally agreed targets (Figure RS 5). The remaining 45 percent use an OGS product below Tier 1—pico products, such as solar lanterns. Achieving the Sustainable Development Goal (SDG) 7 objective of universal access to "affordable, reliable, sustainable, and modern

15 GOGLA data.

16 Lighting Global, Market Opportunity for PULSE, 20.

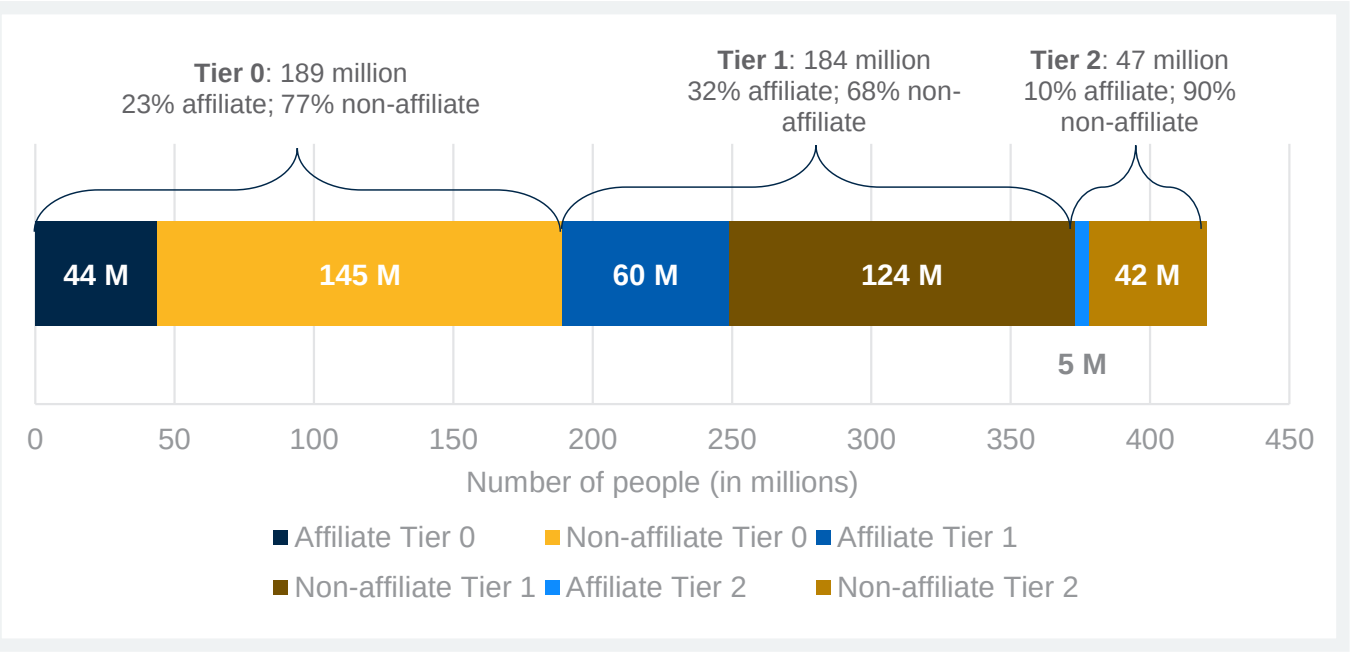
17 RZB Group, "RZB Founded New Subsidiary RZB Lighting Asia & Pacific Sdn. Bhd.," news release, June 5, 2014, https://www.rzb.de/en/media-centre/press-releases/article/1183-rzb-founded-new-subsidiary-rzb-lighting-asia-pacific-sdn-bhd-kuala-lumpur-malaysia/.

18 BBOXX, "BBOXX Receives Invitation to Meet President of Togo to Roll Out 300,000 Solar Home Systems," news release, July 17, 2017, https://www.bboxx.co.uk/bboxx-receives-invitation-meet-president-togo-roll-300000-solar-home-systems/; and Ayi Renaud Dossavi, "CIZO Project: SOLEVA Starts Operations as Planned," Togo First, June 3, 2019, https://www.togofirst.com/en/energy/0306-3298-cizo-project-soleva-starts-operations-as-planned.

19 Vivid Economics and OCA consultations.

energy" will require not only reaching currently unserved populations, but also helping those using below Tier 1 products move up to Tier 1 systems. Growing sales of larger systems that can provide at least Tier 1 service indicates progress towards that goal.

Figure RS 5: People Benefiting from Access to Electricity through OGS Devices (Millions)



Source: Vivid Economics and Open Capital Advisors.

THE FOCUS ON FINANCIAL SUSTAINABILITY HAS ACCELERATED INNOVATION IN BUSINESS MODELS, AND NEW MODELS CONTINUE TO EMERGE. VALUE CHAIN SPECIALIZATION IS INCREASING AS COMPANIES FOCUS ON CORE CAPABILITIES.

Two new shifts have emerged in business models: (1) companies moving "beyond energy" and (2) the rise of next-generation off-grid utilities. Moving beyond energy, OGS companies are using data from PAYGo platforms to understand customer creditworthiness and upselling additional products to customers, including small loans for education, cash loans, micro-loans for small businesses, micro-insurance products, and partnerships to distribute fast-moving consumer goods. Meanwhile, the next-generation off-grid utility offers an integrated suite of energy products and services to off-grid or unreliable grid customers. These companies leverage their platforms to provide a wide range of off- and on-grid energy products to customers, including PnP OGS lighting products, liquefied natural gas solutions, small mini-grids, and on-grid solar battery backup installations.

We are also continuing to see the disintegration of vertically integrated business models in off-grid energy, as companies solidify their niches and increase efficiency along the value chain. New partnerships and adaptations

are emerging at each link of the value chain (Figure RS 6) that allow companies to focus on their core businesses to bolster profitability.

Figure RS 6: Overview of OGS Supplier Value Chain

Source: Vivid Economics and Open Capital Advisors.

Examples of key trends include the following:

- **Hardware manufacturing and design.** Manufacturers are increasingly seeking quality verification and developing their own brands to potentially compete with well-established brands; these manufacturers could provide lower-cost products for customers at consistently higher levels of quality.
- **Software development.** Software specialists are providing more customizability and open architectures that lower the barriers to entry for PAYGo models while increasing the usability of PAYGo platforms to drive effective business decisions.
- **Marketing and distribution.** Large international companies are better leveraging data to optimize their sales and distribution models, while more hardware companies are partnering with local distributors to reach previously unserved markets.
- **Consumer financing.** PAYGo uptake is increasing, with continued innovation on payment terms, credit processes, and enabling technology. Also, companies are finding new ways to partner directly with financial institutions to decouple consumer finance from their business models.
- **After-sales support.** Remote monitoring is enabling companies to improve both customer service and asset management, and companies are beginning to incorporate e-waste disposal considerations into their business models or through partnerships with third-party providers.

COMPETITION REMAINS STRONG ACROSS THE SECTOR IN TERMS OF BOTH PRICE AND QUALITY, WITH HUNDREDS OF PRODUCT CHOICES AVAILABLE IN THE MARKET.

While competition has historically been based on price, increased familiarity with OGS products among users means quality is an increasingly important competitive attribute. The pico product segment has been largely characterized by a "race to the bottom" on price, with solar lantern prices as low as US$ 3. As prices have begun to stabilize, however, users are placing more weight on quality; with quality-verified products starting to replace previous sales of cheaper, low-quality products. Among SHS products, price still drives competition in markets where PnP SHS cash sales are common, with non-affiliate PnP systems competing with more expensive affiliate brands. PnP SHS also often struggle to compete against component-based systems on price, a particularly acute challenge in

Asia due to the higher influx of cheap OGS components from China in this region. With the continued growth in sales of PAYGo PnP systems, especially in East Africa, total product price is becoming less important as many consumers focus primarily on down payment costs and companies increasingly differentiate themselves based on their PAYGo terms and product bundles.

Affiliate manufacturers face increasing pressure from a large number of non-affiliate manufacturers, including those seeking to enter the affiliate market through quality verification. While affiliate distributors rank quality as the most important criterion when sourcing products from manufacturers, they are becoming more price-sensitive. Some are considering moving to lower-priced, high-quality non-affiliate manufacturers, even if these manufacturers do not become Lighting Global quality-verified. Yet some non-affiliate manufacturers are already planning to seek Lighting Global quality verification, which could put downward pricing pressure on existing affiliate manufacturers, unless they can demonstrate their products are worth a higher price.

SECTOR CONSOLIDATION COULD FUNDAMENTALLY ALTER MARKET DYNAMICS BUT WILL LIKELY REMAIN OPPORTUNISTIC IN THE NEAR FUTURE.

The past two years marked the first signs of sector consolidation through ENGIE's acquisitions of Simpa Networks, Mobisol, and Fenix. Other strategic investors, particularly other energy conglomerates and multi-sectoral Japanese conglomerates, have recently shown increased interest in the off-grid sector. Strategic acquisitions could massively alter market dynamics, leading to consolidation and investment exits for early-stage investors. However, mergers and acquisitions in the sector remain nascent; consolidation to date has been rare and opportunistic. For consolidation to accelerate from opportunistic transactions into a broader trend, OGS companies would need to demonstrate the increased maturity-in terms of profitability and scale-required to attract strategic investors.

Increased consolidation or competition could both provide significant benefits to the sector, but it is too early to tell which market dynamic will predominate moving forward. Increased competition could drive down costs and foster innovation in a sector where both are crucial to providing reliable energy to the un- and underserved, but the high cost of launching OGS companies could limit new entrants to the market, particularly if early-stage equity remains difficult to access. Conversely, if companies can demonstrate the scale and profitability required to attract strategic investors, consolidation could create OGS companies with huge scale, supported by large amounts of capital, able to aggregate sector expertise, and achieve significant economies of scale – which would drive down system costs and accelerate energy access.

Photo credit: © BRIGHT

THE GLOBAL POTENTIAL MARKET REMAINS SUBSTANTIAL, WITH 840 MILLION PEOPLE WITHOUT ELECTRICITY ACCESS GLOBALLY IN 2017 AND MORE THAN ONE BILLION USING AN UNRELIABLE GRID CONNECTION.[20]

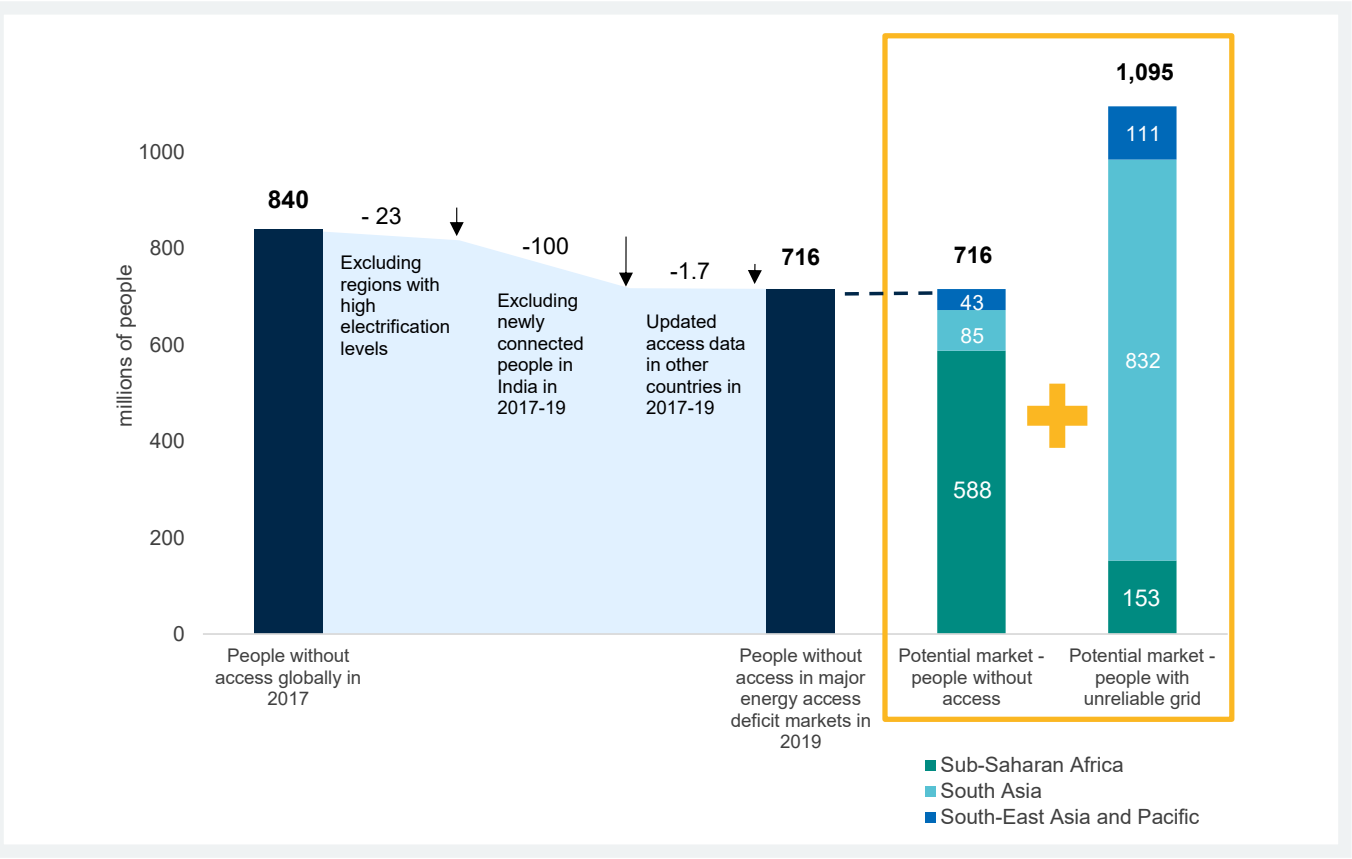
Electrification - both through grid connections and off-grid solutions offering Tier 1 or higher access - has improved rapidly from 83 percent of the global population in 2010 to 89 percent in 2017, with the most significant progress in Central and South Asia.[21] Since 2010, many countries have adopted electrification plans to reach universal access by 2030, and these increasingly include off-grid aspects alongside grid and mini-grid solutions. However, in most of the 20 countries with the largest energy-access deficits, the rate of electrification has not kept pace with population growth, increasing the number of people in these countries without access to electricity. In countries with unserved populations of more than 50 million people, such as the Democratic Republic of Congo, Nigeria, and Pakistan, electricity access in terms of the percentage of the population with access expanded by less than one percentage point each year between 2010 and 2017.

The potential market for OGS products across Sub-Saharan Africa and Asia-Pacific—the regions with the largest energy deficits as well as the focus of this report—consists of 716 million people without electricity access and more than 1 billion people with an unreliable grid. Over the last two years, some countries in these regions have continued to make strides towards universal electrification, most notably India, where almost 100 million people gained new access between 2017 and 2019 (Figure RS 7). Despite this progress, global demand for OGS remains high across households and microenterprises that currently do not have electricity access, and among people using an unreliable grid connection, although the entire market cannot be addressed and reached through commercial business models. While markets with major energy-access deficits in Sub-Saharan Africa and the Asia-Pacific region account for the majority of OGS sales to date, low-access countries such as Yemen in the Middle East, or Haiti in Latin America and the Caribbean, provide additional market opportunities.

20 While the figure of 1.095 billion people with unreliable grid connections was estimated for this report, 840 million people without acccess was estimated by the International Energy Agency et al. Tracking SDG 7, 1–2.

21 International Energy Agency et al., Tracking SDG 7.

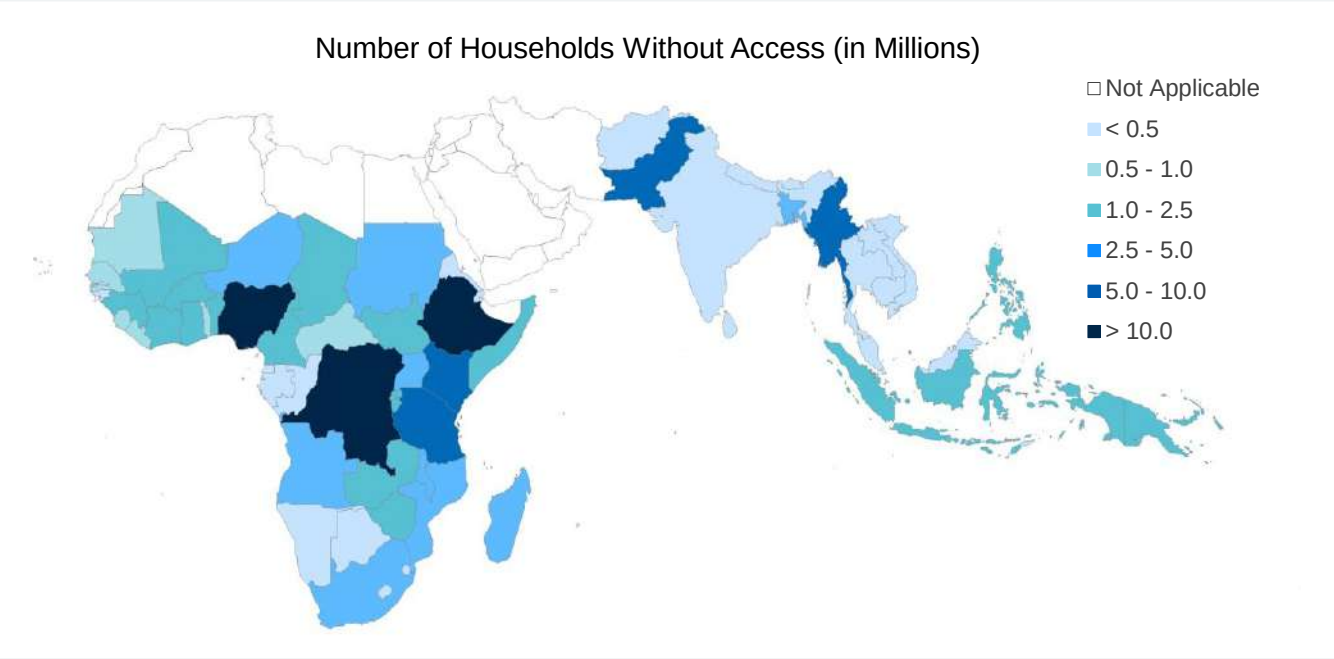
Figure RS 7: The Potential Market in Sub-Saharan Africa and Asia–Pacific Consists of 716 Million People Without Electricity Access and More than 1 Billion with an Unreliable Grid



Source: Vivid Economics and Open Capital Advisors analysis.

The vast majority (over 80 percent) of people without electricity access live in Sub-Saharan Africa (Figure RS 8). Within this region, the countries with the largest populations without access in terms of absolute numbers are Nigeria (89 million), the Democratic Republic of Congo (68 million), and Ethiopia (61 million). Smaller countries also represent substantial opportunities, especially where populations without access are highly concentrated; in Burundi, for example, the total population is just 11 million, but more than 90 percent of Burundians do not have access to electricity. In South and South East Asia, even though grid electrification rates are high, sizeable populations still lack access to electricity, and many in remote, hard-to-reach regions use OGS products as their primary source of electricity.

Figure RS 8: Across Key Energy-Deficit Countries in Africa and Asia–Pacific, 716 Million People Do Not Have Access to Electricity (Absolute Numbers)



Source: Vivid Economics and Open Capital Advisors analysis of International Energy Agency et al., Tracking SDG 7.

Note: This report focuses on countries with access deficits in Sub-Saharan Africa and Asia-Pacific. Countries not shaded in this figure have high access rates and high grid reliability and therefore offer less of a focus market for OGS suppliers.

Around 70 percent of the population without access in Sub-Saharan Africa and Asia–Pacific could afford to pay the monthly installments for a Tier 1 multi-light product, so the current addressable market for this product is 476 million people.[22] The remaining 240 million people who cannot afford a Tier 1 OGS product are mostly concentrated in Sub-Saharan Africa, which reflects the region's lower ability to pay compared to Asia–Pacific. The addressable market for a basic SHS (21–50 Wp) is smaller at 43 percent (310 million people) of the global target population. While this affordability gap persists for quality-verified, Tier 1–enabling products and above, almost all people in these markets can now afford an entry-level, single-light pico product.[23]

PAYGo and other business models offering consumer finance are bringing OGS products within reach to a larger share of the population. While only 476 million people could afford a Tier 1 multi-light system if they were to pay equal monthly installments of product cost throughout its lifetime, 670 million could afford the system by saving the PAYGo deposit over three months and subsequently paying a lower amount per month. This leads to a 40 percent increase in the addressable market for this product.[24] As ability to cover the deposit is often considered the main barrier to affordability in practice, this demonstrates how PAYGo brings higher-capacity systems within reach to a much higher share of the population.

Even when OGS products are affordable, they must compete against a range of alternatives. Competing alternatives include connecting a grid connection (where available), mini-grids, battery-operated torches, (sometimes-

22 "Affordable" in this context means the OGS product costs less than 5 percent of total monthly expenditures. We compare this to the average cost of a high-end pico product (multi-light and mobile charger system) of 3–11 Wp, which provides Tier 1 access to at least one person and offers Tier 1 access to a household at the high end of the power range. We use the annualized cost of the system over its lifetime.

23 With non-affiliate products on the market costing as little as US$ 5 or less.

24 In this calculation, we assume that a PAYGo deposit is affordable when it is less than three months of savings at 5 percent of total monthly expenditure.

subsidized) kerosene for basic lighting, and petrol- or diesel-powered generators.[25] Willingness to pay for OGS depends on the availability, reliability, convenience, and pricing of alternatives, but can also be influenced by marketing and consumer-awareness campaigns. As a result, consumers may be willing to allocate larger amounts to products that they see as highly desirable, especially if they offer services "beyond energy," such as insurance, cash loans, and other durable goods.

In addition to the 'without-access' market, the unreliable grid market is increasingly being tapped into by OGS products, thereby providing a more reliable energy supply to households and microenterprises. Particularly in rural areas, many people connected to the main electric grid receive less than 12 hours of supply per day, experience voltage surges and low-voltage days that damage or limit their use of appliances, or both.[26] A substantial part of this unreliable grid market comprises small businesses, which often require larger-capacity OGS products.

The largest concentrations of people with unreliable grid connections are in South Asia and West Africa.[27] In South Asia, while grid access rates have expanded rapidly, some 832 million people have an unreliable grid connection (Figure RS 9). This translates to about 46 percent of all grid-connected people. In West Africa, the majority of all grid-connected households in Guinea and Nigeria report not having electricity "half of the time."[28]

While the total potential market as a result of unreliable grid exceeds one billion people, only a subset of these people are realistic customers for OGS backup energy products. Although unreliable grid populations are increasingly important markets for OGS products, market penetration remains relatively low against the large number of people with unreliable grid connections. Countries for which data are available, supported by consultations with industry stakeholders, suggest that OGS devices currently reach only 5 percent or less of unreliable-grid users, even in markets where the grid is very weak.[29] Nonetheless, anecdotal evidence and interviews with companies show that unreliable grid populations are increasingly viewed as an important growth market for OGS companies, particularly in South Asia. As a realistic benchmark of what could be reached in the coming five to 10 years, we estimate one in four people with an unreliable grid connection may also buy an OGS product, which would bring the market down from more than one billion to around 250 million people.[30]

25 In some countries, especially in South Asia, where kerosene subsidies are still in place, many people also continue to use kerosene lamps during outages or because they cannot afford electricity. Tara Laan et al., Policy Approaches for a Kerosene to Solar Subsidy Swap in India (Geneva: International Institute for Sustainable Development Global Subsidies Initiative, April 2019), https://www.iisd.org/library/india-kerosene-solar-swap. For a more geographically general discussion of competition for off-grid solar from dirty fuels, see: Nicholas L. Lam et al., The Dirty Footprint of the Broken Grid: The Impacts of Fossil Fuel Back-up Generators in Developing Countries (Washington, DC: International Finance Corporation, September 2019), https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/financial+institutions/resources/dirty-footprint-of-broken-grid; and Prabhakar Yadav, Anthony P. Heynen, and Debajit Palit, "Pay-As-You-Go Financing: A Model for Viable and Widespread Deployment of Solar Home Systems in Rural India," Energy for Sustainable Development 48 (February 2019): 139–53, https://doi.org/10.1016/j.esd.2018.12.005.

26 Abhishek Jain et al., Access to Clean Cooking Energy and Electricity: Survey of States 2018 (New Delhi: Council on Energy, Environment & Water, November 2018), https://www.ceew.in/publications/access-clean-cooking-energy-and-electricity; Vivek Sen and Saloni Sachdeva, "Post Saubhagya: Moving Beyond Connections to Quality of Supply," Shakti Sustainable Energy Foundation (blog), March 12, 2019, https://shaktifoundation.in/post-saubhagya-moving-beyond-connections-to-quality-of-supply/; Sreekumar Nhalur, Ann Josey, and Manabika Mandal, "Rural Electrification in India: Looking Beyond 'Connections for All' to 'Power for All,'" Economic and Political Weekly 53, no. 45 (November 17, 2018), http://www.prayaspune.org/peg/publications/item/399-rural-electrification-in-india-from-connections-for-all-to-power-for-all.html; and Prayas (Energy Group), "Electricity Supply Monitoring Initiative (ESMI)," published March 2015, https://www.prayaspune.org/peg/resources/electricity-supply-monitoring-initiative-esmi.html.

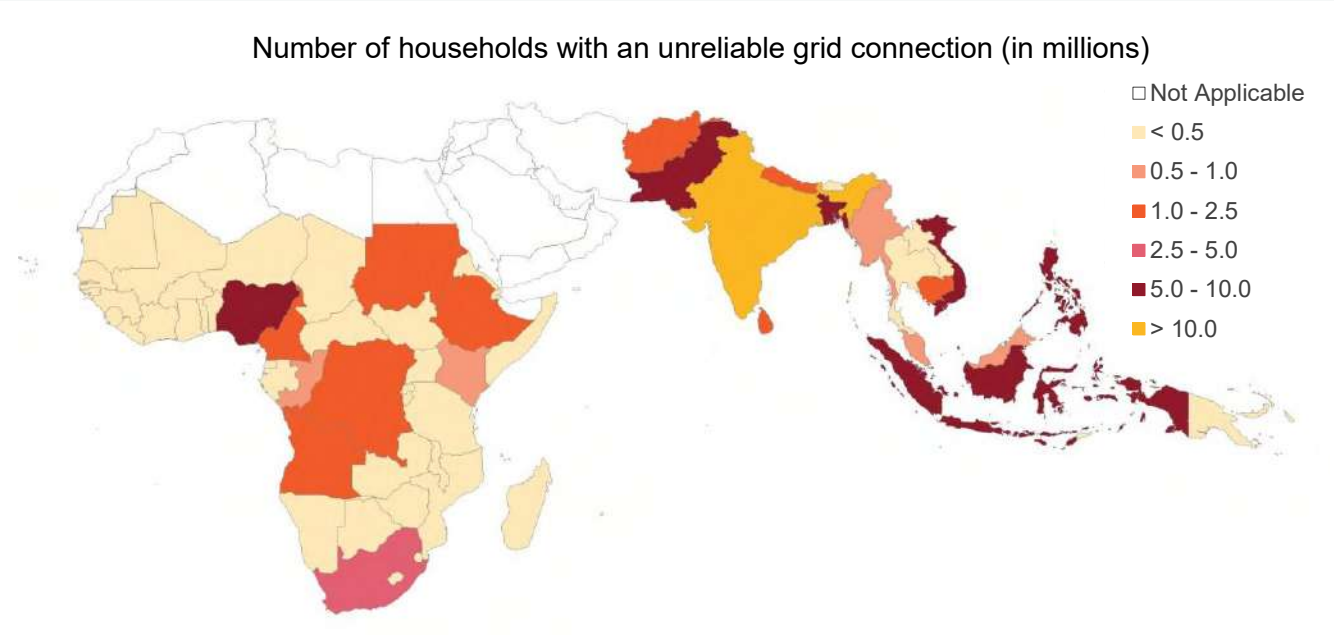
27 The share of unreliable grid connections is based on three sources, in order of robustness: (1) the data underlying ESMAP's Beyond Connections reports, available for seven countries; (2) the Afrobarometer Round 7 survey results; (3) and the World Bank Enterprise Surveys. The answer buckets for these surveys were slightly different, but we only include the share of people who responded their grid was "unreliable" or "very unreliable," which means we do not include slightly unreliable connections in the potential unreliable grid market. ESMAP, Energy Access Diagnostic Reports Based on the Multi-Tier Framework (MTF): Beyond Connections, https://www.esmap.org/node/56715; Afrobarometer, Merged Round 7 Data (34 Countries) (2019), https://www.afrobarometer.org/data/merged-round-7-data-34-countries-2019; The World Bank, Enterprise Surveys: What Businesses Experience, https://www.enterprisesurveys.org/en/data.

28 Afrobarometer, Round 7 Data.

29 Based in part on data, available for seven countries, underlying ESMAP, Diagnostic Reports Based on the MTF.

30 Estimate based on the current reach of OGS products to grid connected customers from MTF survey data, and stakeholder consultations

Figure RS 9: More than One Billion People Suffer From an Unreliable Grid Connection, Many of Whom Are in South Asia and West Africa



Source: Vivid Economics and Open Capital Advisors analysis of ESMAP, Diagnostic Reports Based on the MTF; Afrobarometer, Round 7 Data; and The World Bank, Enterprise Surveys.

Notes: This report focuses on countries with access deficits in Sub-Saharan Africa and Asia–Pacific. Countries not shaded in this figure have high access rates and high grid reliability and therefore offer less of a focus market for OGS suppliers.

The OGS market has evolved rapidly beyond lighting and consumptive energy services for households and microenterprises, offering a range of PULSE applications. Demand for dual-use appliances (providing both residential and productive use services), as well as demand for SWPs, cold storage solutions, and solar milling solutions for smallholder farmers, is substantial and expected to grow.

- **The potential SWP market exceeds 67 million smallholder farmers worldwide, and SWPs can help relieve the strain on overstretched main grids.**[31] Sub-Saharan Africa is the largest potential market for SWPs, with more than 43 million smallholder farmers currently without access to the main grid. In South Asia at least 22 million smallholders are not currently connected to the grid, with a further two million smallholders in South East Asia without grid connections. In addition, governments are increasingly incentivizing uptake of SWPs by grid-connected farmers, opening a large potential market. For example, the governments of India and Bangladesh are supporting the deployment of SWPs to reduce the strain on over-stretched electricity distribution grids.
- **Solar-powered cold storage solutions also have large market potential, with 6.5 million smallholder farmers in Sub-Saharan Africa alone active in sectors that would benefit from refrigeration.**[32] Six-and-a-half million smallholder farmers working in the dairy and horticulture sectors in SSA have no access to the grid and require cooling technologies, ranging from small cooling units for low volumes of dairy or horticultural produce to large walk-in storage facilities serving multiple smallholders.[33]

31 This assumes that all smallholder farmers without electricity access are potential SWP customers. In reality, the demand for irrigation to improve productivity varies by crop type, access to market, quality of seed, and other non-energy-related aspects. In addition, demand is influenced by farmers' ability to pay and SWPs' affordability.

32 Lighting Global, Market Opportunity for PULSE, 22

33 Lighting Global, Market Opportunity for PULSE.

- **The potential demand for solar mills and threshers in Sub-Saharan Africa is around 940,000 units.** In Sub-Saharan Africa, 38 percent of a total 120 million metric tons of produce is processed by smallholder farmers, of whom approximately 75 percent are off-grid. Assuming a capacity of 55 metric tons per processing unit, this market could be serviced by 940,000 processing units.[34]
- **Dual-use PULSE appliances—used for both residential and productive use which include fans, televisions, and refrigerators—represent a market of 38 million users. Fans enable small and microenterprises to work longer and more productively in very hot climates—and have been a major driver of OGS sales in countries like Pakistan.** Televisions provide a potential income stream, with 12 percent of off-grid television owners in East Africa showing television for a fee.[35] Refrigerators are primarily used by small businesses to sell cold goods and avoid food spoilage.[36] Finally, solar-power electric cookstoves and hand tools such as drills, saws, and hair clippers also show promise, as they could save their relevant micro-enterprises significant time and labor.

Unlocking the PULSE market potential requires tackling specific affordability challenges. Affordability presents especially specific challenges in the agricultural PULSE market, with repayments heavily dependent on crop yields and timing of revenue. Business models and payment schemes must be adapted to income levels and the seasonality of agricultural income to allow farmers to reap the benefits of increased earnings.

Public institutions such as education and health facilities represent an important potential for OGS technologies. In 78 low- and middle-income countries, 59 percent of health care facilities lack access to reliable electricity, and in the Democratic Republic of Congo just 9 percent of health care facilities have access to reliable electricity.[37] Similarly, for education facilities, just 34 percent of primary schools in Sub-Saharan Africa and 52 percent in South Asia have access to electricity.[38]

Serving these public institutions will require continued refinement of sustainable OGS technologies and business models. Two of the major challenges that supply models need to address are (1) tailoring OGS technology to the specific and varied needs of public institutions and (2) adapting business models to a business-to-public (B2P) sector approach, in particular taking into account affordability for the public purse and incentivizing long-term sustainability. The upfront cost of systems poses a major constraint for governments, which have limited public budgets, as does the cost of ensuring the systems are well-maintained and operational. Institutional OGS systems often break down due to a lack of dedicated financing for operations and maintenance, as well as due to a lack of awareness of the need, or a lack of technical capacity, to maintain these systems.[39] To address these challenges, innovative financing structures are emerging, including public–private partnerships and fee-for-service arrangements with local service providers.

34 Lighting Global, Market Opportunity for PULSE, 23.

35 Emmanuel de Dinechin, Guillaume de Chorivit, and Oliver Reynolds, Powering Opportunity: The Economic Impact of Off-Grid Solar (Utrecht: GOGLA, July 2018), https://www.gogla.org/resources/powering-opportunity-the-economic-impact-of-off-grid-solar, 56.

36 Dalberg, Off-Grid Appliance Market.

37 Ryan Cronk and Jamie Bartram, "Environmental Conditions in Health Care Facilities in Low- and Middle-Income Countries: Coverage and Inequalities," International Journal of Hygiene and Environmental Health 221, no. 3 (April 2018): 409–22, https://doi.org/10.1016/j.ijheh.2018.01.004; and Jem Porcaro et al., Lasting Impact: Sustainable Off-Grid Solar Delivery Models to Power Health and Education (Washington, DC: United Nations Foundation; Vienna: Sustainable Energy for All, April 2019), https://www.seforall.org/publications/lasting-impact-sustainable-off-grid-solar-delivery-models, 24.

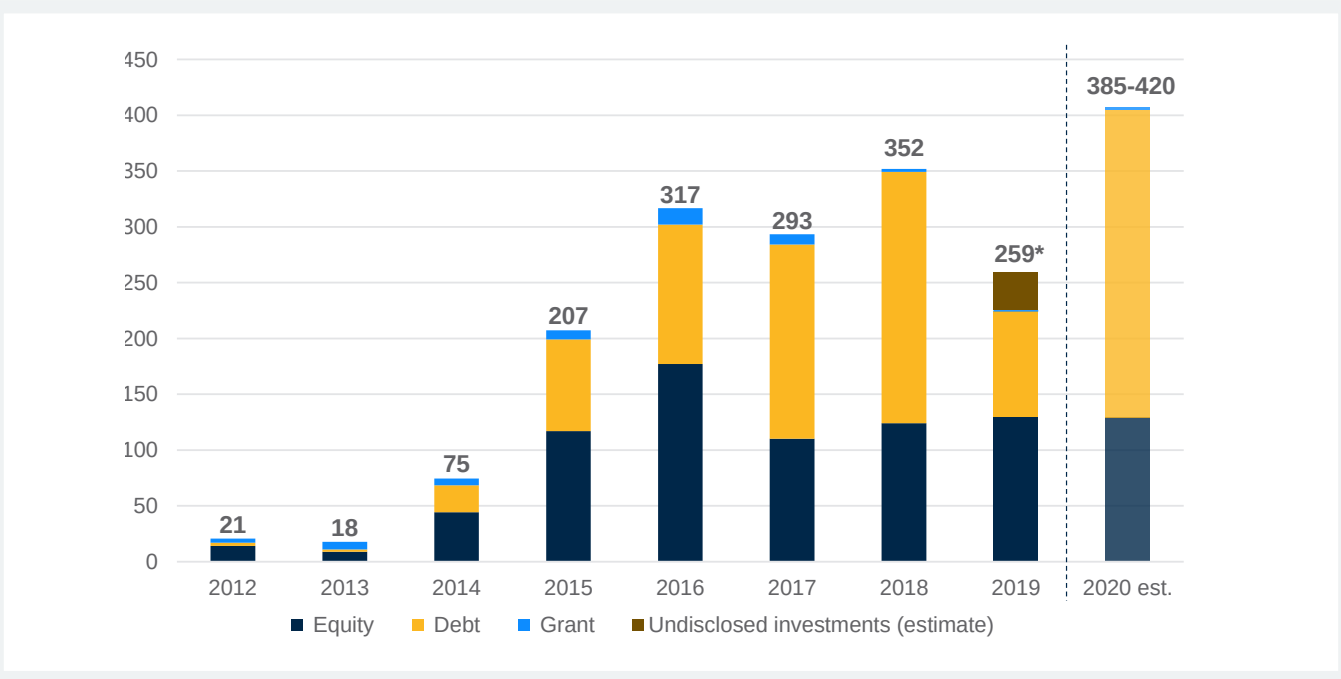
38 According to data for 2015–2018. UNESCO, UIS.Stat, http://data.uis.unesco.org/.

39 Consultations.

SEVERAL SIGNS INDICATE THE INDUSTRY'S GROWING FINANCIAL MATURITY, SUCH AS AN INCREASE IN DEBT INVESTMENTS AND LARGER INVESTMENT SIZES.

As of the end of 2019, the OGS sector had attracted more than US$ 1.5 billion in investment, with growth in the early years primarily driven by equity, and debt becoming more common recently.[40] From 2012 to 2018, capital investment in the OGS sector grew at a 50 percent compound annual growth rate (CAGR), with investments in 2018 reaching an all-time high at US$ 352 million (Figure RS 10). The decline in 2019 should not be cause for concern but is rather symptomatic of (1) the concentration of investments in First-Generation companies, which raise debt funds cyclically, and (2) the long time horizons on debt deals. A number of First-Generation companies raised significant debt in 2017/18, so the decline in 2019 is unsurprising; several First-Generation companies are expected to close large debt financing rounds again in 2020. In addition, increasingly large and complex debt deals are taking longer to close, with the anticipated announcement of around US$ 100 million in debt delayed from 2019 to early 2020. This puts 2020 on course to be a bumper year for debt investments, potentially driving total annual investment to an estimated all-time high of US$ 385–420 million.

Figure RS 10: Capital Invested by Type (2012–2019, 2020 Est.)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

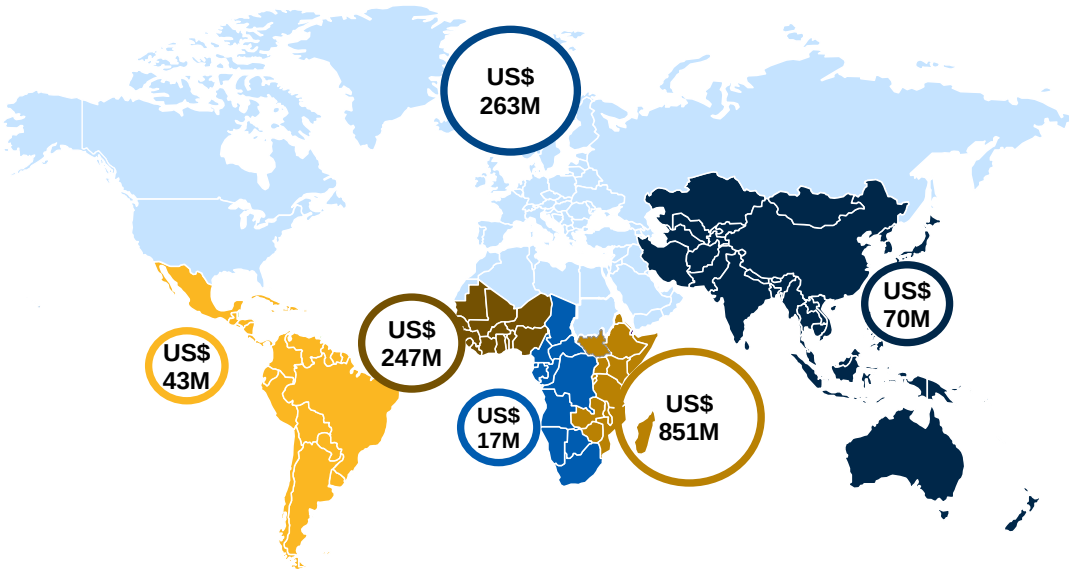
Note: The GOGLA database does not include 2019 investments. As such, deals have been sourced from secondary research and publicly available information. Undisclosed investments for 2019 are included based on investment trends from 2016 to 2018; 2020 estimates are based on current investment trends and deals that are expected to be announced in the first quarter of 2020 after failing to close in 2019.

40 2019 investments have not yet been collected by GOGLA and have been sourced from secondary research and publicly available information. As such, 2019 data may not be fully representative of all investments made in the year due to undisclosed deals, for which estimates have been made. GOGLA, Deal Database (Investment Data 2012–2018), https://www.gogla.org/access-to-finance/investment-data.

As the sector matures, debt will continue to drive the total value of investments into the sector, though equity demand remains strong. Equity investments dominated transaction value in the sector's early stages, as companies raised funds to test their business models. In recent years, debt has become the most frequently utilized financing instrument in terms of both value and number of transactions. This is especially true for First-Generation companies that have greater working capital requirements and whose cashflows can support larger amounts of debt. Meanwhile, equity investment has remained relatively constant in recent years, as few new investors enter the sector and others have already chosen players to back and have not yet seen a return on this capital through exit. Grants remain an important but small percentage of the total capital deployed to the sector.

There is a growing gap between the ability of First- and Second-Generation companies to raise capital. Investments have been highly concentrated, with the top 10 recipients of financing receiving 80 percent of the total value of investment to date. Second-Generation companies have struggled to raise equity, as existing early-stage investors in the sector have already made equity plays, and these companies are still too small to interest later-stage investors. Investments are also geographically concentrated (Figure RS 11), with East Africa dominating in terms of both value and number of investments, having received 60 percent of total capital to date due to the presence of several large First-Generation companies that can absorb large amounts of debt. While investments in West Africa appear to be increasing, this is driven by just two First-Generation companies in the region, with very limited capital flowing to the dozens of other, smaller companies present. Similarly, investments into Asian markets are limited to major investments in two First-Generation companies that launched in Asia.

Figure RS 11: Total Cumulative Investments by Region (2012–2019)



Legend: Eastern Africa, Western Africa, Middle & Southern Africa, Asia, Latin America & the Caribbean, Global (see note)

Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

Note: Regions are based on GOGLA definitions. Global refers to investments raised by companies that operate across multiple regions, such as Angaza, d.light, and Greenlight Planet, and that generally do not raise capital on a region-by-region basis.

INVESTOR TYPES ARE SHIFTING, WITH AN INCREASED PRESENCE OF LARGER STRATEGIC INVESTORS, SPECIALIZED DEBT PROVIDERS, AND CROWDFUNDING; WHILE LOCAL BANK INVOLVEMENT REMAINS NASCENT, LOCAL CURRENCY DEBT IS ANTICIPATED TO INCREASE.

- **Strategic investors,** such as ENGIE, Mitsubishi, Shell New Energies, and Sumitomo have invested in large First-Generation companies, with deals spiking in 2018 and 2019. These investors have deep pockets and long-term interests, making them ideal investors to help exit other equity positions and bring capital, expertise, and global networks to support the sector. But this trend is nascent; most strategic investors are waiting to see signs of further scale and maturity before committing further capital.
- **Impact investors and venture capital (VC) funds,** instrumental in catalyzing the sector, are unable to recycle their capital as a lack of exits prevents them from liquidating their early investments. Hence, these investors have not been able to continue investing as they had in the sector's early days.
- **Crowdfunding platforms** have gained prominence in the sector after the first investments in 2015/16. Crowdfunding leverages popular interest in the sector and has gained traction, particularly for companies between Series A and B rounds that struggle to access more commercial debt capital. In some cases, larger companies have also benefited from crowdfunding due to the often-concessional rates and speed at which funds can be deployed, though ticket sizes tend to be small.
- **Specialized debt providers** are gaining prominence, filling an important niche for smaller, harder deals due to their deep sector knowledge, which allows them to evaluate credit profiles more efficiently. Their role is anticipated to increase as their successes attract additional funding from their own investors.
- **Development finance institutions (DFIs)** are making more direct investments as companies reach the scale to absorb larger ticket sizes; DFIs also continue to support the sector through indirect investments. DFIs invest large amounts of capital, often at concessional rates, in impact investors, specialized debt providers, VC firms, and local banks, which then invest in the OGS sector. They plan to continue catalyzing the sector in this way, as well as driving an increase in the value of local currency financing in the sector, either directly or through credit facilities administered by local banks.
- **Private equity (PE) and traditional asset managers** have made initial investments in the sector, though this trend is unlikely to accelerate soon due to limited profitability and some high-profile losses, such as Investec's investment in Mobisol. Private equity investors write the larger ticket sizes the sector now requires but are more commercial, expecting higher returns over shorter periods. This does not fit the current profile of the OGS sector, which requires higher risk tolerance and more-patient investments.
- **Local banks** have been involved in few OGS transactions to date, though there are signs that this may be changing as stakeholders continue to support their engagement. Key hurdles for further involvement will be increasing banks' understanding of OGS-specific credit risks, demonstrating increased profitability in the sector, and continuing to de-risk local banks' investments through syndication. Increasing local banks' involvement can yield huge benefits for the sector because they are able to supply local-currency financing and act as a new source of capital for OGS companies.

The currently increasing availability of local currency financing and hedging instruments will enable companies to better manage their foreign exchange risk. In the past, OGS companies have struggled to manage foreign-exchange risk due to the lack of available local currency financing. Most investment in the sector has been in hard currency, while companies often have local currency revenues and long revenue cycles for PAYGo sales. This exposes them to potential local currency depreciation risks as they convert local currency revenues to repay hard currency financing over time. Since the last Market Trends Report, this trend has begun to change, driven by several DFIs, funds that offer direct local currency financing, and hedging providers that offer to assume this currency risk. There also appears to be an opportunity to involve local banks and institutional investors, which have expressed greater interest in the sector and, in some cases, have already been involved in local currency financing rounds.

ACCELERATING FUNDING FOR THE SECTOR WILL REQUIRE INNOVATIVE FINANCING MECHANISMS, AND COMPANIES NEED TO DEMONSTRATE PROFITABILITY AND INCREASE TRANSPARENCY AROUND OPERATIONAL EFFICIENCIES.

While the US$ 1.5 billion capital inflow to date has fueled the sector's growth, it is not yet anywhere near sufficient to serve the available market opportunity. The vast majority of companies report a lack of available finance, and Second- and Third-Generation companies particularly report a shortage of equity capital. The reasons for this lack of capital can be summarized by four key themes: (1) very few new equity investors are entering the sector; (2) the lack of exits prevents investors from liquidating to reinvest equity and discourages potential new investors; (3) commercial investors require large ticket sizes to invest, requiring companies to reach sufficient scale; and (4) investors are increasingly requiring near-term signals of profitability and positive cash flows, which they are not yet finding.

A range of financing mechanisms, such as off-balance-sheet financing, will enable additional capital to flow into the OGS sector. Off-balance-sheet financing has increased in the past few years, although uptake has been slower than anticipated due to the high complexity, costs, and risks of this mechanism. However, significant progress has been made in sensitizing the sector to off-balance-sheet financing, with some companies expected to announce large deals within the next 24 months. This could pave the way for securitization to further accelerate capital availability by de-risking investments. Some companies are looking at bond structures, including green, climate, and social bonds, as ways to attract new sources of capital.

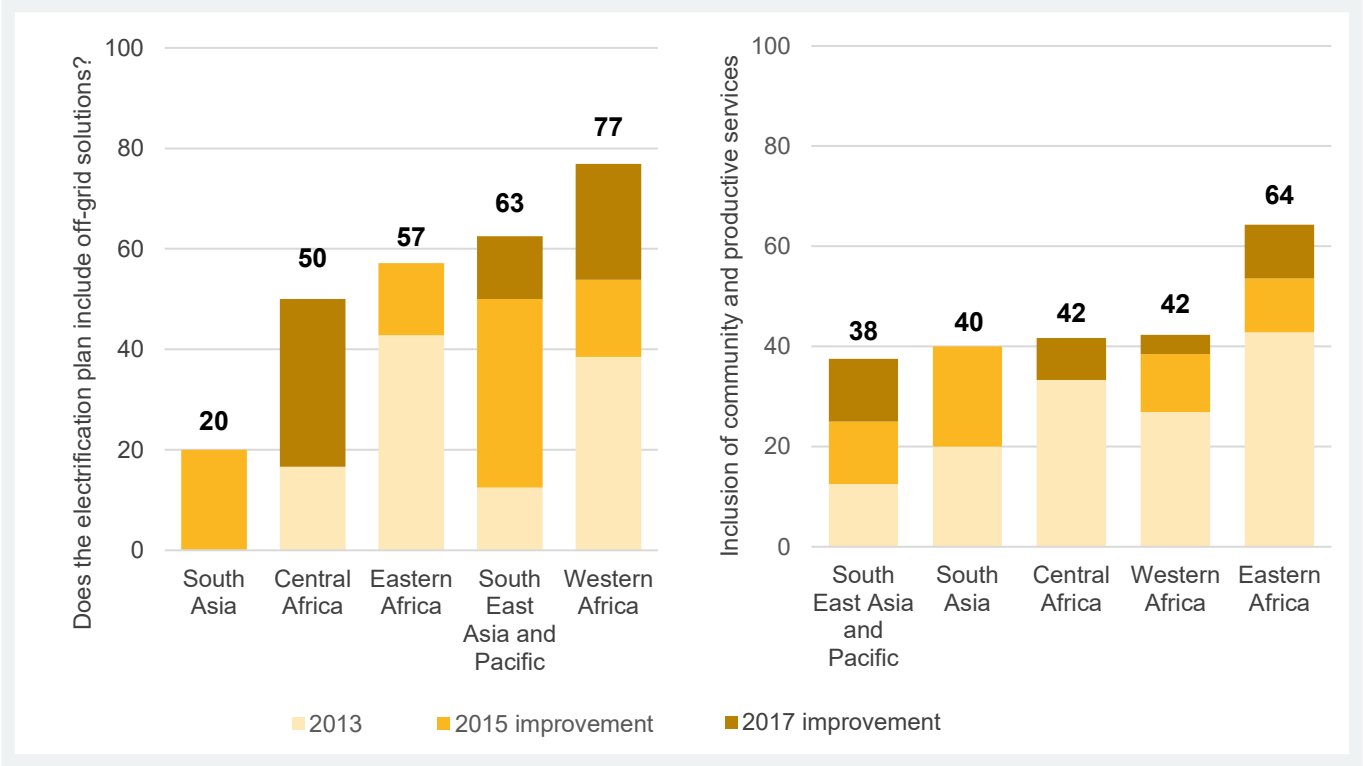
Some companies are now well on their paths to profitability, which will attract new sources of capital. Companies have begun to achieve EBITDA profitability, at least within key country markets. However, the complexity of OGS business models means that EBITDA profitability might not tell the whole story. Companies are now increasingly focusing on understanding their fundamental unit economics and cashflows, as well as on more transparent Key Performance Indicators (KPIs) such as customer acquisition costs, average revenue per customer, contribution margin, cost of capital, utilization, and collection efficiency.[41] Projects such as the PAYGo PERFORM, a joint initiative by IFC, CGAP, and GOGLA, underpin moves to standardize financial reporting metrics for the PAYGo sector to increase investor confidence.

41 Acumen and Open Capital Advisors., Lighting the Way: Roadmap to Exits in Off-Grid Energy (New York: Acumen; Nairobi: Open Capital Advisors, 2019), https://acumen.org/energy-exits-report/, 29–32.

GOVERNMENTS INCREASINGLY RECOGNIZE OGS AS A KEY DRIVER FOR REACHING UNIVERSAL ENERGY ACCESS (SDG 7) BY 2030, INCREASING PUBLIC FUNDING FOR THE MARKET.

The policy landscape continues to improve, with almost all governments in countries with energy-access deficits now including a role for off-grid electricity solutions in their electrification plans. Alongside growing OGS contributions to national electrification rates, governments are increasingly cognizant of the sector's potential and are stepping up their support for OGS.[42] As captured in the World Bank's Regulatory Indicators for Sustainable Energy (RISE) index, the majority of governments in all regions except South Asia include a defined role for stand-alone off-grid solutions (Figure RS 12), a drastic improvement since 2013. There has also been continued improvement in fiscal incentives to support standalone solar systems, with 65 percent of governments implementing duty exemptions or subsidy programs in 2017, compared to just 43 percent in 2013.[43] Progress is, however, uneven across countries, and implementation of plans sometimes lags behind policy changes.

Figure RS 12: Scores on Key RISE Indicators Have Improved Substantially since 2013



Source: Vivid Economics and Open Capital Advisors from World Bank data underlying its 2018 RISE index.

Geospatial least-cost electrification planning tools are now more and more available and increasingly inform national electrification plans. These emerging geospatial planning tools are transforming electrification planning by allowing for accelerated, relatively low-cost, and visually powerful modelling of least-cost electrification pathways that

42 Juliette Besnard et al., "Chapter 1: Access to Electricity," in Tracking SDG 7, by the International Energy Agency et al. (Washington, DC: The World Bank, May 2019), 32–33.

43 Of the 65 percent of governments with duty exemptions, subsidies, or both in place in 2017, 80% had duty exemptions and 63% provided subsidies.

Photo credit: © Lighting Africa / Zeleman communication

clearly define the role of main grids, mini-grids, and OGS technologies. Open-source tools are emerging to make geospatial planning tools widely available, in particular with the launch of the Global Electrification Platform (GEP) in November 2019.[44] The World Bank and ESMAP have supported or are in the process of supporting geospatial least-cost electrification plans in 20 countries. Other development partners, such as GIZ and Power Africa, are providing additional support.

Best practices for OGS integration into national electrification programs are now emerging. Togo and Ethiopia are among the successful examples of how OGS has been incorporated into national electrification plans to catalyze demand and facilitate suppliers' routes to market. In Togo, a clearly defined role for OGS technologies, transparent licensing requirements, and government support to relieve key market barriers has attracted private-sector operators. Similarly, Ethiopia has set a clear national policy framework for the country's pathway to universal access, using OGS as both a transition and a long-term solution. Meanwhile, Kenya is leading the way in demonstrating how government support can unlock hard-to-reach and low-affordability customers by providing targeted local currency financing and results-based incentives. All three countries have also adopted favorable tax regimes for OGS products.

Governments are increasingly adopting quality standards, promoting consumer awareness, and implementing consumer-protection measures. Building consumer confidence in OGS products is essential—especially in younger markets—and governments play a key role in protecting consumers from exposure to low-quality products or excessive financial risks. Raising awareness of the benefits of (high-quality) OGS products is critical to catalyzing demand among new potential customers. Lack of awareness among consumers is the most common reason for their lack of uptake, ranking even above affordability.[45] Governments increasingly are adopting and implementing internationally recognized quality standards, often tying tax and import exemptions to qualifying products. For example, Ethiopia recently adopted international standards, which lowered importation costs for OGS companies and helped reduce the inflow of low-quality products.

PAYGo solutions are the fastest-growing business model—and require an enabling environment that expands traditional energy sector policies and regulations to reach their full potential. Creating a positive enabling environment for PAYGo requires consideration of the interlinkages among energy sector policies, financial inclusion, and digital finance, as well as, more broadly, regulations around the provision of consumer credit and the banking sector. This means that energy authorities must closely coordinate with their counterparts in the digital and financial sectors; furthermore, regulatory changes in these sectors can inadvertently affect OGS.

Governments play a critical role in creating an enabling environment to put PAYGo on a sustainable growth path, with customer protection a key consideration. Unbanked customers buying solar home systems through microfinance or the PAYGo business model may have limited prior exposure to consumer finance. Working with consumers is key to ensure they can meet repayment profiles and that the OGS product is affordable without placing poor households under unanticipated financial strain. Government policy and regulation can help protect consumers against risks related to consumer finance, but these cross-sector policies must be developed in close consultation with the industry to ensure that they enable and do not restrict financial inclusion. The industry recently adopted the GOGLA code of conduct which recognizes companies' duty to consider consumer protection against these risks. Governments can draw on this code in setting policy.

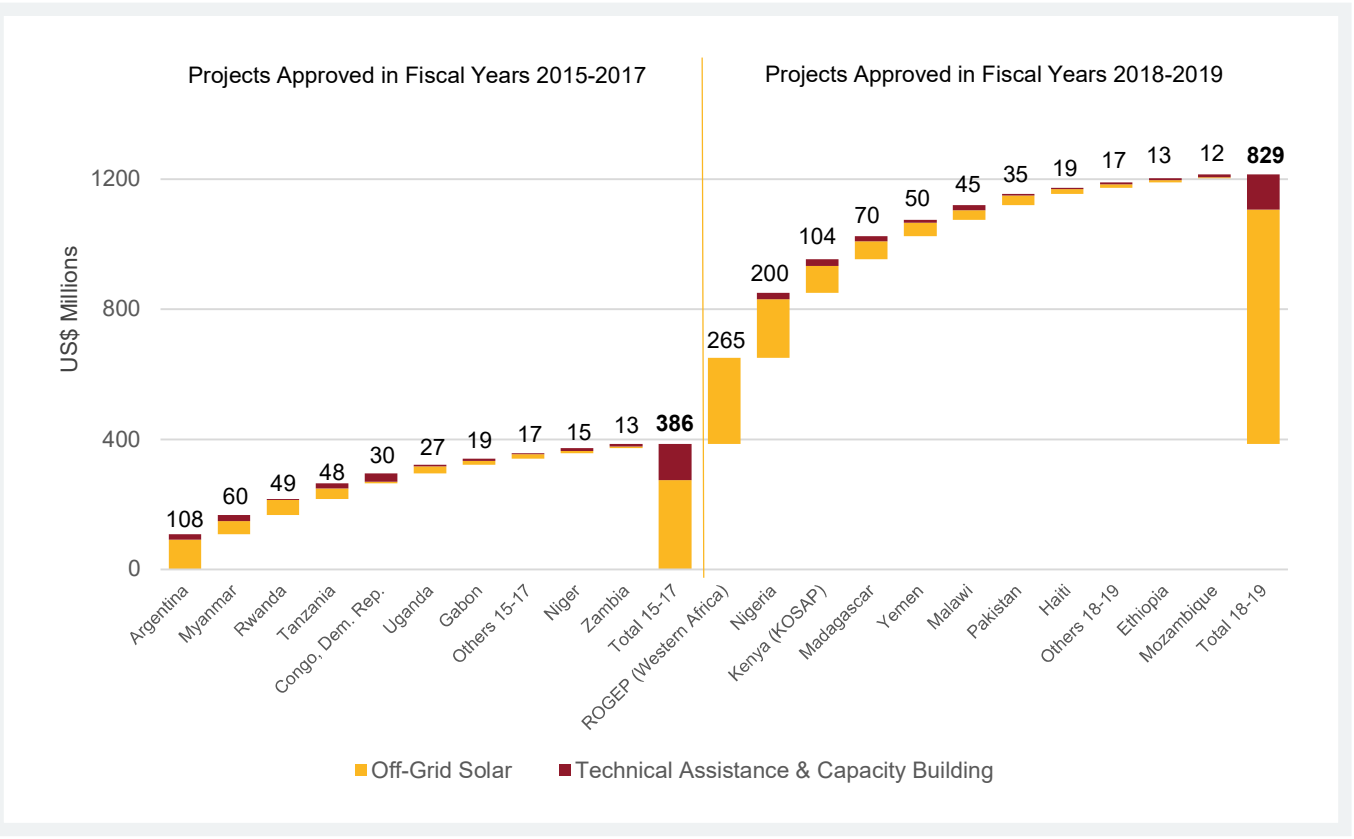
The new policy and regulatory frameworks supporting OGS need to be flexible to keep pace with a fast-evolving sector. These frameworks will need to evolve to address new opportunities and challenges, such as PAYGo, PULSE applications, and the electrification of public institutions. In addition, the impact of policy measures will depend on whether governments have the capacity and political will to adequately support their implementation. It is too early to evaluate the success of the most recent wave of national policies, but it is clear that policy goals must be met by strong and quickly implemented plans. In this spirit, development partners must support governments to ensure that they have the financial and technical resources they need to implement ambitious policies and strategies and that the support for off-grid electrification does not fade as a result of political or capacity constraints.

44 The GEP analyzes different pathways to national electrification for more than 50 countries based on an open source, geospatial, least-cost electrification model. ESMAP, "Global Electrification Platform," https://electrifynow.energydata.info/.

45 Kat Harrison and Tom Adams, An Evidence Review: How Affordable is Off-Grid Energy Access in Africa? (New York: Acumen, March 2017), https://energypedia.info/wiki/Publication_-_An_Evidence_Review:_How_Affordable_is_Off-grid_Energy_Access_in_Africa%3F.

Public funding for the OGS sector has grown rapidly, with over US$ 800 million for OGS and energy access–related technical assistance approved by the World Bank from 2018 to 2019 alone.[46] This represents a significant increase in the availability of finance compared to the US$ 386 million approved by the World Bank between 2015 and 2017 (Figure RS 13). The World Bank has a forward-looking commitment to continue the levels of funding seen in the last few years, with approximately US$ 400 million for OGS and technical assistance already in the pipeline for 2020 and 2021. The vast majority of this funding is provided in the form of loans to governments, with governments' willingness to borrow funds to support the sector underlining their growing commitment to the role of OGS in achieving universal electricity access.

Figure RS 13: World Bank Funding for Off-Grid Solar Has Increased Substantially over the Last Four Years



Source: Vivid Economics and Open Capital Advisors analysis of funding for the OGS sector by the World Bank's energy access projects, based on the World Bank's "Project Appraisal Documents," 2015–2019.

Note: The figure shows only the committed amount for off-grid funding and technical assistance for projects with an off-grid component, although the technical assistance component itself is not exclusive to off-grid but is instead allocated for energy access in general. Energy access projects often include grid-based and mini-grid components.

In addition to this World Bank funding, a wide range of bi- and multilateral funds are available for OGS. For example, the Off-Grid Energy Fund launched by the AfDB, Nordic Development Fund, and the Global Environment Facility has committed capital of almost US$ 60 million, and this is just one of a large number of funds offering finance to the OGS sector.

Supply- and demand-side subsidies will continue to play a key role in scaling up commercial opportunities, unlocking further market potential, and reaching the poorest and hardest-to-reach consumers (including in fragile and conflict-affected states).

- **In markets with commercial potential, supply-side subsidies channeled through companies and investors are best placed to support market development.** These include a range of initiatives, such as concessional debt facilities, grant funding, and risk-sharing instruments. Results-Based Financing (RBF) instruments, for

46 Based on the World Bank's "Project Appraisal Documents," 2015–2019. n.b. World Bank fiscal years.

example, are proving an effective means to support market expansion. Examples include RBF schemes targeted at companies seeking to accelerate market growth (in, for example, Nigeria and Myanmar), targeted at hard-to-reach populations (such as the Kenya Off-Grid Solar Access Project), or to incentivize entry and expansion in yet unexplored markets, such as Burundi.

- **To address affordability and attract OGS companies in markets where ability to pay is low, direct consumer subsidies are being explored to complement supply-side subsidies.** Demand-side subsides remain in the pilot stage, and more evidence is needed to demonstrate working subsidy models before they can be scaled.

Both supply- and demand-side subsidies must be carefully designed to ensure that they are well targeted, sustainable, and minimize the risks of market distortions. Distortions ultimately impede market development. Despite their risks, subsidies will be needed to achieve universal access to electricity, especially to connect the 30 percent of households globally that cannot yet afford a Tier 1 system.

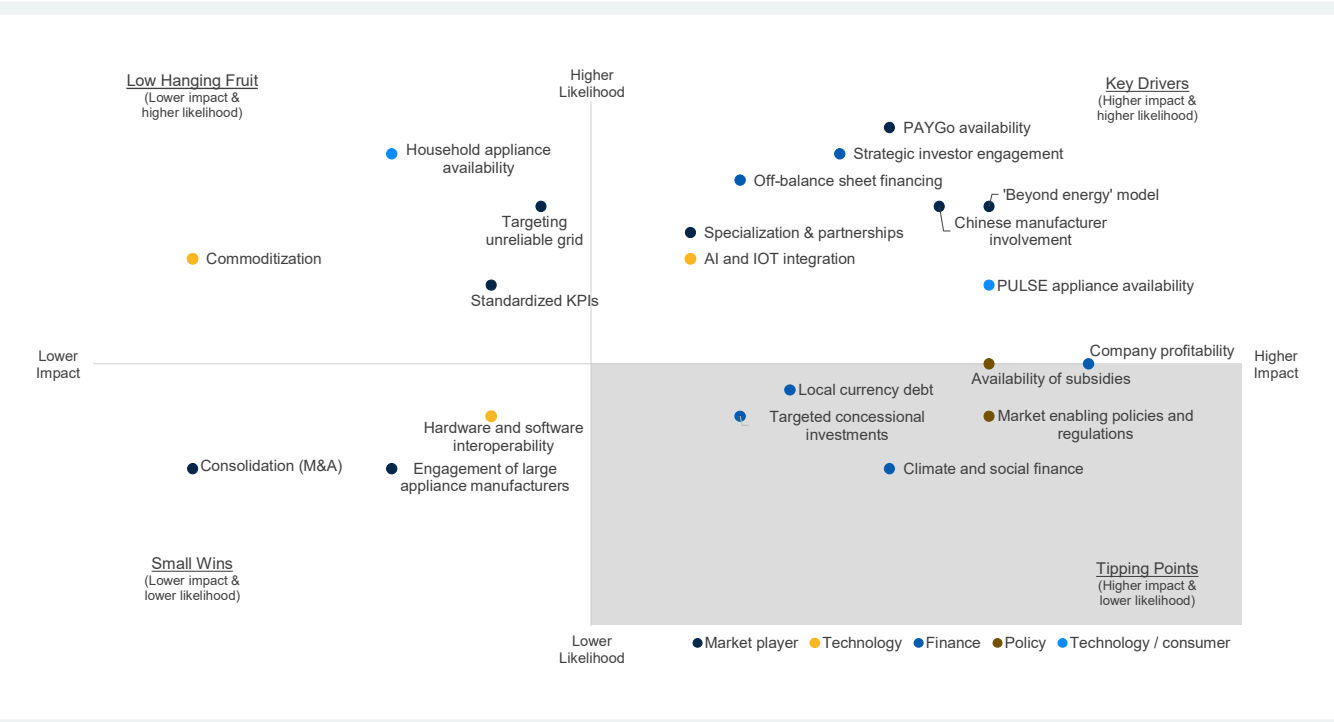
For continued success, the sector must find ways to leverage public funds to create sustainable and economically viable markets that attract increasing levels of commercial capital. It is crucial that public funding be used to relieve market barriers and crowd-in commercial investment, catalyzing fully (or at least increasingly) commercial markets. Design of any facility should be judged by its ability to crowd-in commercial funds. Growing competition between concessionary and commercial capital for transactions risks decreasing interest rates on debt and crowding out or delaying market entry by commercial lenders.[47] Blended finance is likely to emerge as a stronger trend in the future, with public funds structured to address early-stage sector risk and, thus, crowd-in commercial investors. Similarly, crowdfunding platforms are increasingly blending investment from their customer base with public money (in the form of guarantees and matching funds), which allows crowdfunders to offer much-needed smaller ticket sizes alongside more flexible conditions.

THE OGS MARKET REMAINS ON A STRONG GROWTH TRAJECTORY, BUT NEEDS AN ADDITIONAL BOOST TO REACH UNIVERSAL ACCESS (SDG 7) IN THE NEXT DECADE.

Potential Game Changers for the sector influence both a projected growth scenario (what is likely to happen) and a universal access scenario (what needs to happen to achieve SDG 7). We identified a long list of potential Game Changers for the OGS sector and ranked them based on likelihood as well as relative impact (Figure RS 14).

47 Johanna Galan, Juliana Martinez, and Dieter Poortman, "The Top 5 Investment Trends in the Off-Grid Solar Energy Sector," GOGLA (blog), May 9, 2019, https://www.gogla.org/about-us/blogs/the-top-5-investment-trends-in-the-off-grid-solar-energy-sector.

Figure RS 14: Relative Ranking of Game Changers for the OGS Sector



Source: Vivid Economics and Open Capital Advisors.

The **"Key Drivers"** are current high-impact market trends that we think are likely to accelerate going forward, enabling our projected growth scenario. The **"Low Hanging Fruit"** are also high likelihood but lower impact, and will influence our projected growth scenario to a lesser extent. To achieve SDG7, the **"Tipping Points"** have the potential to propel the OGS sector towards faster growth to close the universal access gap by 2030, but are lower likelihood and will require support across a range of sector stakeholders. Along the way, sector stakeholders may also help support the lower priority **"Small Wins"** that will have incremental impact on sector growth.

IN THE PROJECTED GROWTH SCENARIO, THE MARKET IS ON TRACK TO REACH 823 MILLION USERS BY 2030.

The OGS sector will have CAGR in sales of 6 percent over the next decade and reach 823 million users by 2030.[48] Of these 823 million users, 389 million are expected to have an OGS product that will provide them with Tier 1 service or above. In this projected growth scenario, 6 percent CAGR in sales implies a reduced annual growth rate in unit sales from 10 percent today to 4 percent in 2030.

OGS sector growth will be driven by business model adaptations, sales of larger systems and appliances, and new capital sources and structures. Pico sales will continue to represent a large share of the OGS market in

48 Today's annual growth rate of 10 percent in sales is not expected to continue over the next decade. Annual growth rates have historically declined; however, given volatility in the historic data, the rate of decline in annual sales growth rate is difficult to estimate. The current growth trajectory CAGR of total sales was therefore estimated in our model as the growth rate that would be needed to reach the full addressable market of 827 people (177 million households) in 2030. This was translated into an annual growth rate that declines by 8 percent every year, starting from an annual rate of growth of 10 percent in 2019. Assuming that the ratio of Below Tier 1 and Tier 1 products remains the same in 2030 as in 2019, we estimated the number of people with Tier 1 products in 2030 at 389 million.

unit sales and will be dominated by Chinese manufacturers who are expected to become LG verified and engage more directly with end-consumers. Current affiliate players will focus on higher value products, such as large SHS, appliances and PULSE products, which are expected to drive faster revenue growth and help companies make strides toward profitability.

Below, we explore the potential impact of these and additional "Key Drivers," as well as what could happen to sector growth if these likely "Key Drivers" lose momentum or do not materialize.

- **Increased specialization across the value chain will drive efficiencies.** Previously vertically integrated firms will continue to shed value chain operations to increase focus on their core business by partnering more effectively with other players in the value chain. Meanwhile, new companies entering the sector will specialize in individual components of the value chain. This will allow companies to achieve profitability more quickly. In contrast, if the market reverts towards vertically integrated players, we expect to see more failures that have a chilling effect on investor engagement as companies struggle to achieve profitability.
- **Chinese manufacturers will engage directly with end markets.** Chinese manufacturers will continue to sell higher-quality, self-branded products through local distribution partners and increasingly through their own distribution networks, including on PAYGo. This will increase competition at the product level and increase the amount of high-quality but lower-cost products reaching the market. If Chinese manufacturers are deterred by the market barriers that have limited their direct involvement to date, including poor knowledge of end markets, fewer lower-cost products may be available in the market, resulting in less consumer choice and decreased consumer affordability.
- **PAYGo will become more widely available, driving market growth.** As enabling conditions such as mobile-money availability improve in new markets, an increasing number of companies will adopt the PAYGo model beyond East Africa. This will increase the affordability of larger products and the level of service for consumers, potentially also improving profitability for companies that can market additional products and services through their PAYGo platforms. However, if growth in mobile-money availability stalls, certain markets will remain underserved as a result of persistent gaps in affordability coupled with challenges in providing consumer financing through other channels.
- **Increased appliance efficiency and income-generation potential will drive growth in the PULSE market.** Continued improvements in appliance efficiency and lower manufacturing costs will help companies tap into the large potential demand for PULSE appliances. PULSE appliances will also see fast growth as a result of the income-generating opportunities they provide, making them attractive for consumer financing. However, if PULSE technology does not improve and manufacturing costs don't decrease even while increasing efficiency, PULSE products will not be able to compete with current alternatives, and businesses founded on these PULSE products will not reach scale.
- **More companies will implement and expand their offerings "beyond energy."** Effective use of consumer PAYGo data will allow companies to offer consumer financing services that go beyond basic energy access, including financing for other consumer electronics, educational loans, and insurance. This will support company sustainability while also unlocking additional benefits for consumers, but the sector must be wary of over-leveraging consumers with debt. If the "beyond energy" model fails to flourish, however, companies seeking profitability will need to continue moving away from pico products towards higher-margin, larger products. This could negatively impact the sector's ultimate goal of achieving SDG 7 as companies shift away from serving generally poorer customers without electricity access.
- **Off-balance-sheet financing will accelerate.** As the risk level of receivables portfolios become better understood in a maturing sector, ever-larger amounts of off-balance-sheet financing will be used to better manage receivables and continue to help operations reach scale. This could be further accelerated through securitization to de-risk investments and attract more commercial investors to the sector. If the promise of off-balance-sheet financing continues to fall short in reality, scale in the PAYGo model will be limited by high working capital needs for ever-expanding receivables portfolios.

- **Strategic investors will play an increasingly large role.** Strategic investors will continue to take equity stakes in companies, leading to additional exits that can help free impact investor capital for investment in Second- and Third-Generation companies. Their involvement will also gradually change companies' trajectory away from fast-paced innovation and towards more sustainable growth. If strategic investors back away from the sector, the shortage of equity capital for Second- and Third-Generation companies will persist. Early-stage equity capital will remain tied up in large First-Generation companies, which may also struggle to attract later-stage equity investment.
- **Artificial Intelligence (AI) and the Internet of Things (IoT) will improve customer service and increase operational efficiency.** More companies will incorporate IoT and AI into their product offerings, allowing tailored performance management of devices to improve customer service and reduce costs.

In addition to the continued momentum of the "Key Drivers," US$ 1.7–2.2 billion in total external investment will be required from 2020 to 2024 to maintain the current growth trajectory.[49] This financing need is driven primarily by funding consumer receivables of PAYGo businesses and increased inventory financing. Therefore, debt is expected to continue being the major source of capital, representing 65 percent of this external investment need. Companies will also require equity and grant financing to test out new products and expand to new markets. Equity is expected to represent 30 percent of this financing need while grants would represent 5 percent.

DESPITE THE STRONG MARKET GROWTH TRAJECTORY, THE SECTOR WILL LIKELY MISS SDG7 BY AT LEAST 228 MILLION PEOPLE.

Achieving universal access to electricity by 2030 would require that as many as 617 million people be served through OGS products as their main source of electricity, providing Tier 1 access or above. Based on geospatial least-cost electrification projections for the 2030 population, OGS products could be the primary source of electricity for 16 percent (617 million people) of the population in Sub-Saharan Africa and Asia.[50]

Consequently, if the sector continues on its current growth trajectory, it will likely be 228 million people short of its potential to contribute to universal access. The OGS share of universal access in 2030 will of course depend on a range of factors, including how quickly and cost-effectively national utilities are able to expand the grid and whether mini-grids are able to scale towards 2030 at the pace required to reach their electrification potential.[51] In all scenarios, because of relatively low costs, modularity, proven business models, and continued innovations, the OGS sector nevertheless offers a key part of the technology mix needed to close the gap towards universal electricity access for all.

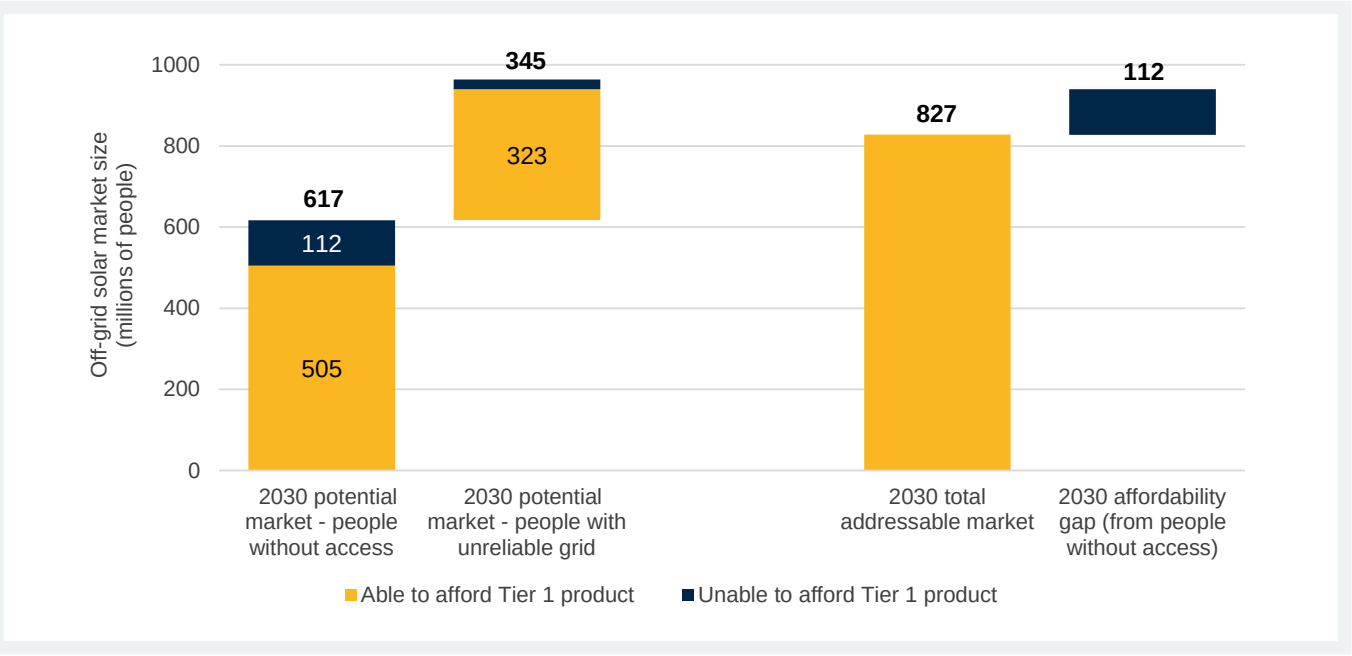
49 The lower figure for investment need is based on scaling up total investment to date to arrive at the investment needed from 2020 to 2024. The higher figure extrapolates inventory and receivables need per unit to cumulative forecast Tier 1 sales volumes.

50 Based on the recently launched World Bank/ESMAP Global Electrification Platform (GEP) projections under the "universal access" scenario, given medium population growth, GEP estimations of cost for on-grid and PV costs, and a low top-down demand target. The choice of a low demand target reflects the least-cost plan, consistent with the ambition to ensure that every household has at a minimum Tier 1 electricity access by 2030. ESMAP, "Global Electrification Platform," https://electrifynow.energydata.info/.

51 ESMAP, Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers, Technical Report 014/19 (Washington, DC: The World Bank, June 2019), https://openknowledge.worldbank.org/handle/10986/31926.

Of the potential market of 617 million people with OGS as their main source of access, 505 to 603 million will be able to afford a product that will bring them Tier 1 access or higher.[52] This affordability range is driven by two factors: (1) people's rising incomes up to 2030 and (2) different methods of determining affordability. The lower 505 million figure reflects the most conservative combination of these two factors, using present-day incomes and evaluating people's ability to afford monthly payments across the entire product lifetime (Figure RS 15). By contrast, the upper 603 million figure combines 2030 incomes (which will be higher) with an evaluation of people's ability to afford only the PAYGo deposit with three months' savings, assuming people will be able to make the monthly payments after that.[53] The affordability gap is only relevant for people without access, as only these people must be served to reach universal access goals. In addition, a further 345 million people are expected to use an OGS device as a backup for an unreliable grid.

Figure RS 15: By 2030, the Potential Market Consists of 617 Million People Without Electricity Access and 345 Million People With an Unreliable Grid, About 85 Percent (827 Million People) of which is Addressable



Source: Vivid Economics and Open Capital Advisors.

Note: Conservative scenario, assuming present-day income and evaluating households' ability to afford monthly payments across the entire product lifetime.

52 To estimate the addressable market, we consider the total potential market in 2030 (people without access and "realistic" number of people with an unreliable grid), determining their ability to pay the average price of a Tier 1 product. We then segment this addressable market by comparing the total system costs of pico and SHS products and assuming people will purchase the highest-capacity product they can afford. The unreliable grid market is based on current estimates of grid unreliability per country, assuming the 2018 share of unreliability will remain constant to 2030. It further assumes 25 percent of unreliable grid people could also purchase an OGS product as a backup device for residential use, to power their SME or microbusiness, or both.

53 To determine affordability, we compared monthly PAYGo payments to 5 percent of monthly household expenditures (today and in 2030). Ability to pay the PAYGo deposit is compared to three-month savings at 5 percent of monthly expenditure (today and in 2030).

REACHING SDG7 BY 2030 WILL REQUIRE THE OGS SECTOR TO GROW AT AN ACCELERATED ANNUAL RATE OF 13 PERCENT, AS WELL AS US$ 6.1 TO 7.7 BILLION IN EXTERNAL INVESTMENT FOR OGS COMPANIES AND US$ 0.5–3.4 BILLION OF PUBLIC FUNDING TO BRIDGE THE AFFORDABILITY GAP.

Closing the gap towards universal access requires the sector to grow at an average annual growth rate of 13 percent, over double current projections. This growth rate would allow the sector to provide the addressable market of people without access and those currently below Tier 1 with a Tier 1 product—taking continued efforts of grid and mini-grid electrification into account. To additionally provide people with an unreliable grid with a Tier 1 product would require even faster growth at 18 percent CAGR in sales.

Achieving this growth rate will require concentrated efforts across stakeholders. Companies need to prove profitability to expand sustainably and drive investor confidence. Investors need to double down and drive new flows of capital into the sector. Policymakers need to create favorable enabling environments for OGS. And donors need to close the affordability gap for consumers and incentivize companies to move into new markets.

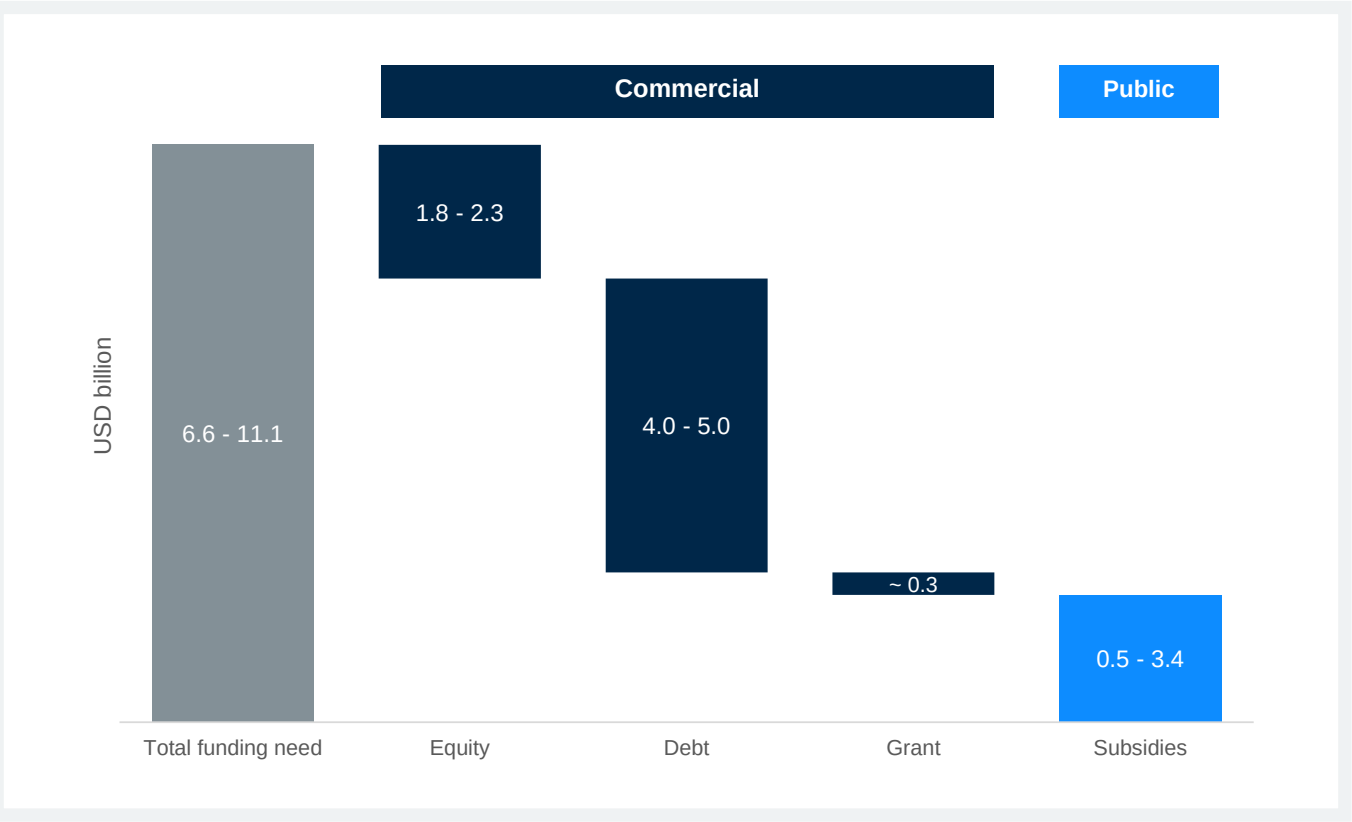
Below, we explore the "Tipping Points" that could supercharge sector growth, but these will require increased investment and focus across different sector stakeholders.

- **Companies need to achieve profitability and become cashflow positive.** Profitability underpins long-term sector growth and sustainability and would drive a new wave of investment into the sector – including from a new, currently untapped, later-stage commercial investor base.
- **Market-enabling policies, regulations, and enforcement need to improve.** Governments can drive policy and regulatory changes to support the sector more quickly than ever before. Accompanied by robust implementation plans, they can thereby crowd-in public and private capital to finance ambitious off-grid electrification plans. However, now that governments have realized the importance of the OGS sector and begun to incorporate OGS in national electrification plans as well as their tax and customs regimes, over-regulation may be a risk that could impede sector growth. For example, the growth of the PAYGo sales model (a Key Driver supporting the sector's current growth trajectory) could be severely curtailed if policymakers decide to regulate PAYGo companies like financial institutions.
- **Supply-side incentives and demand-side subsidies are needed to address the affordability gap and catalyze markets.** The right supply-side incentives can encourage OGS companies to develop new markets and serve more users. The right demand-side incentives can help achieve SDG 7 by closing the affordability gap for the poorest consumers. However, these public finance initiatives must be well-targeted to accelerate market development and increase market inclusion for the poorest consumers without distorting commercial markets.
- **Concessional finance needs to be targeted at early-stage companies and nascent markets, creating a new wave of innovation.** As some market segments move to profitability, concessional finance can be targeted to catalyze nascent markets, support continuing innovation in PULSE products for early-stage companies, electrify public institutions, and serve the hardest-to-reach residential markets.
- **A stronger link between climate change or social finance and the OGS sector is needed to enable a new wave of funding.** As the OGS sector expands, it is well-placed to take advantage of climate and social impact bonds, which would unlock massive amounts of new concessional capital.

- **Increased access to local currency loans is needed to de-risk investments and drive growth.** In the short term, larger amounts of local currency financing could be available from specialized debt providers, currency hedging providers, and DFIs to help companies manage their foreign-exchange risk. Within the next decade leading up to 2030, OGS companies will need to access local currency financing directly from local banks.

To realize the OGS sector "Tipping Points," investors, governments, and donors will need to inject an additional US$ 6.6–11 billion in financing (Figure RS 16).[54] The majority of this financing, US$ 6.1 to 7.7 billion, will be external investments into OGS companies in the form of debt, equity and grants. Debt will be critical for companies to finance receivables at such an accelerated pace of growth while equity and grants will enable companies to rapidly expand to unserved markets. But investment into OGS companies will not be enough. Up to US$ 3.4 billion of public funding from governments and development partners will be required to bridge the affordability gap for people without electricity access that are unable to afford a Tier 1 OGS product.[55]

Figure RS 16: Total Funding Needed to Reach SDG7



Source: Vivid Economics and Open Capital Advisors.

Achieving universal access by 2030 therefore requires the sector to grow much faster, with significantly more external investment and public funding to bridge the affordability gap. Given the sector's track record, its proven ability to innovate, expansion in terms of geography and products, falling costs and rising quality, even in the nonaffiliate market, together with the enhanced focus by governments and development partners on the SDG7 goal, the OGS sector certainly could surpass the current growth trajectory forecast, particularly if public funds can be used to catalyze markets and crowd-in private sector finance.

54 Taking into account repeat purchases from now to 2030 as asset life of the products expires. Overall asset life is the weighted average of pico and SHS products. The lower investment figure is based on scaling up total investment to date to arrive at the investment needed from 2020 to 2030 to achieve the cumulative sales targets, while the higher figure extrapolates the inventory and receivables need per unit to reach cumulative Tier 1 sales volumes from 2020 to 2030.

55 The US$ 3.4 billion reflects the more conservative combination of present-day (lower) incomes and people's ability to afford the monthly payments over the product lifetime. As incomes rise between now and 2030, the number of people that require financial support to afford OGS products will decrease, expanding the addressable market and shrinking the affordability gap to US$ 1.4 billion in 2030. If we consider the least conservative combination of people's 2030 income and their ability to afford the PAYGo deposit, the affordability gap would be US$ 0.5 billion.

CHAPTER 1
INTRODUCTION

Photo credit: © NIWA Solar

The Off-Grid Solar Market Trends Report (MTR) has been established over the past 10 years as the report of record for the off-grid solar (OGS) industry. In 2020, this report is jointly undertaken by Lighting Global, GOGLA, and ESMAP, produced in partnership with Vivid Economics and Open Capital Advisors and aggregating insights from more than 100 consultations with key industry players.

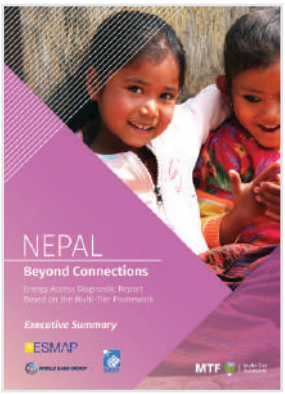
The sector has appreciably matured over the past two years. The OGS sector has grown from a US$ 1 billion market in 2017 to US$ 1.75 billion in 2019, but this has only scratched the surface; 1.8 billion people remain in need of improved access to electricity. The unreliable-grid population has also become an important new customer segment. Investors have doubled down, deploying US$ 1.5 billion in cumulative investments in 2019, up from US$ 931 million in 2017. Governments are realizing the importance of the OGS sector to achieving their 2030 universal electrification targets, complementing grid-extension, and mini-grids to reach underserved areas more cost-effectively.

Against this backdrop, the purpose of this 2020 MTR is to comprehensively track and describe the state of the commercial OGS market, including market dynamics, trends, and the market outlook to 2030. This MTR explores how OGS devices can contribute to reaching access to affordable, reliable, sustainable, and modern energy for all: Sustainable Development Goal (SDG) 7. The insights in this report are presented to inform companies and investors so that they can act on the latest market intelligence, as well as governments and development organizations, so that they can support the sector towards SDG 7.

The OGS sector has quickly evolved in recent years, since the publication of the previous report in this series in 2018. This report benefits from an increasingly broad and deep set of information and data sources. Particularly notable additions to the literature over the last two years include the following, on which this report draws.

The Global Electrification Platform
launched in November 2019

The GEP provides a single, centralized source for national, geospatial least-cost electrification planning tools to project the least-cost electrification strategy to achieve universal access by 2030. The platform includes 216 scenarios for 46 countries across Sub-Saharan Africa and will cover more countries in the coming years. At the moment, the tool includes one model developed using OnSSET, but the platform can incorporate other open-source electrification planning tools.



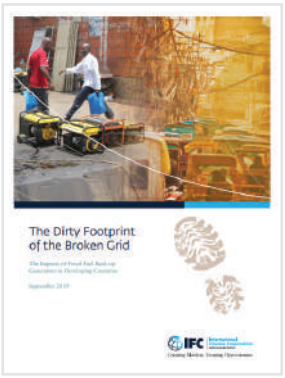
Multi-Tier Framework Household Surveys
ongoing by ESMAP

MTF has already conducted household surveys in sixteen countries and published the reports for nine countries — Bangladesh, Cambodia, Ethiopia, Kenya, Myanmar, Nepal, Rwanda, São Tomé and Príncipe, and Zambia — each covering around 3,500 households. Our team had access to survey data from 8 countries. Further MTF household surveys are now being rolled out in six additional countries.

The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa

published by Lighting Global in 2019

The report comprehensively reviews the demand for PULSE appliances in Sub-Saharan Africa, including solar processing appliances, solar water pumps, and solar cooling technologies. The report estimates future trends in demand and outlines affordability considerations.



The Dirty Footprint of the Broken Grid

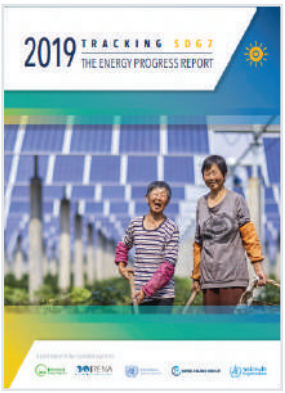
published by IFC in 2019

This report estimates the scale and impact of generators serving energy access needs within developing regions of the world. With a broad geographic scope that includes 167 developing countries (excluding China), it covers 94 percent of the population living in low- and middle-income regions of the world. The estimates are designed to help clarify the opportunity in developing countries for clean technologies, such as solar and storage (solar + storage), to replace generators and avoid their costs and impacts.

State of the Off-grid Appliance Market

published by Efficiency for Access in 2019

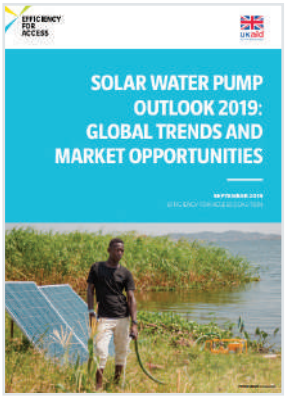
This report analyzes major trends in the off-grid appliance sector, establishes its position as a fast-growing and attractive market, and seeks to mobilize investment and policy support to accelerate the sector's growth.



Tracking SDG 7: The Energy Progress Report 2019

published by IEA, IRENA, UNSD, the World Bank, and WHO in 2019

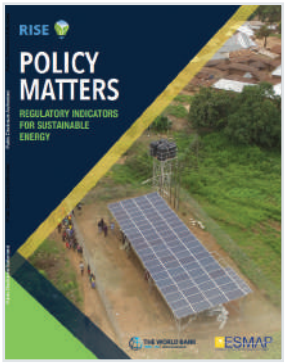
This report chronicles progress toward SDG 7 at the global, regional, and country levels. It is a joint effort of the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO), all appointed by the United Nations as global custodian agencies responsible for collecting and reporting data related to the energy targets of SDG 7.



Solar Water Pump Outlook 2019

published by Efficiency for Access in 2019

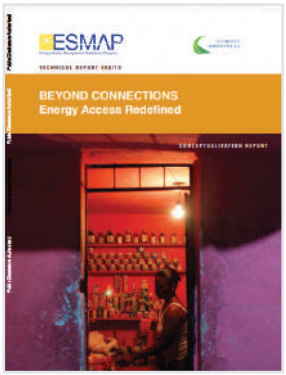
The report provides a first overview of the potential market for solar water pumps in Sub-Saharan Africa and India.



RISE platform; and Policy Matters: Regulatory Indicators For Sustainable Energy

published by World Bank RISE in 2018

RISE—Regulatory Indicators for Sustainable Energy—is a global inventory of policies and regulations that support the achievement of SDG7: electricity access, clean cooking, energy efficiency, and renewable energy. RISE tracks regulatory indicators for comparison across 133 developed and developing economies (from Afghanistan to Zimbabwe) and over time (from 2010 to 2017).



ESMAP: Beyond Connections: Energy Access Redefined

published by the World Bank in 2015

ESMAP—Energy Sector Management Assistance Programme—is a global knowledge and technical assistance program administered by the World Bank. The report moves beyond a binary "on"- or "off"-grid understanding to a Multi-Tier framework for defining and measuring energy access.

The remainder of this report is structured as follows:

- **Chapter 2 – The State of the Off-Grid Solar Market,** sets out the sales and turnover of the OGS sector and the key technological innovations and adaptations in business models underlying the market's growth. Additionally, it examines competition and consolidation in the sector and estimates the total potential demand for OGS products.
- **Chapter 3 – Access to Finance,** describes the investment landscape, considers the role of various forms of commercial finance, and outlines how to increase access to finance.
- **Chapter 4 – Enabling Environment,** assesses the policy, catalysts for demand, and partnerships that are required to unlock progress in energy access.
- **Chapter 5 – Socio-Economic and Environmental Impact,** assesses the wider impact of the OGS sector.
- **Chapter 6 – Market Outlook 2030,** illustrates the opportunity presented by the sector for users and investors in the period up to 2030, estimating both the level and types of investment that will be needed to unlock the sector's potential and achieve SDG7. It further examines those "game-changers" which could accelerate the sector's development and impact.

CHAPTER 2

THE STATE OF THE OFF-GRID SOLAR MARKET

Photo credit: © Niwa

The off-grid solar sector has grown tremendously over the past 10 years into a vibrant, US$ 1.75 billion annual market, which remains on a solid growth curve. The sector is currently serving 420 million users. From 2017 to 2019, revenues grew rapidly at 30 percent annually, while sales volumes grew at 10 percent annually. A shift towards higher-priced Pay-As-You-Go (PAYGo)–enabled products that provide higher levels of energy service has driven this rapid growth in sector turnover. While pico products still comprise around 83 percent of all sales since 2010, the growing reach of larger SHS products means that over half of off-grid solar customers now receive "Tier 1" access or higher to a clean, modern, and reliable source of electricity.

Trends in technology, such as declining manufacturing costs and increasing appliance efficiency, have sustained this shift towards larger systems. SHS manufacturing costs have declined by approximately 5 to15 percent over the last two years. There are also now highly efficient DC appliances on the market, representing an increasingly cost-effective option for users. The combination of continued efficiency gains for appliances, declining manufacturing costs, and the use of the PAYGo business model to increase affordability will continue to accelerate the shift towards larger, higher-margin SHS sales in response to growing consumer demand for appliances and backup systems.

As the sector matures, companies are focused on financial sustainability, consequently accelerating their innovation in business models and specialization across the value chain. Companies are moving into new geographies and underserved markets as established markets become more saturated. They are also accelerating the shift towards larger, higher-margin SHS sales in response to growing consumer demand for appliances and backup systems, which dovetails with their focus on financial sustainability. In addition, two new business models are solidifying: (1) "beyond energy" companies using consumer PAYGo data to offer financing for non-energy products and services, and (2) next-generation off-grid utilities using software platforms to manage a wide array of off- and on-grid energy assets. The vertically integrated business model in off-grid energy also continues to disintegrate, as companies focus on their core capabilities and increasing efficiency. New partnerships and adaptations are emerging at each link of the value chain that allow companies to focus on their core businesses to bolster profitability.

The global potential OGS market remains substantial, with 840 million people without electricity access, over 1 billion connected to an unreliable grid, over 70 million farmers who could leverage OGS for productive use and a promising public institutions market. Productive Use Leveraging Solar Energy (PULSE) solutions, such as solar water pumps (SWPs), cold storage, and solar milling, and products servicing public institutions are natural expansions of the traditional OGS market, which serves households and microenterprises. Both of these markets hold tremendous potential opportunities.

PAYGo and other business models offering consumer finance are expanding the global addressable market, bringing OGS products within affordable reach of a larger share of the population. While only 476 million people could afford a Tier 1 multi-light system if we assume they pay equal monthly installments of a product's cost throughout its lifecycle, 670 million would be able to afford the same system if they can save three months for the PAYGo deposit and subsequently pay a lower monthly amount.

The remainder of this chapter proceeds as follows:

- **Section 2.1** examines trends in sales volume and turnover for pico, SHS, appliance, and PULSE products.
- **Section 2.2** highlights the key market drivers of the sector's development, including technology innovations and business model adaptations.
- **Section 2.3** explores competition and consolidation and discusses related trends that may change dynamics in the sector.
- **Section 2.4** estimates the total remaining market potential given both unconnected and unreliable grid populations, further estimating the addressable market based on affordability considerations.

2.1 Trends in Sales Volume and Turnover

KEY MESSAGES

- Over the past 10 years, the global off-grid solar market has grown tremendously into a vibrant US$ 1.75 billion annual market.
- Pico and SHS sales revenues grew rapidly at 30 percent annually from 2017 to 2019, driven largely by increasing sales of larger systems that provide higher levels of service to customers and improve profitability for OGS companies.
- Pico and SHS unit sales also grew at 10 percent annually from 2017 to 2019, resulting in 84 million "live" products and 17 percent market penetration today.
- In pursuit of scale, companies are increasingly moving into new geographies and underserved markets beyond the better-established OGS markets, such as East Africa and South Asia.
- Off-grid household appliances are becoming a major driver for the sector, with a current estimated global addressable market of US$ 12.6 billion that could grow to US$ 25.3 billion by 2030.
- Productive use leveraging solar energy (PULSE) products also represent an emerging opportunity for the sector, although the market is still in its infancy and will continue to evolve.

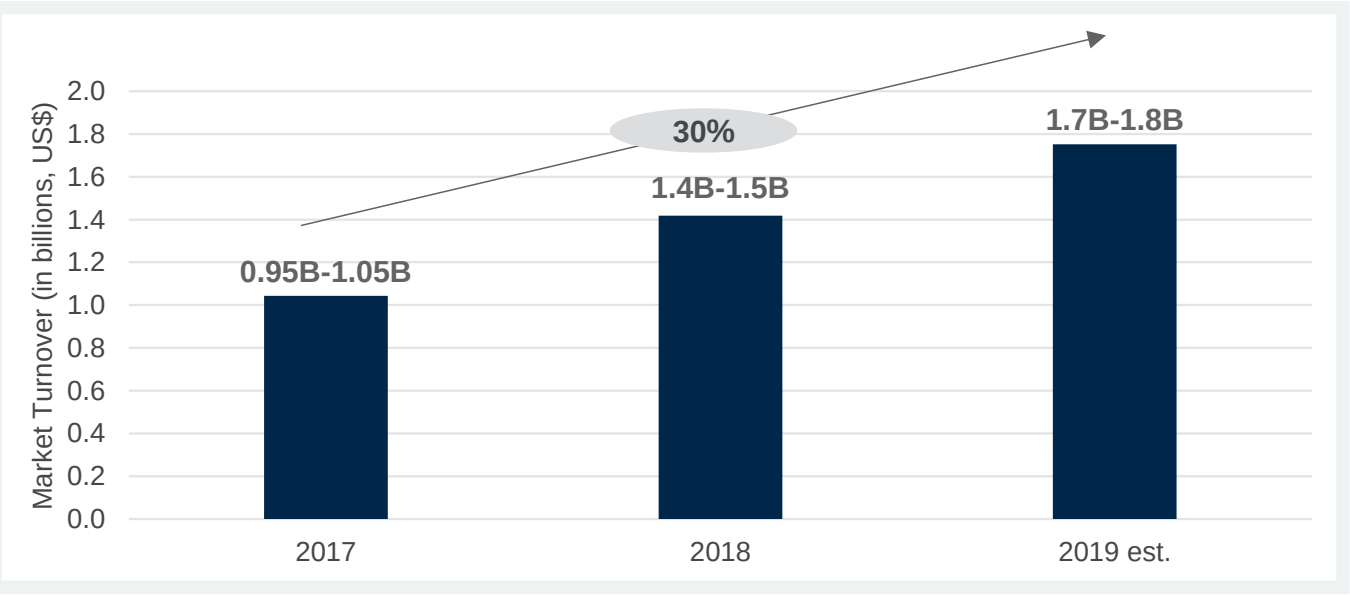
Photo credit: © Lighting Africa

2.1.1 Pico and SHS Sales Volume and Turnover

SALES REVENUES GREW RAPIDLY AT 30 PERCENT ANNUALLY FROM 2017 TO 2019, WHILE UNIT SALES ALSO GREW AT 10 PERCENT ANNUALLY, RESULTING IN 84 MILLION "LIVE" PRODUCTS AND AN ESTIMATED 17 PERCENT PENETRATION OF THE POTENTIAL MARKET FOR OGS PRODUCTS TODAY.

In 2017, the industry reached a significant milestone, hitting US$ 1 billion in annual turnover. Since then, turnover has continued to grow to US$ 1.42 billion in 2018 and will reach approximately US$ 1.75 billion in 2019. This represents an annual growth rate of 30 percent from 2017 to 2019 (Figure 1).

Figure 1: Estimated OGS Annual Market Turnover (2017–2019 Estimated)



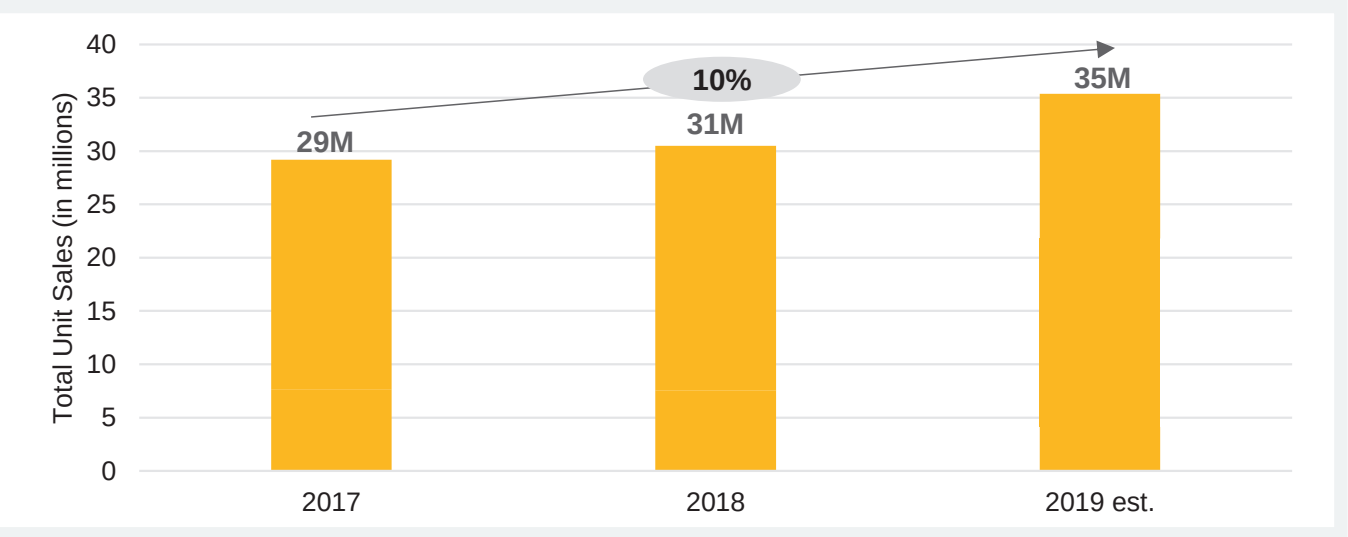
Source: Vivid Economics and Open Capital Advisors analysis of Stiftung Solarenergie. Sendea gGmbH, "Mangoo Marketplace," https://www.mangoo.org/; Aurélien Boyer et al., Pricing Quality: Cost Drivers and Value Add in the Off-Grid Solar Sector (Utrecht: GOGLA, 2019), https://www.hystra.com/reaching-scale-in-access-to-energy-2017; GOGLA data; and MTF survey data.

Note: Market turnover was derived through a multi-tiered approach. For cash sales, we used conservative price estimates from our pricing analyses for each wattage category, calculating a weighted average price for pico and SHS products based on these estimates. We then multiplied that average combined pico and SHS pricing by global cash sales volumes to estimate an annual market turnover for pico and SHS products bought in cash. For PAYGo, we assume a two-year repayment period, and we recognize revenue in the first year as the revenue collected from the down payment plus revenue collected from ongoing payments expected that year. Additionally, here and throughout the report where applicable, H2 2019 sales data are estimated. Historically, sales in the second half of the year are typically higher; however, this report conservatively estimates H2 2019 sales as equal to H1 2019 sales.

Year-on-year unit sales also continue to grow at 10 percent annually, with more than 30 million OGS units sold in 2018 and 2019 on course to exceed this figure.[56] Following the sector's rapid acceleration between 2010 and 2015, with annual growth rates of 133 percent, the industry saw a decline in sales leading up to 2017 due to localized shocks in key pico product markets and companies' adaptations to sector-wide trends. Since then, growth in annual unit sales has stabilized to 10 percent from 2017 to 2019, showing signs of a maturing market (Figure 2).

56 GOGLA data and MTF analysis.

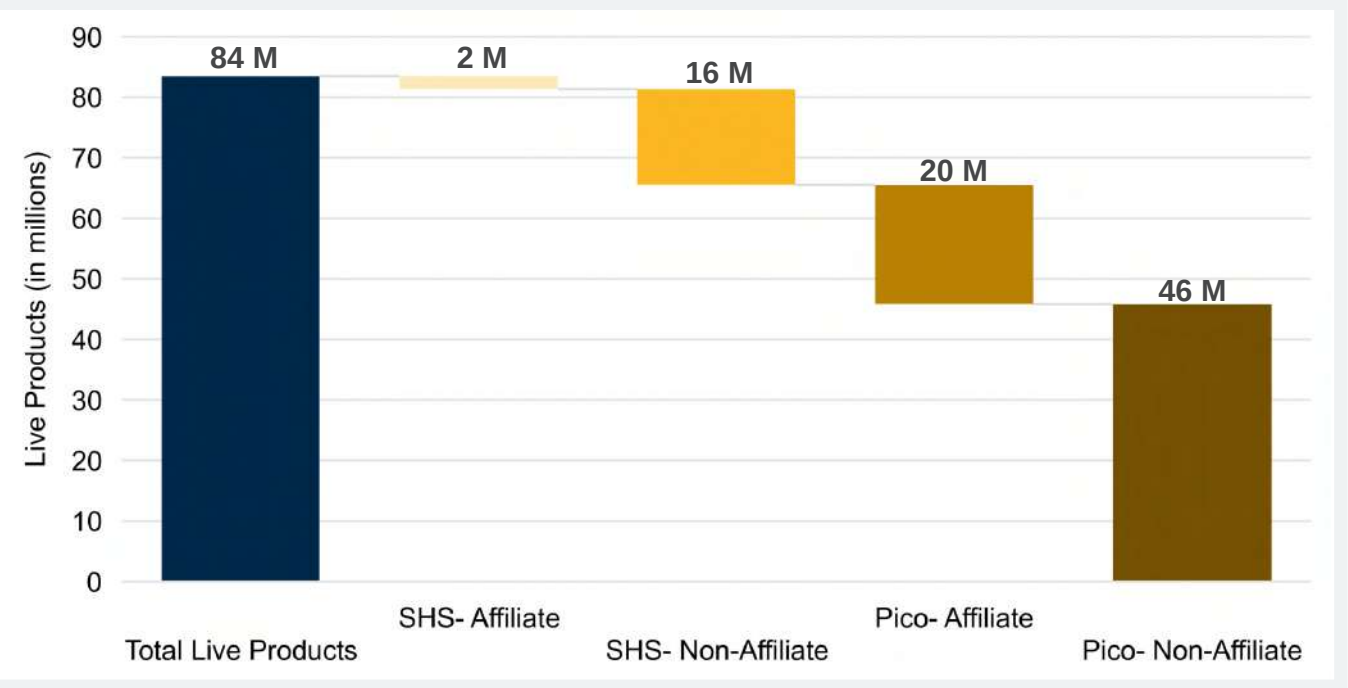
Figure 2: Estimated Annual OGS Unit Sales (2017–2019 Estimated)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA sales data, 2017–2019.

In total, around 180 million OGS units have been sold worldwide since 2010, comprising 150 million pico and 30 million SHS products. Accounting for the lifecycle of these products, approximately 84 million units are "live," that is, in use today, benefiting more than 420 million people (Figure 3). This represents an estimated market penetration of 17 percent.[57]

Figure 3: Global Estimate of Live Products on the Market by Product Segment (as of H1 2019)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA live product data and MTF data. Vivid Economics and Open Capital Advisors analysis of GOGLA live product data and MTF survey data.

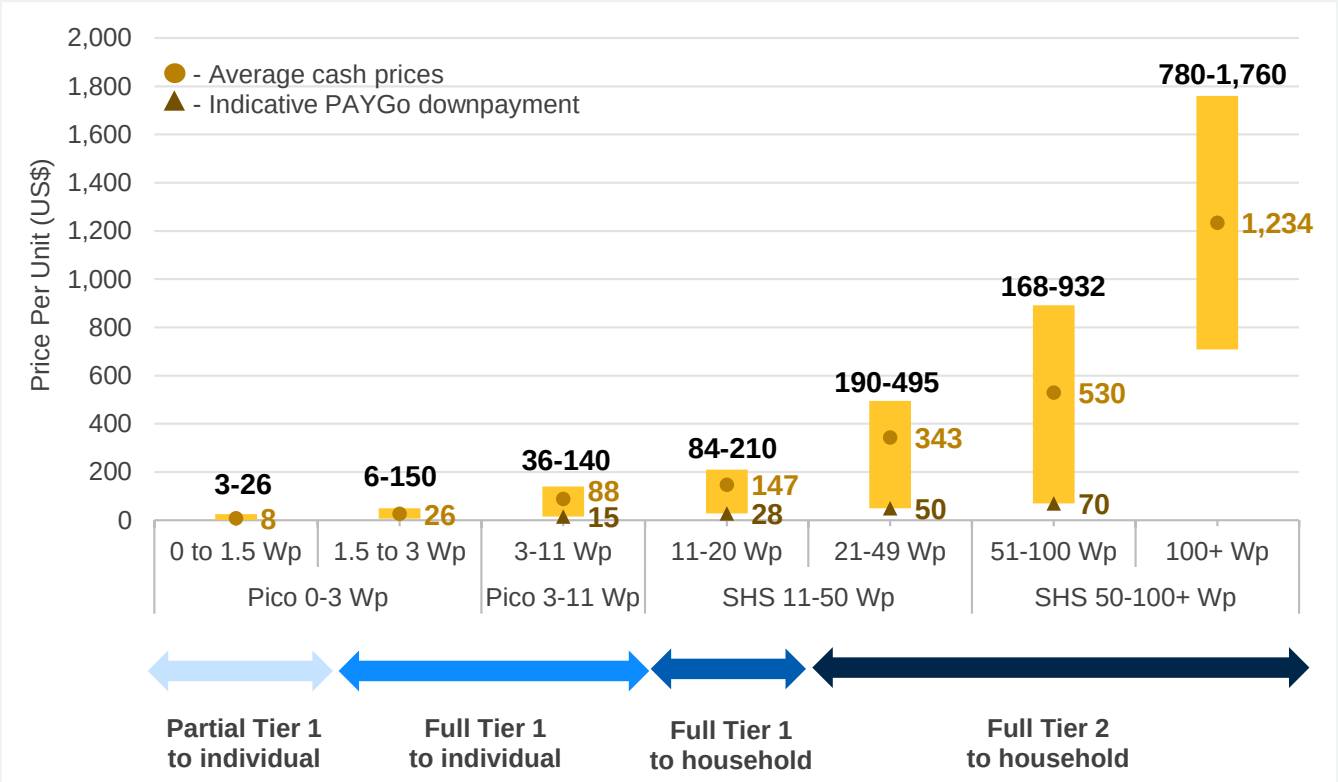
Note: Total live products in the market are derived from GOGLA reported data on live products. This number is then adjusted up to a global estimate using our estimates for non-affiliate market share.

57 Market penetration is derived as the share of households that have been served by OGS solutions out of the total potential market of households for OGS. The total potential market includes both households without grid connections and those with unreliable grid connections.

This report distinguishes between "affiliate" and "non-affiliate" products available to users. Affiliate products are sold by companies that are connected to any of the partner organizations involved in the semi-annual GOGLA sales data reporting process, including GOGLA members, companies selling products that meet Lighting Global Quality Standards, and appliance companies that participated in the Global LEAP Awards, or are engaging with the Low Energy Inclusive Appliances (LEIA) program. Much less data are available on the non-affiliate portion of the market, though it contributes significantly to sales volumes (Figure 13).

The OGS market has evolved to offer a wide variety of products at different price points (Figure 4). Globally, price points increase with increasing system size, as expected, given the larger components and increased functionality of larger systems.[58] This is particularly relevant when evaluating the cost of electrification, as the cost of a system that can provide higher than Tier 1 access is much higher than the cost of a basic solar lantern that does not provide Tier 1 access. As systems get larger, the spread of prices increases with the diversity of potential configurations.

Figure 4: Global Indicative Price Ranges of Pico and SHS Products by Wattage and MTF Tier



Source: Vivid Economics and Open Capital Advisors analysis of Stiftung Solarenergie, "Mangoo Marketplace"; and Boyer et al., Pricing Quality in OGS.

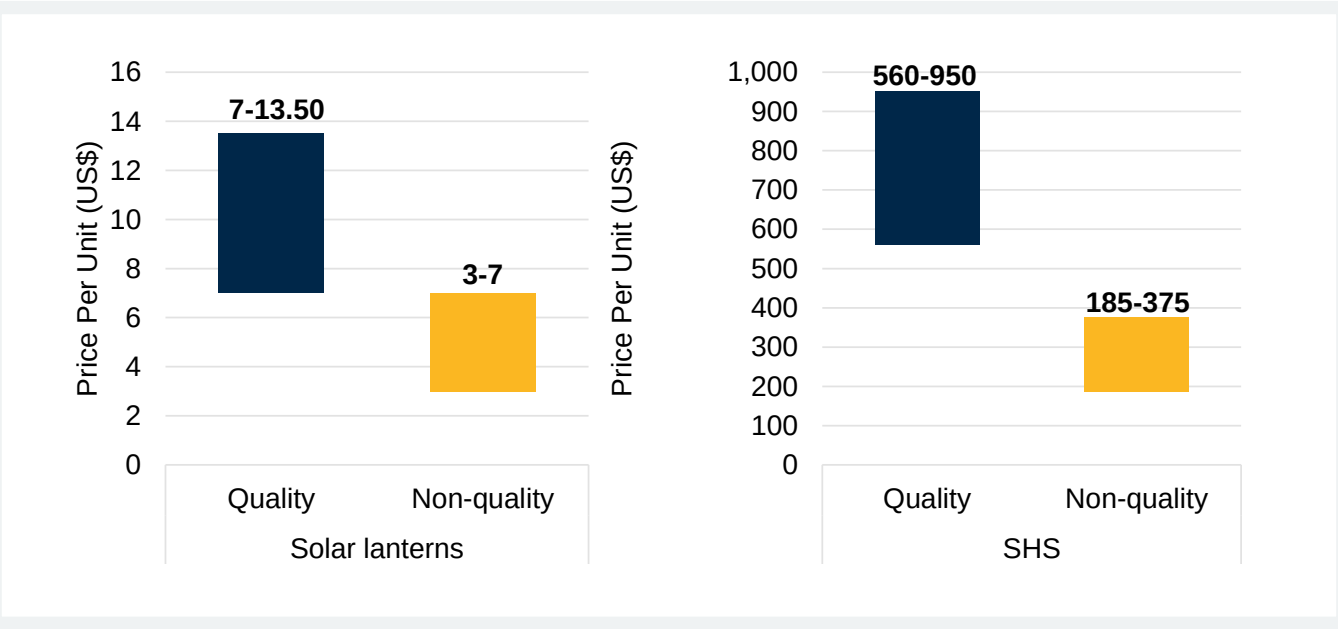
Note: Price ranges derived from the Mangoo marketplace, GOGLA, affiliate and non-affiliate company websites, consultations with off-grid companies and Chinese manufacturers, and industry reports and Lighting Global–commissioned market research, such as Ipsos studies of Kenya, Ethiopia, and Tanzania. All available pricing data from these multiple sources were then consolidated in a database with corresponding price ranges by product segment—pico, SHS, and appliances—and by wattage. These price estimates do not fully represent all products in the marketplace; missing, for instance, are counterfeit and copy-cat products that would typically be cheaper than quality-verified or certified lighting products. Indicative down payments are based on price points collected from affiliate companies, through company interviews, and from company websites. Because of limited data on systems greater than 100 Wp, we do not include an estimate for that category.

58 Pricing data derived from the Mangoo marketplace, GOGLA, affiliate and non-affiliate company websites, consultations with off-grid companies and Chinese manufacturers, and industry reports and Lighting Global–commissioned market research, such as Ipsos studies of Kenya, Ethiopia, and Tanzania.

The SHS segment comprises two distinct types of systems: (1) plug-and-play (PnP) integrated systems, mostly using lithium battery technology and marketed by affiliate companies, and (2) component-based systems offered by a wide variety of distributors, often unbranded and typically using lead-acid batteries. Component-based systems are generally cheaper than PnP systems of similar wattage.

In addition, quality can vary substantially within segments, which also impacts the price (Figure 5). Quality products are priced relatively higher compared to non-quality products; quality products use higher-quality components, must be tax-compliant with the region of sale, are often branded, often undergo quality verification, and require the provision and servicing of warranties, all of which contribute to the final cost of goods. On the other hand, non-quality products use lower-quality components, lack quality verification, and may be imported through informal channels, thus bypassing tax authorities.

Figure 5: Price Ranges for Quality and Non-Quality Pico and SHS Products



Source: Based on Hystra analysis of quality and non-quality products. The Hystra report defines quality products as products that meet relevant IEC standards and could meet Lighting Global Quality Standards, offer services including warranty and after-sales support, can potentially offer consumer finance through PAYGo, and are sold by responsible businesses. Non-quality products, on the other hand, are characterized as products without the same services as quality products that typically compete on price. Boyer et al., Pricing Quality in OGS.

By region, product pricing is lower in South Asia and East Africa.[59] Solar lanterns, for instance, are notably cheap in India, with its large, price-conscious consumer base close to major off-grid manufacturing hubs in the region. Off-grid products, both pico and SHS, are also relatively affordable in East Africa, where competition among OGS companies is strong and distribution networks in Kenya and Uganda are relatively well-established.

In other regions, such as West Africa and East Asia and Pacific, prices are relatively higher. Analysis of product pricing indicates that the median price for both an entry-level 0–1.5 Wp pico solar lantern and a 1.5–3 Wp pico product sold in West Africa can be 70 and 30 percent higher, respectively, than in East Africa. Less competition among private-sector players, greater infrastructure challenges, higher costs of transportation and fuel, safety risks, and unfavorable tax and regulatory regimes (such as import duties levied or VAT not waived on OGS products) drive up costs in West African markets compared to East Africa. In East Asia and Pacific, shipping and distribution to smaller island nations raise costs compared to the distribution of similar products to countries such as India or Bangladesh.

59 Consistent with the GOGLA sales data collection methodology, this report uses regional groupings outlined by the World Bank country and lending groups and sub-regional groupings in Sub-Saharan Africa using the United Nations categorization of geographical sub-regions.

RAPID GROWTH IN TURNOVER IS BOLSTERED LARGELY BY INCREASING SALES OF LARGER SYSTEMS, PREDOMINANTLY THROUGH PAYGO-ENABLED SOLAR HOME SYSTEMS (SHS), THAT PROVIDE HIGHER SERVICE LEVELS TO CUSTOMERS.

Pico products have dominated the market to date, comprising 78 percent of live products and more than 75 percent of global unit sales in 2018.[60] This reflects low prices in the pico segment and a customer base that is not yet able or willing to pay for larger products. The most popular pico products over the last two years have been solar lanterns with mobile charging (1.5–3 Wp), followed by solar lanterns with only a single light (0–1.5 Wp), each representing 48 and 33 percent of pico unit sales, respectively.

Today, the pico product segment is heavily commoditized and competitive, providing users with highly affordable lighting solutions. Non-affiliate manufacturers and unbranded products are firmly established in the market, representing the majority of pico sales. Non-affiliate manufacturers are also expanding their offerings to focus on designing their own brands, in some cases distributing directly to the market. This increased competition has driven down prices and made products more affordable, particularly small pico products that serve as an important entry point for many users to OGS products.

As a result, unit sales for affiliate pico products have gradually declined since their peak in 2015 (Figure 6). Increased commoditization and fragmentation of the pico market has meant that many affiliate companies struggle to compete with lower-priced non-affiliate pico products. Manufacturers of pico products, which have typically obtained US$ 4–5 per unit, are increasingly challenged to lower their prices as far as US$ 1–2 to compete with existing products in certain markets, such as India.[61] From 2017 to 2018, the market for affiliate pico products declined 6 percent.[62] Multi-light pico products (3–10 Wp) fell the most (14 percent) over that period, although the decrease in the multi-light pico category was due to a large bulk purchase in the previous period (H2 2017).[63] West Africa experienced the most significant decline in sales of pico products between 2017 and 2018 (29 percent). West African markets are relatively nascent and, as such, experienced high volatility in unit sales.[64] The Indian market, which accounts for more than 90 percent of affiliate sales in South Asia, also recorded a 35 percent drop in solar lantern sales from 2016 to 2018.[65] As approximately 10 million solar lamps and lanterns were sold in India in 2018 (including non-affiliate products), India is a significant contributor to global pico sales.[66] The drop is in part, attributed to demonetization of the Indian rupee in 2017, as well as to increasing uncertainty over unfavorable import regulations for OGS products and saturation of the primary sales channel for quality solar products (microfinance institutions, or MFIs).[67]

60 GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H1 2018 (Utrecht: GOGLA; Washington, DC: Lighting Global, October 2018), https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2018-sales-and-impact-data; GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H2 2018 (Utrecht: GOGLA, May 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h2-2018-sales-and-impact-data; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

61 Analysis of Open Capital and Vivid Economics consultations.

62 Based on analysis of GOGLA sales data and hence representative of the affiliate market. Non-affiliate sales proportions likely differ.

63 Decrease caused by an outlier from H2 2017, when there was a significant purchase of products in this segment. Without this outlier, multi-light systems experience growing sales over time. GOGLA and Lighting Global, Off-Grid Solar Market H1 2018; and GOGLA and Lighting Global, Off-Grid Solar Market H2 2018.

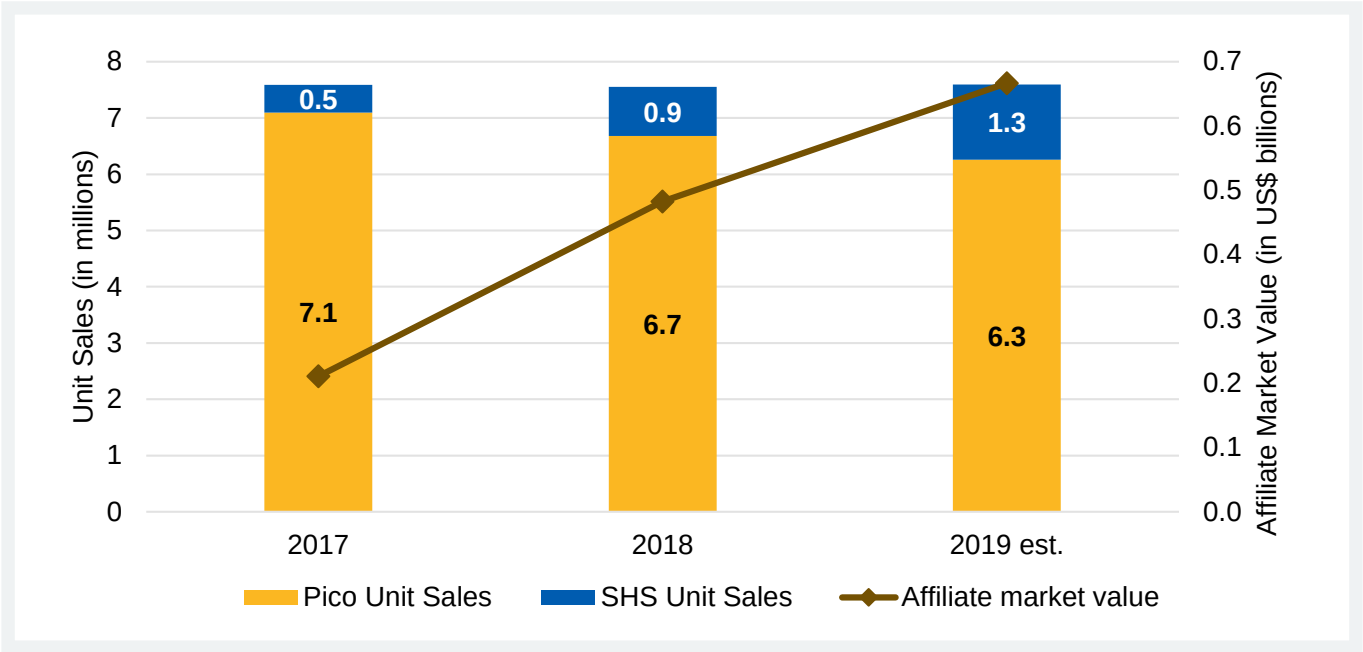
64 GOGLA and Lighting Global, Off-Grid Solar Market H2 2017.

65 GOGLA and Lighting Global, Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H1 2019 (Utrecht: GOGLA, October 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2019-sales-and-impact-data; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

66 William Brent, "Is Off-Grid Solar Lighting Still Relevant in India?," Power for All Insights: DRE Technologies (blog), September 16, 2019, https://www.powerforall.org/insights/dre-technologies/grid-solar-lighting-still-relevant-india.

67 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019; industry consultations; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

Figure 6: OGS Product Segment Share of Affiliate Unit Sales against Affiliate OGS Market Value (2017–2019 Estimated)

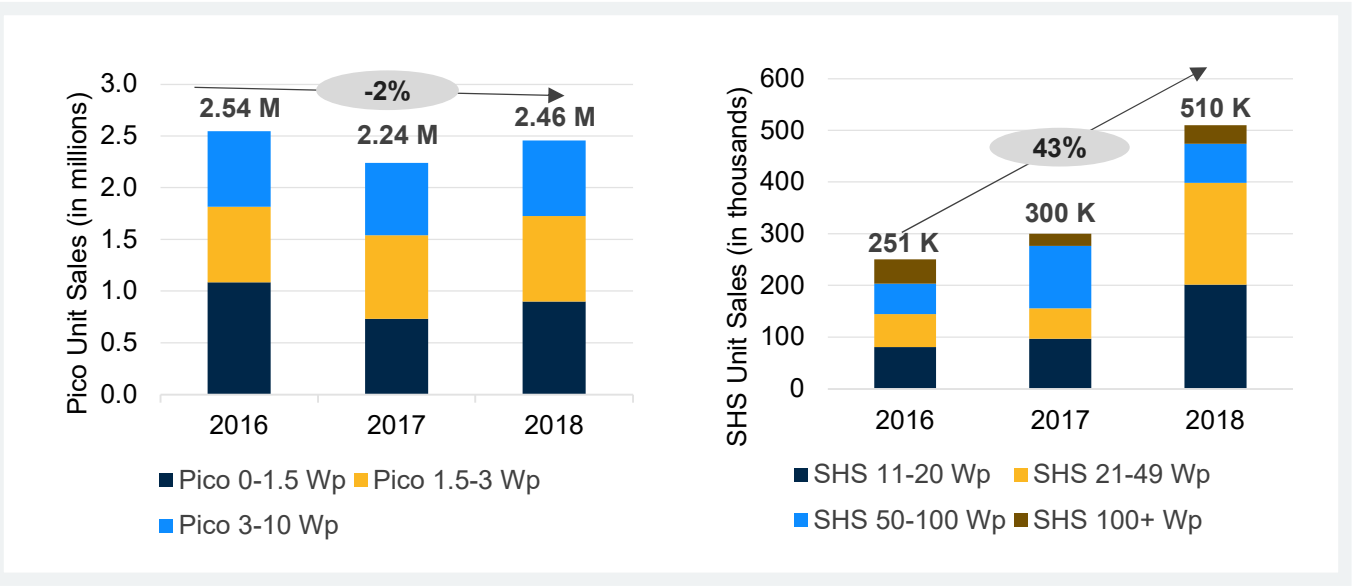


Source: Vivid Economics and Open Capital Advisors analysis of GOGLA sales data, 2017–2019.

Solar home systems, which currently represent about 17 percent of unit sales, will increasingly drive growth in the years to come. The SHS segment comprises two distinct types of system: (1) PnP integrated systems, mostly using lithium battery technology and marketed by affiliate companies, and (2) component-based systems offered by a wide variety of distributors, often unbranded and typically using lead-acid batteries. Affiliate unit sales of SHS have continued to grow strongly in recent years. Relative to the pico segment, annual growth rates for the SHS segment have been high over the last two years (2017 and 2018, at 32 percent and 77 percent, respectively).[68] In East Africa, while the market recorded a 2 percent annual decrease in overall unit sales of pico systems from 2016 to 2018, unit sales of SHS systems increased by 43 percent annually (Figure 7). Similarly, the South Asian pico market declined 8 percent annually in unit sales, while SHS unit sales in this market increased 76 percent. Globally, the fastest-growing segment is the 100+ Wp segment, which grew 267 percent in 2018. Despite this growth, the 100+ Wp segment still only represents around 10 percent of the SHS market; sales in the other SHS categories (11–20 Wp, 21–49 Wp, and 50–100Wp) each represent 29–35 percent of the total SHS market. Solar home systems, which currently represent about 17 percent of unit sales, will increasingly drive growth in the coming years.

68 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019.

Figure 7: Pico and SHS Sales Trends (East Africa, 2016–2018)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H2 2016 (Utrecht: GOGLA; Washington, DC: Lighting Global, May 2017), https://www.gogla.org/resources/global-off-grid-solar-market-report-h2-2016-sales-and-impact-data; GOGLA and Lighting Global, Off-Grid Solar Market H1 2017; and GOGLA and Lighting Global, Off-Grid Solar Market H1 2018; Off-Grid Solar Market H2 2018.

Growth in the SHS segment, especially for larger SHS, has been fueled by growing customer demand for SHS-powered appliances. Cumulative unit sales for all SHS products rated 11 Wp and above grew by 53 percent year-on-year from 2016 to 2018. Specifically, 21–49 Wp was the best-selling wattage category of SHS, with sales increasing 76 percent over the same period.[69] This is the smallest size of a system able to power televisions, which customers increasingly demand.

Companies are also serving unreliable grid customers with products specifically tailored to this segment. For example, the Zola Infinity product includes modular 320 Wp solar panels and 2.3 kWh batteries that can be stacked to increase system size. These components are 4 and 12 times larger, respectively, than Zola's higher-end PnP SHS product. Beebeejump, a startup based in Nigeria, sells its larger SHS kit with an AC inverter, for use by unreliable grid customers during grid outages. Such larger systems seek to lower fuel costs for customers who otherwise rely on expensive, noisy, and polluting diesel generators.

These larger systems not only meet evolving customer demand but also provide companies with higher revenues and improved cashflow, which is important as they face pressure to generate profits. In H1 2019, at least three affiliate companies reported sales of 100+ Wp systems for the first time in West Africa, marking a shift in product direction.[70] These systems improve company revenues and cashflows, since the 100+ Wp product segment primarily comprises cash sales targeted at wealthier customers seeking backup power solutions, as well as large-scale, government-subsidized programs in South East Asia.[71] Systems smaller than 100 Wp, on the other hand, are primarily sold on credit through PAYGo, which strains working capital and exposes companies to default risk. Although this shift towards larger than 100 Wp systems benefits company profitability, the shift could impact the sector's ultimate goals to achieve SDG 7 if companies move away from serving generally poorer, unconnected customers.

69 Vivid Economics and Open Capital Advisors analysis of GOGLA sales data.

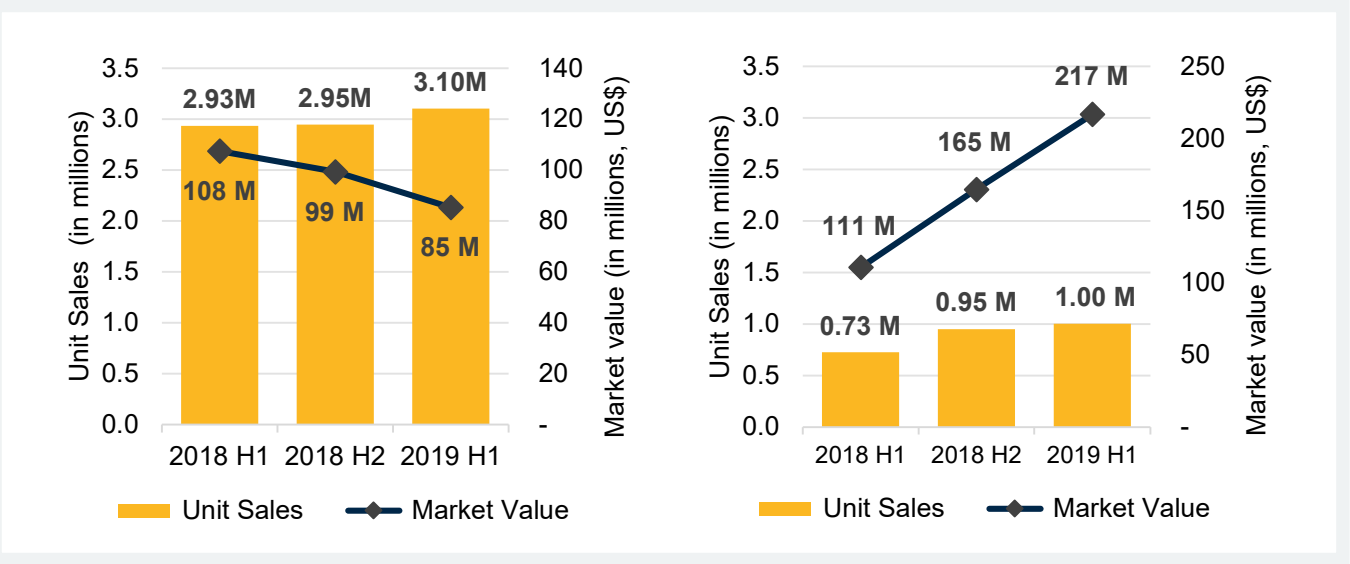
70 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019.

71 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019.

THE PAYGO BUSINESS MODEL USED TO FINANCE BOTH SHS AND PICO SOLAR PRODUCTS IS RAPIDLY INCREASING ITS MARKET SHARE, REACHING 24 PERCENT OF UNIT SALES IN H1 2019 FROM 20 PERCENT IN H1 2018.[72]

PAYGo boosts affordability, unlocking larger PnP systems that provide higher levels of energy service in addition to a wide variety of high-value, non-energy services that can be offered over PAYGo platforms. With PAYGo sales, customers obtain an OGS device on credit, first making a down payment and then paying the balance in installments up to 24 months after making the initial deposit.[73] Many investors encouraged companies to enter the PAYGo space in the face of reducing margins for cash sales of pico products.

Figure 8: Global Affiliate Unit Sales and Market Value (2018–2019 H1), Cash (Left Panel) and PAYGo (Right Panel)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA and Lighting Global, Off-Grid Solar Market H1 2018; Off-Grid Solar Market H2 2018; and Off-Grid Solar Market H1 2019.

Note: Collected sales data began to be segmented by cash and PAYGo in the GOGLA sales reporting process in H1 2018. This chart, therefore, details data for all available reporting periods. The market value of off-grid products is a proxy for the retail value of products sold in the market. For cash products, the analysis considers the Free on Board (FOB) price, a scalar to estimate retail price, and expected breakage rates. The market value for PAYGo products is based on the total cost of ownership for the PAYGo product, breakage rates, and default and nonpayment rates.

The PAYGo segment has grown much faster than the cash segment over the last three semi-annual reporting periods, coinciding with sales of larger SHS (Figure 8). Affiliate PAYGo sales increased 38 percent from H1 2018 to H1 2019, thus accounting for 24 percent of total unit sales. Sales of larger SHS account for a large portion of the sales growth, while sales of PAYGo pico products have not increased significantly. In line with the volume increase of 38 percent, the market value of PAYGo sales increased by 96 percent from H1 2018 to H1 2019, accounting for 72 percent of the total affiliate market value in H1 2019.

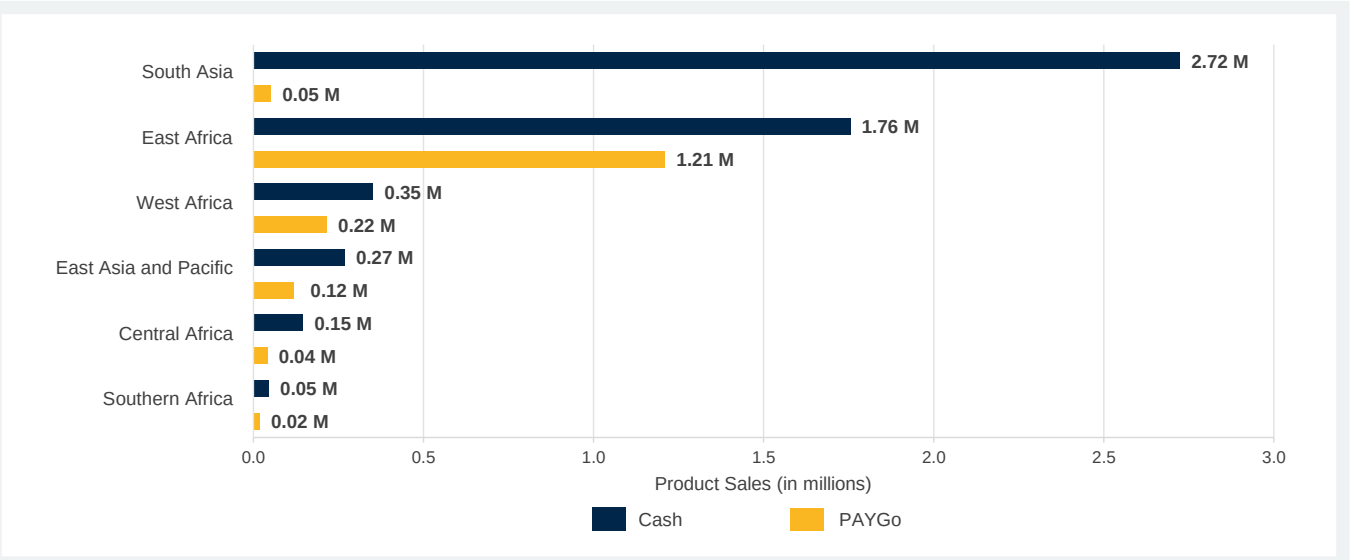
72 These figures apply only to the affiliate portion of the market.

73 Emmanuel de Dinechin et al., Powering Opportunity in East Africa: Proving Off-Grid Solar is a Power Tool for Change (Utrecht: GOGLA, September 16, 2019), https://www.gogla.org/resources/powering-opportunity-in-east-africa-proving-off-grid-solar-is-a-power-tool-for-change.

Larger, PAYGo-enabled systems are providing customers with energy access levels of Tier 1 and higher, which is crucial to achieving energy access targets. Over half of people using an OGS product have at least "Tier 1" access, which is generally considered the minimum tier to count as electricity access. The remaining 48 percent of people use an OGS product below Tier 1—namely, pico products, such as solar lanterns—which provide partial access to electricity.

West Africa recorded the highest increase in the market value of PAYGo products, while East Africa continues to record the most sales and highest market value for PAYGo. Although mobile-money penetration in West Africa was low when the PAYGo model took off in East Africa, as of 2017, West Africa accounted for 30.9 percent of the mobile money market in Sub-Saharan Africa, up from 16.7 percent in 2012.[74] Countries such as Côte d'Ivoire, Togo, and Senegal have seen increased sales of OGS devices and appliances through the PAYGo model, especially SHS (Figure 11); as a result, PAYGo accounted for 47 percent of unit sales and 92 percent of market value in West Africa in H1 2019. East Africa, especially Kenya, continues to record the most sales of and highest market value from PAYGo systems of any region (Figure 9).[75] East Africa's consistency in PAYGo sales results from its high mobile-money penetration and historically strong government support for the sector. In addition, the region hosts many companies competing and exploring new markets and products, including an increasing range of appliances now made affordable through improved efficiency and PAYGo financing.

Figure 9: OGS Unit Sales by Region, Cash versus PAYGo (2018)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA sales data.

Nonetheless, cash-based sales of pico products will remain the backbone of the sector in terms of unit sales over the next few years. More than 75 percent of affiliate products and the vast majority of non-affiliate products are sold on a cash basis. Given the low incomes of target customers for off-grid products, some consumers can still only afford the smallest pico products, which are generally not sold on a PAYGo basis. Globally, cash sales grew 6 percent from H1 2018 to H1 2019 and represented 76 percent of OGS units sold in 2019.[76] Cash payment is most typical for pico products, but SHS are also often sold in cash. South Asia accounts for 50 percent of the total affiliate market value for cash products and 46 percent of unit sales in cash, likely reflecting cash sales to retailers or products financed through MFIs instead of on PAYGo as is more common in other markets, such as East Africa. For example, MFI financing accounts for approximately 70 percent of sales in India.[77] Though the global volume of cash sales has

74 GSM Association, State of the Industry Report on Mobile Money 2017 (London: GSM Association, February 26, 2018), https://www.gsma.com/mobilefordevelopment/resources/2017-state-industry-report-mobile-money/.

75 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

76 Vivid Economics and Open Capital Advisors analysis of GOGLA sales data.

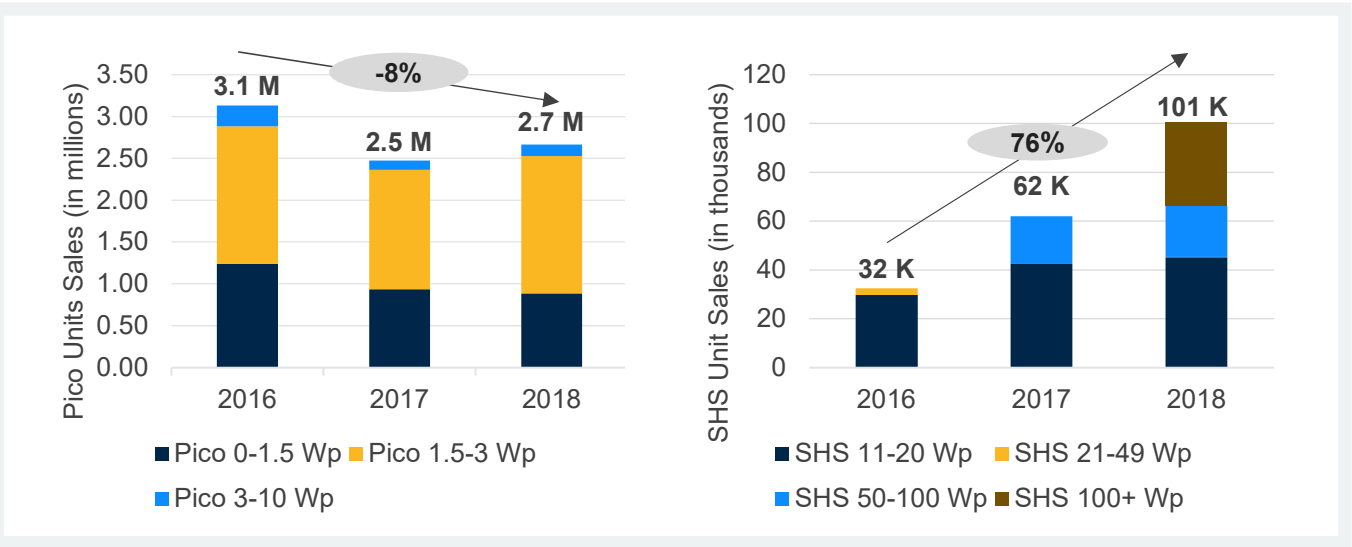
77 Vivid Economics and Open Capital Advisors consultations.

increased slightly, their total value has decreased by 21 percent, potentially indicating lower average prices per unit sold and supporting the impression that cheaper pico products are driving growth in the volume of cash sales while PAYGo sales are driving growth in SHS.[78]

COMPANIES ARE MOVING INTO NEW GEOGRAPHIES AND UNDERSERVED MARKETS IN PURSUIT OF SCALE.

Sub-Saharan Africa (mainly East Africa) and South Asia account for 87 percent of pico and SHS units sold by affiliates. The South Asian SHS market in 2018 is an estimated one sixth the size of the SHS market in Sub-Saharan Africa, but unit sales in this nascent market are increasing quite quickly (Figure 10). Affiliates in this region, as throughout the world, are transitioning towards larger product segments. Overall, the Indian market dominates South Asia, accounting for more than 90 percent of annual recorded affiliate sales.[79]

Figure 10: Pico and SHS Sales Trends (South Asia, 2016–2018)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA and Lighting Global, Off-Grid Solar Market H2 2016, Off-Grid Solar Market H1 2017; and GOGLA and Lighting Global, Off-Grid Solar Market H1 2018, Off-Grid Solar Market H2 2018.

However, companies are expanding into new geographies to capture untapped markets and take advantage of new incentives in historically less-attractive regions. Several providers in East Africa have expanded into new markets, especially in West Africa, as established markets become more saturated. In Nigeria, companies are introducing new products; for example, Zola launched its Infinity backup product to serve the large unreliable grid market in that country, and Beebeejump offers an SHS product with an AC inverter, a category in which several other companies are currently testing products. Other international companies, such as RZB Lighting, are looking at Vietnam, Indonesia, and the Philippines as new core markets of interest in Asia, after achieving mixed success in more developed off-grid markets, such as India.[80] With the goal of accelerating energy access, an increasing number

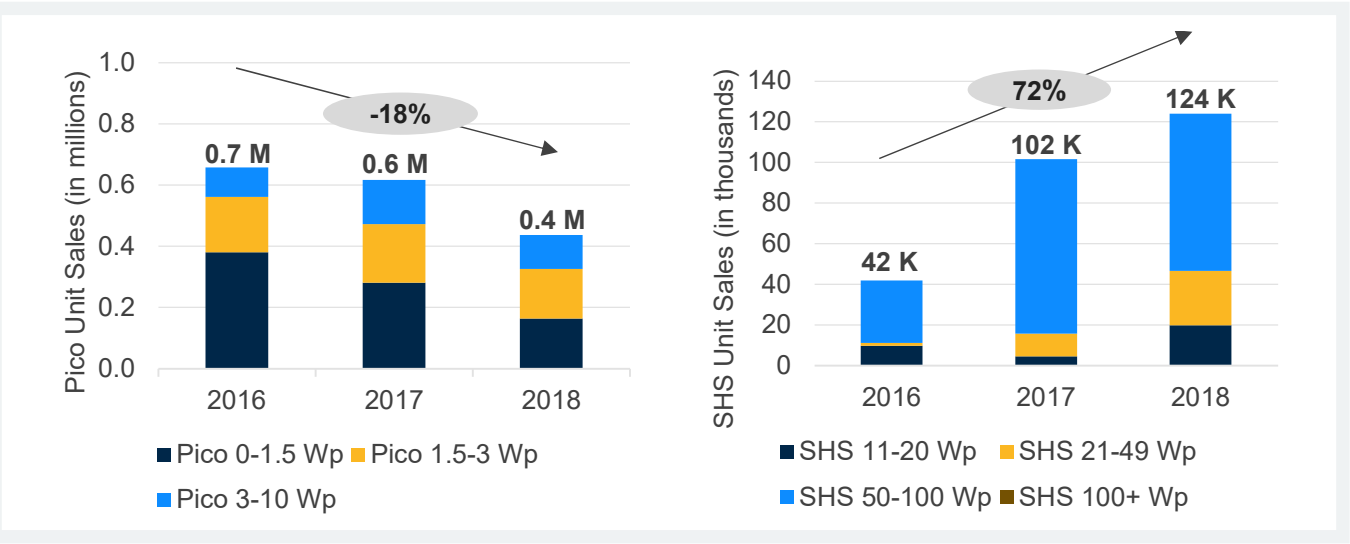
78 The market value of off-grid products is an estimated retail value of products sold in the market. For cash products, the analysis considers the Free on Board (FOB) price, a scalar to estimate retail price, and expected breakage rates. The market value for PAYGo products is based on the total cost of ownership for the PAYGo product, breakage rates, and default and nonpayment rates.

79 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

80 RZB Group, "RZB Founded New Subsidiary RZB Lighting Asia & Pacific Sdn. Bhd.," news release, June 5, 2014, https://www.rzb.de/en/media-centre/press-releases/article/1183-rzb-founded-new-subsidiary-rzb-lighting-asia-pacific-sdn-bhd-kuala-lumpur-malaysia/.

of government incentives are encouraging expansion to underserved regions. In Togo, both BBOXX and Soleva have entered to take advantage of the Togolese government's incentive scheme for SHS.[81]

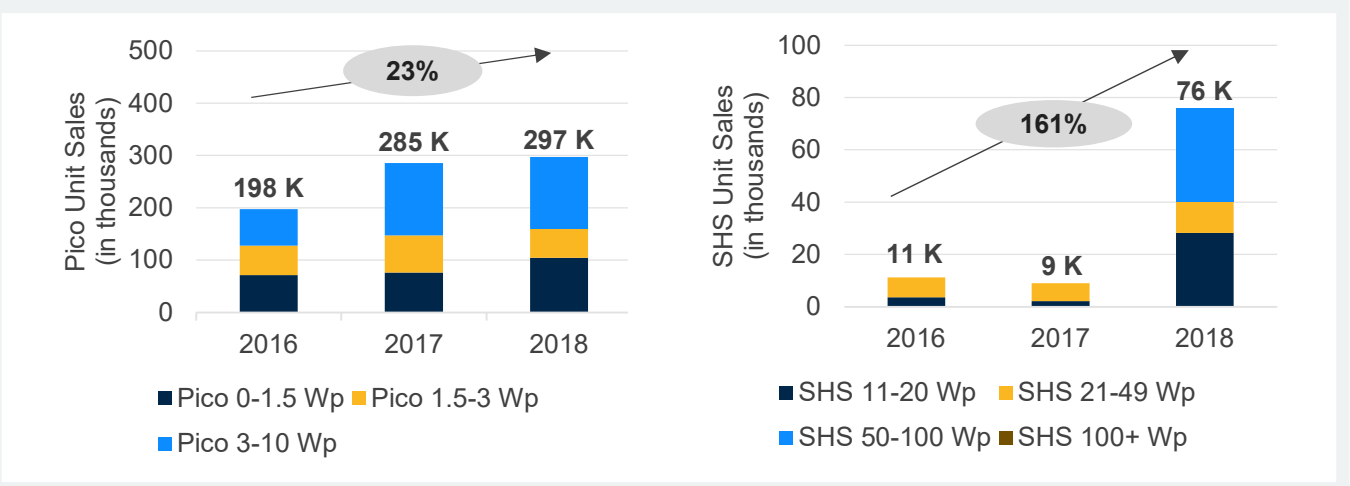
Figure 11: Regional Sales Trends by Product Category (West Africa, 2016–2018)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA and Lighting Global, Off-Grid Solar Market H2 2016, Off-Grid Solar Market H1 2017; and GOGLA and Lighting Global, Off-Grid Solar Market H1 2018, Off-Grid Solar Market H2 2018.

Compared to other regions, the East Asian and Pacific market has recorded the fastest growth in both the pico and SHS product segments (at 23 percent and 161 percent, respectively), similar to growth experienced in other regions during the early stages of market development. East Asia and Pacific is the fourth-largest regional market after South Asia, East Africa, and West Africa. Consumers in the East Asian and Pacific have shown a preference for pico products and small SHS (Figure 12) given their low disposable incomes. Sales of large systems (50–100 Wp) can be attributed to incentive schemes and bulk purchases by government programs, with the former reflecting latent demand for larger systems.[82]

Figure 12: Pico and SHS Sales Trends (East Asia and Pacific, 2016–2018)



Source: Vivid Economics and Open Capital Advisors analysis of Vivid Economic and Open Capital Advisors analysis of GOGLA and Lighting Global, Off-Grid Solar Market H2 2016, Off-Grid Solar Market H1 2017; and GOGLA and Lighting Global, Off-Grid Solar Market H1 2018, Off-Grid Solar Market H2 2018.

81 BBOXX, "BBOXX Receives Invitation to Meet President of Togo to Roll Out 300,000 Solar Home Systems," news release, July 17, 2017, https://www.bboxx.co.uk/bboxx-receives-invitation-meet-president-togo-roll-300000-solar-home-systems/; and Ayi Renaud Dossavi, "CIZO Project: SOLEVA Starts Operations as Planned," Togo First, June 3, 2019, https://www.togofirst.com/en/energy/0306-3298-cizo-project-soleva-starts-operations-as-planned.

82 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019.

NON-AFFILIATE PRODUCTS ACCOUNT FOR THE MAJORITY OF SALES VOLUMES (72 PERCENT).[83]

Approximately 200 non-affiliate manufacturers of OGS products play an important role in an organic and competitive marketplace.[84] However, the non-affiliate market is not well understood. While non-affiliate products can represent a cheaper and sometimes quality alternative, they can also be low-quality, which can erode consumer confidence in all OGS products. This report estimates that 23 million non-affiliate products (or 72 percent of total market share) were sold in 2018, compared to 7.6 million affiliate products (Figure 13). While non-affiliate products dominate both the pico and combined (plug-and-play, or PnP, and component-based) SHS markets, we estimate that affiliates represent over 50 percent of the market for PnP SHS specifically. The market share of non-affiliate products varies widely by country; for example, non-affiliate market share is 98 percent in Nepal, 65 percent in Kenya, 54 percent in Zambia, and 3 percent in Rwanda.[85]

With non-affiliate products accounting for the majority (72 percent) of products on the market, this portion of the market warrants more study moving forward. This report uses a new evidence base, primarily from the Multi-Tier Framework household survey. Non-affiliate market share is determined for each country by comparing estimates of total live product penetration from the MTF datasets with affiliate live product data from GOGLA. Global non-affiliate market share is then calculated using a weighted average of non-affiliate market share for 12 countries. Where MTF data are not available, we use estimates from secondary sources.[86]

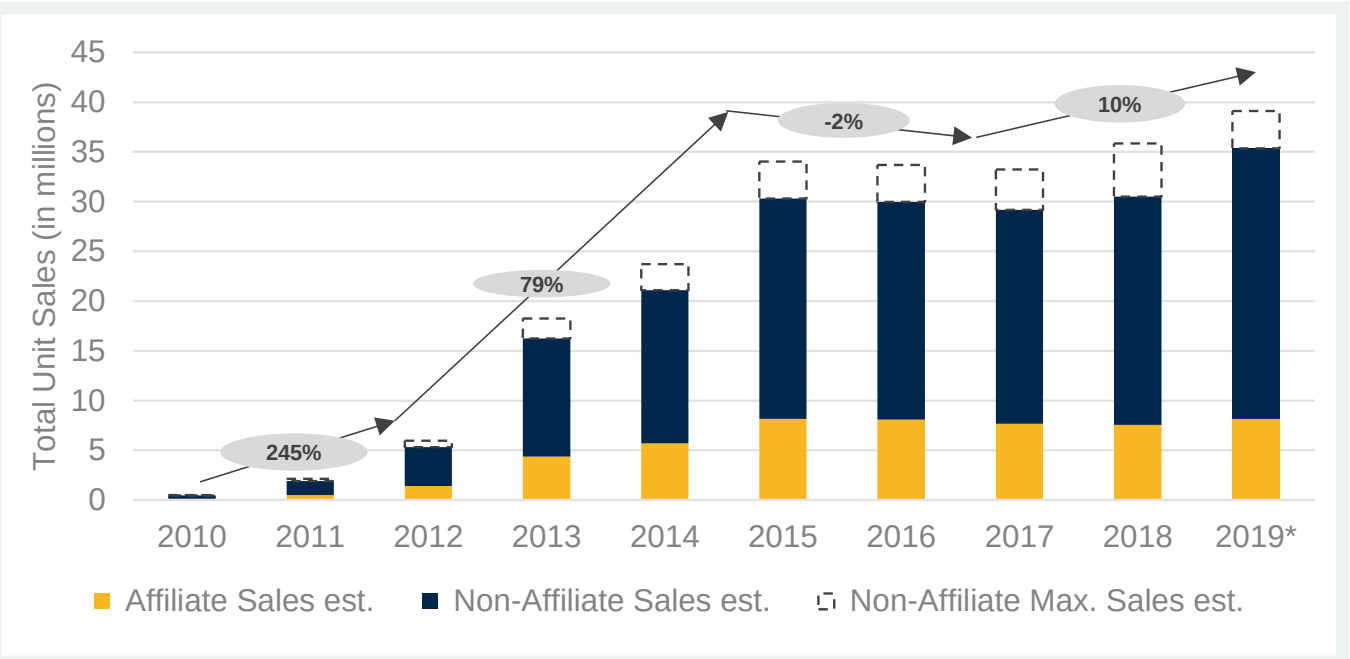
83 Non-affiliate products are those that are not sold by companies involved in the GOGLA sales data reporting process. Limited data are collected on this portion of the market, but household survey data reveals the extent of their role in the market.

84 Vivid Economics and Open Capital Advisors analysis and consultations.

85 CLASP, Off-Grid Appliance Market Survey: Perceived Demand and Impact Potential of Household, Productive Use and Healthcare Technologies, 3rd ed. (London and Washington, DC: Efficiency for Access, September 2018), https://efficiencyforaccess.org/publications/off-grid-appliance-market-survey; The World Bank, Open Data, https://data.worldbank.org/; Demographic and Health Surveys, DHS Data, https://dhsprogram.com/data/; Ipsos market research commissioned by Lighting Global; MTF household survey data; GOGLA live product data; and industry interviews. Notably, the expected lifetime of high-quality affiliate products is higher than that of low-quality, non-affiliate products. Therefore, the use of live product data to calculate the non-affiliate share of sales may underestimate the number of non-affiliate products sold in the market.

86 For Rwanda: Simon Rolland, Razvan Sandru, Alfons Schmid, and Yvette Ingabire, Rwanda: Off-Grid Sector Status 2016: Achievements in 2016 and Trends for 2017 (Kigali: Energizing Development Rwanda, May, 2017), https://endev.info/images/9/95/EnDev_Rwanda_Off-grid_Sector_Status_2016.pdf; for Tanzania: Ipsos market research commissioned by Lighting Global in July and December 2017; for Bangladesh, India, and Nepal: confidential off-grid market analysis by International Renewable Energy Agency (IRENA) in September 2019; and, for Togo: Lighting Global, Togo Off-Grid Solar Market Assessment (Washington, DC: Lighting Global, December 7, 2018), https://www.lightingglobal.org/resource/togostudy/.

Figure 13: Global Estimates of Annual Sales of OGS Lighting Products, Affiliate versus Non-Affiliate (2010–2019 H2 Estimated)



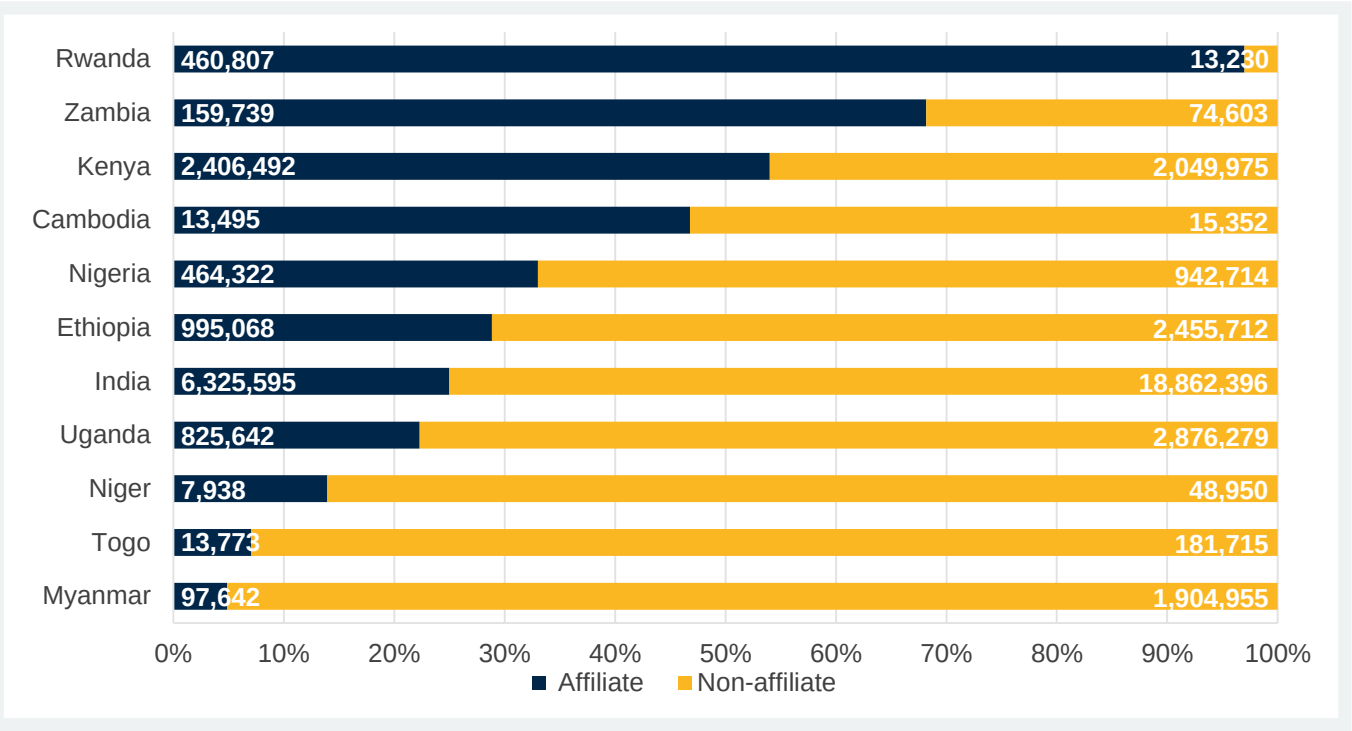
Source: Vivid Economics and Open Capital Advisors analysis of ESMAP, Energy Access Diagnostic Reports based on the Multi-Tier Framework (MTF): Beyond Connections, https://www.esmap.org/node/56715; other MTF survey data; GOGLA and Lighting Global, Off-Grid Solar Market H2 2016, Off-Grid Solar Market H1 2017; and GOGLA and Lighting Global, Off-Grid Solar Market H1 2018, Off-Grid Solar Market H2 2018; and Lighting Global, Market Trends 2018.

Rwanda is an example of a country with particularly low penetration of non-affiliate products (Figure 14). In 2016, the Government of Rwanda implemented quality verification standards to protect consumers from the risks of poor-quality products. These standards aligned with Lighting Global Quality Standards to ensure that only high-quality products could be sold or qualify for Government support.[87] Importer compliance with national standards has led to a market dominated by affiliate products, including BBOXX, Greenlight Planet, NOTS and Ignite.

At the other end of the spectrum, non-affiliate products in Myanmar represent 95 percent of all sales. Component-based systems produced most often by non-affiliate manufacturers, are especially common in Myanmar, partly because the country is close to Chinese manufacturing centers. Also, government intervention in Myanmar has incentivized the sale of component-based products that meet the incentive program's required quality standards, which many non-affiliate products in this particular market do.

87 Ministry of Infrastructure, Rural Electrification Strategy (Kigali: Government of the Republic of Rwanda, May 2016), http://www.fao.org/faolex/results/details/en/c/LEX-FAOC175794/.

Figure 14: Affiliate versus Non-Affiliate Share of Live Products by Country (Data from Years Ranging from 2016 to 2018)



Source: Vivid Economics and Open Capital Advisors analysis of ESMAP, Diagnostic Reports Based on the MTF; Brent, "Solar Lighting Relevant in India?," Lighting Global, Market Trends 2018; and other MTF survey data.

Note: For additional countries like Nigeria, Rwanda, India, and Togo, where MTF survey data were not available, the report uses previously reported data to calculate the estimated split between affiliates and non-affiliates. See n. 86 above.

Non-affiliate products often entice consumers with relatively low prices, presenting a competitive challenge for affiliate companies. In Kenya, for example, GD Lite sells a solar lighting system at prices roughly half the price of similar affiliate kits on the market.[88] This has led to a rapid uptake of GD Lite products in Kenya, as they are cheap enough for customers to purchase outright and priced very competitively to the total cost of ownership of affiliate PAYGo products.[89] In Ethiopia, an Ipsos study conducted in 2018 reported that non-affiliates have the largest share of the market, where consumers are price-sensitive, with relatively low willingness and ability to pay. Retailers in Ethiopia note that product pricing is equally as crucial to their customers as product lifespan and quality verification.[90]

While some non-affiliate products are designed and manufactured to high standards, many poor-quality products on the market fail to meet safety, durability, and performance standards. In 2017, Lighting Global Quality Assurance identified 17 top-selling, non-quality-verified products from five countries—Ethiopia, Kenya, Myanmar, Nigeria, and Tanzania—and tested them against the Lighting Global Quality standards across three categories: truth-in-advertising, safety, and durability. 94 percent of these products failed to meet Lighting Global standards due to lack of warranty, false advertising, or lack of product durability. Although all products met requirements for physical protection from ingress, 88 percent lacked consumer-facing warranties, consumer electronics safety certification, and correct advertisement of battery capacity.[91] Though not all non-affiliate products are of poor quality, local distributors note that certain non-affiliate brands of SHS typically break in less than a year, which could erode customer confidence in the market. Suggestions for how governments can increase the number of quality products on the market are included in Chapter 4: Enabling Environment.

88 While most GD Lite products are not Lighting Global quality-verified, the firm has since received quality verification for one of its products.

89 Ipsos market research commissioned by Lighting Global on "Penetration and Access to Solar Products in the Last Mile" in 2018.

90 Ipsos market research commissioned by Lighting Global on Ethiopia in October 2018.

91 Lighting Global, "Quality Matters," Technical Notes, no. 27, August 28, 2018, https://www.lightingglobal.org/resource/quality-matters/.

Box 1: The Impact of Copycat Products in Ethiopia

Counterfeit or "copycat" solar products are one category of non-affiliate products that are designed to mimic quality, branded solar products in appearance and basic functionality but are sold at a lower price. Producers of copycat products mimic the designs of leading products but instead use cheaper, lower-quality parts, thereby allowing their copycat products to be sold at lower prices. A 2018 Ipsos study highlighted that the most popular copycat product in the Ethiopian market is priced at Br 100 (about US$ 3), while its quality-verified equivalent retails around Br 250 (about US$ 8). In Ethiopia, counterfeits are so prevalent in the pico product segment, due to their low prices, that consumers are aware of their presence. The study revealed that 44 percent of customers inquired about the influx of fake or low-quality products in the market when purchasing a new product, and 30 percent asked about counterfeit products.[92] While it is unclear whether these customers still elect to buy the counterfeit products, price is clearly the key decision variable for customers: according to retailers, affordability is the primary driver of the fastest-moving brands.[93]

Exact figures for non-affiliate OGS unit sales remain unavailable, but the market has experienced an influx of non-affiliate products of varying quality over the years. In 2014, Papua New Guinea, for instance, had low penetration of OGS products in the market.[94] This lack of existing brands initially permitted manufacturers of quality-verified products to dominate the market. However, the country has seen an increase in non-quality-verified products, which had grown to 82.5 percent of all OGS products sold in Papua New Guinea by 2019.[95] Chinese manufacturers have gained awareness of new markets through conferences and industry platforms, such as Lighting Global. As a result, a few manufacturers, such as Beebeejump in Nigeria, have established their own value chains to distribute directly to consumers. Others have partnered with local distributors to sell their products. Despite the growth in unit sales of non-affiliate OGS products, Chinese manufacturers often have little knowledge of some regional markets, hindering greater penetration by these manufacturers directly.

92 Ipsos market research commissioned by Lighting Global in 2018.

93 Open Capital and Vivid Economics consultations.

94 Nienke Stam et al., Lighting Papua New Guinea: PNG Off-Grid Lighting Market Analysis 2014 (Port Moresby: Lighting Papua New Guinea, May 2014), https://www.lightingglobal.org/resource/png-off-grid-lighting-market-analysis-2014/.

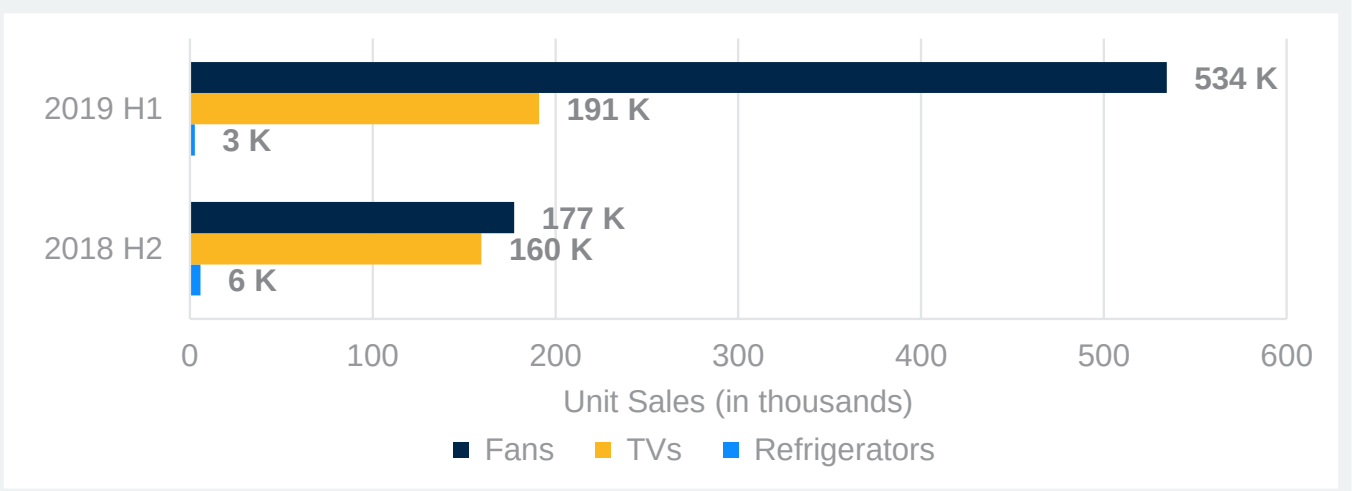
95 Tobias F. Engelmeier and Nabin Raj Gaihre, Going the Distance: Off-Grid Lighting Market Dynamics in Papua New Guinea (Port Moresby: Lighting Pacific, 2019), http://documents.worldbank.org/curated/en/802451567681915534/Going-the-Distance-Off-Grid-Lighting-Market-Dynamics-in-Papua-New-Guinea.

2.1.2 Appliance Sales Volume and Turnover

THE HOUSEHOLD APPLIANCE CATEGORY IS BECOMING A MAJOR DRIVER FOR THE SECTOR; AFFILIATE COMPANIES SOLD MORE THAN 1 MILLION APPLIANCES IN H2 2018 AND H1 2019.

High-efficiency DC appliances are contributing to the increase in PnP SHS sales. Between H2 2018 and H1 2019, appliance sales increased by 111 percent, with televisions and fans accounting for 99 percent of recorded sales (Figure 15).[96] Demand is high for televisions and fans, as they are relatively affordable compared to other, larger household appliances, such as refrigerators. Fans recorded the highest increase in sales (over 200 percent), followed by televisions (20 percent increase). Given the limited timeframe over which sales data were collected for appliances, these increases cannot signify broader trends, but they do provide benchmarks for future growth.

Figure 15: Global Unit Sales of Affiliate Appliances



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA and Lighting Global, Off-Grid Solar Market H2 2018, and Off-Grid Solar Market H1 2019.

Most fans are sold in South Asia, while most televisions—typically more expensive than fans—are sold in East Africa, where PAYGo financing is very prevalent. South Asia reported 96 percent of global cumulative affiliate fan sales, with 93 percent of these sales in Pakistan and Bangladesh. Of affiliate sales in Sub-Saharan Africa, West Africa, particularly Nigeria and Côte d'Ivoire, accounted for 61 percent of fan sales.[97] All of these countries have hot and humid weather patterns, likely driving demand for and therefore sales of fans.[98] Fans are largely sold in cash, particularly in South Asia, where PAYGo platforms remain nascent. For televisions, Sub-Saharan Africa accounted for 93 percent of the global cumulative total, of which East Africa comprised 70 percent. Kenya alone represents 40 percent of all global affiliate television sales. In these markets, televisions are often bundled with SHS systems

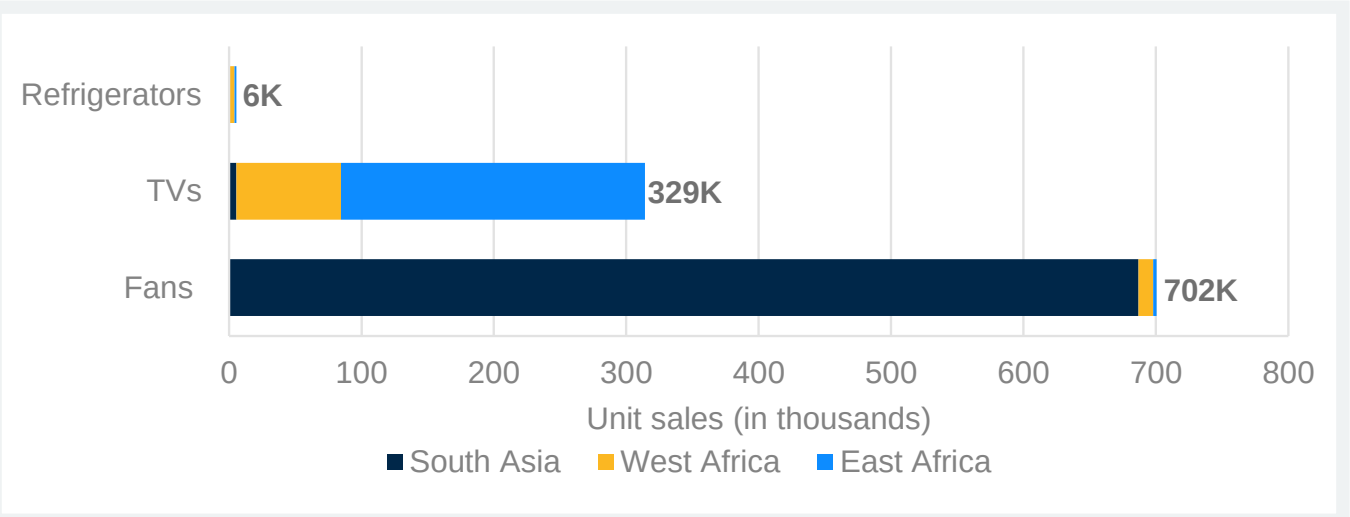
96 GOGLA and Lighting Global, Off-Grid Solar Market H2 2018; GOGLA and Lighting Global, Off-Grid Solar Market H1 2019; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

97 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019, 66–71; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

98 Dalberg, The State of the Off-Grid Appliance Market (London and Washington, DC: Efficiency for Access, October 2019), https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report, 14.

or provided as an upgrade.[99] PAYGo financing in these markets has made televisions affordable, unlocking sales of this high-demand product. Affiliate refrigerator sales, though a much smaller portion of appliance sales, are most common in West Africa, followed by East Africa (Figure 16). Excluding fans, which are smaller appliances and, therefore affordable on a cash basis, 96 percent of affiliate appliances are sold on a PAYGo basis.[100]

Figure 16: Affiliate Sales of Refrigerators, Televisions, and Fans by Region (H2 2018 – H1 2019)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA and Lighting Global, Off-Grid Solar Market H2 2018, and Off-Grid Solar Market H1 2019.

99 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019, 61–65.

100 GOGLA and Lighting Global, Off-Grid Solar Market H2 2018; Off-Grid Solar Market H1 2019, 58; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

2.1.3 PULSE Sales Volume and Turnover

PRODUCTIVE USE LEVERAGING SOLAR ENERGY (PULSE) INCLUDES SOLAR WATER PUMPS AND COLD STORAGE FOR AGRICULTURAL APPLICATIONS, AS WELL AS REFRIGERATION AND APPLIANCES FOR MICROENTERPRISES.

This report focuses on a subset of the market where PULSE products are most prevalent: smallholder farmers and microenterprises, most without grid electricity, and able to increase their productivity through solar-powered appliances. PULSE products support a range of agricultural and microenterprise activities. Solar Water Pumps (SWPs) and solar milling solutions can fulfill farmers' irrigation and processing needs, while solar refrigeration products can supply cold storage for their produce and dairy products. Microenterprises that require cooling can use solar refrigeration units, and a broad range of stand-alone solar appliances, such as televisions and radios, can provide entertainment and other services. A wider set of applications (Figure 17), including milking, electric fencing, and lighting for night fishing, have less mature markets, with scarce data to date on sales or products in development. PULSE products range in size both across and within product types—from full-kit solutions to smaller, standalone DC appliances.

Figure 17: PULSE Products Are Used in a Wide Range of Applications

Source: Lighting Global, The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa (Washington, DC: Lighting Global, September 2019), https://www.lightingglobal.org/resource/pulse-market-opportunity/.

PULSE PRODUCTS REPRESENT AN EMERGING OPPORTUNITY FOR THE OGS SECTOR, ALTHOUGH THE MARKET IS STILL IN ITS INFANCY AND WILL CONTINUE TO LEARN AND EVOLVE.

The PULSE supplier landscape has steadily expanded over the last few years as technology has improved, and business models have developed to make PULSE solutions affordable (Box 2 Overview of PULSE Supplier Landscape and Figure 18). In Sub-Saharan Africa alone, more than 100 companies are now developing PULSE technology, with several hundred more distributors.[101] The market in South and South East Asia has also grown. The landscape of suppliers now includes a variety of players, including PAYGo solar companies, product distributors, and mini-grid operators, serving specific markets sustainably and exploring ways to reach last-mile customers with PULSE products.[102]

While the technology underlying many PULSE products is decades-old, innovative startups, adapting existing technology, have experimented with business models to reach different off-grid customer segments. Solar water pumps, for instance, have existed since the 1970s, but only recently have startups adapted the technology and business models to serve smallholder farmers. Startups such as Bright Solar, FuturePump, Inspira Farms, and SunCulture were founded between 2010 and 2012 and proved initial demand for affordable PULSE products in Sub-Saharan Africa by piloting their products and business models. These companies have experimented with applying PAYGo business models to increase affordability, although many pump sales still rely on government subsidies, community-based models, or fee-for-service models. Generic appliance providers and larger brand manufacturers such as Lorentz, Shakti Pumps, and Grundfos have also developed products targeting smallholder farmers.[103] Reflecting the diversity in suppliers, the 2019 Global LEAP competition for Solar Water Pumps named both specialist startups and larger brand manufacturers as winners and finalists.[104]

Box 2: Overview of PULSE Supplier Landscape

Three key business models have emerged among PULSE suppliers, which overlap in some ways with the standard business models for pico and SHS suppliers.[105] Hardware manufacturers specialize in the manufacture and assembly of products, occasionally providing after-sales support for their products. Distribution specialists cover aspects of customer acquisition, pre-sales support, retail, and occasionally financing and customer service. Finally, end-to-end integrators bring products from manufacture through sale to end customers. They provide all of the above-mentioned services in addition to installation, maintenance, and ongoing monitoring, mirroring the vertically integrated business models used for pico and SHS products.

101 Lighting Global, Market Opportunity for PULSE, 8.

102 Lighting Global, 29–32.

103 Dalberg, Solar Water Pump Outlook 2019: Global Trends and Market Opportunities (London and Washington, DC: Efficiency for Access, September 2019), https://clasp.ngo/publications/solar-water-pump-outlook-2019-global-trends-and-market-opportunities, 9–10.

104 The Global LEAP competition is an international competition for the best and most energy-efficient appliances. Global LEAP Awards, 2019 Buyer's Guide for Solar Water Pumps (London and Washington, DC: Efficiency for Access, 2019), https://storage.googleapis.com/e4a-website-assets/2019-Global-LEAP-SWP-Buyers-Guide_final.pdf.

105 Lighting Global, Market Opportunity for PULSE, 31–32.

Figure 18: Segmentation of Productive Use Suppliers with Example Companies

Source: Vivid Economics and Open Capital Advisors consultations and analysis of framework adapted from Lighting Global, Market Opportunity for PULSE, 31.

THE MARKET FOR SOLAR WATER PUMPS HAS SEEN LIMITED COMMERCIAL DEVELOPMENT; EXISTING SALES ARE HEAVILY DRIVEN BY GOVERNMENT SUBSIDIES.

The market for solar water pumps (SWPs), especially the private market targeting smallholder farmers, remains in its infancy. Affiliate companies sold fewer than 10,000 SWPs under 3 kW designed for households or microenterprises in H2 2018 and H1 2019 combined.[106] Of these, Sub-Saharan Africa accounted for 92 percent of sales, with East Africa a primary market because of the prevalence of the PAYGo business model in this region.[107] This figure likely underestimates total sales; the actual market could be much larger.[108]

Thus far, many SWP suppliers have sold larger pumps that rely heavily on government subsidies. In India, over 150,000 units of SWPs have been sold to date, although the Government of India has provided subsidies amounting

106 GOGLA and Lighting Global, Off-Grid Solar Market H2 2018, 70; Off-Grid Solar Market H1 2019, 77; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

107 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019, 76; and Vivid Economics and Open Capital Advisors analysis of other GOGLA sales data.

108 SWP sales could be underestimated for several reasons, including: (1) the data cover only affiliate products; (2) data collection has only occurred over two reporting periods; (3) data do not cover larger, standalone SWPs; and (4) leading SWP suppliers chose not to participate.

to 30–90 percent of the upfront cost of the system, sometimes coupled with concessional loans to further boost affordability.[109] In Uganda, pumps are sold for more than US$ 7,000, primarily to government projects.[110]

To increase affordability and reduce the need for subsidies, service models, and technology are evolving. Some service models are adapting to reduce costs for smallholder farmers, such as the fee-for-service model in Bangladesh (see Box 3 Solar Water Pumping in Bangladesh: A Fee-for-Service Model for Smallholder Farmers).[111] Companies in Sub-Saharan Africa have developed pumps for smallholder farmers that typically range from 75 to 370 Wp, sized to meet these farmers' irrigation requirements.[112] These systems cost approximately US$ 500 to 1,000, and companies such as SunCulture have adopted the PAYGo model to reduce upfront costs for farmers.[113] Businesses are also currently investigating more flexible payment plans that cluster payments at harvest time to match schedules of payment to farmers' timing and patterns of income.

Box 3: Solar Water Pumping in Bangladesh: A Fee-for-Service Model for Smallholder Farmers

After a decade of limited trials, around 1,500 solar irrigation pumps were deployed in Bangladesh between 2013 and 2019, almost all with finance provided by the Infrastructure Development Company Limited (IDCOL), a government-owned financial institution. Irrigation is vital to overcome water scarcity in Bangladesh for at least half the year, most critically for the "boro" rice season between January and April (in May, June, and July, monsoons bring heavy rainfall to the country).

Almost all of these SWPs are provided under a "fee-for-service" model, which accommodates a larger system—typically around 25 kWp—to serve multiple farmers. IDCOL provides concessional financing for the projects through a 50 percent grant and a 35 percent concessional loan, with 15 percent equity required by project sponsors. Eligibility for financing requires the project sponsor to meet minimum standards set by the Technical Standards Committee (TSC), which include an approved list of suppliers. The project sponsor then installs the pumps and sells irrigation to farmers for a fee per hectare. Beyond financing, IDCOL provides technical assistance, working with farmers to study feasibility and offer advice on crop seasons, crop rotation, and the development of additional revenue-generating activities. A significant challenge in the fee-for-service model is working with farmers to encourage usage because they have no contractual commitment to use the systems. IDCOL is also trialing community-owned and smaller individually owned pumps.

To make businesses more commercially sustainable, companies are looking to unlock revenue potential beyond irrigation sales. Companies such as Solar Gao are investigating innovative ways of generating additional revenue beyond irrigation services (Figure 19), including hybrid solutions incorporating both SWPs and micro-grids, with solar power used to support agricultural activities. Possibilities include solar-powered harvest and milling machines and, for systems with larger solar arrays, solar-powered cold storage. Solar Gao also works closely with farmers to maximize the value of land around solar panels by, for example, introducing crops that can grow in the shade, such as mushrooms.

109 Dalberg, Solar Water Pump Outlook, 6; and Abhishek Jain and Tauseef Shahidi, Adopting Solar for Irrigation (Pradesh, India: Council on Energy, Environment, and Water, January 17, 2018), http://www.ceew.in/sites/default/files/CEEW-Adopting-Solar-for-Irrigation-Farmers-Perspectives-from-UP-Report-17Jan18.pdf.

110 Economic Consulting Associates and African Solar Designs, Market Assessment Study: Standalone Solar for Productive Uses in Uganda (Washington, DC: World Bank, forthcoming).

111 Open Capital and Vivid Economics consultations with industry.

112 Dalberg, Solar Water Pump Outlook, 9.

113 Pricing estimates gathered through stakeholder consultations, Mangoo marketplace, and company websites.

Figure 19: Innovative Alternative Revenue-Generating Activities alongside the Provision of Irrigation

Source: Solar Gao.

THE MARKETS FOR COLD STORAGE AND REFRIGERATION AND AGRO-PROCESSING ARE EVEN LESS DEVELOPED, WITH COMPANIES STILL TESTING BUSINESS MODELS AND A WIDE VARIETY OF TECHNOLOGIES.

Companies are market-testing a wide variety of potential technologies. Affiliate companies sold fewer than 10,000 off-grid refrigerators in H2 2018 and H1 2019, and only a portion of these are used for productive use. Systems range from small-scale refrigerators of under one cubic meter to larger cold rooms over 100 cubic meters in size. Small refrigerators can be powered by smaller SHS (e.g., 100W) and cost from US$ 600 to 1,000.

Solar refrigeration technology and business models have evolved to serve smallholder farmers who lack access to on-grid cold-storage facilities, helping to limit food loss and increase farmer revenue. Solar refrigeration for vaccines has existed for 30 years, but stringent technical standards drive prices out of reach for smallholders, keeping new applications from building on this success.[114] Government- and donor-funded procurement programs have pushed off-grid refrigeration products and business models through the prototyping phase. Experimental commercial business models around solar refrigeration for smallholder farmers target segments based on the value of produce or product stored or share costs across multiple farmers. Some suppliers, realizing that solar refrigeration is uneconomical for most smallholders unless the produce is high in value and the farmers maximize system utilization, have targeted applications such as fish freezing and milk chilling.[115] For less valuable products,

114 Lighting Global, Market Opportunity for PULSE; and Efficiency for Access, Off-Grid Refrigeration: Technology Roadmap (London and Washington, DC: Efficiency for Access, June 2019), https://efficiencyforaccess.org/publications/off-grid-refrigeration-technology-roadmap.

115 Lighting Global, Market Opportunity for PULSE, 9.

like fresh produce, companies such as ColdHubs offer a "Pay-As-You-Store" model, which allows customers to pay a daily flat fee for each crate of produce stored in a shared storage space.

With the largest market for cold-storage solutions at the point of harvest, community-based models of cold chain and refrigeration can extend the life of produce waiting for local sale. For instance, InspiraFarms, in partnership with the Rwandan Ministry of Agriculture and the World Bank, has introduced 10 modular, solar-powered cold-storage units targeting smallholder farmer cooperatives across the country. The units are strategically positioned to target specific farmer collectives, which rotate the use of the cold-storage units according to when they harvest their crops. Evidence shows that these cooperatives have responded to their access to cold storage by growing higher-value agricultural products.[116]

PULSE solutions such as solar mills, threshers, and dryers are not currently commercially deployed because the market lacks appropriate technology and business models.[117] Many solar-milling business models and technologies are in the pilot phase, though they struggle to compete with existing solutions. Diesel-powered milling or hulling machines are already very common, and most solar-powered machines struggle to compete with fossil fuel-powered machines in terms of technical performance and unit economics.[118] This nascent technology requires further development to compete with existing alternatives.

Beyond agro-processing, even more specialized productive use applications have emerged for specific value chains such as poultry, dairy, and coffee.[119] Though this segment remains in its infancy, its attractiveness is clear from the rapid expansion in market participants.

116 Paula Rodriguez, "InspiraFarms Delivers a Multi-Unit Refrigerated Storage Project in Rwanda," news release, November 27, 2018, https://www.inspirafarms.com/blog_cold-storage-project-rwanda/.

117 Vivid Economics and Open Capital Advisors consultations.

118 Lighting Global, Market Opportunity for PULSE, 27.

119 Lighting Global, Market Opportunity for PULSE, 16.

2.2 Market Drivers

KEY MESSAGES

- Declines in manufacturing costs are helping companies to push for profitability while increasing affordability and level of service for consumers.
- The improved efficiency of DC appliances offers off-grid customers a higher level of service by enabling the use of appliances previously reserved for grid-connected, AC customers.
- From the main OGS business model archetypes, two shifts have emerged: (1) companies moving beyond energy and (2) the rise of next-generation off-grid utilities.
- The vertically integrated business model in off-grid energy continues to disintegrate, as companies specialize in their respective niches and increase efficiency along the value chain.

Photo credit: © Futurepump - IWMI and Jeffrey M. Walcott

2.2.1 Technology Innovations

TECHNOLOGICAL INNOVATIONS THAT HAVE DECREASED MANUFACTURING COSTS AND INCREASED APPLIANCE EFFICIENCY HAVE ENABLED THE PROVISION OF HIGHER LEVELS OF SERVICE TO CONSUMERS.

The trends of falling costs and rising efficiency will continue, albeit more slowly than in recent history, unlocking new business models and advancing the sector's impact. Historically, the essential improvements in efficiency and cost of pico lanterns and SHS have involved three main components: (1) solar photovoltaic (PV) panels, (2) lights based on light-emitting diodes (LED lights), and (3) batteries. Improvements to battery technology will be the key driver of future cost reduction. The efficiency of DC appliances is also improving rapidly, decreasing the price of existing technologies to enable a greater number of appliances to enter the off-grid market. Manufacturing costs comprise 20 to 30 percent of the end-consumer price, and cost declines for both appliances and the OGS systems that power them have made appliances more affordable for end users, especially when coupled with PAYGo. These trends in both the lighting and appliance segments of the off-grid sector and their impact are discussed below.

Solar PV prices have fallen faster than expected over the last two years due to falling costs of raw materials and improved economies of scale, contributing significantly to the reduced cost of SHS and PULSE appliances. Wholesale prices (modules larger than 200 W) of high-efficiency crystalline modules fell from US$ 0.50 per Wp in May 2018 to US$ 0.39 per Wp in 2019.[120] The raw material of PV modules, polysilicon, also decreased in price by 40 percent between Q2 2018 and Q2 2019.[121] As the existing mature technology reaches its limits, and global demand increases more slowly, meaning further economies of scale will not be achieved, these prices will stabilize, slowing the cost declines of OGS products. Further manufacturing innovations, particularly around ultra-efficient solar panels, are still far from becoming cost-effective for the OGS sector.

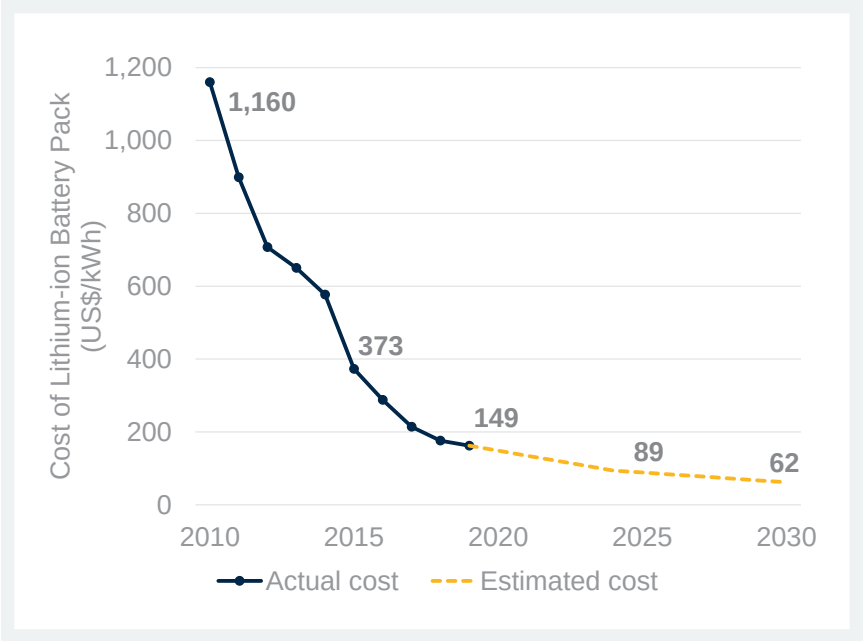
Batteries are generally the most expensive component of an OGS device, so reductions in battery costs could significantly reduce product costs. Both lithium-ion and lead-acid batteries are commonly used in OGS devices. Batteries vary dramatically in quality, both between and within types of battery technology. Lithium-ion batteries are more efficient at storing power per unit mass and have a longer lifecycle compared to the older lead-acid technology—and they are correspondingly more expensive. Given products of the same category and power level, better-quality batteries can cost as much as 1.8 times more.[122] This leaves significant scope for decreasing the manufacturing costs of OGS products through improvements in battery technology.

120 Prices converted from Euros to U.S. Dollars at an exchange rate of €1 to US$ 1.1075. Pricing for small modules for pico solar products and SHS are typically somewhat higher on a per Wp basis, though the general declining trend still applies. Martin Schachinger, "May 2019: Fridays Forever," PV Magazine, April 11, 2019, https://www.pv-magazine.com/features/investors/module-price-index/.

121 Solar Energy Industries Association (SEIA) and Wood Mackenzie Power & Renewables, U.S. Solar Market Insight Report 2019 Q3 (Washington, DC: SEIA, September 17, 2019), https://www.seia.org/research-resources/solar-market-insight-report-2019-q3.

122 Boyer et al., Pricing Quality in OGS, 21.

Figure 20: Lithium-Ion Battery Pack Prices (US$/kWh)



Source: Logan Goldie-Scot, "A Behind the Scenes Take on Lithium-Ion Battery Prices," BloombergNEF (blog), March 5, 2019, https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/.

The average price of lithium-ion batteries fell 85 percent from 2010 to 2018 (Figure 20).[123] Costs fell as a result of technological improvements, use across multiple industries (e.g., the electric car industry), and economies of scale. The high energy density of lithium-ion batteries, which allows products to be smaller, lighter, and easier to transport, has led to their extensive use in pico products as costs have fallen. Additionally, many plug-and-play SHS have shifted from lead-acid to lithium-ion technology; the longer expected lifetimes of lithium-ion batteries make them more attractive for PAYGo business models that require repayment over 12–36 months.[124] According to BloombergNEF market research, lithium-ion battery prices will continue to decrease, albeit at a slower rate.[125]

Despite their disadvantages, lead-acid batteries are still commonly used in larger or component-based systems because of their lower cost, but lead-acid battery prices are unlikely to decline. The cost per unit of energy stored over a lead-acid battery's lifetime is higher and the energy density per unit mass is lower than lithium-ion, making them bulky and difficult to maneuver, while self-discharge can lead to damage and product failure. Despite these shortcomings, lead-acid batteries are cheaper per kWh than lithium-ion by 40–75 percent, depending on the quality and size, making them attractive for lower-priced products.[126] Additionally, due to the presence of local recycling facilities for lead-acid batteries, some African governments have shown a preference for this technology. Production for this mature technology has consolidated into a relatively small number of reputable manufacturers against stable global demand, so relatively few cost reductions are anticipated.

Batteries in OGS devices operate in hot and challenging environments under constant use, which can lead to reduced performance and potential safety issues. The lifetime of both battery types typically decreases by approximately 50 percent for every 10°C increase in operating temperature over 20–25°C. Direct cooling of the battery can offset high temperatures in operating environments, but this adds significant cost for incommensurate gain. Depth of discharge and overcharging, poor-quality batteries, or tampering with devices by end users, either during repair or when building component-based systems, can cause additional, unexpected degradation or safety issues, including fire or explosions. While battery technology is generally safe given proper manufacturing techniques and appropriate precautions (i.e., the use of an appropriately sized charge controller), it is important that high-quality batteries be used and systems be designed properly to ensure end consumer safety and long product lifetimes.

Due to lower operating costs, longer life spans, and higher efficiency, LED lights are the bulb of choice for OGS products, and costs are stabilizing. The cost of manufacturing LEDs has fallen roughly 90 percent since 2010 as a result of investments in R&D that have increased efficiency and enabled global-scale mass production. The off-grid sector will continue to benefit from the declining cost of LEDs, albeit at

123 Goldie-Scot, "Lithium-Ion Battery Prices."

124 Sheridan Few et al., Energy Storage Trends for Off-Grid Storage in Emerging Markets: Insights from Social Enterprises (London: Shell Foundation and the Grantham Institute at Imperial College, September 2018), https://shellfoundation.org/learning/energy-storage-off-grid-trends-in-emerging-markets/, 14.

125 Goldie-Scot, "Lithium-Ion Battery Prices."

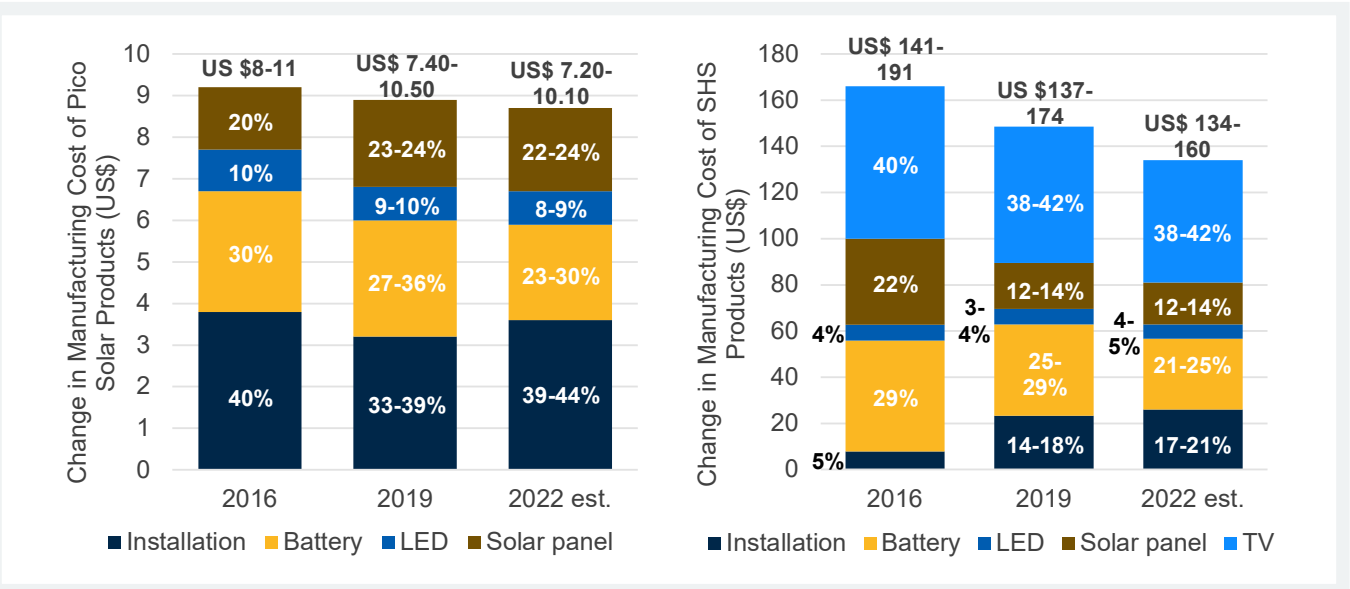
126 Few et al., Energy Storage Trends Off-Grid, 20–21.

a slower rate due to the maturity of the technology, which also contributes to declining overall manufacturing costs because LEDs allow off-grid devices to use smaller panels for the same brightness and duration of light.

Expected increases in labor costs will impact the overall cost of OGS products. Additional costs of manufacturing include the housing, wiring, and labor (installation costs). Prices of raw materials for wiring and the housing will remain stable, but increasing labor costs in China, where most products are manufactured, will affect overall costs. However, overall system costs will continue to decline as this increase in labor costs will be mitigated by the cost reduction in solar PV panels, batteries and LEDs.

Manufacturing costs of pico solar products and SHS (excluding appliances) have declined by an estimated 3–10 percent and 5–15 percent, respectively, over the last two years, helping companies to reach towards profitability and increasing affordability and level of service for consumers. While the cost of components is declining, varying quality and design makes it difficult to determine the exact impact on overall manufacturing costs, which vary by 30–40 percent across both pico products and SHS for higher- versus lower-quality systems.[127] Manufacturing costs of lower-quality products have declined faster due to commodification and the use of cheaper, and often poorer-quality components. As the cost of components (solar PV panels, batteries, and LEDs) begins to stabilize, reductions in manufacturing cost will slow and be driven increasingly by improvements in appliance efficiency for SHS (explored in more detail below). Declines in manufacturing costs will continue to help increase affordability and increase the level of service for end consumers, in addition to improving margins for OGS companies. This report estimates an indicative range of costs over time for both quality and non-quality off-grid products in the pico and SHS segments for systems of a standard size (Figure 21).

Figure 21: The Changing Manufacturing Costs of Pico and SHS Products



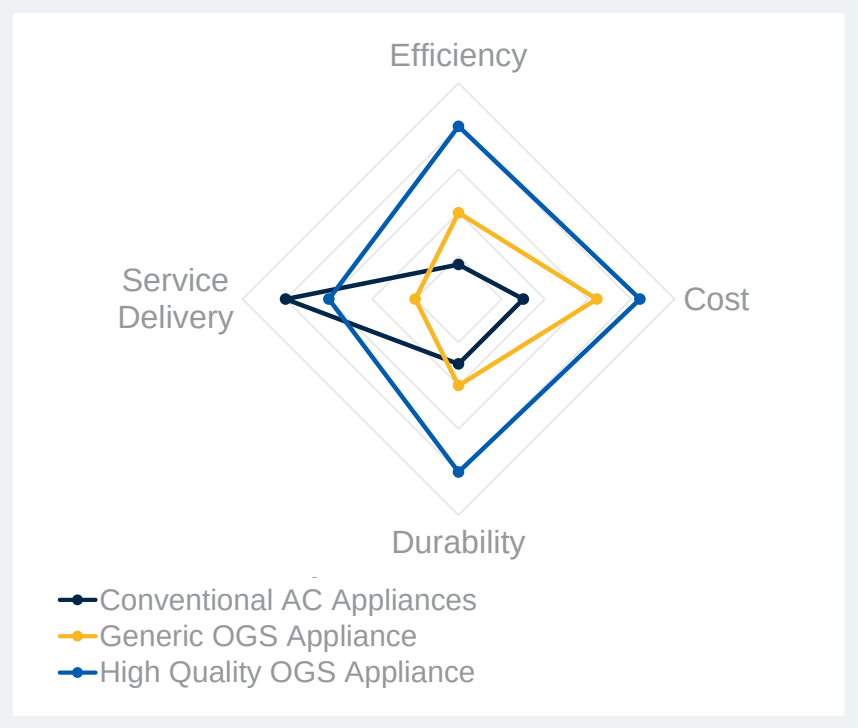
Source: Vivid Economics and Open Capital Advisors analysis; consultations; and Boyer et al., Pricing Quality in OGS, 21.

Note: Total costs are estimates based on the high variability in component costs. The indicative pico product has a solar PV of 2–4 Wp, 65–85 lumens of light, and a 12–16 Wh battery. The indicative SHS product has a solar PV of 30–40 Wp, 450–550 lumens, and 120–150 Wh battery.

127 Boyer et al., Pricing Quality in OGS, 20–23.

RAPID IMPROVEMENT IN APPLIANCE EFFICIENCY IS DECREASING PRICES AND UNLOCKING MARKET POTENTIAL, BUT MORE INVESTMENT IS NEEDED TO ACCELERATE R&D.

Figure 22: Performance of Off- and On-Grid Appliances



Source: Modified from Dalberg, Off-Grid Appliance Market.

The improved efficiency of DC appliances offers off-grid customers a higher level of service by enabling the use of appliances previously reserved for grid-connected, AC customers. Commercial viability requires that off-grid appliances meet targets for energy efficiency, cost, functionality, and durability, as compared to on-grid appliances (Figure 22). Appliances comprise a significant proportion of the manufacturing cost of an SHS, around 40 percent in the case of televisions, and since off-grid appliances are powered by an accompanying solar device, the total end-user price includes both the cost of the appliance and the cost of the solar device.[128] Off-grid appliances must, therefore, be highly efficient to minimize the required size of the SHS or PV panels for standalone appliances. For example, one study found that a highly efficient, DC television could reduce the cost of the SHS required to power it by about 25 percent compared to a "standard" television because it required a 50 percent smaller solar PV panel and battery.[129] Off-grid appliances also generally operate in harsh conditions and must be highly durable besides meeting consumers' high demands for functionality. As a result, manufacturers of DC appliances require specialized expertise and often have high R&D costs.

Increasing numbers of high-quality and efficient off-grid appliances are now available on the market. The OGS sector initially focused on offering lighting systems and basic, low-energy-consumption appliances such as mobile phone charging or radios. However, technological improvements over the past decade, driven by customer demand and access to a new, relatively captive market segment, have increased the range of available products to include fans, televisions, refrigerators, and SWPs. Further technological advancements and market demand will lead to the availability of more appliances, such as electric cookstoves, solar mills, air conditioners, sewing machines, and irons (Figure 23).

128 Assuming a 40 Wp SHS. Boyer et al., Pricing Quality in OGS, 22.

129 Won Young Park and Amol A. Phadke, "Adoption of Energy-Efficient Televisions for Expanded Off-Grid Electricity Service," Development Engineering 2 (2017): 111, https://doi.org/10.1016/j.deveng.2017.07.002.

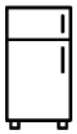
Figure 23: Commercial Viability of Off-Grid Appliances

Source: Vivid Economics and Open Capital Advisors.

However, lack of data concerning demand is limiting R&D funding and participation from global appliance manufacturers, hindering the pace of technological development. While demand for off-grid appliances is clearly increasing amid substantial innovation (Table 1), the total demand or market opportunity is unclear, particularly for emerging technologies. This raises uncertainty over the potential return on manufacturers' investments in R&D, limiting overall investment and innovation. Funding is needed for market intelligence to better understand customer needs, potential market size, and market segments to de-risk and guide R&D investment and attract large global manufacturers to the space, which could supercharge innovations in appliance technologies. Donors are stepping in to fill this gap through programs such as the Efficiency for Access R&D fund, the Transforming Energy Access Program (TEA), the Low-Energy Inclusive Appliances (LEIA) program, supported by UK Aid, and USAID's Powering Agriculture.[130]

130 Efficiency for Access, "Low Energy Inclusive Appliances (LEIA) Programme," https://efficiencyforaccess.org/leia.

Table 1: The Goals of Technology Innovations and the Trends

Goal		Innovations and Trends in Technology
	Higher cooling rates	• The efficiency of fans is increasing rapidly; many fans today have a higher efficiency than the 2016–2017 Global LEAP award-winning products.[136] • Brushless DC motors are currently expensive but increase durability and reduce energy consumption by up to 50 percent.[137] • Blade designs providing higher airflow can increase efficiency by 15 percent.[138]
	Larger screens Longer watch times	• Efficiency has increased by 39 percent between 2013/14 and 2016/17 and increased economies of scale have reduced cost per square inch of screen size from an average of US$ 1.57 in 2015 to US$ 1.06 in 2017.[139] • Optimized LED-backlit screens are decreasing energy consumption by 20 percent.[140] • Manufacturers have reduced screen brightness to save energy, which has minimally impacted consumer perceptions of quality.[141]
	Higher pumping capacity	• Overall, the cost of SWPs has fallen by 80 percent over the past two decades due to falling PV panel costs and increased R&D to meet consumer demand for smaller pumps.[142] • Brushless DC motors are increasing the efficiency of SWPs, further reducing the size of solar panels required.
	Adapting existing refrigeration technology for household and small business use[143] Lower distribution and servicing costs	• While the average off-grid refrigerator requires around 0.74 kWh per day (an SHS with at least 200 Wp), higher-performing refrigerators require only 0.4 kWh per day, demanding a far cheaper 100 Wp SHS. • Improvements to the compressor and insulation could decrease energy consumption by more than 50 percent. • Magnetic cooling systems could improve energy efficiency by up to 50 percent but remain too costly for use in off-grid products.[144] • Solar direct-drive refrigerator technology reduces costs and improves durability by reducing the need for batteries.[145]
	Meeting consumer demand for additional appliances	• Solar mills are already emerging in the market, with innovation driven by a few specialized companies. However, system costs are still prohibitively high in most markets when compared to diesel mills, despite lower operating costs. • Electric cooking solutions could reduce harmful indoor fumes, but most are currently too energy-intensive for off-grid use. • Demand is high for sewing machines and irons, but their efficiency and cost remain too high for most off-grid households. Quality-of-life appliances, such as washing machines and air conditioners, are far from commercially viable at the household level.

Source: Vivid Economics and Open Capital Advisors.

131 Dalberg, Off-Grid Appliance Market, 57.

132 CLASP and Energy Saving Trust, Appliance Data Trends 2018: Insights on Energy Efficiency, Quality, and Pricing for Off-Grid Appropriate TVs, Fans, and Refrigerators (London and Washington, DC: Efficiency for Access, September 2018), https://efficiencyforaccess.org/publications/appliance-data-trends, 14.

133 Nakul Sathaye et al., Potential Global Benefits of Improved Ceiling Fan Energy Efficiency (Berkeley, California: Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, October 2012), https://ies.lbl.gov/publications/potential-global-benefits-improved.

134 More recent data from testing are not yet available. CLASP and Energy Saving Trust, Appliance Data Trends 2018, 9–11.

135 Won Young Park et al., "Efficiency Improvement Opportunities in TVs: Implications for Market Transformation Programs," Energy Policy 59 (August 2013): 361–72, https://doi.org/10.1016/j.enpol.2013.03.048.

136 Dalberg, Off-Grid Appliance Market, 56.

137 Amit Khare and Nicole Economu, Solar Water Pump: Technology Roadmap (London and Washington, DC: Efficiency for Access, May 2019), https://clasp.ngo/publications/solar-water-pump-technology-roadmap, 17.

138 As noted above, OGS refrigerators have been commercially available for many years, primarily for use in health clinics to store vaccines. A relatively high willingness and ability to pay, particularly among NGOs, and limited demand slowed innovation and made refrigerators unaffordable for OGS consumers until recently.

139 CLASP, Low-Energy Inclusive Appliance Technology Summaries (London and Washington, DC: Efficiency for Access, September 2017), https://efficiencyforaccess.org/publications/low-energy-inclusive-appliance-technology-summaries, 20.

140 Dalberg, The State of the Global Off-Grid Appliance Market 2017 (London and Washington, DC: Global LEAP, 2017), https://efficiencyforaccess.org/publications/the-state-of-the-global-off-grid-appliance-market-2017, 41.

2.2.2 Business Model Adaptations

AS THE SECTOR MATURES, COMPANIES ARE INCREASINGLY FOCUSED ON FINANCIAL SUSTAINABILITY.

In response to both investor pressure and the challenges of building a sustainable OGS business, companies are shifting from growth at all costs to focus on unit economics and profitability. In the sector's early days, many first-mover companies pursued aggressive growth across markets. However, given both complicated business models and challenging markets scaling off-grid energy businesses proved difficult resulting in a lack of profitability to date. As companies mature and look to attract later-stage commercial investors, these investors have pushed companies to focus on unit economics and profitability. Companies' increasing focus on profitability and sustainable scale are reflected in part by the above-described shifts towards higher-value systems and into new geographies with high growth potential. The following sections highlight additional shifts in business models that support companies' pursuit of financial sustainability.

TWO NEW SHIFTS HAVE EMERGED IN BUSINESS MODELS: (1) COMPANIES MOVING "BEYOND ENERGY" AND (2) THE RISE OF NEXT-GENERATION OFF-GRID UTILITIES.

More companies are moving beyond energy, offering new product lines such as insurance, cash loans, and other durable goods. The use of PAYGo payments' data generates an official financial record for customers, allowing companies to better understand customer creditworthiness. Companies can then upsell non-traditional OGS products and services to their existing customers, including financial products such as small loans for education, cash loans, healthcare insurance, and micro-loans for small and growing businesses. Fenix and PEG, for example, have recently experimented with bundled health insurance and solar payments.[141] In doing so, off-grid companies expand their product portfolio and deepen their relationship with existing customer networks to increase the value per customer. Companies are also expanding PAYGo financing to new, non-energy products, with high consumer interest in mobile phones.[142]

Companies thereby increase their customers' access to otherwise unavailable products while improving their own financial sustainability. Many off-grid energy customers have no formal financial inclusion before purchasing a PAYGo solar system. In Uganda, 16 percent of OGS PAYGo customers used mobile money for the first time as a result of purchasing their solar product.[143] PAYGo financing has provided an infrastructure which increases financial inclusion. Besides being impactful for end users, companies can layer additional financial products on top of solar loans, increasing revenues per customer. Since 2016, OGS PAYGo companies have issued millions of dollars in loans and other financial services across East Africa alone.[144]

Another shift is the emergence of the next-generation off-grid utility. These companies are developing platforms to manage a wide range of energy assets, including plug-and-play SHS, liquefied natural gas solutions, micro-grids,

141 Vivid Economics and Open Capital Advisors consultations and analysis; and Chris Emmott, "Lighting the Way: How the PAYGo Solar Industry is Expanding to Other Life-Changing Products," NextBillion, January 15, 2020, https://nextbillion.net/paygo-solar-industry-products/.

142 Vivid Economics and Open Capital Advisors consultations and analysis.

143 Dalberg Data Insights, "Digital Finance for Energy Access in Uganda: Putting Mobile Money Big Data Analytics to Work," infographic, United Nations Capital Development Fund (UNCDF), September 19, 2019, https://www.uncdf.org/article/4913/infographic-digital-finance-for-energy-access-in-uganda.

144 Emmott, "PAYGo Solar Expanding to Other Products."

and on-grid solar battery backup systems for unreliable grid connections. For example, in 2018, BBOXX partnered with General Electric to deploy solar-diesel hybrid power generation and battery-storage systems in the city of Goma, Democratic Republic of Congo, providing energy access to small businesses, schools, and local organizations. The system is linked with both GE's Predix digital remote monitoring and diagnostics platform and BBOXX's PULSE cloud platform to enable seamless troubleshooting of issues between the energy assets and optimize customer service.[145] In 2019, Zola launched its Infinity power system, which combines solar with smart energy storage to serve as a modular replacement for diesel generators and unreliable grid power.[146]

Improved software applications enable the interconnection of energy assets, increasing assets under management for off-grid utilities while also supporting integrated electrification. OGS software providers have developed an application programming interface (API) that allows full software integration for mini- or micro-grid developers to integrate OGS PAYGo into their platforms. This enables the integrated management of both mini-grid and OGS revenue streams. As more countries pursue integrated electrification planning, requiring on-grid, mini-grid, and OGS solutions, the seamless integration of different assets across the energy ecosystem will be vital.

THE DISINTEGRATION OF THE VERTICALLY INTEGRATED BUSINESS MODEL IN OFF-GRID ENERGY ALSO CONTINUES, AS COMPANIES SOLIDIFY THEIR NICHES AND INCREASE EFFICIENCY ALONG THE VALUE CHAIN.

The supplier landscape has evolved rapidly over the past decade. The sector now has a diverse array of companies, ranging from global, vertically integrated companies to small and local, last-mile distribution companies focused on one segment in the value chain (Figure 24).

Figure 24: Overview of OGS Supplier Value Chain

Source: Vivid Economics and Open Capital Advisors.

Note: This mapping is not comprehensive of the entire sector, though it is representative of the types of currently operational companies. Greenlight Planet, listed as vertically integrated, nevertheless purchases software from a third-party supplier. In addition, the hardware manufacturing section in the vertically integrated segment is blank, as vertically integrated companies typically source products from or contract directly with various Chinese manufacturers.

145 BBOXX, "BBOXX and GE partner in DRC," news release, September 25, 2018, https://www.bboxx.co.uk/2379-2/.

146 Julia Pyper, "Zola Electric Unveils a New 'Smart' Storage System to Displace Diesel and Eliminate Outages," Green Tech Media, March 14, 2019, https://www.greentechmedia.com/articles/read/zola-electric-smart-storage-infinity-rive.

New partnerships and innovations are now emerging at each link of the OGS value chain, which allow companies to focus on their core businesses to bolster profitability. Though many companies vertically integrated out of necessity due to the lack of specialized players, the industry is now seeing more specialization, including from previously vertically integrated companies. This shift is both necessary, in order for companies to focus on achieving financial sustainability, and possible now that the industry is large enough to support a wider array of specialist firms. Below, we detail each component of the value chain, highlighting key considerations and trends.

Hardware Design and Manufacturing

A larger number of manufacturers have created healthy competition in this part of the value chain, a competition to which specialist design firms have responded by developing new and more efficient products. In China, product designs for certain pico products are publicly available, creating low barriers to entry in the market. With more entrants, commoditization of pico products, and, to a lesser extent, SHS, has exerted downward pressure on prices. To combat commoditization, design firms and manufacturers such as Amped Innovations and Fosera are differentiating themselves by introducing new and innovative products, such as larger SHS with options for high-efficiency appliances. Some of these companies are establishing a niche in the newer appliance segment and putting additional pressure on the vertically integrated product suppliers.

Competition is further increasing as Chinese manufacturers seek quality verification and develop their own brands to compete with well-established OGS brands. Manufacturers in China indicate they face significant barriers to direct market entry, at least in Sub-Saharan Africa, because they lack the local knowledge, local language competence, and the capital investments required to establish a local brand presence. As a result, there are hundreds of brands in markets like Kenya, Ethiopia, and Tanzania, but few well-known Chinese brands. Despite these barriers, many Chinese manufacturers are looking to move from their traditional role as Original Design Manufacturer (ODM) and Original Equipment Manufacturer (OEM) suppliers for other companies to instead develop, promote, and in some cases directly distribute their own branded products (Box 4 Role of Chinese ODMs and OEMs in the Off-Grid Solar Sector). This will increase competition at the product level, potentially reducing the costs of high-quality products for end users.

Box 4: Role of Chinese ODMs and OEMs in the Off-Grid Solar Sector

How has Chinese manufacturing engaged in the OGS value chain to date?

Hardware design and manufacturing in China have been essential to the development of the OGS value chain. Before the emergence of "affiliate" companies, several Chinese ODMs and OEMs were already designing, producing, and supplying solar lighting products—solar lanterns, solar lighting kits, SHS, and component-based devices—for distribution, often through government or donor programs across South East Asia and Africa. Starting in 2006, early affiliate companies, including d.light and Greenlight Planet, began designing solar lighting devices, in some cases alongside Chinese ODMs and OEMs. More affiliates emerged in 2011-2012 as the first wave of PAYGo companies, prototyping and then manufacturing their products in partnership with Chinese ODMs and OEMs.

Some Chinese manufacturers are ODMs, focusing on both design and manufacturing, while others are OEMs, solely manufacturing products designed by other companies. A brand marketer or design firm, such as Lumos, Amped Innovation, or BioLite, can work with either ODMs or OEMs depending on their needs, which might include design support or contract manufacturing. These manufacturers fall into the following categories:[147]

147 The Lighting Global team in China provided the initial segmentation, which we updated based on 15 consultations Open Capital Advisors held with manufacturers in China.

- **Segment 1 (The PV Leaders)** are relatively large photovoltaic manufacturers with little experience to date in the OGS segment, though some have experience with larger off-grid standalone systems and mini-grids. A few manufacturers in this segment are interested in developing smaller-scale off-grid products, although these would represent a large departure from their current product portfolio and would require a new marketing approach focused on fast-moving consumer goods (FMCG). If they do enter the OGS sector, they all generally have significant resources to invest in the development of products, brands, and distribution networks. Manufacturers in this segment are larger than the other segments, with up to US$ 10 billion in annual turnover.
- **Segment 2 (The Off-grid Specialists)** manufacturers devote a significant portion of their business to pursuing their own brands in off-grid products (that is, they are ODMs). They have strong track records with off-grid products, operate strategically in their product design, and may have introduced their own brands. They have a deep understanding of the end consumer with ambitions to move closer to the market. Annual turnover in this segment varies widely, from US$ 100,000 to US$ 100 million.
- **Segment 3 (The Contractors)** comprises primarily OEM manufacturers that supply many OGS products based on customer requests, often branded by the contracting company. More focused on pure manufacturing, they have less knowledge of the end consumer market and little intention of moving close to end consumer markets. The annual turnover for this segment ranges from US$ 1 million to US$ 10 million.
- **Segment 4 (The Generalists)** is made up of smaller manufacturers of a wide range of generic lighting products, including small product lines in OGS products, most often in the pico segment. Mainly relying on generic, publicly available designs in the pico segment, these manufacturers rarely have their own, proprietary product designs. Product quality varies, but most products are intended for high-volume, low-margin sales. The annual turnover for these manufacturers is as low as US$ 20,000 and as high as US$ 10 million.

Chinese ODMs and OEMs today produce a full range of OGS hardware and software. Recognizing the uptake of smaller OGS products, many manufacturers are now developing their own solar kits, either pico or SHS. While many developed remote lock-out technology for PAYGo years ago, companies like LEMI have also developed their own PAYGo platforms within the last few years. Others partner with companies such as Angaza (Kenya) or K-pay (India) to shorten the lead time of hardware-software integration from five months to three months.

Most Chinese ODMs and OEMs today sell their own OGS products through third-party retail distributors. Many have found it challenging to develop direct-to-consumer business models like d.light and Greenlight Planet's B2C channel. Potential consumers are unfamiliar with Chinese brands, and many manufacturers are unfamiliar with both consumer needs and local distribution networks. As a result, many manufacturers work with local distributors, with clients including both leading global affiliate brands (for example, MKOPA, Fenix, and Mobisol) and various well-known local brands. In many cases, these third-party distributors prefer not to co-brand, though manufacturers sell smaller volumes of their own branded products through smaller importers, distributors, and retailers. They connect with customers over the Internet (through company websites and Alibaba) and at lighting expositions.

What have been the primary misconceptions about Chinese ODMs and OEMs?

Misconception #1: Chinese ODMs and OEMs are unsophisticated in product design and react only to the needs of other companies that do design and marketing.

Product development happens both independently and in partnership with existing brands, and manufacturers take various degrees of involvement in the design process. Some manufacturers, most often those in Segment 3 (The Contractors), do manufacture products largely based on designs provided to them by leading brands. Others, however, operate more collaboratively, designing products alongside OGS companies, as happened with some initial products of the leading affiliate companies. Manufacturers in Segment 2

(The Off-grid Specialists), however, have conducted extensive market research to understand consumer needs before designing systems to fit their target markets. Some manufacturers in Segment 2 have also launched their own programs to target markets in Sub-Saharan Africa, where they see genuine private-sector potential.

Misconception #2: Chinese ODMs and OEMs only churn out cheap, low-quality products.

Many manufacturers in China have been producing high-quality products for years. While manufacturers admit that some Chinese manufacturers produce very low-quality and cheap products in large volumes, others have indeed focused on quality. For example, Chinese ODMs and OEMs have produced high-quality components and products to meet standards required for subsidy programs in countries such as Myanmar. They may not always receive branded recognition for their quality, however; when companies act as OEMs for other brands, those brands attain certification rather than the manufacturers.

Chinese ODMs and OEMs see quality verification as a means to differentiate their products, access new markets, and compete with leading brands. Many Chinese ODMs and OEMs identify both leading OGS brands and other Chinese manufacturers (producing both high- and low-quality products) as their main competition. Manufacturers increasingly see quality verification as a critical competitive advantage, acknowledging that the race to the bottom in pricing is unsustainable. At the time of writing, 12 Chinese ODMs produced Lighting Global quality-verified products, and 15–16 additional manufacturers are expected to receive quality verification by mid-2020.[148] Though testing and verifying products carry costs, Lighting Global quality verification secures customers and access to markets. Countries such as Ethiopia and Rwanda have introduced importation requirements for various off-grid product segments based on Lighting Global Quality Standards, effectively closing these markets to companies not meeting these standards. Companies involved in the program also learn about new markets quickly and gain access to local partners to more readily reach end consumers.

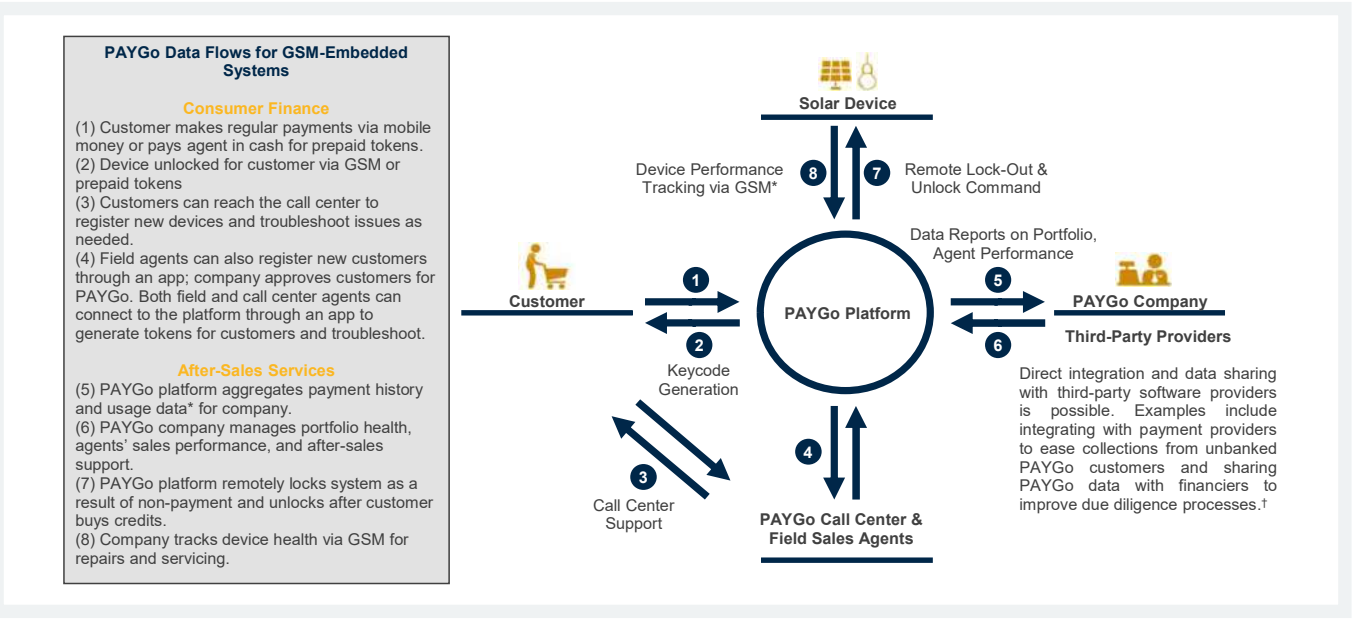
Chinese ODMs and OEMs can increase their local brand presence through quality verification or affiliation with other OGS industry groups. They can also potentially lower product prices for consumers in the sector by leveraging their expertise in manufacturing and partnering directly with local distributors. Manufacturers and regional distributors alike see strong market competition moving forward. Chinese manufacturers will continue to develop strategies to maintain price competitiveness and also meet quality standards.

Software Development

Off-grid solar companies can either develop their own software or purchase software from a third-party provider that enables them to register sales, accept cash or mobile money payments, manage inventory, and remotely monitor and control devices as part of their PAYGo operations. Software solutions in the market today are mostly used to: (1) process customer PAYGo payments via either mobile money or proof-of-payment codes sent by SMS in the absence of mobile money; (2) remotely regulate and lock usage of solar devices based on prepaid credit balances; (3) provide call center support to register customers and troubleshoot technical issues; and (4) manage customer usage data and track and monitor customer payment performance, sales agent performance, and inventory levels (Figure 25). Companies like Zola Electric and M-KOPA develop their own software, often for use in their own products, while several third-party providers, such as Angaza, Solaris, and Paygee, offer PAYGo software to OGS companies in different parts of the value chain.

148 Vivid Economics and Open Capital Advisors consultations.

Figure 25: PAYGo Data Flows



Source: Vivid Economics and Open Capital Advisors.

* Usage data are only captured for GSM-enabled systems with bi-directional data transfer capabilities and are not broadly available for all systems.

† For specific examples, see: Angaza, "Angaza and SIMA Announce Investment Fund for Distributors," news release, November 19, 2019, https://www.angaza.com/2019/11/19/distributor-financing-fund/; and Nigeria Off-grid Market Acceleration Program (NOMAP), "Five PAYGO Solar Companies Integrated into Swifta's Agent Network," news release, February 21, 2019, https://offgridmap.ng/five-paygo-solar-companies-integrate-into-swiftas-agent-network/.

Software specialists are providing their clients with more customizability. Software development requires highly skilled technical expertise to design and troubleshoot systems and integrate those systems with existing solar hardware. While several companies, like Angaza and Solaris Offgrid, provide off-the-shelf PAYGo software solutions, software often requires customization to specific hardware configurations and operating environments. For example, Oolu Solar used the Angaza software platform solely for remote lockout and key code generation to manage its PAYGo sales and payments. However, recognizing the need for more tailored software solutions, the company developed customized software for managing its sales and payments. Niche software developers, such as Enable Digital, have emerged to fill the gap in customized software solutions by building customized packages for off-grid companies to address needs ranging from inventory management to CRM and business intelligence.[149] PAYGo platforms will also likely continue to move towards more customization, with different modules and tiered services for customers that suit the diversity of distributors' business needs.[150]

The software segment is moving towards more open architectures, lowering the barriers to entry into the PAYGo model while increasing the usability of PAYGo platforms to drive effective business decisions. With these platforms, distributors can customize key features, such as telco and SMS integration, for their business models at competitive market rates and without committing themselves to one software provider. PAYGo platforms will also be able to connect to additional, third-party players that can use the data and capabilities of these platforms in innovative ways. As PAYGo platforms evolve to become more open, new systems will emerge built with interoperability in mind, allowing a PAYGo company to use multiple platforms for different flows of data based on their needs. Open, interoperable platforms would enable manufacturers and distributors to choose their preferred PAYGo platforms with full ownership of data and the ability to conveniently exit any platform.

Advancements in software technology are also helping companies to monitor their products remotely, leading to increased product lifespans, improved customer experience, enhanced research and development, and value-added services. Advances in software such as the Internet of Things (IoT), cloud computing, and artificial intelligence (AI) will

149 Enable Digital, https://enable.digital/projects/.

150 Vivid Economics and Open Capital Advisors consultations and analysis.

continue to influence the sector. SunCulture uses IoT in its Rainmaker2 product to convey data to farmers in real-time, predict trends, and optimize user experience by, for example, ensuring continued operation on cloudy days. Devices with such technologies can remotely predict faults, detect system performance, and aggregate insights about client usage. This improves a company's ability to maintain devices and enhance system performance while further improving user experience and loyalty by reducing the amount of downtime customers experience.[151] Data collected from such systems can also be analyzed to improve the design of future products, lowering costs, and providing better service to consumers. The cost for GSM integration is about US$ 10 on the high end. Originally cost-prohibitive, GSM integration is now economical for larger systems; a lack of connectivity in certain areas, however, remains a barrier to adoption. Technological advances beyond GSM, including low-power wireless area networks (LPWANs), could further improve product functionality.

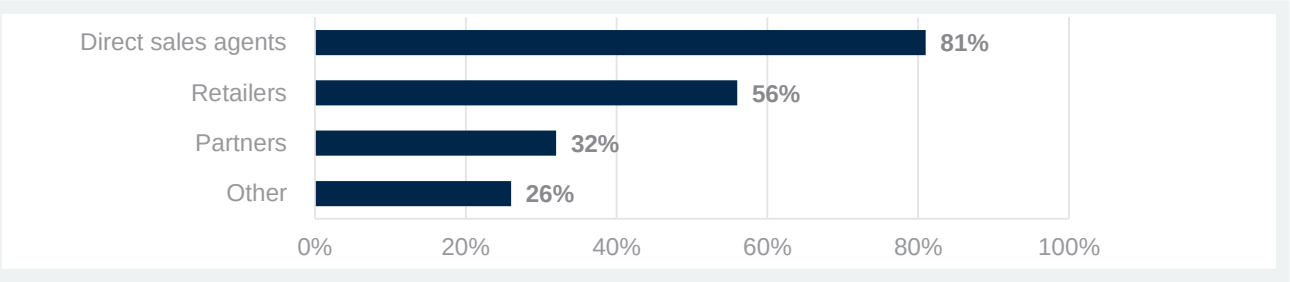
Marketing and Distribution

Marketing and distribution companies focus on retail and last-mile distribution (Box 5 Snapshot on Last-Mile Distribution) to sell to businesses (B2B) or directly to consumers (B2C). B2B involves sales to local B2C companies and distributors, as well as to wholesalers and general traders. B2C, on the other hand, consists of the distribution of OGS products directly to end users through agent networks, brick-and-mortar retail outlets, and other partnerships. Several companies, such as M-KOPA, BBOXX, d.light, and Greenlight Planet, have established vast, on-the-ground B2C distribution networks spanning multiple countries and use a mix of field-based staff, marketing materials, and customer care centers to deliver products and after-sale services to last-mile consumers. Certain OEMs, hardware, and software specialists meanwhile, have adopted B2B distribution models, selling products and services directly to wholesale distributors, general traders, and B2C companies; for example, d.light also sells to PAYGo companies such as PEG Africa and Pawame, which then distribute products to their customers.

Box 5: Snapshot of Last-Mile Distribution

Last-mile distributors (LMDs) have two primary channels for B2C marketing and distribution: networks of sales agents and retail shops (Figure 26), though many LMDs reach customers through multiple channels. Standard marketing techniques include community events and door-to-door demonstrations.[152] Development programs sponsored by the World Bank, IFC, and UNCDF, as well as initiatives by social enterprises, such as SunnyMoney, invest in campaigns to build awareness of the benefits of quality solar products and raise trust to foster active, local, and sustainable markets.[153] LMDs have also adopted software platforms, most of which currently manage sales and payment (e.g., Angaza, Solaris), or help with data collection and communication (e.g., Enventure and Kopernik).[154]

Figure 26: Share of LMDs Utilizing Different Distribution Channels



Source: Vivid Economics and Open Capital Advisors analysis.

151 GOGLA, "Off-Grid Solar E-Waste: The Industry Is Growing Responsible in Waste Management," GOGLA Blog, March 28, 2019, https://www.gogla.org/about-us/blogs/off-grid-solar-e-waste-the-industry-is-growing-responsible-in-waste-management.

152 Global Distributors Collective, Last Mile Distribution: State of the Sector Report (Rugby, UK: Practical Action Publishing, 2019), https://globaldistributorscollective.org/state-of-the-sector-report, 13.

153 "How We Work," SolarAid, https://solar-aid.org/how/.

154 Global Distributors Collective, Last Mile Distribution, 29.

Large international companies are partnering with local distributors to reach previously unserved markets. Last-mile distribution is costly for off-grid firms, and large-scale last-mile distribution by international off-grid companies to remote markets is logistically complex and requires in-depth knowledge of customer preferences, needs, and purchasing decisions. Furthermore, several off-grid companies initially relied on concessional financing to expand distribution, which masked the true costs. Local distributors such as Altech in the Democratic Republic of Congo and Mwezi in Kenya, however, can distribute more efficiently within their own regional markets. These companies invest in localized sales and distribution networks to reach and service highly remote, often cash-constrained rural off-grid customers and may be better positioned than large international companies to sustainably serve specific markets.[155]

To reach end users, some OGS companies have strategically partnered with companies outside the sector that already have well-established distribution networks. In early 2018, Azuri partnered with StarTimes, a leading digital television provider, to offer PAYGo solar televisions with access to StarTimes content.[156] Then, later in 2018, Azuri partnered with Unilever to distribute co-branded products through Unilever's network of 67,000 local traders. Both partnerships built upon Azuri's existing distribution channels with Raj Ushanga and Mobicom.[157] Technology platforms are also improving distribution for off-grid companies. In Zambia, Fenix has partnered with a logistics company, Musanga Logistics, to track the status of their deliveries and analyze data to improve delivery efficiency.[158] In Asia, solar companies have taken advantage of existing distribution channels for consumer goods to distribute solar products. Greenlight Planet, for instance, provided solar energy access to 150,000 Filipinos by partnering with retail distributors, financial services institutions, non-profit organizations, and disaster relief organizations.[159]

Companies focused on distribution can, however, face long sourcing and shipping lead times—three months on average—and must carefully manage inventory and cash flows. Manufacturers who partner with local distributors typically require these off-grid companies to assume responsibility and liability for both shipping costs and logistics from ports of departure (e.g., Shenzhen, China) to the designated port of entry in Africa or Asia. One particular risk is a product held in customs clearance for a long time. Depending on negotiated terms, distributors may be required to pay significant portions of the total order size either upfront or before the shipment arrives at the destination port, clears customs checks, and is delivered to company warehouses for onward sale to consumers. Over time, the differential timing between the company's upfront payment for goods and payment collected from its customers can hinder financial operations. International distributors can often negotiate better terms than single-market distributors, so the development of regional warehouses or country importers (e.g., Total) has helped alleviate this challenge for smaller, local distributors.

Consumer Financing

PAYGo (Box 6 The Pay-As-You-Go (PAYGo) Business Model) has been the leading consumer finance model, but developing PAYGo systems in-house is capital intensive, and assessing customer creditworthiness is challenging. PAYGo companies require large amounts of working capital to fund customer receivables over the repayment period. PAYGo companies must also develop strong in-house capabilities to assess consumer creditworthiness and manage sales team incentives to avoid sales to uncreditworthy customers who are more likely to default. Because PAYGo implementation requires digital payment infrastructure, PAYGo approaches have enjoyed remarkable success in East Africa, where mobile penetration and mobile money uptake are widespread, in part because of favorable regulation and government support.[160] Low mobile-money penetration in other geographies, such as in West and Central Africa, especially, presents a significant challenge for PAYGo expansion.

155 Global Distributors Collective, Last Mile Distribution, 17

156 Azuri Group, "Azuri Partners with StarTimes to Expand TV Reach to Off-Grid Customers," news release, April 24, 2018, https://www.azuri-group.com/azuri-partners-with-startimes-to-expand-tv-reach-to-off-grid-customers/.

157 Azuri Group, "Azuri and Unilever Partner in Kenya to Bring Pay-as-You-Go Solar Home Lighting to Millions Off-Grid," news release, August 30, 2018, https://www.azuri-group.com/azuri-and-unilever-partner-in-kenya/; and Azuri Group, "Azuri's Unique PayGo Solar TV System Now Available Nationwide at Mobicom," news release, May 24, 2017, https://www.azuri-group.com/azuris-unique-paygo-solar-tv-system-now-available-nationwide-at-mobicom/.

158 Wakunyambo Mwanamuke and Brown Musepa, "Re-Imagining Solar Distribution: The Fenix International – Musanga Logistics Partnership," Mobile for Development, June 7, 2019, https://www.gsma.com/mobilefordevelopment/blog/re-imagining-solar-distribution-the-fenix-international-musanga-logistics-partnership/.

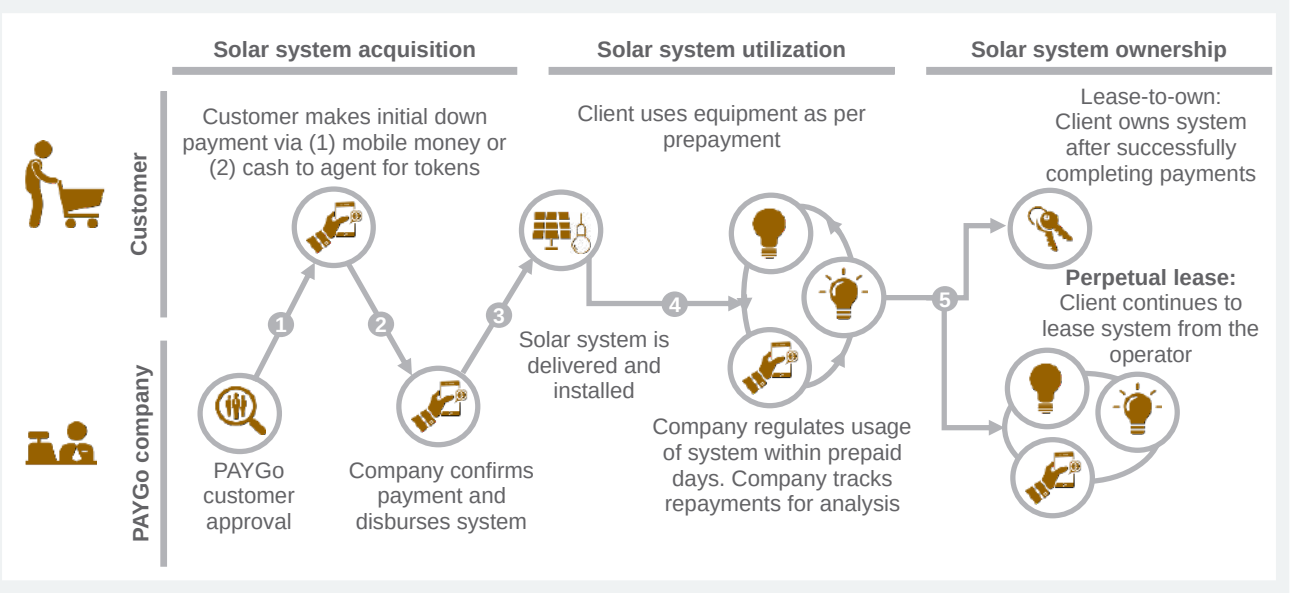
159 Greenlight Planet, "Greenlight Planet Celebrates Providing Clean Energy Access to 150,000 Filipinos, Participates in Bangkarera 2019," news release, May 31, 2019, https://www.greenlightplanet.com/presss/greenlight-planet-celebrates-providing-clean-energy-access-to-150000-filipinos-participates-in-bangkarera-2019/.

160 GSM Association, Report on Mobile Money.

Box 6: The Pay-As-You-Go (PAYGo) Business Model

The PAYGo business model (Figure 27) allows consumers to pay for OGS assets over time, boosting affordability for larger products. Consumers make an initial down payment and then regularly pay the off-grid company, gaining access to energy services for a specified period. The product is used as collateral, and systems can initially be de-activated and later even repossessed in the event of non-payment.

Figure 27: The PAYGo Business Model



Source: Vivid Economics and Open Capital Advisors.

The PAYGo business model addresses the affordability gap by allowing customers to pay in installments, but this also generates large amounts of receivables, which can be difficult for OGS companies to manage. For example, a company selling 1,500 units per month can create a loan book of approximately US$ 1 million after five months.[161] Managing this loan book requires a company to maintain substantial working capital and allocate significant resources to collections and after-sales support. This requires skills akin to managing MFI loans beyond just those needed to handle product or distribution businesses. Companies must, therefore, hire the right talent to manage both sales and consumer financing. Companies must also have a realistic understanding of their collections to make appropriate provision for bad debt when calculating their unit economics; this is critical to ensuring the business can scale sustainably. Optimistically, some companies have learned to manage this risk effectively, with country-level operations reaching profitability faster in new markets.[162]

To mitigate the challenges of the PAYGo model, some companies have fledgling partnerships directly with financial institutions to decouple consumer finance from their business models. Decoupling the servicing of energy systems from the servicing of loans could allow investors to isolate risk and gain more comfort in financing off-grid energy receivables directly to help the industry scale. One key issue for investors has been the lack of certainty around what happens to receivables if the originating off-grid company becomes insolvent.[163] Though there is limited precedent for companies assuming responsibility for PAYGo loan servicing, several off-grid companies have

161 Assumes total PAYGo cost of system of US$ 200, with an 18-month repayment period.

162 Vivid Economics and OCA consultations.

163 Daniel Waldron et al., Taming the Strange Beasts: Servicing and the Future of PAYGo (Washington, DC: CGAP, November 2018), https://www.cgap.org/research/publication/taming-strange-beasts-servicing-and-future-paygo, 12.

expressed interest in and intent to outsource finance to both MFIs and larger financial institutions as they focus on their core capabilities (e.g., product or software).

Some MFIs are starting subsidiary companies with the sole purpose of selling, distributing, and financing solar products. FINCA Uganda and Baobab in Senegal are examples of MFIs that have opened subsidiary companies, BrightLife and Baobab+ (Box 7 Baobab+ Case Study: MFIs Venturing into the PAYGo Solar Market) respectively, in a bid to distribute and finance solar systems.[164] Both MFIs have used PAYGo data to extend other loans to off-grid consumers, highlighting the trend of financial institutions showing greater interest in off-grid energy.

Box 7: Baobab+ Case Study: MFIs Venturing into the PAYGo Solar Market

Baobab+ was launched in late 2015 as a subsidiary of Baobab Group, formerly known as Microcred Group, to provide energy products to the African market. Domiciled in Senegal, the company seeks to serve the West African market, particularly Senegal, Côte d'Ivoire, and Mali, as well as other African countries, such as Madagascar.

Baobab+ has marketed, distributed, and financed solar products to Baobab Group's 300,000 existing clients in addition to customers outside of Baobab Group's network. To date, the company has sold more than 150,000 PAYGo SHS. Meanwhile, Baobab Group ran a pilot in mid-2018 to explore extending credit to its PAYGo customers. Baobab+ collected payment history from its customers and shared this information with Baobab Group, which scored Baobab+ customers algorithmically and set a borrowing limit. Baobab Group then offered these customers its existing Taka product, an unsecured line of credit with a 90-day repayment period and flat interest rate. Of 359 scored and eligible Baobab+ customers, 166 expressed interest in the Taka loan.

Baobab and Baobab+ offer an example of how MFIs can reach a broader market through PAYGo solar systems and deploy their resources and expertise to develop PAYGo systems and improve livelihoods.

Overall, varied approaches to MFI implementation have been tested in Sub-Saharan Africa and Asia, with mixed success.[165] India's high population density has led to an MFI model, which leverages personal connections with customers in group meeting settings to support repayment and stimulate demand. MFIs in Sub-Saharan Africa have also adopted different models to succeed. For example, in Nigeria, LAPO has grown lantern sales through group lending. Additionally, capacity-building initiatives such as those led by the UNCDF Clean Start program have tested the viability of MFI-led consumer energy lending in Sub-Saharan Africa and South Asia, with positive results in some countries, such as Nepal, where more than 120,000 households and small businesses were able to access and repay energy products via MFIs. In other markets, such as Uganda, however, the MFI model has not taken off at scale given the lack of strong government support for the microfinance market and lack of competitiveness against other consumer finance alternatives.[166]

Looking forward, regulation on micro-financing or asset leasing may potentially extend to the PAYGo operations of off-grid energy companies, posing a risk for the sector. While PAYGo companies have generally been exempt from many of the regulations impacting MFIs, despite their provision of consumer credit, some indications suggest that governments could tighten regulations and subject PAYGo companies to higher levels of scrutiny. This could increase the cost of doing business for off-grid companies that provide direct consumer finance, leading them to alter their business models and accelerating the trend of partnering to outsource consumer finance.

164 Daniel Waldron, Alexander Sotiriou, and Jacob Winiecki, A Tale of Two Sisters: Microfinance Institutions and PAYGo Solar (Washington, DC: CGAP, November 2019), https://www.cgap.org/research/publication/tale-two-sisters-microfinance-institutions-and-paygo-solar, 7.

165 Waldron, Sotiriou, and Winiecki, Two Sisters: Microfinance and PAYGo, 7.

166 Teresa Le, "PayGo vs. MFIs: What Works Better for Energy Access Consumer Financing – And Does it Have to Be Either/Or?," NextBillion, December 21, 2018, https://nextbillion.net/paygo-vs-mfi-energy-access/.

After-Sales and End-of-Life Support

Currently, few companies operate exclusively in this part of the value chain; most after-sales support services are integrated into the operations of companies that also provide distribution and consumer financing. After-sales support includes technical services such as operation, repair, and maintenance of products in addition to various public-sector programs initiated to promote solar equipment recycling. Some newer companies, such as Village Energy in Uganda, are providing tailored after-market services like the maintenance and repair of existing solar systems.[167] Beyond managing product repairs, companies that finance solar systems must also manage call centers to troubleshoot customer issues and implement reverse logistics when products under warranty do require maintenance.

Poor infrastructure and a dispersed customer base raise the cost of performing after-sales support in most markets, particularly for off-grid customers in rural, hard-to-reach areas. Only a large (and hence expensive) network of technicians can cover a widely dispersed customer base, and high costs are associated with traveling out to meet customers and repair and maintain existing systems. Further, not all products lend themselves well to component replacement, instead requiring costly full system replacement. These problems pose more significant threats in the context of revenue-generating appliances, where appliance downtime results in revenue loss for customers, potentially undermining consumer confidence.

Remote monitoring is enabling companies to improve customer service and asset management. Companies can use geolocation data to organize and streamline after-sales services and surmount challenging logistics in remote areas. Hot spots can be identified to deploy after-sales support teams most effectively. For example, BBOXX's SMART technology provides a web-based tool allowing BBOXX and third-party distributors to manage their portfolio of products. The tool displays the rough location of units on a map, enabling the company to identify where products are being used. This was made possible by using Cell ID and Wi-Fi-based location services, avoiding expensive GPS technology, which helps BBOXX to keep the cost of its products down. With this technology, BBOXX can more cost-effectively position its service agents in the field to provide after-sales support to customers.

End-of-life (EOL) disposal of off-grid products remains a challenge given the above-mentioned logistical hurdles; however, more companies are starting to incorporate end-of-life into their business models. EOL companies rely on contracts with off-grid companies or governments for the disposal of their e-waste rather than being intrinsically financially motivated to collect EOL products for any residual disposal value. Companies are finding ways to manage e-waste better. For example, SunnyMoney has developed a take-back scheme as a Global LEAP Solar E-Waste Award Winner.[168] To reduce waste, other companies are making products more durable by, for example, carefully selecting plastics and remotely monitoring products to proactively maintain systems.[169] Though there are impediments to the commercial uptake of this model, increased regulation around e-waste will lead to more off-grid and disposal companies effectively managing the growing volume of waste. For more details on e-waste policy, see Section 4.1.5.

167 Village Energy, "Technical Services," http://villageenergy.com/technical-services/.

168 E-waste is any byproduct generated when an electronic product can no longer be repaired and has reached its "end of life." CLASP, "CLASP Announces the Winners of the 2019 Global LEAP Awards Solar E-Waste Challenge," news release, August 8, 2019, https://clasp.ngo/updates/2019/clasp-announces-the-winners-of-the-2019-global-leap-awards-solar-e-waste-challenge.

169 Vivid Economics and Open Capital Advisors consultations.

2.3 Competition and Consolidation

KEY MESSAGES

- Competition is driven by price and increasingly quality, with hundreds of products available on the market.
- The affiliate segment of the market is relatively concentrated, dominated by large First-Generation companies.
- Sector consolidation could fundamentally alter market dynamics by creating larger OGS companies, but there have been few examples to date.
- Consolidation in the sector will likely remain limited because of high valuations, complex business models, and a lack of profitability.

Photo credit: © FINCA International

Increased consolidation or competition could both provide significant benefits to the sector, but it is too early to tell which market dynamic will predominate moving forward. Increased competition could drive down costs and foster innovation in a sector where both are crucial to providing reliable energy to the un- and underserved, but the high cost of launching OGS companies could limit new entrants to the market, particularly if early-stage equity remains difficult to access. Conversely, if companies can demonstrate the scale and profitability required to attract strategic investors, consolidation could create OGS companies with huge scale, supported by large amounts of capital, able to aggregate sector expertise, and achieve significant economies of scale – which would drive down system costs and accelerate energy access.

2.3.1 Competition

COMPETITION IS DRIVEN BY PRICE AND INCREASINGLY QUALITY, WITH HUNDREDS OF PRODUCTS AVAILABLE ON THE MARKET.

A range of factors influence competition in the OGS sector, including product type, geographical region, and consumer financing. However, evaluating the level of competition in the sector is difficult because little information is available on the non-affiliate portion of the market. While GOGLA collects sales data on the affiliate portion of the market, no such centralized database exists for the non-affiliate segment. Studies conducted by Ipsos on behalf of Lighting Global have begun to shed some light on the non-affiliate portion of the market. Along with company interviews and consumer insights, this provides the basis for better understanding competition in the OGS sector.

Competition is very high in the pico segment of the market, driven primarily by price, but retailers are becoming more aware of the market and reputational risk of stocking low-priced counterfeit or faulty products. There are many more non-affiliate than affiliate pico lantern products on the market, with more than 200 different products available in Ethiopia alone in 2018. Retailers in Ethiopia, Kenya, and Tanzania all say customers choose products primarily based on price. Indeed, the market leaders in each country in terms of availability are the cheapest products. However, retailers and consumers are becoming more aware of the shortcomings of low-quality products. Competition also appears to be driving products out of the market; in both Kenya and Ethiopia, the number of available products dropped 40 percent between 2015 and 2018, with non-affiliate products squeezed out the most, indicating rising levels of consumer awareness about quality in these markets (Table 2).

Table 2: Number of Affiliate and Non-Affiliate Brands in the Pico Segment, 2015 and 2018

	Kenya			Ethiopia			Tanzania		
Pico	Affiliate	Non-affiliate	Total	Affiliate	Non-affiliate	Total	Affiliate	Non-affiliate	Total
2015	48	103	151	37	298	335	N/A	N/A	N/A
2018	39	53	92	36	165	201	29	119	148

Source: Ipsos market research commissioned by Lighting Global.
Note: Tanzania data are from late 2017.

In the PnP SHS segment of the market, price also drives competition for cash sales. While non-affiliate brands dominate global SHS sales, Kenya and Tanzania have a roughly equal number of affiliate and non-affiliate PnP products available in the market (Table 3). In Kenya, four times as many non-affiliate brands were available in 2018 as compared

to 2015, while the leading product, a non-affiliate brand, is almost 50 percent cheaper than its closest affiliate competitor. Non-affiliate PnP systems are thus entering the market to compete with more expensive affiliate brands.

Table 3: Number of Affiliate and Non-Affiliate Brands in the SHS Segment, 2015 and 2018

	Kenya			Ethiopia			Tanzania		
SHS	Affiliate	Non-affiliate	Total	Affiliate	Non-affiliate	Total	Affiliate	Non-affiliate	Total
2015	31	11	42	25	283	308	N/A	N/A	N/A
2018	42	41	83	17	152	169	31	39	70

Source: Ipsos market research commissioned by Lighting Global.
Note: Tanzania data are from late 2017.

In the PnP SHS segment of the market, price also drives competition for cash sales. While non-affiliate brands dominate global SHS sales, Kenya and Tanzania have a roughly equal number of affiliate and non-affiliate PnP products available in the market (Table 3). In Kenya, four times as many non-affiliate brands were available in 2018 as compared to 2015, while the leading product, a non-affiliate brand, is almost 50 percent cheaper than its closest affiliate competitor. Non-affiliate PnP systems are thus entering the market to compete with more expensive affiliate brands.

Cash sales of PnP SHS often struggle to compete against component-based systems on price. Consumers or product aggregators often assemble their own OGS devices by purchasing individual components to build SHS from individual parts, rather than buying a complete system. While this occurs globally, OGS companies providing PnP systems in Asia have especially highlighted their struggle to compete with component-based systems assembled from a massive influx of cheap OGS components from nearby China.

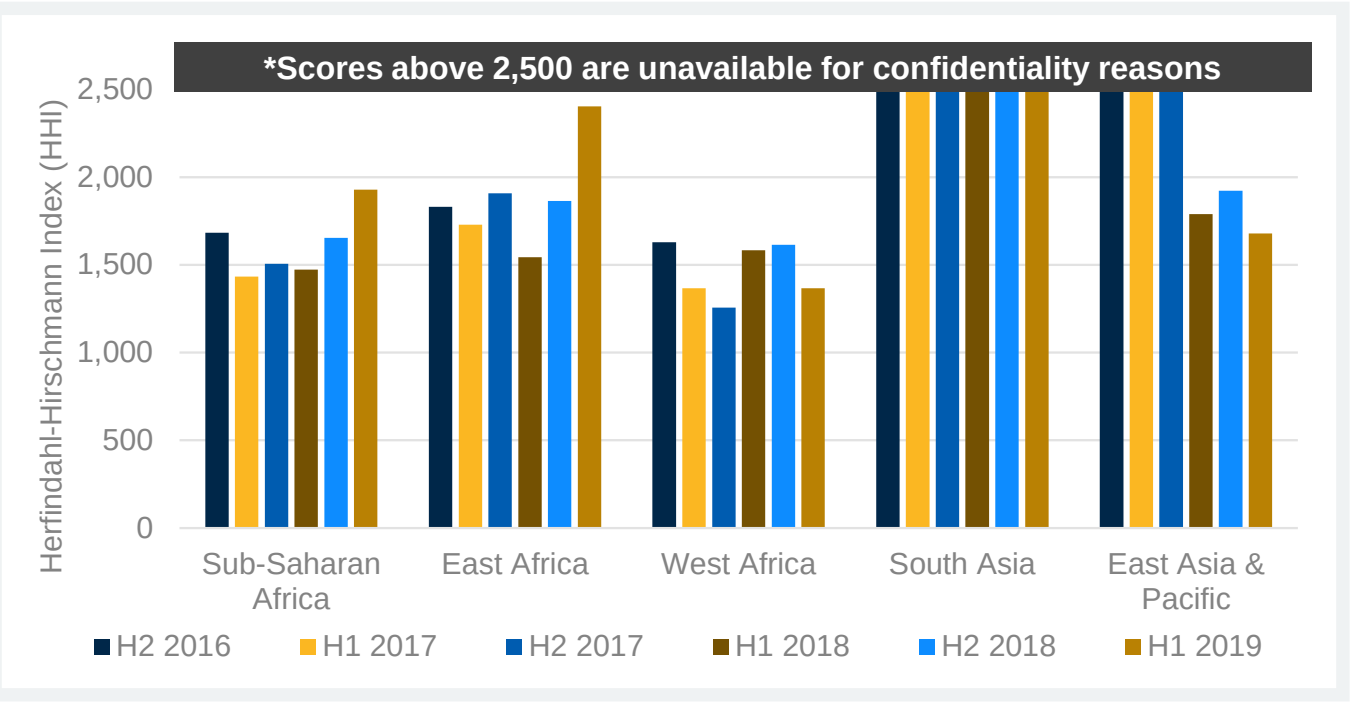
With the continued growth of PAYGo PnP systems, consumers are focused on down payment costs, PAYGo terms, and SHS product bundles. One of the main barriers to acquiring potential PAYGo customers is the cost of the deposit. Many consumers are attracted to PAYGo products with lower upfront costs, so companies must balance lower deposits against credit risk. In addition, affiliate companies are responding to consumer demand for higher levels of service by providing consumers with more attractive product bundles, including appliances or "beyond energy" services.

THE AFFILIATE SEGMENT OF THE MARKET IS RELATIVELY CONCENTRATED, DOMINATED BY LARGE FIRST-GENERATION COMPANIES THAT COMPETE ON PAYGO TERMS AND PRODUCT BUNDLES.

West Africa is the only region with a notable increase in the number of operating affiliate companies since H1 2018, indicating that few new affiliate companies are being established or receiving quality certification. The sector is dominated by large, First-Generation companies that attracted early equity investments and took advantage of low levels of competition in easier markets to scale. Newer companies struggle to raise the equity needed to establish themselves and are operating in markets with latent demand that are much more difficult to enter (compared to, for example, East Africa in the sector's early days). For more affiliate companies to enter the sector and compete, the industry will need to implement serious measures to support newer companies, including concessional financing.

Among affiliate manufacturers, the market remains moderately to highly concentrated, as shown by the industry's score on the Herfindahl–Hirschmann Index (Figure 28).[170] The Herfindahl–Hirschman Index (HHI) is used to measure market concentration. A score below 100 indicates a highly competitive industry, 101–1,500 signifies an unconcentrated industry, 1,501–2,500 suggests moderate concentration, and above 2,500 represents a highly concentrated industry.[171] The OGS sector has remained moderately to highly concentrated over the last three years. A small increase in concentration in East Africa in H1 2019 is likely a result of fluctuations in the sales of affiliate manufacturers rather than one company asserting its market dominance, while the sustained decrease in concentration in East Asia and Pacific indicates that new manufacturers have taken advantage of opportunities there to enter the market. The relatively high levels of overall market concentration result from the high cost of developing new products for the market and the limited number of quality-verified manufacturers. There is room in the market for more affiliate manufacturers to enter, which would increase competition and may drive down prices. With an increasing number of Chinese manufacturers seeking to become affiliates, we expect concentration in the market to decrease in the future.

Figure 28: Herfindahl–Hirschmann Index for Affiliate OGS Manufacturers Across Off-Grid Solar Markets



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA and Lighting Global, Off-Grid Solar Market H2 2016; GOGLA and Lighting Global, Off-Grid Solar Market H1 2017; and GOGLA and Lighting Global, Off-Grid Solar Market H1 2018, Off-Grid Solar Market H2 2018, and Off-Grid Solar Market H1 2019.

Affiliate manufacturers of pico and PnP SHS products face increasing pressure from a large number of non-affiliate manufacturers, including those seeking to enter the affiliate market through quality verification. While affiliate distributors rank quality as the most important criterion when sourcing products from manufacturers, some are considering moving to lower-priced non-affiliate manufacturers as their product quality improves. In addition, several non-affiliate manufacturers are seeking quality verification for their products, which would make them more attractive to affiliate distributors. Combined with the fact that there are around 200 non-affiliate manufacturers of OGS products in the market, existing affiliate manufacturers will likely face increased competition from either newly verified affiliate brands or from the non-affiliate portion of the market. Affiliate manufacturers will need to demonstrate that their products are worth the higher price—or lower their prices—to stay relevant.

170 GOGLA only provides sales data for affiliate manufacturers and cannot provide disaggregated sales data to calculate HHI scores for affiliate distributors. Additionally, because of the lack of sales data across the whole market, including non-affiliate companies, calculating a full HHI for the OGS sector is not possible.

171 Scores above 2,500 are not shown for reasons of confidentiality.

Box 8: Appliance Manufacturers: An Increasingly Competitive Landscape

Competition among manufacturers of household and PULSE appliances is increasing as the size of the market grows. Fewer data are currently available on off-grid appliances. However, work by CLASP and the Global LEAP Awards program has clearly shown that manufacturers see high potential for growth in this area. In 2014, the Global LEAP Awards had just two to five entries per product category—off-grid televisions, fans, and refrigerators—and only a handful of products for use in Africa and South Asia. By 2017, CLASP was aware of 11 refrigerator manufacturers, eight television manufacturers, and seven fan manufacturers.[172] Continuing this growth, the 2019 Global LEAP Awards received submissions from 21 manufacturers across 15 countries for refrigerators, 67 percent of which were first-time applicants. Competition among manufacturers has translated to increased customer choice, with a 2018 survey of off-grid appliances in 10 rural markets in Tanzania identifying 16 unique brands (12 televisions, 11 fans, and two refrigerators).[173] The competitive landscape could further evolve if the sector sees an influx of multinational appliance brands that have traditionally specialized in AC appliances. To date, the market has primarily comprised specialized companies that are dedicated to DC appliances for the OGS sector. However, multinational brands, such as Embraco (under its Youmma venture) and Mitsubishi, have ventured into the DC refrigerator market, and Cello has started to manufacture DC televisions. As the market for OGS appliances grows, more such companies will likely enter the sector, whether competing directly or partnering with traditional OGS companies.

172 Dalberg, Off-Grid Appliance Market, 14.

173 CLASP and Energy Saving Trust, Appliance Data Trends 2018, 12.

2.3.2 Consolidation

CONSOLIDATION COULD FUNDAMENTALLY ALTER MARKET DYNAMICS IN THE SECTOR BY CREATING LARGER OGS COMPANIES WITH A COMPETITIVE ADVANTAGE, BUT EXAMPLES OF STRATEGIC ACQUISITIONS AND OTHER M&A IN THE SECTOR HAVE BEEN ISOLATED TO DATE.

Strategic acquisitions remain rare, with only ENGIE thus far completing full takeovers. Strategic investors, particularly energy conglomerates and multi-sectoral Japanese conglomerates, have shown increased interest in the sector over time. After strategic investors completed several significant equity investments into leading OGS companies, many stakeholders have started to see these investors as the most likely pathway to exit.[174] Different types of strategic investors have varying reasons for entering the OGS space.

Energy conglomerates have been the most active strategic acquirers in the sector. With their industry overlapping the OGS sector, the global move to renewable sources of power, and their knowledge of key drivers in the utility space towards distributed power, energy conglomerates plan to grow their renewable energy coverage and gain greater presence in emerging markets by expanding their distribution and product offerings through existing channels, such as OGS companies. By combining their existing on-grid energy expertise with additional off-grid experience, these conglomerates could become attractive to governments as partners to achieve their national electrification plans. As more governments include an off-grid component in their national electrification initiatives, these conglomerates could then service governments' on- and off-grid electrification needs. ENGIE is currently the most likely conglomerate to fulfill this type of role, as they have so far made three acquisitions.[175]

This group of potential investors nevertheless takes different perspectives on the OGS sector, influencing the likelihood of consolidation. Some utilities see their activities in the off-grid sector as part of their CSR activities, choosing to invest in research and development for technologies such as batteries or solar PV panels. Others have chosen more direct routes into the OGS sector, developing their own off-grid products or setting up subsidiaries to deliver services, such as Rafiki Power, a mini-grid company founded by the German utility E.ON.[176] These two approaches are less likely to lead to full acquisitions (and, by extension, sector consolidation) in the short to medium term. Conversely, others have integrated off-grid into their long-term strategies, leading to significant commitments in the sector, which could lead to consolidation in the nearer future. For example, four leading French energy companies (Box 9) all have off-grid strategies, but each has engaged in the sector with their own specific objectives and views towards consolidation.

174 Acumen and Open Capital Advisors., Lighting the Way: Roadmap to Exits in Off-Grid Energy (New York: Acumen; Nairobi: Open Capital Advisors, 2019), https://acumen.org/energy-exits-report/.

175 Vivid Economics and Open Capital consultations; and Acumen and Open Capital Advisors, Exits in Off-Grid Energy, 23.

176 In August 2019, PowerGen acquired Rafiki Power.

Box 9: One Sector, One Country; Four Approaches

Électricité de France (EDF)

EDF's OGS strategy uses the concept of decentralized service companies, which are incorporated under local laws and run by local managers. EDF forms partnerships with leading private-sector companies across Africa, typically taking 50 percent stakes in joint venture special-purpose vehicles, as they did in BBOXX's Togo operations in 2018. Additionally, EDF has demonstrated increased interest in supporting the sector, working with NEot Capital, Meridiam, and Mitsubishi to launch the NEoT Offgrid Africa investment platform in 2017. EDF has also shown interest in PULSE specialists, including SunCulture. Whether or not EDF will start to make full acquisitions remains to be seen, although EDF may soon begin to take more majority stakes to promote the regional expansion of its portfolio companies, which could lead to full acquisitions and consolidation in the sector.

ENGIE

ENGIE appears to be shifting towards renewable energy and away from its traditional focus on oil and gas. The multinational is especially interested in decentralized solar energy, historically making investments through its fund, ENGIE Rassembleurs d'Energies. Launched in 2011 with a €10 million budget, the fund quintupled in size in 2016 to €50 million. Through this fund, ENGIE has made significant investments in numerous mini-grid and off-grid companies. Besides the investments made through its fund, ENGIE has shifted its strategy since 2017 to take a majority shareholding in companies, as with its acquisitions of Fenix International, Mobisol, and Simpa Networks. The combination of ENGIE's existing expertise in on-grid energy with off-grid services could create a one-stop-shop for national initiatives and UN objectives by providing a full suite of electrification services.[177]

Schneider Electric

Schneider Electric has chosen to take direct involvement in manufacturing and product research and development in addition to its investment arm. Schneider products cover the entire OGS spectrum, including solar lanterns, SHS, micro-grids, and a solar water pump. Schneider also invests in companies through two investment funds. The Schneider Electric Energy Access Fund (SEEAF) invests its €4.2 million fund into small, innovative, and early-stage OGS companies. SEEAF's portfolio includes well-known names such as Simpa and Fenix (both exited to ENGIE); Lumos Global (exited to majority shareholder); SunFunder, which makes investments on their behalf; and Okra Solar. Schneider's second fund is Energy Access Ventures (EAV), a venture capital fund that has subsequently received funding from major DFIs in the sector to reach €54.5 million. EAV has a wide investment mandate, including hydropower, biomass, wind, and geothermal. It has also invested in PULSE specialists, including InspiraFarms and SunCulture. While Schneider Electric has so far exited their investments rather than making full acquisitions, they could make acquisitions in the future.

Total

Total, one of the largest oil producers in Africa, has been considering OGS for almost four decades. Unlike the other three French firms, Total's activity in OGS has almost exclusively focused on the manufacturing and distribution of OGS products. Total launched its own line of OGS products under the Awango by Total brand. Total plans to expand its lamp offering into larger systems and appliances, including fans and refrigerators. Total's distribution activities are strongly supported by its expansive network of petrol stations across Africa and Asia, which account for 60 percent of Total's global OGS sales. Total has no specific energy access fund, but through its venture capital fund, Total Energy Ventures, Total identifies innovative ideas that have the potential to provide the multinational energy company with strategic learning and benefits. Given this unique objective, Total has placed minimal direct investment in OGS companies, which suggests that they are far from making full acquisitions.

Source: Vivid Economics and Open Capital Advisors consultations; and Harald Schützeichel, "Four French Musketeers Are Embossing the Off-Grid Market: EDF, Engie, Schneider, Total," Sun-Connect Off-Grid News: Market Reviews, no. 1, 2019, https://www.sun-connect-news.org fileadmin/DATEIEN/Dateien/New/SC_Market_Review_1.pdf.

177 Acumen and Open Capital Advisors., Exits in Off-Grid Energy, 25.

Deep-pocketed, multi-sectoral Japanese conglomerates are starting to make their mark on the OGS sector. Negative interest rates and an increased focus by the Japanese government on renewable energy have led several Japanese conglomerates to invest in the OGS sector.[178] For example, Sumitomo invested in M-KOPA, Mitsui invested in both M-KOPA and OMC Power, Mitsubishi invested in BBOXX and NEoT Capital, and Marubeni led an equity investment in Azuri Technologies. These companies view the OGS sector as an opportunity to grow their core businesses. Although they largely seem to be testing the waters at this stage, this group of investors has indicated a willingness to invest more in the sector, which could lead to future consolidation.

CONSOLIDATION IN THE SECTOR WILL LIKELY REMAIN RARE AS A RESULT OF HIGH VALUATIONS, COMPLEX BUSINESS MODELS, AND A LACK OF PROFITABILITY.

Additional strategic acquisitions which could lead to consolidation (Table 4) are hindered by OGS companies' complex business models and the sector's lack of scale and profitability. OGS companies, especially the large, vertically integrated companies in which strategic investors would be most interested, are incredibly complex. They often significantly diverge from the core capabilities of strategic investors. Full vertical integration is uncommon in other industries, which makes OGS companies even more challenging to understand. Potential strategic acquirers also generally believe that large, well-established OGS companies are over-valued and have yet to demonstrate a path to profitability, while smaller companies have not reached enough scale to be of interest.[179] However, if valuations were to decrease or if more companies started to struggle financially, strategic investors could make opportunistic purchases, as in the case of Mobisol's recent acquisition by ENGIE. However, the consolidations and few insolvencies that have occurred in the market to date should not be seen as a sector-specific trend but rather as a healthy stage of market maturation and development.

Table 4: Other Potential Strategic Acquirers which Could Lead to Consolidation

Type	Current Alignment with the OGS Sector	Opportunities for Consolidation	Barriers to Consolidation
Private Equity Funds	• Have equity investments in leading OGS companies (e.g., Africa Infrastructure Investment Managers invested US$ 31 million into BBOXX in 2019).	• Consolidation in the sector could lead to improved market opportunities for portfolio companies.	• No long-term alignment with the sector. • Generally, only have equity investments in one company. • Limited track record of profitability in the sector.
Appliance and Component Manufacturers	• Aligned with OGS value chain through manufacturing of OGS products and appliances.	• Access to OGS companies' broad client base across geographies would allow them to upsell or replace old products.	• For DC appliances, the OGS market has not reached sufficient scale to generate interest. • Lacking visibility of the whole value chain.

178 Clowes et al., Exits in Off-Grid Energy, 25.

179 Clowes et al., Exits in Off-Grid Energy.

Type	Current Alignment with the OGS Sector	Opportunities for Consolidation	Barriers to Consolidation
Mobile Network Operators	• Existing long-term partners with OGS companies in payments and distribution (e.g., MTN partnership with Nova Lumos and Orange to source and distribute products).	• A possible new frontier for expansion, providing increased services to customers and increasing customer loyalty.	• Distinct businesses which may be challenging to integrate. • Have not yet tested the waters through any investment.
Microfinance Institutions	• Currently providing financing for OGS products in some markets (e.g., Greenlight Planet partnerships with numerous MFIs in India).	• MFIs and OGS companies serve a similar, rural customer base. MFIs are experts in financing with high synergies in managing PAYGo portfolios.	• Not retail companies, so unfamiliar with the sales aspect of the OGS business model. • Perceived high credit risk of OGS customers. • Limited capital availability.
Fast-Moving Consumer Goods (FMCG) Companies	• Distribution partnerships with OGS companies (e.g., Unilever and Azuri partnership in Kenya).	• Access to last-mile distribution networks. • Expand their customer base to include OGS customers.	• Lack of familiarity with PAYGo financing and back-end software.

Source: Vivid Economics and Open Capital Advisors.

Consolidation through sector M&A will be rare in the short to medium term as a result of capital constraints and challenges in integrating business operations. Sector M&A will only occur in opportunistic circumstances when valuations, business models, or operations align to make an opportunity exceed the significant challenges (Table 5). For example, in one rare case of sector M&A, Greenlight Planet acquired Global Cycle Solutions (GCS) in 2017 to support its operations in Tanzania. This only occurred because of the strong existing relationship between the two companies, GCS's desire to sell and Greenlight Planet's desire to build their presence in Tanzania.

Table 5: Types, Examples, and Challenges of Sector Consolidation

	Horizontal Integration	Vertical Integration
Type	Consolidation involving two companies operating in the same areas of the value chain.	Consolidation involving one company operating across the value chain and one specialized in just one area.
Example	EcoEnergy Pakistan acquired the customer portfolio of Brighterlite Pakistan in 2017 to upgrade Brighterlite's customers to their higher-capacity devices.	Mobisol acquired Lumeter, a software provider, in a bid to improve their software capabilities and better offer software-as-a-service as part of their core business.
Rationale	Successful companies could purchase others for geographic expansion rather than building out operations from scratch in a new market or to expand their customer base in existing countries for additional products and services.	Allows fully integrated companies to improve their capabilities or service offerings in specific areas of the value chain without conducting additional research and development. This could include a large SHS company acquiring a PULSE specialist to add PULSE appliances to their product offering.
Challenges	Companies have limited capital availability and view valuations as too high. Integrating different business models presents challenges, especially since many companies in the sector have developed highly specialized software capabilities. Companies, therefore, believe it to be easier to expand into a new country themselves rather than to buy an established OGS company.	Companies are skeptical of purchasing specialized companies for vertical integration, believing that they can build better and more tailored solutions themselves. For example, uptake of third-party software has been slow among large, vertically integrated companies due to the amount of customization and flexibility each company requires.

Source: Vivid Economics and Open Capital Advisors.

2.4 Market Potential

KEY MESSAGES

- Globally, 840 million people still lack access to electricity and all are potential OGS customers, of whom about 70 percent are in Sub-Saharan Africa.
- In addition to this market, the market of unreliable grid connections comprises more than 1 billion people (mainly in Asia) and is increasingly served by OGS products that provide better security of energy supply to households and microenterprises.
- With rising affordability and awareness of OGS, households, and microenterprises are increasingly able and willing to purchase OGS products—especially if they offer services "beyond energy."
- Delivering OGS products to the complete addressable demand nevertheless remains a key challenge, as those least able to pay are often also the most expensive to reach.
- The potential PULSE market is growing, encompassing more than 70 million farmers worldwide.
- PULSE products generate additional income, but there remain affordability gaps that shrink the addressable market.
- While still at a very early stage, emerging business models could serve demand from public institutions, unlocking a substantial potential market of public facilities which are not connected to the main grid.

Photo credit: © OffGridElectric

2.4.1 Potential Market of People without Electricity Access or with Unreliable Grid Connections

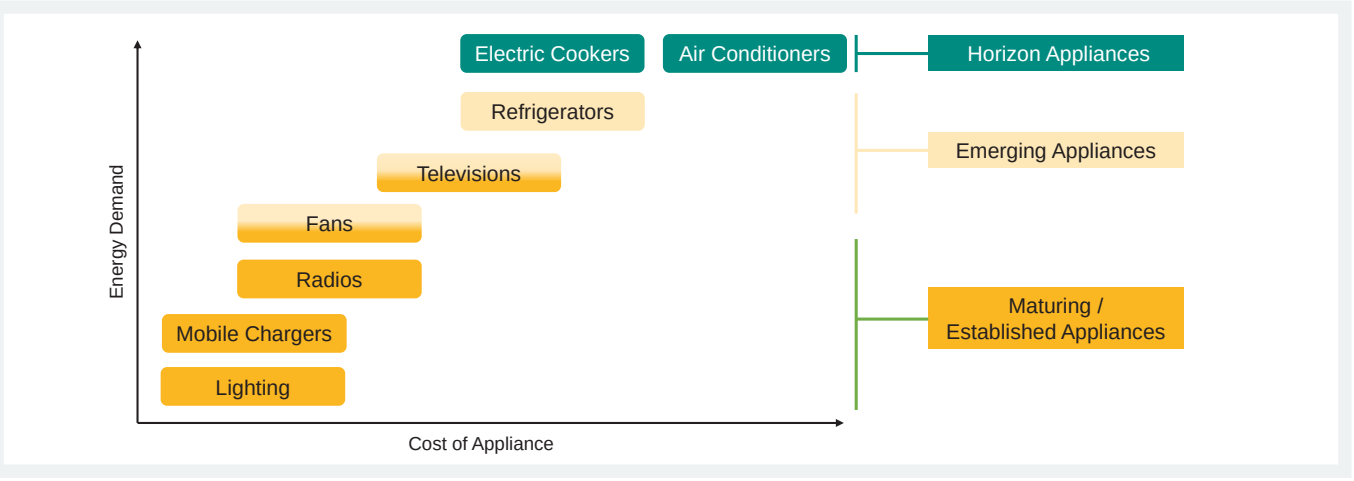
DESPITE SIGNIFICANT PROGRESS IN ELECTRIFICATION, OGS RETAINS MASSIVE POTENTIAL.

Electrification — both through grid connections and off-grid solutions offering Tier 1 or higher access – has improved rapidly from 83 percent of the global population in 2010 to 89 percent in 2017, with the most significant progress in Central and South Asia.[180] Global electrification rates have outstripped global population growth, decreasing the relative share of people living without access to electricity. Many countries have adopted electrification plans to reach universal access by 2030, including both on- and off-grid solutions.

Despite this progress, the market potential in absolute terms remains substantial, with 840 million people lacking electricity access globally in 2017 and more than 1 billion using unreliable grid connections.[181] The focus on global progress masks significant regional differences. In a majority of the 20 countries with the largest energy-access deficits, the rate of electrification has not kept pace with the rate of population growth, increasing the number of people in these countries without access to electricity. In countries with unserved populations of more than 50 million people, such as the Democratic Republic of Congo, Nigeria, and Pakistan, electricity access in terms of the percentage of the population with access has expanded very little in terms of annualized average change between 2010 and 2017.[182]

Off-grid solar products can help serve these populations and reach universal access for all, with products ranging from small pico products to SHS of increasing sizes. Households and small enterprises increasingly demand appliances that can be powered by high-capacity OGS products (Figure 29).

Figure 29: Demand for Appliances Expands beyond Lighting and Mobile Phone Chargers



Source: Vivid Economics and Open Capital Advisors, adapted from Dalberg, Off-Grid Appliance Market; and CLASP, Off-Grid Appliance Market Survey: Perceived Demand and Impact Potential of Household, Productive Use and Healthcare Technologies, 3rd ed. (London and Washington, DC: Efficiency for Access, September 2018), https://efficiencyforaccess.org/publications/off-grid-appliance-market-survey.

180 International Energy Agency et al., Tracking SDG 7: The Energy Progress Report 2019 (Washington, DC: The World Bank, May 2019), https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019.

181 While the figure of 1.095 billion people with unreliable grid connections was estimated for this report, 840 million unconnected was estimated by the International Energy Agency et al. Tracking SDG 7, 1–2.

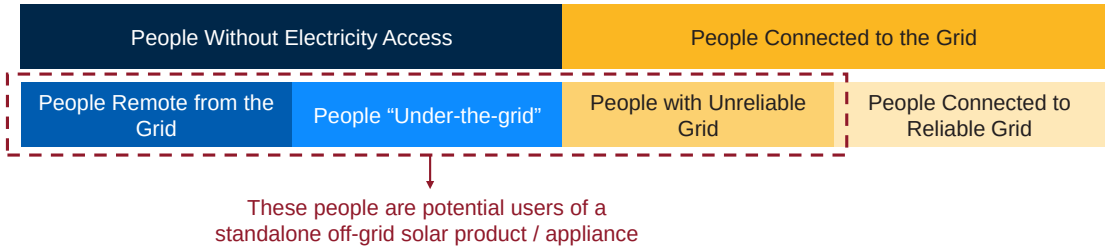
182 International Energy Agency et al., Tracking SDG 7, 16.

KEY CUSTOMER SEGMENTS OF THE POTENTIAL OGS MARKET ARE HOUSEHOLDS AND MICROENTERPRISES WITHOUT ELECTRICITY ACCESS OR WITH UNRELIABLE GRID CONNECTIONS.

Demand for electricity comprises four market segments (Figure 30). People without electricity access, who have not yet experienced electricity, typically demand up to Tier 2 enabling products, while people with an unreliable grid, who have experienced electricity, demand products anywhere between Tiers 1 and 4. Demand across Tiers differs, however, in terms of both desired products and expectations. Some evidence suggests that smaller products, such as pico devices, bring people onto the energy staircase, facilitating their access to higher-feature products over time, but they need not always take this route (see Section 5.2.1).[183]

- **People remote from the grid.** People that are remote from and not connected to mini-grids, the grid or other sources of electricity.[184] All of these people are potential customers for OGS products.
- **People "under-the-grid".** People that are near to but not connected to mini-grids. Even where a grid connection is nearby, and a connection would be technically realistic, people may choose not to connect because of affordability constraints (either high connection costs to the grid or high tariffs to consume from the grid, or both) and poor reliability of service. All of these people are potential customers for OGS products.
- **People with an unreliable grid.** These people face frequent or lengthy outages of grid electricity or experience voltage fluctuations that can damage electrical appliances. Some, but not all of these people currently represent a potential market for OGS products, which can offer an alternative source of power when the grid provides an unsatisfactory quality of service.
- **People connected to a reliable grid.** These people rarely or never face outages of grid electricity and do not experience voltage fluctuations that could damage electrical appliances. These people do not represent a substantial market for OGS products, as the grid fully meets their current and future needs. They do not require OGS products beyond specialty uses.

Figure 30: Defining Key Customer Segments



Source: Vivid Economics and Open Capital Advisors.
Note: The sizes of the boxes do not reflect the relative size of each market segment.

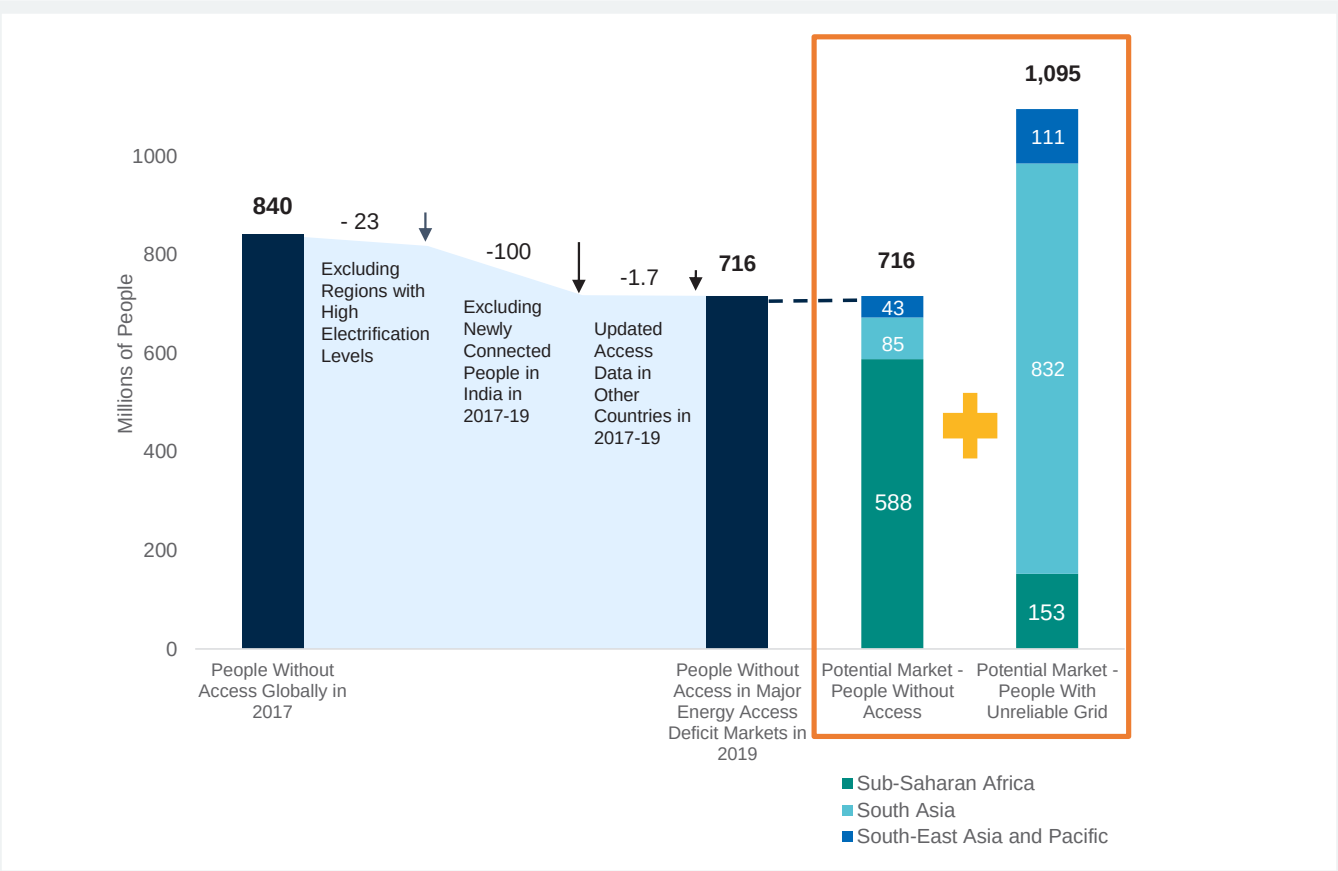
183 Acumen Lean Data and BBOXX, Energy Lean Data: Baseline in Rwanda (Nairobi: Acumen and BBOXX, November 2017), https://drive.google.com/file/d/1UuTjk-kMNlFiSXthspWhVDutPTl5JvCEw/view; and Scott Graham, Anahit Tevosyan, and Eric Verploegen, First Steps: How Early Adopters Climb the Solar Energy Ladder (Washington, DC: FINCA International, October 8, 2019), https://finca.org/insights/how-early-adopters-climb-the-solar-energy-ladder/.

184 Most grid-connected households are connected to the main grid. However, with mini grids increasingly common, the term "grid" can apply to both main and mini-grids.

THE CURRENT POTENTIAL MARKET FOR OGS PRODUCTS ACROSS SUB-SAHARAN AFRICA AND ASIA–PACIFIC CONSISTS OF 716 MILLION PEOPLE WITHOUT ACCESS TO ELECTRICITY AND MORE THAN 1 BILLION WITH AN UNRELIABLE GRID.

This report focuses on the potential market for OGS products in major energy-access deficit markets across Sub-Saharan Africa and Asia–Pacific (Figure 31). Over the last two years, some countries in these regions have continued to make strides towards universal electrification, most notably India, where almost 100 million people gained new access between 2017 and 2019. Despite this progress, global demand for OGS remains high across households and microenterprises that currently do not have electricity access, and among people using an unreliable grid connection, although the entire market cannot be addressed and reached through commercial business models. While markets with major energy access deficits in Sub-Saharan Africa and the Asia-Pacific region account for the majority of OGS sales to date, low-access countries such as Yemen in the Middle East, or Haiti in Latin America and the Caribbean, provide additional market opportunities.

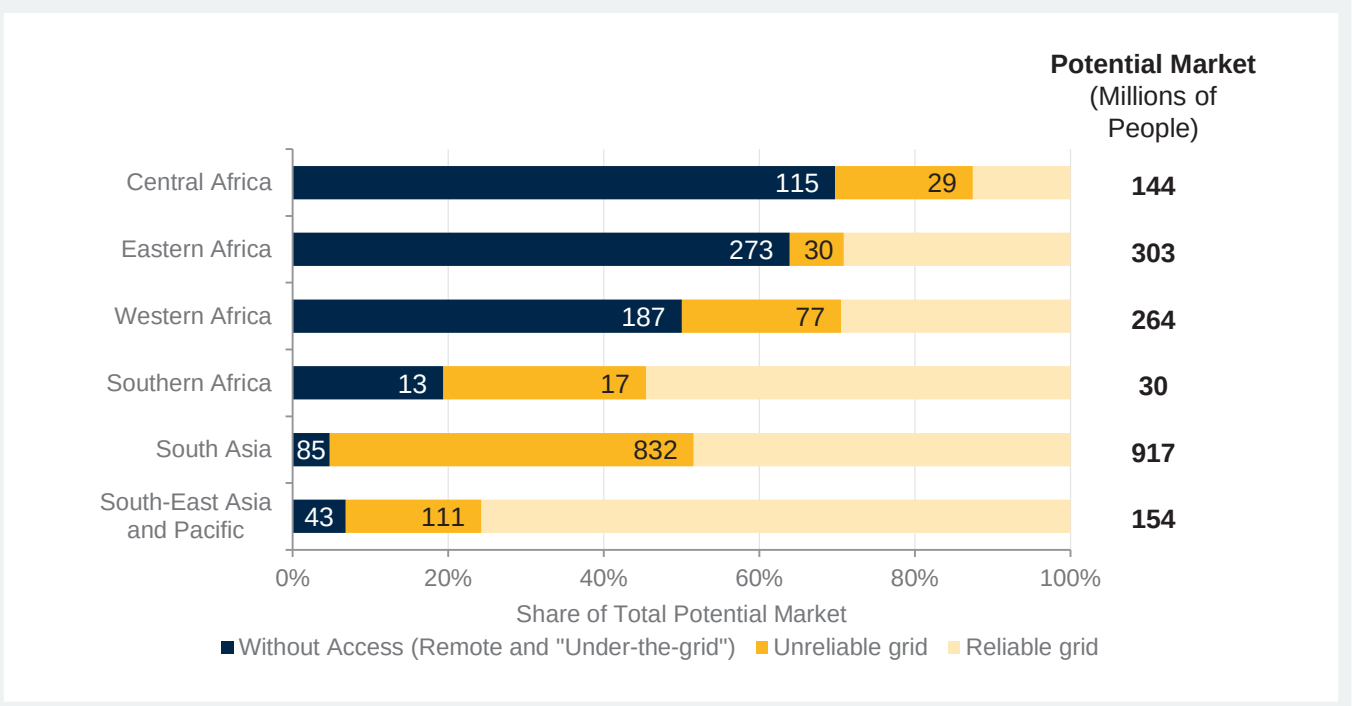
Figure 31: Potential Market in Sub-Saharan Africa and Asia–Pacific



Source: Vivid Economics and Open Capital Advisors. While the figure of 1.095 billion people with unreliable grid connections was estimated for this report, 840 million unconnected was estimated by the International Energy Agency et al. Tracking SDG 7, 1–2.

THE VAST MAJORITY (OVER 80 PERCENT) OF PEOPLE WITHOUT ELECTRICITY ACCESS LIVE IN SUB-SAHARAN AFRICA, WHILE THE BULK OF THOSE WITH UNRELIABLE GRID CONNECTIONS (ABOUT 75 PERCENT) IS IN SOUTH ASIA (FIGURE 32).

Figure 32: People without Electricity Access Comprise the Largest Share of the Potential OGS Market in Sub-Saharan Africa, while People with Unreliable Grid Access Comprise the Largest Segment in Asia



Source: Vivid Economics and Open Capital Advisors analysis of data from ESMAP, Diagnostic Reports Based on the MTF; Afrobarometer, Merged Round 7 Data (34 Countries) (2019), https://www.afrobarometer.org/data/merged-round-7-data-34-countries-2019; and World Bank, Enterprise Surveys: What Businesses Experience, https://www.enterprisesurveys.org/en/data.

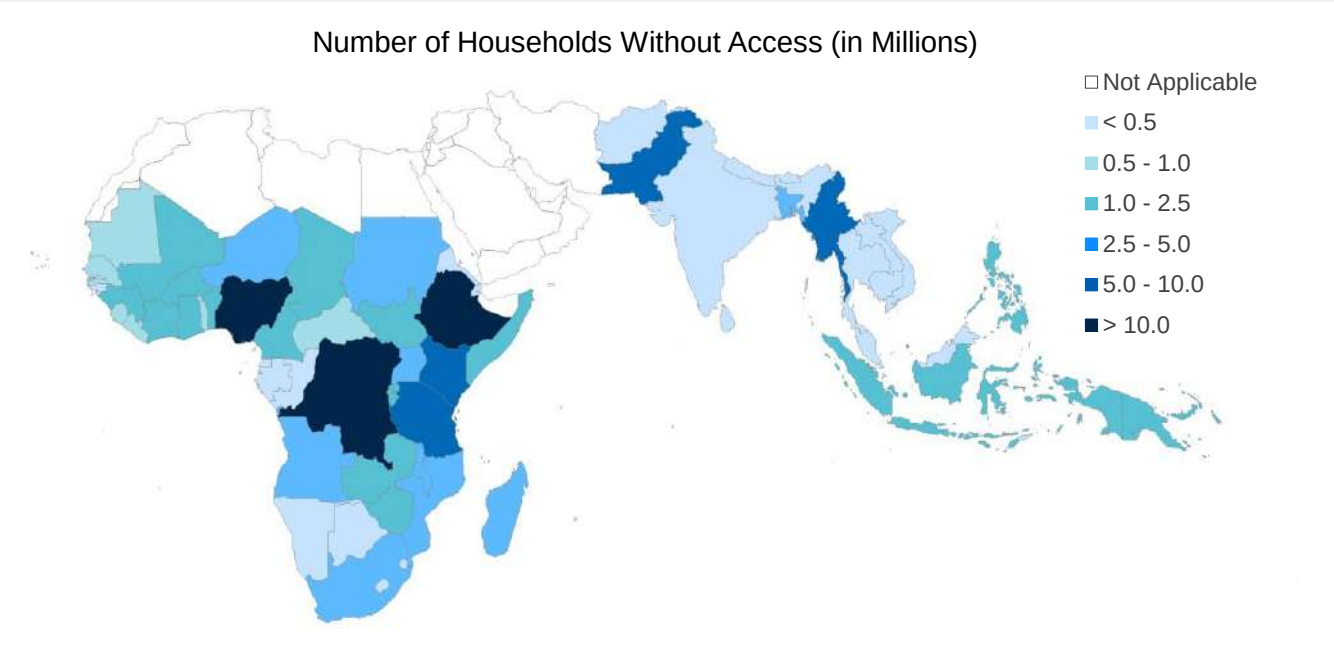
Note: The numbers inside the "without access" and "unreliable grid" bars represent the potential markets of people without access and people with unreliable grid connections, respectively, in millions of people. Their sum is presented at the far right to present potential market per region (in millions of people). National-level data on electrical outages experienced by firms is from The World Bank, Enterprise Surveys; national-level data on mains electricity is available for selected African countries from Afrobarometer, Round 7 Data; and household-level data on electricity access for selected Asian and African countries are as surveyed by ESMAP, Diagnostic Reports Based on the MTF, with reports on several additional countries forthcoming.

Most countries with large populations lacking electricity access are in Sub-Saharan Africa. The largest of these are Nigeria (89 million), the Democratic Republic of Congo (68 million), and Ethiopia (61 million; Figure 33 and Figure 34). Smaller countries also represent substantial opportunities, especially where populations without access are highly concentrated; in Burundi, for example, the total population is just 11 million, but more than 90 percent of Burundians do not have access to electricity.

In Asia, even though grid electrification rates are high, the potential market of people without access nevertheless remains sizeable at 128 million people. Off-grid solar will continue to play a role as the primary source of electricity for populations in South and South-East Asia that are unlikely to ever have grid connections because of their remoteness or the cost-ineffectiveness of supply.

Future grid connections will somewhat reduce the size of the OGS market for people without access, but this effect will vary with proximity to the grid. In Cambodia, some 62 percent of people without access are within 1 kilometer of a grid connection, compared to 31 percent in Uganda. Even though national grids may reach villages, not all villagers immediately gain a connection. While these "under-the-grid" people represent potential customers for OGS products today, their expectation of receiving a future grid connection may lead them to demand short- to medium-term solutions from OGS products rather than long-term or permanent solutions. By contrast, people without access who predominantly live far from the grid represent a very different potential customer group. The ability to reach all remote people without electricity access is discussed further in Section 2.4.2.

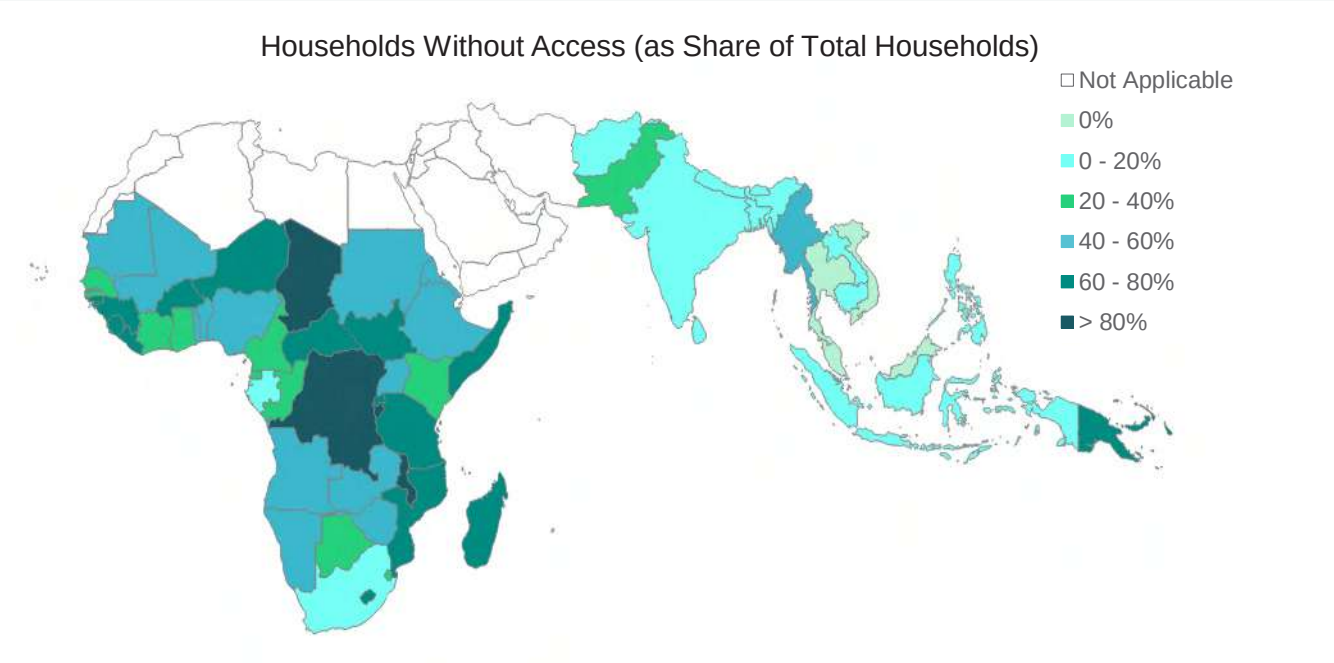
Figure 33: Most of the Population without Access Is in Sub-Saharan Africa



Source: Vivid Economics and Open Capital Advisors analysis of International Energy Agency et al., Tracking SDG 7.

Note: This report focuses on countries with access deficits in Sub-Saharan Africa and Asia–Pacific. (Unshaded countries have high connection rates and relatively high grid reliability.)

Figure 34: By Percentage, More than 80 Percent of Households Lack Access in the Democratic Republic of Congo, Malawi, Chad, and Burundi



Source: Vivid Economics and Open Capital Advisors analysis of International Energy Agency et al., Tracking SDG 7.

Note: This report focuses on countries with access deficits in Sub-Saharan Africa and Asia–Pacific. (Unshaded countries have high connection rates and relatively high grid reliability.)

THE UNRELIABLE GRID MARKET IS INCREASINGLY SERVED BY (MOSTLY) LARGER-CAPACITY OGS PRODUCTS, PROVIDING BETTER SECURITY OF ENERGY SUPPLY TO HOUSEHOLDS AND MICROENTERPRISES AND POTENTIALLY HIGHER MARGINS AND TURNOVER TO OGS COMPANIES.

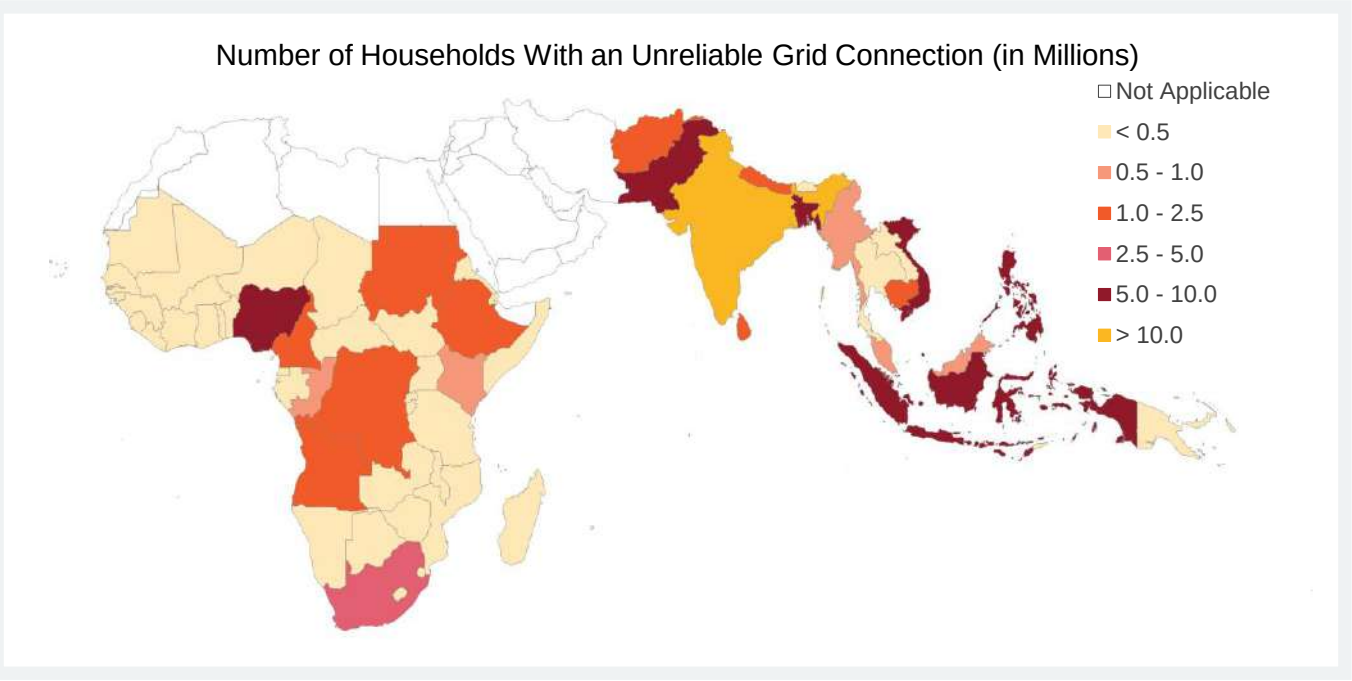
People using unreliable grid connections could offer a large market for OGS products, including microenterprises, which often demand larger-capacity systems as a backup for grid outages. Especially in rural areas, many people connected to main grids receive fewer than 12 hours of supply a day, experience voltage surges and low-voltage days that damage or limit the use of appliances, or both.[185] People with unreliable grid connections often use alternative sources of energy, such as disposable or rechargeable battery-powered torches, (sometimes-

185 Abhishek Jain et al., Access to Clean Cooking Energy and Electricity: Survey of States 2018 (New Delhi: Council on Energy, Environment & Water, November 2018), https://www.ceew.in/publications/access-clean-cooking-energy-and-electricity; Vivek Sen and Saloni Sachdeva, "Post Saubhagya: Moving Beyond Connections to Quality of Supply," Shakti Sustainable Energy Foundation (blog), March 12, 2019, https://shaktifoundation.in/post-saubhagya-moving-beyond-connections-to-quality-of-supply/; Sreekumar Nhalur, Ann Josey, and Manabika Mandal, "Rural Electrification in India: Looking Beyond 'Connections for All' to 'Power for All,'" Economic and Political Weekly 53, no. 45 (November 17, 2018), http://www.prayaspune.org/peg/publications/item/399-rural-electrification-in-india-from-connections-for-all-to-power-for-all.html; and Prayas (Energy Group), "Electricity Supply Monitoring Initiative (ESMI)," published March 2015, https://www.prayaspune.org/peg/resources/electricity-supply-monitoring-initiative-esmi.html.

subsidized) kerosene for basic lighting, or backup generators for more demanding uses requiring electricity.[186] Much of this unreliable grid market comprises small businesses, which often demand larger-capacity OGS products that need a different business proposition and offer relatively higher margins and revenues for OGS companies.

South Asia and West Africa have the largest share and absolute number of people with unreliable grid connections (Figure 35).[187] Although the number of grid-connected people has increased rapidly in South Asia, almost half have an unreliable grid connection (Figure 36).

Figure 35: The One Billion People with an Unreliable Grid Connection Are Mainly in South Asia



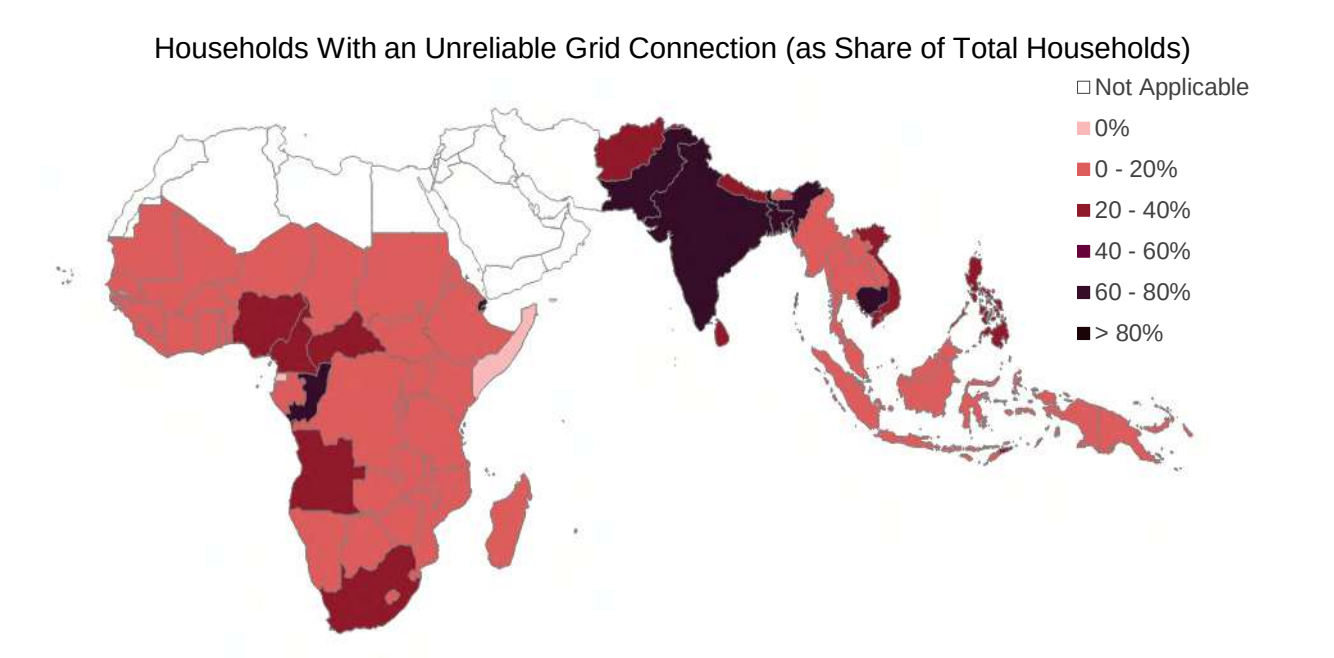
Source: Vivid Economics and Open Capital Advisors analysis of ESMAP, Diagnostic Reports Based on the MTF; Afrobarometer, Round 7 Data; and The World Bank, Enterprise Surveys.

Note: This report focuses on countries with access deficits in Sub-Saharan Africa and Asia–Pacific. (Unshaded countries have high connection rates and relatively high grid reliability.)

186 In some countries, especially in South Asia, where kerosene subsidies are still in place, many households also continue to use kerosene lamps during outages or because they cannot afford electricity. Tara Laan et al., Policy Approaches for a Kerosene to Solar Subsidy Swap in India (Geneva: International Institute for Sustainable Development Global Subsidies Initiative, April 2019), https://www.iisd.org/library/india-kerosene-solar-swap. For a more geographically general discussion of competition for off-grid solar from dirty fuels, see: Nicholas L. Lam et al., The Dirty Footprint of the Broken Grid: The Impacts of Fossil Fuel Back-up Generators in Developing Countries (Washington, DC: International Finance Corporation, September 2019), https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/financial+institutions/resources/dirty-footprint-of-broken-grid; and Prabhakar Yadav, Anthony P. Heynen, and Debajit Palit, "Pay-As-You-Go Financing: A Model for Viable and Widespread Deployment of Solar Home Systems in Rural India," Energy for Sustainable Development 48 (February 2019): 139–53, https://doi.org/10.1016/j.esd.2018.12.005.

187 The share of unreliable grid connections is based on three sources, in order of robustness: (1) the data underlying ESMAP's Beyond Connections reports, available for seven countries; (2) the Afrobarometer Round 7 survey results; (3) and the World Bank Enterprise Surveys. The answer buckets for these surveys were slightly different, but we only include the share of people who responded their grid was "unreliable" or "very unreliable," which means we only include the share of people who experience serious capacity or availability limitations of their grid electricity, frequent outages, or damaging voltage fluctuations. We do not include slightly unreliable connections (households that experience only occasional outages).

Figure 36: By Percentage, Many Households in Asian Countries Still Receive an Unreliable Supply



Source: Vivid Economics and Open Capital Advisors analysis of ESMAP, Diagnostic Reports Based on the MTF; Afrobarometer, Round 7 Data; and The World Bank, Enterprise Surveys.

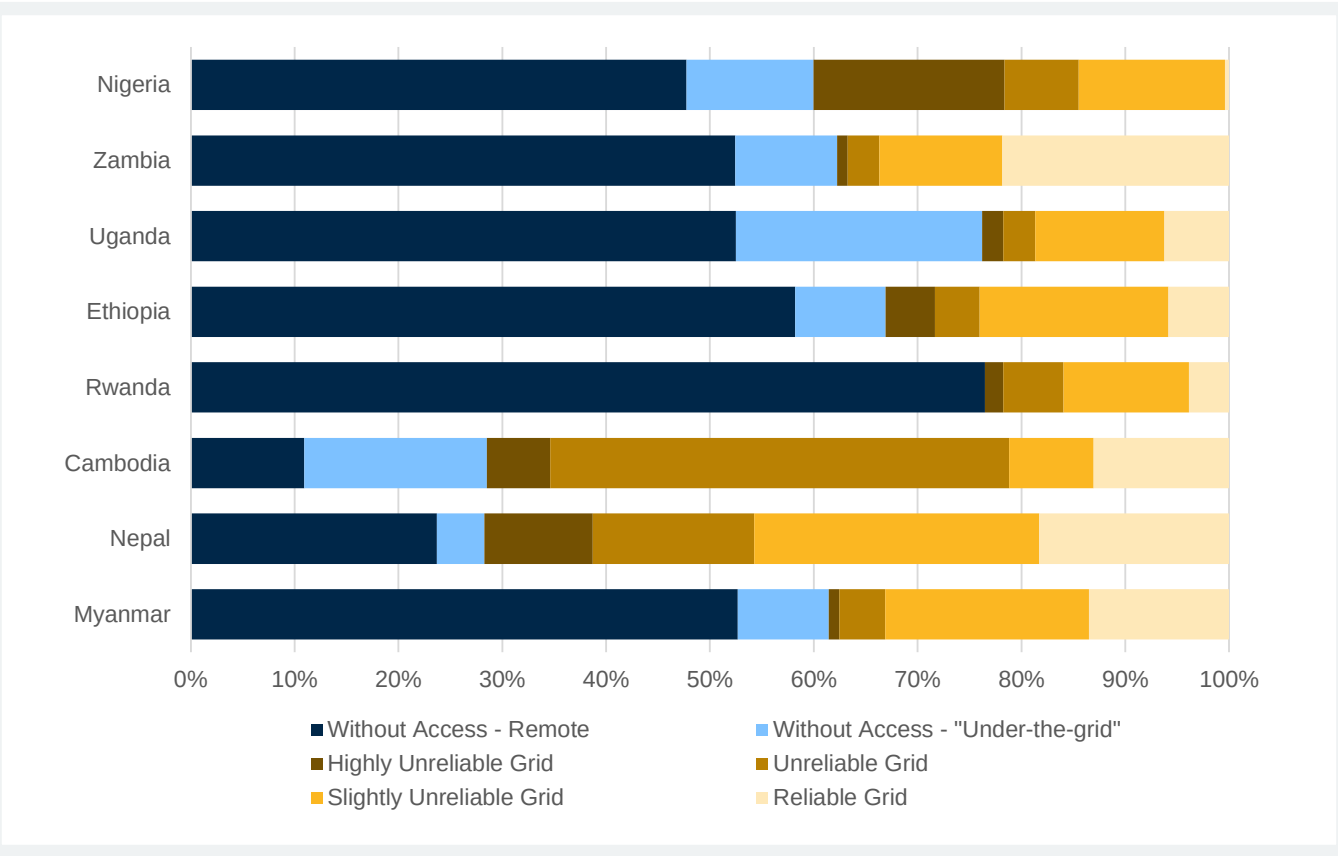
Note: This report focuses on countries with access deficits in Sub-Saharan Africa and Asia–Pacific. (Unshaded countries have high connection rates and relatively high grid reliability.)

Regional estimates of unreliable grid mask varying levels of service among countries (Figure 37).[188] In Sub-Saharan Africa, 34 percent of grid-connected people have an unreliable grid, although this percentage is much higher in individual countries like Malawi or Guinea, where over half of the grid-connected people report not having electricity "half of the time."[189] Similarly, while a relatively high share of households in Cambodia and Nepal are connected to the grid, only a small proportion receive reliable service.

188 The ongoing Multi-Tier Framework surveys measure the reliability of grid electricity in high detail, with data currently available for three countries in South East Asia and six countries in Sub-Saharan Africa. The surveys assess numerous attributes of household-level energy access, including the quality of grid electricity, as determined by the incidence of high-voltage surges that can damage electrical appliances, and its reliability, as measured by the frequency and duration of outages. ESMAP, Diagnostic Reports Based on the MTF.

189 Afrobarometer, Round 7 Data.

Figure 37: Many Grid-Connected Households Experience Poor Reliability of Supply



Source: Vivid Economics and Open Capital Advisors analysis of ESMAP, Diagnostic Reports Based on the MTF.

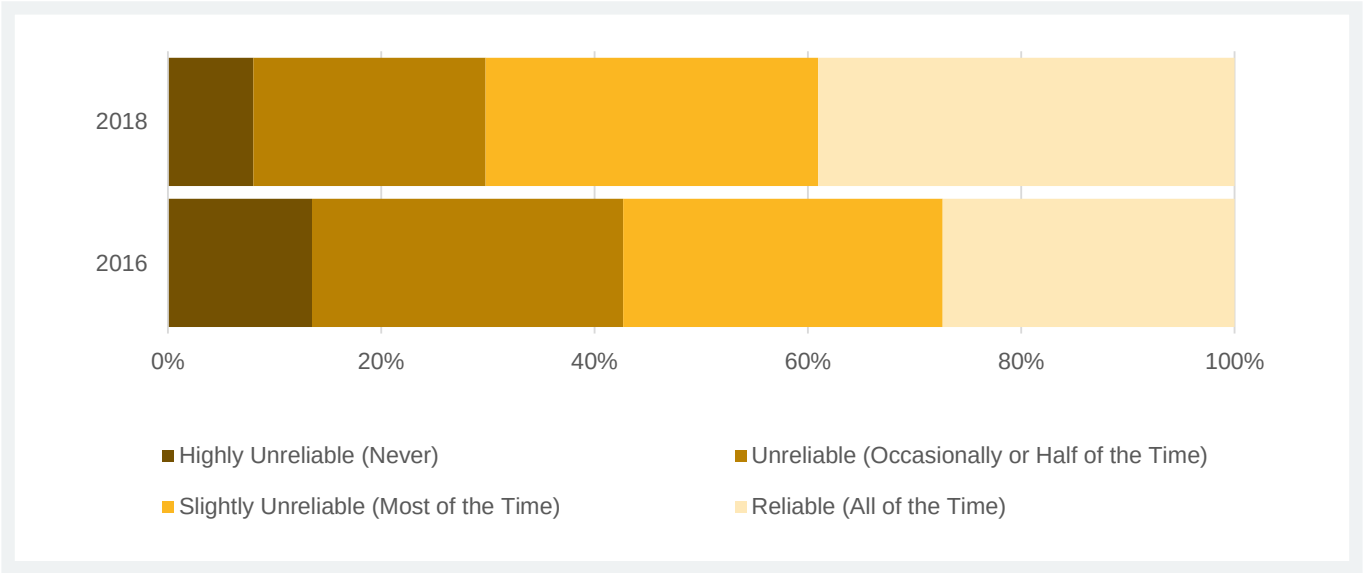
Note: In percent of households. MTF surveys gathered household-level data on electricity access for these eight selected Asian and African countries. Results for Nigeria are only from Kano and Kaduna states.

People connected to unreliable grids represent a growing market for OGS, as they see the demonstration effect of reliable OGS electrical service. By and large, these potential customers are easier to reach and better able to afford the higher levels of service to which they are accustomed. Although average grid reliability in Sub-Saharan Africa is improving overall (Figure 38), in some countries, it is remaining constant or even getting worse.[190] Nigeria, Cameroon, Malawi, and Mali, recorded worsening scores for grid reliability between 2016 and 2018.[191]

190 Catherine Wolfram, "The Developing World Is Connecting to the Power Grid, but Reliability Lags," Energy Institute Blog, May 30, 2017, https://energyathaas.wordpress.com/2017/05/30/the-developing-world-is-connecting-to-the-power-grid-but-reliability-lags/.

191 Afrobarometer, Merged Round 6 Data (36 Countries) (2016), http://afrobarometer.org/data/merged-round-6-data-36-countries-2016; and Afrobarometer, Round 7 Data.

Figure 38: Main Grid Reliability Has Improved on Average across Sub-Saharan Africa over the Last Few Years



Source: Vivid Economics and Open Capital Advisors analysis of Afrobarometer, Round 6 Data, and Afrobarometer Round 7 Data.
Note: The categories in this graph refer to answers to the question "How often is electricity actually available from this connection?" (if respondent had indicated they have an electric connection to their home from the mains) from the Afrobarometer surveys.

While the total potential unreliable grid market is large (more than 1 billion people), only a subset comprises realistic customers for OGS backup energy products. Market penetration remains low against a large number of people with unreliable grid connections. Countries for which data are available, supported by consultations with industry stakeholders, suggest that OGS devices currently reach only 5 percent or less of unreliable-grid users, even in markets where the grid is very weak.[192] Competing solutions to OGS, such as battery storage which is charged whenever grid electricity is available or diesel generators, remain viable options for these people. Moreover, rather than purchasing large OGS devices to fully meet their energy needs, some people may simply decide to wait in the expectation that the quality of grid electricity will improve over time (Box 10). Nonetheless, anecdotal evidence and interviews with companies show that OGS companies increasingly view unreliable grid populations as an important growth market, particularly in South Asia. As a benchmark of what could be reached in the coming 5 to 10 years, we believe one in four people with an unreliable grid connection may also buy an OGS product, which would bring the realistic market down from more than 1 billion to around 250 million people.

192 Based on data underlying ESMAP, Diagnostic Reports Based on the MTF.

Box 10: What Happens when the Grid Arrives? Evidence from India, Bangladesh, and Nigeria

Even in countries with high electrification rates, OGS continues to have a role to play, often as a secondary source of electricity to boost the quality of supply. The three examples below explore the role of OGS products alongside an unreliable main grid. In India and Bangladesh, the grid reaches the vast majority of the population, yet households still seek OGS products even once connected to the grid, to boost reliability. In Nigeria, households with grid connections have very unreliable connections, with households spending more on standalone generator sets than on consumption from the grid. Here, larger OGS products are emerging specifically to serve the relatively high-consumption segment of households looking to supplement their unreliable grid connections.

India

The Government of India claims nearly 100 percent of households were electrified in March 2019,[193] up from just 43 percent in 2000.[194] Under the Saubhagya scheme, the Government of India (GoI) offered a grid connection to all households that applied and were eligible.[195] Free connections were offered to households living under the poverty line, while those above were required to pay a standard connection fee. Nonetheless, non-grid sources (both solar and diesel generators) continue to compose 16 percent of the rural energy mix for households and 40 percent for enterprises, suggesting the grid does not cover demand.[196]

Reliability of the grid remains low, especially in rural areas; in some of India's largest states, more than 50 percent of electrified rural households get less than 12 hours' supply each day.[197] A regular monitoring initiative shows that 57 percent of monitored areas experience outages of more than 15 hours.[198] State-owned power utilities have little incentive to improve supply since electricity rates are kept low by regulation. Therefore, even if consumers would be willing to pay more for higher-quality service, producers would not perceive a corresponding price signal under the current system.[199]

Bangladesh

In Bangladesh, the IDCOL-led SHS program reached more than 4 million households by 2018, but sales have slowed from a peak of 80,000 per month to around 4,000 per month as the grid has expanded. While demand from people without electricity access has declined as national electrification rates have increased, serving weak grid customers (especially enterprises) with backup solar devices can offer OGS companies an entirely new market to serve. 63 percent of firms currently own or share a backup generator, reflecting a significant potential commercial market.[200]

Nigeria

The collective capacity of Nigeria's gasoline generators exceeds by eight times the capacity of Nigeria's entire national grid, which even at its peak is insufficient for current consumption needs.[201] With Nigerians spending US$ 12 billion each year buying and operating small gasoline generators, this backup market represents an interesting opportunity for OGS suppliers.

193 REC Limited, "Saubhagya Dashboard," https://saubhagya.gov.in/.

194 Shalu Agrawal, Nidhi Bali, and Johannes Urpelainen, Rural Electrification in India: Customer Behaviour and Demand (New Delhi: Smart Power India, February 19, 2019), https://www.rockefellerfoundation.org/report/rural-electrification-india-customer-behaviour-demand/, 2.

195 A village is considered electrified if 10 percent of households are electrified and electricity is provided to public places such as schools and community centres. A household is considered "willing" if they have applied for grid connection, but millions of households chose not to do so. REC Limited, "Saubhagya Dashboard," https://saubhagya.gov.in/.

196 Agrawal, Bali, and Urpelainen, Rural Electrification in India, 2.

197 Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, Odisha, and West Bengal. Jain et al., Access to Clean Energy Survey.

198 Prayas (Energy Group), Electricity Supply Monitoring Initiative, Summary Analysis – May 2019 (Pune, India: Prayas, May 2019), http://www.watchyourpower.org/uploaded_reports.php.

199 Kuwar Singh, "India's Successful Village Electrification Drive Has a Casualty: Solar Appliances," Quartz India, November 20, 2019, https://qz.com/india/1751712/modis-saubhagya-village-electrification-hits-solar-appliance-cos/.

200 The World Bank, Enterprise Surveys.

201 Dalberg, Putting an End to Nigeria's Generator Crisis: The Path Forward (Berlin: Access to Energy Institute, June 2019), https://a2ei.org/resources/uploads/2019/06/A2EI_Dalberg_Putting_an_End_to_Nigeria%E2%80%99s_Generator-Crisis_The_Path_Forward.pdf.

Box 11: Displaced Populations, Whose Energy Needs Are Largely Underserved, Also Provide a Significant Potential Market for OGS at Almost 71 Million People as of End 2018

Of almost 71 million displaced persons (DPs) worldwide as of the end of 2018, the vast majority have minimal access to energy. Over a third (25 million) live in Sub-Saharan Africa, while 7 percent are in South Asia, 4 percent in Southeast Asia, and the rest predominantly are in the Middle East.[202] According to the UN High Commissioner for Refugees' latest strategy for sustainable energy, 97 percent of DPs in camps have limited or no access to electricity.[203]

DPs could represent a strong OGS market, with benefits beyond energy access. Almost 80 percent of DPs are in protracted situations of displacement,[204] creating fertile grounds for vibrant informal markets to emerge, as the IFC found in a 2018 report on the Kakuma settlement in Kenya.[205] In 2018 alone, DPs spent over an estimated US$ 223 million for off-grid lighting.[206] Through OGS products, both displaced people and their host communities can reap economic and social benefits. Examples include job creation (both upstream in the off-grid supply chain and downstream through productive use of OGS products) and reduced gender-based violence (by reducing time spent collecting firewood for cooking and lighting, as well as improving the lighting of public spaces).

Leveraging concessional finance, market-oriented models that depart from traditional procurement are gaining momentum. Humanitarian agencies are moving towards more market-based models offering cash transfers rather than giveaways, while governments and donors are seeking to de-risk these market-based models.[207] For example, in the Kakuma and Kalobeyei settlements in Kenya, several initiatives have promoted OGS solutions in an attempt to catalyze viable commercial operations. OGS suppliers like BBOXX, Azuri, Pawame, Greenlight Planet, and Sollatek have distributed a small number of SHS and solar lanterns within these communities, supported by the Market-Based Energy Access initiative by SNV in collaboration with EnDev and the Moving Energy Initiative.[208] Although these pilot projects demonstrate that commercial sales are possible within these communities, penetration remains low.[209]

DPs decide to purchase OGS despite multiple factors that limit their ability to pay, such their limited ability to work because they lack legal rights to work (and therefore earn incomes) or save. The reason for displacement also affects the ability to pay. People displaced by conflict rather than by poverty, for example, could have higher savings and flows of inward remittances.

202 UN High Commissioner for Refugees, Population Statistics, http://popstats.unhcr.org/en/overview.

203 UN High Commissioner for Refugees, Global Strategy for Sustainable Energy (Geneva: UN High Commissioner for Refugees, 2019), https://www.unhcr.org/5d-b16a4a4, 11.

204 The UN High Commissioner for Refugees defines a protracted refugee situation as one in which 25,000 or more refugees from the same nationality have been in exile for five consecutive years or more in a given host country. UN High Commissioner for Refugees, Global Trends: Forced Displacement in 2018 (Geneva: UN High Commissioner for Refugees, June 2019), https://www.unhcr.org/globaltrends2018/, 22.

205 World Bank, Kakuma as a Marketplace: A Consumer and Market Study of a Refugee Camp and Town in Northwest Kenya (Washington, DC: IFC, April 2018), http://documents.worldbank.org/curated/en/482761525339883916/Kakuma-as-a-marketplace-a-consumer-and-market-study-of-a-refugee-camp-and-town-in-northwest-Kenya.

206 OCHA Services, "Moving Energy Initiative," last updated November 20, 2019, https://data.humdata.org/organization/moving-energy-initiative.

207 United Nations Institute for Training and Research, "Global Plan of Action (GPA) for Sustainable Energy Solutions in Situations of Displacement," last updated October 2018, https://unitar.org/sustainable-development-goals/peace/our-portfolio/global-plan-action-gpa-sustainable-energy-solutions-situations-displacement.

208 UN High Commissioner for Refugees, "Kakuma Camp & Kalobeyei Settlement, Kenya (1 – 31 July 2018)," Monthly Operational Update, August 15, 2018, https://reliefweb.int/report/kenya/unhcr-monthly-operational-update-kakuma-camp-kalobeyei-settlement-kenya-1-31-july-2018; and Laura Patel, Faisal Razzaq, and Karin Sosis, Assessing the Potential for Off-Grid Power Interventions in Turkana County with a Focus on the Communities around Kakuma and Kalobeyei (London: Energy 4 Impact, March 2019), https://www.energy4impact.org/smart-communities-coalition-make-change-pilot-assessing-potential-grid-power-interventions-turkana-0.

209 Patel, Razzaq, and Sosis, Off-Grid in Kakuma and Kalobeyei, 30.

2.4.2 The Addressable Market of People without Access or with an Unreliable Grid

THE ADDRESSABLE MARKET FOR A TIER 1 OGS PRODUCT COMPRISES 476 MILLION PEOPLE—OR 70 PERCENT OF THE POPULATION WITHOUT ELECTRICITY ACCESS IN SUB-SAHARAN AFRICA AND ASIA–PACIFIC.

Across Sub-Saharan Africa and Asia–Pacific, 476 million people could afford to pay the monthly installments for a Tier 1 multi-light OGS product.[210] The remaining 240 million people who cannot afford a Tier 1 OGS product are mostly concentrated in Sub-Saharan Africa, which reflects the region's lower ability to pay compared to Asia–Pacific. While this affordability gap persists for quality-verified, Tier 1–enabling products and above, almost all people in these markets can now afford an entry-level, single-light pico product.[211]

PAYGo and other business models offering consumer finance are bringing OGS products within reach of a larger share of the population. While only 476 million people could afford a Tier 1 multi-light system if they were to pay equal monthly installments of the product cost throughout its lifecycle ("theoretical affordability"), 670 million could afford the system by saving the PAYGo deposit over three months and subsequently paying a lower amount per month ("practical affordability"). This leads to a 40 percent increase in the addressable market for this product.[212] The practical affordability approach seeks to account for liquidity constraints and better reflects the reality that the the main barrier to affordability is often considered to be the ability to pay the PAYGo deposit, rather than the full cost of the system over time.[213] The practical affordability approach demonstrates how PAYGo brings higher-capacity systems within reach of a much higher share of the population.

We estimated the addressable markets for different products according to both theoretical and practical affordability in Sub-Saharan Africa (Figure 39) and Asia–Pacific (Figure 40). In Sub-Saharan Africa, most people can afford smaller (below Tier 1) pico products, but some may struggle to get the liquidity needed to pay the PAYGo deposit for for Tier 1 multi-light products; in other words, theoretical affordability for this product is lower than practical affordability. As the entry-level SHS has a longer asset life than the multi-light system, its affordability is higher under theoretical affordability (assuming equal monthly installments over its lifetime). However, even under practical affordability, the entry-level SHS is relatively affordable, if a stretch, for most households.

Affordability will remain an issue for the poorest of the poor. We used an average consumption budget across percentiles of the population, but the distribution of income within each percentile may be uneven. Therefore, affordability is a stronger constraint for the poorest of the poor.

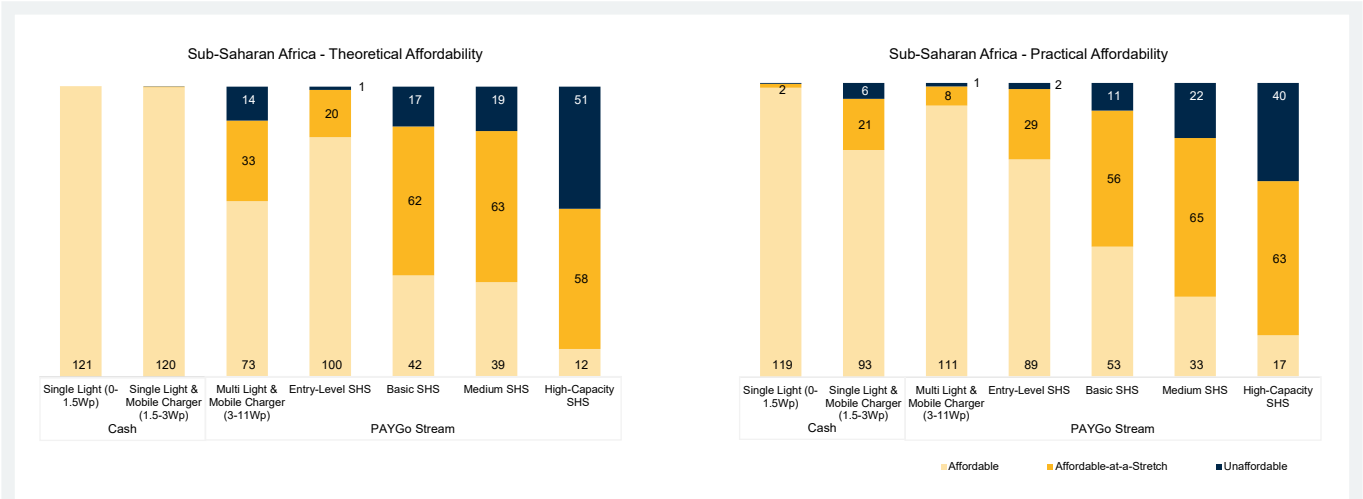
210 "Affordable" means the OGS product costs less than 5 percent of total monthly expenditure. We compare this to the average cost of a high-end pico product (multi-light and mobile charger system) of 3–11Wp, which provides Tier 1 access to at least a person up to a household. Tier 1 access can also be realized with multiple qualifying products but for the purposes of modelling, we assume 1 multi-light system per multi-person household. We use the annualized cost of the system over its lifetime.

211 With non-affiliate products on the market costing as little as US$5 or less.

212 In this calculation, we assume the PAYGo deposit is affordable when it exceeds three months of savings at 5 percent of total monthly expenditure.

213 Vivid Economics and Open Capital Advisors consultations.

Figure 39: The Addressable Market in Sub-Saharan Africa for Different OGS Products (Total Potential Market, 121 Million Households without Electricity Access)



Source: Vivid Economics and Open Capital Advisors.

Note: "Affordable" means the OGS product costs less than 5 percent of total monthly expenditure; "Affordable-at-a-stretch" means the OGS product costs up to 10 percent of overall monthly expenditure for pico products and up to 15 percent for larger systems; and "Not Affordable" means the OGS product costs more than 10 percent of total monthly expenditure for pico products and more than 15 percent for larger systems.

Figure 40: The Addressable Market in Asia–Pacific for Different OGS Products (Total Potential Market, 24 Million Households without Electricity Access)

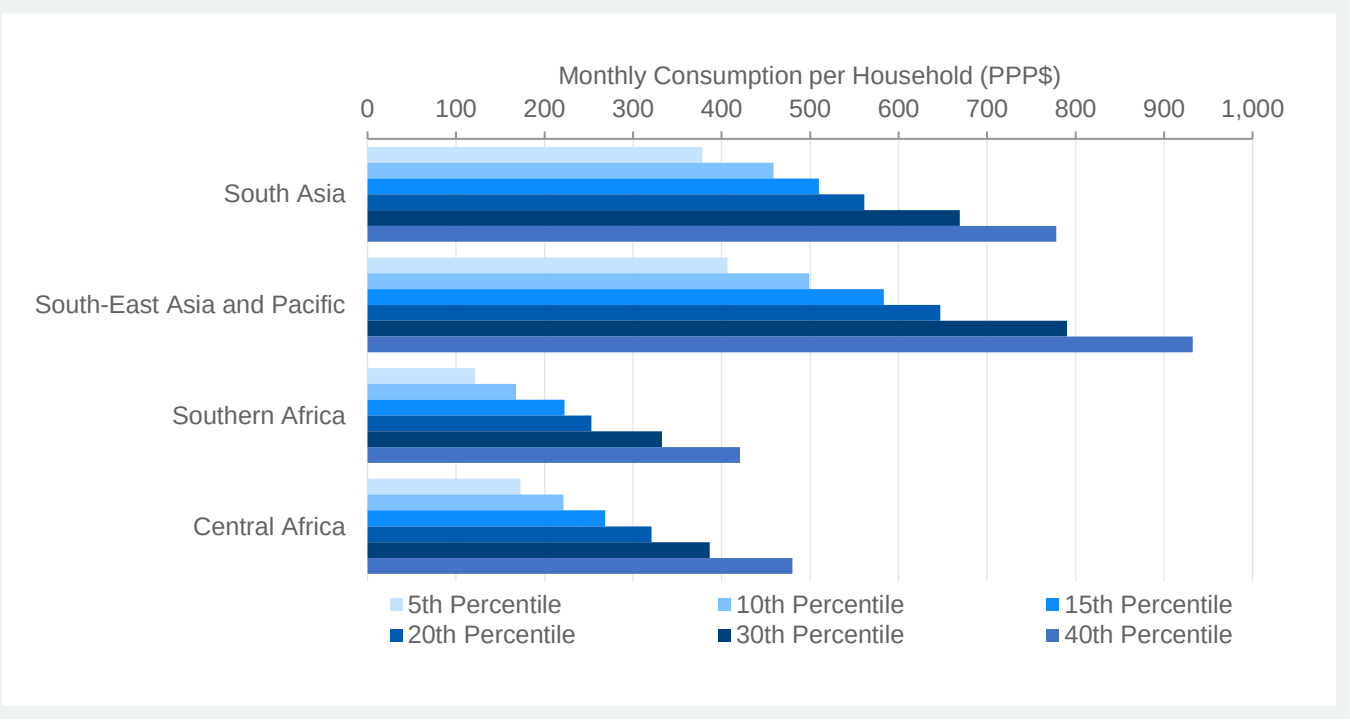
Source: Vivid Economics and Open Capital Advisors.

Note: "Affordable" means the OGS product costs less than 5 percent of total monthly expenditure; "Affordable-at-a-stretch" means the OGS product costs up to 10 percent of overall monthly expenditure for pico products and up to 15 percent for larger systems; and "Not Affordable" means the OGS product costs more than 10 percent of total monthly expenditure for pico products and more than 15 percent for larger systems.

AFFORDABILITY OF OGS PRODUCTS IS CONSTRAINED BY CONSUMPTION BUDGETS, AND THE SHARE OF THAT BUDGET THAT POTENTIAL OGS CUSTOMERS ARE ABLE AND WILLING TO (RE)ALLOCATE TO OGS PRODUCTS AND OGS PRODUCT PRICES.

Low consumption budgets remain a significant constraint to reaching the full potential market, particularly in Sub-Saharan Africa (Figure 41). Current household expenditures are lowest in Central Africa, where for the bottom 5 percent of the population, average household consumption per month is only US$ 137 in PPP-equivalent terms, compared to US$ 359 for the bottom 5 percent in South Asia and US$ 403 in South-East Asia and Pacific.[214]

Figure 41: Affordability Is a Much Larger Constraint in Sub-Saharan Africa Compared to Asia



Source: Vivid Economics and Open Capital Advisors analysis of expenditure data from World Bank, PovcalNet.

Note: Figures presented are the average incomes of households in the 5th, 10th, 15th, 20th, 30th, and 40th percentiles. The distribution of income within each percentile may be uneven.

As a proxy for the affordability of OGS devices we defined three thresholds of consumption expenditure — the proportion of the budget that potential customers are able and willing to spend on OGS (Box 12).

- **Affordable:** the OGS product costs less than 5 percent of the total monthly expenditure.
- **Affordable-at-a-stretch:** the OGS product costs between 5 and 10 percent of total monthly expenditure for pico, cash-based products, or between 5 and 15 percent of overall monthly expenditure for larger systems, mostly delivered through PAYGo.

214 We used data from PovcalNet to build an expenditure distribution for countries across Sub-Saharan Africa and Asia–Pacific (Box 12). World Bank, PovcalNet, http://iresearch.worldbank.org/PovcalNet/povOnDemand.aspx.

- **Not affordable:** the OGS product costs more than 10 percent of total monthly expenditure for pico products and more than 15 percent of overall monthly expenditure for larger systems.

The "affordable-at-a-stretch" threshold reflects both (1) observed ability to pay for smaller systems in some settings, despite requiring restraint of other expenditures, and (2) potential customers' willingness to pay more for OGS products if they can add value (in a bundle with consumer goods) beyond kWh of electricity. Households accessing larger systems, such as medium-to-large SHS, gain access not only to a source of electricity that meets all (or nearly all) of their electricity needs but also to a package of consumer goods, including, for example, a television or radio. For these households, this bundling of goods and energy service means a comparison to a threshold of consumption for energy access is likely conservative and understates affordability, as they would be spending or willing to spend more than this threshold on the combined bundle. Conversely, for smaller pico products, which may provide only partial Tier 1 access, households may need to supplement an OGS device with expenditure on other sources of electricity (such as batteries or kerosene). Nonetheless, analysis of MTF household survey data does suggest that in some countries, households will spend 10 percent or more of consumption expenditure even on small pico systems.[215]

To estimate the affordability of OGS products, we use the upfront outlays for products of different sizes. Device prices range from US$ 3 to US$ 26 for a small, single light to US$ 708 to US$ 1,760 for a high-capacity SHS (both of these ranges are cash prices). To estimate affordability, we use seven stylized OGS products (Table 6).

Table 6: Price Points for Affordability Analysis of Off-Grid Solar Products

OGS Device	Corresponding MTF Tier of Electricity Access Enabled by Use of Product*	Business Model	MTR 2018: Average	MTR 2020: Minimum Price	MTR 2020: Maximum Price	MTR 2020 Cash or Deposit: Average
Single Light (Less than 1.5 Wp)	Partial Tier 1 for one person	Cash	5	3	26	8
Single Light & Mobile Charger (1.5–3 Wp)	Full Tier 1 for at least one person, partial to household	Cash	25	6	50	26
Multi-Light & Mobile Charger (3–11Wp)	Full Tier 1 for at least one person up to full household	PAYGo	20	36	94	15 (deposit)
Entry-Level SHS (11–21 Wp)	Full Tier 1 for a household	PAYGo	36	84	146	28 (deposit)
Basic SHS (21–50 Wp)	Full Tier 2 for a household when coupled with high-efficiency appliances	PAYGo	53	190	495	50 (deposit)
Medium SHS (50–100 Wp)	Full Tier 2 for a household even when using conventional appliances	PAYGo	102	168	892	70 (deposit)
High-Capacity SHS (100+ Wp)		PAYGo	N/A	708	1,760	N/A

Source: Vivid Economics and Open Capital Advisors analysis of Stiftung Solarenergie, "Mangoo Marketplace"; Boyer et al., Pricing Quality in OGS; company websites; and Vivid Economics and Open Capital Advisors consultations with stakeholders.

Note: All prices in US$. The indicative minima and maxima listed are for cash prices and do not include additional costs for delivering through PAYGo. No average is available for high capacity SHS (100+ Wp) given a lack of data. Pico product prices are higher than in 2018 because we considered only online marketplaces, which generally offer products of a higher average price compared to cash-based non-affiliate sales in retail shops.

* Based on GOGLA product categorization.

215 In Ethiopia, households typically spend upward of US$ 84 per year on off-grid lighting and mobile phone charging; in the Democratic Republic of Congo, households may be spending upwards of 25 percent of annual income on lighting and mobile phone charging alone. Additionally, transport costs for trips dedicated to mobile-phone charging can in some cases reach US$ 25 per month. Michael Taylor and Eun Young So, Solar PV in Africa: Costs and Markets (Bonn: International Renewable Energy Agency, September 2016), https://www.irena.org/publications/2016/Sep/Solar-PV-in-Africa-Costs-and-Markets, 10–11. Unsurprisingly, then, an Acumen review suggested that poorer households spend a relatively larger share of their total expenditures on energy compared to wealthier households. Kat Harrison and Tom Adams, An Evidence Review: How Affordable is Off-Grid Energy Access in Africa? (New York: Acumen, March 2017), https://energypedia.info/wiki/Publication_-_An_Evidence_Review:_How_Affordable_is_Off-grid_Energy_Access_in_Africa%3F, 3.

Box 12: Estimating the Addressable Market

To convert the total potential market estimated in Section 2.4.1 into an addressable market, we match the price points of seven different types of OGS products (Table 6) to the three thresholds for the ability to pay described in the main text.

- First, we convert the potential market from millions of people to households using UN country-level estimates of household size.[216]
- Second, we fit a household consumption expenditure distribution to represent the potential customers of OGS products. Using World Bank PovcalNet data on total monthly expenditure by country and number of households in a consumption percentile, we estimate average household consumption per month by population percentile. As a conservative assumption, potential customers of OGS products are proxied by the rural household income distribution. Using the USAID DHS data on population by wealth quintiles,[217] we construct a simple distribution of the number of households within and across percentiles by assuming a uniform distribution between percentiles for all population segments.
- Third, as set out in the main text, we define three ability and willingness to pay thresholds based on the share of monthly expenditure that a typical household would be able to spend on electricity. These thresholds are based on a literature review, with the most recommended consumption thresholds for energy access expenditure ranging between 5 and 10 percent.[218]
- Fourth, we define price points for theoretical and practical affordability, which build on the average prices for each type of product (Table 6). For theoretical affordability, we evaluate the annualized cost of the system over its lifetime. For practical affordability, we compare three months of savings to make the full (cash) payment for pico products and to make the PAYGo deposit for larger systems.

WILLINGNESS TO PAY FOR OGS DEPENDS ON AVAILABILITY, RELIABILITY, CONVENIENCE, AND THE PRICING OF OGS PRODUCTS AND THEIR ALTERNATIVES; MARKETING AND CONSUMER AWARENESS CAMPAIGNS ALSO HAVE INFLUENCE.

OGS products compete against a range of alternatives, including connecting to the grid (where available), mini-grids, battery-operated torches, (sometimes-subsidized) kerosene, and backup generators.[219] Currently connected or "under-the-grid" households and microenterprises that face high connection costs or high tariffs for

216 United Nations Department of Economic and Social Affairs, Population Division, "Household Size and Composition Around the World 2017," data booklet, https://www.un.org/en/development/desa/population/publications/pdf/ageing/household_size_and_composition_around_the_world_2017_data_booklet.pdf.

217 Demographic and Health Surveys, DHS Data, https://dhsprogram.com/data/.

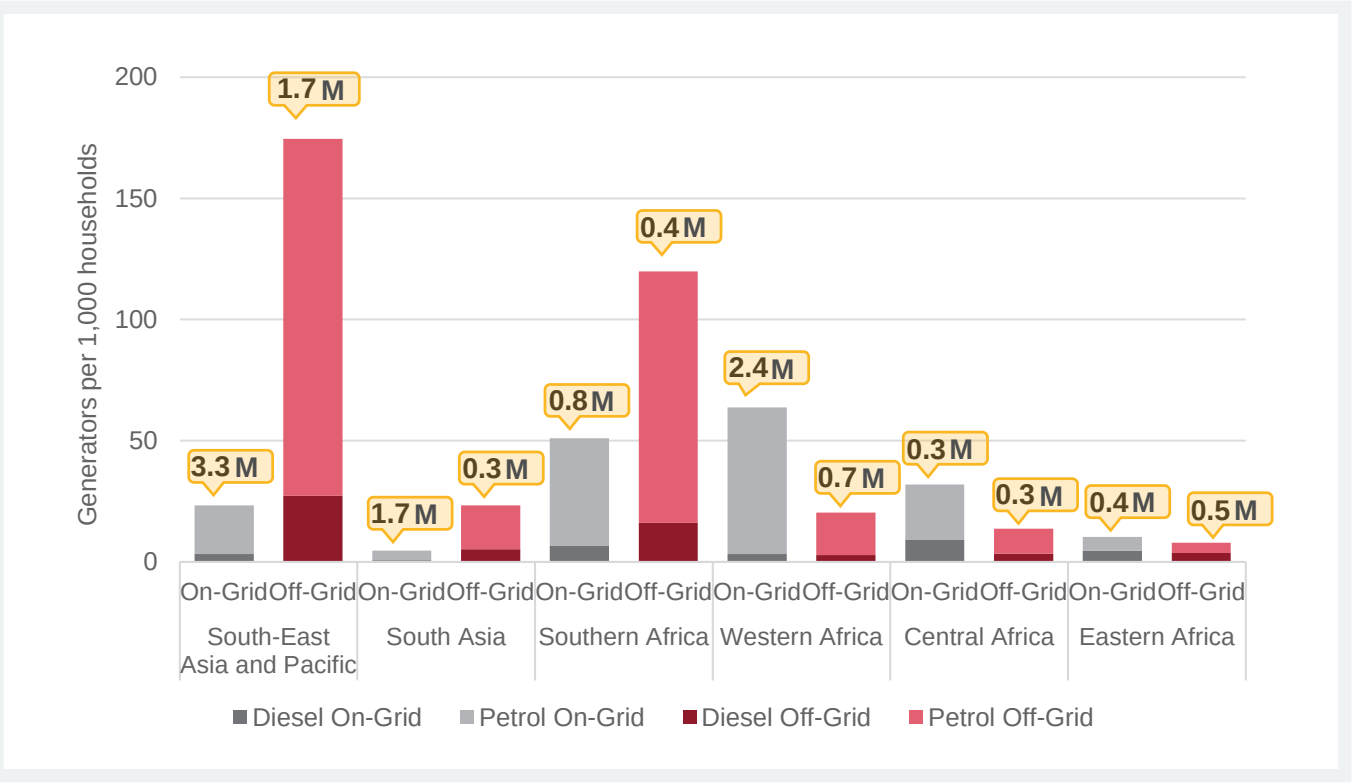
218 Catalyst Off-Grid Advisors and E3 Analytics, Energizing Finance: Taking the Pulse 2019 (Vienna: Sustainable Energy for All, October 22, 2019), https://www.seforall.org/publications/energizing-finance-taking-the-pulse-2019; ESMAP, Regulatory Indicators for Sustainable Energy (Washington, DC: World Bank, 2018), http://documents.worldbank.org/curated/en/553071544206394642/pdf/132782-replacement-PUBLIC-RiseReport-HighRes.pdf; Rudolf Schuessler, "Energy Poverty Indicators: Conceptual Issues, Part I: The Ten-Percent-Rule and Double Median/Mean Indicators" (Discussion Paper No. 14-037, ZEW, Mannheim, Germany, May 2014), http://ftp.zew.de/pub/zew-docs/dp/dp14037.pdf; Dalberg, Off-Grid Appliance Market; Mikul Bhatia and Nicolina Angelou, Beyond Connections: Energy Access Redefined, Technical Report 008/15 (Washington, DC: ESMAP, July 2015), https://www.esmap.org/node/56715; Harald Winkler et al., "Access and Affordability of Electricity in Developing Countries," World Development 39, no. 6 (June 2011): 1037–50, https://doi.org/10.1016/j.worlddev.2010.02.021; and Kristin Komives et al., Water, Electricity, and the Poor: Who Benefits from Utility Subsidies? (Washington, DC: World Bank, 2005), http://documents.worldbank.org/curated/en/606521468136796984/Water-electricity-and-the-poor-who-benefits-from-utility-subsidies.

219 For more on kerosene subsidies and continued kerosene use, see n. 193.

grid electricity may be more willing to purchase OGS alternatives. Potential customers in the Democratic Republic of Congo, Papua New Guinea, and Rwanda should be more willing to consider an OGS product than customers elsewhere, as consumer affordability of grid electricity in these countries (both tariffs and connection fee) is much worse than, for instance, in the Philippines, Indonesia, and Myanmar.[220]

For electricity needs beyond the basics, households, and microenterprises currently using backup generators are potential customers for larger OGS products—if those products can provide the same (or better) quality of service. In South Asia, grid-connected and off-grid people are almost equally likely to use a generator, suggesting that demand for backup energy systems may not necessarily be eroded by higher rates of grid electrification (Figure 42). Off-grid households, however, spend larger amounts on fuel than on-grid households, using their generators more intensively (Figure 43).[221]

Figure 42: Generators Are More Commonly Used by Grid-Connected People in East, Central, and West Africa and by Off-Grid People Access in Southern Africa and Asia

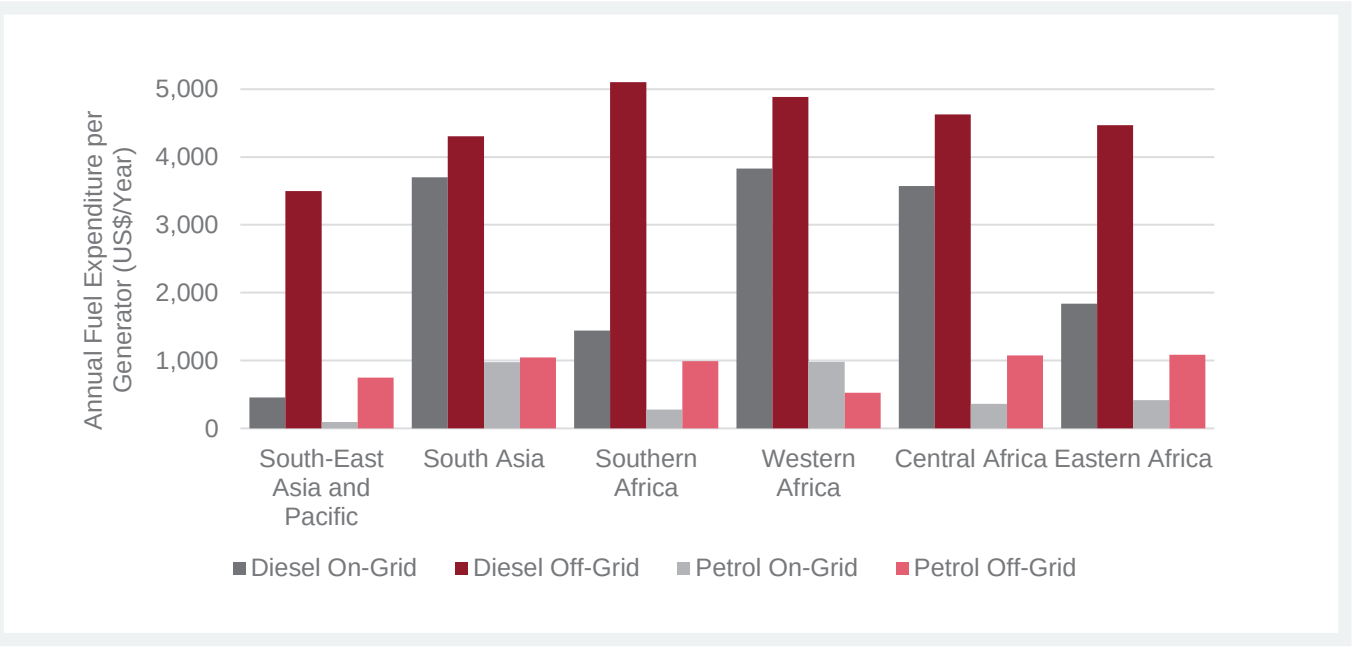


Source: Vivid Economics and Open Capital Advisors analysis of data from Lam et al., Dirty Footprint of the Broken Grid.
Note: The yellow boxes represent the total, absolute number of diesel and petrol generators used by on- and off-grid households in each different region.

220 ESMAP, Regulatory Indicators for Sustainable Energy.

221 Vivid Economics and Open Capital Advisors analysis of the data underlying Lam et al., Dirty Footprint of the Broken Grid.

Figure 43: Off-Grid People Spend More on Fuel than On-Grid People, Using Their Generators More Intensively



Source: Vivid Economics and Open Capital Advisors analysis of data from Lam et al., Dirty Footprint of the Broken Grid.

Beyond affordability, potential customers are typically less willing to pay for a product or service of which they do not know how to use effectively. Indeed, evidence suggests that a lack of information on OGS products is the most common reason for lack of market adoption, with affordability second.[222] Similarly, evidence suggests that direct marketing from OGS companies and general consumer education efforts by development agencies influence rural households' decisions to purchase a solar product.[223] This demonstrates that effective sales calls, demonstration campaigns, and radio advertising help to improve literacy about solar technology and, therefore, customers' ability to evaluate the relative benefits of OGS devices. As a result of these efforts, potential customers may be willing to allocate larger amounts of their income to products that they see as highly desirable, especially if these products offer services "beyond energy."

DELIVERING OGS PRODUCTS TO THE ENTIRE ADDRESSABLE MARKET REMAINS A KEY CHALLENGE, AS THOSE LEAST ABLE TO PAY ARE OFTEN THE MOST EXPENSIVE TO REACH.

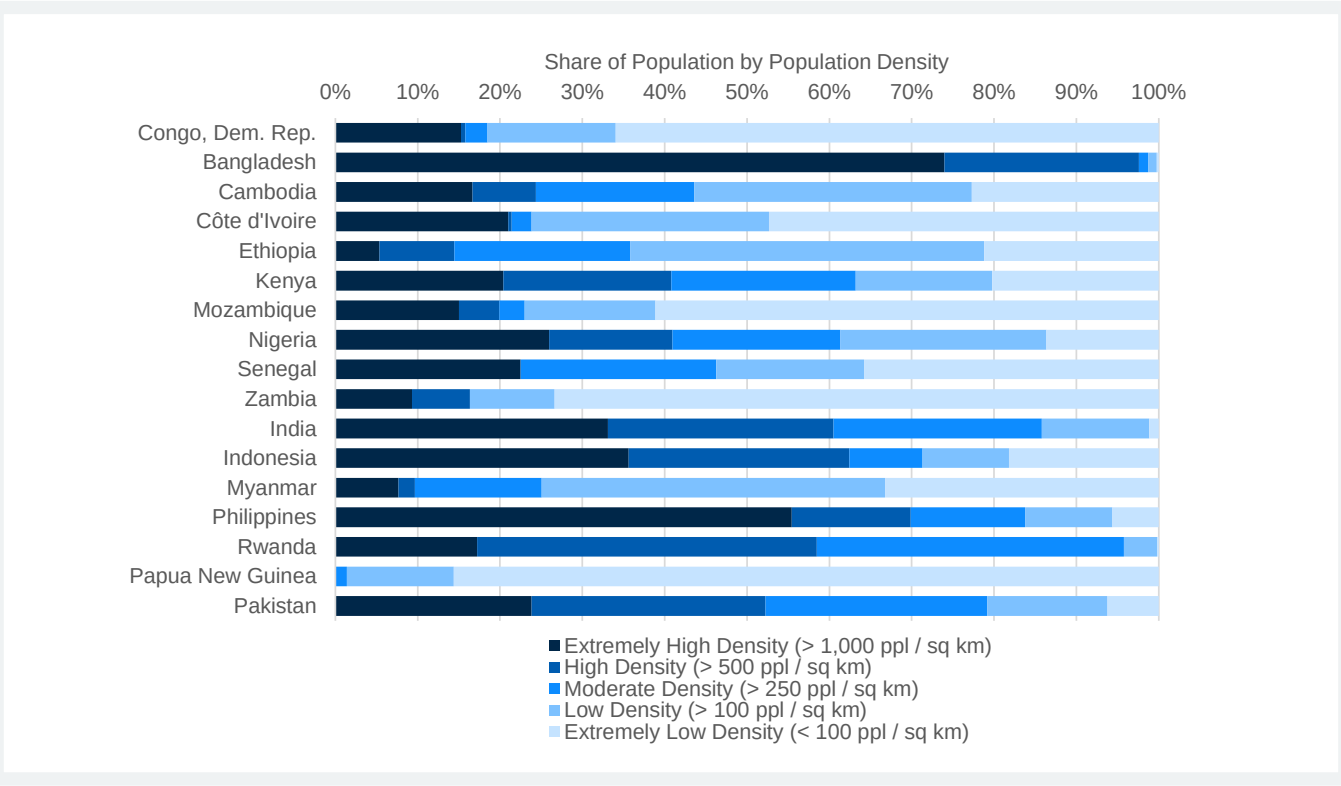
A large share of the remaining people without electricity access are likely to be in deep rural areas that are expensive to reach and likely have very low-income levels. A substantial share of people who could be using OGS products are in areas of low population density that can be costly to reach (Figure 44). In countries with low population density, such as Papua New Guinea, Zambia, or the Democratic Republic of Congo, sales agents can

222 Harrison and Adams, Affordable Off-Grid Africa?, 5.

223 Richa Goyal, Arne Jacobson, and Robin Gravesteijn, "Spotlight: Does PAYGO Unlock Energy Access and Financial Inclusion?," Inclusive Business Voices (iBAN blog), September 17, 2018, https://www.inclusivebusiness.net/ib-voices/spotlight-does-paygo-unlock-energy-access-and-financial-inclusion; and B. van der Kroon, "Climbing the African Energy Ladder: Internal and External Factors Influencing Household Demand for Improved Cookstoves and Modern Fuels in Sub-Saharan Africa" (PhD diss., Vrije Universiteit Amsterdam, 2016), https://research.vu.nl/en/publications/climbing-the-african-energy-ladder-internal-and-external-factors-.

reach only a fraction of the potential customers they could in a higher-density country such as India. Costs are similarly raised for other services, like maintenance, repair, and after-sales support. Poor transport infrastructure and low access to quality roads, furthermore, drive up transportation costs. Fragile and conflict-affected states, especially, face exponentially more difficult logistical barriers and higher concordant costs.

Figure 44: A Substantial Share of People Who Could Be Using OGS Products Are in Areas of Low Population Density, Which May Make Them Hard to Reach



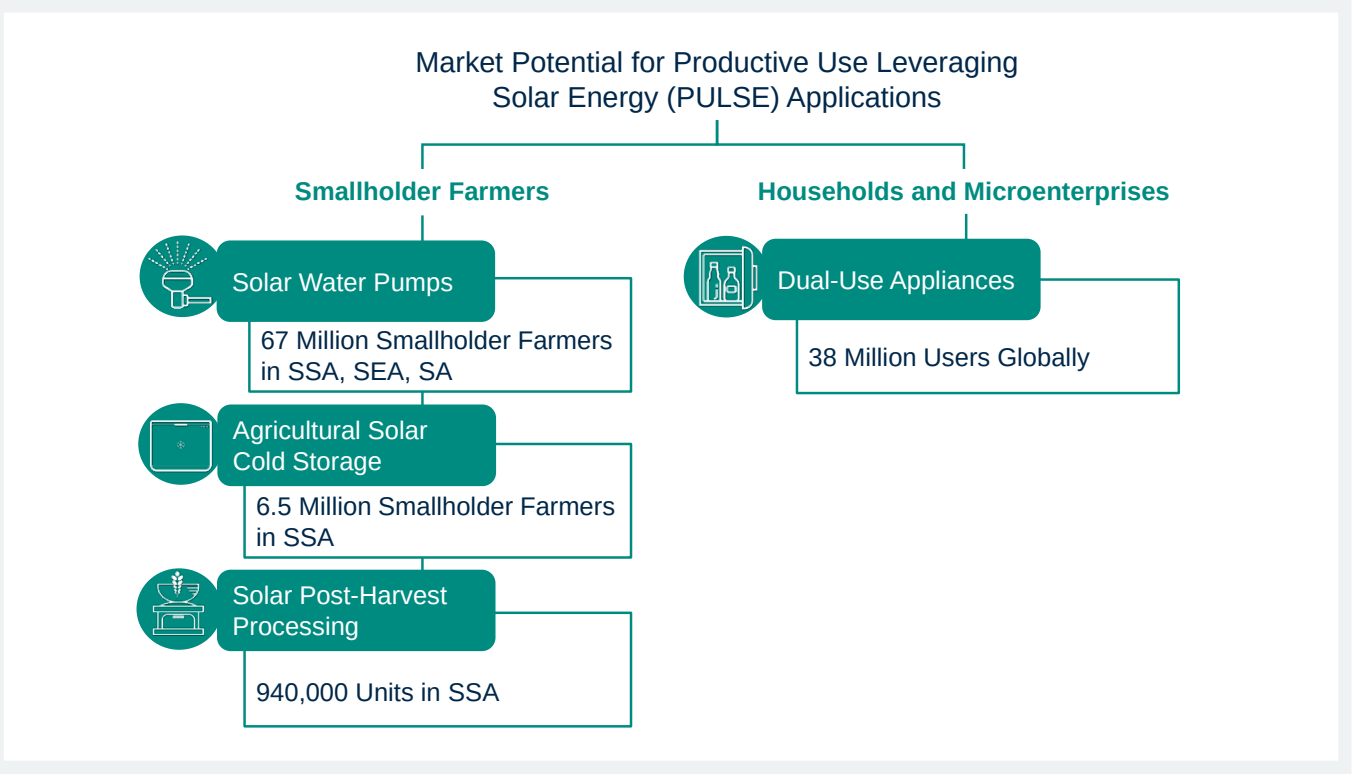
Source: Vivid Economics and Open Capital Advisors analysis of data from the Center for International Earth Science Information Network (CIESIN) at Columbia University. See "Documentation for the Gridded Population of the World, Version 4 (GPWv4), Revision 11, Data Sets," NASA Socioeconomic Data and Applications Center (SEDAC), updated December 2018, https://sedac.ciesin.columbia.edu/data/collection/gpw-v4/documentation.

2.4.3 The Potential Market for PULSE Products among Farmers and Microenterprises

THE GROWING POTENTIAL PULSE MARKET INCLUDES MORE THAN 70 MILLION FARMERS WORLDWIDE AND NEARLY 40 MILLION MICROENTERPRISES.

The OGS market has evolved rapidly beyond lighting for households and microenterprises, offering a range of Productive Use Leveraging Solar Energy (PULSE) applications. Demand for dual-use appliances (providing both residential and productive use services), as well as for solar water pumps (SWPs), cold storage solutions, and solar milling solutions for smallholder farmers, is substantial and expected to grow. Figure 45 provides an overview of the potential market as currently defined by recent studies on PULSE for households, microenterprises, and smallholder farmers.

Figure 45: Overview of Current Market Potential for PULSE

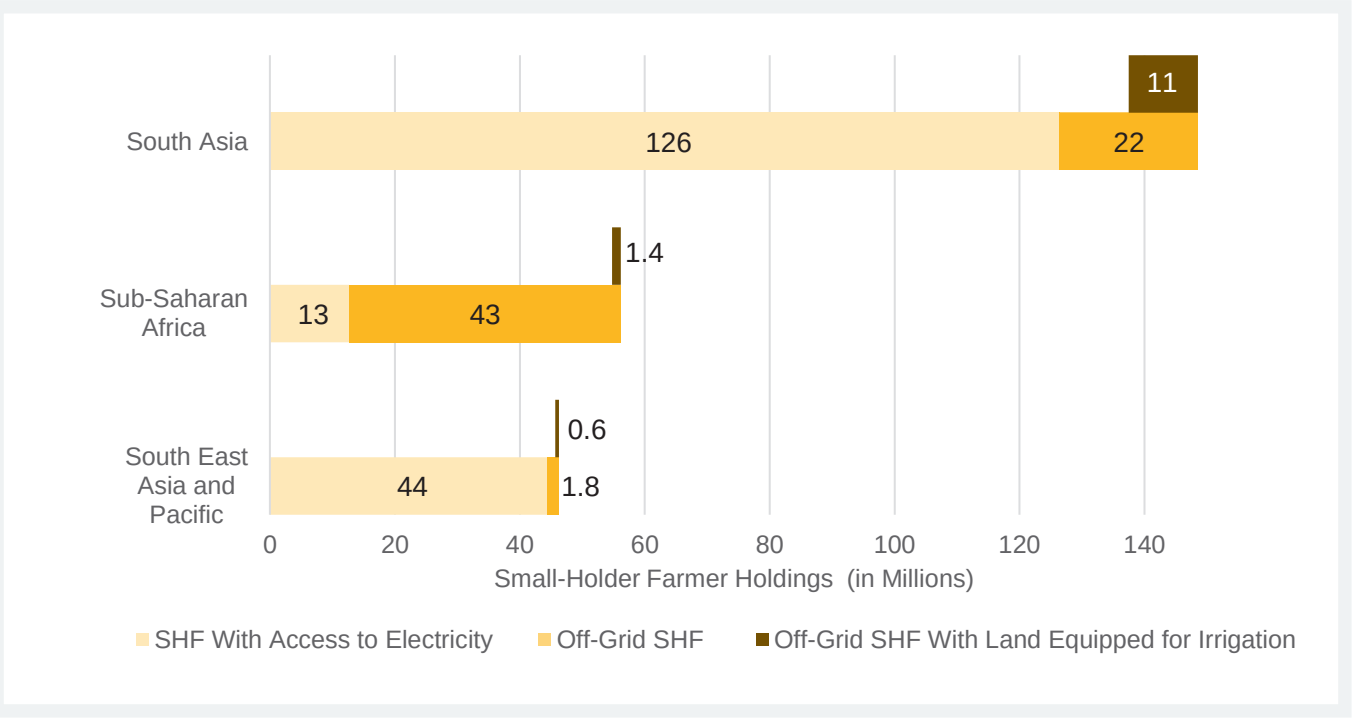


Source: Vivid Economics and Open Capital Advisors analysis of the Food and Agriculture Organization of the United Nations, FAOSTAT, http://www.fao.org/faostat/en/; World Bank, World Development Indicators, https://datacatalog.worldbank.org/dataset/world-development-indicators; national census data; Lighting Global, Market Opportunity for PULSE; and Dalberg, Off-Grid Appliance Market.

SWPs have a potential market of up to 67 million smallholder farmers who are without electricity access in Sub-Saharan Africa, South Asia, and South East Asia. Sub-Saharan Africa is the largest potential market for SWPs, with more than 43 million smallholder farmers lacking access to the main grid (Figure 46). Given the relatively high penetration of the grid in South Asia, the number of smallholders without electricity access in South Asia is

much smaller (22 million), even though South Asia has a larger total number of smallholder farmers than Sub-Saharan Africa. South East Asia has just under 2 million smallholders without grid access. The size of the potential market could be much larger if smallholder farmers with unreliable grid connections are also included across the 3 regions. An approximate total of 75 million smallholder farmers have unreliable grid connections, with 4 million in Sub-Saharan Africa, 62 million in South Asia, and 8 million in South East Asia.[224]

Figure 46: Sub-Saharan Africa Has the Largest Potential Market for SWPs, with 43 Million Smallholder Farmers Lacking Electricity Access



Source: Vivid Economics and Open Capital Advisors analysis of the Food and Agriculture Organization of the United Nations, FAOSTAT, http://www.fao.org/faostat/en/; World Bank, World Development Indicators, https://datacatalog.worldbank.org/dataset/world-development-indicators; and national census data.

Note: The total potential market is calculated by applying the rate of rural electrification to the total number of smallholder plots per region. Of this total, the number of off-grid smallholder farmers with land equipped for irrigation is identified by applying the proportion of agricultural land equipped for irrigation in that region. Land equipped for irrigation refers to land areas equipped with irrigation infrastructure and equipment to provide water to crops that is in working order.

Solar-powered cold storage solutions have a potential market of 6.5 million smallholder farmers in Sub-Saharan Africa alone, who do not currently have access to electricity.[225] This potential market includes demand for small cooling units for low volumes of dairy or horticultural produce, as well as demand for large walk-in storage facilities, which can service more than one smallholder. The specific solutions demanded, depend on the purpose of cold storage and the cost of the system.[226]

Post-harvest PULSE solutions, such as solar mills and threshers, are emerging technologies, with a market potential of 940,000 processing units in Sub-Saharan Africa alone. The potential market for solar-powered post-harvest processing is captured by the proportion of total produce off-grid smallholder farmers process.[227] Further research is needed to tailor this useful initial estimate of potential demand to the specific locations of demand, willingness to pay, and current substitutes.

224 These figures are derived by applying the proportion of grid-connected households with an unreliable grid connection across the three regions to the total number of grid-connected smallholder farmers: 49 percent in South Asia, 17 percent in South East Asia, and 34 percent in Sub-Saharan Africa.

225 Lighting Global, Market Opportunity for PULSE, 22.

226 Lighting Global, Market Opportunity for PULSE.

227 In Sub-Saharan Africa, 38 percent of a total 120 million metric tons (MT) of produce is processed by smallholder farmers, of which approximately 75 percent are off-grid. Therefore, 51.4 million MT of produce processed by off-grid smallholder farmers could be serviced by 940,000 processing units, assuming a capacity of 55 MT per processor unit. Lighting Global, Market Opportunity for PULSE, 23.

Dual-use PULSE appliances—used for both residential and productive use and which include fans, televisions, and refrigerators—have a market of 38 million users in Sub-Saharan Africa and South Asia.[228] Fans enable small and micro-enterprises to work longer and more productively in very hot climates—and have been a major driver of OGS sales in countries like Pakistan. Televisions provide a potential income stream, with 12 percent of off-grid television owners in East Africa showing television for a fee.[229] Refrigerators are primarily used by small businesses to sell cold goods and avoid food spoilage.[230] Despite the large size of the current appliance market, sizeable markets for solar cold storage for micro-enterprises are untapped. In Kenya, for instance, 570,000 micro-enterprises report facing electricity constraints, but penetration of solar refrigeration technology is close to zero. As prices fall and awareness increases, these micro-enterprises could represent a cumulative US$ 20 million market for solar cold storage in Kenya alone.[231] Finally, solar-power electric cookstoves and hand tools such as drills, saws, and hair clippers also show promise, as they could save their relevant micro-enterprises significant time and labor.

AFFORDABILITY, AWARENESS, AND TECHNICAL KNOW-HOW REMAIN BARRIERS TO UNLOCKING THE PULSE MARKET.

PULSE products are in the early stages of market development; achieving scale will require overcoming barriers - including affordability, consumer awareness, and technical capabilities. Of the total potential market, only a proportion of consumers can afford PULSE appliances at current income levels, availability of finance, and existing business models. Additionally, consumer awareness and technical familiarity with these new products remain relatively low.

Low incomes among smallholder farmers limit the affordability of PULSE agricultural appliances in Sub-Saharan Africa. For SWPs, only 13 percent of the potential market could afford a 220-watt pump, assuming a price of US$ 650.[232] Of the total potential market for agricultural refrigeration, only 4 percent could afford a US$ 820, 100-liter refrigerator.[233] Finally, just 6 percent of the potential market for agro-processing technology could afford a US$ 1,625 system able to process 200 kilograms per hour. These product specifications are based on the average-sized SWPs, refrigerators, and pilot agro-processing solutions in the Sub-Saharan African market.[234] The proportion of the total potential market that can afford a solution is the addressable market (Box 13).

228 Dalberg, Off-Grid Appliance Market, 33.

229 Emmanuel de Dinechin, Guillaume de Chorivit, and Oliver Reynolds, Powering Opportunity: The Economic Impact of Off-Grid Solar (Utrecht: GOGLA, July 2018), https://www.gogla.org/resources/powering-opportunity-the-economic-impact-of-off-grid-solar, 56.

230 Dalberg, Off-Grid Appliance Market.

231 Dalberg, Off-Grid Appliance Market, 67.

232 Lighting Global, Market Opportunity for PULSE.

233 Lighting Global, Market Opportunity for PULSE.

234 Lighting Global, Market Opportunity for PULSE.

Box 13: Current and Future Addressable Market for PULSE Technologies

Several recent studies have estimated the current and future addressable market for PULSE.[235]

Table 7: Current and Future Addressable Markets for PULSE Solutions

Segment	Region	Potential Market	Addressable Market 2019	Addressable Market 2030
SWP	Sub-Saharan Africa	5.4 million smallholder (non-subsistence) farmers*	701,000 smallholder (non-subsistence) farmers	2.83 smallholder (non-subsistence) farmers
Solar Cold Storage	Sub-Saharan Africa	6.5 million farmers	225,000 farmers	1.6 million farmers
Solar Agro-Processing	Sub-Saharan Africa	940,000 units	54,000 units	257,000 units
Appliances	Global		38 million households	60 million households

Source: Vivid Economics and Open Capital Advisors based on Lighting Global, Market Opportunity for PULSE; and Dalberg, Off-Grid Appliance Market.

* This number is different from the 43 million number above, because it only includes the estimated number of non-subsistence farmers without access to the grid and with access to water.

Use of PULSE products generates income streams that boost affordability up to three times.[236] SWPs can increase agricultural yields two to three times, depending on crop type and climate conditions.[237] Additionally, given crop cycles, irrigation is unnecessary about 30–40 percent of the time, which could enable smallholders to generate additional revenue by selling or using water or electricity from the solar PV panels for other uses.[238] Smallholders using cold-storage solutions can sell their produce at higher prices because quality upon delivery increases and they can also sell a higher volume of produce because of reduced losses.[239] Similarly, for micro-enterprises, access to PULSE products can more than double daily income. For example, in Uganda, the use of a refrigerator by surveyed micro-enterprises raised business owners' daily incomes by 2.5 times.[240]

However, despite boosted incomes, affordability represents a different challenge in the PULSE market, with repayments to OGS companies heavily dependent on crop yields and timing of revenue. Farmer cash flows depend on a range of factors, of which irrigation is just one. Farmers may correctly deploy and use their SWP technology and still not see increased income to enable repayment if crop yields are low for other reasons. Variation in yields of key crops in selected African and Asian countries (Figure 47) is a proxy for income volatility, as farmer incomes are closely tied to crop yield. (The Democratic Republic of Congo has much lower income volatility compared to Mozambique because the yield from major crops harvested there is relatively invariable.)

235 Lighting Global, Market Opportunity for PULSE; and Dalberg, Off-Grid Appliance Market.

236 This estimate is based on the average size of pilot agro-processing products in the market (150- to 350-watt mills, threshers, and graters). Lighting Global, Market Opportunity for PULSE.

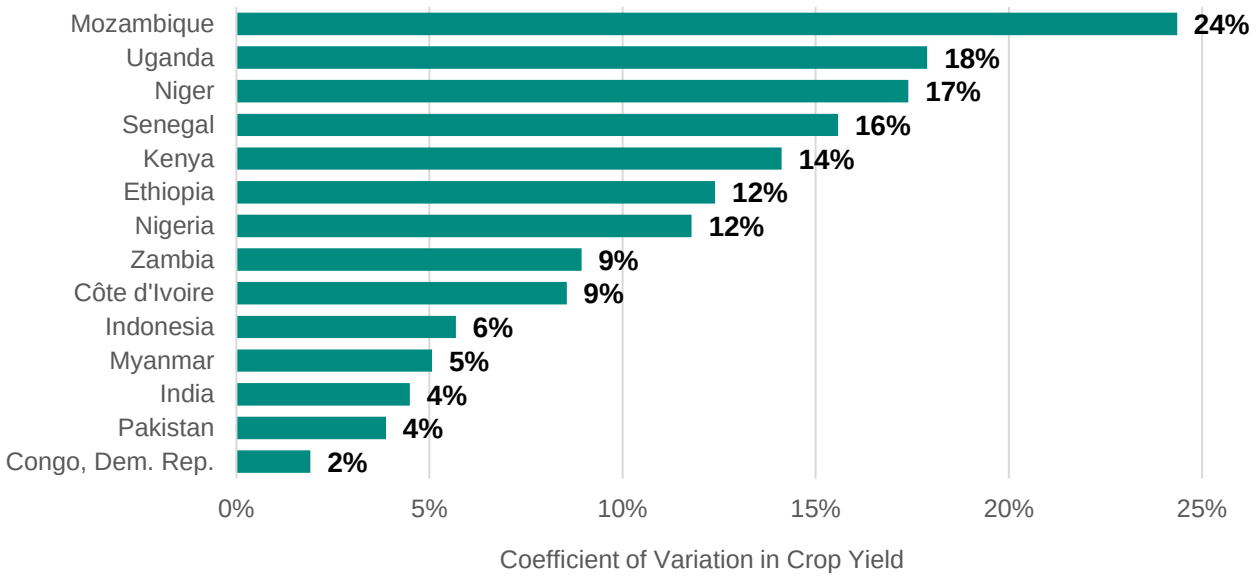
237 Dalberg, Solar Water Pump Outlook, 9.

238 Dalberg, Solar Water Pump Outlook, 18.

239 Lighting Global, Market Opportunity for PULSE, 36.

240 Dalberg, Off-Grid Appliance Market, 11.

Figure 47: Smallholder Income Variability Is Tied to Variability in Crop Yield, which Affects Prices and Overall Smallholder Revenue



Source: Vivid Economics and Open Capital Advisors, based on the Food and Agriculture Organization of the United Nations, FAOSTAT.

Note: Variation in crop yields is used as a proxy for income volatility. The coefficient of variation takes variability in crop yield from 1990 to 2016, weighted by the production of that crop type, for major crop types in each country. This is calculated as the weighted average variation in crop yields for all major crops (all crops contributing at least 5 percent of national output as recorded in FAO statistics).

Business models and payment schemes must be adapted to income levels and seasonality of agricultural income to allow farmers to reap the benefits of increased earnings.

- **Consumer finance can help address affordability constraints, although traditional lending institutions are often reluctant to lend to smallholders.** In Kenya, 70 percent of consumers use loans to acquire SWPs, which would otherwise cost 6 to 12 months of their household income.[241] Traditional lending institutions, however, demand up to 30 percent of the price of the pump upfront, putting financing out of reach for lower-income smallholders—and many financial institutions are unwilling to carry any smallholders' risk profile for a large enough loan to cover a PULSE appliance.[242]
- **The PAYGo business model can help make larger products more affordable by spreading repayments over the life of the asset.** GOGLA sales data show that in H1 2019, affiliates sold 70 percent of solar water pumps through PAYGo, a significant increase from H2 2018 when PAYGo accounted for just 35 percent of sales.[243] This growth in the market share of PAYGo sales shows that OGS companies are addressing barriers to affordability in this segment. Upfront costs can be lowered in favor of a repayment schedule that assumes increased income from the use of the PULSE appliance.
- **An adaptation of PAYGo for the agricultural sector, "Pay-as-you-Grow," is often used to match the collection of payments to times when the farmer is most able to pay—that is, around harvest seasons.** Unlocking the income-generating potential of an SWP may require adjustment and training for farmers, who, by definition, either are not currently using irrigation or are using a different type of irrigation. The repayment cycle must also be carefully calibrated to when farmers are best able to make repayments, avoiding attempts

241 Dalberg, Solar Water Pump Outlook, 18.

242 Dalberg, Solar Water Pump Outlook, 20.

243 GOGLA and Lighting Global, Off-Grid Solar Market H2 2018; and GOGLA and Lighting Global, Off-Grid Solar Market H1 2019.

at collection when farmers are cash-poor (for example, at the beginning of planting seasons, when they need to buy inputs).

- **Government programs and policy can increase the affordability of PULSE solutions by lowering the cost through subsidies or by increasing the availability of finance for smallholders and microenterprises.** Subsidies can be an effective instrument to reduce the upfront cost and ongoing repayments of PULSE solutions. In India, the government is supporting its ambitious SWP deployment targets with a subsidy for those switching from diesel to solar irrigation. As a result, 4.2 million farming households have demanded a pump and can afford one.[244]

As a relatively nascent market, awareness of the technology and benefits from the use of PULSE for irrigation, refrigeration, and agro-processing use may be low among consumers.[245] Survey evidence from Sub-Saharan Africa reveals that 24 percent of those using non-solar irrigation chose that technology because of a lack of awareness or availability of alternative solutions, such as solar water pumps.[246] Additionally, the technical capacity to capture all potential economic gains from the use of these technologies is limited. Smallholder farmers who are currently irrigating manually or with rainwater must learn how to operate and maintain a solar water pump effectively to maximize its benefits in terms of increased crop yield and revenue.[247] On a survey of SWP users, 42 percent of respondents reported experiencing a challenge related to equipment malfunction. Similarly, microenterprises have limited awareness of the differences between commercial and household refrigeration appliances; therefore, consumers that purchase cheaper household refrigerators may find they are not fit for purpose, which could lower overall consumer confidence and demand.[248]

OGS companies and governments will, therefore, need to invest in building consumer awareness and developing technical know-how. Building consumer confidence through marketing and educational campaigns will increase awareness of the potential gains from PULSE appliances. Additionally, training and after-sales support can ensure that customers derive the full economic benefits required to make repayments affordable.

Governments, development partners, and the private sector will need to work together to create the right enabling environment to overcome these barriers in the PULSE market, as discussed further in Section 4.1.

244 Dalberg, Solar Water Pump Outlook, 6.

245 Lighting Global, Market Opportunity for PULSE.

246 Efficiency for Access, Use and Benefits of Solar Water Pumps: Kenya, Tanzania & Uganda (London and Washington, DC: Efficiency for Access, June 2019), https://efficiencyforaccess.org/publications/use-and-benefits-of-solar-water-pumps, 23.

247 World Bank, Solar Pumping: The Basics (Washington, DC: World Bank, 2018), http://documents.worldbank.org/curated/en/880931517231654485/Solar-pumping-the-basics.

248 Efficiency for Access, Off-Grid Refrigeration Roadmap, 20.

2.4.4 The Potential Market for OGS Products to Serve Public Institutions

Access to reliable electricity supports the delivery of key public services. Electrification enables a range of public services by lighting streets, health and education facilities, and public or community spaces and office buildings. Reliable electricity access for public institutions improves safety and security, the quality and efficiency of health and education services, and increases civil service capabilities, among other benefits (Figure 48).

Figure 48: Off-Grid Solar Supports Public-Service Delivery across Five Main Categories

Street Lighting	Increases safety and mobility; improves quality of life and working conditions
Health Facilities	Preserves medicine and vaccines; operates medical equipment; improves staff retention and quality; increases resilience
Educational Institutions	Extends hours of access; enables access to ICT; improves staff retention and teacher training
Community Buildings	Increases cohesion in local communities through improved services at community centres, such as prayer groups and the arts
Public Offices	Improves functioning of civil service through e-governance and access to ICT, as well as enabling longer working hours

Source: Vivid Economics and Open Capital Advisors based on Bhatia and Angelou, Beyond Connections: Energy Access Redefined.

IN MANY COUNTRIES IN SUB-SAHARAN AFRICA (AND TO A LESSER EXTENT IN ASIA–PACIFIC), A SUBSTANTIAL PROPORTION OF HEALTH AND EDUCATION FACILITIES ARE UNCONNECTED TO OR UNDERSERVED BY THE MAIN GRID.

Rural health and education facilities represent a substantial market for OGS products, with most facilities in some countries lacking access to reliable electricity.[249]

- **While only limited data are available on electricity access of health care institutions, access is below 10 percent in some countries with available information.** One study of low- and middle-income countries found that 59 percent of health care facilities lack access to reliable electricity.[250] In Ethiopia, 95 percent of Health Posts (the smallest facility in many health systems, typically staffed with one or more nurses and

249 This report summarizes recent evidence on the rate of electrification of health and education facilities. Less information is available on the rate of electrification of other types of public facilities—such as local government offices, street lighting, and community buildings—which could also represent important potential markets for OGS products as business models continue to adapt to serve demand from public institutions.

250 Ryan Cronk and Jamie Bartram, "Environmental Conditions in Health Care Facilities in Low- and Middle-Income Countries: Coverage and Inequalities," International Journal of Hygiene and Environmental Health 221, no. 3 (April 2018): 409–22, https://doi.org/10.1016/j.ijheh.2018.01.004.

providing basic medical services to small communities) and 82 percent of Health Clinics lack access to electricity,[251] while in the Democratic Republic of Congo, only 9 percent of health care facilities have access to electricity.[252]

- **Just 34 percent of primary schools in Sub-Saharan Africa and 52 percent in South Asia have access to electricity.[253]** Lower and upper secondary schools have higher rates of electrification across regions as compared to primary schools (Table 8).

Table 8: Proportion of Schools in Sub-Saharan Africa, South Asia, and Southeast Asia without Access to Electricity

Country	Primary schools	Lower secondary schools	Upper secondary schools
Sub-Saharan Africa	**66%**	**53%**	**43%**
Democratic Republic of the Congo	91%	86%	86%
Côte d'Ivoire	62%	*	*
Kenya	17%	*	*
Rwanda	26%	15%	12%
Senegal	50%	23%	8%
Togo	75%	46%	17%
Zambia	64%	*	49%
South Asia	**48%**	**32%**	**11%**
Bangladesh	57%	8%	5%
India	51%	34%	10%
Southeast Asia	**16%**	**7%**	**5%**
Indonesia	7%	3%	1%
Myanmar	73%	40%	31%

Source: Vivid Economics and Open Capital Advisors based on UNESCO, UIS.Stat.
* indicates data not available.

WHILE STILL AT A VERY EARLY STAGE, EMERGING PRODUCTS AND BUSINESS MODELS ARE ADAPTED TO SERVE THE DEMAND FROM PUBLIC INSTITUTIONS.

Business models to reach public institutions must overcome three major challenges:

- **Tailoring the technology to the specific and varied needs of public institutions.** The electricity demand of public institutions varies substantially. In the case of health facilities, "health posts," which distribute supplies and treat minor ailments, only need a limited supply of electricity, while "health centers," which provide essential

251 These facilities comprise 98 percent of health facilities in the country. The remaining 2 percent comprise around 300 hospitals, which have a much higher rate of access to electricity, at 70 percent electrified. Federal Democratic Republic of Ethiopia, National Electrification Program 2.0: Integrated Planning for Universal Access (Addis Ababa: Federal Democratic Republic of Ethiopia, 2019), https://minigrids.org/wp-content/uploads/2019/04/Ethiopia-2.0.pdf.

252 Jem Porcaro et al., Lasting Impact: Sustainable Off-Grid Solar Delivery Models to Power Health and Education (Washington, DC: United Nations Foundation; Vienna: Sustainable Energy for All, April 2019), https://www.seforall.org/publications/lasting-impact-sustainable-off-grid-solar-delivery-models, 24.

253 UNESCO, UIS.Stat, http://data.uis.unesco.org/.

primary health services and may store blood and medicines, need between 4 and 10 kWh per day. Hospitals can require as much as 200 kWh per day and are more likely to be grid-connected—although their supply of electricity often suffers from a lack of reliability.[254]

- **Taking into account affordability for the public purse.** The upfront cost of systems poses a major constraint to governments that have limited public budgets, even if OGS products could reduce ongoing expenditure compared to alternative energy supplies.
- **Ensuring sustainability of operational assets.** Ensuring systems are maintained, and operational is a particular challenge when serving public institutions. Systems break down because of a lack of either awareness of the need or the technical capacity to maintain systems.[255] Furthermore, ongoing budget allocations are required to ensure continued operations and management; otherwise, when systems fall out of operation, stakeholders can perceive OGS technologies as too new and unreliable.[256]

Innovative business models and financing structures, including public–private partnership (PPP)–style arrangements are evolving to address these challenges. In one early example of a PPP-style arrangement, the Global Environment Facility's Energy for Rural Transformation (ERT) project in Uganda facilitated access to electricity for 560 schools (including 60 computer labs) and 522 health centers between 2008 and 2016.[257] Under this arrangement, the World Bank took on the financing of upfront capital expenditure as the implementing agency, while the government signed a five-year operations and maintenance contract with private companies. Operations and maintenance remained consistent while the contract was in place, although inadequate provisioning after the contract's expiration has since reduced diligence in repairs.

Further pilots are underway in Niger and Nigeria to improve sustainability and increase private-sector engagement through long-term service contracts. Under these pilots, the World Bank is arranging for private companies to finance the upfront capital expenditures for systems and enter into a 10- to 20-year Power Purchase Agreement (PPA) with governments. To further de-risk these investments, the World Bank is also exploring the use of guarantees and capacity-building with government partners to strengthen payments from the governments under the PPA.[258]

254 Porcaro et al., Sustainable Off-Grid Health and Education, 24.

255 Vivid Economics and Open Capital Advisors consultations.

256 Porcaro et al., Sustainable Off-Grid Health and Education, 12–14.

257 Porcaro et al., Sustainable Off-Grid Health and Education, 73–75.

258 Payments cover both operation and maintenance and repayment of the upfront capital expenditure.

CHAPTER 3
ACCESS TO FINANCE

Photo credit: © M-KOPA/Allan Gichigi

Several signs indicate the industry's growing financial maturity, such as an increase in debt investments and larger investment sizes. As of the end of 2019, the OGS sector has attracted more than US$ 1.5 billion in investment, with growth in the early years primarily driven by equity and debt becoming more common recently. However, a gap is growing between the ability of First- and Second-Generation companies to raise capital. Investments have been highly concentrated, with the top 10 recipients of financing receiving nearly 80 percent of the total value of investment to date. Second-Generation companies have struggled to access finance because of a shortage of equity and grant capital.

Investor types are shifting, with an increased presence of larger strategic investors, specialized debt providers, and crowdfunding; while local bank involvement remains nascent, local currency debt is anticipated to increase. In the sector's early stages, the primary investors included impact investors, venture capital (VC) funds, and development finance institutions (DFIs). At present, later-stage investors, including private equity (PE) funds and strategic corporates, seem tempted to enter the sector in volume but have mostly tested the waters with limited but prominent transactions. Specialized debt providers and crowdfunding platforms have also made notable advancements in the OGS sector and will be important sources of capital moving forward. While local banks remain hesitant to substantively engage in the sector, the currently increasing availability of local currency financing and hedging instruments will enable companies to better manage their foreign exchange risk.

Accelerating funding for the sector will require innovative financing mechanisms, and companies need to demonstrate profitability and increase transparency around operational efficiencies. Some companies are now well on their paths to profitability and positive cash flows. Other barriers to further investment are also being addressed, such as standardizing Key Performance Indicators (KPIs), increasing transparency around operational efficiencies, and understanding fundamental unit economics. Meanwhile, we anticipate newer debt mechanisms, such as off-balance-sheet financing, will expand in availability, and, while larger commercial lenders are still exploring the sector, key stakeholders recognize their presence as critical to increasing available debt investment. Other innovative forms of financing, such as climate or social bonds, could also increase access to debt.

The remainder of this chapter proceeds as follows:

- **Section 3.1** examines historical investment trends in the sector and discusses the role investors and local currency financing will play in catalyzing the sector's growth.
- **Section 3.2** highlights barriers the sector faces to attracting capital and how stakeholders can work towards overcoming them.

3.1 Investment Trends

KEY MESSAGES

- Companies in the OGS sector have cumulatively raised more than US$ 1.5 billion through 2019.
- While a growing appetite for debt financing indicates that the sector is maturing, the sector's growth is limited by shortages of equity and grant capital, particularly for Second-Generation companies.
- Investments have been highly concentrated, with the top 10 recipients of financing receiving 78 percent of total investment to date.
- Investor types are shifting, with an increased presence of larger strategic investors, specialized debt providers, and crowdfunding.
- While local bank involvement remains nascent, local currency debt is anticipated to increase, which will enable companies to better manage their foreign exchange risk.

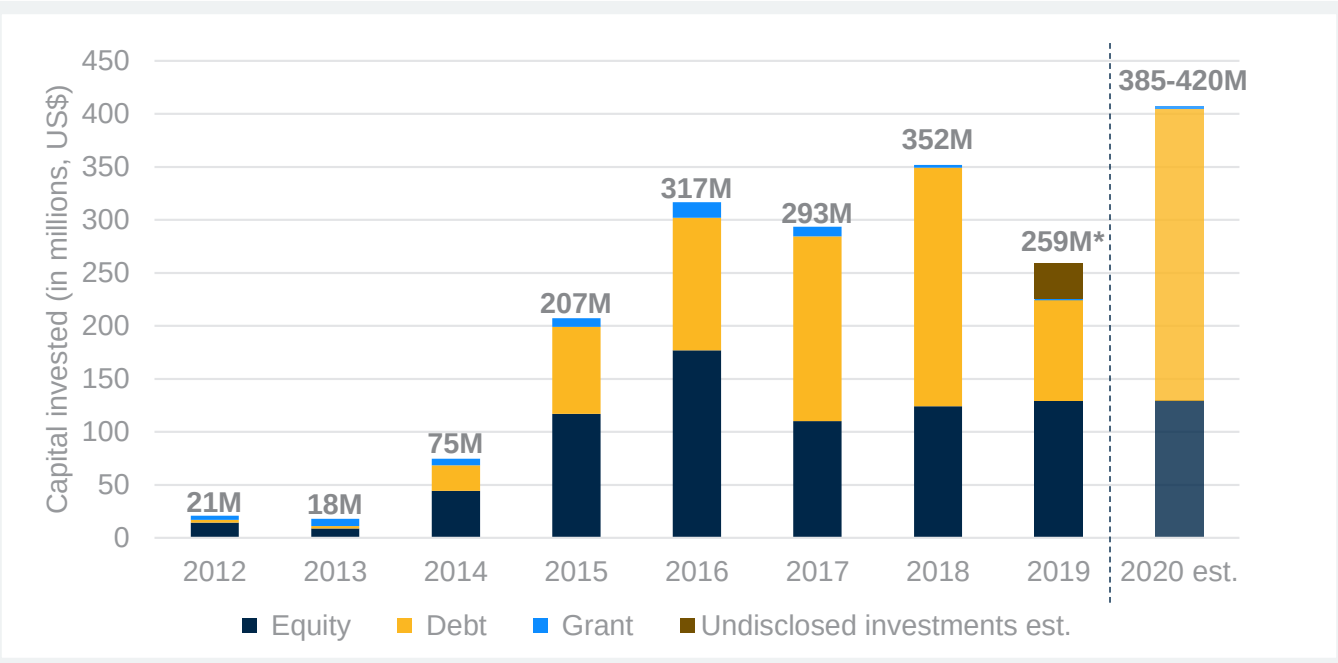
Photo credit: © CLASP

3.1.1 Historical Investment Trends

SEVERAL SIGNS INDICATE THE INDUSTRY'S GROWING FINANCIAL MATURITY, SUCH AS AN INCREASE IN DEBT INVESTMENTS AND LARGER INVESTMENT SIZES.

As of the end of 2019, the OGS sector has attracted more than US$ 1.5 billion in cumulative investment, with growth in the early years primarily driven by equity and debt becoming more common recently.[259] From 2012 to 2018, capital investments in the OGS sector grew at a 50 percent compound annual growth rate (CAGR), with investments in 2018 reaching an all-time high at US$ 352 million (Figure 49). The decline in 2019 in the yearly value of investments should not cause concern but is rather symptomatic of (1) the concentration of investments in First-Generation companies, which raise debt funds cyclically, and (2) the long time horizons on large debt deals. Many First-Generation companies raised significant debt in 2017/18, so the decline in 2019 is unsurprising; several First-Generation companies are expected to close large debt financing rounds again in 2020. Besides, increasingly large and complex debt deals are taking longer to close, with the anticipated announcement of around US$ 100 million in debt delayed from 2019 to early 2020. This puts 2020 on course to be a bumper year for debt investments, potentially driving total annual investment to an estimated all-time high of US$ 385–420 million.

Figure 49: Capital Invested by Type (2012–2019, 2020 Estimated)



Source: Open Capital Advisors and Vivid Economics analysis of GOGLA, Deal Database.

Note: The GOGLA database does not include 2019 investments. As such, deals have been sourced from secondary research and publicly available information. Undisclosed investments for 2019 are included based on investment trends from 2016 to 2018; 2020 estimates are based on current investment trends and deals that are expected to be announced in the first quarter of 2020 after failing to close in 2019.

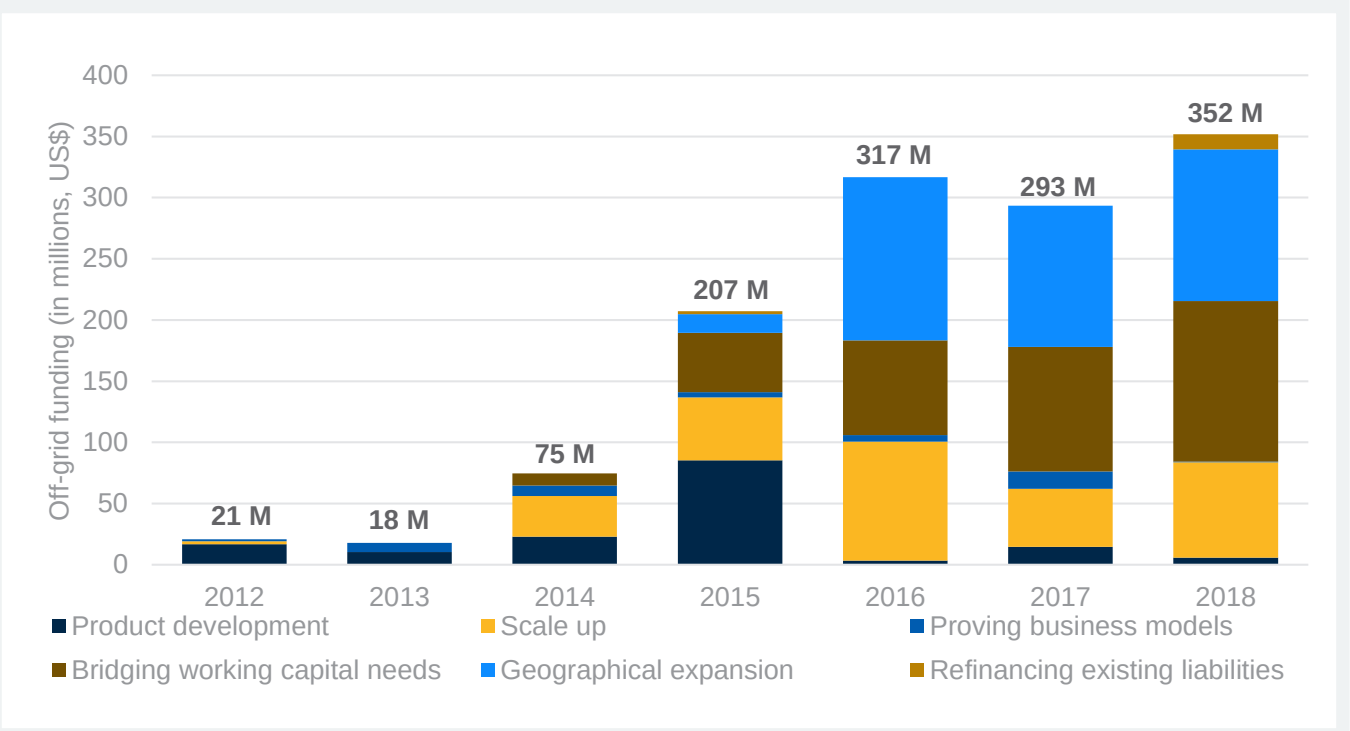
259 2019 investments have not yet been collected by GOGLA and have been sourced from secondary research and publicly available information. As such, 2019 data may not be fully representative of all investments made in the year due to undisclosed deals, for which estimates have been made. GOGLA, Deal Database (Investment Data 2012–2018), https://www.gogla.org/access-to-finance/investment-data.

Although equity investments were overwhelmingly more common in the sector's early stages, debt has now become the most frequently used financing instrument as the industry matures, and companies can absorb larger ticket sizes. Equity investments dominated in terms of transaction value in the sector's early stages because the industry's nascent stage made debt financing largely unavailable between 2012 and 2014. As a result, First-Generation companies relied primarily on equity investments (and to a lesser extent grant funding) to grow their businesses, including to finance the revolutionary PAYGo business model. However, starting from 2015, debt from international investors became more available, which First-Generation companies used to grow rapidly, increasing demand for debt and larger ticket sizes. While debt investments in 2015 and 2016 were dominated by direct investments from DFIs, in 2016, specialized debt providers, such as responsAbility, SunFunder, and SIMA, and crowdfunding platforms, such as Trine and Lendahand, entered the market and accelerated debt financing. New debt-financing models, such as off-balance-sheet financing, are further increasing available capital and providing easier-to-access, alternative forms of debt.

Because equity investments have not kept pace with the sector, younger companies struggle to raise equity capital, which limits their growth. The drop in equity investments after 2016 can be attributed to several factors: (1) current investors are often prevented from providing additional equity by internal restrictions that prohibit or discourage, for example, investment in competitors of existing portfolio companies; (2) few new equity investors have entered the sector; and (3) both current and potential investors are nervous about the concentrated exposure and high valuations of OGS companies. These factors have particularly strongly affected early-stage investors; as a result, many Second- and Third-Generation companies have found their growth slowed by their inability to attract the same levels of equity funding, or even grants, that had flowed into the sector in its early years.

The changing uses of capital further highlight the growing maturity of the market, as First-Generation companies have moved beyond testing their business models and towards financing their working capital needs and geographic expansion (Figure 50). Until 2015, companies used 50 percent of all capital raised to develop OGS products and refine their business models. In recent years, companies have sought capital to bridge working capital needs, grow their businesses, or expand geographically; since 2016, more than 90 percent of investment in the industry has been raised for these purposes. This indicates the rapid growth of the PAYGo model, which is highly capital-intensive, as well as companies' desire to attract customers in more nascent markets, such as West Africa. Companies have nevertheless highlighted that the lack of equity investments, particularly for younger companies, is stifling innovation, with less money available to test new business models or fund further research and development of new products to meet growing customer demand for larger systems and appliances.

Figure 50: Use of Funding in the Off-Grid Sector (US$ Millions Equivalent)

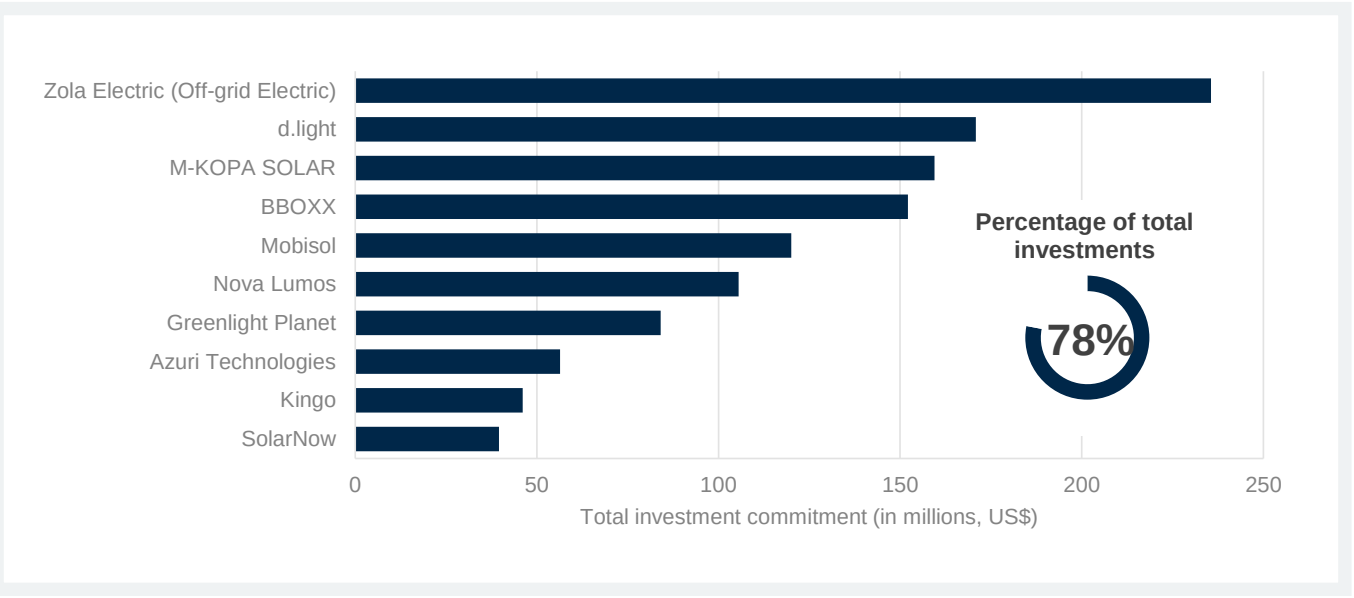


Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.
Note: Excludes 2019 funding, since companies have not yet disclosed their uses of capital to GOGLA.

INVESTMENTS HAVE BEEN HIGHLY CONCENTRATED IN A FEW COMPANIES AND REGIONS, WITH THE TOP 10 RECIPIENTS OF FINANCING RECEIVING 78 PERCENT OF TOTAL INVESTMENT TO DATE AND EAST AFRICA–BASED COMPANIES CONTINUING TO ATTRACT THE MOST INVESTMENT OVERALL.

Investments have been highly concentrated in the top 10 recipients of financing, with less capital available for newer companies. Collectively, these 10 companies (Figure 51) received 78 percent of all capital invested in the sector between 2012 and 2019. Among the oldest in the sector, these companies attracted large amounts of capital in the industry's early stages in the form of equity from impact investors and, to a lesser extent, grants. Investors were attracted to the impact story of the OGS sector and the PAYGo model. As they reached a certain level of scale, these companies then attracted debt capital from later-stage investors that require higher minimum ticket sizes. In this way, First-Generation companies financed their working-capital needs and solidified their local operations, relying less on equity investment over time. This path to growth is difficult for newer companies to emulate because equity and grant capital is now limited in availability.

Figure 51: Top 10 Companies by Total Investment Commitments since 2012 (Millions US$ Equivalent)



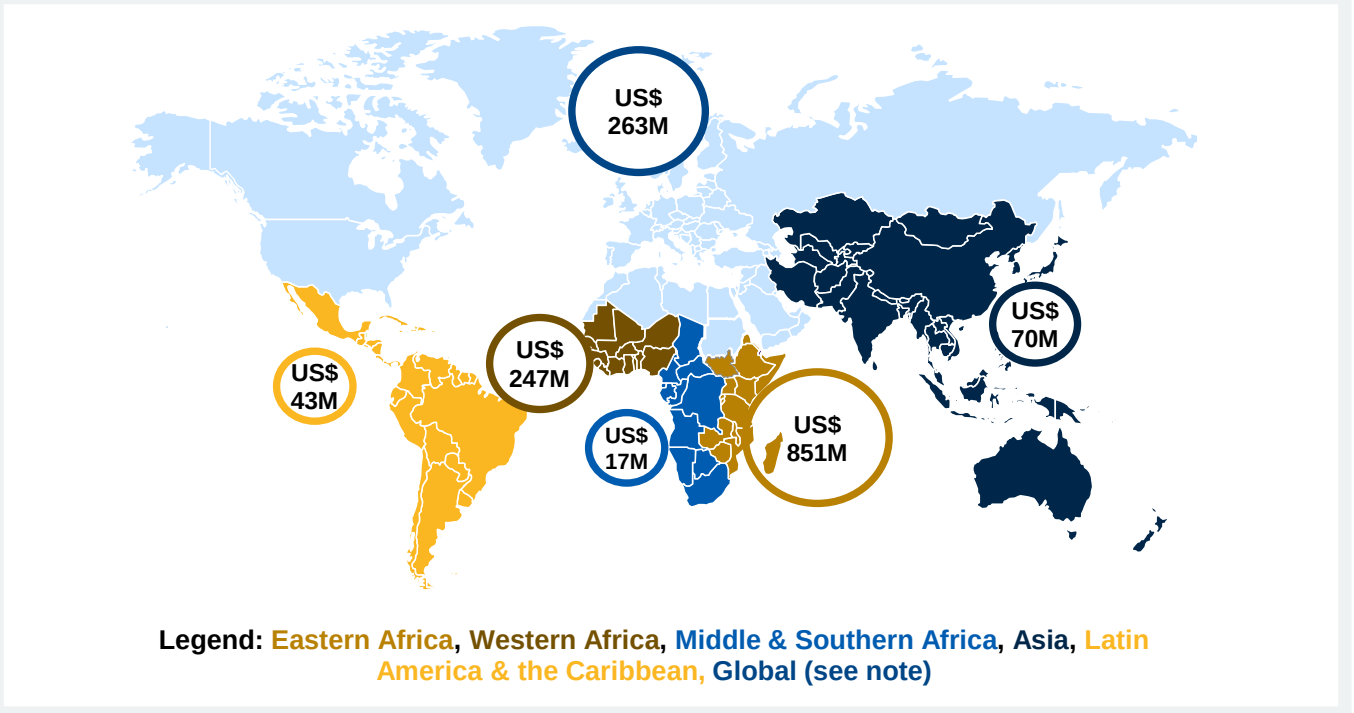
Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

Consolidation in the sector has also affected investment trends, as companies acquired by large investors no longer raise capital from external sources. ENGIE acquired Fenix International, Simpa Networks, and Mobisol for undisclosed sums.[260] These acquisitions have provided these companies with a new source of internal capital, and they will likely no longer raise external investment. For example, before ENGIE's takeover in 2018, Simpa Networks was one of the top 10 companies by value of cumulative investment raised (US$ 26 million), while Mobisol has dropped two places since 2017 (in Figure 51); neither has raised capital from external sources since acquisition. Additionally, Fenix International, while never one of the top 10 companies by capital raised, has not publicly raised any capital since its acquisition in 2018. Consolidation will reduce the total value of capital raised from external sources unless existing investors shift to investing in other OGS companies.

Geographically, East Africa remains at the heart of the sector in terms of value and number of investments, having received 60 percent of the total value of investment to date (Figure 52 and Figure 53). Investment into East Africa was driven by early adoption of PAYGo, high mobile-money penetration, a positive regulatory environment, governmental support, and general ease of doing business. These factors encouraged many early OGS investors to invest in East Africa–based companies, which allowed these companies to reach a certain scale and attract even more funds. Investors and businesses continue to track these investment criteria when considering expansion to other regions. As other regions develop in favor of these key investment criteria, benefiting the OGS companies operating in those regions and allowing them to expand, we expect to see other regions attract additional capital.

260 The value of these investments has not been made public, and they are not included in GOGLA, Deal Database.

Figure 52: Total Cumulative Investments by Region (2012–2019)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

Note: Regions are based on GOGLA definitions. Global refers to investments raised by companies that operate across multiple regions, such as Angaza, d.light, and Greenlight Planet, and that generally do not raise capital on a region-by-region basis.

More companies are entering the West African market, but the total value of investments is not increasing, and a few key players still receive the most investment. As mobile-money penetration increases and companies develop a deeper understanding of the regional market, an increasing number of companies are setting up operations in West Africa. However, the region has not seen a rapid increase in the value of investments to match. Many companies in West Africa are expanding from existing operations in East Africa and, with the notable exceptions of BBOXX and Azuri Technologies, have not yet raised capital specifically designated for the region. Additionally, Nova Lumos and ZOLA Electric have dominated investment into West Africa, accounting for 65 percent of all investments to date; smaller companies still struggle to raise capital. As more players operating in West Africa show significant signs of progress, however, future investment could be drawn to a more diverse group of companies in this region.

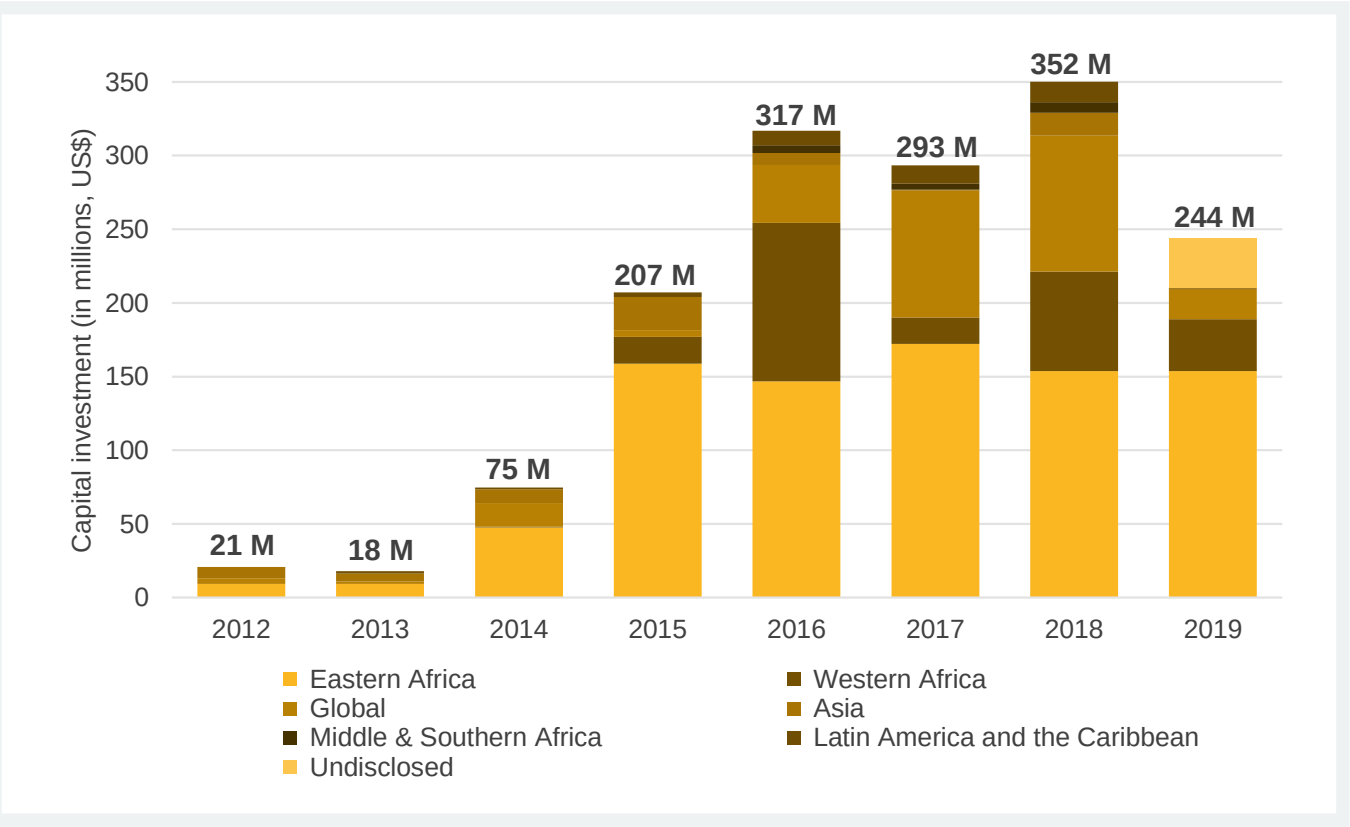
Investment into Asian markets currently shows no general trend towards growth, with investments into Greenlight Planet and Simpa Networks accounting for 50 percent of the value of investments in the region.[261] The acquisition of Simpa Networks by ENGIE in 2018 is one potential cause of the lack of overall growth in investment in this region, as Simpa Networks has not raised capital from external investors since acquisition. The Asian markets, especially in India, are also dominated by non-affiliate companies, whose fundraising activities GOGLA does not capture; thus, the true value of OGS investments in the region is likely higher than estimated. Chinese manufacturers, most of which are non-affiliates, have struggled to raise capital from commercial sources because they lack visibility among traditional investors in the off-grid sector. Finally, the limited penetration of the capital-intensive PAYGo business model in Asia also contributes to the lack of capital raised, as cash or MFI sales models, which are more prevalent in Asia, do not require companies to raise large amounts of debt. Compounding these factors, doing business in several key South Asian countries has historically been difficult for investors, with India, Pakistan, and Sri Lanka all traditionally ranking poorly on the World Bank's global Ease of Doing Business rankings.[262] However,

261 Greenlight Planet has primarily raised capital globally; this is a one-off investment designated to Asia.

262 World Bank, "Fact Sheet: South Asia" (Doing Business, Washington, DC, 2016), https://www.doingbusiness.org/content/dam/doingBusiness/media/Fact-Sheets/DB16/FactSheet_DoingBusiness2016_SouthAsia.pdf.

significant reforms in these countries since 2016 have led them to rank higher; India and Pakistan have particularly been recognized for consistent reforms over the past several years. As a result, we expect to see more investment in the region as international investors gain confidence.[263]

Figure 53: Capital Investment by Region over Time (US$ Millions Equivalent)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

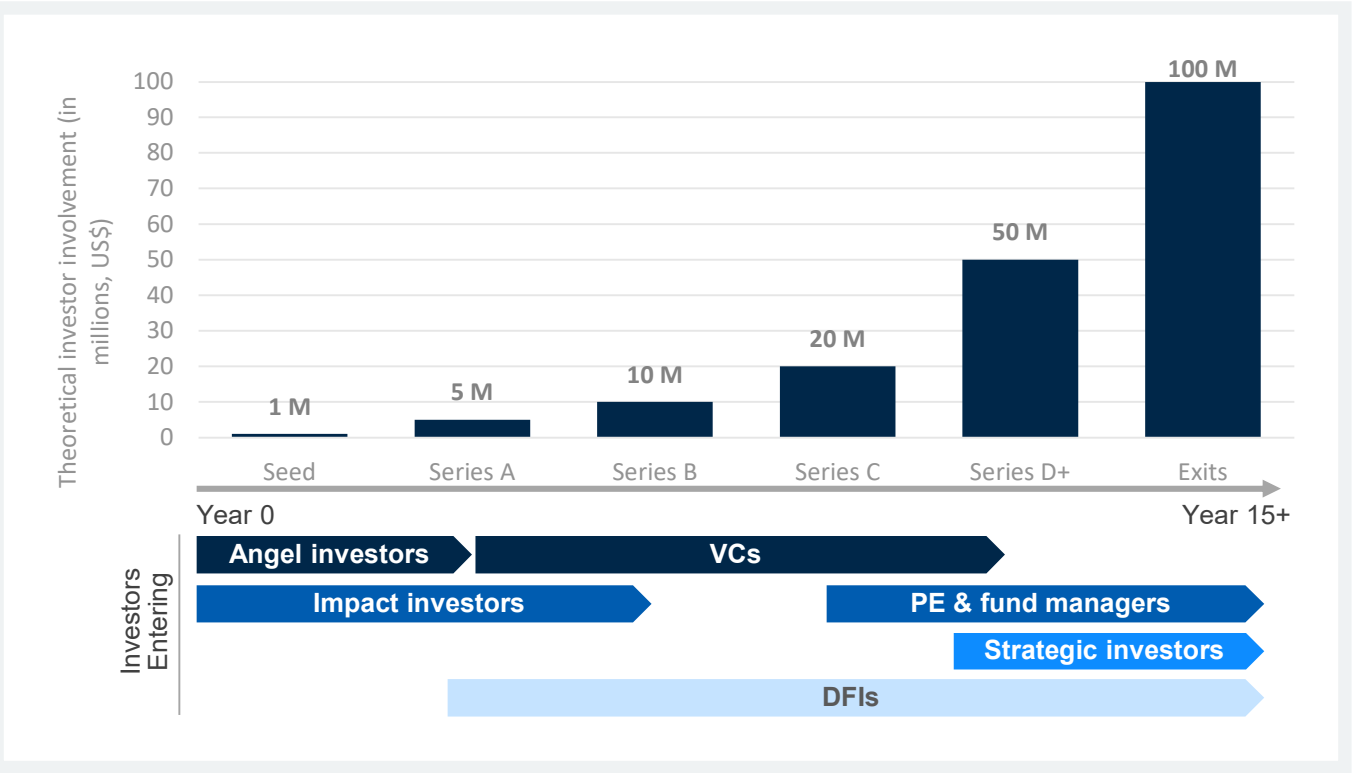
263 World Bank, "Fact Sheet: South Asia" (Doing Business, Washington, DC, 2020), https://www.doingbusiness.org/content/dam/doingBusiness/pdf/db2020/DB20-FS-SAR.pdf.

3.1.2 The Evolution of the Investor Landscape

INVESTOR TYPES ARE SHIFTING, WITH AN INCREASED PRESENCE OF LARGER STRATEGIC INVESTORS, SPECIALIZED DEBT PROVIDERS, AND CROWDFUNDING.

The evolving investor mix points to the sector's growing maturity. Over the last decade, the primary investors by value in off-grid energy have been impact investors, DFIs, and governments, with only a few exceptions. As the sector matures, a sustained influx of later-stage investors, such as PE firms, strategic investors, and various debt providers, is required to elevate the sector to the next level of growth (Figure 54). This sub-section explores the types of investors active in the sector, their investment profile, impact to date, and the role we expect they will play in the future.

Figure 54: Theoretical Equity Investor Involvement by Growth Stage

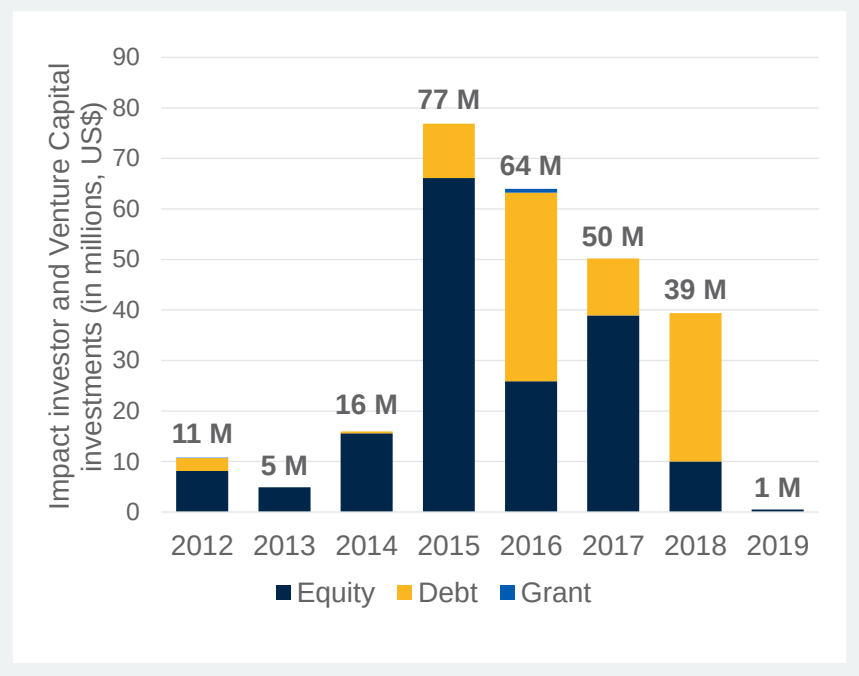


Source: Acumen and Open Capital Advisors., Lighting the Way: Roadmap to Exits in Off-Grid Energy (New York: Acumen; Nairobi: Open Capital Advisors, 2019), https://acumen.org/energy-exits-report/, 26.

IMPACT INVESTORS AND VC FUNDS WERE INSTRUMENTAL IN SUPPORTING THE SECTOR'S INITIAL DEVELOPMENT, BUT FUNDING CONSTRAINTS ARE NOW DIMINISHING THEIR INFLUENCE ON THE SECTOR.

Early-Stage Investors (Impact Investors, Individuals, and VCs)	
Market Role	Early-stage risk-takers who fund innovation and catalyze additional capital.
Example	Energy Access Ventures invested US$ 300,000 of equity into Zonful Energy in 2018. Gaia Impact Fund provided US$ 600,000 in debt to Solaris Offgrid in 2018.

Figure 55: Impact Investor and VC Investments (US$ Millions)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

For early-stage investors to continue supporting the sector, they must begin to see exits that enable them to reinvest capital. While most investors initially anticipated that they would be able to exit their OGS equity investments in roughly seven years, it is increasingly evident that 10–12 years is a more realistic target given the few exits in the sector to date.[264] Early-stage investors depend on liquidating their existing investments to redeploy funds into new businesses if they are not able to raise a new fund. Investors are also often prevented from making equity investments into multiple companies in the same sector, which would be perceived as investing in their investees' competitors. Therefore, a pool of later-stage investors in the market is essential to enable secondary equity sales or acquisitions; such investors, however, have been missing, and early-stage investors have become more cautious in the wake of previous high valuations. The declining total value of new equity investments made by impact investors and VCs since 2015 makes these trends clear (Figure 55). Unless later-stage capital becomes available, future innovations from newer companies and competition in the sector may be limited as smaller companies struggle to access the equity they require to innovate and reach scale.

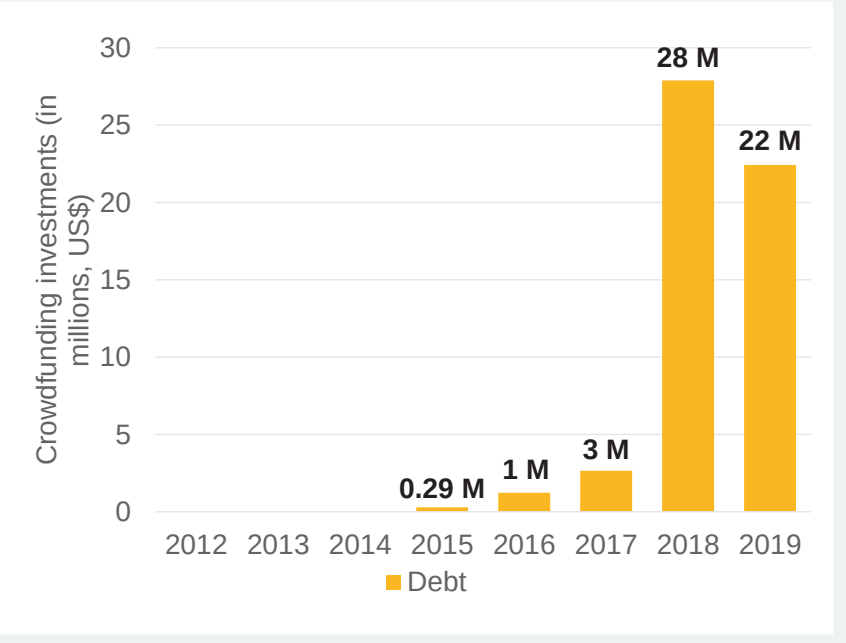
Early-stage investors—initially focused on equity investments—are increasingly investing through debt as they look for other ways to catalyze the sector. With shorter timelines for returns on debt investments, these investors are turning to debt as a means to continue making catalytic investments into OGS companies while cash-constrained (Figure 55). This trend could provide much-needed debt for newer companies in the sector that struggle to raise debt capital from more commercial sources, but it does not address the challenge they face concerning lack of equity.

264 Acumen and Open Capital Advisors., Exits in Off-Grid Energy, 18.

CROWDFUNDING AND SPECIALIZED DEBT PROVIDERS ARE BECOMING MORE PREVALENT, PROVIDING CAPITAL TO COMPANIES THAT CANNOT ACCESS MAINSTREAM, NONSPECIFIC DEBT.

Crowdfunding	
Market Role	Providing growth capital for companies that cannot access commercial lenders.
Example	Trine provided a US$ 600,000 facility to Ecoenergy in 2018. Energise Africa (a joint venture between Lendahand and Ethex) provided US$ 2.3 million in debt to Azuri Technologies in 2018.

Figure 56: Crowdfunding Investments (US$ Millions)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

Since its emergence in 2007, crowdfunding has quickly risen to become a large source of capital for companies across the world, entering the OGS sector in 2015. The global market value for crowdfunding was an estimated US$ 10.2 billion in 2018.[265] This financing mechanism is now making exciting inroads into the OGS sector. In 2015, when crowdfunding first started to gain traction in the sector (Figure 56), microloans dominated. Now, crowdfunding is dominated by peer-to-peer (P2P) business lending. In this model, individual investors own "parts" of a consolidated loan facility to a company and receive loan repayments over the duration of the loan.[266] There are several primary crowdfunding platforms, including Kiva, TRINE, Energise Africa, Lendahand, Bettervest, and Crowdcredit.

Crowdfunding has gained traction in the off-grid sector as a new source of working capital, particularly for companies between Series A and B rounds, but larger companies are also using crowdfunding. Earlier-stage companies are hard-pressed to access debt financing from commercial lenders because they can absorb only smaller ticket sizes. Crowdfunding platforms fill this gap, offering smaller ticket sizes, often below commercial rates (and to date generally only in hard currency). Increasingly, however, larger companies are utilizing crowdfunding to access capital. BBOXX and Azuri Technologies have made extensive use of crowdfunding, raising US$ 7.3 million and

265 Valuates Reports, "The Global Crowdfunding Market Was Valued at 10.2 Billion US$ in 2018 and Is Expected to Reach 28.8 Billion US$ with a CAGR of 16% by 2025," news release, June 17, 2019, https://www.prnewswire.com/in/news-releases/the-global-crowdfunding-market-was-valued-at-10-2-billion-us-in-2018-and-is-expected-to-reach-28-8-billion-us-with-a-cagr-of-16-by-2025-valuates-reports-888819175.html.

266 For more in-depth explanations of the different types of crowdfunding and P2P lending, see: Davinia Cogan and Peter Weston, Crowdfunding & P2P Lending for Energy Access: State of the Market 2018 (London: Energy 4 Impact, 2018), https://www.energy4impact.org/crowdfunding-p2p-lending-energy-access-%E2%80%93-state-market-2018-0.

US$ 1.9 million, respectively; this represents roughly 40 percent of all crowdfunding raised in 2018. Crowdfunding's popularity is also increasing because crowdfunding platforms can deploy capital more quickly than other investors.

Crowdfunding platforms deployed a burst of capital in 2018, attributed to an increased supply of investors in high-income countries looking for impact investment opportunities, increased demand for working capital at good rates by companies, and the rise of P2P business-lending platforms.[267] Investors from high-income countries looking to make contributions towards combating climate change alongside reasonable returns have been the primary drivers of increased supply. The OGS sector also benefited from additional spikes of investment through crowdfunding as large players, such as BBOXX and Azuri Technologies, utilized these platforms for capital raises. If these more established companies accelerate the use of crowdfunding as a source of capital for its flexibility, transaction speed, and attractive terms, capital might be diverted away from smaller companies. Alternatively, demand from large players could attract more investors onto crowdfunding platforms, increasing their credibility and the total amount of capital available. It remains to be seen over the next two years whether crowdfunding will continue to fill a critical financing gap for small companies.

Governments and DFIs have supported the growth of crowdfunding platforms by providing debt-guarantee facilities and funds to hedge foreign-exchange risk. First-loss guarantees appear to significantly impact lender behavior, with several lenders citing guarantees as a deciding factor in how much to invest.[268] For DFIs and philanthropists, providing guarantees for debt crowdfunding can be a cost-effective way to catalyze impact and enable diversification of risk by supporting multiple campaigns. For example, Sida issued a guarantee to crowdfunded investments through Trine to spur private investment into off-grid companies in Sub-Saharan Africa. Protection remains effective even at 10 and 25 percent of the campaign target.[269] Additionally, some governments are providing matching funds to crowdfunding platforms to encourage participation. Energise Africa, a joint effort of Ethex and Lendahand, is supported by UK Aid, which provided matching funding for certain campaigns on the platform.[270]

While debt crowdfunding to affiliate companies has dominated the sector thus far, crowdfunding could play an increasing role in raising both equity and debt for non-affiliate companies. Equity crowdfunding is a fast-growing activity, with US$ 1.4 billion raised in the United States in 2017 alone. To date, US$ 3.4 million in equity has been raised through crowdfunding by non-affiliate OGS companies, including Buffalo Grid and WakaWaka, with a DFID-funded project, Crowd Power 2, working to increase equity investments through crowdfunding.[271] Traditional investors in the sector have shied away from investment in non-affiliate businesses due to a lack of visibility, perception that they are higher risk, or smaller ticket sizes. Impact-driven crowdfunders offer an alternative route for non-affiliate companies to raise much-needed capital.

Crowdfunding has channeled previously untapped capital into the off-grid sector, boosting overall investment, but it could be limited by regulatory regimes. The United States has a much tougher regulatory environment compared to Europe, as the latter allows retail investors to earn interest on their investments (on many platforms, this amount can be as small as US$ 30). Additional restrictions include fundraising only from donors domiciled in the platform's jurisdiction or region of incorporation.[272] It remains to be seen how regulations will develop as policymakers become more familiar with this form of fundraising.

Syndication could further increase the rate at which crowdfunding platforms can provide funds to the off-grid market. Traditional lenders in the off-grid sector have commonly offered syndicated debt, but crowdfunding platforms have so far only conducted individual deals. DFID's Transforming Energy Access program and Crowd Power 2 have been working with crowdfunding platforms and specialized debt providers in the sector to develop a standard framework for syndicating crowdfunded loans. This could increase crowdfunding platforms' availability to provide larger tickets sizes of debt that would otherwise require the direct support of a DFI or other investors with the ability to write large checks.[273]

267 Cogan and Weston, Crowdfunding for Energy Access.

268 Open Capital Advisors and Vivid Economics consultations.

269 Swedish International Development Cooperation Agency (SIDA), "Crowdfunding Guarantee 2017," June 2018, https://www.sida.se/English/publications/160267/crowdfunding-guarantee/.

270 Energise Africa, "About," https://www.energiseafrica.com/about.

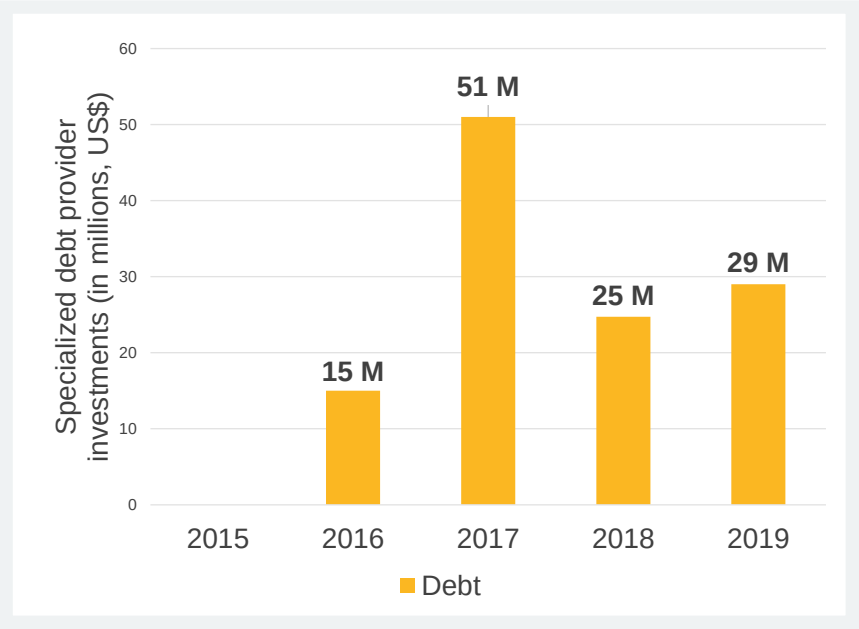
271 Davinia Cogan and Simon Collings, Crowd Power: Can the Crowd Close the Financing Gap? (London: Energy 4 Impact, July 2017), https://www.energy4impact.org/news/new-report-explores-role-crowdfunding-raising-finance-energy-access-businesses-and-projects.

272 This restriction is more specifically targeted at equity crowdfunding.

273 Open Capital Advisors and Vivid Economics consultations.

Specialized Debt Providers	
Market Role	Technical expertise in the deployment of debt capital into the OGS, often working in partnership with DFIs to crowd-in investment from local banks.
Example	A SunFunder, DWM, and SIMA syndicate provided US$ 18 million debt to d.light in 2019. SIMA Funds provided US$ 600,000 debt to EcoEnergy in 2018.

Figure 57: Specialized Debt Provider Investments (US$ Millions)



Source: Open Capital Advisors and Vivid Economics research and analysis of GOGLA, Deal Database.

Specialized debt providers have emerged in the sector due to the growing traction of OGS companies and their ability to absorb larger amounts of debt capital (Figure 57). These investors have increased debt investment into the sector, contributing 14 percent of all commercial debt provided since 2012. Driven by their limited partners, specialized debt providers have specific mandates to grow the renewable energy sector for impact and have built sector expertise that allows them to do smaller, harder deals, and evaluate credit more efficiently. While they have sometimes lent in local currency, they usually offer hard currency loans, leaving a substantial gap remaining in the market.

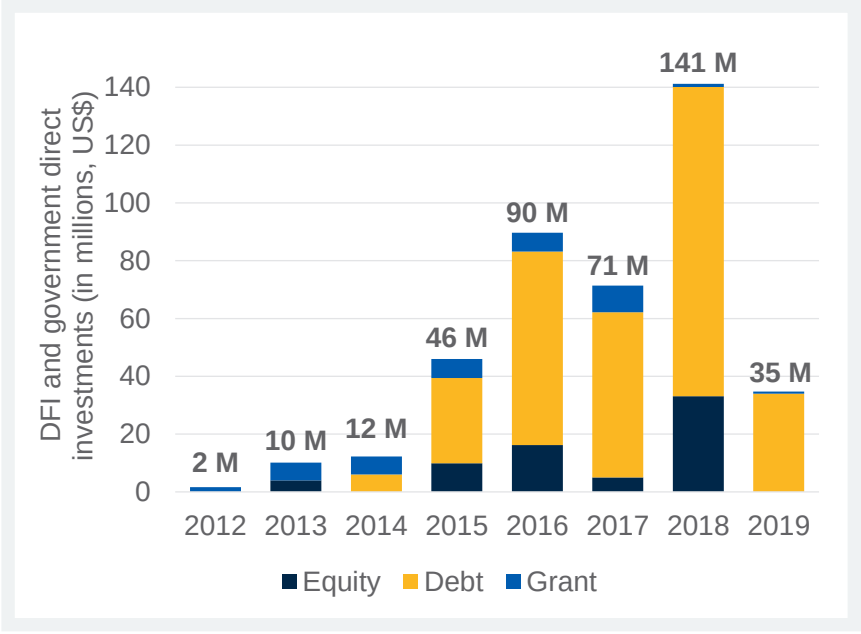
As the sector has matured, specialized funds and DFIs in some cases compete for similar deals.[274] In the past, DFIs invested not only indirectly in specialized debt funds but also directly in OGS companies, acting as competitors to those same funds. This challenge has been caused by a limited pipeline of eligible investments in the space with the targeted risk-return profile.

274 Open Capital Advisors and Vivid Economics consultations.

DFIS HAVE SHIFTED TO PROVIDING DIRECT FUNDING TO COMPANIES IN LOCAL AND HARD CURRENCIES WHILE CONTINUING INDIRECT INVESTMENTS INTO FUNDS AND DEBT FACILITIES.

DFIs and Government	
Market Role	Creating an enabling environment for sector growth and supporting the development of emerging financial markets. Activities include the provision of capital through indirect investments and credit facilities, as well as direct investments.
Example	IFC provided a US$ 45 million quasi-equity anchor investment in the US$ 150 million Access to Energy Debt Fund, managed by responsAbility in 2019. FMO invested Tanzanian Shilling 74 billion (US$ 32.5 million) in debt as part of a syndicate with Symbiotics' equity investment into Zola (Off-Grid Electric) in 2018.

Figure 58: DFI and Government Direct Investments (US$ Millions)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

DFIs help develop the sector from business-model validation onwards through both direct and indirect investments (Figure 58). Direct investments by DFIs account for 29 percent of the total value of investments since 2012; while the exact value of indirect investments by DFIs is unknown, it is estimated to be at least US$ 100 million.[275] Through indirect investments, DFIs invest large amounts of capital, often at concessional rates, in impact investors and VC firms, which then invest in the OGS sector. Such early-stage investors can invest the smaller ticket sizes that DFIs could not directly. Similarly, DFIs and governments often lend to financial institutions to encourage them to lend to companies (e.g., Niger Solar Electricity Access Project, or NESAP), but such programs have so far seen mixed success; financial institutions are reluctant to then lend to companies because their perceived risk is high, among other factors.

We expect DFIs will increasingly offer direct debt to the sector, often in local currency. Like early-stage investors, DFIs often cannot provide equity directly to multiple companies in the same sector. Since debt has different dynamics, recent direct DFI investments have predominantly been made through debt, a trend that will continue in the future. FMO and CDC have also indicated that DFIs will lead the charge to provide more local currency loans to fill the gap caused by lack of lending by local financial institutions. To avoid distorting the market, these DFIs have indicated that they will price their debt facilities in line with local standards and interest rates.[276]

275 Open Capital Advisors and Vivid Economics analysis.

276 Open Capital Advisors and Vivid Economics consultations.

Box 14: The Development Bank of Ethiopia (DBE) Credit Facility

Access to foreign exchange is a major issue in Ethiopia, making it challenging to import OGS devices since manufacturers generally require payments in U.S. dollars. This limits the growth of the market and jeopardizes national electrification targets. In 2013, the Government of Ethiopia, the World Bank, and Lighting Africa set up a financing facility worth US$ 20 million, since doubled to US$ 40 million, so local companies can access US$ to purchase quality-verified OGS devices.

The facility, administered by the Development Bank of Ethiopia (DBE), has additional components. The Collateral Support Facility helps smaller companies meet collateral requirements for the credit facility. Additionally, loans repaid by companies in birr become a working capital facility for MFIs to provide loans for OGS products at the household level.

The facility is also supported through carbon finance. If the project meets its targets to import 2.8 million solar lanterns and 214,000 SHS, it will receive US$ 11.2 million in carbon credits. These funds will cover the costs of replacing SHS batteries, administering warranty tracking and customer information systems, and operations and maintenance.

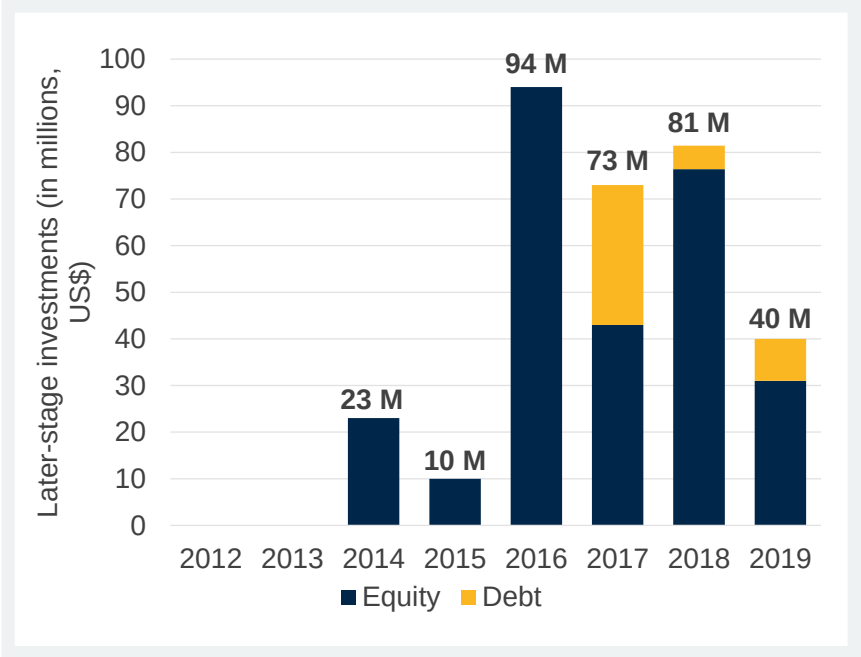
The project's impact has been substantial, and it is on track to achieve its targets. The loans, with no defaults to date, enabled the importation of more than 850,000 quality-verified solar lighting products.

DFIs can also "crowd-in" local financial institutions. Safeguards such as loss-sharing guarantees can increase local financial institutions' lending to the sector, which is critical to the sector's long-term growth. DFIs have also tried to familiarize financial institutions with the industry by co-financing capital raises. The most recent example of this was the offer by Stanbic Bank, CDC, FMO, and Norfund of a syndicated US$ 55 million loan to M-KOPA in 2017 in Kenyan and Ugandan shillings.

LATER-STAGE AND STRATEGIC INVESTORS COULD PROVIDE THE LARGE AMOUNTS OF CAPITAL THE SECTOR REQUIRES AND ARE SHOWING MORE INTEREST IN THE SECTOR, BUT TRANSACTIONS REMAIN LIMITED.

Later-Stage Investors (Private Equity and Asset Managers)	
Market Role	Provide growth capital and guidance for mature companies with a clear path to profitability.
Example	A Helios-led syndicate provided US$ 55 million in equity to Zola (Off-Grid Electric) in 2018. Africa Infrastructure Investment Managers provided US$ 31 million in equity to BBOXX in 2019.

Figure 59: Investments by Later-Stage Investors (Private Equity and Asset Managers; US$ Millions)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

PE firms and traditional asset management companies are showing a growing interest in the sector as companies mature (Figure 59). PE firms have expressed interest in the market leaders, and several have "placed bets." Most, particularly traditional asset managers, have waited and watched, not yet familiar or confident enough with the sector to act. These investors require demonstrated financial stability and profitability, which nearly all companies in the sector lack, and they also prefer ticket sizes over US$ 50 million. To attract these investors, both companies and early-stage investors are adjusting their strategic focus to demonstrate that OGS companies can be sustainable and profitable businesses (for more, see Section 3.2).

As more PE firms and asset managers enter the sector, they could facilitate exits for early-stage investors. PE firms have substantial assets dedicated to Africa and could be a major source of capital for the sector. However, while failures in the sector are the exception rather than the norm (Box 15), failures at a few market-leading companies may have prematurely chilled market entry by later-stage investors, including PE firms.

Box 15: Insolvencies: Growing Pains, Not a Trend

Mobisol's insolvency early this year may have delayed entry by later-stage investors into the market because Investec had an investment in the company. While other companies have encountered financial difficulties, such as Solar Kiosk and WakaWaka, Mobisol had attracted investment from the IFC, FMO, KfW, and Finnfund, among others, before Investec's first investment, indicating high market confidence in the firm. Investec was one of the first PE firms to meaningfully enter the sector through their initial 2016 and follow-on investments in Mobisol. This was seen as a promising sign that the sector was mature enough to attract later-stage investors. However, Mobisol filed for self-administration in mid-2019.[277] While a thorough autopsy of Mobisol's insolvency may never be completed, as ENGIE acquired the firm in September 2019 with financial details undisclosed,[278] statements by Andrew Goodwin, the managing director in self-administration, to the Financial Times offer insight into contributing factors. Goodwin identified the core of Mobisol's problems as "economic metrics," highlighting affordability constraints and constant pressure from the declining costs of components, which increased competition and prevented the firm from raising prices. Additionally, Mobisol's fully vertically integrated business model put extraordinary financial pressure on the company, with the firm needing to cover costs of product development, liaising with manufacturers in China, logistical challenges caused by poor infrastructure, and demanding after-sales support commitments.[279] It must be noted that vertically integrated firms are starting to better understand these pressures and act accordingly (see Section 2.2.2).

277 John Dizard, "Mobisol: A Cautionary Tale for Impact Investors," Financial Times, May 3, 2019, https://www.ft.com/content/8832bffc-f319-36fa-a720-fadaaf86e4f4.

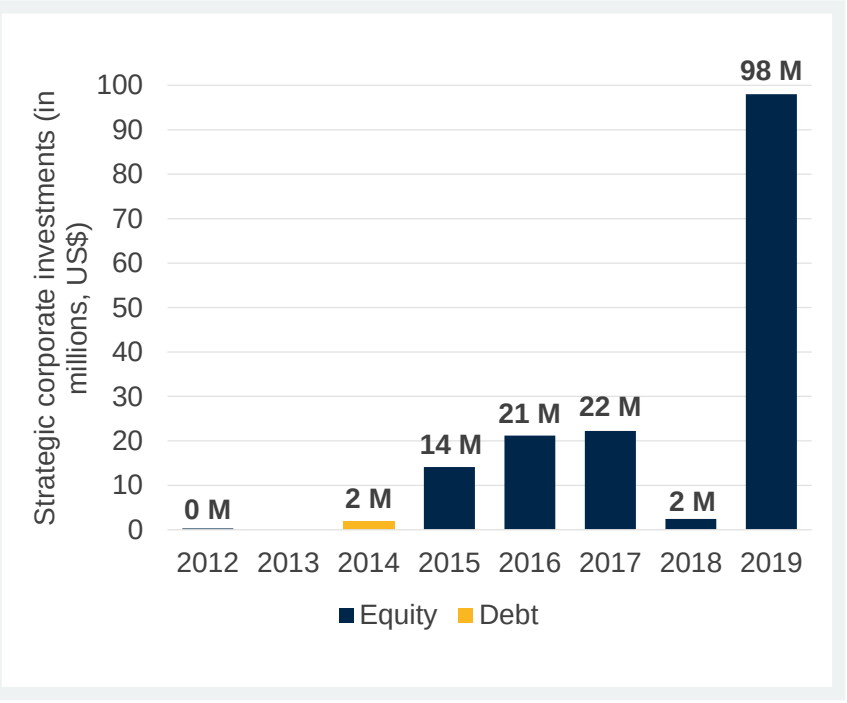
278 Geert De Clercq, "Engie Buys African Offgrid Solar Firm Mobisol," Reuters, September 3, 2019, https://www.reuters.com/article/us-engie-solar-africa/engie-buys-african-offgrid-solar-firm-mobisol-idUSKCN1VO0KM.

279 Dizard, "Mobisol: A Cautionary Tale."

Other investors have seen Mobisol's insolvency as a sign that the sector is unprepared for fully commercial capital, yet one large insolvency does not make a trend. The now-heightened focus across the industry on demonstrating robust financials can only be healthy for the sector. Meanwhile, if later-stage investors do not facilitate exits for early-stage investors and provide large amounts of capital for scale, companies will no longer be able to grow at their historically vigorous rate, slowing the growth of the entire industry.[280]

Strategic Corporates	
Market Role	Spurring growth with large-ticket investments, providing exits and enabling consolidation.
Example	Mitsubishi provided US$ 50 million in equity to BBOXX in 2019. ENGIE acquired Fenix International, Simpa Networks, and Mobisol between 2017 and 2019.

Figure 60: Strategic Corporate Investments (US$ Millions)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

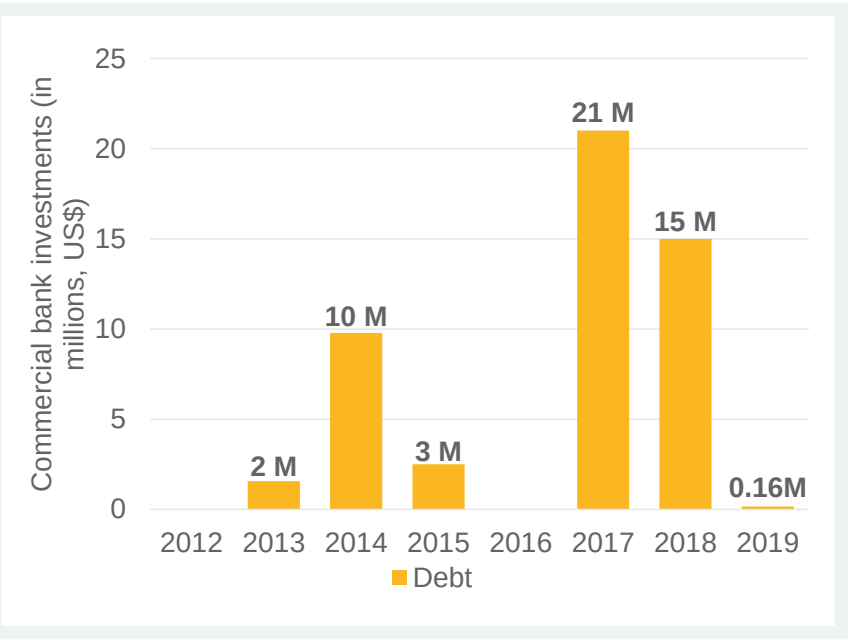
Strategic investors are becoming more interested in equity transactions in off-grid energy companies (Figure 60). These investors typically have deep pockets, enabling them to write very large checks. They also have decades of experience running large and complex business operations; some even have sector-specific experience. Strategic investors introduce an exciting, fresh dynamic to the industry alongside a level of scale and formalization that might not be offered by impact investors or DFIs. They are also the most likely players to facilitate exits for early-stage investors, which promotes early-stage investors' liquidity. The motives of strategic investors include increasing their footprint in developing markets, gaining customer insights through big-data collection, and tapping OGS companies' distribution channels and innovative payment platforms (for more details, including the types of potential strategic acquirers, see Section 2.3.2).

280 Acumen and Open Capital Advisors., Exits in Off-Grid Energy.

LOCAL BANKS REMAIN HESITANT TO SUBSTANTIVELY ENGAGE IN THE SECTOR, THOUGH ECOSYSTEM ACTORS ARE WORKING TO SENSITIZE BANKS TO OFF-GRID BUSINESS MODELS AND INCENTIVIZE LENDING.

Commercial Banks	
Market Role	Providing commercial capital to mature companies demonstrating an ability to repay.
Example	Union Togolaise des Banques provided CFA 2.2 billion (US$ 4 million) in debt to BBOXX in 2018. Centenary Bank provided USh 590 million (US$ 160,000) in debt to Solar Today in 2019.

Figure 61: Commercial Bank Investments (US$ Millions)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

Lending from local financial institutions is still limited but highly important to fill the local currency debt gap (Figure 61). Within the context of lending to OGS companies, financial institutions can be categorized as (1) large or regional banks and (2) mid-sized or local banks. Each has separate OGS strategies, financial products, and barriers to investing in the sector.

Many large banks have coherent OGS lending strategies focused on trade and receivables financing, with regional banks having limited involvement in the sector. In some cases, large banks also have energy teams that understand sector dynamics and have set regional investment strategies. These banks have a bias towards larger OGS companies because of their larger ticket sizes and multi-country focus. They actively seek de-risking arrangements as they perceive the OGS sector, particularly PAYGo companies, to be high-risk. Products offered to OGS companies include financing for trade and receivables financing across multiple transactions, generally requiring more than 50 percent collateral. Special-purpose vehicles and other off-balance-sheet financing instruments are being explored but remain uncommon given the uncertainty around risk. Regional banks have had limited involvement in the OGS sector thus far because their management teams lack experience in the OGS sector, the sector is relatively immature, and OGS companies exhibit limited standardization in terms of data. Some banks have said that guarantees and credit lines targeted at the sector do not provide sufficient coverage.[281]

281 Open Capital Advisors and Vivid Economics consultations.

Mid-sized or local banks typically lend to OGS companies with less complex business and credit models that are easier to assess for creditworthiness and at ticket sizes below US$ 2 million. While these institutions generally do not have dedicated OGS financing strategies, they will often focus on renewable energy in general. Products offered include working-capital facilities for less-established companies at smaller ticket sizes, often funded in part by DFIs (such as the World Bank). Some lend to OGS companies through existing SME lending products, typically below US$ 1 million and requiring significant collateral and other protection measures, including personal or investor guarantees. Lending limits are determined by central banks' "Single Obligor Limit," which varies by country. Key barriers to further lending include inadequate data quality and availability since less-established OGS companies often lack robust data-collection systems; weak credit-management systems among smaller OGS companies, which results in increased credit risk; and banks' lack of experience in the sector, which hinders pipeline development, due diligence processes, and the development of tailored OGS products.[282]

Off-grid companies, governments, development partners, and specialized debt providers are increasingly working to encourage commercial, financial institutions to invest greater sums of capital in the sector. Many industry stakeholders are joining forces to sensitize commercial financial institutions to opportunities in the OGS sector, while some are deploying guarantee facilities, technical assistance, or financial advisory services to enable more deal flow. Government-backed initiatives to provide concessional financing to lower the risk to financial institutions will continue to build these institutions' confidence to invest in the sector. Increased and sustained involvement by financial institutions is critical to the sector's long-term success and sustainability because they can provide local capital and write larger checks to off-grid companies as development partners and DFIs begin to exit to support other initiatives or sectors.

282 Open Capital Advisors and Vivid Economics consultations.

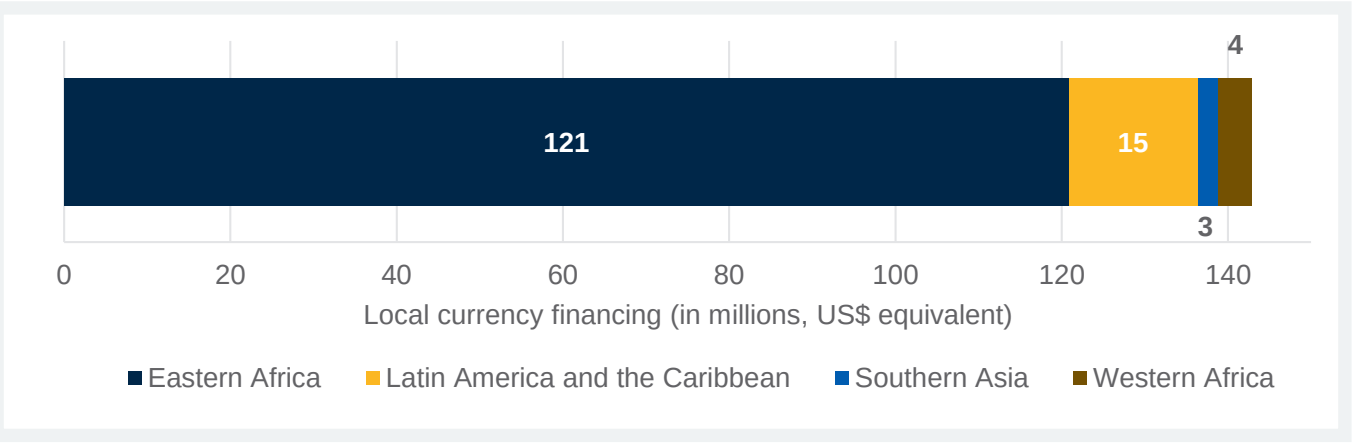
3.1.3 Currency Trends

LOCAL CURRENCY FINANCING IN THE OGS SECTOR HAS BEEN LIMITED TO A FEW LARGE DEALS. LOCAL BANKS' RELUCTANCE TO LEND TO OGS COMPANIES LIMITS THE AVAILABILITY OF LOCAL CURRENCY FINANCING.

Historically, local currency financing and hedging instruments have been rare but are increasing in availability, which will enable companies to better manage their foreign exchange risk. In the past, OGS companies have struggled to manage their foreign-exchange risks. With a lack of local currency financing, most investments have been in hard currency, while companies generate revenues in local currency. Long revenue cycles for PAYGo sales expose companies to potential local currency depreciation as they convert local currency revenues to repay hard currency financing over time. Since the last version of this report, local currency financing has begun to unlock, driven by the involvement of some DFIs. There also appears to be a greater opportunity to involve local banks and institutional investors, who have expressed greater interest and, in some cases, have already been involved in local currency financing rounds. This sub-section explores these trends in more detail.

While the value of local currency financing utilized by the sector has slightly increased in recent years, this is driven by a small number of companies and investors in East Africa (Figure 62). First-Generation companies currently account for all local currency financing to affiliate companies in the sector.[283] This, in part, explains why local currency financing has been concentrated (90 percent) in East Africa, the primary location of First-Generation companies. In addition, the relative stability of East African currencies over the past several years has also reduced the spread in interest rates between hard and local currency debt, making local currency debt more attractive.

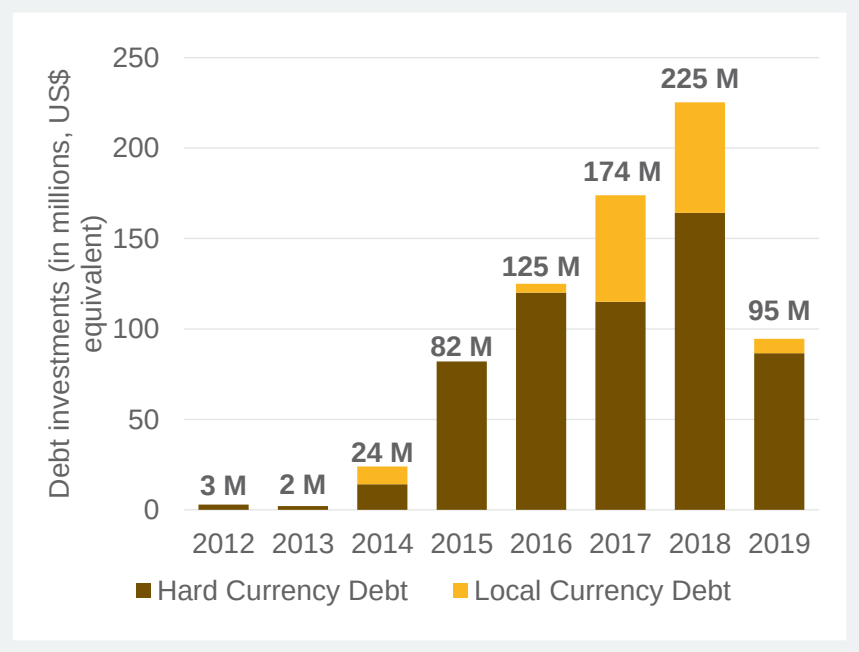
Figure 62: Local Currency Financing by Region (US$ Millions Equivalent)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

283 Vivid Economics and Open Capital Advisors analysis of the GOGLA, Deal Database.

Figure 63: Debt Investments in Local versus Foreign Currency (US$ Millions Equivalent)



Source: Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

Historically, DFIs have been the primary source of local currency debt, as local banks have been reluctant to lend to OGS companies, limiting the availability of local currency financing. DFIs have accounted for 70 percent of local currency financing to affiliate companies.[284] However, these investments remain rare and limited to a few large deals (Figure 63). Local banks were (and largely still are) discouraged from lending to OGS companies by their perception of these companies as high-risk investments given their common lack of positive cashflow. However, local banks are uniquely positioned to offer finance in local currency—their primary currency of operations—because, compared to foreign lenders, they are exposed to less foreign exchange risk. Increased local currency financing is critical for the sector's long-term growth.

CURRENCY FLUCTUATIONS REPRESENT A MATERIAL RISK TO THE FINANCIAL HEALTH OF OGS COMPANIES, BUT MANY CONTINUE TO VIEW LOCAL CURRENCY FINANCING AS TOO EXPENSIVE OR UNNECESSARY.

OGS companies can greatly benefit from local currency financing to minimize the material risk posed by currency fluctuations. Local currency financing primarily enables off-grid companies to finance receivables, relieving the cash flow challenges associated with the PAYGo model. In other words, debt received by a company denominated in local currency is repaid in the same currency in which the company receives consumer payments, avoiding foreign-exchange risk.

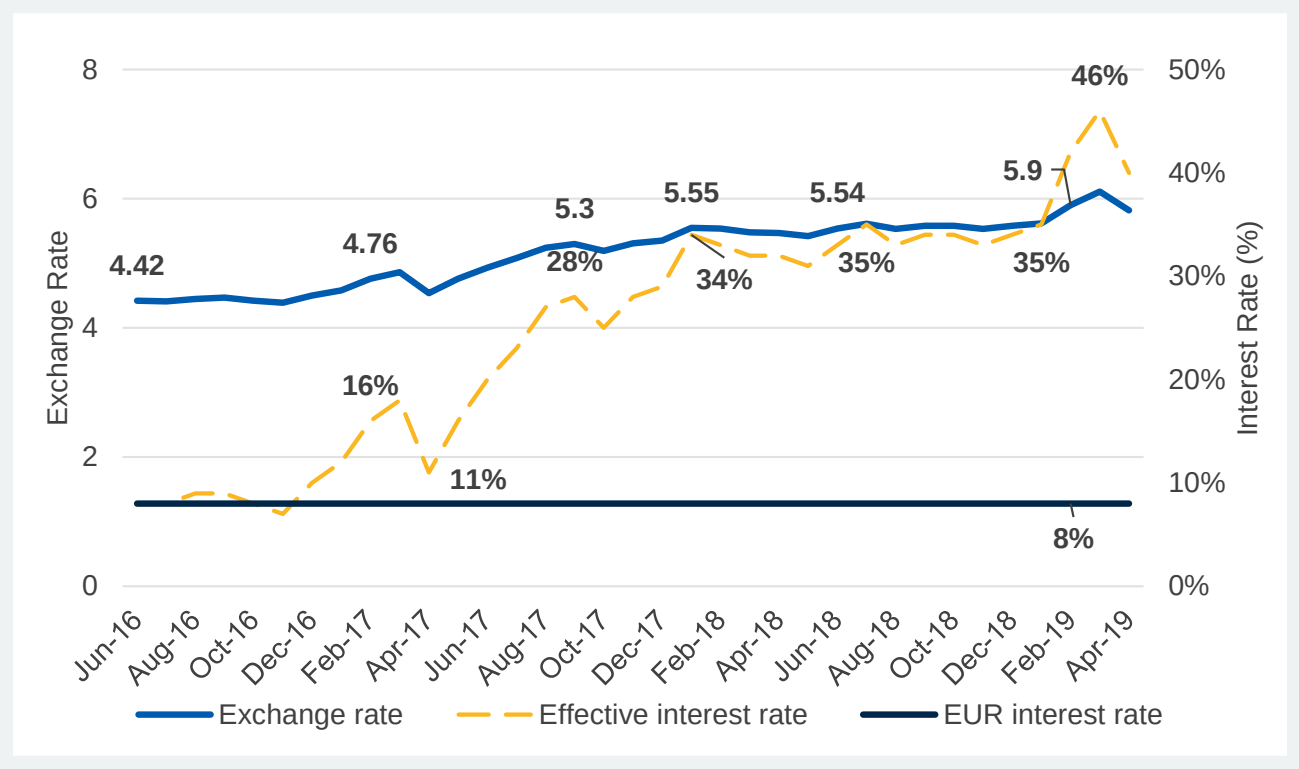
However, companies have historically shied away from local currency loans, because they have been offered at higher interest rates than hard currency loans to cover the risks of currency depreciation. Most companies, therefore, preferred to borrow in hard currency, in effect opting to take on currency risk rather than paying the higher interest rate. However, experienced OGS players are improving their ability to estimate the true, potentially higher cost of hard currency financing based on historical currency fluctuations and operational risks in their businesses. They are also acknowledging the risk of assuming this exposure themselves and recognizing the potential costs of doing so (Box 16 The Potentially High Cost of Hard Currency). They are, therefore, increasingly willing to consider local currency options, which could accelerate local currency financing in the sector.

284 Vivid Economics and Open Capital Advisors analysis of GOGLA, Deal Database.

Box 16: The Potentially High Cost of Hard Currency

Depreciation in the Ghanaian cedi led to an increase in the effective interest rate on hard currency debt (Figure 64). In this example, in June 2016, a three-year loan was taken in euros at an interest rate of 8 percent rather than in local currency at 30 percent. During this time, the depreciation of the cedi, depicted by the blue line below, led the euro-denominated loan to become more expensive, with the effective interest rate rising from 8 percent to 40 percent, the dashed line. In this case, because the currency depreciated, it would have been cheaper for the company to take the debt in local currency at the higher 30 percent interest rate instead of the hard currency loan at 8 percent.

Figure 64: The Increase in Interest Rates on Hard Currency Debt as Local Currency Depreciates



Source: Open Capital Advisors and Vivid Economics.

Some companies at a certain level of scale can limit their foreign-exchange exposure by operating in multiple countries, reducing their desire for local currency financing. By operating in multiple local currencies, companies can in effect hedge against the depreciation of any single currency through diversification, although this is not a fail-safe method. Additionally, such companies might prefer to borrow in a single hard currency to fund their operations, rather than accessing several smaller loans across multiple local currencies, which would increase transaction costs.

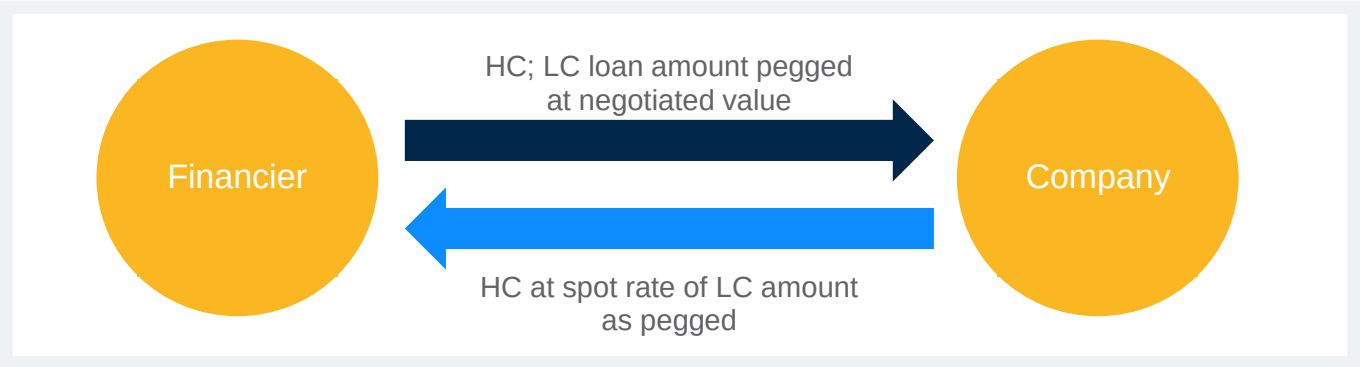
THE INCREASING AVAILABILITY OF DIFFERENT MECHANISMS FOR LOCAL CURRENCY LENDING, AS WELL AS INCREASED DIRECT LOCAL CURRENCY LENDING BY DFIS, WILL INCREASE LOCAL CURRENCY DEBT IN THE SECTOR.

In general, a variety of local currency financing solutions appear set to increase local currency lending in the OGS sector. Despite their initial reluctance, local banks are becoming more interested in the sector, especially as off-grid companies grow and become less risky investment opportunities. Partnerships between foreign and local lenders are helping to facilitate their involvement, in conjunction with initiatives from various industry partners that seek to sensitize local banks to the opportunities of the OGS sector to accelerate local currency financing. DFIs and governments are also expected to accelerate the availability of local currency financing in the sector through credit facilities providing additional security to local financiers.

Direct local lending from financiers with access to local capital is expected to become more common and is key to ramping up local currency investments. Direct local lending is the most straightforward way to lend local currency, as the entire transaction is conducted in the same currency. Local banks and some DFIs with access to local currency accounts, such as CDC or FMO, are uniquely positioned to provide such financing. However, the reluctance of local banks to lend, along with the large ticket sizes required by most DFIs, have kept local currency financing rare to date. As companies grow, DFIs look to lend more in local currency, and local banks gain familiarity with the sector, financing in local currency will become increasingly common. Local banks' involvement is the best way to ensure the long-term, sustainable, and scalable provision of local currency financing. Until that occurs, several interim solutions will help to fill the gap.

Some hard currency lenders are willing to take local currency risk directly through agreements with investees, though this is rare and unlikely to happen at scale. In this form of lending, the lender disburses hard currency and accepts some degree of currency fluctuation risk. The level of risk is negotiated with the investee, with both parties agreeing to a pre-determined, fixed exchange rate for future loan repayments (Figure 65). The risks involved in this type of transaction and the in-depth knowledge required of trends in the local currency have made this form of lending less common in the sector, and it is likely to remain so moving forward.

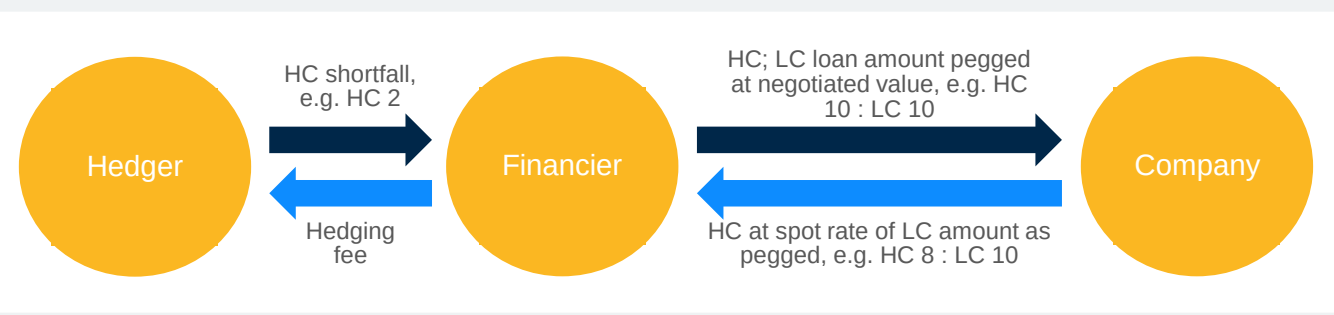
Figure 65: Synthetic Local Currency Lending from a Foreign Financier with No Intermediary



Source: Open Capital Advisors and Vivid Economics.
Note: LC = local currency; HC = hard currency.

We expect synthetic currency hedging through an intermediary will accelerate, increasing the availability of local currency debt. Hedging providers are already very active in the sector and offer hard currency lenders an opportunity to hedge all exposure by paying a hedging fee (Figure 66). In this approach, the company receives hard currency pegged against an agreed amount of local currency, repaying that amount of local currency in the equivalent value of hard currency at the spot rate on the date of repayment. In this case, parties typically negotiate rates as close as possible to the rates local banks offer to convert local currency to the relevant hard currency in each market. While more prominent in other sectors, as with MFIs, there are a few active hedging providers in the OGS sector, such as the Currency Exchange Fund (TCX). The challenge of this approach is its higher hedging costs and complexity of transaction structuring.

Figure 66: Synthetic Currency Hedging through an Intermediary



Source: Open Capital Advisors and Vivid Economics.
Note: LC = local currency; HC = hard currency.

3.2 Increasing Access to Finance

KEY MESSAGES

- Although total capital invested has generally increased year on year, OGS companies report a shortage of capital, particularly equity.
- To attract additional investment to the sector, OGS companies need to demonstrate profitability and signs of positive cashflow.
- The sector is developing standardized metrics to help investors judge the performance of possible investees and reduce investment risk.
- Expanding innovating financing mechanisms, including off-balance-sheet financing, will be critical to spurring further investment into the sector.

Photo credit: © Bright

3.2.1 Attracting New Investment

TO ATTRACT NEW EQUITY INVESTORS TO PROVIDE FRESH CAPITAL AND FACILITATE EXITS FOR EARLY-STAGE INVESTORS, THE SECTOR NEEDS TO DEMONSTRATE TRACK RECORDS OF PROFITABILITY AND INCREASE TRANSPARENCY AROUND OPERATIONAL EFFICIENCIES.

Although total capital invested has generally increased year on year, OGS companies report a shortage of capital, particularly equity. Almost half of the companies in the sector believe that insufficient capital is available.[285] Most notably, while the debt market has greatly improved, equity markets are increasingly challenging for all but a few, large players; grant funding has also dwindled. This disproportionally impacts newer and smaller off-grid companies. Outside of the leading First-Generation companies, financing is difficult to procure, especially between the Seed and Series A stages.[286] Reasons for capital constraints can be summarized into four key themes: (1) very few new equity investors are entering the sector; (2) the lack of exits prevents investors from liquidating to reinvest equity in the sector and discourages potential new investors from entering the market; (3) some key investors require larger ticket sizes to invest, meaning only companies at a certain degree of scale are potential investees; and (4) investors are examining company financials for at least signs of profitability, a shift from their previous focus on impact and scale.

Large equity investors expect to see a track record of profitability in potential investees, but most companies in the OGS sector have not reached this stage. Most early equity investments in the space prioritized revenue growth and market potential above profit, which incentivized companies to expand their revenue base as quickly as possible to attract higher valuations and raise sufficient capital for growth. That dynamic has since shifted, with equity investors now focusing on profitability instead of growth at any cost. This is especially true of larger equity investors and others not yet committed to the market; they would prefer to wait to see further risk mitigation among OGS companies and proof of long-term sustainability.

OGS companies have begun to demonstrate profitability on some metrics—but not yet all. While the sector is seeing more signs of profitability than ever before, challenges and inconsistencies persist around how companies define profitability, often caused by the complexity of OGS business models. First, while some PAYGo companies are starting to show positive EBITDA, a strict focus on this metric may paint an inaccurate picture of a company's health. Positive EBITDA is not the same as positive net profit, which shows a company's true profitability. Second, there is no standard method for how OGS companies record revenues. Most companies record revenues on an accrual basis, meaning that they recognize revenue when earned, at the point of sale. Some might record revenue on a cash basis, recognizing revenue only once cash is received. Others still practice some combination of these.

285 Johanna Galan, Juliana Martinez, and Dieter Poortman, "The Top 5 Investment Trends in the Off-Grid Solar Energy Sector," GOGLA (blog), May 9, 2019, https://www.gogla.org/about-us/blogs/the-top-5-investment-trends-in-the-off-grid-solar-energy-sector.

286 Leslie Labruto and Esha Mufti, Accelerating Energy Access: The Role of Patient Capital (New York: Acumen, 2018), https://acumen.org/accelerating-energy-access/.

INVESTORS ARE CALLING FOR MORE TRANSPARENCY AND CONSISTENCY ON PERFORMANCE METRICS ACROSS THE INDUSTRY, WITH NEW INITIATIVES LOOKING TO STREAMLINE REPORTING.

Inconsistent financial reporting practices discussed above, make investing in OGS companies appear riskier for investors, particularly new ones that are unfamiliar with the sector. Risk manifests in two ways. First, investors require deep sectoral experience to understand the nuances of complex PAYGo companies and accurately judge risk. Many investors, particularly local financial institutions, do not yet have this internal level of comfort with the sector. Second, comparing OGS companies against one another is very difficult, which increases risk perception or transaction (due diligence) costs.

Investors are increasing their calls for companies to focus on and be more transparent about key performance indicators (KPIs). These include customer acquisition costs, average revenue per customer, contribution margin, cost of capital, utilization, and collection efficiency.[287] Some stakeholders are taking their own steps towards standardization, such as the SIMA Angaza Distributor Financing Fund. With the permission of Angaza's customers, this analyzes customer data in a standardized way to assess eligibility for funding from SIMA, as well as to monitor performance. A sector-wide approach is PAYGo PERFORM, which is helping companies to address challenges and improve their performance by developing a reporting framework and a set of KPIs for the PAYGo OGS industry. Such metrics are critical to allow investors to easily gauge a company and its potential against the PAYGo business model's unique performance dimensions. Engagement with this initiative by both companies and investors from across the sector is a positive sign that stakeholders not only recognize the significant remaining challenges in the sector's access to finance but are also collaboratively building towards a solution.

287 Acumen and Open Capital Advisors., Exits in Off-Grid Energy.

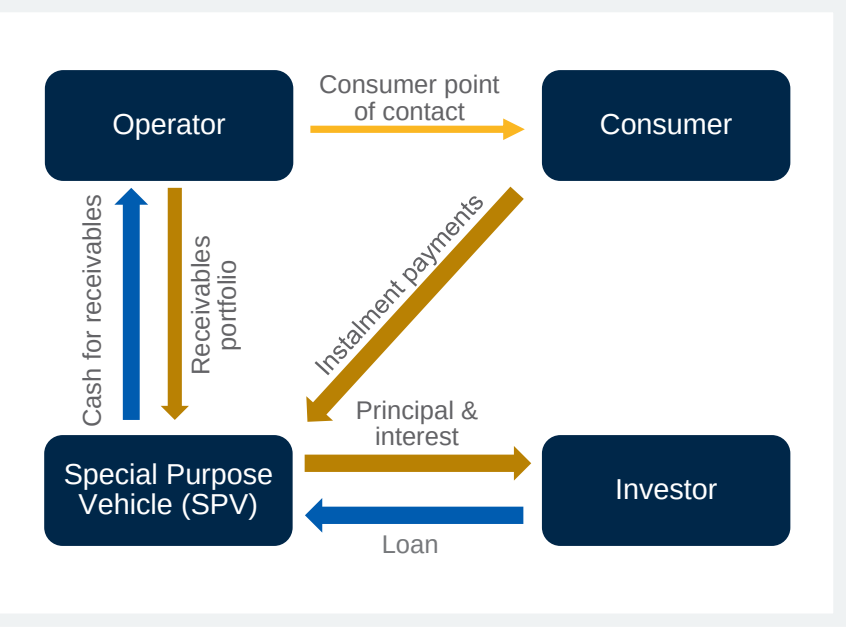
3.2.2 Innovative Financing Models

INNOVATIVE FINANCING MODELS, SUCH AS OFF-BALANCE-SHEET FINANCING AND CROWDFUNDING, ARE STARTING TO CATALYZE ADDITIONAL CAPITAL FOR THE OGS SECTOR BUT WILL NEED TO ACCELERATE.

As the sector grows, innovative financing models now being established could further catalyze the market by providing companies with access to new sources of capital to reach more customers. In this context, innovative financing comprises fundraising mechanisms that extend beyond the traditional approaches of the public or private sectors. Some of the most promising examples in the OGS sector are off-balance-sheet financing and securitization (explored further below), as well as crowdfunding (examined above in Section 3.1.2).

Previous Market Trends Reports—and many stakeholders in the sector—have highlighted the huge potential of off-balance-sheet financing, and possibly securitization, to catalyze an influx of capital into the sector. Stakeholders remain optimistic for the future use of these instruments, which have synergy with and potential scale-enabling benefits for PAYGo business models, which consistently generate consumer leases and loans that require long-term financing. Examples include Azuri's US$ 20 million off-balance-sheet debt financing program with ElectrFi and TRINE in 2018 and Mobisol's transaction of more than US$ 10 million in 2017. In more advanced global industries, off-balance-sheet financing is typically used to securitize a pool of assets or the revenue streams associated with those assets. The pool is then sold in the form of a security to provide upfront liquidity to the operator (Figure 67).

Figure 67: Illustrative Structure of an Off-Balance-Sheet Arrangement



Source: Open Capital Advisors and Vivid Economics.

While initial examples of off-balance-sheet financing have been demonstrated in the OGS sector, challenges to a broader securitization model remain. For many investors, securitization requires a stable pool of assets whose risks can be priced and are well-understood. Given the relatively early stage of the OGS industry compared to major global industries such as cars and car loans, data on the performance of OGS receivables portfolios are limited. Another concern is the lack of third-party administrators who could step in to manage a portfolio of receivables in the event of a default, as is found in other global sectors. Additional concerns such as high complexity and the fees to establish such structures also represent barriers to scale at this early stage.[288]

288 Open Capital Advisors and Vivid Economics consultations.

Despite these challenges, there are strong indications that off-balance-sheet financing and securitization will accelerate over the coming years. Three developments will drive their adoption. First, as PAYGo companies gain experience sustainably managing their long-term receivables (in part through increased use of data), investors will be able to value a receivables portfolio more accurately. Overcoming this key barrier, we expect, will increase demand for off-balance-sheet financing. Second, as demand increases, driving a sufficient level of scale, third-party operators will be incentivized to offer services administering receivables portfolios, off-loading this burden from OGS companies. Finally, the more such structures are utilized, the more setup costs will fall, enabling greater efficiency for all stakeholders. Since OGS companies do not specialize in finance, they would prefer not to bear substantial credit risk on their balance sheets if there were a cost-efficient way to spin off that risk. Investors, meanwhile, have indicated they would have an appetite to finance such instruments in the OGS sector given well-understood, well-structured risk.

ADAPTING FINANCING MODELS FROM OTHER SECTORS, SUCH AS CSR FUNDS, CLIMATE BONDS, OR SOCIAL BONDS, TO THE OGS SECTOR COULD OFFER NEW OPPORTUNITIES TO INCREASE AVAILABLE CAPITAL.

- **Green, social, and sustainability bonds finance projects which are needed to address environmental and social issues, but they have yet to gain traction for the OGS sector.** These bonds generally have tax incentives, making them more attractive investments than comparable taxable bonds. While reaching the required scale to access this form of financing is a challenge for most OGS companies, some are actively considering green bonds. For example, NOTS, a solar company in Rwanda, already offers these in the Netherlands.[289] These mechanisms could offer a future, sustainable source of financing for off-grid companies.
- **Another potentially attractive model implemented in the development space is the "international solidarity levy on air tickets," also known as the airline ticket tax.**[290] A similar initiative could provide additional funds for energy access initiatives in the off-grid sector, but it would require a huge and multilateral approach.
- **Climate-focused CSR funds offer a potentially deep opportunity to support innovation and bridge the affordability gap.** While the OGS sector has already received CSR funds from some related industries, such as utilities, the sector could leverage the global response to climate change to encourage companies from additional industries to commit CSR funds. These funds can be provided through direct grants to OGS companies or, more sustainably and appropriately for the sector, through Grant Co-Financing Facilities (GCFs) and Revolving Loan Funds (RLFs). GCFs and RLFs commonly target areas of interest that have had trouble attracting private sector finance or represent high-risk or no-return investments. This capital could be strongly aligned with serving populations that cannot currently be served through commercial means.

289 Barbara van Est, "Waar zijn die groenfondsen?," Geldgids, August/September 2018, 41–43, https://www.consumentenbond.nl/binaries/content/assets/cbhip-powebsite/gidsen/geldgids/2018/nummer-5—augustus/gg201808p41-groenbeleggen-p.pdf.

290 The funds raised from the international solidarity levy on air tickets goes to UNITAID, a hosted partnership of the World Health Organization (WHO). Das et al., Innovative Finance for Renewable Energy Solutions (Lalitpur, Nepal: SNV Netherlands Development Organization, 2015), https://energypedia.info/wiki/Innovative_Finance_For_Renewable_Energy_Solutions, 38–39.

CHAPTER 4
ENABLING ENVIRONMENT

Photo credit: © Dan Odero

Governments increasingly recognize the off-grid solar (OGS) sector as a key component of reaching universal energy access (SDG 7) by 2030, and most now integrate OGS into their energy sector planning.

However, translating policy and regulation into effective implementation will require building the capacity of local implementing entities. To ensure that policy improvements bear fruit, including National Electrification Plans, governments need to develop experience and expertise in off-grid energy, which is a new area for them. Effective design and implementation of energy policies will require that training and peer-to-peer learning opportunities be made available to policymakers.

Policy and regulation must also continually evolve, especially as OGS companies increasingly offer goods and services beyond energy provision. While most countries have made rapid strides in putting in place energy sector policies and plans to support the OGS sector, OGS technologies and business models increasingly extend "beyond energy" and are thus subject to a wider set of policies and regulations, including those regarding the provision of consumer credit and banking services, mobile and digital payments, and insurance. Getting the balance of these regulations right, so that they do not inadvertently hinder the growth of business models offering consumers a range of high value-add services will continue to be a key challenge for governments.

With growing recognition of the OGS sector's important role in electrification, we have also seen increased public financing and partnerships among the private sector, donors, and governments. Flows of public finance to the OGS sector continue to increase, a trend that will continue. Substantial public financing commitments have already been made by development partners for the next few years.

While public financing will continue to be crucial for the growth and impact of the OGS sector, it must be carefully targeted to unlock sustainable growth in the commercial market. Governments and development partners can now draw on an increasingly rich body of experience in how to target public funds for supply-side initiatives to catalyze markets at different stages of development. The use of supply-side initiatives is well-established to help commercial opportunities reach scale and unlock potential in relatively nascent markets. Going forward, carefully designed demand-side subsidies can help reach the poorest and hardest-to-reach consumers (including those in fragile and conflict-affected states).

The remainder of this chapter proceeds as follows:

- **Section 4.1** describes the evolution of OGS-relevant policy and regulation.
- **Section 4.2** describes how public financing and partnerships help to open up and accelerate the growth of commercial markets and close the affordability gap.

4.1 Policy and Regulation

KEY MESSAGES

- Recognizing the demonstrated value and impact of the OGS sector, most governments now integrate OGS into their energy sector planning.
- However, translating policy and regulation into effective implementation will require building the capacity of local implementing entities.
- Most markets where OGS has thrived have included clear, advantageous, and transparently implemented tax or import policies—or both.
- Policy and regulation must continually evolve as OGS companies increasingly offer goods and services beyond energy provision because regulation in other sectors can inadvertently affect OGS.
- To create an enabling environment for PAYGo, energy authorities must closely coordinate with their counterparts in the digital and financial sectors.
- As OGS products and business models continue to evolve and expand beyond traditional energy goods and services, consumer protection is increasingly important. Internationally recognized quality standards and test methods are increasingly being adopted by national governments and regional bodies.
- While many governments are aware of the risks presented by e-waste, policy concerning e-waste is often still not enacted or inconsistently enforced.

Photo credit: © D.Light

4.1.1 National Electrification Strategies and Off-Grid Energy Planning

RECOGNIZING THE DEMONSTRATED VALUE AND IMPACT OF THE OGS SECTOR, MOST GOVERNMENTS NOW INTEGRATE OGS INTO THEIR ENERGY SECTOR PLANNING.

Most countries in all regions with energy access deficits now include a defined role for off-grid energy solutions in their national electrification plans (Figure 68). This is according to one of the sub-indicators of the World Bank's Regulatory Indicators for Sustainable Energy (RISE) index, which simply captures whether or not there is a dedicated national framework for standalone solar systems.[291] Even in South Asia, where the most recent RISE 2017 data recorded limited inclusion of off-grid energy in national electrification plans (as shown in Figure 68), governments have since made substantial progress. Two of the largest South Asian countries (India and Bangladesh) have developed major policies to support the off-grid energy sector, and Pakistan is in the process of finalizing its "Alternative and Renewable Energy Policy," which includes a defined role for off-grid energy solutions.

Not only have more countries included OGS in their national frameworks, but many countries have also improved the quality and comprehensiveness of those frameworks (Figure 69). Looking across the RISE sub-indicators for standalone solar systems, which also examine whether national frameworks include financial incentives, standards, and quality requirements, we see a steady improvement in country scores. For example, between 2013 and 2017, the average RISE score of West African countries for standalone solar systems improved from 27 out of 100 to 61.[292] Over the same period in South East Asia and Pacific region, the average score increased from 41 to 72. The only region showing little to no improvement was Central Africa, where the score stagnated at 28 in 2017 compared to 26 in 2013. Overall, more than one-quarter of major energy access–deficit countries now have comprehensive OGS policy and regulatory frameworks, while a further 50 percent have put in place at least some critical policies and regulations to support the OGS sector.[293]

Best practices for integrating OGS into national electrification programs are now emerging. Togo and Ethiopia are among the successful examples of how OGS has been incorporated into national electrification plans to catalyze demand and facilitate routes to market for suppliers. In Togo, a clearly defined role for OGS technologies, transparent licensing requirements, and government support to relieve key market barriers has attracted private-sector operators. Similarly, Ethiopia has set a clear national policy framework for the pathway to universal access, using OGS both as a transition and a long-term solution.

The shift towards increasing the inclusion of OGS in national electrification plans is largely driven by the growing availability of geospatial least-cost electrification planning tools. Geospatial planning tools, which are transforming electrification planning, allow for accelerated, relatively low-cost, and visually powerful modeling of least-cost electrification pathways. The resulting models offer a guiding framework for the roles of main grids, mini-grids, and OGS technologies in achieving universal electricity access in a country. Emerging open source geospatial planning tools are now widely available, especially following the launch of the Global Electrification Platform (GEP) in November 2019.[294] The World Bank and ESMAP have supported, or are in the process of supporting, geospatial least-cost electrification plans in 20 countries. Other development partners, such as GIZ and Power Africa, are also providing additional support.

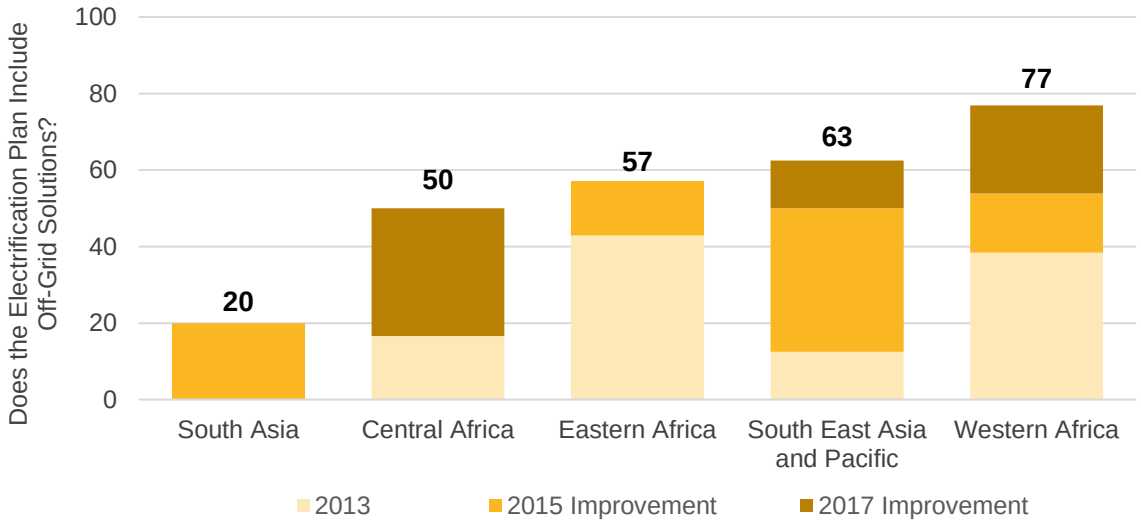
291 Figure 68 presents average scores for each region in response to the (binary) question "Does the electrification plan include off-grid solutions," with 100 answering "yes" and 0 answering "no." ESMAP, Regulatory Indicators for Sustainable Energy (Washington, DC: World Bank, 2018), http://documents.worldbank.org/curated/en/553071544206394642/pdf/132782-replacement-PUBLIC-RiseReport-HighRes.pdf, 117.

292 The RISE sub-indicators are scored as follows: (1) existence of national program, 0 or 100 if there is a program; (2) financial incentives, scored 33, 67, or 100; and (3) standards and quality, scored 0, 33, 67, or 100. The overall indicator is an average across all three sub-indicators.

293 ESMAP, Regulatory Indicators for Sustainable Energy, 35–37.

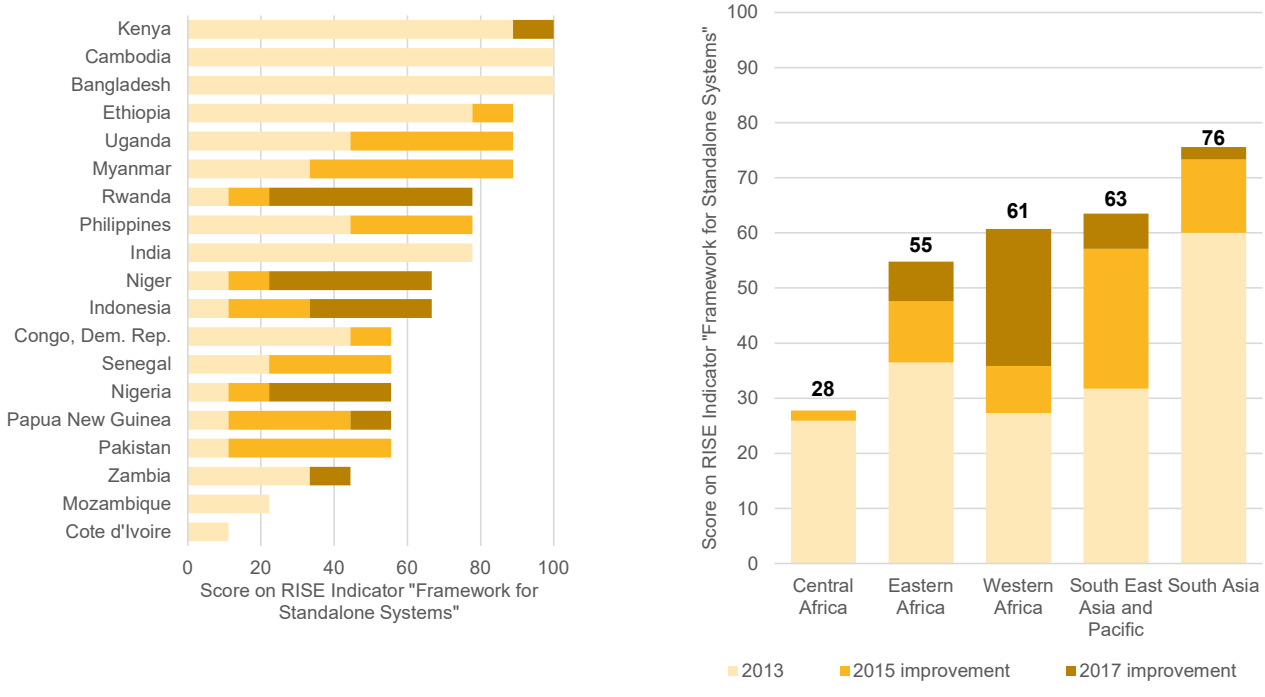
294 ESMAP, "Global Electrification Platform," https://electrifynow.energydata.info/.

Figure 68: Most Countries in Regions with Energy Access Deficits Now Include a Defined Role for OGS



Source: Vivid Economics and Open Capital Advisors from RISE 2017 data.

Figure 69: Across Almost All Countries, the Quality of the Framework for Standalone Solar Systems Improved between 2013 and 2017, and Some Gains Have Been Large

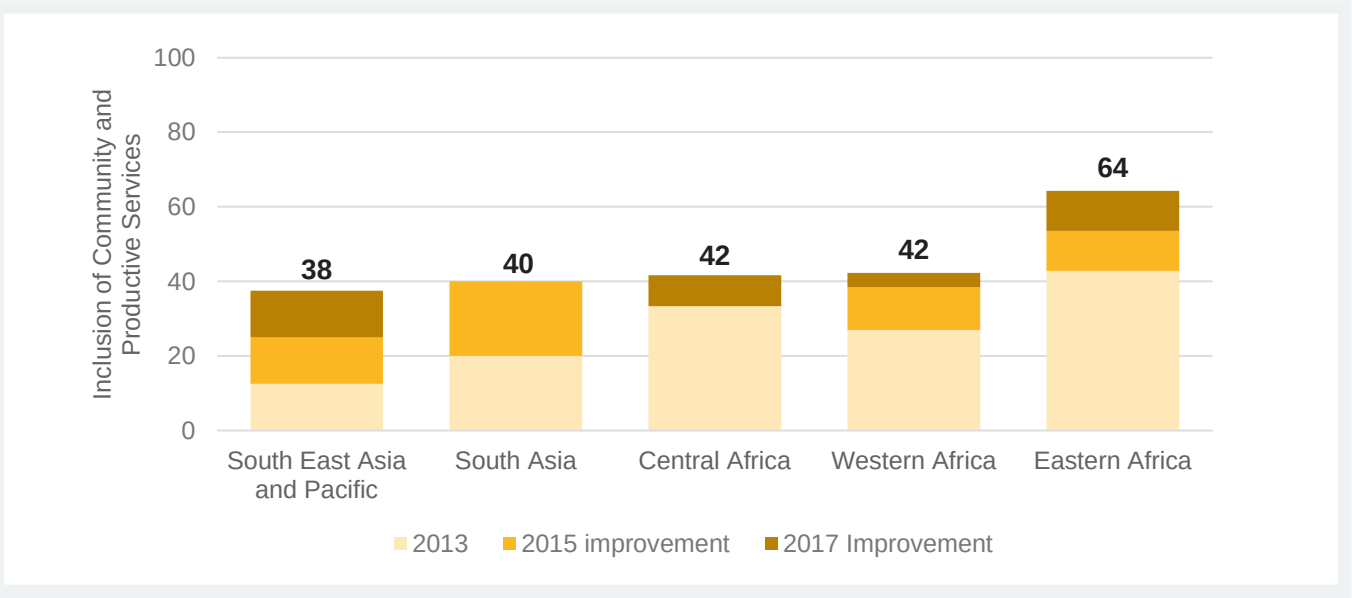


Source: Vivid Economics and Open Capital Advisors from RISE 2017 data.

Note: The sub-component of the RISE index regarding the framework for standalone solar systems measures the overall quality of the regulatory and policy framework for the OGS sector, including indicators such as the existence of national electrification strategies, taxes and subsidies for OGS devices, regulation concerning quality standards, and programs for the development of off-grid solar.

Electrification strategies are also beginning to consider the role of OGS for public institutions and the potential role of PULSE technologies (Figure 70). For public institutions, one challenge is that the mandate for electrification often resides with the respective ministries, such as health and education, or is decentralized to regional or municipal authorities. Effective cross-sector collaboration is necessary to reach this market segment. Government policy also has a key role to play in fostering sustainable market development for the relatively nascent PULSE sector. For example, governments can play a critical role in raising awareness of PULSE technologies and help PULSE distributors overcome initial market barriers (described further in Section 2.4.3), such as low affordability, limited access to finance, and low awareness of or low familiarity with products and the value they can provide.

Figure 70: While Integration of Community and Productive Use of Energy Lags, Electrification Plans Are Beginning to Integrate These Technologies



Source: Vivid Economics and Open Capital Advisors from RISE 2017 data.

HOWEVER, TRANSLATING POLICY AND REGULATION INTO EFFECTIVE IMPLEMENTATION WILL REQUIRE BUILDING THE CAPACITY OF LOCAL IMPLEMENTING ENTITIES.

Successful implementation of policy hinges on building capacity among implementing agencies in local government, many of which have limited resources or experience with OGS technologies. While policies related to OGS have rapidly improved, this has yet to convert to clear results. Rural electrification agencies, national standards bureaus, energy regulators, and other government agencies involved in off-grid electrification, as well as local industry associations, are often working with limited prior experience in the sector and have limited financial and human resources to deliver across a wide electrification mandate. Providing these agencies with the financial and technical capacity to take ownership of the development of the OGS sector is an essential complement to providing increased flows of finance to the sector.

Responding to this need, governments, and development partners are quickly evolving their efforts to build capacity among local institutions and share experiences and best practices. ESMAP's Technical Assistance program works closely with governments to build their capacity to develop electrification plans through least-cost geospatial planning. Lighting Global and GOGLA also work closely with governments to build capacity and improve policy and regulation that may be limiting the growth of the sector. DFID's recently launched Africa Clean Energy (ACE) program will provide technical assistance to national governments and industry associations in 14 countries in Sub-Saharan Africa to encourage the reform of policy and regulation, improve investment readiness, and facilitate learning and coordination. In another example, the Regional Off-Grid Electrification Project (ROGEP) provides harmonized support to governments to improve the enabling environment for OGS products in West Africa (Box 17).

Box 17: Regional Off-Grid Electrification Project (ROGEP): Building an Enabling Environment to Develop the OGS Market by Supporting Governments

ROGEP aims to share knowledge and experience of technological innovations and new business models to improve and harmonize the enabling environment for stand-alone solar products across West Africa. The Economic Community of West Africa States (ECOWAS) Center for Renewable Energy and Energy Efficiency (ECREEE) will work in partnership with the national governments of 19 project countries.

Through ROGEP's collaborative and consultative process, country success stories will motivate others to adopt new policies and change mindsets. Finance and technical assistance will also be provided, including:

- Policy and analytical assistance to inform energy access policy, especially to address trade barriers, promote quality standards for off-grid products, and promote the use of mobile money;
- The establishment of a support center network to promote entrepreneurship in the off-grid space;
- Training and knowledge-exchange programs;
- Promotional campaigns and consumer-awareness programs;
- Capacity-building support for banks and financial institutions; and
- Support to pilot and develop new business models to promote standalone-alone solar systems for public institutions and PULSE applications.

ROGEP also provides a working capital facility for OGS products. This is channeled through the West African Development Bank (BOAD) and pilots a service model for the sustainable off-grid electrification of schools and health facilities.

4.1.2 Tax and Import Duty Regimes

MOST MARKETS WHERE OGS HAS THRIVED HAVE INCLUDED CLEAR, ADVANTAGEOUS, AND TRANSPARENTLY IMPLEMENTED TAX OR IMPORT POLICIES—OR BOTH.

A small but growing body of evidence suggests that taxes act as a very real barrier to OGS market growth, as many consumers are highly price-sensitive. Applicable taxes for the OGS sector include those levied on sales of goods (VAT), customs duties, and import tariffs. In East Africa, one analysis showed, a 20 percent increase in tariffs on SHS would reduce estimated sales of smaller systems and larger kits (including televisions) by 18 percent and 32 percent, respectively.[295] High tariffs are particularly prohibitive to market development for price-sensitive OGS products and in segments where affordability is a constraint.

To address this challenge, governments are increasingly deploying fiscal incentives to support standalone solar systems, with 65 percent of governments implementing duty exemptions or subsidy programs in 2017 compared to just 43 percent in 2013 (Figure 71). Duty exemptions are more common than subsidies, with 52 percent of countries with energy access deficits putting duty exemptions in place, while 41 percent provided subsidies (and 28 percent provided a combination of duty exemptions and subsidies).[296] We discuss subsidies in more detail below (Section 4.2.2), focusing here on a discussion of effective tax and import duty policies.

Togo, Ethiopia, and Kenya are leading examples of implementing favorable import duty or tax incentives for OGS products. Elsewhere, in Bangladesh, recognizing the importance of both grid-tied solar PV plants and off-grid technologies such as solar irrigation and SHS, the National Board of Revenue reintroduced VAT exemptions for solar panels and modules at the end of 2018. In Niger, all OGS components are exempt from import tax and duties, including PV modules, batteries, inverters, and all accessories used for solar products, as well as packaged solar kits.[297] Most recently, Benin has made imports of solar panels exempt from the payment of the VAT in its 2020 finance law.[298]

While duty or tax incentives may reduce immediate tax revenue, countries and their governments stand to benefit from stimulating the OGS sector through fiscal incentives. The growth in the number of countries using fiscal incentives shows governments' recognition of the OGS sector's importance and their willingness to trade off government revenue to catalyze the OGS sector. It helps that this tradeoff is not large, as the revenue generated from an OGS sector taxed at full rates represents a relatively small part of overall government revenue. For example, even in a relatively mature market—Kenya—a 20 percent tariff would provide the government with only an additional US$ 5 million in estimated revenue while causing a reduction in sales of more than 40,000 units each year and leaving those households without access to electricity.[299] Furthermore, the OGS sector stimulates economic activity among consumers and creates jobs in the OGS value chain (described further in Section 5.1), which in the long term may actually generate more government revenue.[300]

295 Rob Fetter and Jonathan Phillips, The True Cost of Solar Tariffs in East Africa, policy brief, Nicholas Institute for Environmental Policy Solutions (Durham, NC: Duke University, February 2019), https://nicholasinstitute.duke.edu/publications/true-cost-solar-tariffs-east-africa.

296 RISE 2017 data.

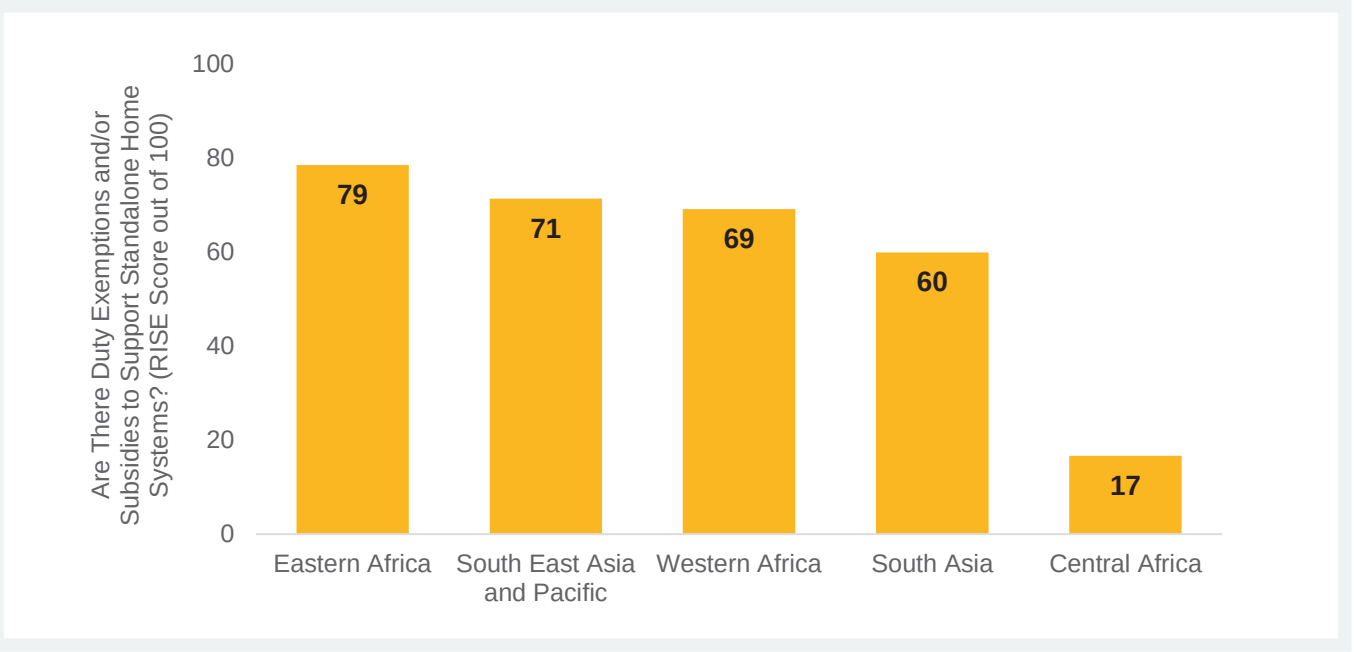
297 Ministère de l'Énergie and Ministère des Finances, République du Niger, "Arrêté conjoint no. 0029 du 13 Sept 2017 portant liste des équipements et matériels à énergies renouvelables à exonérer des droits et taxes perçus en douane," https://www.lightingafrica.org/wp-content/uploads/2018/02/Arret%C3%A9-Conjoint-ME-MF-Exoneration.pdf.

298 Emiliano Bellini, "Benin Introduces VAT Exemption on Imports of PV Panels," PV Magazine, January 27, 2020, https://www.pv-magazine.com/2020/01/27/benin-introduces-vat-exemption-on-imports-of-pv-panels/.

299 Fetter and Phillips, True Cost of Solar Tariffs, 8.

300 Vivid Economics, Off-Grid Solar: A Growth Engine for Jobs (Utrecht: GOGLA, June 7, 2019), https://www.gogla.org/resources/off-grid-solar-a-growth-engine-for-jobs; and Emmanuel de Dinechin, Guillaume de Chorivit, and Oliver Reynolds, Powering Opportunity: The Economic Impact of Off-Grid Solar (Utrecht: GOGLA, July 2018), https://www.gogla.org/resources/powering-opportunity-the-economic-impact-of-off-grid-solar.

Figure 71: Duty Exemptions or Subsidies Are Now Common for Standalone Home Systems in All Regions except Central Africa



Source: Vivid Economics and Open Capital Advisors from RISE 2017 data.

A CLEAR DUTY EXEMPTION POLICY IS A CRUCIAL FIRST STEP, BUT POLICIES MUST BE CONSISTENTLY ENFORCED.

Even countries with a well-developed OGS sector and favorable tax regime like Kenya have had issues with the inconsistent application and interpretation of duty exemption policies. For instance, when not imported as part of a kit, components like lights, batteries, or electrical wiring and mounting are not always tax-exempt, which creates uncertainty for OGS companies.[301] Furthermore, in many countries, the application of taxes can vary from container to container, creating uncertainty for companies around how tax and customs policy will actually be enforced.

As a wider range of both plug-and-play and component-based systems reach markets, tax policies must be rationalized for all solar and related components. Companies are often left facing unclear and inconsistently implemented tax policies, with, for example, different rates applied to PV panels than to a kit including a panel, a lamp, and wiring. Clear policies should be developed and applied to packaged kits that include, for example, radios and televisions—which are often not treated under the same tax code as solar PV panels (where the latter may be exempted). Application of tax exemptions also must be carefully considered so that exemptions only apply to the intended solar products. For example, the East African Community noted that "solar" batteries could potentially be used for other, non-intended purposes, including car batteries.

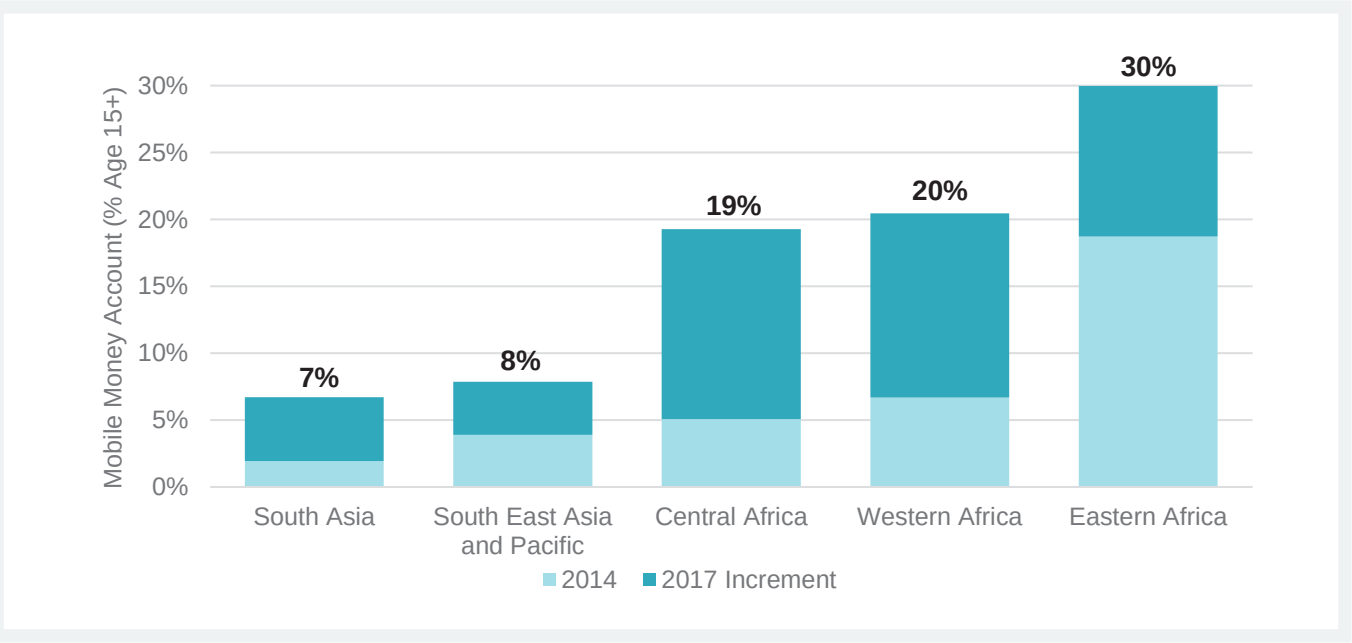
301 Power Africa, Off-Grid Solar Market Assessment: Kenya (Washington, DC: United States Agency for International Development, October 2019), https://www.usaid.gov/powerafrica/beyondthegrid/off-grid-solar-assessment/kenya.

4.1.3 PAYGo and Consumer Financing Regulation

POLICIES AND REGULATIONS MUST CONTINUALLY EVOLVE AS OGS COMPANIES INCREASINGLY OFFER GOODS AND SERVICES BEYOND ENERGY PROVISION BECAUSE REGULATION IN OTHER SECTORS CAN INADVERTENTLY AFFECT OGS.

Companies are now applying PAYGo and consumer financing, key enablers of access to OGS products, to offer services beyond energy, with a host of implications for policies and regulations across the digital and financial sectors. The use of mobile money has expanded rapidly in recent years, a trend that will continue—opening up new markets for the PAYGo business model (Figure 72). Access to mobile money correlates with access to OGS technologies; for example, in Nigeria, the highest concentration of households without access to electricity is also in regions with low penetration of mobile phones and a low proportion of people with access to financial services. Policies and regulations around mobile money and digital payment services are, therefore, very important to the OGS sector. Until very recently, Nigeria's financial sector policy limited payment services to registered banks. In other countries (e.g., India), regulations limit the ability of companies to offer a product on credit if they do not have a banking license.

Figure 72: Access to Mobile Money Has Grown Rapidly across All Regions, Particularly in Sub-Saharan Africa



Source: Vivid Economics and Open Capital Advisors analysis of Asli Demirgüç-Kunt et al., The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution (Washington, DC: World Bank, 2018), https://datacatalog.worldbank.org/dataset/global-financial-inclusion-global-findex-database.

Off-grid solar business models have adapted to the policy and regulatory environment they face to offer products on a PAYGo basis or through other forms of consumer credit. For example, Lumos partnered with MTN in Nigeria, using mobile airtime as a payment mechanism; in Senegal, meanwhile, money transfer companies have offered payment transaction services. While partnerships with MFIs have had mixed results in Sub-Saharan Africa, they are a common way to reach rural customers in South Asia (for example, Greenlight Planet has partnered with some of the largest microfinance institutions in India).[302] In Nigeria, Azuri recently announced its partnership with FirstBank to leverage its proprietary 16,000 agent network to sell solar home TV products with FirstBank providing consumer finance, while Zola Electric has made similar arrangements with Sterling Bank.[303] However, these alternatives to the PAYGo business model are often more costly, underlining the need for a clear and supportive regulatory framework to enable companies to offer payment services.

TO CREATE AN ENABLING ENVIRONMENT FOR PAYGO, ENERGY AUTHORITIES MUST CLOSELY COORDINATE WITH THEIR COUNTERPARTS IN THE DIGITAL AND FINANCIAL SECTORS.

Governments are increasingly implementing supportive regulatory frameworks to enable companies to offer payment services under the PAYGo business model. For example, the Central Bank of Nigeria recently authorized mobile network operators (MNOs) to offer limited banking services, which is expected to result in much more widespread use of mobile money over the next few years.[304]

As PAYGo companies partner with telecommunications companies, ensuring cross-sector partnerships are open and do not limit competition will be a key consideration. A particular risk is that where there is a dominant telecommunications company or mobile-money provider, they may corner the market by requiring OGS companies to exclusively use their mobile-money platform. As the mobile-money market evolves, ensuring interoperability between payment systems will be key to developing scalable markets at the national level.

Finally, there is a risk that "over"-regulation of mobile and digital based financial services may prohibit sustainable market development. Given the range of regulatory mandates that now cover elements of the PAYGo business model—including energy regulations, financial regulations, and telecommunications regulations—it is crucial that regulators work together to streamline their respective regulations and ensure they do not inadvertently restrict (or slow) the growth of the PAYGo sector.

302 Daniel Waldron, Alexander Sotiriou, and Jacob Winiecki, A Tale of Two Sisters: Microfinance Institutions and PAYGo Solar (Washington, DC: CGAP, November 2019), https://www.cgap.org/research/publication/tale-two-sisters-microfinance-institutions-and-paygo-solar; and Sneha Verma, "Greenlight Planet Launches Solar Fans for Rural India," Saur Energy International, May 7, 2019, https://www.saurenergy.com/solar-energy-news/greenlight-planet-launches-solar-fans-for-rural-india.

303 Lighting Global, Pay-As-You-Go Market Attractiveness Index 2019, Case Study: Nigeria (Washington, DC: Lighting Global, August 2019), https://www.vivideconomics.com/casestudy/paygo-market-attractiveness-nigeria-country-focus/.

304 Central Bank of Nigeria, Guidelines for Licensing and Regulation of Payment Service Banks in Nigeria (Abuja: Central Bank of Nigeria, October 2018), https://www.cbn.gov.ng/Out/2018/FPRD/OCTOBER%202018%20EXPOSURE%20PAYMENT%20BANK.pdf.

4.1.4 Consumer Protection and Quality Standards

AS OGS PRODUCTS AND BUSINESS MODELS CONTINUE TO EVOLVE AND EXPAND BEYOND TRADITIONAL ENERGY GOODS AND SERVICES, CONSUMER PROTECTION IS INCREASINGLY IMPORTANT.

Strong consumer-protection mechanisms in the OGS sector are necessary to limit the exposure of vulnerable consumers to product and financial risks. The OGS sector mostly targets low-income consumers in remote rural areas whose exposure to product risk has significant consequences.[305] Consumers face defective products, as well as fraudulent and insufficient after-sales support, while faulty products can even cause physical harm to the user. For example, batteries manufactured with appropriate techniques and precautions are safe, but low-quality batteries can cause fires or even explosions.[306]

The introduction of the GOGLA Consumer Protection Code highlights the importance of consumer protection, especially as companies move "beyond energy" in the services they provide to consumers. Developed collaboratively with stakeholders across the sector, the framework provides safeguards for customers through six principles of best practice, along with an assessment framework for companies to measure and monitor their performance (Figure 73).[307] First, the consumer should receive fair and respectful treatment; second, members should provide good consumer service. Third, the sector should operate with transparency and, fourth, with responsible sales and pricing. This means OGS companies must share accurate information on their products and pricing with their target markets to ensure that they fully inform consumers before those consumers make a significant financial investment. Fifth, technological advances and the growth of the PAYGo sector mean that companies must commit to appropriate handling of gathered data, following international and national regulations and including keeping data secure and confidential. Sixth and finally, companies must offer high-quality products. The code is officially endorsed by GOGLA members, who view it as a means to mitigate risks and accelerate responsible market growth.[308]

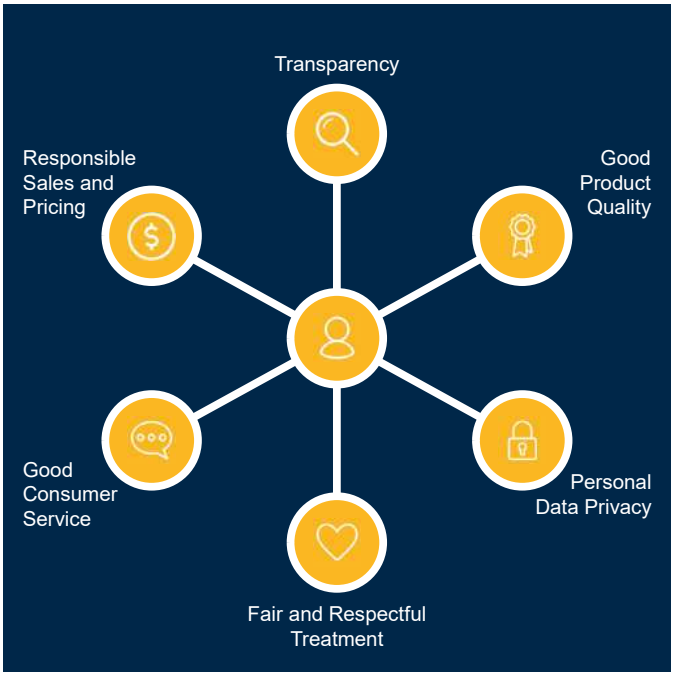
305 Daniel Rozas et al., Consumer Protection Insights: Learnings and Recommendations from the GOGLA Consumer Protection Code (Utrecht: GOGLA, June 2019), https://www.gogla.org/resources/consumer-protection-insights-learnings-and-recommendations-from-the-gogla-consumer, 4.

306 Rozas et al., Consumer Protection Insights.

307 Rozas et al., Consumer Protection Insights, 5–8.

308 GOGLA, "GOGLA Industry Opinion on Consumer Protection," June 20, 2019, https://www.gogla.org/resources/gogla-industry-opinion-on-consumer-protection.

Figure 73: GOGLA's Consumer Protection Code Identifies Six Key Pillars of Effective Protection



Source: Rozas et al., Consumer Protection Insights, 5.

CONSUMER EDUCATION AND AWARENESS CAMPAIGNS ARE ESSENTIAL IN HELPING TO BUILD CONSUMER CONFIDENCE—ESPECIALLY IN YOUNGER MARKETS.

Governments play a key role in protecting consumers from exposure to low-quality products or excessive financial risks through consumer education. Raising awareness of the benefits of (high-quality) OGS products is critical to catalyzing demand among new potential customers. Lack of awareness among consumers is the most common reason for their lack of uptake, ranking even above affordability.[309]

International platforms also have an important role to play in supporting consumer awareness campaigns and in building consumer education capacity alongside the private sector. For example, Lighting Global and the associated regional programs have all included consumer education programs as an essential strategic pillar. These programs have been critical components of the successful market building, as with the Suryodaya consumer-awareness campaign in India that ran in 9,370 villages across 31 districts in Bihar, Uttar Pradesh, and Rajasthan.[310]

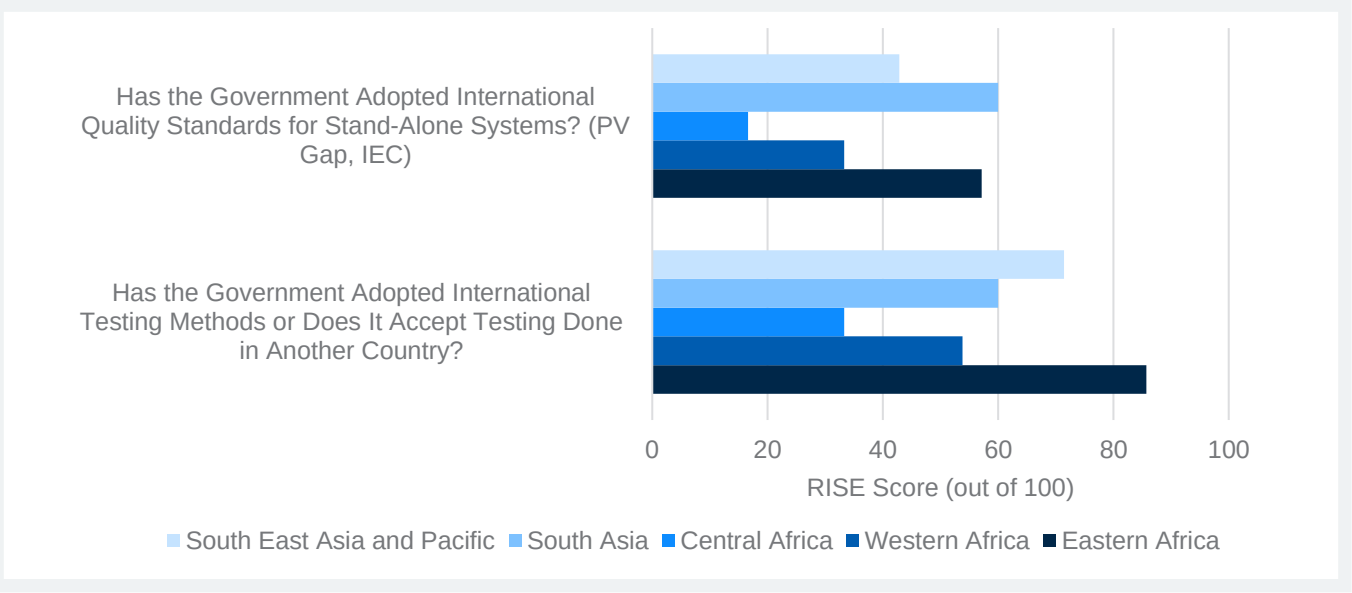
309 Kat Harrison and Tom Adams, An Evidence Review: How Affordable is Off-Grid Energy Access in Africa? (New York: Acumen, March 2017), https://energypedia.info/wiki/Publication_-_An_Evidence_Review:_How_Affordable_is_Off-grid_Energy_Access_in_Africa%3F.

310 Lighting Asia, "Consumer Awareness," http://lightingasia.org/india/consumer-awareness.

TO UNDERPIN CONSUMER EDUCATION AND PROTECTION EFFORTS, INTERNATIONALLY RECOGNIZED QUALITY STANDARDS AND TEST METHODS ARE INCREASINGLY BEING ADOPTED BY NATIONAL GOVERNMENTS AND REGIONAL BODIES.

Quality standards help the sector develop if properly implemented and enforced, including through streamlined importation processes and quality assurance logistics. Low-quality products have higher lifetime costs and can erode consumer trust.[311] In East Africa, one of the most mature OGS regions, both national and regional regulations have adopted international quality standards and testing methods as part of their regulations, including accepting testing being done elsewhere (Figure 74).

Figure 74: Adoption of International Standards and Testing Methods



Source: Vivid Economics and Open Capital Advisors from RISE 2017 data.

More countries are adopting the International Electrotechnical Commission (IEC)/Lighting Global standards and testing procedures for plug-and-play systems. More than 15 countries have now adopted the IEC/Lighting Global testing procedures, up from four identified in the previous Market Trends Report.[312] The adoption of international quality standards and testing methods for OGS products standardizes measures in the sector and ensures that the standards are fit for purpose.

311 Dalberg, The State of the Off-Grid Appliance Market (London and Washington, DC: Efficiency for Access, October 2019), https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report, 67–68.

312 Affiliate IEC member countries (developing countries able to adopt IEC standards without charge) who follow IEC 62257-9-5 standards and testing procedures are Afghanistan, Botswana, Ethiopia, Namibia, Rwanda, Senegal, Tanzania, Togo, Uganda, and Zimbabwe. International Electrotechnical Commission, "Adoption of EC International Standards by Affiliate Country," last updated November 22, 2019, accessed January 3, 2020, https://www.iec.ch/affiliates/facts/adopt_by_country.html. (A country's status may be verified by individually selecting each country and going through the list of standards.) In addition, several full and associate IEC members have national verified standards and testing procedures for OGS systems, namely India, Indonesia, Kenya, Malaysia, South Africa, Thailand, and Vietnam. Two years ago, the four countries were Ethiopia, Kenya, Rwanda, and Tanzania. Cf. Lighitng Global., Off-Grid Solar Market Trends Report 2018 (Washington, DC: Lighting Global, January 2018), https://www.lightingglobal.org/resource/2018-global-off-grid-solar-market-trends-report, 155.

Standards can be mandatory or an incentive to access financial support programs. Mandatory standards reduce the risk of importation of low-quality products. Incentive-based standards are increasingly being used, for example linking tax incentives, or results-based finance, to the sale of only qualifying products meeting recognized quality standards. In this way, quality-verified systems can be identified at the point of import or export and would qualify for tax or import duty exemptions based on their quality certificate. A "Pre-Verification of Conformity" (PVoC) process further supports efforts to maintain quality standards, a process in which a licensed organization assesses before shipment whether or not a product conforms with national standards.

Testing can be streamlined if a country adopts international testing methods and accepts product testing before shipment. For example, in Ethiopia, standards were initially imposed without adequate consideration as to how they would be enforced, resulting in significant delays in product approval caused by the insistence on local testing in local laboratories with limited capacity. To address this, the Government of Ethiopia recently adopted international standards, accepting product testing before shipment, using a PVoC process to lower importation costs for OGS companies and help keep low-quality products from flooding the market.

Given the increasing prevalence of component-based systems, Lighting Global has started to develop quality standards and testing procedures for these systems. For example, standards for component systems are being piloted in Vanuatu and Uganda to make sure that component-based systems are not excluded from the support programs available for full solar kits. Quality standards and related regulations need to continue to respond to the scope and evolution of products on the market.

For quality standards to be effective, they must be enforced and policed, building on a growing range of best practices. Customs and national standards agencies must have the capacity to implement and police standards effectively. For example, Uganda is implementing a comprehensive quality standards program that includes strengthening the capacity of implementing agencies (Box 18).

Box 18: Uganda Is Implementing a Comprehensive Quality Assurance Strategy for OGS Products to Drive towards Universal Electricity Access

OGS products are playing an increasing role in Uganda's electrification efforts, reaching 29 percent of the population.[313] Meanwhile, 22 percent are reached by the national grid and mini-grids. These data have heightened the Ugandan government's appreciation of the OGS sector's importance in achieving universal access to electricity. They have also raised awareness of the need to protect the growing number of OGS consumers from poor-quality solar products.

The Government of Uganda is implementing quality standards for plug-and-play and component-based systems:

- For plug-and-play solar products up to 350 watts, Lighting Global Quality Standards were adopted alongside IEC test methods (IEC/TS 62257-9-5). Going forward, the Government of Uganda is considering an update to the IEC test method following the newly approved IEC standard (IEC/TS 62257-9-8) for OGS products up to 350 watts. As both IEC test methods are based on the Lighting Global Quality Standards, there will be a smooth transition from the existing interim quality assurance approach to the newly approved IEC standard.
- For component-based solar systems, the Rural Electrification Agency has adopted an interim quality standard for procurement of solar products under the World Bank–funded Energy for Rural Transformation Phase III Project (ERT III). This quality assurance framework considers existing international standards for individual system components along with system design guidelines and installation and warranty requirements.

During the initial implementation period for this new quality assurance framework, training will be provided to the Customs Authority, Uganda Revenue Authority, and National Bureau of Standards. Also, an awareness campaign will inform trade associations about the new quality assurance framework. After one year of initial implementation, the quality assurance framework will be enforced at the national level.

313 The Uganda Bureau of Statistics recently conducted a survey based on the multi-tier framework from which these figures derive.

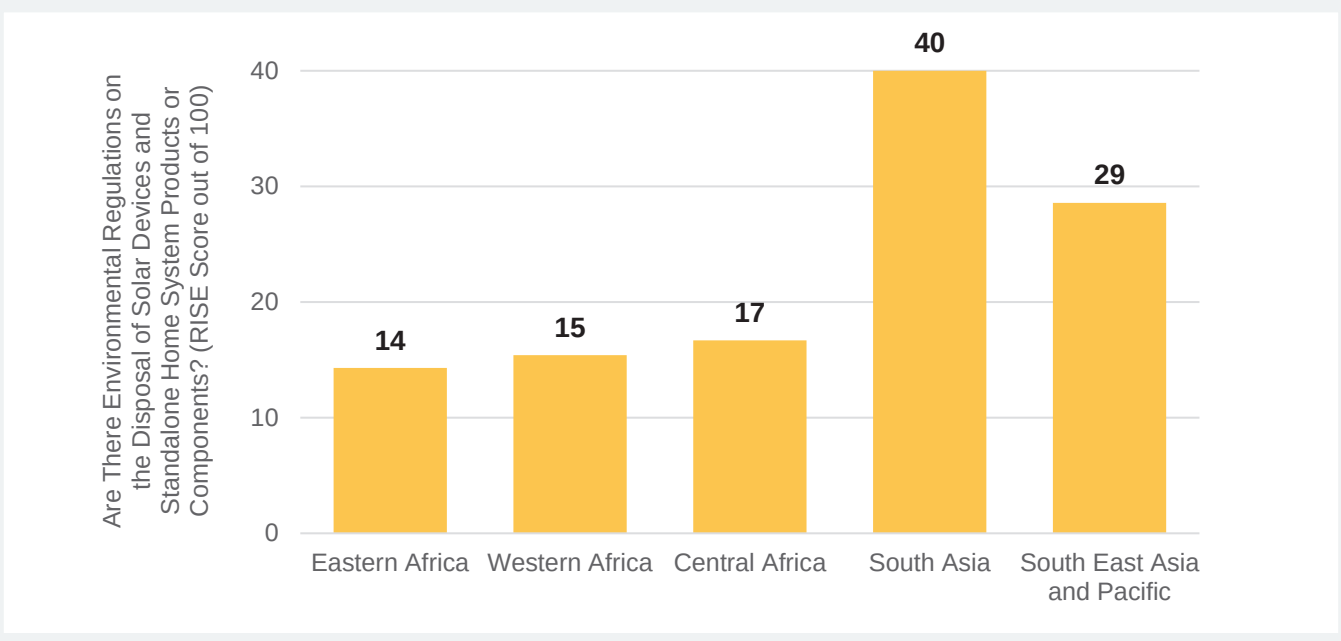
4.1.5 E-Waste Policy

WHILE MANY GOVERNMENTS ARE AWARE OF THE RISKS PRESENTED BY E-WASTE, POLICY CONCERNING E-WASTE IS OFTEN STILL NOT ENACTED OR INCONSISTENTLY ENFORCED.

To date, governments have adopted either an eco-levy or an extended producer responsibility (EPR) approach to regulating e-waste. The first approach, an eco-levy, is a fiscal responsibility which is payable by all electronic importers, the funds from which are used by the government to support e-waste collection, recycling, and disposal. The second approach, an EPR, is an operational responsibility, which can be implemented alongside a fiscal responsibility and mandates that companies must collect and manage their own e-waste.

However, many e-waste policies have either yet to be enacted or are poorly enforced (Figure 75). Ethiopia, Kenya, Rwanda, Tanzania, and Zambia, for example, all have draft bills, but they have not yet been enacted. Ghana, Ivory Coast, and Nigeria have e-waste regulations in place, but minimal coordination among government bodies makes enforcement inconsistent.

Figure 75: Most Governments Have No Regulations in Place on the Disposal of OGS Systems and Components



Source: Vivid Economics and Open Capital Advisors from RISE 2017 data.

Note: The scores reflect a regional aggregation of the country-level scores on the RISE indator "Are there environmental regulations on the disposal of solar devices and standalone system produts or components?"

THE OGS SECTOR ACCOUNTS FOR ONLY A SMALL PORTION OF ALL E-WASTE GENERATED, BUT THE VOLUME IS GROWING. GOVERNMENTS WILL NEED TO WORK CLOSELY WITH THE PRIVATE SECTOR AND INTERNATIONAL INITIATIVES TO TACKLE THIS KEY CHALLENGE.

Although EPR is a global norm, it may be challenging to implement in the OGS context, especially in markets with a large share of unbranded, generic products that cannot be traced back to specific producers or where regulations are enforced in a blanket fashion across sectors. The OGS sector's contribution to e-waste is currently small (less than 0.1 percent of global e-waste), and the sector has significant positive impacts by replacing disposable batteries.[314] E-waste regulations could have an oversized impact on the OGS sector if they are not developed in a way that accounts for the sector's unique market dynamics, particularly as e-waste regulators are not necessarily energy agencies and so could lack the necessary insights into the OGS sector. Poorly designed regulations could unfairly affect branded, affiliate producers if they are forced to bear the cost of managing the waste of unbranded products, distorting the market by forcing affiliate producers to increase their prices.[315] Governments must develop e-waste regulations holistically across sectors and in close consultation with the off-grid industry so that the resulting regulations are implementable and do not impede OGS market growth. Governments also need to ensure that waste-management infrastructure is in place before companies are mandated to manage their e-waste. For example, while local recycling facilities are often available for lead-acid batteries, facilities for the proper disposal of lithium-ion batteries are very limited.

A number of recent initiatives show a growing trend of international leadership in supporting responsible e-waste management. For example, the Global LEAP Solar E-Waste Challenge is a program that supports research and development of more sustainable OGS products. It rewards innovations which "extend product and/or component lifespan; enhance product repairability and recyclability; facilitate refurbishment, reuse or repurposing; or reduce rare metal and hazardous material composition."[316] Additionally, CDC is running e-waste pilots in Kenya, KFW is trialing e-waste buy-back schemes, and GOGLA has developed a comprehensive e-waste toolkit for the sector.

314 Global Leap Awards, "Solar E-Waste Challenge: A Program to Support Innovations in Off-Grid Solar E-Waste Management," https://globalleapawards.org/e-waste.

315 Global LEAP Awards, The Global LEAP Solar E-Waste Challenge: Market Scoping Report (London and Washington, DC: Global LEAP, October 2019), https://efficiencyforaccess.org/publications/global-leap-awards-solar-e-waste-market-scoping-report, 16–17.

316 Global LEAP Awards, "Solar E-Waste Challenge: A Program to Support Innovations in Off-Grid Solar E-Waste Management," https://globalleapawards.org/e-waste.

Box 19: Togo's National Electrification Strategy Incorporates Defined Targets for Off-Grid Solutions, Supported by the "CIZO" Program to Encourage Private-Sector Project Development

Key Insights: In a small and nascent market, a clearly defined role for OGS technologies and a comprehensive government support program to relieve key market barriers attracts private-sector operators.

Key outcomes: CIZO has already confirmed BBOXX and Soleva as licensees, with both companies targeting 300,000 units sold by 2022.[317]

Togo's National Electrification Strategy (NES) includes the goal of electrifying 555,000 households with solar kits by 2030. This represents about 43 percent of households of the total 1.3 million needing electrification to achieve universal access by 2030.[318]

The NES also specifies that OGS solutions must be deployed to target productive uses and public institutions. Off-grid solar will fill the current estimated need for 35,000 streetlamps and electrification of 1,720 educational facilities and 50 to 100 health centers. The NES also anticipates 4,000 to 5,000 solar water pumps will be sold by companies with customers making repayments over time.

The NES is supported by the government-launched CIZO initiative to incentivize private-sector OGS companies. Under CIZO, licensed private-sector operators will own operations along the value chain, receiving exemptions from VAT and import duties and preferential rates for the use of state-owned distribution and logistics channels, such as the National Post and government warehouses. Licensees will also enjoy a 50 percent lower fee when using the domestic platform for mobile money payments.

The government further offers financial instruments aiming to lower the costs of CIZO licensees. Concessional credit lines made available through regional banks will reduce companies' costs of capital from 10 to 2.5 percent.

By 2030, the goal is to have four to five government-issued licenses for OGS company operations under CIZO, contingent on meeting these quality criteria:

- Quality of service, including after-sales services;
- Minimum 20-watt solutions with the option to upgrade;
- Product quality that meets IEC/Lighting Global standards; and
- Machine-to-machine (M2M) connectivity with the option to connect to a national data platform.

To bridge the affordability gap for poor and underserved people, CIZO plans to launch credit lines for MFIs and deploy consumer subsidies to reach the most sensitive populations. Togo's off-grid population has little ability to pay; at current prices, only an estimated 30 percent could afford an OGS system. Concessional credit lines through MFIs will reduce the cost of consumer financing from 13 to 5 percent. Additionally, a consumer subsidy program, for which pilots are underway, will help serve the most price-sensitive parts of the unelectrified population. This pilot uses PAYGo platforms to automatically trigger subsidy payments each time the customer pays an installment through the platform, which greatly simplifies the monitoring, verification, and administration of the subsidy.

317 Lighting Global, Togo Off-Grid Solar Market Assessment (Washington, DC: Lighting Global, December 7, 2018), https://www.lightingglobal.org/resource/togostudy/.

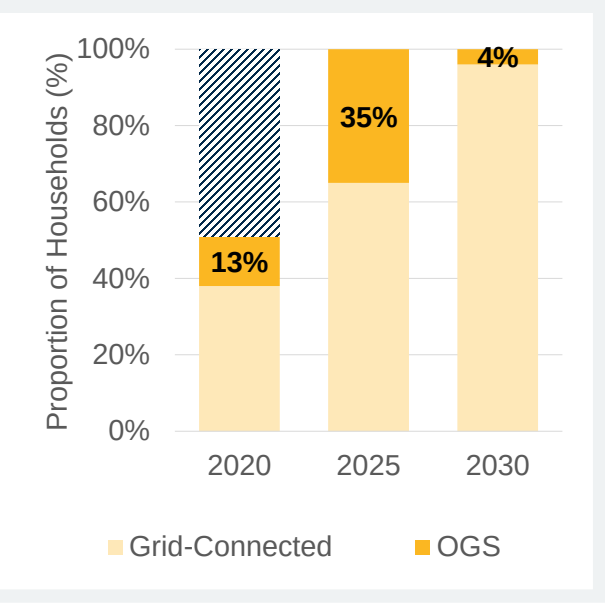
318 Lighting Global, "Togo Electrification Strategy" (presentation, June 2018), https://www.lightingglobal.org/wp-content/uploads/2018/12/Togo-Electrification-Strategy-Short-EN-Final.pdf.

Box 20: Ethiopia's National Electrification Plan (NEP) 2.0 Defines How OGS Can Contribute to Universal Access to Electrification, Including as an Interim Solution Until the Main Grid Arrives

Key Insights: A clear national policy framework should set out the pathway to universal access, using OGS as both a transition and a long-term solution. Targeted financing can assure that OGS products leave no one behind.

Key outcomes: The World Bank is supporting the NEP 2.0 through an International Development Association (IDA) credit to implement one of the largest and most ambitious electrification programs the World Bank has ever undertaken in Africa.

Figure 76: Proportion of Kenyan households connected to OGS in 2020, 2025 and 2030



Ethiopia's second national electrification plan in the space of 18 months, the NEP 2.0, highlights the importance of national policy in driving the development of the OGS sector. At the time of writing the last Off-Grid Solar Market Trends Report (2018), Ethiopia was an outlier in East Africa in that it lacked a clear and implemented national policy framework. Just two years later, the government's NEP 2.0 sets out a clear role for OGS technologies and will be supported by one of the World Bank's largest off-grid solar projects to date. The NEP was first published in 2017 and updated in 2019, specifically to integrate support for off-grid solutions.

The NEP 2.0 identifies a pivotal role for OGS technologies to achieve universal access by 2025, with the grid expanding in the longer term. It uses a least-cost geospatial model to identify the best technology mix to reach all households. By 2025, the ambition is for OGS technologies to provide electricity to 6 million rural households, representing 35 percent of all connections.[319] Beyond 2025, the grid and mini-grid electrification will continue expanding, absorbing some of these households that were initially using OGS. Nonetheless, off-grid solutions, the plan anticipates, will remain a long-term solution for 4 percent of households (largely in deeply rural areas). The NEP 2.0 also identifies about a million rural households that are not commercially attractive customers, most in remote areas where many households live more than 25 km away from the main grid, have relatively low incomes, and are expensive to reach with OGS distribution networks. To guarantee service provision to these households, the government plans to offer companies financial support.

A cross-sectoral approach is adopted to support PULSE and OGS for public institutions. Priority phasing for new connections is given to areas with high potential for economic growth, especially in the agricultural sector. For key public institutions, the target is to achieve 100 percent electrification of schools, hospitals, and primary health centers by 2025, using a geospatial study to estimate their energy needs and determine least-cost solutions—both grid and off-grid.

The government has also adopted IEC/Lighting Global quality standards to protect customers and implemented regulations to discourage counterfeit products. Lighting Global has also worked to increase consumer awareness in Ethiopia of counterfeit products. Finally, the government has introduced duty and excise tax exemptions for products accompanied by a certificate of quality.

319 Federal Democratic Republic of Ethiopia, National Electrification Program 2.0: Integrated Planning for Universal Access (Addis Ababa: Federal Democratic Republic of Ethiopia, 2019), https://minigrids.org/wp-content/uploads/2019/04/Ethiopia-2.0.pdf.

4.2 Public Finance and Partnership

KEY MESSAGES

- Because of the demonstrated impact of OGS, new sources, and increasing amounts of public funding are flowing into the sector.
- For continued success, the sector must find ways to leverage public funds to create sustainable, economically viable markets that attract increasing levels of commercial capital.
- Public finance will help catalyze commercial markets and bridge the affordability gap.
- Governments and development partners can now draw on an increasingly rich body of experience when targeting public funds to catalyze markets at different stages of development.
- With increasing flows of public funding into the OGS sector, coordination and collaboration across a diverse range of stakeholders are increasingly necessary.

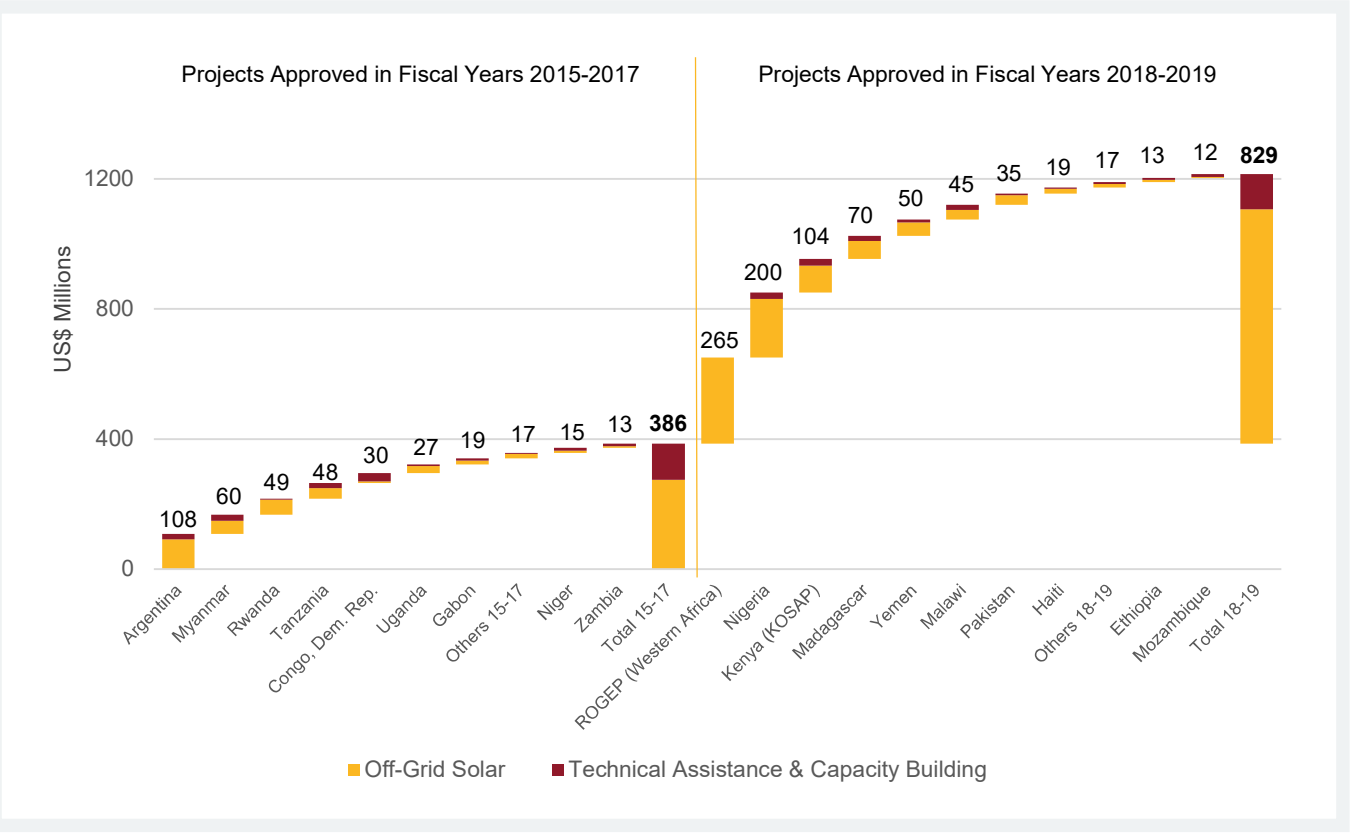
Photo credit: © Lighting Africa/Andres Bifani

4.2.1 The Increasing Availability of Public Finance

BECAUSE OF THE DEMONSTRATED IMPACT OF OGS, NEW SOURCES, AND INCREASING AMOUNTS OF PUBLIC FUNDING ARE FLOWING INTO THE SECTOR.

**Public funding for the OGS sector has grown rapidly, with over US $800 million for OGS and energy access–related technical assistance (TA) approved by the World Bank from 2018 to 2019 alone.**[320] This represents a significant increase in the availability of finance compared to the US$ 386 million approved by the World Bank between 2015 and 2017 (Figure 77). The World Bank has a forward-looking commitment to continue the levels of funding seen in the last few years, with approximately US$400 million for OGS and TA already in the pipeline for 2020 and 2021. The vast majority of this funding is provided in the form of loans to governments, with governments' willingness to borrow funds to support the sector underlining their growing commitment to the role of OGS in achieving universal electricity access.

Figure 77: World Bank Funding for Off-Grid Solar Has Increased Substantially over the Last Four Years



Source: Vivid Economics and Open Capital Advisors analysis of funding for the OGS sector by the World Bank's energy access projects, based on the World Bank's "Project Appraisal Documents," 2015–2019.

Note: The figure shows only the committed amount for off-grid funding and technical assistance for projects with an off-grid component, although the technical assistance component itself is not exclusive to off-grid but is instead allocated for energy access in general. Energy access projects often include grid-based and mini-grid components.

320 Based on the World Bank's "Project Appraisal Documents," 2015–2019. n.b. World Bank fiscal years.

In addition to this World Bank funding, a wide range of bi- and multilateral funds are available for OGS. Examples include the following:

- The US$ 250 million Africa Enterprise Challenge Fund (AECF), launched at the end of 2017, provides catalytic funding in the form of repayable and non-repayable grants (at 0 percent interest) to businesses that would not otherwise have access to adequate financing.
- The Off-Grid Energy Fund, launched by the African Development Bank, the Nordic Development Fund, the Global Environment Facility, Calvert Impact Capital, and All On, has committed capital of approximately US$ 60 million and aims to provide flexible debt instruments in local currency to companies providing consumer finance.[321]
- Bilateral development partners have also ramped up financing for OGS technologies. For example, DFID's Access to Clean Energy (ACE) program, amounting to around US$ 85 million, provides grants, loan support, and technical assistance to 14 countries in Africa, while DFID's BRILHO program comprises more than US$ 40 million to support the deployment of off-grid electricity and cooking technologies in Mozambique. Another DFID program, Transforming Energy Access (TEA), is providing around US$ 80 million to support early-stage testing and growth of innovative technologies and business models that will accelerate access to affordable, clean energy services for poor households and enterprises, especially in Africa.
- USAID's Power Africa Beyond the Grid (BTG) program aims to provide around 20 million solar home system connections, with commitments exceeding US$ 1 billion from more than 60 different investors and practitioners.[322]
- The Energizing Development (EnDev) program will run until 2021 to provide energy access to at least 22 million people across 25 countries in Africa, Asia, and Latin America.[323]

FOR CONTINUED SUCCESS, THE SECTOR MUST FIND WAYS TO LEVERAGE PUBLIC FUNDS TO CREATE SUSTAINABLE, ECONOMICALLY VIABLE MARKETS THAT ATTRACT INCREASING LEVELS OF COMMERCIAL CAPITAL.

It is critical that public funding be used to relieve market barriers, catalyzing fully—or at least increasingly—commercial markets. The design of any facility should be judged by its ability to crowd-in commercial funds. Blended finance will likely emerge as a stronger trend, with public funds structured to address early-stage sector risk and thus crowd-in commercial investors. Similarly, crowdfunding platforms are increasingly blending investment from their customer bases with public money (guarantees and matching funds), which allows crowd funders to offer much-needed smaller ticket sizes under more flexible conditions.

321 African Development Bank, "African Development Bank, Nordic Development Fund and Partners Launch Off-Grid Energy Access Fund with US$58 million," news release, August 27, 2018, https://www.afdb.org/fr/news-and-events/african-development-bank-nordic-development-fund-and-partners-launch-off-grid-energy-access-fund-with-us-58-million-18432.

322 The US$ 1 billion is allocated across the entire program, which also includes micro-grids and transaction advisory for larger projects.

323 For more information on the EnDev country programs see https://endev.info/content/Countries.

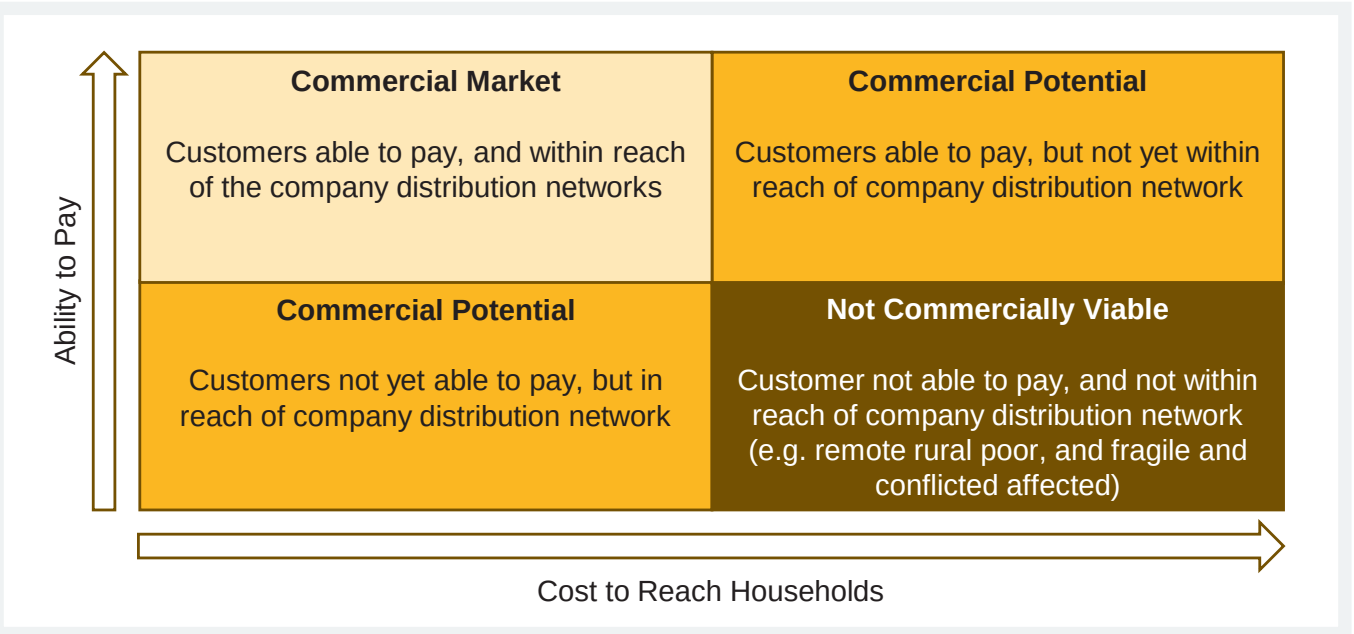
4.2.2 Supply- and Demand-Side Initiatives

PUBLIC FINANCE WILL HELP CATALYZE COMMERCIAL MARKETS AND BRIDGE THE AFFORDABILITY GAP.

As discussed in Chapter 2, affordability remains a major constraint to achieving universal access to electricity; commercial business models will not reach the poorest and hardest-to-reach customer segments. This results from some combination of two factors (Figure 78): (1) low ability to pay by the poorest customers, and (2) high costs or operational risks to reach households in remote, dispersed, rural settings or fragile and conflict-affected states.

To scale up commercial opportunities, unlock further market potential, and reach markets that are not currently commercially viable will require a mix of policies and programs. In general, markets become commercially viable where the cost to serve customers is lower than the ability—or, more precisely, the willingness—to pay for the product. Markets at the intersection of both low cost to serve and high ability to pay are most commercially viable (Figure 78).

Figure 78: Unlocking the Commercial Potential of the OGS Market



Source: Vivid Economics and Open Capital Advisors, adapted from GOGLA, Providing Energy Access through Off-Grid Solar: Guidance for Governments, 2nd ed. (Utrecht: GOGLA, November 2018), https://www.gogla.org/resources/providing-energy-access-through-off-grid-solar-guidance-for-governments, 36.

GOVERNMENTS AND DEVELOPMENT PARTNERS CAN NOW DRAW ON AN INCREASINGLY RICH BODY OF EXPERIENCE WHEN TARGETING PUBLIC FUNDS TO CATALYZE MARKETS AT DIFFERENT STAGES OF DEVELOPMENT.

Supply- and demand-side initiatives will continue to play a key role to scale up commercial opportunities, unlock further market potential, and reach the poorest and hardest-to-reach consumers, including in fragile and conflict-affected states. Market-based approaches alone will not reach all potential off-grid solar users or will reach scale less quickly than they could with the right blend of public and private finance.

- **In markets with commercial potential, supply-side subsidies channeled through companies and investors are best placed to support market development.** The range of supply-side initiatives includes concessional debt facilities and risk-sharing instruments, as well as grant funding. Results-Based-Financing (RBF) instruments, for example, are proving an effective means to support market expansion (Box 21). Examples include RBF incentive schemes targeted at companies seeking to accelerate market growth (for example, Nigeria and Myanmar RBF schemes), serving hard-to-reach populations (such as the Kenya Off-Grid Solar Access Project), or entering and expanding in yet-unexplored markets, such as Burundi.
- **In markets where the ability to pay is low, direct consumer subsidies are being explored as a complement to supply-side subsidies to address these affordability gaps and attract OGS companies.** Demand-side subsidies remain in the pilot stage; more evidence is needed on what works before they can be expanded (Box 22).

Box 21: Results-Based Financing as a Tool for Market Acceleration and Geographic Expansion

Myanmar's Department of Rural Development (DRD) is implementing a US$ 3.5 million RBF grant program to accelerate commercial market solutions for quality-verified solar devices and kits.

The RBF grant program, supported by Lighting Global, incentivizes deployment of high-quality OGS products up to 50 Wp, with payment linked to product performance (calculated as US$ cent per lumen hour) and verification of sales. The level of payment varies according to the customer's ability to pay, and the program encourages after-sale services by requiring companies to offer minimum warranty periods, provide maintenance and repair within that warranty period, and supply spare parts on an ongoing basis.

The RBF grant is expected to leverage more than US$ 9 million in private-sector investment, and it complements IFC-led interventions under Lighting Myanmar to foster a sustainable market through customer-awareness campaigns, product quality assurance, business-to-business support, and access to finance.

Under the Kenyan Off-Grid Solar Project (KOSAP), the Ministry of Energy is implementing a US$ 12 million RBF program aimed at expanding off-grid markets into remote areas.

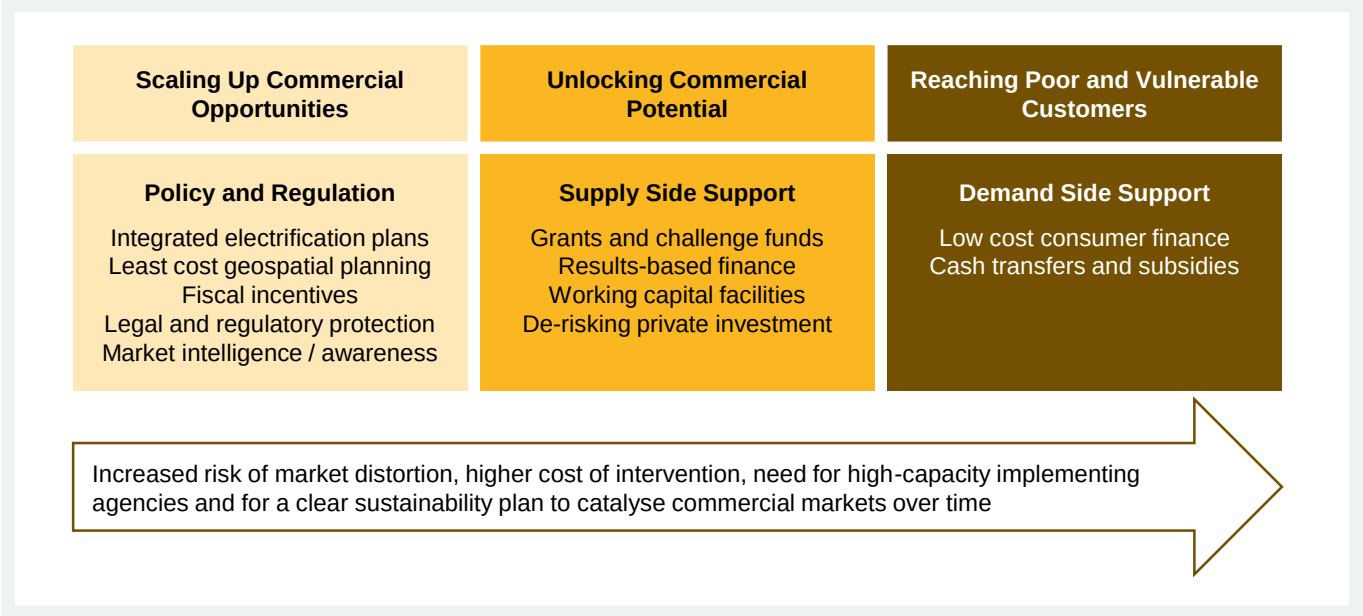
The RBF facility, implemented with the support of SNV and SunFunder, is designed to encourage uptake of OGS products in 14 of the most remote Kenyan counties (out of 47 counties total nationwide) that have the least-developed infrastructure and are relatively socio-economically underserved. The Government of Kenya launched its first call for applications for the RBF in 2019, with 30 companies provisionally selected for award in the first quarter of 2020.

The KOSAP RBF compensates OGS companies for initial, ongoing, and associated opportunity costs to expand their operations to customers they would not otherwise have served under their current business models. The RBF is divided into three payments:

- 30 percent upon signing the contract to support initial market-entry activities, typically including awareness-raising and marketing campaigns, sales and distribution, and forming long-term consumer relationships;
- 60 percent based on reaching pre-agreed sales target milestones for OGS products sold to households in the target counties; and
- 10 percent upon verification of providing after-sales services and honoring warranties, accessible only after a minimum of one year after sales to ensure that OGS products remain in good working condition, as confirmed by customer and product surveys.

Crucially, both supply- and demand-side support mechanisms must be designed as transition mechanisms to boost affordability and develop sustainable commercial markets.[324] Public financing can distort markets and undermine commercial operations when subsidized products leak outside of the populations targeted by the subsidy or when subsidies lead consumers to expect subsidized products and delay purchase through commercial markets. Support mechanisms are important for helping households gain access to a reliable energy access product, but they must be accompanied by an exit strategy to build sustainable commercial markets in the long run. Demand-side subsidies must not "crowd out" a sense of ownership or the longer-term feasibility of maintaining and operating systems to avoid creating a longer-term dependency on cash transfers. At the same time, subsidies must avoid a cliff that leaves consumers in the lurch if programs lapse before a commercial market is viable.

Figure 79: Policy Phases to Unlock Commercial Potential and Reach Poor and Vulnerable Customers



Source: Vivid Economics and Open Capital Advisors, adapted from GOGLA, Guidance for Governments.

324 For example, one of the reasons PAYGo provider BrighterLite ceased operations in Myanmar was competition from cheaper subsidized systems. Jørund Buen, "The Danger of Subsidized Solar: How Government and Donors Unwittingly Hobbled Our Business," Next Billion, January 8, 2018, https://nextbillion.net/danger-subsidized-solar-government-donors-unwittingly-hobbled-business/.

Box 22: Targeting and Administering Demand-Side Subsidies: Building on Kenya's National Safety Net Program and Expanding Government Social Cash Transfers

In Kenya, UNICEF is piloting a demand-side subsidy project to help a subset of recipients in the Government's "National Safety Net Program" purchase OGS products. The program is targeting 1,500 households falling under three categories of vulnerable recipients: orphans and vulnerable children, persons with disabilities, and the elderly. These customers are given a conditional cash transfer to boost the affordability of off-grid energy products.

The program has two objectives: to test whether conditional cash transfers create a better sense of ownership for recipients and to increase the affordability of OGS products for vulnerable customers. It provides a 100 percent subsidy for the deposit and installment payments, but the program requires the customer to make an initial commitment of US$ 2.50 equivalent.

While the pilot remains in its early stages, results are mixed. Only a relatively small proportion of households appear to be taking up the scheme to buy a solar product, although it is too early to evaluate the program's success.

This project already offers several key learnings that may be useful for future subsidy programs. First, demand-side programs need enough time for implementation. Even though this pilot project had customer data from the Government's Safety Net Program, it still took nine months to set up an 18-month project. Second, demand-side subsidies require building trust not only with companies but also with end users, which can be challenging depending on the cultural nuances of the community (for example, if programs need to go through village leaders instead of direct-to-consumer) and can potentially present politically charged problems. Lastly, many end users are likely to have negative impressions of OGS products based on their past use of poor-quality products. Providing high-quality products through subsidies alongside community-awareness campaigns is an effective way to shift this perception and create long-term OGS customers.

4.2.3 Partnerships and Coordination

WITH INCREASING FLOWS OF PUBLIC FUNDING INTO THE OGS SECTOR, COORDINATION AND COLLABORATION ACROSS A DIVERSE RANGE OF STAKEHOLDERS ARE INCREASINGLY NECESSARY.

Many initiatives are emerging to facilitate coordination among development partners. GOGLA, Lighting Global, and the World Bank/ESMAP support regular conferences that bring together investors, the private sector, development partners, and governments, such as the annual "Unlocking Solar Capital" conference and the "Global Off-Grid Solar Forum and Exposition" held every two years. Other initiatives include Scaling Off-Grid Energy (SOGE), which brings together foundations and donors in Africa's off-grid energy sector to coordinate investments. There is also an increasing depth of market intelligence products, including half-yearly sales and impact reporting, the bi-annual market trends reports (of which this is one), GOGLA policy briefs, and the 10 recently published "Beyond the Grid" off-grid market assessments.[325]

GOVERNMENTS AND THE PRIVATE SECTOR WILL NEED TO WORK TOGETHER EFFECTIVELY TO KEEP UP WITH A FAST-MOVING, INNOVATIVE SECTOR.

National off-grid energy task forces are an effective tool for establishing channels of communication and collaboration among the key public- and private-sector stakeholders. Task forces can include officials from key government ministries, including energy and finance, as well as private-sector members such as representatives of companies or private-sector industry associations. Task forces can be assigned mandates to facilitate feedback from the private sector on government policy, set targets for the development of the sector through concrete actions, and build capacity among industry associations (as an example, consider Sierra Leone's Energy Revolution Taskforce, described in Box 23).

International exchange among governments and private-sector professionals is also expanding as the sector grows. The "Community of Champions" provides an opportunity for exchanges among governments, the private sector, and development partners to work collaboratively towards a supportive policy environment to help achieve universal energy access in Africa.[326] In Bangladesh, IDCOL's experience-sharing program has been attended by more than 150 professionals from Africa and Asia to learn from its renewable-energy financing programs.

Market accelerators are another framework through which governments, the private sector, and donors can effectively collaborate. For example, the Uganda Off-Grid Market Accelerator (UOMA), founded in 2017, is a dedicated and neutral intermediary focused on accelerating the growth of off-grid energy to enable universal energy access. Its project management unit coordinates initiatives around access to finance, unserved populations, product use technology, government policy, and sector-wide communication.

325 GOGLA, "Sales and Impact Data Reporting," https://www.gogla.org/source-type/sales-and-impact-data-reporting; and USAID, "Beyond the Grid," https://www.usaid.gov/powerafrica/beyondthegrid.

326 The Community of Champions is supported by GOGLA, World Bank/ESMAP, Shell Foundation, USAID/Power Africa, DFID, and SEforAll.

Box 23: Sierra Leone's "Energy Revolution Taskforce" Catalyzes Private-Sector Provision of Off-Grid Solar

Sierra Leone's Energy Revolution Taskforce has led to several advances in the country's off-grid solar sector.[327] The task force, comprising members from the energy ministry, international donors, and the private sector, achieved the implementation of Africa's first quality-linked VAT/tariff exemption for solar products in 2016. It also supported the development of awareness campaigns and the establishment of the Renewable Energy Association of Sierra Leone to represent the private sector. As a result of these initiatives, the OGS sector in Sierra Leone has attracted several companies, including Azuri, Barefoot, Mobile Power, Ignite, Greenlight Planet, d.light, and Total.[328]

327 Donn Tice, Energy Africa Access Campaign: Policy Compact Sierra Leone (London: Evidence on Demand, June 2016), https://assets.publishing.service.gov.uk/media/5aec17b7ed915d42f7c6beab/Energy_Africa_Access_Campaign_-_Policy_Compact_Sierra_Leone_Final_Report.pdf.

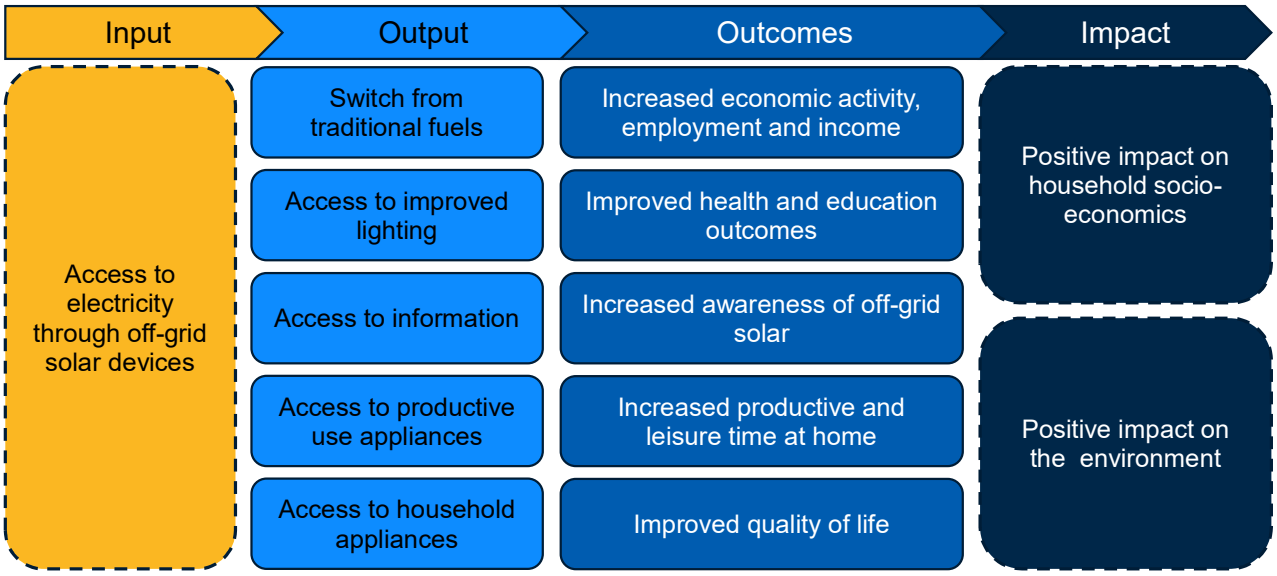
328 Kristina Skierka et al., Decentralized Renewables: From Promise to Progress (San Francisco: Power for All, March 2017), https://infohub.practicalaction.org/handle/11283/620506, 9.

CHAPTER 5
SOCIOECONOMIC AND ENVIRONMENTAL IMPACT

Photo credit: © Little Sun

An estimated 420 million people worldwide are currently benefiting from off-grid solar (OGS) products, of which 231 million currently receive Tier 1 or higher access to electricity. Off-grid devices are now almost universally accepted as a vital technology not only for achieving Sustainable Development Goal (SDG) 7 but also for enabling several other SDGs. Off-grid products improve households' access to affordable, reliable, sustainable, and modern energy, which in turn enables wider socio-economic benefits for households, communities, and nations, as well as benefits for our shared planet. This impact potential of the OGS sector attracted large amounts of impact capital and donor funding, helping build the sector to where it is today.

Figure 80: Simplified Overview of the Theory of Change for Electrification through Off-Grid Solar Products



Source: Vivid Economics and Open Capital Advisors.

While the entire sector generally accepts the OGS theory of change (Figure 80), the extent of impacts and how they evolve over time are not fully understood. Studies examining the impact of off-grid lighting products have either had insufficient scale or revealed mixed and contradictory results. Further complicating the study of impact, many of the indirect benefits of off-grid lighting products, such as education, are influenced by numerous other factors. As the availability of off-grid devices increases, the potential benefits of the off-grid sector are rapidly increasing, but few studies have attempted to fully quantify these benefits. The potential benefits of off-grid devices have all been traditionally viewed through the metaphor of the energy ladder, by which households would progress to increasingly advanced energy solutions over time and thereby increase the benefits they received. Recent evidence should discourage the sector's embrace of this model; a better understanding of consumers' energy-consumptive behavior is now required and will enable stakeholders to improve their effectiveness and impact in the sector.[329]

The remainder of this chapter proceeds as follows:

- **Section 5.1** evaluates the OGS sector's impact in terms of access to electricity and its wider socio-economic and environmental impact.
- **Section 5.2** discusses replacing the energy ladder model with the energy staircase model, as well as using impact to shape stakeholder decision-making.

329 Richa Goyal and Arne Jacobson, Energy Access and Off-Grid Solar Use in Uganda: Examining Solar Adoption and the Role of Flexible Payment Mechanisms as a Driver for Energy Access (New York: UNCDF CleanStart, February 19, 2019), https://sun-connect-ea.org/energy-access-and-off-grid-solar-use-in-uganda-report/.

5.1 The Impact of the Off-Grid Solar Sector

KEY MESSAGES

- An estimated 420 million people worldwide are currently benefiting from OGS products, and 55 percent of these people (231 million) currently benefit from Tier 1 or better access to electricity.
- OGS products not only promote electricity access but also have a positive enabling impact on other Sustainable Development Goals.

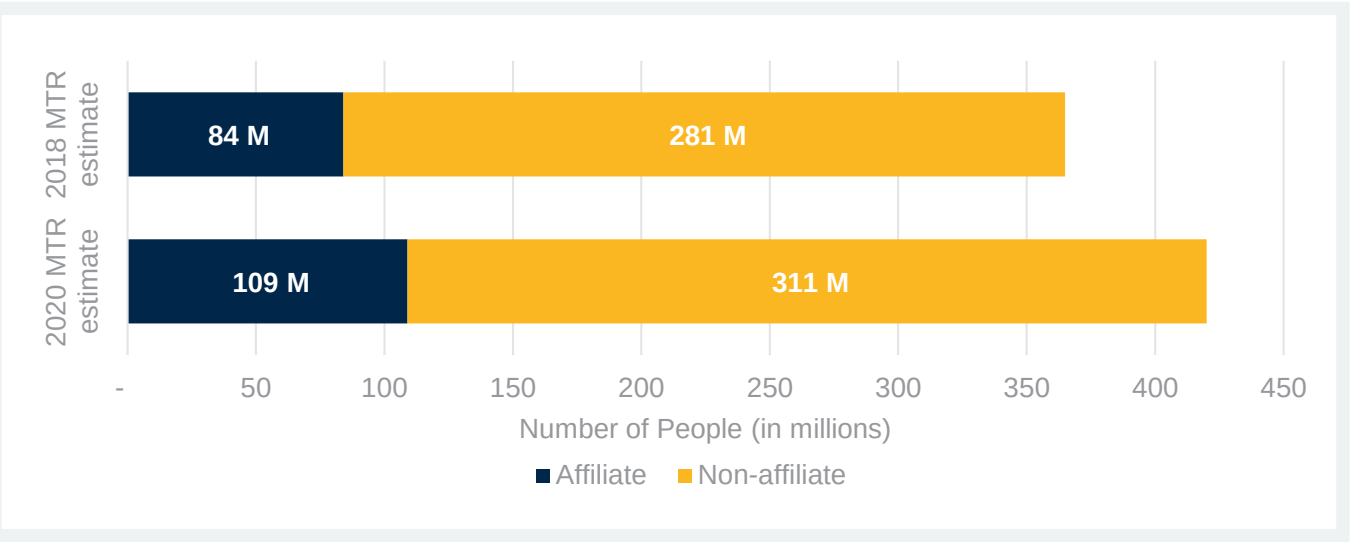
Photo credit: © Solar Sister

5.1.1 Electricity Access

AN ESTIMATED 420 MILLION PEOPLE WORLDWIDE ARE CURRENTLY BENEFITING FROM OFF-GRID SOLAR PRODUCTS, BUT ONLY 55 PERCENT OF THESE PEOPLE (231 MILLION) CURRENTLY BENEFIT FROM TIER 1 OR BETTER ACCESS TO ELECTRICITY.

An estimated additional 55 million people are now benefiting from OGS products compared to the 2018 Market Trends Report (Figure 81), but not all OGS products have an equal impact on their end users.[330] Some provide lighting for less than one hour per day, while others provide many hours of lighting and power appliances such as televisions or refrigerators. To understand the impact of pico lanterns and SHS, beneficiaries must be analyzed according to the ESMAP Multi-Tier Framework (MTF) for measuring access to household electricity supply and services.[331]

Figure 81: Global Number of People Benefiting from Access to Electricity through Off-Grid Solar Devices, 2018 versus 2020 (Millions)



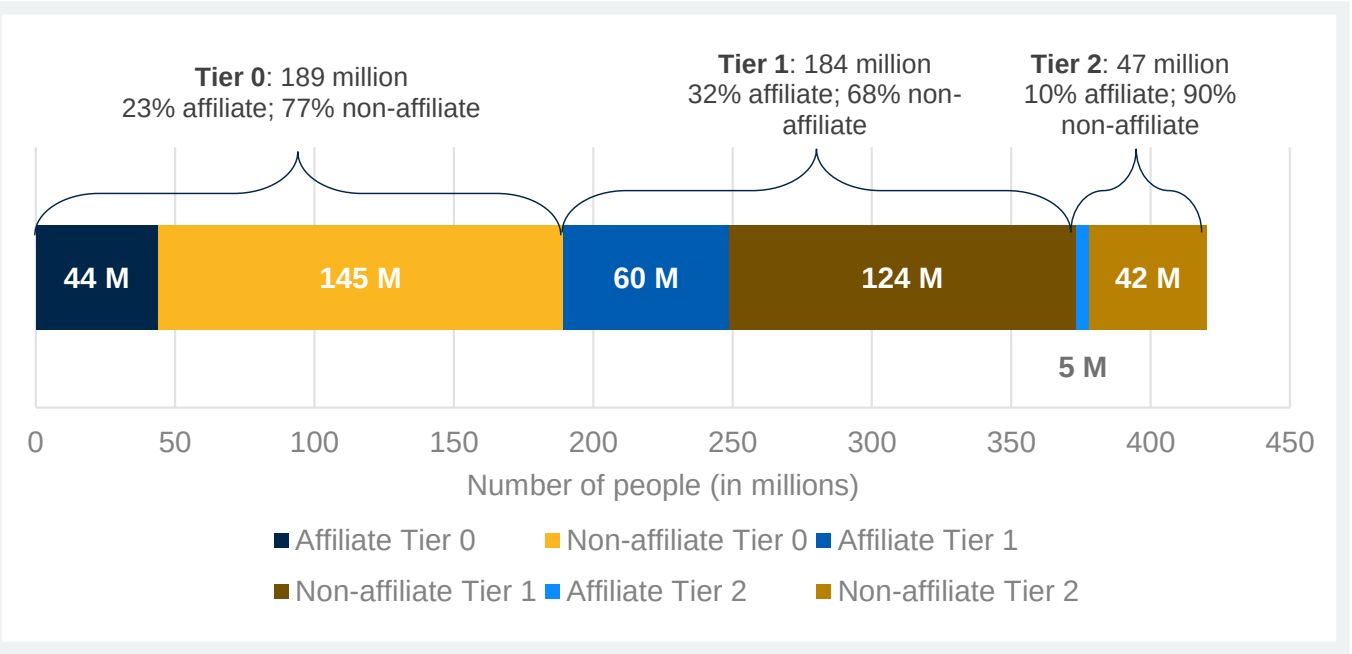
Source: Vivid Economics and Open Capital Advisors analysis. Conservative estimate based on five people per household, following GOGLA Impact Working Group, Standardized Impact Metrics for the Off-Grid Solar Energy Sector (Utrecht: GOGLA, September 26, 2018), https://www.gogla.org/resources/standardized-impact-metrics-for-the-off-grid-solar-energy-sector.

Note: Most of the increase since 2018 can be attributed to increasing sales of the off-grid sector, but part must also be attributed to improved availability of data, which enables more accurate estimates.

330 Most of the increase since 2018 can be attributed to increasing sales of the off-grid sector, but part must also be attributed to improved availability of data, which enables more accurate estimates.

331 More information can be found in the Context and Key Definitions section of this report. Mikul Bhatia and Nicolina Angelou, Beyond Connections: Energy Access Redefined, Technical Report 008/15 (Washington, DC: ESMAP, July 2015), https://www.esmap.org/node/56715.

Figure 82: Conservative Estimate for the Number of People Worldwide Benefiting from Access to Electricity through Off-Grid Solar Devices (Millions)



Source: GOGLA; and Vivid Economics and Open Capital Advisors analysis of ESMAP, Energy Access Diagnostic Reports Based on the Multi-Tier Framework (MTF): Beyond Connections, https://www.esmap.org/node/56715.

Note: GOGLA calculated the number of people benefiting from Tiers 1 and 2 through affiliate products. We estimated the number of people benefiting by Tier through non-affiliate products by analyzing ESMAP, Energy Access Diagnostic Reports, assigning an average Tier of access to non-affiliate products. This conservative estimate assumes non-affiliate products provide a lower Tier of access compared to affiliate products.

Fifty-five percent of people possessing an OGS device currently benefit from Tier 1 or above access to electricity (Figure 82).[332] This means that while 231 million customers have products classified as Tier 1 or Tier 2 and therefore count towards universal electrification targets, 189 million people with OGS devices are at below Tier 1 access and do not count towards electrification targets. Additionally, while many global stakeholders classify access to electricity as all those achieving Tier 1 access, some set their national targets to a higher standard. The Government of Rwanda, for example, considers Tier 2 the minimum level of electricity access required to count towards their national electrification targets. Such government requirements can impact strides towards universal electrification, as government electrification plans sometimes insufficiently take into account whether people can afford higher-Tier products.

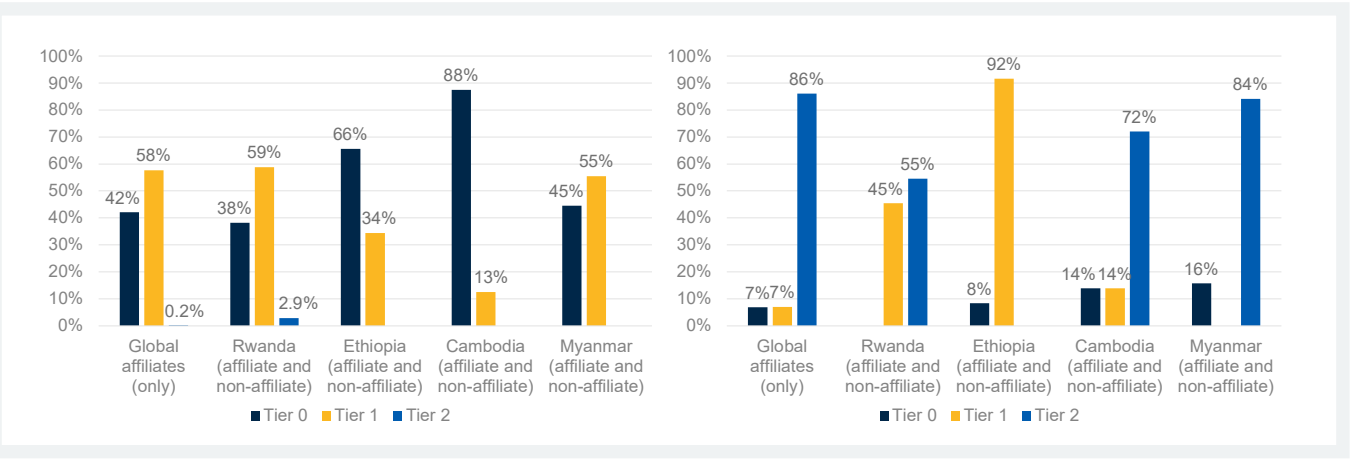
Ownership of Tier 1 and even below Tier 1 products nevertheless represents crucial first steps towards achieving universal electricity access. Customers of these products are sensitized to the benefits of off-grid products and still receive some electricity service. Achieving SDG 7 will require focusing not only on providing access to currently unserved populations but also on helping existing customers below Tier 1 access improved off-grid products, progressing them up the energy staircase.

332 This conservative estimate assumes that non-affiliate products have less capability than affiliate products, in line with the findings of ESMAP, Energy Access Diagnostic Reports. A full breakdown of the range of Tier 1 and 2 may be found in the Appendix.

DISCREPANCIES IN THE CAPABILITIES OF NON-AFFILIATE PRODUCTS MAKE IT CHALLENGING TO OBTAIN A TRUE PICTURE OF THE SECTOR'S CONTRIBUTION TOWARDS UNIVERSAL ELECTRIFICATION.

Of people possessing an OGS device, 109 million use affiliate products, while 311 million use non-affiliate products whose Tier is often unknown. Because the Tier of most non-affiliate products is unknown, it is difficult to determine the number of people with off-grid devices that count towards universal electrification targets. GOGLA provides insights into the Tier of all affiliate products sold by its members, but assigning a Tier to non-affiliate products is complicated by their huge variety in type, quality, and capability.[333] The findings of ESMAP's Energy Access Diagnostic Reports provide one source of data regarding the level of access by Tier provided by non-affiliate products. From these, it is clear that these products are highly variable in terms of Tier of access and potential contribution towards universal electrification (Figure 83).[334] Pico products in Ethiopia and Cambodia generally only provide below Tier 1 access, whereas those in Myanmar align closely with the level of access provided by affiliate products. In the SHS segment of the market, no SHS in Ethiopia provides Tier 2 access, whereas Tier 2 access is high in Cambodia and Myanmar. Given that these countries' markets are all dominated by non-affiliate products, more research is clearly needed to gain a better understanding of the Tier of electricity access provided by non-affiliate products. Using the resulting data, the OGS sector can better ensure consumers receive a high level of service and track progress towards achieving universal electrification.

Figure 83: Tier for Global Affiliate Products and Products Recorded by ESMAP's Energy Access Diagnostic Reports for Pico (left) and SHS (right) Products



Source: GOGLA and Lighting Global, Off-Grid Solar Market H1 2019; ESMAP, Rwanda Beyond Connections; Dave et al., Cambodia Beyond Connections; ESMAP, Ethiopia Beyond Connections; and ESMAP, Myanmar Beyond Connections.

333 GOGLA Impact Working Group, Standardized Impact Metrics; and GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H1 2019 (Utrecht: GOGLA, October 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2019-sales-and-impact-data.

334 ESMAP has to date published Beyond Connections: Energy Access Diagnostic Reports for Cambodia, Ethiopia, Myanmar, and Rwanda. These reports are based on household surveys that collect information on product performance, which is therefore less precise than the GOGLA methodology for affiliate products, which is based on performance testing. ESMAP, Rwanda – Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework (Washington, DC: World Bank, June 2018), https://openknowledge.worldbank.org/handle/10986/30101; ESMAP, Cambodia – Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework (Washington, DC: World Bank, June 2018), https://openknowledge.worldbank.org/handle/10986/29512; ESMAP, Ethiopia – Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework (Washington, DC: World Bank, June 2018), https://openknowledge.worldbank.org/handle/10986/30102; and ESMAP, Myanmar – Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework (Washington, DC: World Bank, May 2019), http://documents.worldbank.org/curated/en/312751568213372366/Myanmar-Beyond-Connections-Energy-Access-Diagnostic-Report-Based-on-the-Multi-Tier-Framework.

5.1.2 The Wider Impact of the OGS Sector

ACCESS TO CLEAN AND RELIABLE SOURCES OF LIGHTING AND ELECTRICITY IMPROVES USERS' ECONOMIC, HEALTH, AND EDUCATIONAL STATUS, AS WELL AS IMPROVING THEIR SOCIAL STANDING AND THE WIDER ENVIRONMENT.

Household Economics

Using OGS devices can save households money as they replace expenditure on kerosene, batteries, or charging mobile phones, although this depends on the size of the system. Before purchasing a solar product, households generally use kerosene, candles, or dry-cell batteries for lighting. Additionally, many pay for mobile phone charging, spending on average US$ 1.00 to 2.50 per week.[335] After purchasing a solar device, around 60 to 80 percent of households reduce or eliminate their expenditure on other sources of lighting, while up to 93 percent stop spending on phone charging.[336] However, these savings must be considered against the lifetime cost of the device to determine net household savings on energy expenditure. Customers using pico products generally see cost savings on energy expenditure between US$ 100 and 200 over the lifespan of the product, around 10 to 15 percent of their average weekly incomes.[337] However, the repayments on larger systems generally increase household expenditure, with households using a 50 Wp system potentially doubling their expenditure on energy. A study in Uganda examined the net present value (NPV) of different solar devices, and larger systems had negative NPV after two years of ownership.[338] Therefore, users' desire to own an SHS must be based on more than just savings on fuel, batteries, or phone charging; they must also consider the opportunities these systems bring for increased economic activity and quality-of-life improvement.

335 In East Africa, kerosene is the main source of lighting prior to solar light purchase, whereas in South and West Africa, torches are the main source. Kat Harrison and Tom Adams, An Evidence Review: How Affordable is Off-Grid Energy Access in Africa? (New York: Acumen, March 2017), https://energypedia.info/wiki/Publication_-_An_Evidence_Review:_How_Affordable_is_Off-grid_Energy_Access_in_Africa%3F, 20; and Emmanuel de Dinechin, Guillaume de Chorivit, and Oliver Reynolds, Powering Opportunity: The Economic Impact of Off-Grid Solar (Utrecht: GOGLA, July 2018), https://www.gogla.org/resources/powering-opportunity-the-economic-impact-of-off-grid-solar, 49.

336 Dinechin et al., Powering Opportunity, 44–51; and Acumen Lean Data and BBOXX, Energy Lean Data: Baseline in Rwanda (Nairobi: Acumen and BBOXX, November 2017), https://drive.google.com/file/d/1UuTjkkMNlFiSXthspWhVDutPTl5JvCEw/view.

337 Dinechin et al., Powering Opportunity; Andrew Scott et al., Accelerating Access to Electricity in Africa with Off-Grid Solar: The Impact of Solar Household Solutions (London: Overseas Development Institute, January 2016), https://www.odi.org/publications/10200-accelerating-access-electricity-africa-grid-solar; Fadi Hassan and Paolo Lucchino, "Powering Education I" (working paper 17/2014, Enel Foundation, Rome, December 2014), https://www.enelfoundation.org/topic/a/2018/11/PowerEducation; and Fadi Hassan and Paolo Lucchino, "Powering Education II" (working paper, Enel Foundation, Rome, July 2016), https://www.enelfoundation.org/topic/a/2018/11/PowerEducation.

338 Goyal and Jacobson, Energy Access and Off-Grid Solar Use in Uganda: Examining Solar Adoption and the Role of Flexible Payment Mechanisms as a Driver for Energy Access, 28.

Box 24: Energy Savings for Public Institutions

Solar systems could offer public institutions, such as schools and health clinics, considerable cost savings. A study in Niger identified solar systems as having high potential for cost savings compared to diesel generators, kerosene lamps, and gas appliances.[339] The business case for institutions to switch to solar from traditional systems, which applies across countries, is stronger with higher electricity consumption. The use of off-grid products in these institutions frees capital for use to improve their core services, which can have significant benefits to the community in terms of education, health, and other public services.

Increased economic activity and income generation are crucial outcomes for households to be financially better off from using a larger SHS. GOGLA estimates that 5.1 million people are currently undertaking more economic activity as a result of affiliate OGS lighting products.[340] A conservative estimate that includes non-affiliate products puts the total global figure around 14 million.[341] Off-grid devices can benefit end consumers by providing them with lighting for more productive time at work or home or by enabling new income-generating activities.[342] Depending on the region and system size, between 19 and 34 percent of households report undertaking more economic activity as a result of the SHS.[343]

Working for longer hours is the most common way in which end users report being able to undertake more economic activity through the acquisition of a solar device. Up to 29 percent of users spend more time at work, primarily by shifting daytime tasks in the home to the evening.[344] Time available to work is also increased when consumers no longer need to spend time traveling to purchase fuel or charge their phones. However, longer hours at work do not always translate into additional income; even when they do, the amounts are highly variable depending on the type of business. The percentage of users reporting increased income varies wildly; between 17 and 75 percent of users report increased income of up to 60 percent, but the causal relationship between the use of a solar device and increased income has been insufficiently investigated in controlled trials.[345]

OGS devices also enable consumers to start new income-generating activities or improve an existing business. An estimated 24 percent of customers use their OGS devices to directly support an existing business or a new income-generating activity.[346] Households with an existing business can increase their income by up to 69 percent, depending on the business. For households starting a new business, phone charging is the most common, earning US$ 12.80 per month on average for smaller systems but as much as US$ 100 per month with larger, dedicated systems.[347] Additionally, an SHS-powered television provides another potential income stream, with around 12 percent of owners showing television for a fee, potentially earning US$ 43.50 per month.[348] Of course, as more households acquire access to electricity and televisions, the income-generating potential from these particular businesses will decline alongside increased supply, as demonstrated by a follow-up study which indicated that the number of users showing television for a fee had declined to just three percent.[349]

339 Open Capital Advisors, Off-Grid Solar Market Assessment in Niger & Design of Market-Based Solutions (Nairobi: Lighting Africa, December 2017), https://www.lightingafrica.org/publication/off-grid-solar-market-assessment-niger-design-market-based-solutions/.

340 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019.

341 Open Capital Advisors and Vivid Economics analysis.

342 There are also indications that some users get new jobs as a result of having solar devices, with one estimate from GOGLA putting this figure at 7 percent. Dinechin et al., Powering Opportunity, 15. Others seem to hire additional employees. Information on this is limited, however, and the causal link between OGS devices and job creation is poorly understood. Dinechin et al., Powering Opportunity; Bob Tortora and Magali Rheault, "In Sub-Saharan Africa, Most Workers Are Without Electricity," Gallup, January 5, 2012, https://news.gallup.com/poll/151889/sub-saharan-africa-workers-without-electricity.aspx.

343 Emmanuel de Dinechin et al., Powering Opportunity in East Africa: Proving Off-Grid Solar is a Power Tool for Change (Utrecht: GOGLA, September 16, 2019), https://www.gogla.org/resources/powering-opportunity-in-east-africa-proving-off-grid-solar-is-a-power-tool-for-change; Emmanuel de Dinechin et al., Powering Opportunity in West Africa: Improving Lives, Powering Livelihoods with Off-Grid Solar (Utrecht: GOGLA, 2019), https://www.gogla.org/powering-opportunity; Scott et al., Accelerating Electricity in Africa; Hassan and Lucchino, "Powering Education"; and Acumen Lean Data and BBOXX, Energy Lean Data.

344 Dinechin et al., Powering Opportunity East Africa; Dinechin et al., Powering Opportunity West Africa; Scott et al., Accelerating Electricity in Africa.

345 Dinechin et al., Powering Opportunity East Africa; Dinechin et al., Powering Opportunity West Africa; Scott et al., Accelerating Electricity in Africa.

346 Dinechin et al., Powering Opportunity East Africa, 36.

347 Scott et al., Accelerating Electricity in Africa, 12.

348 Dinechin et al., Powering Opportunity, 62.

349 Dinechin et al., Powering Opportunity East Africa, 38.

Jobs Created

By 2022, the OGS sector could support an estimated 1.3 million full-time-equivalent jobs.[350] As the sector expands, employment opportunities are generated across the value chain, including in sales and distribution and customer support, and ranging from entry-level to highly skilled. Of these jobs, most will be in rural areas, creating jobs in diversified sectors (compared to existing activity) among what are often economically disadvantaged and vulnerable communities. Wages in the sector are aligned with or higher than average national wages, and many companies are helping their staff expand their skills and capacity through training and development programs. These opportunities have crucial impacts on individual livelihoods, rural and urban development, and the entire economy through increases to GDP and tax revenues.

Financial Inclusion

Through the PAYGo business model, the off-grid sector has expanded financial inclusion to those in remote areas and motivated the adoption of mobile money. One survey found that 30 to 50 percent of new customers of OGS devices were also first-time users of mobile money. PAYGo providers help customers to sign up for mobile money, teach them how to use it, and occasionally create mobile money kiosks.[351] Even customers already using mobile money primarily used the technology for low-value transactions. By increasing the value of transactions made through mobile money and encouraging regular repayments, PAYGo providers can help customers develop credit histories. The resulting data on clients—a credit rating—and source of collateral (the SHS) can be used to leverage the purchase of other financed assets.[352]

Health & Safety

Households using OGS products report positive impacts on their health and safety. Solar lighting's major health benefit to households is the replacement of kerosene lanterns, which emit fine particulates and toxic gases that can harm health and cause burns or fires.[353] A recent study in Uganda found that 87 percent of pico lantern users and 95 percent of SHS users reported perceived health benefits across a range of areas since acquiring the product (Figure 84).[354] Moreover, a study in Rwanda found that 45 percent of households receiving a solar lantern reported improved air quality in their homes.[355] However, these health indicators are self-reported; little evidence directly links off-grid product usage to a reduction in actual health problems, in large part because a myriad of other factors influence health.

350 This figure excludes manufacturing jobs, which are likely to increase significantly as the output of OGS products increases. It also excludes jobs created due to increased economic activity by consumers. Vivid Economics, Off-Grid Solar: A Growth Engine for Jobs (Utrecht: GOGLA, June 7, 2019), https://www.gogla.org/resources/off-grid-solar-a-growth-engine-for-jobs.

351 Daniel Waldron, "Financial Inclusion and Off-Grid Solar: Three Takeaways," CGAP Financial Inclusion and Energy (blog), April 18, 2016, https://www.cgap.org/blog/financial-inclusion-and-grid-solar-three-takeaways."

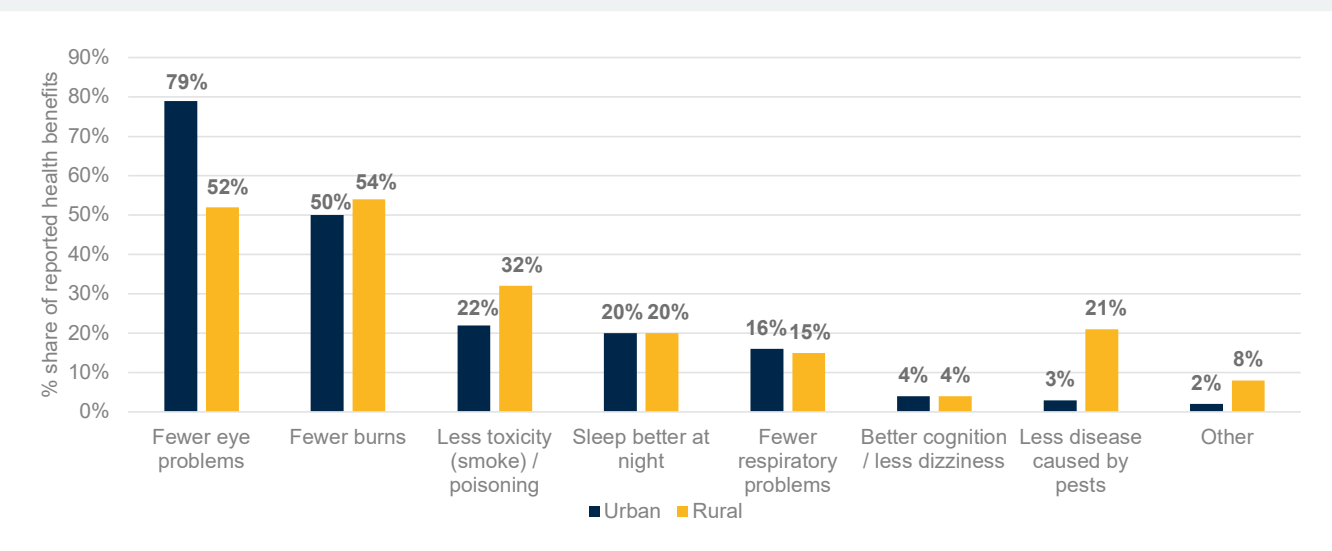
352 Daniel Waldron and Xavier Faz, "Digitally Financed Energy: How Off-Grid Solar Providers Leverage Digital Payments and Drive Financial Inclusion" (CGAP brief, Washington, DC, March 2016), https://openknowledge.worldbank.org/handle/10986/24566.

353 Connections to morbidity and mortality are not proven. Nicholas L. Lam et al., "Exposure Reductions Associated with Introduction of Solar Lamps to Kerosene Lamp: Using Households in Busia County, Kenya," Indoor Air 28, no. 2 (March 2018): 218–27, https://acumen.org/wp-content/uploads/Kenya-Kerosene-Exposure-Study.pdf, https://doi.org/10.1111/ina.12433; and World Health Organization (WHO), WHO Guidelines for Indoor Air Quality: Household Fuel Combustion (Geneva: World Health Organization, November 12, 2014), https://www.who.int/airpollution/guidelines/household-fuel-combustion/en/.

354 Scott Graham and Anahit Tevosyan, Perceived Health Benefits of Off-Grid Products: Results of an End-User Survey in Uganda (Washington, DC: FINCA International: January 7, 2019), https://finca.org/insights/perceived-health-benefits-off-grid-products/.

355 Michael Grimm et al., "A First Step Up the Energy Ladder? Low Cost Solar Kits and Household's Welfare in Rural Rwanda" (Policy Research Working Paper no. WPS 7859, World Bank Group, Washington, DC, October 2016), http://documents.worldbank.org/curated/en/966011476292381076/A-first-step-up-the-energy-ladder-low-cost-solar-kits-and-households-welfare-in-Rural-Rwanda, 33.

Figure 84: Reported Health Benefits Attributed to the Acquisition of a Solar Lantern



Source: Graham and Tevosyan, Perceived Health Benefits of Off-Grid Products.

Health facilities could also benefit from OGS products. A survey in 78 low- and middle-income countries found that only 41 percent of health care facilities have reliable electricity.[356] Off-grid solutions could help to fill this gap given their lower operational and maintenance costs and the ability to provide reliable electricity. This could result in numerous benefits, including lighting to improve conditions for personnel delivering services during the day and at night; power for appliances, such as vaccine refrigerators; and improved communication, education, and outreach.[357]

Education

Children study for longer hours if they have a solar lantern; however, there is no definitive link to improved educational outcomes. Evidence suggests that study times are often shifted to after dark, freeing daylight hours for other activities. However, the increased study time can vary from no increase up to 88 percent, with boys often benefiting more than girls. Studies in Uganda and Kenya have found a link between solar lighting and improved educational outcomes, and anecdotal evidence from teachers indicates educational outcomes improve. However, these results have not been replicated on a wider scale. More work is needed to claim a definitive impact of solar lighting on education while controlling for other influencing variables.[358]

Providing schools with a reliable source of electricity supports universal education efforts. Just 35.1 percent and 50.7 percent of primary schools in Sub-Saharan Africa and Southern Asia, respectively, have access to electricity.[359] The educational impact of energy access for schools includes extended study hours, enhanced staff

356 Ryan Cronk and Jamie Bartram, "Environmental Conditions in Health Care Facilities in Low- and Middle-Income Countries: Coverage and Inequalities," International Journal of Hygiene and Environmental Health 221, no. 3 (April 2018): 409–22, https://doi.org/10.1016/j.ijheh.2018.01.004.

357 Jem Porcaro et al., Lasting Impact: Sustainable Off-Grid Solar Delivery Models to Power Health and Education (Washington, DC: United Nations Foundation; Vienna: Sustainable Energy for All, April 2019), https://www.seforall.org/publications/lasting-impact-sustainable-off-grid-solar-delivery-models.

358 Grimm et al., "Solar and Household's Welfare in Rwanda"; Chishio Furukawa, "Do Solar Lamps Help Children Study? Contrary Evidence from a Pilot Study in Uganda," The Journal of Development Studies 50, no. 2 (November 12, 2013): 319–41, https://doi.org/10.1080/00220388.2013.833320; Adina Rom, Isabel Günther, and Kat Harrison, The Economic Impact of Solar Lighting: Results from a Randomised Field Experiment in Rural Kenya (Nairobi: Acumen, February 2017), https://acumen.org/wp-content/uploads/2015/10/Report-The-Economic-Impact-of-Solar-Lighting.pdf; Yuya Kudo, Abu S. Shonchoy, and Kazushi Takahashi, "Impacts of Solar Lanterns in Geographically Challenged Locations: Experimental Evidence from Bangladesh" (Discussion Paper No. 502, Institute of Developing Economies, Japan External Trade Organization, Chiba, Japan, March 2015), https://www.ide.go.jp/English/Publish/Download/Dp/502.html; World Bank, State of Electricity Access Report 2017 (Washington, DC: World Bank, 2017), https://openknowledge.worldbank.org/handle/10986/26646; and Hassan and Lucchino, "Powering Education."

359 According to data for 2015–2018. UNESCO, UIS.Stat, accessed December 2018, http://data.uis.unesco.org/.

training and retention, community benefits enabled by energy access, increased access to technology, and better school performance.[360]

Environment

OGS devices reduce carbon emissions and replace disposable batteries. GOGLA estimates that, through affiliate member sales, 66.6 million metric tons of CO2 and black carbon emissions have been avoided since July 2010 through the replacement of kerosene lamps.[361] Including the non-affiliate portion of the market, this figure could be at least four times higher. Additionally, households often use dry cell batteries, which can contain harmful materials requiring safe disposal. Consumer awareness of this fact is low, and proper disposal and recycling systems may not exist. One study found that 95 percent of households using dry-cell batteries for lighting throw used batteries into pit latrines, with the remainder either throwing them in the garbage, which is often burnt, or into their backyard. Improper disposal could leak toxic substances into groundwater, while burning batteries can release toxic gases or explode, causing injury.[362] OGS products reduce household use of these batteries, cutting down on a potentially significant source of e-waste and improving consumer safety. While the OGS sector faces its own e-waste and safety challenges related to poor-quality batteries, early signs are promising that the sector will implement thorough e-waste policies, sustainable designs, and quality standards.

OFF-GRID SOLAR APPLIANCES CAN PROVIDE HOUSEHOLDS WITH SIMILAR BENEFITS AS PICO AND SHS IN TERMS OF EDUCATION, QUALITY-OF-LIFE, AND HEALTH, AS WELL AS POTENTIALLY ENABLING INCOME-GENERATING ACTIVITIES.

Television

Besides potentially providing an additional source of income, televisions provide access to previously unavailable information and education. Televisions can lead to improved educational outcomes and positive behavioral change. While often seen only as entertainment devices, users report using televisions to access news as much as entertainment, and television also offers educational programs.[363] Shamba Shape Up, for example, is a farm makeover show in East Africa providing tips on farm management, with a 2014 study indicating that almost half a million households have made improvements to their farms as a result of the show.[364] Television can also have positive impacts on the social status of marginalized groups, a household's financial literacy, and children's reading, writing, and speaking skills.[365] However, studies have struggled to define causal or quantifiable links.

360 Benjamin Sovacool and Ivan Vera, Electricity and Education: The Benefits, Barriers, and Recommendations for Achieving the Electrification of Primary and Secondary Schools (New York: United Nations Department of Economic and Social Affairs, December 2014), https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=1608&menu=1515.

361 GOGLA and Lighting Global, Off-Grid Solar Market H1 2019, 16.

362 Grimm et al., "Solar and Household's Welfare in Rwanda," 34.

363 Nyamolo Abagi, "Getting to Know Off- and Weak-Grid Consumers: The Unforeseen Impacts of Energy Efficient Off-Grid Appliances," CLASP Updates, February 26, 2019, https://clasp.ngo/updates/2019/getting-to-know-off-and-weak-grid-consumers-the-unforeseen-impacts-of-energy-efficient-off-grid-appliances.

364 University of Reading, Assessing the Impacts of Shamba Shape Up (Nairobi: Africa Enterprise Challenge Fund, October 2014), https://ccafs.cgiar.org/publications/assessing-impacts-shamba-shape-report-commissioned-aecf-and-led-university-reading#.Xin4mWgzbIU.

365 Robert Jensen and Emily Oster, "The Power of TV: Cable Television and Women's Status in India," The Quarterly Journal of Economics 124, no. 3 (August 2009): 1057–94, https://doi.org/10.1162/qjec.2009.124.3.1057; World Bank, "Mucho Corazón: Using a Soap Opera as a Vehicle for Financial Education in Mexico," World Bank Projects & Operations, September 4, 2014, https://www.worldbank.org/en/results/2014/09/04/using-a-soap-opera-as-a-vehicle-for-financial-education-in-mexico; and Azuri Technologies, "Azuri Unveils Custom 32-Inch Pay-as-You-Go Solar Satellite TV System for Off-Grid Africa," news release, February 4, 2019, https://markets.businessinsider.com/news/stocks/azuri-unveils-custom-32-inch-pay-as-you-go-solar-satellite-tv-system-for-off-grid-africa-1027920567.

Fan

Fans can improve household quality-of-life and reduce infant mortality in hot climates or during heatwaves. Solar-powered fans are most common in hotter and more humid climates, such as South Asia and West Africa, providing cooling at relatively low cost. Aside from anecdotal experience of comfort, evidence shows that electric fans help to regulate body temperature in simulated heat-wave conditions.[366] Meanwhile, high heat is most dangerous to infants and the elderly, and climate change is forecast to increase heatwaves, potentially leading to up to 100,000 deaths annually by 2030.[367] Fans may alleviate these dangers; however, studies quantifying these impacts, particularly in off-grid settings, are scarce, and the results on health are mixed. The major benefits of fans may mostly relate to improved quality-of-life for end users.[368]

Radio

As with television, radio has long been used as a route for education in developing countries, providing users with access to news, educational programming, and government announcements. Numerous reports describe radio programs developed to support education across countries, as radio is often the only source of information for many households in rural areas.[369] One study on an educational agricultural show focused on reducing pests found that listeners reported twice as much knowledge on the topic after listening to the show compared to before.[370] The state financed Radio Rwanda reaches over 90 percent of the population with community stations focused on regional-area broadcasts of entertainment, informational announcements, and news. One of these, Radio Rusizi, dedicates around three hours per day to shows with an educational orientation on topics such as hygiene, agriculture, and animal husbandry.

PULSE APPLIANCES CLEARLY ENABLE INCREASED ECONOMIC PROSPERITY AND RESILIENCE FOR OFF-GRID COMMUNITIES, BUT ADDITIONAL STUDIES ARE STILL REQUIRED TO QUANTIFY SOME OF THESE POTENTIAL BENEFITS.

Refrigerator

Refrigerators can reduce food losses, which stand at 30 percent of production or US$ 4 billion in annual value in Sub-Saharan Africa, as well as increasing income for micro, small, and medium-sized enterprises.[371] Refrigerators allow users to store fresh food safely for relatively long periods, which can improve both food safety and nutrition.[372] Household members also no longer need to shop daily, an

366 Nicholas M. Ravanelli and Ollie Jay, "Electric Fan Use in Heat Waves: Turn On or Turn Off?," Temperature 3, no. 3 (August 5, 2016): 358–60, https://doi.org/10.1080/23328940.2016.1211073.

367 Ravanelli and Jay, "Electric Fan Use"; World Health Organization, "Climate Change and Health" (fact sheet, February 1, 2018), https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health.

368 Saurabh Guptam et al., "Electric Fans for Reducing Adverse Health Impacts in Heatwaves," Cochrane Database of Systematic Reviews 11, no. 7 (July 11, 2012): CD009888, https://doi.org/10.1002/14651858.CD009888.pub2.

369 Ndubuisi Goodluck Nwaerondu and Gordon Thompson, "The Use of Educational Radio in Developing Countries: Lessons from the Past," International Journal of E-Learning & Distance Education 2, no. 2 (1987): 43–54, http://www.ijede.ca/index.php/jde/article/view/315/209.

370 Mohammad Reza Nazari and Abu Hassan Hasbullah, "Radio as an Educational Media: Impact on Agricultural Development," SEARCH: The Journal of the South East Asia Research Centre for Communication and Humanities 2 (2010): 13–20, https://www.researchgate.net/publication/258517524_Radio_as_an_Educational_Media_Impact_on_Agricultural_Development.

371 United Nations Environment Programme, "Worldwide Food Waste," ThinkEatSave, https://www.unenvironment.org/thinkeatsave/get-informed/worldwide-food-waste.

372 Elvira Uccello et al., Nutrition-Sensitive Agriculture and Food Systems in Practice: Options for Intervention (Rome: Food and Agriculture Organization of the United Nations, 2017), http://www.fao.org/3/a-i7848e.pdf.

activity often left to women, saving them time that can be used on other activities. While refrigerators may be used as household appliances, costs are still high enough that productive use of the appliance is generally required to make them economically viable for end consumers. Results from the 2018 Global LEAP baseline survey on refrigerator use showed that refrigerators were overwhelmingly used in shops, followed by use in bars or restaurants.[373] Data from a recent field test in Uganda show that small businesses using off-grid refrigerators increased their daily income by 2.5 times.[374]

Solar Water Pump

Solar water pumps (SWPs) to irrigate crops can increase smallholder farmers' yields by 100 to 300 percent, depending on geography and crop type, among other factors. Additionally, strong evidence suggests that irrigation allows farmers to plant more diversified crops and add an additional growing season, enabling more stable income throughout the year and augmenting income by allowing the timing of crop sales to periods when supply is lower in the market. Besides enabling additional income, the planting of more diverse crops and an increase in the number of planting seasons increases resiliency in the face of climate shocks, such as unreliable rainfall patterns and drought. Farmers also save the estimated 17 hours per week they currently spend collecting water, time that can be used to improve farm infrastructure or sell produce.[375]

Benefits in terms of yield and cost savings on inputs ultimately translate into significant increases in income for smallholder farmers. Farmers switching to SWPs from diesel save fuel costs—one study indicated a savings of US$ 268 per acre per year—and increase their profitability (as interviews in India suggested, this increase can reach 50 percent).[376] Additional savings come from avoided food purchases, which can reach 50 to 80 percent of smallholders' incomes, as increased yields improve their self-sufficiency.[377] These benefits lead to a better quality of life and enable smallholder farmers to save and pay for other expenditures and to build resilience to mitigate unforeseen risks.[378]

SWPs also reduce CO2 emissions by replacing diesel pumps for irrigation. In Bangladesh, a program to replace 1.3 million diesel pumps nationwide with solar pumps will avoid a projected 3.2 million metric tons of greenhouse gas emissions per year.[379]

SWPs used for households' or communities' water consumption rather than agriculture can greatly improve their quality of life. A study in East Africa estimated that 22 percent of solar water pumps are used for domestic or small-scale commercial use.[380] SWPs provide reliable, clean water, with significant health benefits and an outsized impact on women, who often must travel to collect water for their households.[381]

373 Dalberg, The State of the Off-Grid Appliance Market (London and Washington, DC: Efficiency for Access, October 2019), https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report, 73.

374 Dalberg, The State of the Off-Grid Appliance Market (London and Washington, DC: Efficiency for Access, October 2019), https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report, 11.

375 Katrin Glatzel et al., Water-Wise: Smart Irrigation Strategies for Africa (Dakar: The Malabo Montpellier Panel, 2018), https://www.mamopanel.org/resources/reports-and-briefings/water-wise-smart-irrigation-strategies-africa/; Efficiency for Access, Use and Benefits of Solar Water Pumps: Kenya, Tanzania & Uganda (London and Washington, DC: Efficiency for Access, June 2019), https://efficiencyforaccess.org/publications/use-and-benefits-of-solar-water-pumps; CDC Group, "SunCulture: How a Kenyan Company is Helping Farmers with Irrigation," Investment Stories, 2017, https://www.cdcgroup.com/en/sustainable-investing/solar-powered-irrigation-kenya/; and George Rapsomanikis, The Economic Lives of Smallholder Farmers: An Analysis Based on Household Data from Nine Countries (Rome: Food and Agriculture Organization of the United Nations, 2015), http://www.fao.org/3/a-i5251e.pdf.

376 François Lepicard et al., Reaching Scale in Access to Energy: Lessons from Best Practitioners (Paris: Hystra Hybrid Strategies Consulting, August 2017), https://www.adb.org/publications/reaching-scale-access-energy-lessons-practitioners, 77; and, on India, Open Capital Advisors and Vivid Economics consultations and analysis.

377 Jennifer Burney et al., "Solar-Powered Drip Irrigation Enhances Food Security in the Sudano–Sahel," Proceedings of the National Academy of Sciences of the United States of America (PNAS) 107, no. 5 (February 2, 2010): 1848–53, https://doi.org/10.1073/pnas.0909678107.

378 Efficiency for Access, Use of Solar Water Pumps, 34–36.

379 Dalberg, Solar Water Pump Outlook 2019: Global Trends and Market Opportunities (London and Washington, DC: Efficiency for Access, September 2019), https://clasp.ngo/publications/solar-water-pump-outlook-2019-global-trends-and-market-opportunities, 23.

380 Efficiency for Access, Use of Solar Water Pumps, 19.

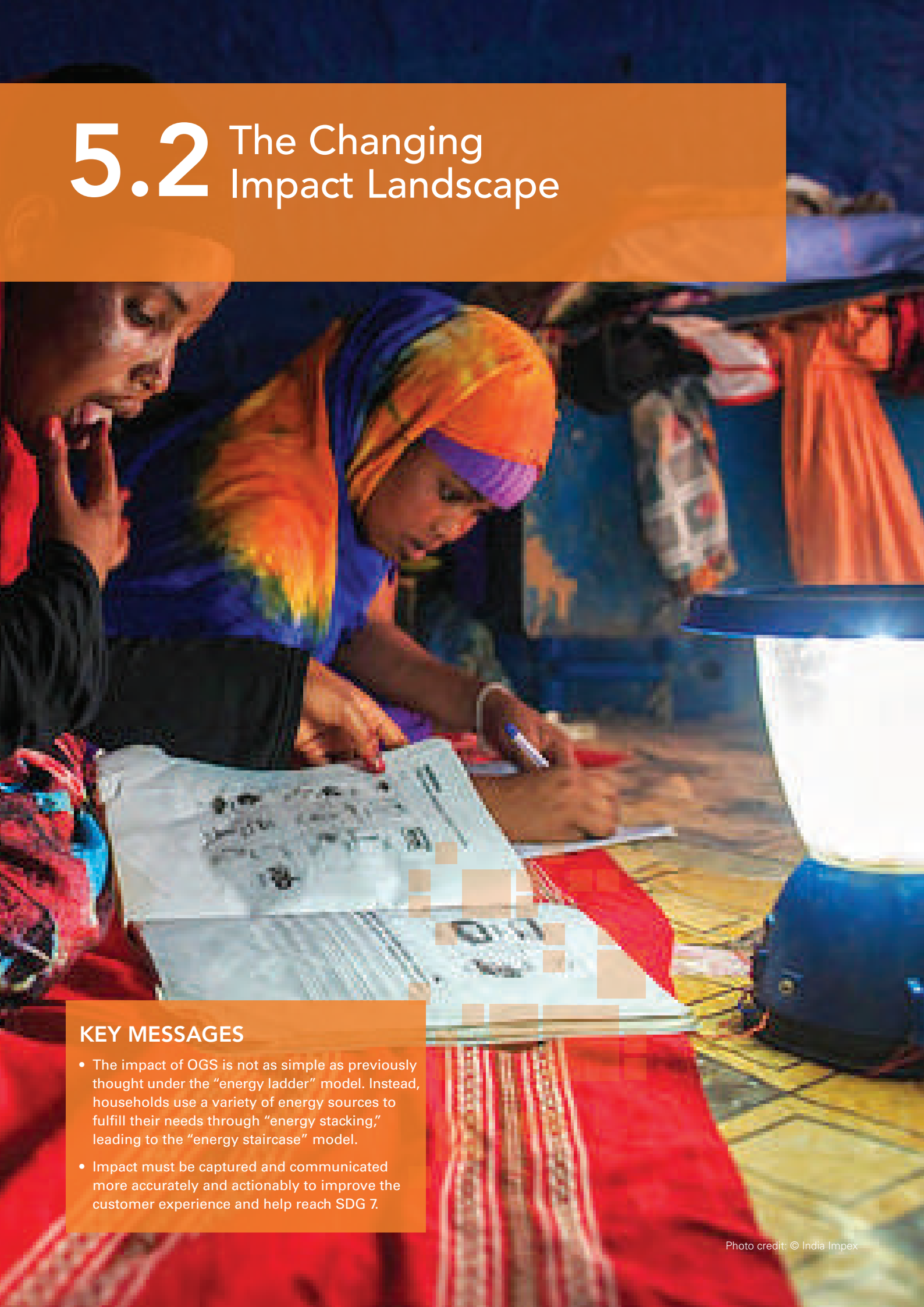
381 Jan Nederstigt et al., Renewable Energy for Smallholder Irrigation: A Desk Study on the Current State and Future Potential of Using Renewable Energy Sources for Irrigation by Smallholder Farmers (Ouagadougou: SNV Netherlands Development Organisation, May 2014), https://www.practica.org/wp-content/uploads/2014/10/Renewable_Energy_for_Smallholder_Irrigation.pdf; and Likimyelesh Nigussie et al., "Gender Dimensions of Community-Based Groundwater Governance in Ethiopia: Using Citizen Science as an Entry Point" (Working Paper 184, International Water Management Institute, October 15, 2018), https://www.iwmi.cgiar.org/2018/10/gender-dimensions-of-community-based-groundwater-governance-in-ethiopia-using-citizen-science-as-an-entry-point/.

Solar Milling

While few studies have quantified the potential impact of solar milling, it could improve both household and community economics, with positive implications for quality of life. Maize, the most-milled crop across Sub-Saharan Africa, is traditionally ground in diesel-powered mills located far from the fields, and mill operators often have to travel far to obtain fuel. Solar-powered mills would decentralize mills, putting them directly in rural communities. This would reduce time spent traveling to mills or collecting fuel, enabling increased productivity for farmers and increased income for millers. Since milling adds value to maize, solar-powered milling could also help keep money in local communities, with farmers able to sell milled rather than unprocessed maize. While solar milling could offer strong benefits, prices of mills remain much too high to enable wider access, and additional studies are needed to better understand their quantitative impact.[382]

382 Open Capital Advisors and Vivid Economics consultations.

5.2 The Changing Impact Landscape



KEY MESSAGES

- The impact of OGS is not as simple as previously thought under the "energy ladder" model. Instead, households use a variety of energy sources to fulfill their needs through "energy stacking," leading to the "energy staircase" model.
- Impact must be captured and communicated more accurately and actionably to improve the customer experience and help reach SDG 7.

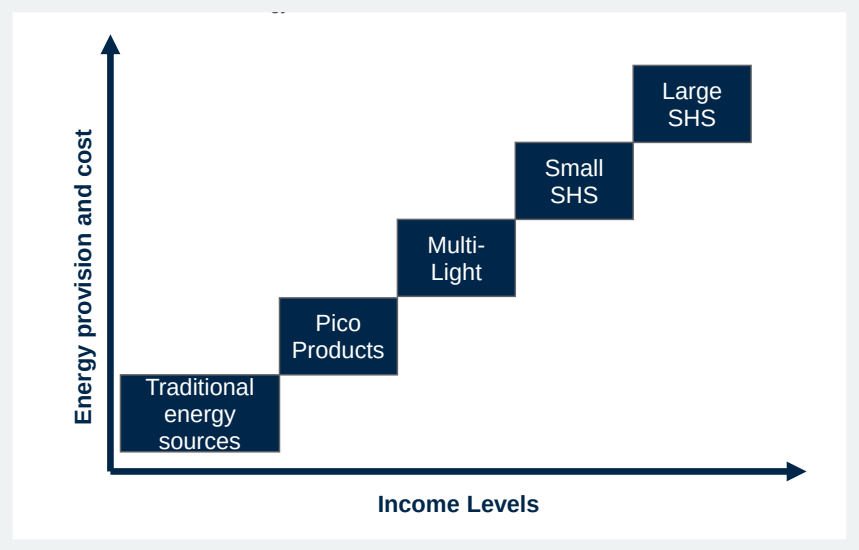
Photo credit: © India Impex

5.2.1 Models for Off-Grid Solar: The Energy Ladder versus the Energy Staircase

THE NOTION OF AN "ENERGY STAIRCASE" PROVIDES A MORE USEFUL FRAMEWORK FOR UNDERSTANDING HOW END USERS BEHAVE COMPARED TO THE "ENERGY LADDER" MODEL USED TO DATE.

The energy ladder model was foundational for the OGS sector. Originally proposed in the 1970s, the model describes how households move from traditional to more modern energy sources. The energy ladder proposes that households will use the most sophisticated source of energy they can afford, switching to new energy sources with rising income and thus moving up the ladder. In the context of off-grid solar, increased awareness of the benefits of OGS devices leads to the purchase of larger OGS systems with rising incomes (Figure 85).

Figure 85: The Off-Grid Solar Energy Ladder



Source: Vivid Economics and Open Capital Advisors.

Yet research indicates that the energy ladder is too simple a model; "energy stacking" better describes how individual households access energy.[383] The energy ladder model implies that households abandon lower-rung energy sources in favor of those that are higher up the ladder, moving, for example, from a pico lantern to an SHS. Yet substitution does not appear to occur in this manner; instead, households use multiple energy sources to meet their energy needs.[384] Such energy stacking can include the continued use of traditional fuels, such as kerosene, in conjunction with a solar product.

We, therefore, support the notion of the energy staircase. Rather than switching to progressively larger OGS products or completely eliminating kerosene from their fuel mix to climb the energy ladder alongside rising income, households' energy-purchasing decisions are influenced by a complex range of factors. For example, a recent study in Uganda found that users do not purchase systems based solely on their levels of income but are instead also influenced by access to distributors, product bundles, and affordable financing

383 Dinechin et al., Powering Opportunity, 36–37; Goyal and Jacobson, Energy Access and Off-Grid in Uganda; Harrison and Adams, Affordable Off-Grid Africa?, 12; and Darragh Cotter, "Investor Q & A with Kat Harrison, Acumen Fund," GOGLA (blog), August 2, 2016, https://www.gogla.org/about-us/blogs/investor-q-a-with-kat-harrison-acumen-fund.

384 Omar R. Masera, Barbara D. Saatkamp, and Daniel M. Kammen, "From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model," World Development 28, no. 12 (December 2000): 2083–103, https://doi.org/10.1016/S0305-750X(00)00076-0; Wuyuan Peng, Zerriffi Hisham, and Jiahua Pan, "Household Level Fuel Switching in Rural Hubei," Energy for Sustainable Development 14, no. 3 (September 2010): 238–44, https://doi.org/10.1016/j.esd.2010.07.001; Analaya Nansaior et al., "Climbing the Energy Ladder or Diversifying Energy Sources? The Continuing Importance of Household Use of Biomass Energy in Urbanizing Communities in Northeast Thailand," Biomass and Bioenergy 35, no. 10 (October 15, 2011): 4180–88, https://doi.org/10.1016/j.biombioe.2011.06.046; and Goyal and Jacobson, Energy Access and Off-Grid in Uganda.

options, such as those enabled by PAYGo.[385] This process of consumers using multiple energy sources and being influenced by more than just their income when purchasing OGS products is becoming commonly known as the energy staircase.

THE ENERGY STAIRCASE MODEL IMPLIES THAT MORE CONSUMER EDUCATION AND SUPPORT ARE REQUIRED TO SHIFT CONSUMERS TO HIGHER TIERS OF ENERGY ACCESS.

The energy staircase model requires a more detailed study to understand how consumers can access higher-capability OGS products, and to enable the design of more impactful energy-access programs. Several implications of the energy staircase model for the OGS market are immediately clear. Further research will be required to fully understand the model's nuance and consequences for the sector.

- First, how and why consumers decide to purchase larger systems needs to be better understood. This will enable companies and development organizations to offer better consumer-awareness campaigns to progress consumers to higher Tiers of electricity access. Direct marketing, referrals, and demonstrations are critical not only to acquire new customers for the OGS sector but also to convince existing customers to upgrade. Best approaches and practices in this regard need testing and development.
- Second, stakeholders must consider consumer preferences for subsequent purchases. A study in Uganda found that more than 95 percent of existing customers say they want to purchase their next devices with cash upfront rather than by PAYGo.[386] If this finding is replicable in other countries, this may have important consequences for business models and the expected length of time customers will take to upgrade.
- Thirdly, how impact is calculated requires close examination. Most impact calculation methodologies in the sector make assumptions about fuel replacement. If, however, households continue to use alternative sources of fuel or own multiple systems, with this varying significantly by system size and geography, a more nuanced approach to calculating impact will be required. Continuing kerosene usage could impact the actual level of emission reductions, while a household that owns multiple systems could have the true extent of its electrification masked if not accurately calculated.
- Finally, it is important to understand why consumers continue to use other energy sources after purchasing an OGS product. This will enable development partners to design more effective energy-access programs that help consumers to cut out their continued reliance on traditional fuel sources, and enable companies to design products that meet more of their consumers' needs.

385 Goyal and Jacobson, Energy Access and Off-Grid in Uganda.

386 Goyal and Jacobson, Energy Access and Off-Grid in Uganda, 35.

5.2.2 Impact as a Tool for Change

IMPACT MUST BE CAPTURED AND COMMUNICATED MORE ACCURATELY AND ACTIONABLY TO IMPROVE CUSTOMER EXPERIENCE AND HELP REACH SDG 7.

The replacement of the OGS energy ladder with the energy staircase model highlights the need for better ways to measure impact. Impact measurement has sometimes stopped at the question of which impact metrics should be measured at the expense of how to measure them. Measuring impact can be time-intensive and expensive. In communicating their impact, stakeholders in the sector typically try to quantify metrics such as the number of people benefited, CO2 emissions avoided, or kerosene lamps replaced. These metrics generally rely on impact calculations based on assumptions that are not standard across regions or not always fully up to date. Energy stacking further challenges many of these assumptions to the extent that these assumptions overlook consumers' continued use of other forms of energy.

Impact must be captured and communicated both accurately and actionably so that all stakeholders can make strategic decisions, listen to consumers, and ultimately contribute to the achievement of SDG 7, as well as other SDGs. Measuring impact starts from a clear understanding of (1) what the outcomes are, (2) who the customer is, (3) how much impact is achieved, (4) how off-grid solar contributes to SDG 7, and (5) the risk of the impact not being achieved.[387] Organizations such as 60 Decibels are working towards turning the perception of impact measurement from cumbersome and expensive to simple and valuable.[388] A key recommendation is to conduct lower-cost, direct customer research to better understand the needs of consumers. Implementing such practices in the OGS sector can lead not only to greater impact but also to improved business operations, greater returns for investors, and higher customer satisfaction. Additionally, better impact data sharing, such as through industry benchmarks like those currently offered by GOGLA to its member companies, can help companies compare themselves to their peers, offering context for their data, and suggesting improvements while enabling investors to make better-informed investment decisions. Finally, more rigorous independent studies that isolate the impact of OGS products from external variables and consider local context would help development partners design better theories of change for energy access initiatives, even at the local level. In this way, shifting the use of impact from a way to communicate work done towards a tool to inform future decision-making can yield benefits for companies, investors, and consumers.

387 The Impact Management Project (IMP) determined the five dimensions of impact through consensus of over 2,000 practitioners. Impact Management Project, "What Is Impact?," https://impactmanagementproject.com/impact-management/what-is-impact/.

388 60 Decibels, A Simpler Way to Measure Impact (New York: 60 Decibels, June 2019), https://www.60decibels.com/user/pages/03.Work/_measure_better/60_Decibels_A_Simpler_Way_To_Measure_Impact.pdf.

CHAPTER 6

MARKET OUTLOOK 2030

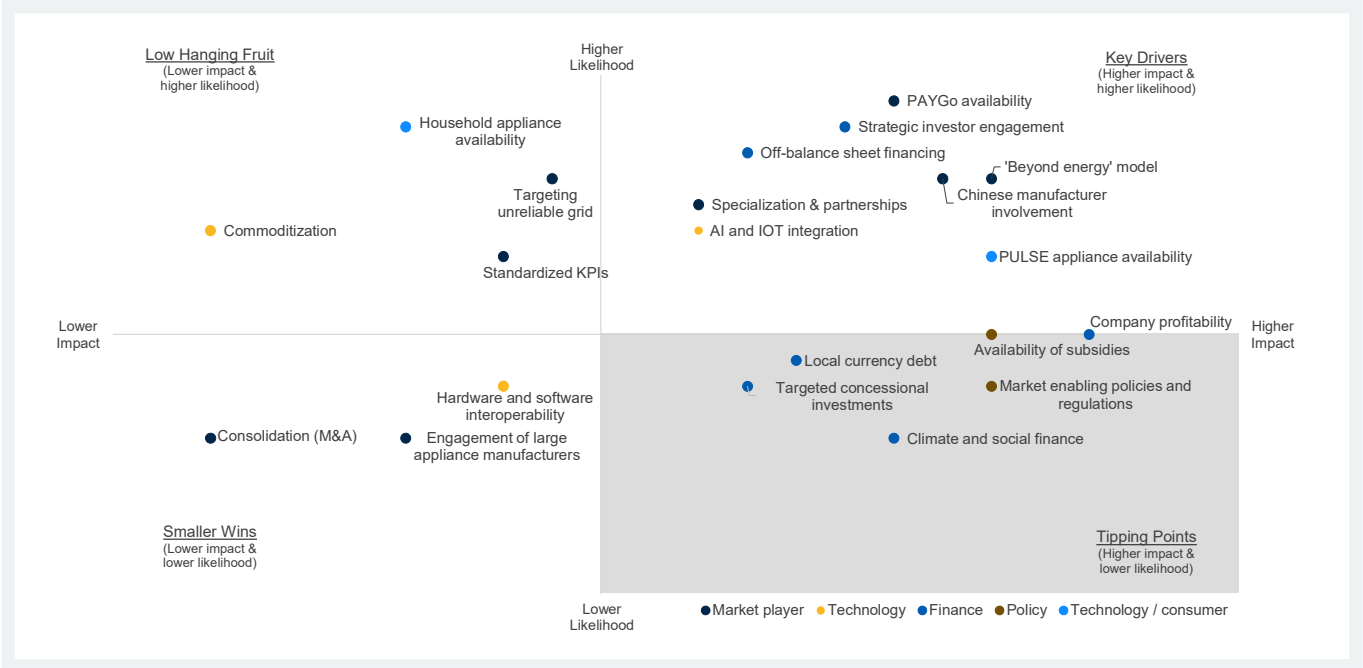
Photo credit: © FINCA International

The OGS market remains on a strong trajectory, but with only a decade left to reach the 2030 universal access goal (SDG 7), the industry needs an additional boost if SDG 7 is to be achieved. We identify a long list of potential Game Changers for the OGS sector and rank them based on their likelihood of occurring by 2030 and their relative impact on sector growth (Figure 86). We then consider how these Game Changers would translate into a projected growth scenario (what is likely to happen) and a universal access scenario (what needs to happen in order to achieve SDG 7).

In the projected growth scenario, the market is on track to reach 863 million users by 2030. This projected growth scenario depends on the continuation of the "Key Drivers," which are current high-impact market trends that we think will likely accelerate going forward. The "Low Hanging Fruit," which we think are also high likelihood but lower impact, also influence our projected growth scenario, though to a lesser extent.

To achieve universal access by 2030, however, sector stakeholders will have to work together to close a gap of 228 million people who will not have access to Tier 1 OGS system based on the sector's likely projected growth. Propelling the OGS sector towards faster growth to close this gap will require companies, investors, governments, and donors to coalesce behind certain "Tipping Points," which we believe will have high impact on the sector's growth, but are unlikely to happen without increased support. Along the way, sector stakeholders may also help support the lower-priority "Small Wins" that will have an incremental impact on the sector's growth.

Figure 86: Relative Ranking of Game Changers for the OGS Sector



Source: Vivid Economics and Open Capital Advisors.

The remainder of this chapter proceeds as follows:

- **Section 6.1** presents our projected growth scenario for the OGS sector based on the continued momentum of "Key Drivers" and "Low Hanging Fruit."
- **Section 6.2** assesses the gap to achieve universal access by 2030.
- **Section 6.3** discusses the "Tipping Points," "Small Wins," and financing needed to propel the sector forward to achieve universal access by 2030.

6.1 Projected Growth of the OGS Market

KEY MESSAGES

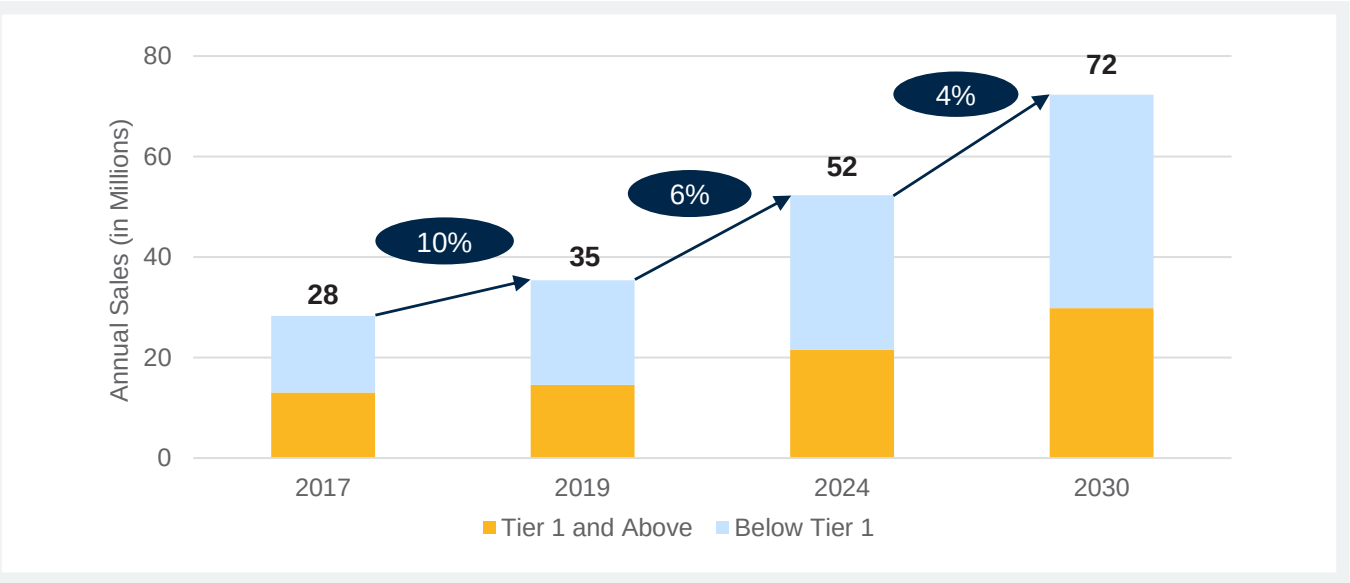
- The OGS sector remains on a strong growth trajectory, projected to reach 823 million users with OGS products by 2030.
- To stay on its current growth trajectory, the sector will require an investment of US$ 1.7–2.2 billion over the next five years.
- "Key Drivers" of OGS sector growth will be business model adaptations, sales of larger systems and appliances, and new capital sources and structures.

Photo credit: © FuturePump

THE OGS SECTOR REMAINS ON A STRONG GROWTH TRAJECTORY, PROJECTED TO REACH 823 MILLION USERS WITH OGS PRODUCTS BY 2030. TO STAY ON ITS CURRENT GROWTH TRAJECTORY, THE SECTOR WILL REQUIRE AN INVESTMENT OF US$ 1.7–2.2 BILLION OVER THE NEXT FIVE YEARS.

Under the projected growth scenario, the market will provide 176 million OGS products to a total of 823 million people by 2030, growing by 6 percent annually (on average) over the next decade.[389] About 47 percent of these people (389 million) will be reached by a product that provides Tier 1 service or above, using the device either as their primary source of electricity or alongside an alternative, for instance, an unreliable grid.[390] As the sector continues to mature, we expected year-on-year growth in unit sales to gradually decline from 10 percent today to 4 percent in 2030 to reach 72 million annual sales of all OGS products in 2030 (Figure 87).[391]

Figure 87: Over the Next Decade, Annual Sales of OGS Products Are Projected to Increase from 35 to 72 Million



Source: Vivid Economics and Open Capital Advisors.

Note: The dark blue bubbles depict the cumulative annual growth rates for the different scenarios, i.e., the year-on-year growth rate. For example, in the period 2017-2019, sales increased by 10 percent per year or 25 percent in total.

389 The number of people is based on the weighted average of household sizes of all countries in the analysis.

390 This assumes that the ratio of products below Tier 1 to products Tier 1 and above remains the same in 2030 as in 2019 and that the proportion of SHS and pico sales remains the same as today.

391 Today's annual growth rate of 10 percent in sales is not expected to continue over the next decade. Annual growth rates have historically declined; however, given the volatility in the historic data, the rate of decline in annual sales growth rate is difficult to estimate. The projected growth scenario's CAGR of total sales was therefore estimated in our model as the growth rate that would be needed to achieve the full commercial market of 827 million people in 2030. This was translated into an annual growth rate that declines by 8 percent every year, starting from an annual rate of growth of 10 percent in 2019.

OGS sector growth will be driven by business model adaptations, sales of larger systems and appliances, and new capital sources and structures. Pico sales will continue to represent a large share of the OGS market in terms of unit sales, dominated by Chinese manufacturers, which, we expect, will become Lighting Global quality-verified and engage more directly with end consumers. Current affiliate players will focus on higher-value products, such as large SHS, appliances, and PULSE products, which we expect to drive faster revenue growth and help companies make strides toward profitability.

Below, we explore the potential impact of these and additional "Key Drivers," as well as what could happen to sector growth if these likely "Key Drivers" lose momentum or do not materialize.

Increased specialization across the value chain will drive efficiencies. Previously vertically integrated firms will continue to shed value chain operations to increase focus on their core business by partnering more effectively with other players in the value chain. Meanwhile, new companies entering the sector will specialize in individual components of the value chain. This will allow companies to achieve profitability more quickly. In contrast, if the market reverts towards vertically integrated players, we expect to see more failures that have a chilling effect on investor engagement as companies struggle to achieve profitability.

Chinese manufacturers will engage directly with end markets. Chinese manufacturers will continue to sell higher-quality, self-branded products through local distribution partners and increasingly through their own distribution networks, including on PAYGo. This will increase competition at the product level and increase the amount of high-quality but lower-cost products reaching the market. If Chinese manufacturers are deterred by the market barriers that have limited their direct involvement to date, including poor knowledge of end markets, fewer lower-cost products may be available in the market, resulting in less consumer choice and decreased consumer affordability.

PAYGo will become more widely available, driving market growth. As enabling conditions such as mobile-money availability improve in new markets, an increasing number of companies will adopt the PAYGo model beyond East Africa. This will increase the affordability of larger products and the level of service for consumers, potentially also improving profitability for companies that can market additional products and services through their PAYGo platforms. However, if growth in mobile-money availability stalls, certain markets will remain underserved as a result of persistent gaps in affordability coupled with challenges in providing consumer financing through other channels.

Increased appliance efficiency and income-generation potential will drive growth in the PULSE market. Continued improvements in appliance efficiency and lower manufacturing costs will help companies tap into the large potential demand for PULSE appliances. PULSE appliances will also see fast growth as a result of the income-generating opportunities they provide, making them attractive for consumer financing. However, if PULSE technology does not improve and manufacturing costs don't decrease even while increasing efficiency, PULSE products will not be able to compete with current alternatives, and businesses founded on these PULSE products will not reach scale.

More companies will implement and expand their offerings "beyond energy." Effective use of consumer PAYGo data will allow companies to offer consumer financing services that go beyond basic energy access, including financing for other consumer electronics, educational loans, and insurance. This will support company sustainability while also unlocking additional benefits for consumers, but the sector must be wary of over-leveraging consumers with debt. If the "beyond energy" model fails to flourish, however, companies seeking profitability will need to continue moving away from pico products towards higher-margin, larger products. This could negatively impact the sector's ultimate goal of achieving SDG 7 as companies shift away from serving generally poorer customers without electricity access.

Off-balance-sheet financing will accelerate. As the risk level of receivables portfolios become better understood in a maturing sector, ever-larger amounts of off-balance-sheet financing will be used to better manage receivables and continue to help operations reach scale. This could be further accelerated through securitization to de-risk investments and attract more commercial investors to the sector. If the promise of off-balance-sheet financing continues to fall short in reality, scale in the PAYGo model will be limited by high working capital needs for ever-expanding receivables portfolios.

Strategic investors will play an increasingly large role. Strategic investors will continue to take equity stakes in companies, leading to additional exits that can help free impact investor capital for investment in Second- and Third-Generation companies. Their involvement will also gradually change companies' trajectory away from fast-paced innovation and towards more sustainable growth. If strategic investors back away from the sector, the shortage of equity capital for Second- and Third-Generation companies will persist. Early-stage equity capital will remain tied up in large First-Generation companies, which may also struggle to attract later-stage equity investment.

Artificial Intelligence (AI) and the Internet of Things (IoT) will improve customer service and increase operational efficiency. More companies will incorporate IoT and AI into their product offerings, allowing tailored performance management of devices to improve customer service and reduce costs.

The "Low Hanging Fruit" will also likely continue to support the OGS sector's growth, although their contribution will be less critical than the "Key Drivers".

Household appliance sales will continue to grow. Consumer demand for appliances will increase alongside continued improvements in appliance efficiency, resulting in declining prices for end consumers. The resulting continued growth in appliance sales will provide consumers with higher levels of service and increase the sustainability of OGS companies.

Companies will further target the unreliable grid market. Products that are specifically designed for consumers with unreliable grid connections will be increasingly available. This will accelerate OGS companies' drive to sustainability by enabling them to extend their potential market to people that currently have unreliable grid access.

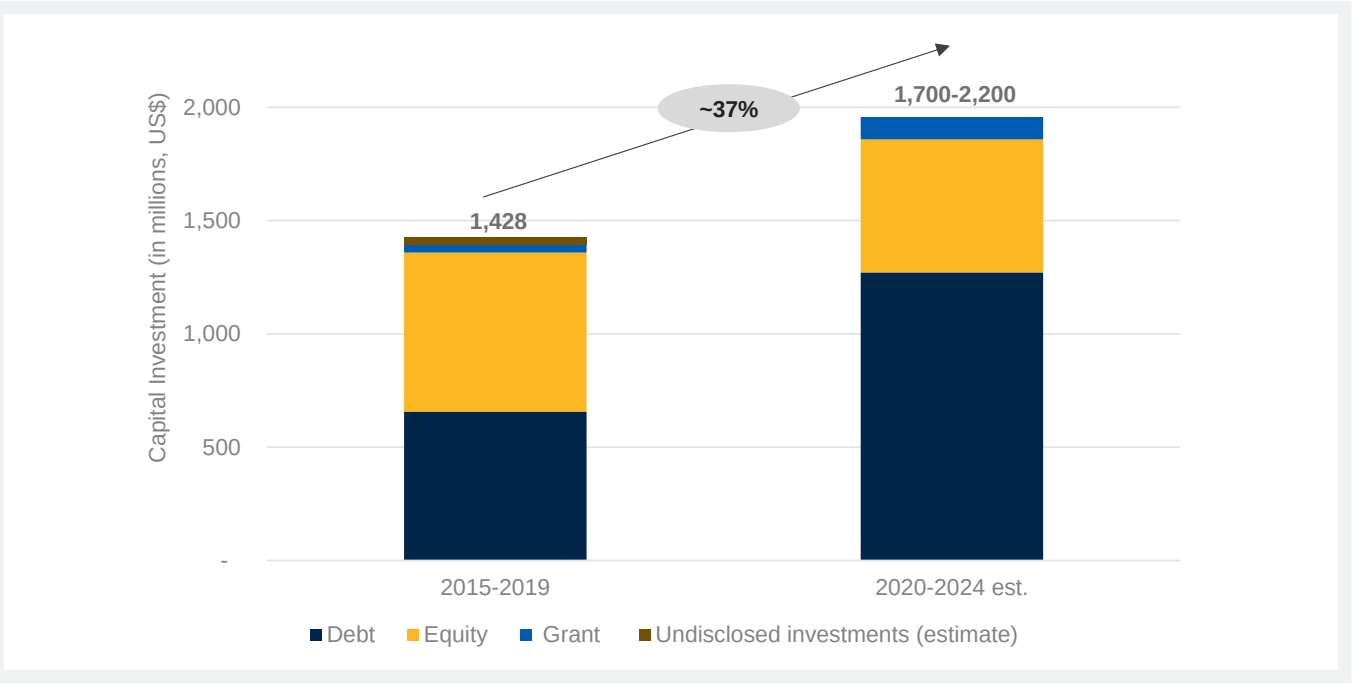
Commoditization and declines in production costs will continue. The cost of manufacturing higher-quality pico and SHS products will continue to decline, albeit at a slower rate as component costs begin to bottom out. This will increase affordability and continue to drive the shift towards higher-margin, larger systems.

Standardized key performance indicators (KPIs) for assessing company performance will attract more investment into the sector. All OGS companies will adopt a standardized set of KPIs, such as those being developed by the PAYGo PERFORM project, which will enable stakeholders to more accurately evaluate company performance and encourage additional investment through increased investor confidence.

The continued momentum of the "Key Drivers" will facilitate an influx of US$ 1.7–2.2 billion of external investment that companies need over the next five years to sustain the sector's growth trajectory. This need for financing primarily comprises consumer receivables of PAYGo businesses and increased inventory. Therefore, debt will continue as the major source of capital, representing 65 percent of this external investment need (Figure 88). Companies will also require equity and grant financing to test new products and expand to new markets. We expect equity to constitute 30 percent of this financing need, while grants would account for 5 percent.

The "Key Drivers" and some of the "Low Hanging Fruit" could catalyze the additional needed investment by increasing the attractiveness of OGS companies to investors. For example, increased operational efficiencies from value chain specialization and the use of AI and IoT technology could improve companies' performance and thus their attractiveness to investors. Standardized KPIs could create more transparency around company performance, helping to build investor confidence.

Figure 88: Debt will Continue as the Major Source of Capital (65 Percent of External Investment Need)



Source: Vivid Economics and Open Capital Advisors.

6.2 Potential Market in 2030

KEY MESSAGES

- To achieve universal access, 617 million people would need to be served by OGS products as their main source of electricity by 2030.
- Of these 617 million people, 505 to 603 million will be able to afford a product that will bring them to Tier 1 access or higher.
- A further 345 million people are expected to use an OGS device as a backup to an unreliable grid connection.

Photo credit: © ZOLA Electric

DESPITE THE MARKET'S STRONG GROWTH TRAJECTORY, TO ACHIEVE UNIVERSAL ACCESS, 617 MILLION PEOPLE WOULD NEED TO BE SERVED BY TIER 1 OGS PRODUCTS AS THEIR MAIN SOURCE OF ELECTRICITY BY 2030; THE CURRENT TRAJECTORY WOULD MISS THIS TARGET BY AT LEAST 228 MILLION PEOPLE.

OGS products could be the main source of electricity for 16 percent of the population (617 million) in Sub-Saharan Africa, South East Asia, and South Asia by 2030.[392] Based on geospatial least-cost electrification projections of the 2030 population, household demand for OGS products as a primary source of electricity will remain strong despite increasing rates of grid penetration and anticipated expansion of mini-grids (Box 25). To reach universal access for all, every household will need a product that will bring them to full Tier 1 access or higher.[393] The OGS share of universal access in 2030 will depend on a range of factors, including how quickly and cost-effectively national utilities can expand the grid and whether mini-grids can expand at the pace required by 2030 to reach their electrification potential.[394] While the actual number of people using OGS as their main source of electricity could, therefore, be either higher or lower, in all scenarios, because of its relatively low costs, modularity, proven business models, and continued innovation, the OGS sector will remain a key part of the technology mix to close the gap towards universal electricity access.

392 This 617 million number comprises people that do not currently have access to electricity and those that are already using OGS as their main source of electricity today and will continue to do so in 2030.

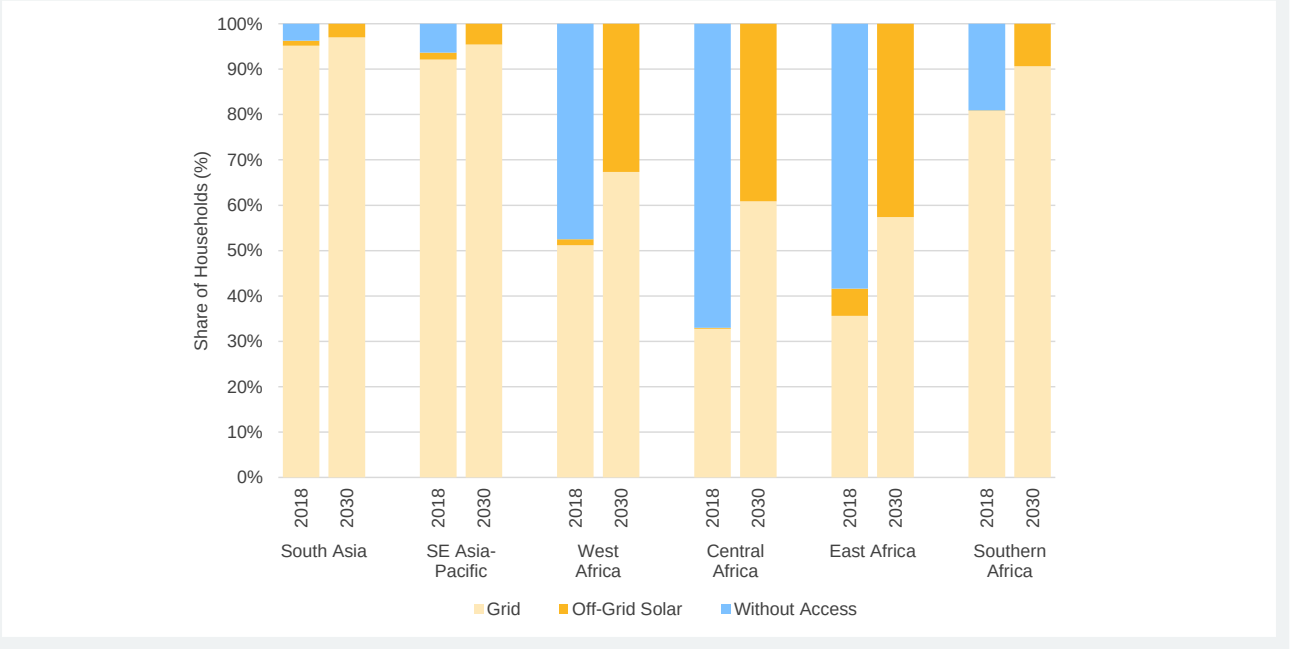
393 For Tier 1 access, we evaluate a high-end pico product (multi-light and mobile charger system of 3–11 Wp), which provides Tier 1 access to at least a person up to a household, following GOGLA product categories. GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H1 2019 (Utrecht: GOGLA, October 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2019-sales-and-impact-data, 10–11.

394 ESMAP, Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers, Technical Report 014/19 (Washington, DC: The World Bank, June 2019), https://openknowledge.worldbank.org/handle/10986/31926.

Box 25: Projecting the Number of People Using OGS as Their Primary Source of Electricity in 2030

In 2030, we expect OGS to connect a substantial share of the households currently without electricity access, especially in Sub-Saharan Africa.[395] In West Africa, Central Africa, and East Africa, OGS is expected to be the primary source of electricity for over a third of all connections. While South Asia and South East Asia and Pacific will have a lower share of OGS as a primary source of electricity, in absolute terms, this still represents a large market of more than 20 million households.

Figure 89: The Expected Access by Source in 2030 (Compared to 2018) Based on Geospatial Least-Cost Electrification Projections and Assuming Universal Access in 2030



Source: Vivid Economics and Open Capital Advisors, analysis of ESMAP, "Global Electrification Platform," https://electrifynow.energydata.info/.

To estimate the expected number of households using a grid, mini-grid, or standalone OGS in 2030, we proceed as follows:

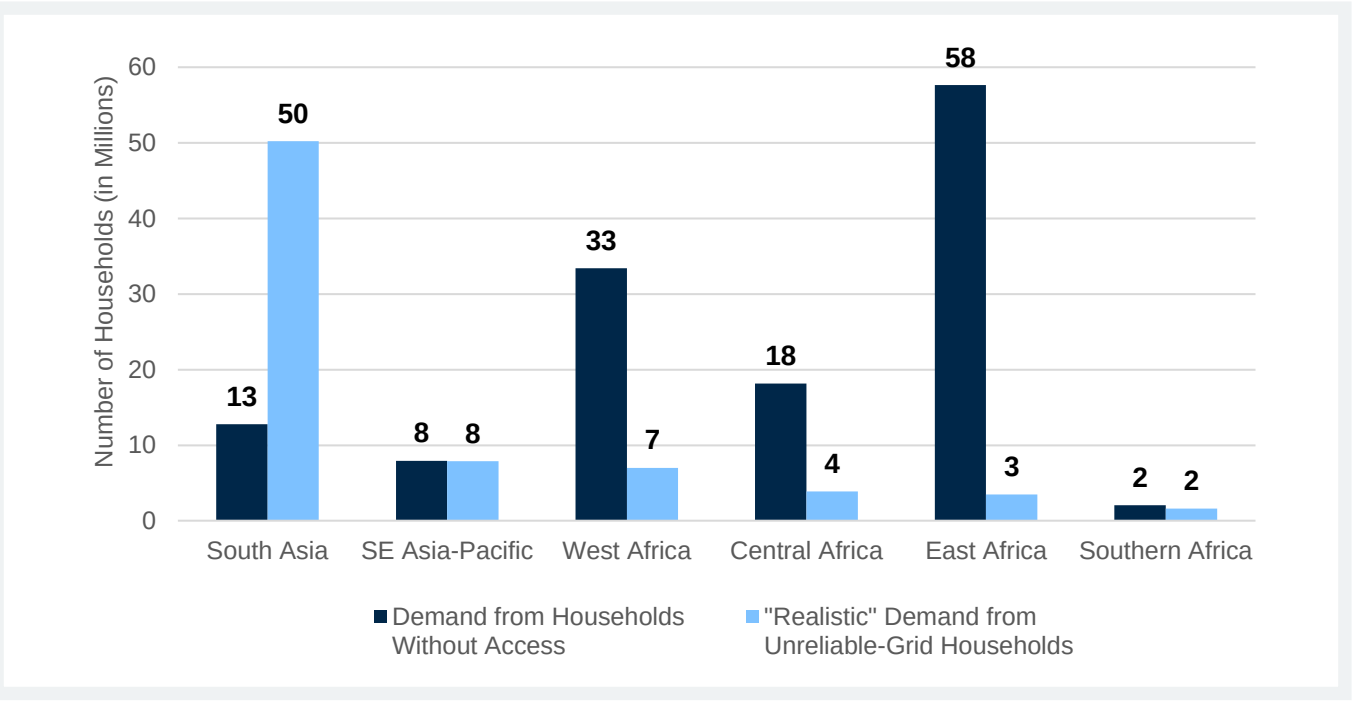
1. We estimate population growth between now and 2030 using data from the UN Population Division. We convert these data into a total number of households in 2030, holding household size constant at today's size. This gives us a total number of households needing access to electricity.
2. We use the recently launched World Bank/ESMAP Global Electrification Platform (GEP) projections, with medium population growth, GEP estimations of cost for on-grid and PV solar, and a low top-down demand target. The choice of a low demand target reflects the least-cost plan, consistent with the ambition to ensure that every household has at a minimum Tier 1 electricity access by 2030. The GEP model is based on a levelized cost of electricity with a single cost figure for OGS solutions of different sizes, which is applied across all countries.
3. For countries without data from the GEP on the relative contributions of the main grid, mini-grids, and OGS products to universal electrification by 2030, we interpolate data from similar countries (based on characteristics such as current electrification rate, current urbanization rate, and current share of grid connections).

395 Vivid Economics and Open Capital Advisors, analysis of ESMAP, "Global Electrification Platform," https://electrifynow.energydata.info/, assuming universal access in 2030.

In addition, we expect 345 million people across Sub-Saharan Africa, South East Asia, and South Asia could use an OGS device as a backup to an unreliable grid, in dual use for both residential electricity and in their microenterprises.[396] As set out in Section 2.4.2 the unreliable grid segment is driven by microenterprises using their OGS in parallel with their residential use (known as "dual use"). While grids are expected to expand rapidly, expansion may strain grids that already experience frequent and often lengthy outages. Furthermore, as described in Section 5.2.1, broad evidence suggests that households often "stack" more than one source of electricity to meet their needs.

The total potential market for OGS products from people using OGS as their main source of electricity and those using OGS alongside a weak or unreliable grid connection is expected to be 962 million people (208 million households) by 2030. South Asia is the only region where we expect the demand for OGS products as a backup or alternative to an unreliable grid will outstrip demand by households without electricity access (Figure 90).

Figure 90: Potential Demand (Millions of Households) for Off-Grid Solar by Households without Electricity Access and for Backup to an Unreliable Grid (Backup)



Source: Vivid Economics and Open Capital Advisors.

Note: As described in Section 2.4.2 we assume "realistic" demand from unreliable-grid households will be 25 percent of total potential demand (based on MTF survey data and stakeholder consultations).

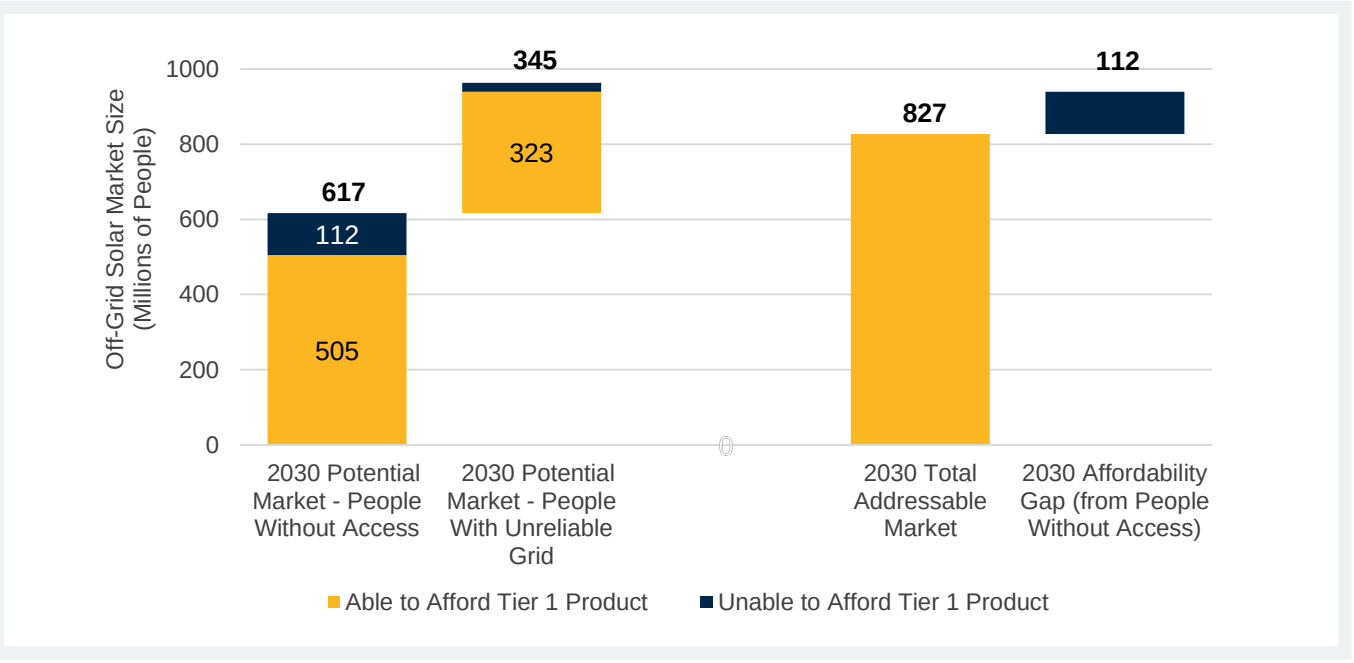
Of the potential market of 617 million people without electricity access (using OGS as their main source of electricity), 505 to 603 million are able to afford a product that will bring them to Tier 1 access or higher.[397] This range is driven by two factors: (1) people's rising incomes up to 2030 and (2) different methods of determining affordability, as described in Section 2.4.2. The lower 505 million figure reflects the most conservative combination of these two factors, using present-day incomes and evaluating people's theoretical affordability—their ability to make equal monthly payments across the entire product lifetime (Figure 91). By contrast, the upper 603 million figure combines 2030 incomes (which will be higher) with an evaluation of people's practical affordability—their

396 This number is based on current estimates of grid unreliability by country, assuming the 2018 share of unreliability will remain constant to 2030. As described in Section 2.4.2, it further assumes that 25 percent of all people with unreliable grid connections are expected to purchase an OGS product as a backup device for residential use, to power their SME or micro-businesses, or both, which yields a smaller "realistic" market.

397 To estimate the addressable market, we consider the total potential market in 2030 (people without access and people in the realistic unreliable-grid market), determining their ability to pay the average price of a Tier 1 product. We then segment this addressable market by comparing the total system costs of pico and SHS products and assuming people will purchase the highest-capacity product they can afford.

ability to pay only the PAYGo deposit after three months' savings, assuming people will be able to make the monthly payments after that.[398] The affordability gap is only relevant for people without access, as only these people must be served to reach universal access goals.

Figure 91: By 2030, the Potential Market Consists of 617 Million People without Access and 345 Million People with Unreliable Grid Connections, About 85 Percent (827 Million people) of which Is Addressable



Source: Vivid Economics and Open Capital Advisors analysis.

Note: The 2030 addressable market and 2030 affordability gap depicted reflect the most conservative scenario: present-day income and evaluating people's ability to afford monthly payments across the entire product lifetime.

Affordability in the Asia–Pacific region is higher than in Sub-Saharan Africa, as almost all people in Asia–Pacific will be able to afford a Tier 1 multi-light system in 2030.[399] In Sub-Saharan Africa, about 80 percent of people will be able to afford the same Tier 1 multi-light product in 2030. Nonetheless, the cost of reaching customers in remote or hard-to-reach areas (for example, very dispersed customers in sparsely populated mountain or island communities) could be much higher than the cost of access used here to provide a benchmark of affordability, which means affordability could be lower than set out here. This could justify a greater role for public funding.

398 To determine affordability, we compared monthly PAYGo payments to 5 percent of monthly expenditures (today and in 2030). Ability to pay the PAYGo deposit is compared to 3-months' savings at 5 percent of monthly expenditure (today and in 2030).

399 Using the conservative combination of present-day income and evaluating people's ability to afford monthly payments spread over the entire product lifetime. We have used the multi-light as a product that can provide Tier 1 access, as per the product categorization in the biannual GOGLA sales reports , which state that a multi-light system "enables full Tier 1 Electricity Access to at least one person up to a full household." GOGLA and Lighting Global, Off-Grid Solar Market H1 2019, 11. Obviously, Tier 1 access can also be realized with multiple qualifying products, but for the purposes of our model, we assumed 1 multi-light system per multi-person household.

6.3 Closing the Gap to Universal Access

KEY MESSAGES

- If the sector continues on its current growth trajectory, it will miss the universal access target by at least 228 million people.
- Reaching universal access by 2030 will require an accelerated annual growth rate (sales CAGR) of 13 percent, US$ 6.1 to 7.7 billion in external investment for OGS companies, and up to US$ 3.4 billion of public funding to bridge the affordability gap.
- Achieving this growth rate will require all stakeholders to make concentrated efforts:
  - Companies need to prove profitability to expand sustainably and drive investor confidence.
  - Investors need to double down and drive new flows of capital into the sector.
  - Policymakers need to create favorable enabling environments for OGS.
  - Donors need to close the affordability gap for consumers and incentivize companies to move into new markets.

Photo credit: Courtesy of Lighting Global and/or affiliates

REACHING UNIVERSAL ACCESS BY 2030 WILL REQUIRE AN ACCELERATED ANNUAL GROWTH RATE (SALES CAGR) OF 13 PERCENT, US$ 6.1 TO 7.7 BILLION IN EXTERNAL INVESTMENT FOR OGS COMPANIES, AND UP TO US$ 3.4 BILLION OF PUBLIC FUNDING TO BRIDGE THE AFFORDABILITY GAP.

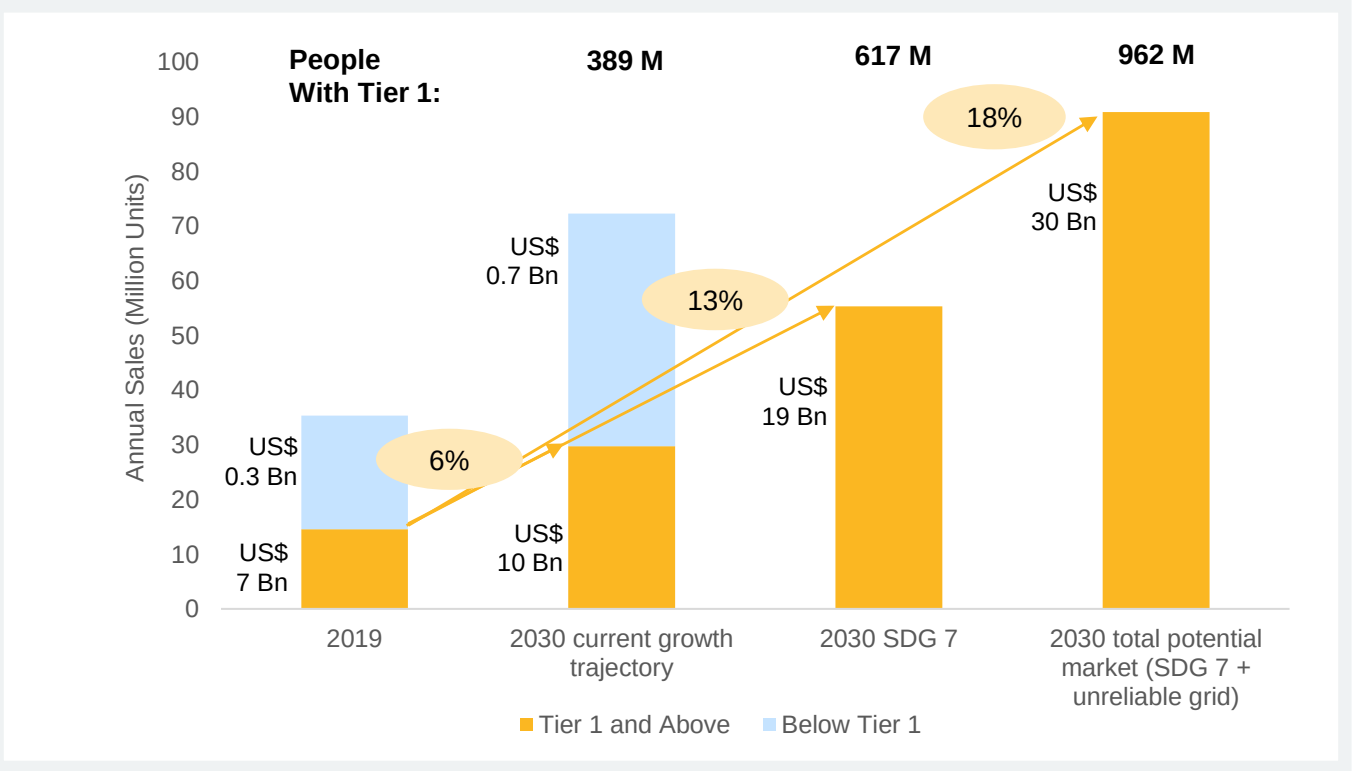
To reach universal access by 2030, the OGS sector needs to serve an additional 228 million people with products that provide Tier 1 or above (Figure 92).[400] This will allow the sector to provide Tier 1 products to all people who, according to GEP projections, would not otherwise be connected through either the grid or a mini-grid. In order to also provide an OGS backup device to those with an unreliable grid, and thereby serve the total potential market, a further 345 million people would need to be reached.[401] The U.S. dollar values in Figure 90 represent turnover figures for these different scenarios, assuming declining product prices up to 2030.[402] Since people with access to unreliable grid connections are still considered electrified according to SDG 7, the remainder of the analysis in this report only considers what must be done to serve the additional 228 million people without Tier 1 electricity access.

400 Live products are calculated based on a weighted average of assumed asset lives for pico and SHS. Asset lives are based on the assumption that systems last about 1.5 times their warranties. GOGLA Impact Working Group, Standardized Impact Metrics for the Off-Grid Solar Energy Sector (Utrecht: GOGLA, September 26, 2018), https://www.gogla.org/resources/standardized-impact-metrics-for-the-off-grid-solar-energy-sector.

401 This is the "realistic" market of 25 percent of the total unreliable grid market. See n. 396 above.

402 To calculate turnover numbers, we began with the average affiliate price for Below Tier 1 products (single light; single light and charger) in 2019 (US$ 17.23). We applied a learning curve, with an average 6.5 percent decrease in manufacturing costs over a two-year period (see Section 2.2.1, where the predicted range for manufacturing cost declines for pico products is estimated at 3–10 percent). Based on this, we calculated the yearly decrease in manufacturing cost (CAGR). Manufacturing costs comprise 30 percent of total cost, and 50 percent of the drops in manufacturing costs are passed on to consumers (Section 2.2.1). This corresponds to a yearly drop in consumer price of 0.5 percent. Applying this yearly drop to the price in 2019, we obtain an average affiliate Below Tier 1 product price of US$ 16.31 for 2030. The respective non-affiliate prices in all years are estimated to be 30 percent lower. The turnover numbers are then calculated by multiplying the affiliate and non-affiliate product prices by the unit sales number in each specific year, applying the Pico affiliate/non-affiliate split. The turnover numbers for Tier 1 and above products have been calculated similarly. To obtain the initial price for Tier 1 and above products, we used the affiliate prices for multi-light and medium SHS systems. Non-affiliate prices were estimated to be 30 percent lower. We then calculated a weighted average of these four price points (weighted by both the observed multi-light/medium SHS split and the observed affiliate/non-affiliate split in 2019) to get the Tier 1 and above price for 2019 (US$ 448.63). Then the learning curve was applied (similar to below Tier 1 products).

Figure 92: Growth Rates Required to Reach SDG 7 and Connect the Total Potential Market (People Using OGS as a Primary Source of Electricity and Those Using OGS Alongside Unreliable Grid Connections)



Source: Vivid Economics and Open Capital Advisors analysis

Note: In the SDG 7 scenario, we assume all people without electricity access will need to be connected to a Tier 1–enabling product. We have used a multi-light 3–11 Wp product in our model, although, of course, Tier 1 access can also be realized with multiple qualifying products. For the 2030 total potential market scenario, we assume that the realistic unreliable grid market is also connected to products providing Tier 1 access or above.

Closing the gap towards universal access will require the sector to grow at an average annual growth rate of 13 percent, more than double current projections. Achieving this growth rate will require concentrated efforts by all stakeholders. Companies need to prove profitability to expand sustainably and drive investor confidence. Investors need to double down and drive new flows of capital into the sector. Policymakers need to create favorable enabling environments for OGS. And donors need to close the affordability gap for consumers and incentivize companies to move into new markets.

Below, we explore the "Tipping Points" that could supercharge sector growth; these will require increased investment and focus by different sector stakeholders.

Companies need to achieve profitability and become cashflow positive. Profitability underpins long-term sector growth and sustainability and would drive a new wave of investment into the sector – including from a new, currently untapped, later-stage commercial investor base.

Market-enabling policies, regulations, and enforcement need to improve. Governments can drive policy and regulatory changes to support the sector more quickly than ever before. Accompanied by robust implementation plans, they can thereby crowd-in public and private capital to finance ambitious off-grid electrification plans. However, now that governments have realized the importance of the OGS sector and begun to incorporate OGS in national electrification plans as well as their tax and customs regimes, over-regulation may be a risk that could impede sector growth. For example, the growth of the PAYGo sales model (a Key Driver supporting the sector's current growth trajectory) could be severely curtailed if policymakers decide to regulate PAYGo companies like financial institutions.

Supply-side incentives and demand-side subsidies are needed to address the affordability gap and catalyze markets. The right supply-side incentives can encourage OGS companies to develop new markets and serve more users. The right demand-side incentives can help achieve SDG 7 by closing the affordability gap for the poorest consumers. However, these public finance initiatives must be well-targeted to accelerate market development and increase market inclusion for the poorest consumers without distorting commercial markets.

Concessional finance needs to be targeted at early-stage companies and nascent markets, creating a new wave of innovation. As some market segments move to profitability, concessional finance can be targeted to catalyze nascent markets, support continuing innovation in PULSE products for early-stage companies, electrify public institutions, and serve the hardest-to-reach residential markets.

A stronger link between climate change or social finance and the OGS sector is needed to enable a new wave of funding. As the OGS sector expands, it is well-placed to take advantage of climate and social impact bonds, which would unlock massive amounts of new concessional capital.

Increased access to local currency loans is needed to de-risk investments and drive growth. In the short term, larger amounts of local currency financing could be available from specialized debt providers, currency hedging providers, and DFIs to help companies manage their foreign-exchange risk. Within the next decade leading up to 2030, OGS companies will need to access local currency financing directly from local banks.

In addition to the "Tipping Points," "Small Wins" could also support the acceleration of sector growth.

Interoperability of hardware components and open-source software should be standard across the sector. The sector should move towards standardized hardware to increase consumer choice, improve end-consumer affordability, and help manage e-waste. Software providers should move to an open-architecture approach, which will enable manufacturers to integrate numerous software platforms with their hardware, increasing choice for distributors, and facilitating the servicing of receivables.

Further consolidation of OGS companies could allow for faster growth and access to additional capital. If the initial engagement of strategic investors translates into increased consolidation in the sector, this could lead to the creation of much larger companies in the OGS sector than at present. These companies could unlock larger pools of capital from strategic investors, benefit from institutional knowledge, and increase operational efficiencies through economies of scale. However, we have seen little evidence of these impacts of consolidation from the strategic acquisitions to date. Consolidation could become a Tipping Point if strategic acquirers target more aggressive growth going forward.

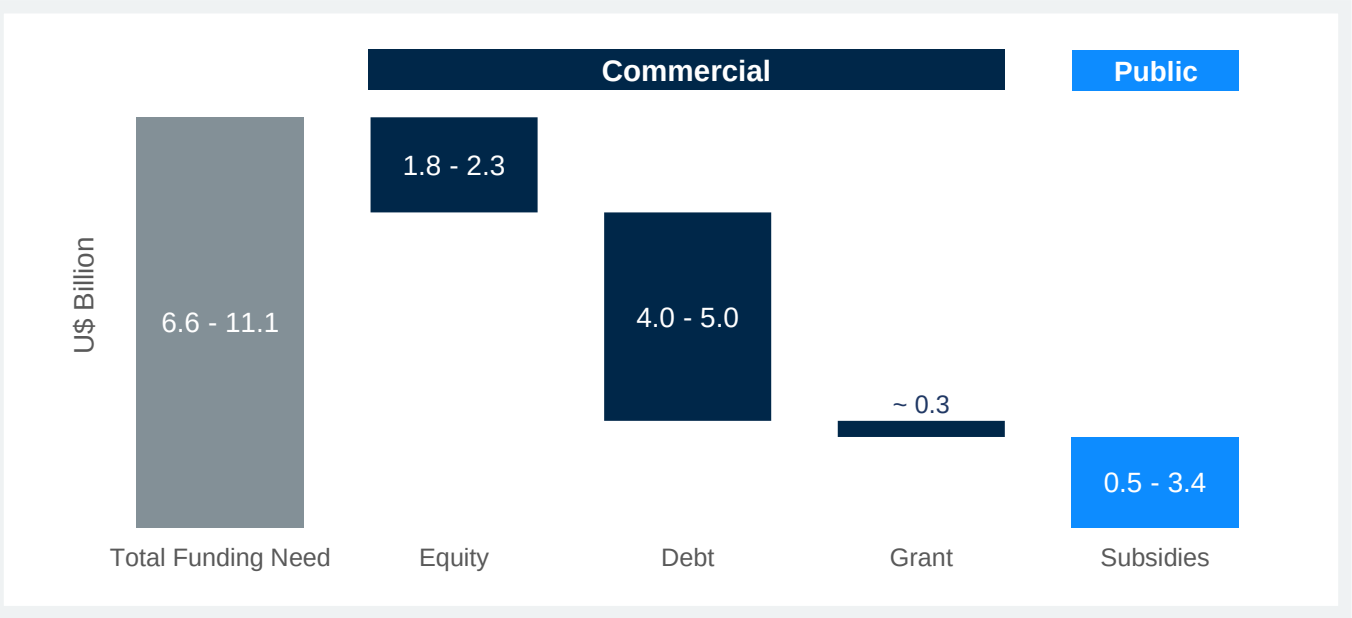
Attracting large AC appliance manufacturers to the sector could accelerate technological innovation. Development partners should accelerate funding for appliance R&D and analysis to quantify demand and attract large, traditional AC appliance manufacturers into the market. These large manufacturers could then accelerate the rate of technological innovation, which would decrease costs, and enable a higher level of service and a greater number of appliances for OGS customers.

To realize the OGS sector "Tipping Points," investors, governments, and donors will need to inject an additional US$ 6.6–11 billion in financing (Figure 93).[403] The majority of this financing, US$ 6.1 to 7.7 billion, will be from external investments into OGS companies in the form of debt, equity, and grants. Debt will be critical for companies to finance receivables at such an accelerated pace of growth, while equity and grants will enable companies to

403 Vivid Economics and Open Capital Advisors analysis

rapidly expand to unserved markets. But investment in OGS companies will not be enough. Up to US$ 3.4 billion of public funding from governments and development partners will be required to bridge the affordability gap for people without electricity access that are unable to afford a Tier 1 OGS product.[404] We hope that additional public and private financing to enable "Tipping Points" will create a virtuous cycle, where the achievement of "Tipping Points" such as company profitability and market-enabling policies creates even more sector momentum and investor confidence, thereby catalyzing even more of the needed investment.

Figure 93: Total Funding Needed to Reach Universal Access



Source: Vivid Economics and Open Capital Advisors analysis

Achieving universal access by 2030, therefore, requires the sector to grow much faster, with significantly more external investment and public funding to bridge the affordability gap. Given the sector's track record, its proven ability to innovate, expansion in terms of geography and products, falling costs and rising quality, even in the non-affiliate market, together with the enhanced focus by governments and development partners on the SDG7 goal, the OGS sector certainly could surpass the current growth trajectory forecast, particularly if public funds can be used to catalyze markets and crowd-in private sector finance.

404 The US$ 3.4 billion reflects the more conservative combination of present-day (lower) incomes and people's ability to afford the monthly payments over the product lifetime. As incomes rise between now and 2030, the number of people that require financial support to afford OGS products will decrease, expanding the addressable market and shrinking the affordability gap to US$ 1.4 billion in 2030. If we consider the least conservative combination of people's 2030 income and their ability to afford the PAYGo deposit, the affordability gap would be US$ 0.5 billion.

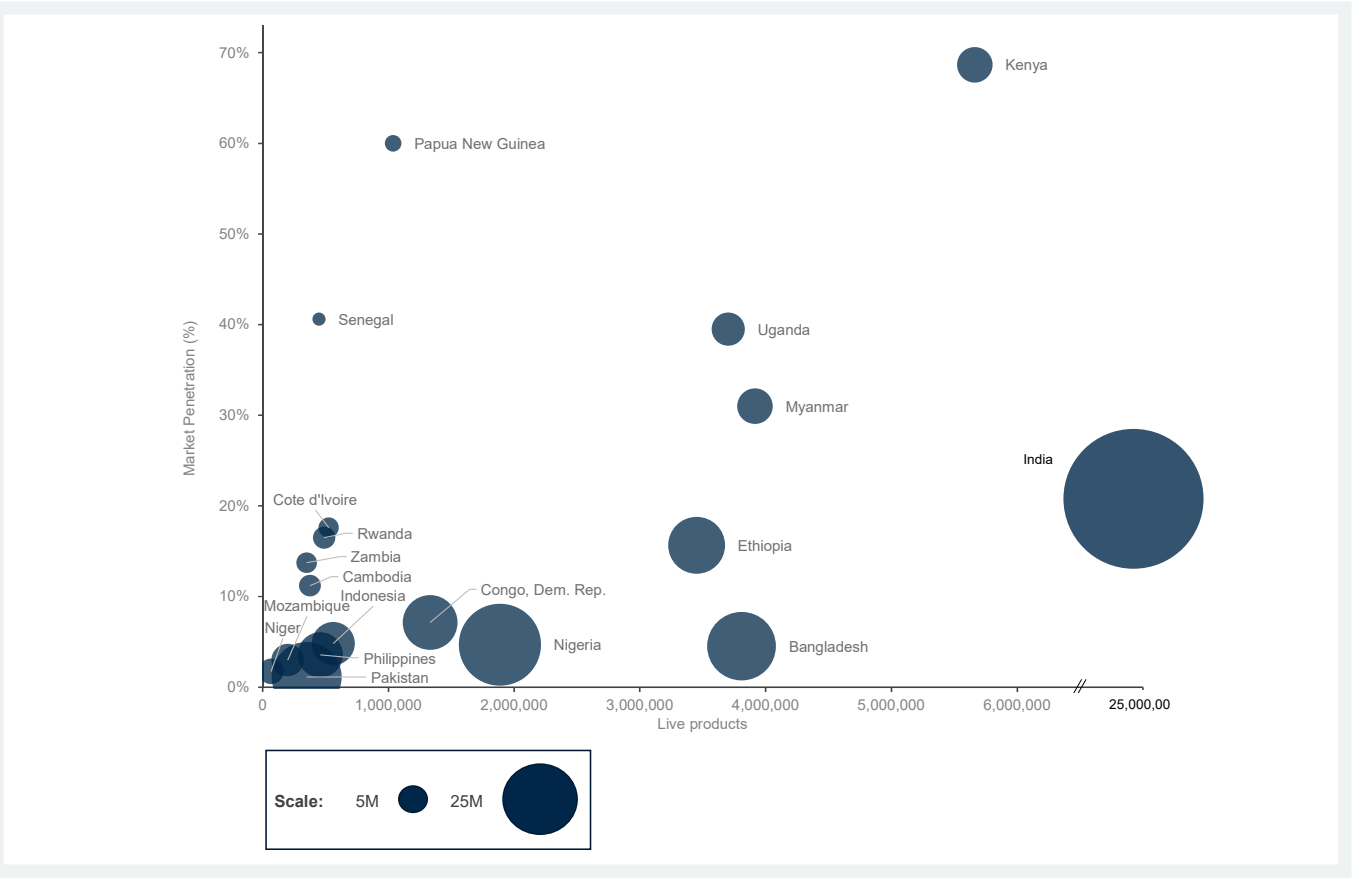
CHAPTER 7
APPENDIX

Photo credit: © Greenlight Planet

Appendix A: Country profiles

This appendix sets out the profiles of select countries that have been highlighted throughout the Off-Grid Solar Market Trends Report 2020. These profiles present key facts about each market and emerging opportunities and challenges for the OGS sector to overcome. Figure 94 compares the current state of each country based on the number of live products and market penetration. The size of each bubble indicates the remaining OGS market potential (including households currently without access to electricity and unreliable grid households), which could be served, showing each country's progress towards total electrification goals and outlining its remaining gap.

Figure 94: Market Penetration, Live Products, and Potential Market of the Profiled Countries



Source: Vivid Economics and Open Capital Advisors analysis

Each country is classified into one of four categories based on the current market penetration, the number of live products, the enabling environment, and specific market context, such as grid-expansion dynamics. The enabling environment includes the country's OGS policies and regulations, as well as development partner interventions that impact the growth of the OGS sector. Examples include, among others, a defined role for the OGS sector, tax exemptions, ease of doing business, consumer-awareness activities, access to technical assistance, and subsidy programs. The market context for each country includes specific insights garnered through extensive research, consultations with local companies, and input from development partners, as well as through years of working with stakeholders in these markets. The four classification categories are as follows:

1. **Firmly Established:** Countries with relatively high market penetration in which OGS companies will continue to consolidate and upgrade sales and find new ways of reaching customers. Their OGS sectors have reached scale through high product penetration. In some cases, this growth has been led by a vibrant private sector (e.g., Kenya), while in others, growth was driven by government and development-partner programs (e.g., Myanmar). Generally, targeted government programs are required to reach the remaining unserved populations.

2. **Maturing:** Countries in which the OGS sector has been growing quickly, but where there is still significant room for expansion. We expect these markets to continue to evolve substantially over the next few years. A strong enabling environment can propel these countries forward by making them more attractive for private-sector players.
3. **High Growth Prospects:** Countries with off-grid energy markets that are showing signs of taking off with the right conditions for growth but which are not currently very active. These are generally large markets with significant demand, making them attractive to private-sector players. Given their large potential markets, they have customers with a very wide set of needs. As they often have weaker enabling environments, large interventions will be needed to catalyze the private sector.
4. **Pioneering:** Countries with a very limited OGS market at present and where the supply, demand, or enabling environment are such that significant barriers hinder their full market potential. To overcome these barriers and unlock the sector's growth, these markets require early market-building interventions such as consumer-awareness campaigns and early support for the private sector.

Source Notes for All Country Profiles

a. Population and GDP per capita from World Bank, World Development Indicators, https://datacatalog.worldbank.org/dataset/world-development-indicators. Electricity access rates and OGS penetration from ESMAP, Energy Access Diagnostic Reports Based on the Multi-Tier Framework (MTF): Beyond Connections, https://www.esmap.org/node/56715; and International Energy Agency et al., Tracking SDG 7: The Energy Progress Report 2019 (Washington, DC: The World Bank, May 2019), https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019. OGS potential 2030 from ESMAP, "Global Electrification Platform," https://electrifynow.energydata.info/.

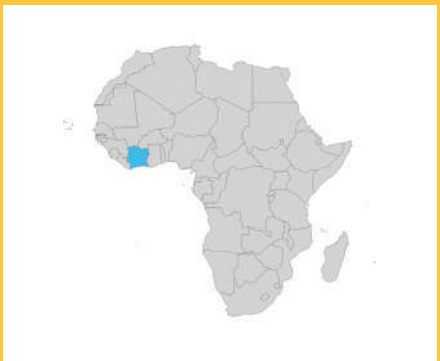
b. For 2018, the segment of electricity-access customers mix is based on the data underlying ESMAP, Diagnostic Reports Based on the MTF; International Energy Agency et al., Tracking SDG 7; Afrobarometer, Merged Round 7 Data (34 Countries) (2019), https://www.afrobarometer.org/data/merged-round-7-data-34-countries-2019; and The World Bank, Enterprise Surveys: What Businesses Experience, https://www.enterprisesurveys.org/en/data. For unreliable-grid customers, we only include the share of people with an "unreliable" or "very unreliable" grid connection, which means we are not including slightly unreliable connections in the potential unreliable-grid market. For 2030, the mix in this segment is based on projections from the recently launched ESMAP Global Electrification Platform, under the "universal access" scenario, with medium population growth, GEP estimations of cost for on-grid and PV solar, and a low top-down demand target. The choice of a low demand target reflects the least-cost plan, consistent with the ambition to ensure that every household has at a minimum Tier 1 electricity access by 2030. We assume that the 2018 share of unreliability will remain constant to 2030 and that 25 percent of unreliable-grid households are potential customers for an OGS product as a backup device for residential use, to power their small or medium-sized enterprise or microbusiness, or both.

c. Live products represent products still currently in use in the market. Total live products in the market are derived from GOGLA reported data on live products. This number for affiliates is then adjusted up to a global estimate using estimates for non-affiliate market share derived from country-specific secondary literature or MTF survey data. For Cambodia, Ethiopia, Kenya, Myanmar, Niger, Uganda, and Zambia: ESMAP, Diagnostic Reports Based on the MTF; and other MTF survey data. For Bangladesh: confidential off-grid market analysis by International Renewable Energy Agency (IRENA) in September 2019. For India: Government of India (2019), "Saubhagya Dashboard," https://saubhagya.gov.in/. For Rwanda: Simon Rolland, Razvan Sandru, Alfons Schmid, and Yvette Ingabire, Rwanda: Off-Grid Sector Status 2016: Achievements in 2016 and Trends for 2017 (Kigali: Energizing Development Rwanda, May, 2017), https://endev.info/images/9/95/EnDev_Rwanda_Off-grid_Sector_Status_2016.pdf. For Nigeria, Lighting Global, Lighting Global., Off-Grid Solar Market Trends Report 2018 (Washington, DC: Lighting Global, January 2018), https://www.lightingglobal.org/resource/2018-global-off-grid-solar-market-trends-report. For Tanzania: Ipsos market research commissioned by Lighting Global in July and December 2017. For Papua New Guinea: Tobias F. Engelmeier and Nabin Raj Gaihre, Going the Distance: Off-Grid Lighting Market Dynamics in Papua New Guinea (Port Moresby: Lighting Pacific, 2019), http://documents.worldbank.org/curated/en/802451567681915534/Going-the-Distance-Off-Grid-Lighting-Market-Dynamics-in-Papua-New-Guinea.

COTE D'IVOIRE

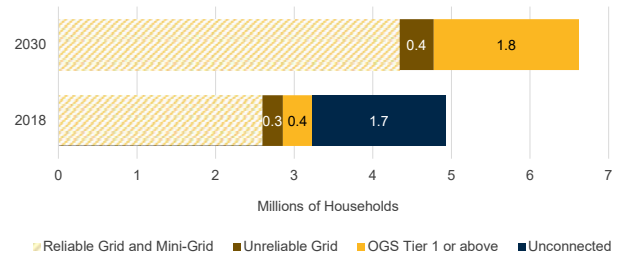
Population:	25.1 million people
GDP per capita 2018:	US$ 1,715
Electricity access rate (Tier 1 or higher) 2018:	66 percent
Current penetration of OGS:	18 percent
OGS potential 2030:	1.8 million households (OGS as main source) + 0.1 million (OGS as backup to weak grid)
Status:	Maturing

Source: See note (a) in Country Annexes Introduction



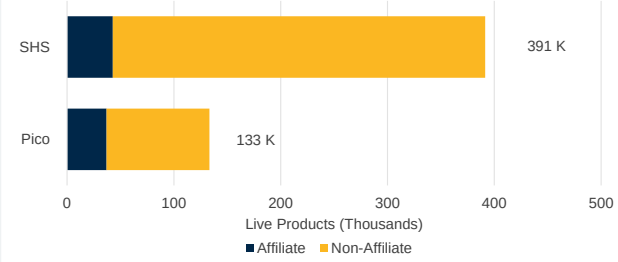
The promising OGS market in Côte d'Ivoire is attracting interest from various companies as a result of the country's strong economic growth and the PAYGo model. The market potential is indicated by a large unelectrified rural population (only 37 percent of households have access to electricity), high uptake of mobile money (9.8 million accounts reported thus far), and a growing number of partnerships. However, the government's prioritization of grid connectivity over OGS, a high and unclear taxation policy (up to 25 percent of the cost of goods), limited access to finance, and low human capital could limit growth of the OGS sector OGS sector.[405]

Primary Source of Electricity in 2018 and 2030 (of 6.6 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

High mobile money penetration, a focus on growing the agricultural sector, and a growing collaboration between the public and private sectors offers a positive way forward for both OGS products and productive use appliances.

- **The World Bank's Regional Off-Grid Electrification Project (ROGEP) has provided US$ 200 million in funding to 19 West African countries, including Côte d'Ivoire, to facilitate the uptake of OGS energy in these countries.[406]** The funding covers financial and technical assistance to attract new players into Côte d'Ivoire's off-grid market.

405 GOGLA, "Côte d'Ivoire," Country Briefs, https://www.gogla.org/policy-and-regulation/country-briefs; Barbara Arese Lucini and Kalvin Bahia, National Overview: Côte d'Ivoire (London: GSM Association, April 2017), https://www.gsma.com/mobilefordevelopment/resources/country-overview-cote-divoire/; and Power Africa, Off-Grid Solar Market Assessment: Côte d'Ivoire (Washington, DC: United States Agency for International Development, October 2019), https://www.usaid.gov/powerafrica/beyondthegrid/off-grid-solar-assessment/cote-divoire.

406 Tom Kerr and Aditi Maheshwari, Unlocking Private Investment: A Roadmap to Achieve Côte d'Ivoire's 42 Percent Renewable Energy Target by 2030 (Washington, DC: International Finance Corporation, 2018), http://documents.worldbank.org/curated/en/566921532638485663/Unlocking-private-investment-A-Roadmap-to-achieve-C%C3%B4te-d-Ivoire-s-42-percent-renewable-energy-target-by-2030.

- **Côte d'Ivoire has the fifth-highest mobile money penetration in the World and the highest in West Africa with 9.8 million subscribers out of a population of 25 million.**[407] This will likely be a key success factor in Côte d'Ivoire, as it was in many East African countries, because the PAYGo model increases consumer affordability of higher-capacity systems.
- **Productive Use Leveraging Solar Energy (PULSE) appliances offer an opportunity to expand the use of OGS products in Côte d'Ivoire.** The most recent government policy on agriculture and PULSE, the National Investment Program for Access to Energy Services in Côte d'Ivoire (PNIASE-CI), prioritizes the use of solar power in agriculture, particularly in irrigation (solar water pumps, or SWPs).[408] Agricultural activities remain a significant economic activity in Côte d'Ivoire, with over 40 percent of both women and men self-employed in the agriculture sector. SWPs provide an opportunity to increase yields for farmers and reduce the risk of uncertain rainfall, an increasingly common occurrence in West Africa.
- **OGS companies are looking for more collaborations with other organizations in Côte d'Ivoire.** One example is the potential partnership among Orange Energie, Baobab+, and Schneider Electric to increase consumer access to affordable, quality-verified products. Another potential collaboration is with the National Federation of Cooperative Food Crops Societies of Côte d'Ivoire, where more than 600 members have expressed interest in using solar for agricultural use.[409] Such partnerships will be vital to rapidly expand OGS in Côte d'Ivoire as stakeholders play to their strengths to overcome market challenges.

Challenges to overcome

Several challenges limit the growth of the OGS sector in the country, including government prioritization of grid over off-grid connections, high and ambiguous tax regimes, and limited access to finance.

- **While the government is pushing for universal electrification by 2030, OGS remains a low priority as the government instead focuses on grid extension to achieve connections.**[410] As a result, less than 5 percent of an estimated US$ 796 million budgeted for electrification through 2020 has been allocated to renewable and off-grid projects.[411] However, the Ministry of Petroleum, Energy, and Renewable Energy Development through the Côte d'Ivoire Energy Society (Société des Energies de Côte d'Ivoire, or CI-Energies) is designing a strategy and policies that will include renewable energy.
- **Local financial institutions lack awareness of the OGS market and are highly risk-averse, so they rarely lend to OGS companies.** Financial institutions struggle to finance standalone OGS products because they have limited knowledge of the technologies involved, inadequate information on potential market size, and doubts on the profitability of these systems.[412] Furthermore, these institutions are skeptical about the creditworthiness of rural customers, which limits consumers' ability to pay.
- **Import duties are applied inconsistently depending on the port of entry, customs officer on the day of import, and product packaging.** Currently, import duties are set at 25 percent of the cost of goods. Duties can vary depending on the port of entry, thus increasing uncertainty for OGS companies and creating risks which are hard to mitigate. The government requires technical assistance on enforcing duties more consistently in order to attract more private sector interest.

407 Lucini and Bahia, National Overview: Côte d'Ivoire.
408 Power Africa, Market Assessment Côte d'Ivoire.
409 Power Africa, Market Assessment Côte d'Ivoire.
410 Kerr and Maheshwari, Unlocking Private Investment.
411 Power Africa, Market Assessment Côte d'Ivoire.
412 Power Africa, Market Assessment Côte d'Ivoire.

SPOTLIGHT

Collaboration to Provide Energy Access

Orange Energie, Baobab+, and Schneider Electric are in discussions to partner to deliver OGS products in Côte d'Ivoire. The collaboration seeks to apply the expertise of each participant to overcome the various challenges in the country. Orange Energie is the largest telecommunications company in the country, Baobab+ has PAYGo and retail experience in Senegal, and Schneider Electric is a global energy supplier with deep experience in processes and supply chain. This and similar partnerships represent an exciting development to drive OGS uptake in the Ivorian market.

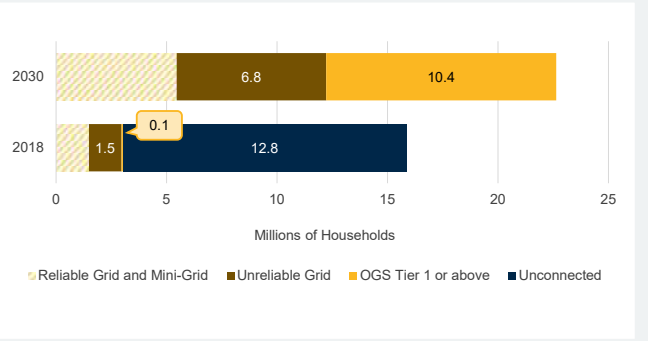
DEMOCRATIC REPUBLIC OF THE CONGO

Population:	84.1 million people
GDP per capita 2018:	US$ 562
Electricity access rate (Tier 1 or higher) 2018:	19 percent
Current penetration of OGS:	7 percent
OGS potential 2030:	10.4 million households (OGS as main source) + 1.7 million (OGS as backup to weak grid)
Status:	Pioneering

Source: See note (a) in Country Annexes Introduction

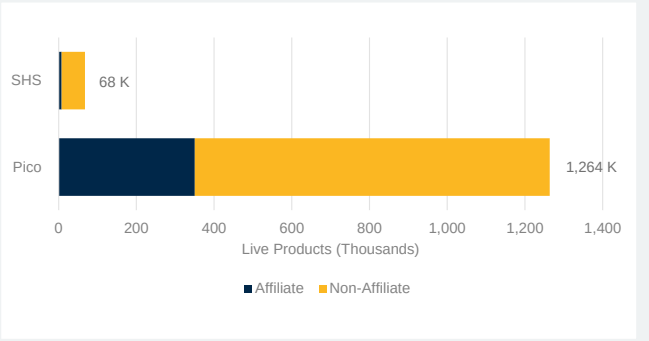
A large unconnected population, an unreliable grid, and few OGS companies in the market offer a huge opportunity despite challenges such as low affordability, high taxes, presence of low-quality component-based systems, and poor infrastructure. With a nationally reported access rate of 9 percent (1 percent rural, 19 percent urban), the Democratic Republic of Congo is one of the least electrified countries in Africa.[413] Most of the country is not covered by the national grid (more than 50 million people live beyond its reach) and will remain so because investments are limited compared to the country's sheer size. Alternatives to OGS, such as diesel generators and component-based systems, tend to be expensive in the long run, of poor quality, and potentially dangerous. As such, the several large, densely populated urban areas with unreliable or no grid connectivity, such as Kikwit or Mbuji-Mayi, offer attractive opportunities for off-grid companies. Furthermore, the national government, via the National Investment Promotion Agency, is leading initiatives to improve ease of doing business in the country. Development partners, such as the World Bank, are supporting the solar energy sector through a results-based financing (RBF) scheme set up via the Electricity Access and Services Expansion (EASE) project to enable increased consumer awareness and uptake of OGS products.

Primary Source of Electricity in 2018 and 2030 (of 23 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Millions)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

If the challenges serving its market can be overcome, the Democratic Republic of Congo offers a large potential market for off-grid energy.

- **Several large, densely populated urban areas have poor or no grid connectivity, creating an attractive opportunity for off-grid companies.** For example, several urban areas have large populations with very little

413 Power Africa, "Democratic Republic of Congo," fact sheet, United States Agency for International Development, Washington, DC, November 2018, https://www.usaid.gov/sites/default/files/documents/1860/DRC-_November_2018_Country_Fact_Sheet_0.pdf.

access to electricity, such as Kikwit and Mbuji-Mayi at 4 and 12 percent, respectively.[414] Larger cities, such as Kinshasa and Lubumbashi, with higher electrification rates also have sizeable numbers of households with poor or no grid access. These urban communities are more densely populated and have a higher ability to pay compared to remote communities, potentially providing a viable market for a range of OGS systems and appliances.

- **Several OGS companies are active in the Democratic Republic of Congo including (but not limited to) Altech Group, BBOXX, d.light, DevSolaire, Ecomwinda, Greenlight Planet, KitAfrica, Proton, and Total.** Some have reported higher average revenues per user compared to off-grid customers in other markets, such as East Africa. Certain reported market factors such as good mobile connectivity, high mobile penetration, and concentration of customers in pilot areas have enabled rapid uptake of OGS products.[415]
- **Initiatives such as the World Bank's results-based financing (RBF) scheme set up via the Electricity Access and Services Expansion (EASE) project and DFID's ELAN program are supporting the uptake of OGS products.** Through the three-year, US$ 3.5 million EASE project launched in November 2019, the World Bank in partnership with the Government of the Democratic Republic of Congo is looking to enable low-income, off-grid households to purchase Lighting Global, quality-verified products between 2 and 350 Wp. DFID's ELAN program, which recently ended, also focused on improving the pico solar sector in the country by creating a local solar association, increasing consumer awareness of quality products, assessing the country's potential market, and providing advice to numerous companies operating in the country.[416]
- **Government agencies such as the National Investment Promotion Agency are also making strides towards making it easier to do business in the country.** These agencies provide information on their websites about what is needed to form a company in the Democratic Republic of Congo, successfully reducing the amount of time required to form a new company to just three days.[417]

Challenges to overcome

Political and economic instability, high import and local transportation costs, a complex logistical landscape, areas with limited mobile money penetration, and little to no quality verification are some of the challenges hindering growth of the OGS sector.[418]

- **The Democratic Republic of Congo has endured protracted conflicts that have destabilized parts of the country.** Many OGS companies have decided against investing in the Democratic Republic of Congo because of security risks. As a result of political instability, much of the country's population also lives in poverty, limiting households' purchasing power and thus their ability to afford OGS products.
- **Off-grid companies in the Democratic Republic of Congo face challenges accessing finance and investment.** Limited access to finance and foreign exchange pose serious challenges for OGS companies operating in the country; as such, the market has only a few active and financially viable companies. This makes expansion of PAYGo particularly difficult, as companies need financing to manage their cash flow while extending credit to customers.
- **Inadequate infrastructure development from years of conflict also results in high distribution costs, putting upward pressure on OGS product prices.** Many potential customers live in remote, hard-to-reach areas, making it challenging for companies to reach them cost-effectively. Companies need to identify strategic partnerships with telecommunications firms and local banks that already have established distribution networks to manage the complex logistics of last-mile distribution.

414 Power Africa, Off-Grid Solar Market Assessment: Democratic Republic of the Congo (Washington, DC: United States Agency for International Development, October 2019), https://www.usaid.gov/powerafrica/beyondthegrid/off-grid-solar-assessment/democratic-republic-congo.

415 BBOXX, "The DRC: The Best Pay-Go Solar Market in the World?," learning report, Shell Foundation, London, June 12, 2018, https://shellfoundation.org/learning/the-drc-the-best-payg-solar-market-in-the-world/.

416 Power Africa, Market Assessment Democratic Republic of Congo.

417 Power Africa, Market Assessment Democratic Republic of Congo.

418 Power Africa, Market Assessment Democratic Republic of Congo.

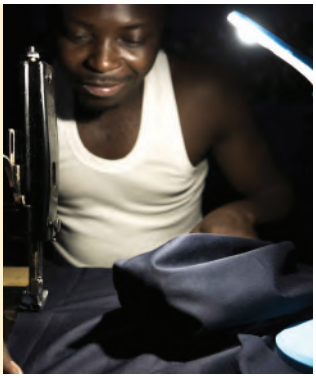
- **Protracted customs procedures and high taxes increase the cost of delivering OGS products to customers.** Lengthy importation processes and high import duties and taxes (up to 35 percent of the final price of an OGS system) increase the cost of doing business for OGS companies and decrease affordability for low-income households.
- **Also, since there are no mechanisms to control the entry of low-quality products into the Democratic Republic of Congo, low-quality OGS systems have flooded the market and further hampered generally low levels of consumer awareness of quality.** Improved consumer education on quality solar products and development of a quality-assurance framework for component-based systems will be necessary to sufficiently address this challenge.

SPOTLIGHT

Photo credit: © Altech

Local Success against the Odds

Altech Group, a home-grown distributor of pico solar products in the Democratic Republic of Congo, is showing promise in a market previously considered too challenging. Founded in 2013, Altech initially specialized in the distribution of pico products to rural and peri-urban households using a door-to-door sales approach. It has now since expanded to include SHS. Altech has sold more than 150,000 solar lamps or lighting kits, employs a network of 300 staff and sales agents, has reached 500,000 people, and aims to reach 2 million by 2021.[419] Its recent success demonstrates that the country has demand for quality solar products.



419 "Altech: Case Study," La Différence, https://www.la-difference.com/case-study-altech.

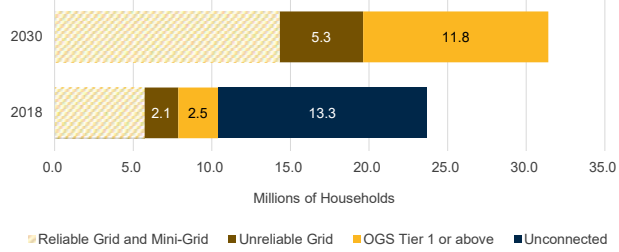
ETHIOPIA

Population:	109.2 million people
GDP per capita 2018:	US$ 772
Electricity access rate (Tier 1 or higher) 2018:	44 percent
Current penetration of OGS:	16 percent
OGS potential 2030:	11.8 million households (OGS as main source) + 1.3 million (OGS as backup to weak grid)
Status:	High growth prospect

Source: See note (a) in Country Annexes Introduction

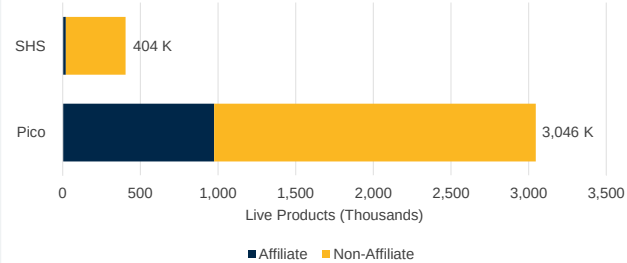
Ethiopia represents a high-potential market for OGS solutions, with a large population and favorable government policies; customs duties have been eliminated for quality-verified OGS products and the National Electrification Program 2.0 (NEP 2.0) aims to provide electricity access for all by 2025. With an unconnected population greater than 60 million and an additional 10 million with unreliable grid connections, Ethiopia offers a large market for off-grid products.[420] To achieve universal access, the government launched its NEP 2.0 in 2019, which aims to provide both on-grid and off-grid solutions to 65 percent and 35 percent of Ethiopia's population, respectively. Consequently, the off-grid program is expected to reach 9.2 million households by 2025.[421]

Primary Source of Electricity in 2018 and 2030 (of 31 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Millions)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

The Ethiopian government is supporting the growth of the OGS sector through its flagship NEP 2.0, among other initiatives, such as improved regulations that promote quality-verified products.

- **NEP 2.0, the second phase of Ethiopia's integrated electrification plan, aims to provide off-grid energy access to 35 percent of households by 2025.**[422] By comparison, off-grid energy comprised 11 percent of access (2.2 million connections) in 2018. The off-grid component of NEP 2.0 supports both standalone solar and mini-grids, with mechanisms to both increase the access to finance that is needed for off-grid companies to reach scale and to provide results-based financing to incentivize the private sector to serve less commercially viable rural areas. NEP 2.0, which updates the NEP released in 2017, incorporates analytics from both the Multi-

420 ESMAP, Ethiopia – Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework (Washington, DC: World Bank, June 2018), https://openknowledge.worldbank.org/handle/10986/30102.

421 Federal Democratic Republic of Ethiopia, National Electrification Program 2.0: Integrated Planning for Universal Access (Addis Ababa: Federal Democratic Republic of Ethiopia, 2019), https://minigrids.org/wp-content/uploads/2019/04/Ethiopia-2.0.pdf, xvi.

422 Ethiopia, National Electrification Program 2.0, 45.

Tier Framework Survey and geo-spatial mapping to better understand the baseline of energy access and to optimize the costs and mechanisms for the off-grid program.[423]

- **The Development Bank of Ethiopia (DBE), as a financial intermediary for World Bank funding, manages a US$ 40 million credit line that provides liquidity and access to otherwise limited hard currency for the off-grid sector.** This Market Development Credit Line (MDCL) has provided retail loans with access to foreign currency to private sector enterprises (PSEs) and small and medium sized enterprises (SMEs), allowing them to import quality products to Ethiopia that must be paid for in foreign currency. The MDCL has also offered low-cost wholesale loans to microfinance institutions (MFIs) to provide consumer finance to end users. The MDCL was initially launched in 2012 with US$ 20 million in funding, with an additional US$ 20 million made available in 2017. This second phase included a 75 percent collateral guarantee. Within one year, the second US$ 20 million allocation was oversubscribed, demonstrating the need for working capital and foreign (hard) currency.[424] Through the MDCL, 85,000 solar home systems and 1 million quality-verified lanterns have been distributed in Ethiopia.[425]
- **Ethiopia also enacted Pre- Verification of Conformity (PVoC) regulations to ensure that only quality-verified products enter the market.** This new regulation eliminates sampling of products before shipping, testing fees, and the 0.5 percent deposit based on shipment value, thereby streamlining importation of quality OGS products.[426]
- **The OGS sector can access extensive distribution channels existing in the country.** Cooperatives, local retailers, MFIs, and other financial intermediaries in Ethiopia all offer potential distribution and consumer finance channels that OGS companies can use.[427] Lighting Global has also offered capacity-building programs for entrepreneurs to improve their business models and distribution strategies with the aim to ultimately increase access to off-grid products.[428]
- **The Ethiopian government is exempting quality-verified OGS products from customs duties.** Quality-verified OGS products below 15 Wp are exempt from custom duties. Larger quality-verified systems are subjected only to 15 percent VAT and 3 percent withholding tax.[429] Other imported goods, by contrast, are charged up to 30 percent duty and excise tax of up to 100 percent.

Challenges to overcome

Local content requirements, access to finance, widespread low-quality or counterfeit products, and stringent banking policies present challenges to the success of the OGS sector in Ethiopia.

- **The overall financing need for the OGS sector in Ethiopia is high, but access to finance—particularly foreign exchange—is low.** Under business-as-usual, the NEP 2.0 estimates that US$ 2.5 billion in financing will be required to reach its off-grid goals by 2025, including $ 1.76 billion for working capital, capital expenditures, and operating expenditures alone.[430] Companies seeking to access hard currency must apply to the National Bank of Ethiopia for approval, which is a long process. To alleviate this issue, the DBE has offered loans with access to foreign currency through MDCL, as described above, but all of the capital allocated for the credit line is now committed.

423 Ethiopia, National Electrification Program 2.0, xvi.

424 Ethiopia, National Electrification Program 2.0, 48.

425 Ethiopia, National Electrification Program 2.0, 47.

426 Ethiopia, National Electrification Program 2.0, 46.

427 Ethiopia, National Electrification Program 2.0, xxix; and Lighting Africa, Developing the Solar Supply Chain in Ethiopia (Addis Ababa: Lighting Global, August 2018), https://www.lightingafrica.org/publication/11907/.

428 Lighting Africa, Solar Supply Chain in Ethiopia.

429 Ethiopia, National Electrification Program 2.0, 47.

430 NEP 2.0 estimates that a total of US$ 3.7B is required to meet OGS companies' needs for access to finance, but it expects to achieve efficiencies in the use of access to finance through a revolving fund. Ethiopia, National Electrification Program 2.0, 59–60.

- **Strict local content regulations limit the number of potential players and business models that can deliver off-grid products in Ethiopia—which also reduces affordability for end users.** Only fully locally-owned companies—those that receive no foreign direct investment—are permitted to obtain a license to import or retail solar products in the country.[431] In addition, regulations prohibit local companies from vertically integrating—a company cannot both wholesale and retail products.[432] These regulations limit both entry into the market and access to finance. With vertical integration impossible, more steps are required to deliver products to end users; this results in end user prices with markups of 50 to 200 percent the cost of systems upon importation.[433]
- **Stringent banking regulations on consumer finance and low mobile penetration present significant challenges to implementing the PAYGo model.** Regulations permit only financial institutions to engage in consumer finance, though some platforms, such as Hello Cash, enable mobile payments.[434] Policymakers are considering legislation to permit non-bank entities to issue e-money and use payment agents, but this legislation has not yet been approved. In addition, low mobile money penetration (currently 34.8 percent) hinders PAYGo uptake in Ethiopia.[435]
- **The OGS sector is characterized by a fragmented supply chain which increases the time required for products to reach consumers.** The market is dominated by local players, mostly importers that work with local wholesalers, retailers, and other distribution channels, such as phone companies. There has been little investment to date in specialized supply chains for the sector;[436] as mentioned above, a fragmented supply chain results in more steps in the value chain and higher costs to end users.
- **The widespread presence of counterfeit products has distorted customer perception of OGS products.** Products that are not quality-verified still dominate the market in Ethiopia. Stakeholders, including Lighting Global, have initiated consumer education programs to promote quality-verified OGS products, but this awareness-building will take time to achieve the desired results.

SPOTLIGHT

Bringing Light through Access to Finance

To aid the import of quality-verified off-grid devices, the Ethiopian Government, Lighting Africa, and the World Bank set up a financing facility worth US$ 40 million with the Development Bank of Ethiopia as the financial intermediary. This facility facilitates lending to both private solar companies and MFIs and offers access to often otherwise inaccessible foreign exchange. Through this facility, more than five million people have benefited from the use of quality-verified devices. About 1 million lanterns and 85,000 solar home systems have been imported into the Ethiopian market, with increased awareness of renewable energy products, particularly quality-verified products, and demonstrated interest in solar products that provide higher levels of energy service.[437]

Photo credit: © Lighting Global

431 Investment Proclamation No. 849/2014.

432 Proclamation No. 980/2016, "Commercial Registration & Licensing," http://www.mot.gov.et/by-category/-/asset_publisher/jzCt7vgBnStr/content/-980-2008-?inheritRedirect=false.

433 Ethiopia, National Electrification Program 2.0, 56.

434 Consultations; "HelloCash," BelCash, https://www.belcash.com/helloservices; and GSM Association, State of the Industry Report on Mobile Money 2017 (London: GSM Association, February 26, 2018), https://www.gsma.com/mobilefordevelopment/resources/2017-state-industry-report-mobile-money/.

435 GSM Association, State of Mobile Money, 11.

436 OCA and Vivid Economics cconsultations.

437 Lighting Africa, "Ethiopia: Reaching Out to Rural End-Users," https://www.lightingafrica.org/country/ethiopia/.

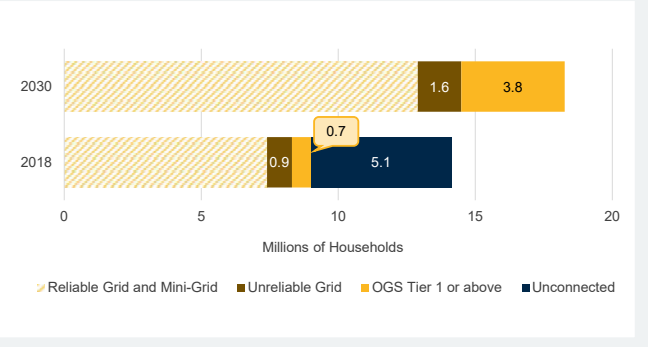
KENYA

Population:	47.6 million people
GDP per capita 2018:	US$ 1,711
Electricity access rate (Tier 1 or higher) 2018:	75 percent
Current penetration of OGS:	69 percent
OGS potential 2030:	3.8 million households (OGS as main source) + 0.4 million (OGS as backup to weak grid)
Status:	Firmly Established

Source: See note (a) in Country Annexes Introduction

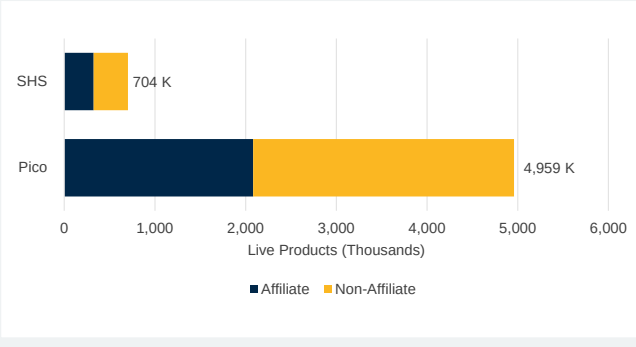
With a vibrant commercial OGS market and relatively high electrification rate compared to its Sub-Saharan Africa peers, Kenya is focusing on electrifying underserved populations to achieve universal electrification. Recognized as one of the global leaders in the OGS sector, Kenya has integrated off-grid solutions into its National Electrification Strategy.[438] Widespread use of mobile money, stable political and economic conditions, relatively high ease of doing business, and government support for the sector have contributed to the country's position as a key market leader.

Primary Source of Electricity in 2018 and 2030 (of 18 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

Strong support by the government and development partners for OGS and a commitment towards quality products indicate that Kenya will continue to be a vibrant hub for the OGS sector.

- **The Kenya Off-Grid Solar Energy Access Project (KOSAP) is a US$ 150 million program targeting increased access in 14 underserved counties.** Using both mini-grids and standalone solar products, KOSAP aims to electrify 1.3 million people in line with Kenya's National Electrification Strategy to achieve universal electrification by 2022.[439] KOSAP utilizes a mix of local-currency debt and results-based financing schemes to engage the private sector. The program also aims to increase electrification of public and community facilities and increase consumer awareness of off-grid products in the target counties.
- **Quality assurance has been a high priority for stakeholders in Kenya, resulting in a large share of quality, affiliate products.** Consumer-awareness programs, business development support for providers of high-quality products, and pre-shipment verification processes have all resulted in one of the highest market shares for affiliate products, at 42

438 World Bank, "Kenya Launches Ambitious Plan to Provide Electricity to All Citizens by 2022," news release, December 6, 2018, https://www.worldbank.org/en/news/press-release/2018/12/06/Kenya-launches-ambitious-plan-to-provide-electricity-to-all-citizens-by-2022.

439 Power Africa, Off-Grid Solar Market Assessment: Kenya (Washington, DC: United States Agency for International Development, October 2019), https://www.usaid.gov/powerafrica/beyondthegrid/off-grid-solar-assessment/kenya.

percent of the total market.[440] The Kenya Bureau of Standards (KEBS), the government agency responsible for ensuring compliance with international quality standards, adopted the International Electrotechnical Commission (IEC) standards aligned with the Lighting Global Quality Assurance Framework.[441] With more than 5.6 million OGS products distributed in the country to date, Kenya is one of the most developed OGS markets in the world.[442]

- **PAYGo is a significant driver of OGS sales in Kenya, a trend that is expected to continue for newer product segments, larger appliances, and productive use devices.** Kenya alone had 31 percent of all globally reported PAYGo sales in 2018, with the business model built on strong mobile money penetration and a supportive enabling environment for the sector. Kenya also represented 43 percent of global PAYGo appliance sales in H2 2018.[443] The country offers a good testing ground for new products, such as solar water pumps, as consumer awareness and mobile money penetration are high.

Challenges to overcome

- **Like other established off-grid markets, sales have been concentrated in more densely populated and relatively wealthy areas.** The key challenge to achieving universal energy access will be to provide electricity to remote and low-income consumers who may not be reachable by usual commercial means. Interventions that reduce prices for end consumers are critical in addressing this challenge but will need to be carefully designed to avoid market distortion.
- **Potential regulation aimed at consumer and environmental protection could present challenges to OGS players in Kenya, including the Draft National E-Waste Management Strategy, the Data Protection Bill, and the Draft Financial Markets Conduct Bill.** The E-Waste Management Strategy places the responsibility for managing e-waste on producers, which would increase costs, though it could present a market opportunity for new entrants that specialize in addressing e-waste. The Data Protection Bill prohibits the transfer and storage of customer data outside of the country, unless those foreign countries have similar legislation protecting consumer data. This poses a potential problem for the many OGS players in Kenya that operate in multiple countries worldwide. Finally, the Draft Financial Markets Conduct Bill would require licenses for companies providing financial services or products, which would create additional regulatory requirements for off-grid companies currently offering such products.[444]

SPOTLIGHT

Accreditation of the University of Nairobi Lighting Laboratory for Pico Product Quality Testing

In May 2018, the University of Nairobi Lighting Laboratory received International Organization for Standardization (ISO) accreditation to quality-test pico solar products rated up to 10 Wp—the first lab of its kind in Sub-Saharan Africa. As of mid-2018, the lab has already tested more than 100 pico products. One of only five facilities with this accreditation around the world, and the first in Africa, the lab is well situated to help expand the market share of quality products in East Africa.[445] We expect this initiative to significantly increase protection for both consumers and businesses competing in the sector across East Africa.

Photo credit: © SunCulture

440 OCA and Vivid Economics analysis.

441 Power Africa, Market Assessment Kenya; OCA and Vivid Economics consultations.

442 OCA and Vivid Economics consultations.

443 GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H2 2018 (Utrecht: GOGLA, May 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h2-2018-sales-and-impact-data.

444 Power Africa, Market Assessment Kenya.

445 Lighting Global, "University of Nairobi Lighting Laboratory Becomes First Accredited Off-Grid Lighting Test Lab in Africa," news release, May 25, 2018, https://www.lightingglobal.org/news/uon-ll-accreditation/.

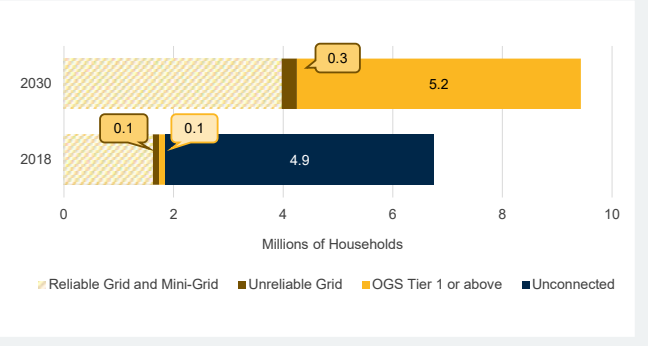
MOZAMBIQUE

Population:	29.5 million people
GDP per capita 2018:	US$ 499
Electricity access rate (Tier 1 or higher) 2018:	31 percent
Current penetration of OGS:	3 percent
OGS potential 2030:	5.2 million households (OGS as main source) + 0.1 million (OGS as backup to weak grid)
Status:	Pioneering

Source: See note (a) in Country Annexes Introduction

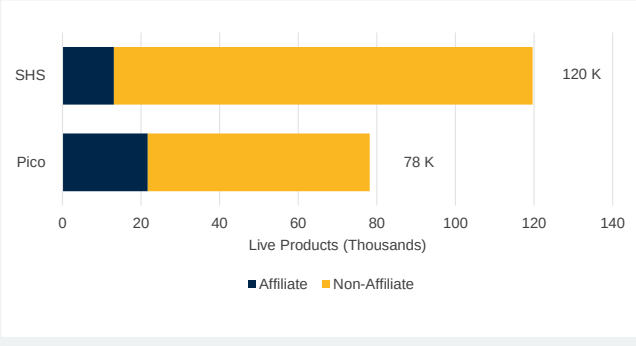
With only 31 percent of households having Tier 1 electricity access, Mozambique offers a large potential OGS market as the government strives towards universal electrification.[446] Development partners, NGOs, and government electrification programs have historically supported the OGS sector. The Energy Fund (Fundo de Energia, FUNAE), a public entity, has in the past promoted the use of low-cost energy solutions and recently transitioned to the implementation of most off-grid access projects. The Mozambican government is committed to achieving universal electricity access. Significant resources and development partner support will be required to create an conducive environment for OGS companies, including regulatory reforms, increased access to finance, improved consumer ability to pay, capacity-building, and market research.

Primary Source of Electricity in 2018 and 2030 (of 9 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

Government and development partner initiatives and programs are jump-starting the OGS sector, and there is demand for OGS products in the market.

- **The government, working with the World Bank, launched a National Electrification Strategy in 2018, with the National Energy Fund (FUNAE) taking the lead on off-grid projects.** Under this strategy, off-grid electricity will provide 30 percent of the country's electricity by 2030.[447]
- **At least eight development partners are active in the country.** An estimated US$ 60 to 70 million is being deployed over a five-year period to jump-start the OGS sector in the country.[448] For example, the GIZ-managed

446 World Bank, Mozambique Energy for All (ProEnergia) P165453, Project Appraisal Document (Washington, DC: World Bank, 2019), http://documents.worldbank.org/curated/en/594061554084119829/pdf/Mozambique-Energy-for-All-ProEnergia-Project.pdf.

447 World Bank, Mozambique Energy for All.

448 World Bank, "Power Efficiency and Reliability Improvement Project (PERIP) and Mozambique Energy for All Project (ProEnergia): Aide Memoire," 2019.

Energising Development (ENDEV) program is a results-based financing facility for companies supplying Lighting Global quality-verified products.[449]

- **As mobile-money penetration increases, OGS companies can increase PAYGo sales.** Mozambique allows non-bank entities to provide mobile money services, which is a positive opportunity for the sector to address the affordability gap and develop rapidly in the country. So far, Solar Works!, Epsilon, and Fenix International are utilizing the PAYGo business model in the country.[450]
- **Off-grid companies may benefit from partnering with existing players to quickly penetrate the market.** Mobile phone operators, retail store chains, and petrol stations have established distribution networks and could provide OGS companies with established distribution channels.[451]

Challenges to overcome

Mozambique faces numerous challenges for the OGS sector to grow, including an underdeveloped economy, high taxes, poor access to capital, low consumer awareness, and lack of skilled labor.

- **Underdeveloped infrastructure, low population density, and high poverty pose significant challenges for companies operating in Mozambique.** Poor infrastructure and low population density (38 people per sq. km)[452] raise last-mile distribution challenges. Furthermore, hindering affordability, around 46 percent of the population lives under the poverty line and most households also do not have a steady source of income.[453] Initiatives such as results-based financing may be required to attract private-sector players and redirect electrification efforts to poorer segments of the population.
- **High interest rates, restrictive collateral requirements, and short tenure of debt from local financial institutions severely limit access to working capital financing.** The MFI sector is also nascent, which further limits availability of capital.[454]
- **High taxation makes off-grid products relatively expensive in Mozambique.** OGS products attract 17 percent VAT and between 7.5 and 20 percent import duties, which in total could add 30-40 percent to the total cost of installation.[455] In addition to these high tax rates, companies report import duties are applied inconsistently at port of entry.
- **Poor-quality solar products dominate the Mozambican market, resulting in negative consumer perceptions of OGS quality and price.** Consumers also do not fully understand the cost-saving benefits of switching to OGS solutions from traditional lighting solutions such as fuel and candles.[456]
- **Limited human capital also presents a challenge for off-grid companies looking to grow in Mozambique.** There is a shortage of skilled labor, particularly for management and technicians to install and maintain OGS products.[457]

449 Economic Consulting Associates (ECA) and GreenLight, Off-Grid Solar Market Assessment in Mozambique (Washington, DC: World Bank, December 2018), https://www.lightingafrica.org/wp-content/uploads/2019/07/Mozambique_off-grid-assessment.pdf.

450 World Bank, Mozambique Energy for All; and Power Efficiency and Reliability Improvement Project (PERIP) and Mozambique Energy for All Project (ProEnergia), Implementation Review and Identification Mission (Washington, DC: World Bank, 2019).

451 ECA and Greenlight, Solar Market in Mozambique.

452 World Bank, DataBank, s.v. "Population Density," https://data.worldbank.org/indicator/EN.POP.DNST.

453 "Mozambique," in The World Factbook (Langley, VA: Central Intelligence Agency, February 2020), https://www.cia.gov/library/publications/the-world-factbook/geos/mz.html; and ECA and Greenlight, Solar Market in Mozambique.

454 Pranab Baruah and Brendan Coleman, Off-Grid Solar Power in Mozambique: Opportunities for Universal Energy Access and Barriers to Private Sector Participation (Seoul: Global Green Growth Institute, March 2017), http://www.aler-renovaveis.org/contents/lerpublication/the-global-green-growth-institute_2019_feb_country-brief-mozambique.pdf.

455 Baruah and Coleman, Off-Grid Solar in Mozambique.

456 OCA and Vivid Economics consultations.

457 OCA and Vivid Economics consultations.

- **A consequence of the above challenges is that very few private-sector companies are operating in the country, impairing the ability of development partner programs to deploy capital.** For example, the BCI credit line (a US$ 16 million facility funded by KfW) failed to meet its mandate to provide loans to OGS companies as a result of a lack of bankable projects.[458]

SPOTLIGHT

Stimulating the Market through Development Partner Funding

In 2019, SNV was awarded the contract to provide services for DFID's five-year BRILHO program, a GBP 23 million project that aims to increase energy access in Mozambique by building a market for OGS companies to operate sustainably. Such companies should ultimately be able to raise funding on their own as a result of the program's intervention. The program also aims to support logistics providers, mobile money providers, and the government with technical-assistance facilities to build capacity on various aspects of working with OGS companies.[459]

Photo credit: © SolarWorks!

458 ECA and Greenlight, Solar Market in Mozambique.

459 DFID, "DFID 8210 BRILHO: Energy Africa Mozambique Contract Award," May 15, 2019, https://www.contractsfinder.service.gov.uk/Notice/c144243d-6d65-46a2-aa17-869bf4437e9e.

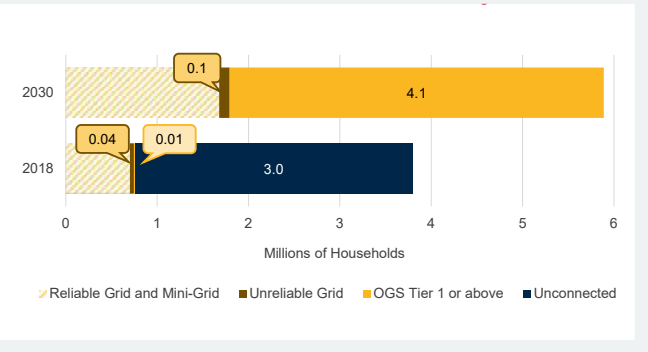
NIGER

Population:	22.4 million people
GDP per capita 2018:	US$ 414
Electricity access rate (Tier 1 or higher) 2018:	20 percent
Current penetration of OGS:	2 percent
OGS potential 2030:	4.1 million households (OGS as main source) + 30,000 (OGS as backup to weak grid)
Status:	Pioneering

Source: See note (a) in Country Annexes Introduction

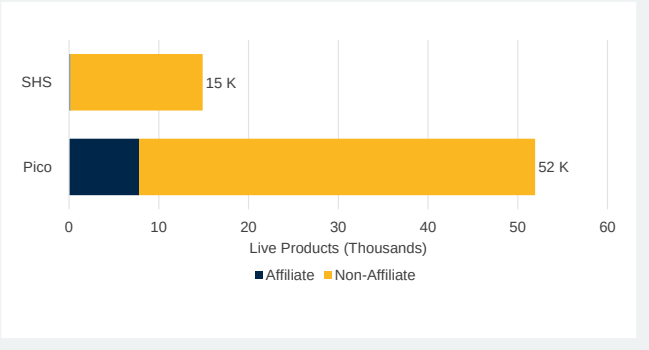
Niger has high OGS market potential despite low population desnsity because its population has very limited grid access. Given low grid connectivity, the potential market for off-grid products comprises more than four million households. The government has shown willingness to enable growth of the OGS sector by creating a National Electrification Strategy (NES) that incorporates OGS. Following the NES, the government plans to provide energy access to 60 percent of the population by 2027 and universal access by 2035.[460] To promote OGS sector growth, the government has eliminated customs duties for quality-verified OGS products. Meanwhile, the Niger Solar Electricity Project (NESAP) is extending a line of credit to private-sector OGS companies to improve access to finance, and is conducting consumer-awareness campaigns on the benefits of quality products. Key challenges that stakeholders in the country must address include affordability and low mobile-money penetration, which has hindered adoption of the Pay-As-You-Go (PAYGo) business model.

Primary Source of Electricity in 2018 and 2030 (of 6 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

Strong support by governments and development partners for OGS provides a positive outlook for the market in Niger.

- **OGS is part of Niger's National Electrification Plan, and the government has implemented initiatives such as tax exemptions to spur sector growth.** Responding to lobbying from various stakeholders, Lighting Global quality-verified products are exempt from import taxes. This should reduce import duties from 52 percent to about 10 percent,[461] increasing distributors' ability to hold stock, improving end-user affordability, and increasing the availability of quality products in the market.

460 Power Africa Off-Grid Project, Off-Grid Solar Market Assessment: Niger (Washington, DC: United States Agency for International Development, October 2019), https://www.usaid.gov/sites/default/files/documents/1860/PAOP-Niger-MarketAssessment-Final_508.pdf.

461 Open Capital Advisors and Vivid Economics consultations.

- **The World Bank-sponsored NESAP and Regional Off-Grid Electrification Project (ROGEP) are in place to help increase the provision of OGS products to both households and the public sector.** These programs provide technical assistance to the private sector, a line of credit for companies and end-consumers, as well as consumer awareness and sensitization programs. ROGEP is also piloting a new public–private partnership model to increase private-sector participation in the provision of OGS for public institutions.
- **To address the affordability gap, companies have started to experiment with PAYGo.** Until now, most OGS products have been sold for cash. While recently – and only in the early stages – international players and local distributors have now introduced the PAYGo model to increase affordability and increase product offerings for customers.

Challenges to overcome

Low consumer purchasing power and awareness, lack of technical skills, and limited access to finance are limiting the uptake of OGS products in Niger.

- **Niger faces particularly high affordability challenges because the population has exceptionally low purchasing power.** As of 2018, Niger's GDP per capita was US$ 414, the fourth-lowest globally that year.[462] Furthermore, low financial literacy further limits accessibility for consumers.
- **Low mobile phone coverage and mobile-money penetration are challenges for launching PAYGo operations.** The mobile phone penetration of unique subscribers is 26 percent, while only 3 percent of Nigeriens have active mobile money accounts.[463] Despite this, companies such as Oolu Solar and Benalya have recently launched PAYGo in the country.
- **Cheaper, low-quality, and counterfeit products have flooded the market, significantly reducing the demand for quality-verified OGS products.** Low-quality and counterfeit products are cheaper in a highly price inelastic market, and awareness is very low of the long-term benefits offered by quality-verified OGS products. As the World Bank–sponsored NESAP's awareness and sensitization activities only started in November 2019, its impact cannot yet be measured. Significant resources will continue to be required to improve consumer awareness in Niger.
- **Besides a lack of accessible finance, there are few companies with which financiers can work.** Companies are unable to access local financing given high interest rates and stringent collateral requirements. However, demand also remains low for finance. For instance, the World Bank extended a US$ 7 million credit line in 2018 to local financial institutions to address the finance gap, with only limited success because so few OGS companies are operating in Niger.[464] To address this gap, the World Bank is reducing the interest rate offered, increasing guarantees to borrowers, and providing technical assistance to financial institutions so they can better understand the risks of the OGS sector. These changes are expected to increase lending and access to finance for OGS companies entering the market.
- **Despite recognizing the potential of OGS and willingness to support the sector, the government currently lacks technical capacity in market development.[465]** Capacity-building will be required to ensure effective enforcement across all OGS programs. Although NESAP has accelerated activity, much more can be done to promote the sector. The creation of a multi-stakeholder platform where all off-grid stakeholders could meet regularly, for example, could much improve coordination in the sector.

462 World Bank, DataBank, s.v. "GDP per capita (current US$) – Niger," https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=NE.

463 GSM Association, The Mobile Economy: Sub-Saharan Africa 2017 (London: GSM Association, 2017), https://www.gsmaintelligence.com/research/?file=7bf3592e6d750144e58d9dcfac6adfab&download; and Open Capital Advisors, Off-Grid Solar Market Assessment in Niger & Design of Market-Based Solutions (Nairobi: Lighting Africa, December 2017), https://www.lightingafrica.org/publication/off-grid-solar-market-assessment-niger-design-market-based-solutions/.

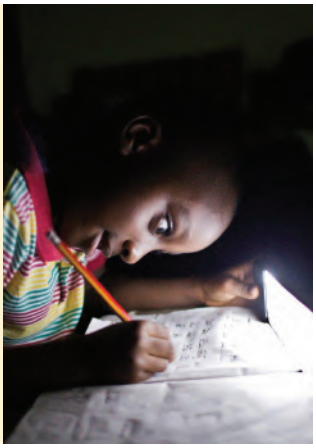
464 Open Capital Advisors and Vivid Economics consultations.

465 Open Capital Advisors and Vivid Economics consultations.

SPOTLIGHT

Supporting Financial Inclusion through PAYGo in Niger

Affordability is a key factor hindering large-scale uptake of renewable energy products for underserved populations in Niger. PAYGo technology can help foster financial inclusion in the country by enabling companies and financial institutions to finance energy access. While mobile phone ownership in Niger is currently at 26 percent of the population, only 3 percent of mobile users have an active mobile money account. Further, only 16 percent of the population has an account at a financial institution, which limits opportunities for consumer financing. Companies such as Oolu and Benalya launched PAYGo-enabled products in 2019, helping Nigerien consumers sign up for and actively use mobile money, thereby enabling them not only to access off-grid products but also to build financial track.



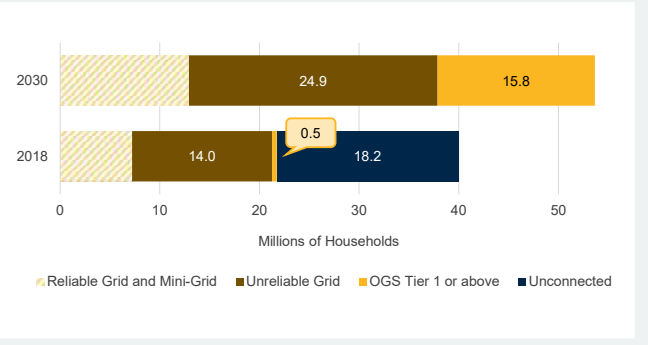
NIGERIA

Population:	195.9 million people
GDP per capita 2018:	US$ 2,028
Electricity access rate (Tier 1 or higher) 2018:	54 percent
Current penetration of OGS:	5 percent
OGS potential 2030:	15.8 million households (OGS as main source) + 6.2 million (OGS as backup to weak grid)
Status:	High growth prospect

Source: See note (a) in Country Annexes Introduction

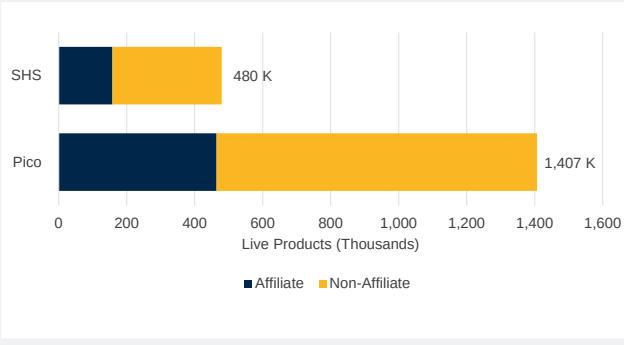
Nigeria seeks to achieve universal electrification by 2030 through a mix of on- and off-grid solutions with the support of development partners and private-sector capital. Nigeria currently has a 54 percent electrification rate, and comprises a large potential market for OGS, with around 93 million people lacking access to electricity. Moreover, OGS companies can also provide larger, backup solar systems for the large segment of population connected to an unreliable grid. The Government of Nigeria is also supporting the OGS sector by prioritizing off-grid solutions as part of the country's overall power sector recovery plan, as outlined by the Off-Grid Electrification Strategy developed by the Nigerian Rural Electrification Agency (REA).[466] Several challenges around access to local currency financing, foreign-exchange risk, and high taxation of OGS products must be addressed to ensure the growth of the OGS market.

Primary Source of Electricity in 2018 and 2030 (of 54 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Millions)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

Continued strong support from government and development partners will be critical to attract additional private-sector partners to serve the large unelectrified population.

- **The Nigeria Electrification Project (NEP) is the country's flagship project implementing the government's Rural Electrification Strategy Implementation Plan (RESIP).** The project's off-grid component (with a value of about US$ 350 million) includes both competitively awarded grants and results-based financing (RBF) to encourage private-sector participation specifically for providers of high-quality systems.[467] The RBF scheme is tiered based on system size and is targeting approximately one million systems over five years.[468]

466 Rural Electrification Agency (REA), World Bank, and Rocky Mountain Institute, The Off-Grid Opportunity in Nigeria (Abuja: REA, December 2017), https://www.esmap.org/sites/default/files/Presentations/REA_Damilola-Off-Grid%20Opportunity_03122017_web.pdf.

467 "Nigeria: A Program Designed to Impact 6 Million People," Lighting Africa, https://www.lightingafrica.org/country/nigeria/.

468 Open Capital Advisors and Vivid Economics consultations.

- **Recent adoption of International Electrotechnical Commission (IEC) standards for OGS products by the Standards Organization of Nigeria (SON) demonstrates the government's desire to support the sector's growth.** In partnership with Lighting Africa, SON seeks to halt the import and trade of substandard OGS products into Nigeria, which will improve the uptake of quality-verified products.[469]
- **Nigeria also benefits from several programs aimed at enabling broader energy access.** These programs include the Nigeria Off-Grid Market Accelerator Program (NoMAP), the World Bank-funded Regional Off-Grid Electrification Project (ROGEP), the Africa Clean Energy Technical Assistance Facility (ACE-TAF), USAID's Nigeria Power Sector Program (NPSP), and the Nigerian Energy Support Program II (NESP II). These programs are catalyzing the market by conducting market assessment studies, supporting startups, mitigating investor risk, providing technical assistance, and enabling consumer awareness.
- **OGS products as backup solutions to the grid have significant potential in Nigeria.** To address the unreliable grid market, several international off-grid energy companies have either developed or are testing off-grid systems with AC inverters that compete with diesel-powered generators. Demand for larger, higher-value solutions for unreliable grid applications is high in Nigeria, presenting a potentially lucrative market for OGS providers.

Challenges to overcome

Macroeconomic challenges, such as foreign-exchange risk and high taxes, pose significant barriers to OGS expansion in Nigeria. In addition, stringent conditions limit companies' ability to raise local currency debt.

- **In 2018/19, KPMG rated foreign-exchange risk the top business risk in Nigeria.** This risk includes volatile exchange rates and limited access to hard currency from local sources as a result of capital controls.[470] This could limit external investment into OGS companies operating in Nigeria unless regulations improve.
- **Companies struggle to access local currency debt in Nigeria because of high interest rates and rigid collateral requirements.** Development partners and the government will need to work closely with local banks to sensitize and de-risk loans to OGS companies. Access to local currency financing is particularly critical in Nigeria because access to hard currency financing in limited.
- **Nigeria charges a total of 25 percent in taxes (including sales and import tax) on OGS products.** This greatly impacts the OGS sector, increasing the price of off-grid products and making them less affordable for end users.[471]
- **Nigeria has lagged behind many other countries in terms of financial inclusion, of which mobile money is a key enabler.** Bank penetration is relatively low, with about 60 percent of the population unbanked. Uptake and awareness of mobile money and agency banking services remain low at 1 and 16 percent, respectively. This limits financing options for end consumers wanting to access OGS products. Mobile money regulations were, however, recently relaxed; operators are now allowed to provide mobile money services. As mobile money penetration increases, it will become easier for OGS companies to provide PAYGo services, which could accelerate OGS penetration.[472]

469 Standards Organisation of Nigeria, "Nigeria Adopt Standards for Renewable Energy, Hybrid Systems for Rural Electrification," news release, January 1, 2020, https://son.gov.ng/nigeria-adopt-standards-for-renewable-energy-hybrid-systems-for-rural-electrification.

470 Tomi Adepoju, "Top 10 Business Risks in 2018/2019," KPMG Nigeria Insights, April 19, 2018, https://home.kpmg/ng/en/home/insights/2018/04/top-10-business-risks-in-2018.html.

471 GOGLA, "Nigeria," country brief, https://www.gogla.org/sites/default/files/resource_docs/nigeria_country_brief.pdf.

472 Kanika Saigal, "Regulators Give Mobile Money in Nigeria a Boost," Euromoney, January 10, 2019, https://www.euromoney.com/article/b1cmtgtzyrglb9/regulators-give-mobile-money-in-nigeria-a-boost.

SPOTLIGHT

Accelerating Energy Access through Innovative Payment Methods

Nigeria has very low mobile money penetration (around 1 percent), which makes the PAYGo model a challenge. NoMAP is piloting an innovative payment method using a network of tens of thousands of collection agents across the country to aggregate payments as an alternative to mobile money. This platform, run by an agent banking company known as SWIFTA, seeks to enable companies to access last-mile customers. Additionally, SWIFTA, in partnership with Lighting Africa, seeks to create awareness for quality-verified solar products, build capacity, and generate demand for its agents. So far, five OGS companies have fully integrated onto this platform, which is showing significant promise to accelerate access to finance for end consumers.

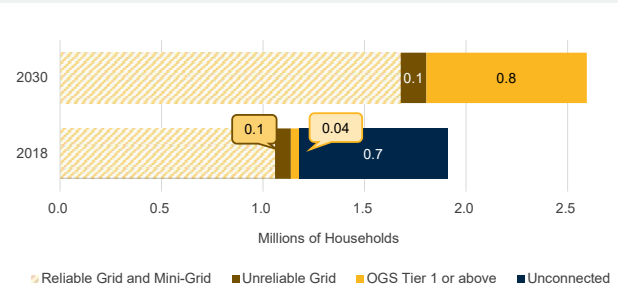
RWANDA

Population:	12.3 million people
GDP per capita 2018:	US$ 773
Electricity access rate (Tier 1 or higher) 2018:	25 percent
Current penetration of OGS:	17 percent
OGS potential 2030:	2 million households (OGS as main source) + 0.1 million (OGS as backup to weak grid)
Status:	Firmly established

Source: See note (a) in Country Annexes Introduction

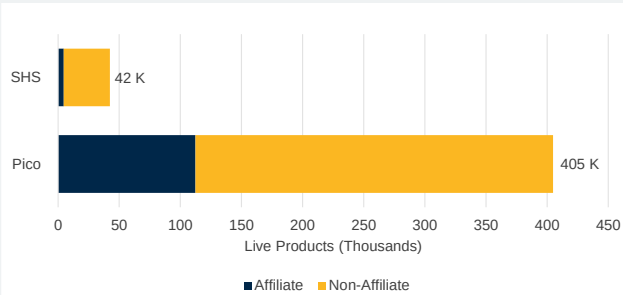
The OGS sector has a strong presence in Rwanda, with the government supporting the sector through favorable policies, including strict enforcement of quality standards. The government affirmed its interest in OGS in its most recent National Electrification Plan, with a goal of 48 percent electrification through off-grid solutions by 2024.[473] Currently, affiliate companies control most of the market due to strict enforcement of quality standards. At 38.5 percent grid penetration, Rwanda offers an OGS market with significant potential for scale.[474] A stable political climate and keen government interest in growing the sector will continue to promote the success of the sector.

Primary Source of Electricity in 2018 and 2030 (of 3 Million Total Households in (2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

The government has laid a foundation for the OGS sector to grow by creating financing mechanisms, enforcing quality standards, and establishing an enabling policy framework.[475]

- **Through the US$ 50 million World Bank–funded Renewable Energy Fund (REF), local currency loans are available to facilitate private-sector participation in renewable off-grid electrification in Rwanda.** The REF, implemented by the Rwanda Development Bank (BRD), provides a local currency line of credit directly to companies to help address constraints to OGS sector growth around access to finance and affordability. The REF will also extend lines of credit to local financial institutions and existing savings and credit societies (SACCOs) to make sub-loans to households and small businesses to promote OGS electrification.
- **Development partner programs, such as GIZ's Energizing Development (EnDev), have also developed a result-based financing (RBF) scheme with end-user price subsidies.** The RBF program is structured to lower prices for low-

473 Rwanda Energy Group, "Off Grid Electricity Access Expansion Programs in Rwanda," presentation to the 5th Mini Grids Action Learning Event: Reaching Universal Energy Access in Ghana by 2020, June 24–28, 2019, https://atainsights.com/wp-content/uploads/2019/06/9.-Uwera-Rwanda-Energy-Group.pdf.

474 "Access," Rwanda Energy Group, http://www.reg.rw/what-we-do/access/; and Ministry of Infrastructure (MININFRA), Energy Sector, Backward Looking Joint Sector Review Report for FY 2018/19 (Kigali: MININFRA, October 2019), http://www.minecofin.gov.rw/fileadmin/templates/documents/NDPR/Joint_Sector_Review/Backward_Looking_JSRs/2018-19_Backward_Looking_JSRs/ENERGY.pdf.

475 Rwanda Energy Group, "Off Grid Access Expansion."

income households and aims to provide off-grid energy access to 1.2 million households by 2024.[476] Robust demographic data are available through Rwanda's Ubudehe system that categorizes households into different categories of poverty levels, which helps concessional finance programs like EnDev's Pro Poor RBF better target relevant population segments.

- **The Rwandan market has not been saturated by low-performing products or counterfeits because the government strictly enforces quality standards.** The Rwandan market is receptive to high-quality products. To further promote sales of quality products and protect consumers from early product failure, the government is extending product warranties to two to three years and requiring a minimum of five years of after-sales services from solar distributors (varies depending on product energy access Tier classification).[477]
- **The government has built a credible reputation of following through with plans, which helps build investor confidence.** For example, solar companies operating in Rwanda have enjoyed tax exemptions on solar energy equipment and appliances since 2015. The government has on occasion, however, made swift changes to market requirements. Continued consultation with the private sector will be necessary to ensure that the private sector is supported as Rwanda aims to meet its electrification goals.

Challenges to overcome

The main challenges in Rwanda relate to the uniform enforcement of quality standards, as well as affordability.

- **The Rwanda Standards Board must work closely with other government agencies to ensure uniform enforcement of the new quality standards.** Customs officials in particular will require additional training to ensure uniform enforcement of the new standards at ports of entry. Clarity on policies and uniformity in verifying imported OGS products will be essential to boosting investor confidence.[478]
- **Affordability presents a challenge for private companies to reach off-grid customers.** Whereas private-sector interest was very high initially, interest has since waned partially because the remaining customer base has relatively low affordability. GDP per capita in Rwanda was US$ 773 in 2018, the sixth lowest of the countries profiled in this report. Affordability constraints are further exacerbated by the new Minimum Standards for SHS that reduce access to lower-cost systems. Development partners and the government are working to address this challenge by providing additional financing through the REF and RBF schemes.

SPOTLIGHT

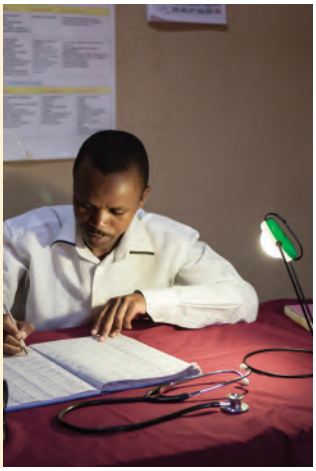
Photo credit: © Mobisol

Increasing Quality-Verified Products in the Rwandan Market Using RBFs —ProPoor Rwanda

Launched in 2019, the EnDev Pro Poor RBF uses a market-based approach to provide access to low-income Ubudehe 1, 2, and 3 households. The RBF program provides an incentive to solar companies for every solar product sold in eligible districts, thus lowering the price for end users.

Pro Poor RBF is open to any solar company as long as the companies' products meet the Minimum Standards set by the Ministry of Infrastructure (MININFRA) and enforced by the Rwanda Standards Board. Companies must also offer a minimum three-year product warranty. Subsequently, end users can access any solar product based on their willingness to pay and eligibility for the Pro Poor program.

The program is currently running in five districts: Ruhango, Gisagara, Nyanza, Nyamagabe and Huye.[479]



476 Rwanda Energy Group, "Off Grid Access Expansion."

477 Tier 0 products have at least one year of warranty, Tier 1 products have a minimum two years of warranty, and Tier 2 and above have a minimum of three years of warranty. Regardless of Tier, all OGS product should offer an after-sales provision for a minimum of five years after the installation of the system. MININFRA, Ministerial Guidelines on Minimum Standards Requirements for Solar Home Systems (Kigali: MININFRA, August 2018), http://www.reg.rw/fileadmin/user_upload/MINSITERIAL_GUIDELINES_On_Minimum_Standards_Requirements_for_Solar_Home_Systems-August_2018.pdf.

478 Overseas Development Institute (ODI), GOGLA, SolarAid, and Practical Action, Off-Grid Solar Country Briefing: Rwanda (London: ODI, January 2016), https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/10253.pdf.

479 Government of Rwanda, "Community-Led Ubudehe Categorisation Kicks Off," news release, February 3, 2015, http://www.gov.rw/news_detail/?tx_ttnews%5Btt_news%5D=1054&cHash=a315a8b0054e76f9c699f05ce24d3eb8; Energising Development, "Call for Applications: Pro Poor Results-Based Financing (RBF) Rwanda," December 2, 2019, https://endev.info/content/Call_for_Applications:_Pro_Poor_Results-Based_Financing_(RBF)_Rwanda; and Open Capital Advisors and Vivid Economics consultations.

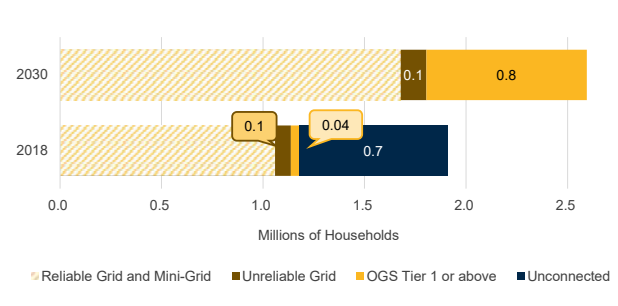
SENEGAL

Population:	15.8 million people
GDP per capita 2018:	US$ 1,522
Electricity access rate (Tier 1 or higher) 2018:	62 percent
Current penetration of OGS:	41 percent
OGS potential 2030:	0.8 million households (OGS as main source) + 30,000 (OGS as backup to weak grid)
Status:	Pioneering

Source: See note (a) in Country Annexes Introduction

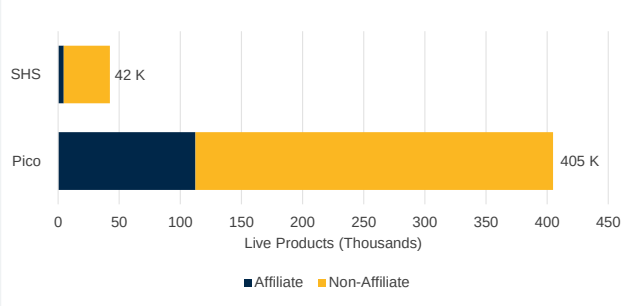
Senegal is a leading OGS market in West Africa but remains relatively nascent. A large unelectrified rural population offers a strong potential market for OGS. The National Rural Electrification Program (PNER) documents Senegal's primary electrification strategy, which aims to achieve 100 percent and 90 percent access in urban and rural areas, respectively, by 2025.[480] The strategy is being implemented by three entities: (1) Senelec, the national utility; (2) the Priority Rural Electrification Program (PPER), a private concessions scheme; and (3) Local Rural Electrification Initiatives (ERILs). ERILs provide off-grid solutions in regions not covered by the grid through both mini-grids and solar home systems (SHS). Under this model, SHS are intended to cover 3.3 percent of villages with low population density.[481] Since only 35 percent of the rural population has access to electricity, OGS will be a critical enabler of the country's electrification goals. Key challenges include high taxes, lack of access to finance, and outdated quality standards.

Primary Source of Electricity in 2018 and 2030 (of 3 Million Total Households in (2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

Government support for OGS, large customer demand, and strong partnerships with microfinance institutions (MFIs) will drive further penetration of OGS companies in Senegal.

- **In addition to the government's intention to integrate OGS into its national electrification strategy, Senegal is part of the over US$ 200 million West African Regional Off-Grid Electrification Project (ROGEP).** This World Bank–funded project promotes the uptake of pico products, SHS, solar water pumps, and solar agro-processing appliances in the ECOWAS (Economic Community of West African States) market, as well as providing technical assistance and market intelligence to the private sector and governments. The program also provides debt and grant funding to OGS companies.[482]

480 Power Africa Off-Grid Project, Off-Grid Solar Market Assessment: Senegal (Washington, DC: United States Agency for International Development, October 2019), https://www.usaid.gov/sites/default/files/documents/1860/PAOP-Senegal-MarketAssessment-Final_508.pdf.

481 Power Africa Off-Grid Project, Market Assessment Senegal.

482 ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE), "ROGEP: Regional Off-grid Electrification Project," http://www.ecreee.org/page/rogep-regional-off-grid-electrification-project.

- **Several other development partner programs also support the OGS sector in Senegal.** GIZ's Being Successful in Senegal promotes job creation by OGS companies in rural areas.[483] The Millennium Challenge Corporation (MCC) Power Compact is a US$ 550 million, energy-focused fund that will include OGS solutions for rural and peri-urban areas in the country.[484] GIZ's Energising Development Program (EnDev) also launched a project in 2019 to promote SHS distribution through local youth associations.[485]
- **Demand is growing for aspirational products, with televisions a popular appliance.** The annualized market opportunity for OGS products in Senegal is an estimated US$ 74.5 million, with PULSE comprising US$ 52 million.[486] Increasing demand for these products is attractive to OGS companies, as they often carry higher margins.
- **A key success factor for OGS companies in Senegal has been strong partnerships with MFIs.** A few major OGS companies have links with MFIs, ranging from partnerships to wholly owned subsidiaries (e.g., Baobab+). As sales unit volume in Senegal is still dominated by the cash-and-carry sales models, like many Asian markets, MFIs primarily provide financing options to customers looking to purchase larger systems.[487] These partnerships address a key challenge of customer ability to pay and will likely continue to be a key success factor given the relatively low mobile-money penetration.

Challenges to overcome

While the Senegalese government is working to address two key challenges in the market—high taxes and lack of updated quality standards—greater support will be required to address access to finance.

- **Import duties and VAT increase the overall cost of OGS products to consumers by around 40 percent.**[488] Import duties are applied at different rates to different component parts and appliances, making pricing a challenge for companies. Furthermore, because VAT is applied to goods after other duties and fees, it has a significant multiplier effect on the end-user cost.
- **Senegal has outdated quality standards (from 1993) for importing OGS products, and they are currently not enforced.** Senegal is soon expected to effect standards harmonized with Lighting Global Quality Standards.
- **Early-stage companies in Senegal report having difficulties accessing equity, with most investors tied up in East African markets.** However, they can access debt through specialist debt providers (e.g., SunFunder) and crowdfunding platforms (e.g., Lendahand).

SPOTLIGHT

Photo credit: © Solar Aid, Kat Harrison

MFIs Enter the OGS Sector

Baobab+ was launched in late 2015 as a subsidiary of Baobab Group, formerly known as Microcred Group, to provide non-financial energy products to the African market. Baobab+ has marketed, distributed, and financed solar products to Baobab Group's 300,000 existing clients. To date, the company has sold more than 150,000 PAYGo SHS.

Baobab Group ran a pilot in mid-2018 to explore extending 90-day unsecured credit to its PAYGo customers through the existing Taka loan product of its parent company, Baobab Group. Of 359 scored and eligible Baobab+ customers, 166 expressed interest in the Taka loan. Based on the success of this pilot, we expect a large share of Baobab+ customers could benefit from end-user financing to purchase OGS products.

483 GIZ, "New Prospects for the Future and for Remaining in Senegal," https://www.giz.de/en/worldwide/68202.html.
484 Millennium Challenge Corporation, "Senegal Power Compact," December 2018, https://www.mcc.gov/where-we-work/program/senegal-power-compact.
485 Power Africa Off-Grid Project, Market Assessment Senegal.
486 GOGLA, "Senegal," country brief, https://www.gogla.org/sites/default/files/resource_docs/senegal_country_brief.pdf.
487 Power Africa Off-Grid Project, Market Assessment Senegal.
488 Power Africa Off-Grid Project, Market Assessment Senegal.

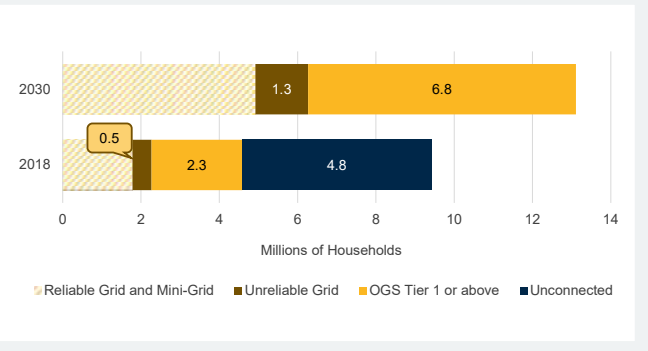
UGANDA

Population:	42.7 million people
GDP per capita 2018:	US$ 643
Electricity access rate (Tier 1 or higher) 2018:	41 percent
Current penetration of OGS:	40 percent
OGS potential 2030:	6.8 million households (OGS as main source) + 0.3 million (OGS as backup to weak grid)
Status:	Firmly Established

Source: See note (a) in Country Annexes Introduction

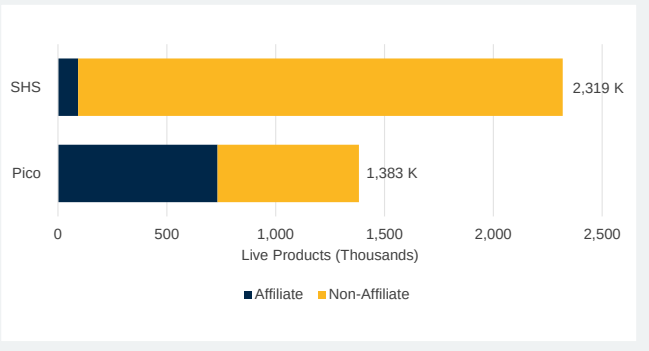
The OGS sector in Uganda has strong private-sector participation enabled by development partner programs and engaged ecosystem players, accelerating the uptake of OGS products. To protect consumers, the Uganda National Bureau of Standards (UNBS), with Lighting Global's support, will lead the process to adopt the Quality Assurance framework as a national standard for component-based systems, which account for a large share of the OGS products in the Ugandan market.[489] The Ugandan government is currently developing a National Electrification Strategy (NES), to be completed by June 2020, aimed at increasing universal access to electricity by 2030 through on- and off-grid technologies. This plan will support increasing access to off-grid electricity services for households, commercial users, and public institutions through both standalone solar and mini-grids. A challenge for the sector to overcome in Uganda is access to finance for both companies and end users.

Primary Source of Electricity in 2018 and 2030 (of 13 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Millions)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

Strong support from development partners, engaged ecosystem actors, and supportive regulations have enabled what is now a robust and diverse set of private companies providing OGS solutions in Uganda.

- **The Ugandan government is developing a new off-grid project, Electricity Access Scale-up Project (EASP), incorporating both off- and on-grid components.** The proposed World Bank–financed project will support the OGS sector by expanding an existing credit-support facility to participating financing institutions for on-lending to OGS companies. This will be administered by the Uganda Energy Credit Capitalization Company (UECCC), which will also provide guarantees to reduce collateral requirements. The EASP will also explore opportunities for a service-based business model for electrification of public institutions aimed at

489 Vivid Economics and Open Capital consultations.

ensuring the sustainability of off-grid electricity provision. EASP will also take steps to support standalone solar for efficient appliances and productive use, including refrigeration and solar water pumps.[490]

- **The World Bank–financed Energy for Rural Transformation Project III (ERT III) promotes SHS to increase quality, protect consumers, and accelerate access.** The promoted SHS include both plug-and-play SHS that are Lighting Global quality-verified and component-based SHS that are quality-verified under a new framework.[491] The project aims to install OGS systems for the public sector, support enforcement of quality standards, and help with business development. The project, through UECCC, will provide credit and guarantee instruments to Participating Financial Institutions (PFIs) in order to facilitate consumer financing and businesses' working capital.[492] Until recently, companies looking to access funding were required to have Lighting Global quality verification, yet many systems on the market are component-based and therefore ineligible. The government has established a quality assurance framework that enables participation in the UECCC-managed facility for OGS companies promoting high-quality, component-based systems. These standards could increase both the quality and the uptake of OGS systems.
- **Development partners and accelerator programs are supporting growth in the OGS sector by creating an enabling environment through favorable policies and access to finance.** The United Nation's Capital Development Fund (UNCDF) continues to provide credit facilities to Ugandan solar companies and technical assistance to financial institutions concerning consumer financing. The Uganda Off-Grid Market Accelerator (UOMA) offers support for companies to grow, test innovations, and raise capital, as well as influencing policy (e.g., tax exemptions).[493]
- **The Uganda Solar Energy Association (USEA) is one of the strongest off-grid industry associations in Sub-Saharan African.** USEA brings together a wide range of companies in the industry—from local distributors to international brand marketers—and advocates for their needs, contributing towards a supportive enabling environment for OGS companies.
- **Beyond household OGS products, PULSE appliances are gaining significant traction in the market, particularly in the agriculture sector.** With 70 percent of the population employed in agriculture, productive use is both a potentially lucrative segment for companies and a highly impactful technology for end users.[494] Futurepump's solar irrigation appliance, for instance, has the potential to increase yields for farmers, particularly in the northern regions of Uganda, while Azuri Technologies chose Uganda to pilot its solar irrigation solution.

Challenges to overcome

OGS is not yet included in Uganda's NES, and companies struggle to access the capital they need to expand their businesses.

- **The OGS market in Uganda comprises large numbers of component-based systems with a wide range of quality.** Though some component-based products are of high-quality, there are also many low-quality systems on the market. Until recently, there was no process to ensure that these systems are high-quality.

490 Ministry of Energy and Mineral Development, "Terms of Reference for Consultancy Services: Identification of Public Institutions to Be Electrified with Solar Installations and Development of an Alternative Payment Option for Energy," Uganda Energy Access Scale-Up Project P166685, https://www.energyandminerals.go.ug/site/assets/files/1281/tor_easp_electrification_of_public_institutions.pdf; World Bank, "Concept Environmental and Social Review Summary Concept Stage (ESRS) Concept Stage," Uganda Energy Access Scale-up Project (EASP) (P166685), September 25, 2019, http://documents.worldbank.org/curated/en/253061572021758449/pdf/Concept-Environmental-and-Social-Review-Summary-ESRS-Uganda-Energy-Access-Scale-up-Project-EASP-P166685.pdf; and Open Capital Advisors and Vivid Economics consultations.

491 Global Sustainable Energy Solutions, Draft Interim Quality Assurance Framework for Component-Based Solar Home Systems (Kampala: Rural Electrification Agency and Uganda Energy Credit Capitalization Company, September 2019), https://sun-connect-ea.org/wp-content/uploads/2019/09/Interim-Quality-Assurance-Framework-Final-9-September-2019.pdf.

492 François Carme and Julius Magala, Compact Development: Final Report, Energy Africa—Uganda (London: DFID, 2016), https://assets.publishing.service.gov.uk/media/5aec184f40f0b63154caae6c/Energy_Africa_-_Uganda_Compact_development_-_FINAL_REPORT.pdf.

493 UOMA, "About Us," https://uoma.ug/our-mission/; United States Agency of International Developent (USAID), Accelerating Access to Local Currency Debt Finance for Solar Home System Businesses in Uganda (Washington, DC: USAID, 2019), https://uoma.ug/wp-content/uploads/2019/11/Accelerating-access-to-local-currency-debt-for-SHS-businesses.pdf.

494 Open Capital Advisors, Promoting Productive Uses of Energy in Uganda: Status and Potential for Growth (Kampala: Shell Foundation, October 2017), https://shellfoundation.org/app/uploads/2018/10/SF-OCA-Uganda-Accelerator-_-Productive-Use-Technology.pdf.

While the government recently developed a quality-assurance framework, it is now of paramount importance to develop strategies and plans to enforce compliance with quality standards.

- **A lack of an NES with a defined role for OGS has limited growth of the OGS sector to date.** While the government is nearing its final stages in developing the NES, it will require technical assistance and the support of development partners to ensure its successful implementation.
- **Commercial banks lack appetite to lend to OGS companies and require both significant collateral and high interest rates that companies struggle to accept.** While development finance institutions such as IFC and CDC have developed risk-sharing facilities, more de-risking facilities are needed.[495]

SPOTLIGHT

The Development of Component-Based Quality Standards

The Ugandan OGS market has many companies providing component-based systems. Although many are high-quality, they have not been eligible for Lighting Global quality verification to date. The UNBS will now lead the process to adopt a quality-assurance framework as a national standard for component-based systems.[496] Systems that are quality-verified under this system will be able to qualify for the UECCC credit facility and other future World Bank projects. This will in turn help accelerate energy access in Uganda and provide a great case study which could be replicated across other countries, if successful.

Photo credit: © Village Power

495 Open Capital Advisors, Increasing Investment from Local Financial Institutions in the Off-Grid Solar Sector: Lessons from East Africa (Nairobi: GOGLA, 2018), https://www.lightingglobal.org/wp-content/uploads/2018/11/181012-Increasing-local-financial-institution-investment-in-OGS-sector_vf3.pdf.

496 Global Sustainable Energy Solutions, Draft Interim Quality Assurance Framework.

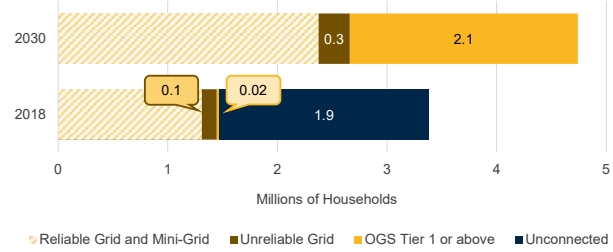
ZAMBIA

Population:	17.4 million people
GDP per capita 2018:	US$ 1,540
Electricity access rate (Tier 1 or higher) 2018:	43 percent
Current penetration of OGS:	14 percent
OGS potential 2030:	2.1 million households (OGS as main source) + 0.1 million (OGS as backup to weak grid)
Status:	Pioneering

Source: See note (a) in Country Annexes Introduction

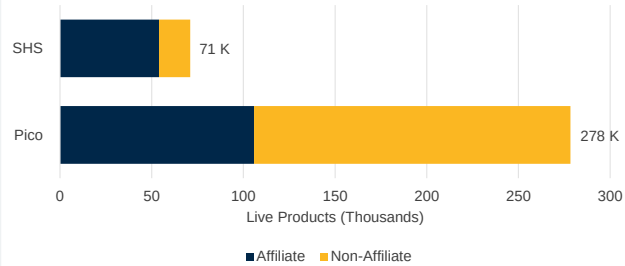
With strong support from the government, the nascent OGS market in Zambia is rapidly evolving. The Zambian market is currently served by some affiliate players, such as Fenix and VITALITE, but limited consumer financing options mean many products are pico and small SHS products sold on a cash basis.[497] Current players have established an industry association to lobby for and support all renewable energy enterprises. Key development partner programs, such as Sida's Beyond the Grid Fund, have also influentially catalyzed the sector, supporting the government's push for universal electrification. The government will need to continue working with development partners to unlock growth in the OGS sector.

Primary Source of Electricity in 2018 and 2030 (of 5 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

Zambia's significant potential OGS market benefits from supportive government policies, including tax exemptions and quality-verification standards.

- **A highly active Off-Grid Task Force (OGTF) has been driving key reforms in the market.** The OGTF sits within the Zambian Ministry of Energy and has representatives from various government agencies, as well as from the private sector. One key change recently led by the task force was the introduction in 2018 of additional tax exemptions for OGS products.
- **Given the expected limited reach of the grid by the 2030 goal for universal electrification, OGS solutions will play a critical role in enabling energy access.** The annual market potential for OGS products in Zambia is an estimated US$ 237 million, targeting 1.8 million unconnected households.[498]

497 Carbon Africa, Stand-Alone Solar Businesses in Zambia: A Guide for Venture Developers and Investors (Eschborn, Germany: Africa–EU Renewable Energy Cooperation Programme, 2018), https://www.gogla.org/sites/default/files/resource_docs/recp-developer-guide_shs-businesses-zambia_2018.pdf.

498 Carbon Africa, Stand-Alone Solar Businesses in Zambia.

- **Some components of OGS products, including batteries and LED lights, are exempt from import duties and zero-rated for VAT.** These exemptions, however, are applied inconsistently at ports of entry. Industry associations are also proposing additional exemptions for solar appliances.
- **As of 2017, importers are required to present the Zambian Bureau of Standards with a certification of product quality that shows the product meets quality standards from the country of origin.** In 2018, the government also introduced Extended Producer Responsibility (EPR), but it is unclear how this will be implemented.[499] Once properly implemented and enforced, such a regulation could improve the sector's Environmental, Social, and Governance (ESG) compliance.

Challenges to overcome

The OGS sector in Zambia faces several challenges, including inconsistent enforcement of tax exemptions, currency devaluation, low mobile-money penetration, and low willingness to pay.

- **Despite tax exemptions currently in place, inconsistent enforcement is deterring companies from entering the market.** Additional regulatory clarity is needed, though the high influx of OGS products into the market also makes enforcement a challenge.[500]
- **The country's fiscal weakness and sustained currency devaluation (e.g., 5.5 percent drop in November 2019) are significant risk factors for investments into the country.[501]** This has severely impacted the availability of capital from foreign investors.
- **Zambia faces low mobile-money penetration (27.8 percent), and general skepticism towards the integrity and safety of mobile money transactions has hindered uptake of PAYGo technology.[502]** Further uptake of the PAYGo model will require increased consumer awareness and onboarding of potential customers to mobile money platforms.
- **Zambian households have low willingness to pay, presenting a challenge for OGS companies.** In particular, a significant proportion of woman-led households stated they would not be willing to pay for an SHS at any cost.[503] Additional research will be needed to identify barriers to willingness to pay and explore ways of addressing this key issue.

SPOTLIGHT

Using Results-Based "Social Impact Procurement" to Reach Last-Mile Customers

The US$ 20 million Beyond the Grid Fund for Zambia by Sida was established to provide 1 million Zambians with clean off-grid energy. The program has strict procurement policies which aim to keep social impact as the primary focus (contrasting with other concessional financing or challenge funds). The fund incentivizes private-sector companies to enter regions which they would otherwise deem unviable and provide energy service subscriptions. The program has robust monitoring and evaluation mechanisms in place to ensure that it maintains the intended social impact across its set performance areas. Operating for two years, the program has already reached more than 500,000 people.[504]

Photo credit: © Fenix International

499 Carbon Africa, Stand-Alone Solar Businesses in Zambia.

500 GOGLA, "Zambia," country brief, https://www.gogla.org/sites/default/files/resource_docs/zambia_country_brief.pdf.

501 Matthew Hill and Taonga Clifford Mitimingi, "Zambia's Bonds, Kwacha Fall as Traders Fret Over Power Shortages," Bloomberg, November 13, 2019 https://www.bloomberg.com/news/articles/2019-11-13/zambia-s-bonds-and-kwacha-fall-as-slight-panic-sets-in.

502 "Zambia," in World Bank, The Little Data Book on Financial Inclusion, 162 (Washington, DC: World Bank, 2018), https://globalfindex.worldbank.org/sites/globalfindex/files/countrybook/Zambia.pdf; Carbon Africa, Stand-Alone Solar Businesses in Zambia.

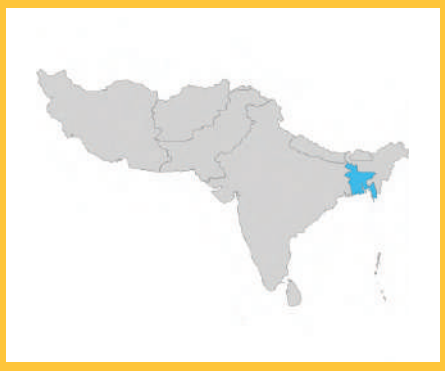
503 ESMAP, Zambia – Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework (Washington, DC: World Bank, May 2019), http://documents.worldbank.org/curated/en/477041572269756712/Zambia-Beyond-Connections-Energy-Access-Diagnostic-Report-Based-on-the-Multi-Tier-Framework.

504 Beyond the Grid Fund for Africa (BFA), https://www.bgfz.org/#about.

BANGLADESH

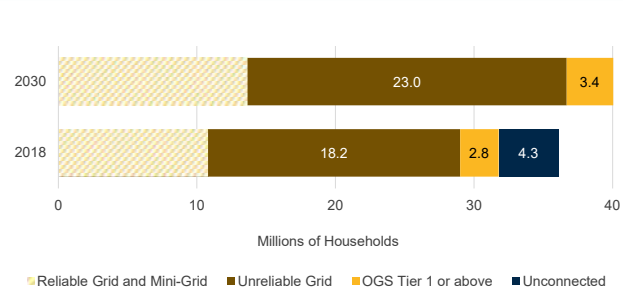
Population:	161.4 million people
GDP per capita 2018:	US$ 1,698
Electricity access rate (Tier 1 or higher) 2018:	88 percent
Current penetration of OGS:	5 percent
OGS potential 2030:	3.4 million households (OGS as main source) + 5.8 million (OGS as back-up to weak grid)
Status:	Maturing

Source: See note (a) in Country Annexes Introduction



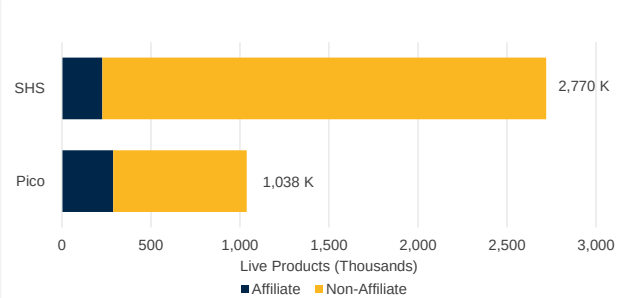
Home to the world's largest single SHS program, the OGS sector in Bangladesh is now having to evolve as the main grid reaches almost all of the population. The Infrastructure Development Corporation Limited (IDCOL) SHS program has sold more than 4.5 million units, with total SHS sales reaching almost 6 million (including further sales beyond the IDCOL program). However, the main grid is now expected to reach all except around 1,000 villages. In this context, OGS solutions hold great potential as a secondary source of power alongside unreliable grid connections and for productive use.

Primary Source of Electricity in 2018 and 2030 (of 40 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

With a strong lead institution in the Sustainable and Renewable Energy Development Authority and a successfully nationally coordinated financing program for off-grid energy technologies implemented by the Infrastructure Development Company Limited (IDCOL), Bangladesh has a clear commitment to the role of OGS technologies.

- **Strong and stable regulatory and financial conditions spurred one of the largest and fastest OGS markets for households.** Clear commitments from SREDA and IDCOL were key to establishing the SHS program and have also been instrumental in the early stages of the solar water pump, mini-grid, and rooftop solar initiatives.
- **IDCOL's technical standards committee set quality standards in line with international standards as a pre-requisite for access to concessional credit line and RBF grants.** With most SHS, mini-grids, and solar water pumps (SWPs) deployed through IDCOL finance, the quality of products in use has remained high. The strong institutional context, robust donor support, and the enabling micro-finance environment have facilitated OGS growth.

- **The appliances market is relatively nascent and should remain buoyant.** For households using OGS either as their primary source of electricity or as a secondary source alongside their grid connections, solar-powered DC appliances offer a way to improve the quality of electricity access. Retailers are seeing strong demand for fans and increasingly for larger appliances, such as fridges and televisions.[505] The Global LEAP RBF aims to catalyze the uptake of high-quality, energy-efficient appliances, with solar water pumps and off-grid refrigerators in Bangladesh among the eligible technologies that were finalists in the 2019 Global LEAP awards.[506]
- **Solar water pumps hold huge potential, with SREDA and IDCOL aiming to grow the market from around 1,500 SWPs today to up to 50,000 in the next five to ten years.** These pumps would primarily replace current diesel pumps and should reduce the burden on the main grid through a national net metering policy for SWPs (currently under development). While SWPs are currently almost all larger pumps and panels around 25 kWp serving multiple farmers under a fee-for-service model, a larger market may offer potential for other business models, including smaller pumps for individual farmers and community-owned larger pumps.
- **Public institutions in rural areas remain unconnected or undersupplied by the main grid.** Around 18,000 rural health centers are either unconnected or receiving only intermittent supply from the grid. Similarly, SREDA estimates that up to 40 MW capacity could be installed in rural education facilities. Government buildings hold similar potential, while religious facilities and railway stations could employ another 10 MW of small-scale off-grid capacity.

Challenges to Overcome

In the presence of a rapidly expanded main grid, OGS products and business models will need to successfully communicate their value alongside the grid to provide full and high-quality access to electricity.

- **As the grid has expanded rapidly, demand for SHS is declining.** From a peak of more than 60,000 unit sales per month, sales have now dropped to an estimated 4,000 per month—mainly as result of grid expansion. Reflecting this shift, along with rising electricity tariffs and poor quality of supply from the grid, companies are increasingly looking to serve grid-connected customers with backup solar electricity systems or to deploy smart peer-to-peer connected systems (e.g., Sol Share).
- **Lower-quality products have emerged on the market.** While the IDCOL program has maintained the quality of products sold under the program, sellers outside the program have imported lower-quality solar panels and components offered at cheaper prices. These systems are less efficient, and their shorter lifespan also causes frustration among users.
- **Continued support is needed to ensure new technologies maintain financial viability as they grow to scale.** Developing sustainable commercial markets in high-potential sectors such as solar water pumps and DC appliances will require a wider range of financiers to be attracted to the sector. At present, there is very limited finance from local commercial banks, although Bangladesh Bank offers re-financing facilities for qualifying "green" projects, and financial institutions must allocate at least 5 percent of their lending portfolios to "green" projects.
- **Raising awareness of the emergence of high-efficiency, high-quality DC appliances.** The supply chain has little awareness of DC appliances. Similarly, consumers lack awareness of the improvements made to DC appliances, which are now very efficient. This means that even users with smaller systems could now purchase and use televisions and small fans, but many are unaware of this possibility.

505 Efficiency for Access, The Appliance Market in Bangladesh: Lessons Learnt from Field Visits and Interviews with Retailers (London and Washington, DC: Efficiency for Access, September 2019), https://efficiencyforaccess.org/publications/the-appliance-market-in-bangladesh-lessons-learnt-from-field-visits-and-interviews-with-retailers.

506 Global LEAP Awards, "Results-Based Financing, 2019–20: Refrigerators & Solar Water Pumps," https://globalleapawards.org/results-based-financing.

SPOTLIGHT

Photo credit: © Solargao

Solar Water Pumping Potential in a Highly Grid-Connected Market

Solar water pumps (SWPs) have high potential in Bangladesh—a country with abundant but seasonal rainfall. Irrigation requirements in the country vary largely by cropping season.

More than one million diesel pumps are installed, with technical potential for over 100,000 SWPs. SREDA and IDCOL are aiming to expand the market from 1,500 SWPs today to up to 50,000 by 2030.

To achieve this, companies like Solargao, in refining their business models, work with farmers and communities to maximize the revenue potential of SWPs and the land around them.

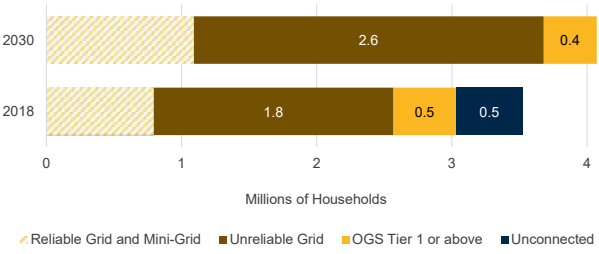
CAMBODIA

Population:	16.2 million people
GDP per capita 2018:	US$ 1,510
Electricity access rate (Tier 1 or higher) 2018:	86 percent
Current penetration of OGS:	11 percent
OGS potential 2030:	0.4 million households (OGS as main source) + 0.6 million (OGS as backup to weak grid)
Status:	Firmly established

Source: See note (a) in Country Annexes Introduction

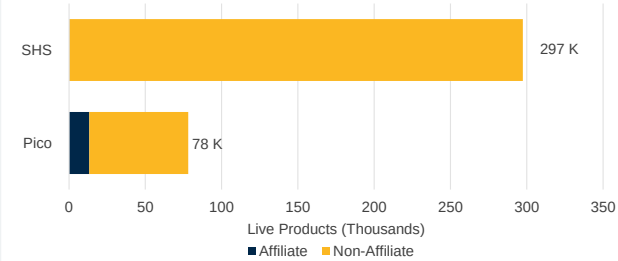
The OGS market in Cambodia has expanded rapidly in the last few years and now serves a third of the households in rural areas.[507] By the end of 2017, the Rural Electrification Fund (REF) SHS subsidy program had supported installation of more than 60,000 SHS.[508] Almost all households using an OGS device—most of which use an SHS—are based in rural areas. Alongside the use of OGS products as a main source of electricity, potential demand is also high for OGS to supplement the main grid. Some 10 percent of grid-connected households receive less than four hours of service per day.[509]

Primary Source of Electricity in 2018 and 2030 (of 4 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities

The OGS market has recently expanded in Cambodia and can play an important role in serving unconnected and unreliable-grid households, particularly in rural areas.

- **The OGS market has expanded over the last five years.** 97 percent of households that have an OGS device obtained their first one within the last five years, and 63 percent did so within the last two years.[510]
- **Currently demand for electricity greatly exceeds the current grid size.** Cambodia has agreed to buy 2,400 MW of electricity from Laos in four phases over a period of 30 years to help meet demand.[511]

507 ESMAP, Cambodia – Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework (Washington, DC: World Bank, June 2018), https://openknowledge.worldbank.org/handle/10986/29512.

508 Asian Development Bank, Cambodia: Energy Sector Assessment, Strategy, and Road Map (Manila: Asian Development Bank, December 2018), http://dx.doi.org/10.22617/TCS189801.

509 Dave et al., Cambodia Beyond Connections.

510 Dave et al., Cambodia Beyond Connections.

511 Shi Yinglun, "Lao Grid to Deliver Electricity to Cambodia," Xinhua, November 11, 2019, http://www.xinhuanet.com/english/2019-11/11/c_138545945.htm.

- **Reliability of the existing grid remains low, and OGS products represent viable alternatives or backups to the grid, especially in rural areas.** More than a quarter (28 percent) of electrified rural households have less than 16 hours of energy supply a day. In addition, 32.6 percent of grid-connected households face voltage issues—such as low or fluctuating service—that can damage appliances.[512]

Challenges to overcome

Key barriers to address include high costs of reaching last-mile customers, declining quality of products, and low levels of affordability.

- **The economics of reaching the last mile via OGS are not attractive for most private companies.** Areas with potential customers are hard to reach (which makes distributing and maintaining the systems expensive); affordability is low, particularly in rural areas (over 11 percent of rural households are in Tiers 0–2 and they spend more than 5 percent of their monthly income on basic electricity service); and public funding for private companies is difficult to access.[513]
- **Quality of OGS products must be maintained.** This can be done through the introduction of quality-verified solar kits, enforcement of quality standards, and increased capabilities of technicians (for example, through certification programs).[514]
- **Financing schemes for customers that spread out payments for SHS, such as PAYGo, should be explored and promoted.** Affordability is the biggest barrier for access to electricity in Cambodia.[515]

SPOTLIGHT

Partnerships to Roll Out the PAYGo Business Model

A partnership approach has proven key to rolling out the PAYGo business model in Cambodia. An OGS hardware manufacturer, Kamworks Limited, has partnered with WING, a mobile-money operator, and CamGSM to deploy a GSM-enabled PAYGO SHS technology, making solar more affordable and accessible to rural households in Cambodia. Consumers pay monthly installments with mobile money. In case of late payment, through its proprietary technology, Kamworks can remotely monitor and switch off the SHS. Kamworks has sold more than 14,000 SHS in Cambodia and also provides clean, reliable electricity to several hospitals, schools, and orphanages through its rooftop solar solutions.

Photo credit: © Kamworks

512 Dave et al., Cambodia Beyond Connections.

513 Dave et al., Cambodia Beyond Connections; and Sophie Truffin, "Results-Based Financing for Off-Grid Solar Energy Access in Cambodia," SNV (blog), June 2018, https://snv.org/update/results-based-financing-grid-solar-energy-access-cambodia.

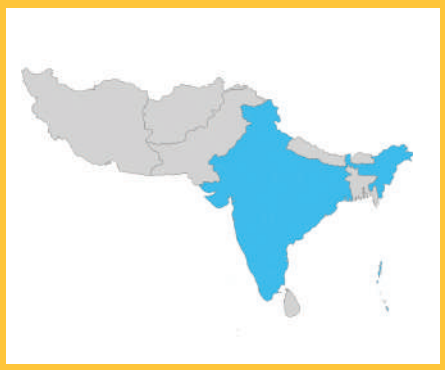
514 Dave et al., Cambodia Beyond Connections.

515 Dave et al., Cambodia Beyond Connections.

INDIA

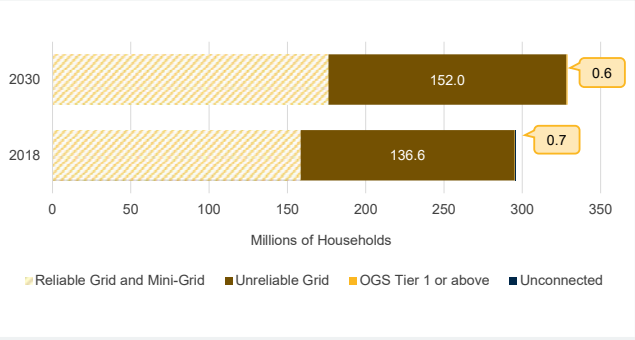
Population:	1.4 billion people
GDP per capita 2018:	US$ 2,010
Electricity access rate (Tier 1 or higher) 2018:	~100 percent
Current penetration of OGS:	15 percent
OGS potential 2030:	0.6 million households (OGS as main source) + 38 million (OGS as backup to weak grid)
Status:	Maturing

Source: See note (a) in Country Annexes Introduction



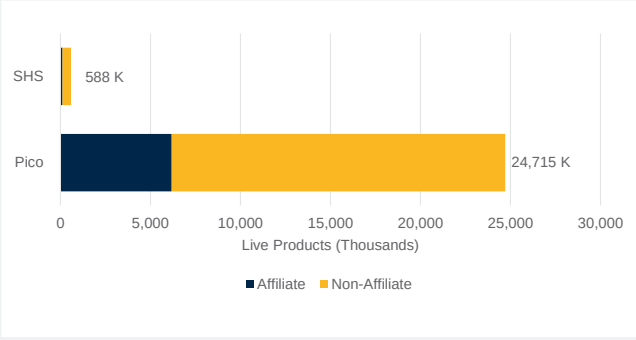
India is the world's largest off-grid solar market in absolute terms, but with the grid now reaching nearly all households, the largest opportunities in the next three to five years will likely involve providing off-grid appliances to the unreliable-grid market. Portable lanterns (<3 W) have recently seen rapid growth, with almost 10 million solar lamps and lanterns sold in both 2017 and 2018.[516] Moreover, 2018 also showed increased (mostly cash) sales of products of larger capacities.[517] At the same time, the country has an electrification rate of almost 100 percent, with the Saubhagya scheme aiming to provide a grid connection to reach almost all households.[518] However, the grid continues to struggle with a lack of reliability and stability, and non-grid sources (both solar and diesel generators) continue to compose 16 percent of the rural energy mix for households and 40 percent for enterprises, suggesting the grid does not cover all demand.[519]

Primary Source of Electricity in 2018 and 2030 (of 329 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Millions)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

The main opportunities for off-grid solar involve complementing the unreliable grid, offering larger systems and accompanying appliances, and targeting last-mile consumers by partnering with MFIs, rural banks, specialized distribution companies and retail networks.

516 William Brent, "Is Off-Grid Solar Lighting Still Relevant in India?," Power for All Insights: DRE Technologies (blog), September 16, 2019, https://www.powerforall.org/insights/dre-technologies/grid-solar-lighting-still-relevant-india.

517 GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H1 2018 (Utrecht: GOGLA; Washington, DC: Lighting Global, October 2018), https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2018-sales-and-impact-data; and GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H2 2018 (Utrecht: GOGLA, May 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h2-2018-sales-and-impact-data.

518 Under the Saubhagya scheme, the Government of India offered a grid connection to all households that applied and were eligible. A village is considered electrified if 10 percent of households are electrified, and electricity is provided to public places such as schools and community centres. A household is considered "willing" if they have applied for grid connection, but millions of households chose not to do so. REC Limited, "Saubhagya Dashboard," https://saubhagya.gov.in/.

519 Shalu Agrawal, Nidhi Bali, and Johannes Urpelainen, Rural Electrification in India: Customer Behaviour and Demand (New Delhi: Smart Power India, February 19, 2019), https://www.rockefellerfoundation.org/report/rural-electrification-india-customer-behaviour-demand/.

- **Reliability of the existing grid remains low, and OGS products represent a viable alternative or backup for the grid, especially in rural areas.** In some of India's largest states, more than half of electrified rural households have less than 12 hours' energy supply each day.[520] On average, 57 percent of regions monitored experience outages of more than 15 hours, and related voltage fluctuations can damage appliances, which may limit demand for (grid-connected) appliances.[521]
- **Although electrification rates have increased rapidly, many households use OGS as their main source of electrification.** For instance, in Uttar Pradesh, the most populous state in India (more than 200 million inhabitants), as many as 20 percent of households have not taken up the offer of a grid connection.[522] The many reasons for this include low ability to pay the upfront fees, lack of trust in the reliability of supply, illegal connections, and lack of awareness.[523] In addition, around 20,000 remote rural households have still not been reached by the grid.[524]
- **There is high availability of rural last-mile consumer finance.** Consumer finance options include agent networks from banks, MFIs, specialized distribution companies, and retail. Many MFIs now also provide asset financing for a variety of off-grid appliances.[525]
- **The retail market for off-grid lighting solutions is large and growing.** Although off-grid lighting products sold at retail are usually low-cost with low consumer expectations around durability, pico solar imports into India have increased over the last few years, and some companies have recently seen an opportunity to put a heavier focus on retail.[526] For solar lighting products to succeed in this category, innovation in product design and increased consumer awareness of quality are essential. As consumer awareness of quality products has increased over the last few years, Lighting Asia is now taking the next step by undertaking a campaign to increase the awareness of quality within retail and distribution networks as well. Manufacturers need to have a clear retail strategy which includes hiring of teams, selection of geographies, and consistent trade policies.

Challenges to overcome

India has an almost 100 percent household electrification rate, subsidized kerosene, and high availability of low-quality imported emergency lights, reducing the demand for OGS products.

- **The Government of India offers to cover initial grid connection costs for households below the national poverty line.[527]** Over the next decade, the grid is expected to provide the primary source of electricity for the vast majority of households.
- **As alternatives to OGS like the grid and kerosene are subsidized and relatively cheap, consumers have low willingness to pay.** For OGS products to be competitive (increasingly as a secondary source of electricity), they will need to target the same price range or offer more or better services than these subsidized alternatives.
- **Targeted product positioning and a localized operational strategy are necessary.** The Indian market is vast and diverse, and acquiring the required reach across many contexts is costly.

520 Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, Odisha, and West Bengal. Abhishek Jain et al., Access to Clean Cooking Energy and Electricity: Survey of States 2018 (New Delhi: Council on Energy, Environment & Water, November 2018), https://www.ceew.in/publications/access-clean-cooking-energy-and-electricity.

521 Prayas (Energy Group), Electricity Supply Monitoring Initiative, Summary Analysis – May 2019 (Pune, India: Prayas, May 2019), http://www.watchyourpower.org/uploaded_reports.php.

522 Based on a survey in 252 villages over 3,024 households. Jain et al., Access to Clean Energy Survey.

523 Johannes Urpelainen, "Universal Rural Electrification in India? Not So Fast," Power for All India (blog), February 6, 2019, https://www.powerforall.org/countries/india/universal-rural-electrification-india-not-so-fast.

524 REC Limited, "Saubhagya Dashboard," https://saubhagya.gov.in/.

525 Dalberg, The State of the Off-Grid Appliance Market (London and Washington, DC: Efficiency for Access, October 2019), https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report.

526 Brent, "Solar Lighting Relevant in India?"

527 Under the Saubhagya scheme, certain households identified via the Socio-Economic and Caste Census (SECC) of 2011 are eligible for free electricity connections, while others are charged Rs 500. Only the initial connection is provided free of cost to below-poverty-line consumers. There is no provision to provide free power to any category of consumers. The cost of electricity consumption must be paid by respective consumers as per the prevailing tariff of the DISCOM/Power Department.

- **Remote rural areas are relatively expensive to reach.** Adding relatively high distribution costs to a customer segment with typically low affordability means companies are less likely to target these households as a sustainable commercial market.[528]
- **Mobile money and PAYGo penetration are low.** Mobile money is not widespread, and this is not expected to change over the coming decade. Companies wishing to provide consumer finance also need to apply for a Non-Banking Financial Company (NBFC) license, an onerous process that has acted as a barrier to offering PAYGo directly to customers.[529] The main channel for selling SHS on consumer credit will likely continue to be through partnerships with MFIs, rural banks, and retail. It remains unclear if there is enough "need" for the PAYGo model in India as there has been in Africa and elsewhere.

SPOTLIGHT

Photo credit: © IFC

Demand for Off-Grid Appliances Is Expected to Be Substantial over the Next Five Years[530]

Driven by increasing incomes and greater energy demand, more products of larger capacity and accompanying appliances have recently been sold on a cash basis in India. India is now the world's third-largest market for off-grid appliances, with 33,105 products (mostly fans) sold in the second half of 2018 alone.15 We expect the 2030 obtainable market size to grow to an estimated US$ 430 million for fans, US$ 3.7 billion for televisions, and US$ 5.3 billion for refrigerators, with unreliable-grid households driving demand for and local distributors and retailers driving distribution of off-grid appliances in India.

528 Vivid Economics and Open Capital Advisors consultations.

529 The NBFC license is only obligatory if it covers more than 50 percent of a company's revenue. Companies might also be insufficiently aware of exact regulations around offering consumer credit and may perceive it as a barrier for that reason.

530 GOGLA and Lighting Global, Off-Grid Solar Market H2 2018; Dalberg, Off-Grid Appliance Market.

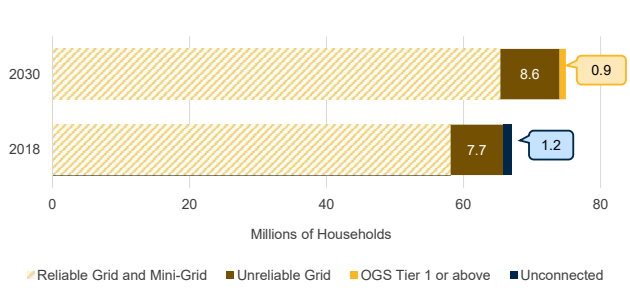
INDONESIA

Population:	267.7 million people
GDP per capita 2018:	US$ 3,894
Electricity access rate (Tier 1 or higher) 2018:	98 percent
Current penetration of OGS:	5 percent
OGS potential 2030:	0.9 million households (OGS as main source) + 2.2 million (OGS as backup to weak grid)
Status:	Pioneering

Source: See note (a) in Country Annexes Introduction

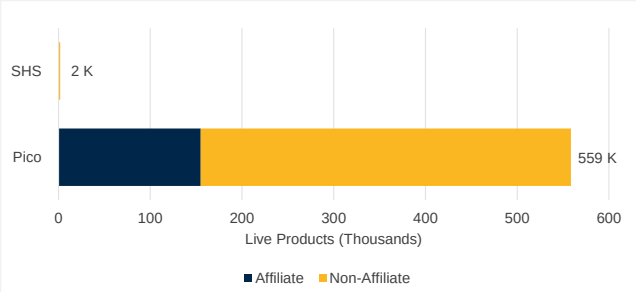
With almost all of Indonesia electrified and low OGS penetration to date, the sector can connect a small number of unconnected, remote households or supplement (mini-) grids in connected areas. Most households in Indonesia are electrified, most through grid connections or an isolated mini-grid powered by medium- or large-scale diesel generators and run by the government-owned electricity company PLN. However, access varies significantly across islands, with Papua and East Nusa Tenggara lagging with access rates of only 60 percent.[531] Penetration of OGS products is low. After the country's sales hit 100,000 units in the second half of 2017, it has not again passed GOGLA's three-point reporting threshold.[532] The Indonesian government is aiming for 100 percent electrification by the end of 2020 and has deployed basic SHS for free to disadvantaged households in the eastern, access-deprived islands through the LTSHE program.[533]

Primary Source of Electricity in 2018 and 2030 (of 75 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

OGS products can be added to existing mini-grids or delivered directly to end consumers, as well as playing an important role in reaching the remaining unconnected households.

- **Indonesia has relatively high potential for adding OGS products to hybrid mini-grids.** Many remote locations are not connected to the main grid but instead have a diesel-powered mini-grid. Adding OGS could create a hybrid system which uses solar and battery power during the day and a diesel generator with

531 Directorate General of New & Renewable and Conversation Energy, Ministry of Energy and Mineral Resources, http://www.ebtke.esdm.go.id/?lang=en.

532 GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H2 2018 (Utrecht: GOGLA, May 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h2-2018-sales-and-impact-data.

533 Ministry of Energy and Mineral Resources, "Presiden Joko Widodo Terbitkan Peraturan Penyediaan LTSHE," news release, April 20, 2017, http://ebtke.esdm.go.id/post/2017/04/20/1631/presiden.joko.widodo.terbitkan.peraturan.penyediaan.ltshe?lang=en.

optimized efficiency at night for electrification and recharging of the battery. This would lower the costs for PLN, which must ship diesel to remote islands at high cost, and increase the reliability of these mini-grids.

- **OGS products are seen as products and can therefore be delivered by the private sector.** PLN has a monopoly in Indonesia to develop and distribute mini-grids, but this monopoly does not extend to SHS.
- **Some local governments partner with SHS or micro-grid developers through a state-owned business entity.** This allows private companies to distribute electricity, and they can reach remote customers through local government networks.
- **In areas where people buy their own generators to obtain higher capacity electricity, OGS presents a cheaper alternative.** The PLN electricity rates are subsidized, so they are relatively cheap. However, if people buy diesel or gasoline directly, their additional electricity is much more expensive. OGS can in this context lower costs for households, as well as for PLN.
- **OGS can help reach Indonesia's remaining unconnected households.** About 10 million rural households in Indonesia have either no electricity or a very unreliable and unsustainable supply of electricity. OGS products can reach these households at a similar or lower cost as compared to the current expenditure, which is maintaining subsidies on kerosene for lighting and electrification with conventional energy.[534]

Challenges to overcome

Private distribution of OGS products is constrained by unfavorable regulations, competition with governmental hand-out programs, and limited opportunities to offer consumer finance.

- **Commercial opportunities for private players are limited because of government regulations and high costs to reach remote villages.** The current regulatory framework subsidizes conventional energy and requires all energy distribution to go through PLN.
- **Private initiatives targeting energy-deprived islands have to compete with the government's LTSHE program.** The LTSHE program organizes "pre-electrification" of villages by tendering multi-light SHS distribution prior to PLN bringing higher-capacity electrification. Therefore, people prefer to wait for the government program to reach them. However, there is no monitoring standard to ensure after-sales service, and the villages' remoteness means that even within the warranty period the companies have little incentive to maintain the products.
- **Opportunities to provide consumer finance alongside OGS products are limited.** MFIs and banks in Indonesia have not shown much interest in the OGS sector. Mobile money is not prevalent in Indonesia, and remote islands have no reliable internet connection, both of which limit prospects for PAYGo. Private-sector participation and innovative financing will be needed to sell higher-capacity OGS systems.

SPOTLIGHT

High-capacity OGS for Javanese Cocoa, Nut, and Coffee Farmers

On the island of Java, small-scale cocoa or coffee-exporting farmers often have their own diesel- or gasoline-powered generators, indicating their relatively high ability and willingness to pay for electricity. In the rainy season and through hurricanes, diesel and gasoline supply lines can be cut. High-capacity OGS products could present an interesting alternative or supplementary source of electricity for these farmers, as it would reduce their reliance on and consumption of diesel while also increasing energy availability.

Photo credit: © Hivos

534 Marc Torra, Alejandra Barrios Paez, and Jacob Gilmour, Sustainable Decentralised Renewable Energy through the RESCO Model in Indonesia (Jakarta: HIVOS South East Asia, July 2019), https://sumbaiconicisland.org/wp-content/uploads/2019/10/Report_Sustainable-Decentralised-Renewable-Energy-through-the-RESCO-Model-in-Indonesia_final.pdf.

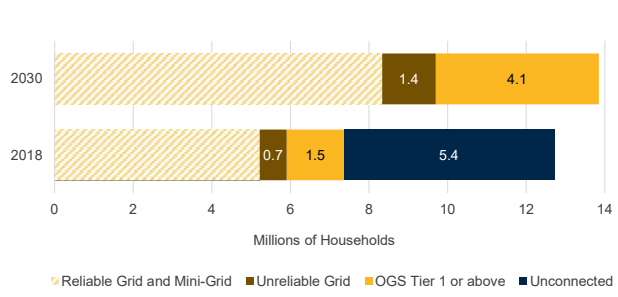
MYANMAR

Population:	53.7 million people
GDP per capita 2018:	US$ 1,326
Electricity access rate (Tier 1 or higher) 2018:	58 percent
Current penetration of OGS:	31 percent
OGS potential 2030:	4.1 million households (OGS as main source) + 0.3 million (OGS as backup to weak grid)
Status:	Maturing

Source: See note (a) in Country Annexes Introduction

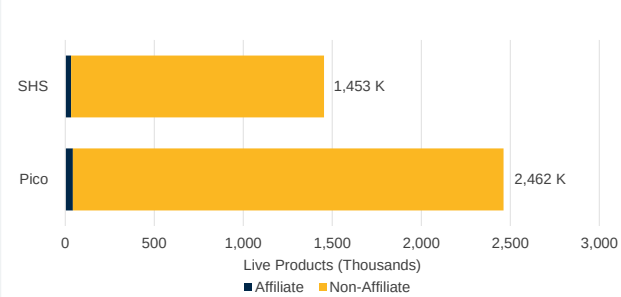
About half of households in Myanmar do not have access to the main grid; OGS is already a major source of electrification. At least 3.5 million households throughout the country are currently using an OGS product. Concessional finance is being deployed to catalyze the OGS market in fragile border areas, with commercial markets starting to mature in other regions. This includes targeting "under-the-grid" customers whose demand for electricity cannot be met by the main grid or mini-grids.

Primary Source of Electricity in 2018 and 2030 (of 14 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

The Government of Myanmar's National Electrification Plan (NEP) aims to reach universal access by 2030 through grid, mini-grid, and OGS solutions. Since the World Bank approved the NEP in 2015, a valuable body of experience has been gained and OGS companies are maturing.

- **The NEP was adopted in 2015, and IFC-led Lighting Myanmar launched in June 2016.** The World Bank is supporting the NEP through a US$ 400 million International Development Association loan, of which US$ 100 million is for off-grid solutions (mini-grid and off-grid solar) and related technical assistance.
- **The Department for Rural Development (DRD) OGS public procurement program aimed to reach 456,500 households, 11,400 public institutions (schools, clinics, religious facilities), and 19,000 public street lighting projects with quality solar products.** About 80% of the SHS target for households has been contracted, and the targets for public facilities and street lighting have already been well exceeded. DRD has set up 31 service centers to provide onsite warranty service.
- **A results-based finance (RBF) grant of US$ 3.45 million will promote the development of a commercial market for Lighting Global–quality-verified products.** The RBF subsidies, calculated based on lumen-hours per

day provided by the systems sold, will be paid to selected companies based on verification of sales. DRD will coordinate the implementation of the RBF program, which is funded by ESMAP and the Global Partnership on Results-Based Approaches (GPRBA). Further activities by Lighting Myanmar to catalyze the sector include market intelligence, customer-awareness campaigns, quality assurance, business-to-business support, increasing access to finance, and capacity-building for DRD, and DRD field offices for implementation.

- **At least 3.5 million OGS products are in use in Myanmar, reaching around 30 percent of the population.** Of these, the DRD public procurement program accounts for around 380,000, and Lighting Global quality-verified estimated sales are a further 100,000. The remaining 3 million are likely cheaper, component-based systems using larger panels imported from neighboring China paired with lead-acid batteries.
- **Lighting Global quality-verified products largely comprise SHS sold by PAYGo.** A handful of companies are deploying or piloting PAYGo products, using scratch cards, for example, as the payment mechanism. Mobile money may be emerging as a viable option through providers such as Wave Money, although the reach and use of digital payment mechanisms are limited in rural areas.

Challenges to overcome

- **Affordability is low in Myanmar; around 37 percent of people live near or below the poverty line.** These people, largely concentrated in rural areas, cannot bear the full cost of an SHS providing Tier 1 or 2 energy access. Furthermore, Myanmar has diverse, multi-ethnic communities, with substantial populations living in fragile and conflict-affected areas. Concessional finance will play an important role in reaching these customers, alongside mechanisms to track customer feedback on service quality and social inclusion.
- **With the fast and multi-faceted expansion under the national electrification initiative, coordination and information-sharing will be pivotal for developing commercial markets while reaching even the poorest populations in fragile areas.** With the grid and mini-grids rolling out quickly and OGS solutions implemented through a combination of public procurement and commercial approaches, coordination and information-sharing are crucial to develop a private sector with a clear and stable addressable market. In this vein, public–private dialogue on the SHS public procurement program has been initiated as part of the RBF Off-Grid Solar preparation process and it is expected to be strengthened during the implementation of the grant.
- **PULSE could represent an important future potential market but remains very nascent.** While international companies, such as Future Pump, have expressed interest and local operators, such as Proximity Design, are already providing solar water pumps, the market has yet to reach sustainable long-term scale.

SPOTLIGHT

The Role of Non-Affiliate Sales

In border areas, up to 90 percent of households are using cheap OGS products imported from China. These households are typically bottom of the pyramid and would struggle to afford the cost of a higher quality system. Cheap products can play an important role to play in providing access to some of these households.

These households often then represent a good market for QV suppliers, as they have experience of the potential benefit of OGS and are more willing to pay for a higher quality system when their first (cheaper) system breaks.

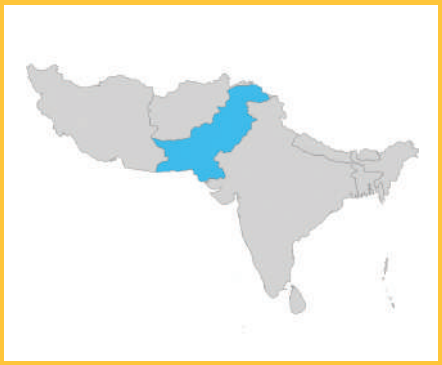
The World Bank Group is providing marketing and communication support to raise awareness of the benefits of quality-verified OGS products.

Photo credit: © IFC

PAKISTAN

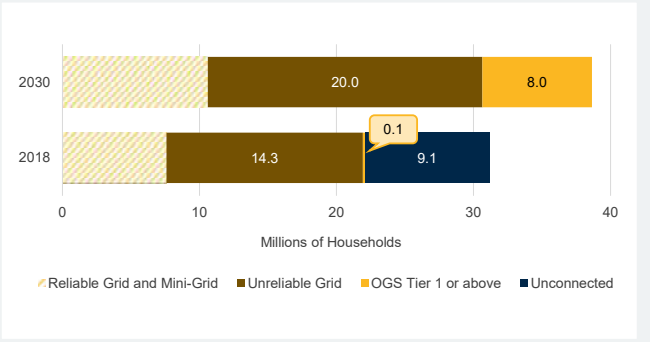
Population:	212.2 million people
GDP per capita 2018:	US$ 1,482
Electricity access rate (Tier 1 or higher) 2018:	71 percent
Current penetration of OGS:	1 percent
OGS potential 2030:	8 million households (OGS as main source) + 5 million (OGS as backup to weak grid)
Status:	Pioneering

Source: See note (a) in Country Annexes Introduction



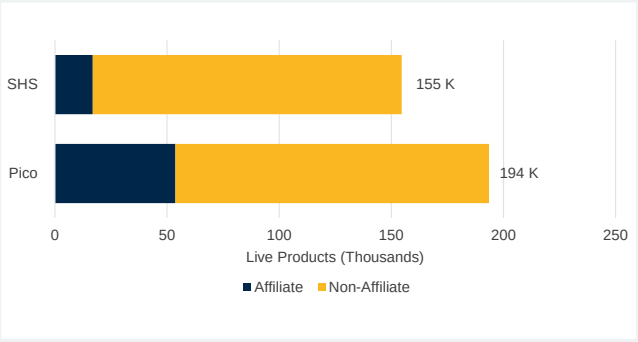
Pakistan represents a large potential market across all OGS product segments. By 2030, more than 11 million households in Pakistan will still not be connected to the main grid or to a mini-grid, offering substantial potential demand for OGS products as the main source of electrification. Furthermore, some 28 million Pakistani households are using a weak grid connection, with many grid-connected customers experiencing load shedding as much as 16 hours per day. PULSE appliances, such as fans and refrigerators, are highly demanded, if prices can be brought down, while solar water pumps (SWPs) could be an important alternative to the more than 1 million diesel and electric-powered pumps in the country at present.

Primary Source of Electricity in 2018 and 2030 (of 39 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities

Pakistan will continue to have both a significant unconnected population and a large population using unreliable grid connections; both markets represent an opportunity for OGS products.

- **The Pakistani government's recent "Alternative and Renewable Energy Policy" introduces a number of policies favorable for the OGS sector.** These include exemptions for off-grid sales to public utilities and exemptions of B2B sales from corporate income tax, as well as exemptions from customs duties.[535] Previously, the Alternate Energy Development Board issued tax-exemption certificates for the import of solar panels, solar lanterns, SHS, SWPs, and solar water heaters.
- **The World Bank is financing a project in Sindh province that will provide partial grants to 200,000 households for the purchase of SHS from private-sector suppliers.** The US$ 100 million International Development Association loan includes a US$ 30 million component meeting around 40 percent of the cost of a

535 Government of Pakistan, "Alternative and Renewable Energy Policy 2019," draft version, July 2019, http://www.aedb.org/images/Draft_ARE_Policy_2019_-_Version_2_July_21_2019.pdf.

typical SHS, available only to qualifying suppliers and administered by the Government of Sindh. The program is not limited to off-grid households and includes households with "low energy access" to the main grid.

- **KfW, in cooperation with the Pakistan Microfinance Investment Company (PMIC), is supporting the deployment of quality-verified products.** The "PRIME" program has earmarked around €15 million for on-lending by microfinance providers and solar suppliers selling Lighting Global quality-verified pico and multi-light systems and plug-and-play SHS packaged with DC fans.
- **GIZ recently implemented a results-based finance (RBF) program in 10 districts. Only Lighting Global quality-verified products were eligible for financing under the RBF scheme of 500,000.**
- **Pakistan represents a large opportunity as a market for appliances, specifically DC fans and DC room coolers.** Customers of OGS products in Pakistan may be less interested in more conventional lighting and mobile phone charging systems and instead demand DC fans and room coolers to improve productivity during very hot daytime periods prevalent in much of Pakistan.
- **Solar water pumps could hold large, and currently untapped potential.** There are over 1.1 million irrigation pumping systems, of which only 30 percent run on electricity from the main grid and the remainder use diesel. Punjab is the province with the largest SWP potential, with more than 900,000 diesel and electric pumps. The provincial government of Baluchistan aims to convert 29,000 tube wells to solar (although the project has yet to launch). Most tube wells across the country currently use diesel-powered pumps, so the economics of replacing them with solar-powered pumps could be attractive.
- **The government has adopted and implemented quality standards for the import of solar equipment.** All pico solar PV products and lighting kits imported into Pakistan must be tested according to the IEC test methods i.e. IEC/TS 62257-9-5 and comply with Lighting Global quality standards. Equipment is tested at the point of import, and a confirmation of inspection and a certificate confirming the product conforms with standards must be provided at the point of origin.

Challenges to overcome

Both entry of new players and increasing the range and depth of existing providers will be key to drive a sustainable market to 2030.

- **Early attempts to stimulate investment from either the public or private sector yielded limited results.** For example, the IFC Lighting Pakistan program is transitioning out of the market, which will leave space for others to step in. One of the major early entrants in the market, Nizam Bijli (part of Nizam Energy), has also scaled back its off-grid activities since 2018.
- **The tradeoff between higher-quality, more expensive products and lower-quality, cheaper products, as well as tax policies for off-grid appliances, are hindering market growth.** While the potential demand for fans is large, the price of high-quality imported products, exacerbated by import duties of nearly 80 percent, makes them unaffordable for many households and small businesses. On the other hand, a local manufacturing industry for off-grid fans has emerged, though their low-quality and low- efficiency remains a problem.
- **Providing unconnected households with access to consumer finance will require a more mature microfinance sector or familiarity with PAYGo as a business model.** Microfinance institutions (MFIs) have typically focused on serving their existing customers with products with which they are relatively familiar, supporting investments, for example, in agriculture and livestock. Limited early-stage trials working with MFIs to provide loans for OGS products have shown some promise. PAYGo providers such as Eco Energy have learned from their experience over the last 10 years, in terms of both understanding their customers and providing more flexible repayment schedules to maximize repayment rates. Ensuring repayment from households using OGS alongside their grid connections can also present a challenge, since the need for OGS is highly seasonal and dependent on when the grid is available.

- **Low affordability and reachability among unconnected households means this customer segment remains heavily dependent on financial support.** Companies do not see the Pakistani market as commercially viable. On purely commercial grounds, the most attractive customer segments are micro-enterprises, where productive use of OGS products and appliances can generate revenue streams to support repayment and upgrades to the system. For SWPs, however, the vast majority (85 percent) of farmers operate on less than 10 hectares and cannot bear the upfront cost of an OGS system.

SPOTLIGHT

Photo credit: © Harness Energy

Serving Customers with "Low Access" to Energy from the Main Grid

Expenditure on alternative sources of energy in Pakistan is relatively high. The average household spends US$ 8.90 per month on a mix of technologies to secure lighting for their home.

While only 0.3 percent of grid-connected households are using a solar device, many use AC-rechargeable portable lights, nearly 40 percent use candles, 24 percent use dry-battery torches, and 20 percent use kerosene. The market for OGS products as a secondary source of power alongside the grid is large.

Companies are now providing a range of systems sized to meet this market, from small 50 watt systems up to 350 watts—and even as large as 1 kilowatt.

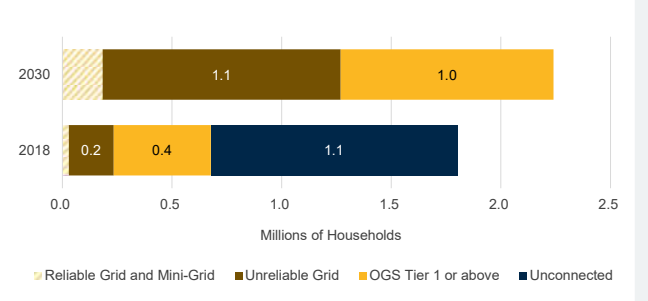
PAPUA NEW GUINEA

Population:	8.6 million people
GDP per capita 2018:	US$ 2,730
Electricity access rate (Tier 1 or higher) 2018:	38 percent
Current penetration of OGS:	60 percent
OGS potential 2030:	1 million households (OGS as main source) + 0.3 million (OGS as backup to weak grid)
Status:	Firmly established

Source: See note (a) in Country Annexes Introduction

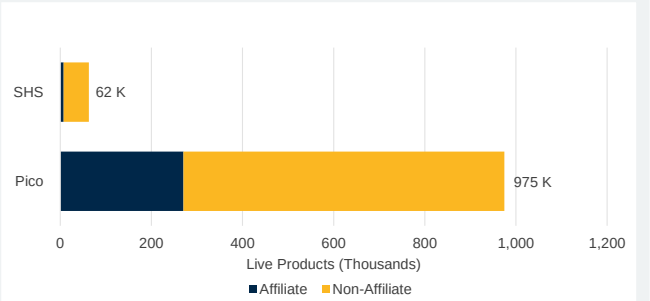
With a persistently low rate of grid electrification and high market penetration of OGS products to date, Papua New Guinea offers a large potential market for OGS products. Only 13 percent of the population has access to the main grid, and more than 80 percent of those with grid connections experience frequent outages.[536] At 60 percent, Papua New Guinea has one of the highest market penetration of OGS products in the world.[537] However, high transport costs and lack of consumer finance solutions present a challenge to wider-scale deployment of OGS products. Cheaper "generic" products comprise over 80 percent of OGS products in use in the country, typically sold in large retail stores as part of a broad product mix.[538] This high presence of cheap and often lower-quality products may reduce consumer satisfaction with, and trust in, OGS technologies, as they require repair twice as often as higher-quality products.

Primary Source of Electricity in 2018 and 2030 (of 2 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

The OGS market in Papua New Guinea currently has high market penetration and will grow even further as a result of population growth, difficulties extending the grid to remote areas, higher awareness of solar products, and the continued rapid growth of lot shops.

- **With 60 percent of all households now owning an OGS device—up from 2 percent in 2012—Papua New Guinea has experienced one of the fastest growth rates in market penetration in the world.** Sales have grown at an annual average rate of 68 percent,[539] comprising mostly non-affiliate and non-quality-verified

536 World Bank, Enterprise Surveys: What Businesses Experience, https://www.enterprisesurveys.org/en/data.

537 Tobias F. Engelmeier and Nabin Raj Gaihre, Going the Distance: Off-Grid Lighting Market Dynamics in Papua New Guinea (Port Moresby: Lighting Pacific, 2019), http://documents.worldbank.org/curated/en/802451567681915534/Going-the-Distance-Off-Grid-Lighting-Market-Dynamics-in-Papua-New-Guinea. The market penetration rate is based on a survey of 703 households covering nine districts across PNG's four regions. In all, 40 villages were visited, and 3,341 respondents surveyed.

538 Engelmeier and Gaihre, Off-Grid Market Dynamics.

539 Engelmeier and Gaihre, Off-Grid Market Dynamics.

products that deliver Below Tier 1 service. Sales are driven by low grid penetration and the high unreliability of the grid. In urban areas, people experience, on average, 42 outages per month of an average duration of 4.5 hours.[540] As a result of the low population density, challenging terrain, and correspondingly little road infrastructure, OGS is the most appropriate solution for electrification in many remote areas.[541]

- **The addressable market for OGS is expected to increase as population growth outpaces new grid connections.[542]** Currently encompassing more than 93 percent of Papua New Guinea's population (1.35 million households), the addressable market will grow at an annual rate of 2 percent per year.[543] Given an average spend of US$ 16 per month on lighting products per household, the annual market for lighting products in Papua New Guinea is an estimated US$ 259 million.[544]
- **District town (mid-mile) sales have grown very rapidly over the past three years due to increased sales through lot shops.** 42 percent of OGS products are purchased in large general stores known as lot shops, and all of this proportion comprises generic products. By contrast, quality-verified products are mostly sold on a cash basis through retail channels in large towns.[545]
- **Households have relatively high ability and willingness to pay for OGS products.** This even includes poorer households, which face a relatively high cost of alternatives like kerosene and grid electricity.[546]
- **Decent telecommunications penetration provides an opportunity to increase mobile payment schemes. Penetration rose from 2 per 100 inhabitants in 2009 to 48 per 100 today.[547]** Although some companies like BSP and Digicel offer mobile payment schemes, the adoption and use of mobile money services remains nascent.[548]

Challenges to overcome

The main challenges in the market concern high transport costs, a lack of supply chain to reach last-mile customers, and flooding of the market by low-quality generic OGS products.

- **Transport costs are high because of accessibility issues and low population density.** Much of the country comprises difficult-to-access mountainous terrain across 600 islands. At only 18 people per sq. km, Papua New Guinea is one of the least densely populated countries in the world, while Port Moresby, the capital and largest city, is cut off from road access to most of the country.[549]
- **Supply chain is lacking to reach last-mile customers.[550]** Most OGS distributors only sell their products at retail stores in the towns; villages are far from these outlets.
- **Papua New Guinea is largely a cash-based society, making it costly and time-consuming for OGS providers to collect payment.** 82 percent of customers purchased their OGS product with cash, while 17

540 World Bank, Enterprise Surveys.

541 Open Capital and Vivid Economics consultation with stakeholders.

542 World Bank, "Project Information Document / Integrated Safeguards Data Sheet," Energy Utility Performance and Reliability Improvement Project (P167820), January 15, 2019, http://documents.worldbank.org/curated/en/909801547764581895/pdf/Concept-Project-Information-Document-Integrated-Safeguards-Data-Sheet-Energy-Utility-Performance-and-Reliability-Improvement-Project-P167820.pdf; and Engelmeier and Gaihre, Off-Grid Market Dynamics.

543 Engelmeier and Gaihre, Off-Grid Market Dynamics.

544 Engelmeier and Gaihre, Off-Grid Market Dynamics.

545 Engelmeier and Gaihre, Off-Grid Market Dynamics.

546 Consumer affordability of grid electricity in Papua New Guinea (both tariffs and connection fee) is relatively low compared to other countries. ESMAP, Regulatory Indicators for Sustainable Energy (Washington, DC: World Bank, 2018), http://documents.worldbank.org/curated/en/553071544206394642/pdf/132782-replacement-PUBLIC-RiseReport-HighRes.pdf.

547 World Bank, Databank, s.v. "Mobile Cellular Subscriptions (per 100 People)," https://data.worldbank.org/indicator/IT.CEL.SETS.P2.

548 Catherine Highet, Michael Nique, H. A. Watson, and Amber Wilson, Digital Transformation: The Role of Mobile Technology in Papua New Guinea (London: GSM Association, 2019), https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/03/Digital-Transformation-The-Role-of-Mobile-Technology-in-Papua-New-Guinea.pdf.

549 World Population Review, "Papua New Guinea Population 2018," http://worldpopulationreview.com/countries/papua-new-guinea-population/.

550 Engelmeier and Gaihre, Off-Grid Market Dynamics.

percent received their OGS product as a gift through the Wantok system.[551] PAYGo and other consumer-financing schemes through banks and microfinance have been limited to date because agent networks and mobile-money infrastructure are limited.[552]

- **The high penetration of cheaper "generics" erodes consumer trust in the OGS market.** These products, which currently face no quality regulations and are therefore susceptible to malfunction, are often preferred by consumers due to their far cheaper price. This erodes the potential market and profitability for quality-verified technology providers.[553] There is a need to further improve consumer awareness of the difference between quality-verified and non-quality-verified products and where they can buy quality-verified products.[554]
- **Obtaining foreign currency is difficult, presenting a challenge for international businesses.** The paucity of foreign exchange in the country makes it difficult for importers to pay for quality-verified products in U.S. dollars or other hard currency, leading to delays and lost business opportunities.[555]

SPOTLIGHT

Photo credit: © IFC

PAYGo or Partnerships to Provide Consumer Finance Alongside OGS Are Key to Growing the Market

PAYGo solutions or partnerships with banks, especially rural banks, or telecommunications companies could boost the OGS market in Papua New Guinea and unlock latent demand for larger and (productive use) systems that are currently unaffordable in cash. PAYGo would relieve barriers derived from households' low banking rate (75–80 percent are still unbanked). OGS providers can onboard households to mobile money platforms, simultaneously increasing financial inclusion. Partnerships with MFIs could be another alternative to reach last-mile customers.

551 The Wantok system refers to the tribal (linguistic) roots of a person, called the "Wantok" ("one talk"). If one member of a Wantok faces difficulties, other members are obliged to assist in any way they can.

552 Engelmeier and Gaihre, Off-Grid Market Dynamics.

553 Open Capital and Vivid Economics consultation with stakeholders.

554 As part of the Lighting Papua New Guinea campaign, Lighting Global has reached out to more than 3.2 million potential customers, in addition to more targeted campaigns that reached close to 85,000 people and SMS outreach to around 200,000 people.

555 Engelmeier and Gaihre, Off-Grid Market Dynamics.

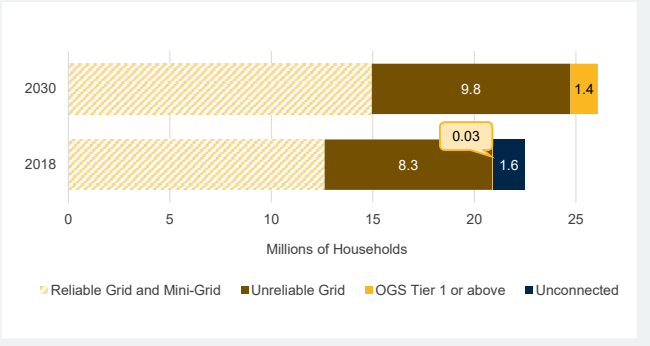
PHILIPPINES

Population:	106.7 million people
GDP per capita 2018:	US$ 3,103
Electricity access rate (Tier 1 or higher) 2018:	93 percent
Current penetration of OGS:	4 percent
OGS potential 2030:	1.4 million households with OGS as main source) + 2.4 million with OGS as backup to weak grid)
Status:	Pioneering

Source: See note (a) in Country Annexes Introduction

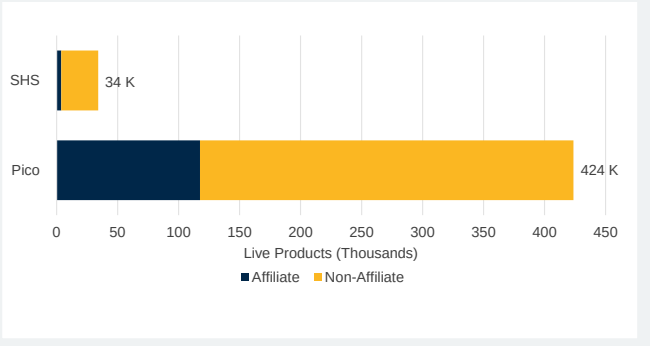
While most households are reached through the main grid and mini-grids, standalone OGS technologies could serve as a primary source of electricity for remote, poor households in the archipelago, especially fragile islands. OGS systems currently provide electricity to just 3 percent of households.[556] In H2 2018, GOGLA affiliate sales reached almost 40,000 units, of which 44 percent were sold under the PAYGo business model, mostly solar lanterns with mobile charging.[557] Most electrification through OGS is currently driven by distribution utilities under a fee-for-service business model.[558]

Primary Source of Electricity in 2018 and 2030 (of 26 Million Total Households in 2030)



Source: See note (b) in Country Annexes Introduction

Live Off-Grid Solar Products in the Market as of 2019 (Thousands)



Source: See note (c) in Country Annexes Introduction

Emerging opportunities and successes

OGS technologies are a well-suited alternative to the main grid to serve a population dispersed across the archipelago.

- **The government's household electrification plan aims for 100 percent electrification by 2021–22, with opportunities for OGS to reach remote areas.** Most of the 2.6 million remaining un-electrified households are located in the remotest areas of the country and can therefore not be reached by the grid. Moreover, population growth will outpace electrification, which means that acceleration across both grid-based and off-grid technologies will be required to reach universal access.[559]

556 Catalyst Off-Grid Advisors and E3 Analytics, Energizing Finance: Taking the Pulse 2019 (Vienna: Sustainable Energy for All, October 22, 2019), https://www.seforall.org/publications/energizing-finance-taking-the-pulse-2019.

557 GOGLA and Lighting Global., Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data H2 2018 (Utrecht: GOGLA, May 2019), https://www.gogla.org/resources/global-off-grid-solar-market-report-h2-2018-sales-and-impact-data.

558 SE4All (2019), 'Energizing Finance: Taking the Pulse'

559 Catalyst Off-Grid Advisors and E3 Analytics, Energizing Finance.

- **Off-grid electrification is supported by international donors, who aim to make OGS affordable for poor, remote households.** Under the US$ 15.8 million World Bank ASEP – PV Mainstreaming program, the World Bank aims to help the Philippine Department of Energy to achieve universal access for all by making SHS affordable for remote communities.[560] The program comprises public tenders implemented in partnership with electric cooperatives. Similarly, under the EU ASEP program, the EU has allocated a grant of more than US$ 3 billion to assist the Philippine Department of Energy to meet its rural electrification targets, with US$ 60 million provided for rural off-grid solar.[561]

Challenges to overcome

Regulatory challenges, an inability to access finance, and a market dominated by (mini-) grids delivered by public electric cooperatives make OGS less attractive for private companies.

- **The economics of reaching the last mile via OGS are unattractive for most private companies.** The areas are hard to reach (which makes maintaining the systems expensive), affordability is low, and public funding for private companies is difficult to access. Through the ASEP programs, the World Bank and the EU aim to help companies reach these "unviable" consumers through public procurement in partnership with local electric cooperatives. As such, they support the sector by setting fee-for-service regulatory frameworks and building capacity in local electric cooperatives to partner with the private sector.
- **A lack of technical capacity regarding OGS leads many electrical cooperatives to exclude OGS from their annual electrification plans.** As a result, these plans tend to focus on grid extension planning. The World Bank has offered further assistance incorporating OGS into this planning on a pilot basis with select cooperatives. Implementing such programs will be crucial to developing electrical cooperatives' capacity around OGS.
- **The Philippine appliance market still remains largely driven by AC products.** Most appliances run on AC, and all technicians are trained for AC. This limits the options to connect currently sold appliances to (larger) OGS systems.[562] Programs to train technicians in DC appliances and solar systems are needed to overcome this challenge.

SPOTLIGHT

Government program is driving solar water pump market for remote farmers

Both on national and regional level, the government is tendering solar pumps as part of the agricultural mechanization law, with over 400 units now installed across the country. All products need to pass through a certification system to ensure a robust design. The Department of Agriculture selects farmer beneficiaries, usually cooperatives, which means the number of pumps and logistics of installing these is included in the bid. The government pays for installation, after which the pump is owned and maintained by the cooperatives.

Photo credit: © One Renewable

560 ASEP stands for Access to Sustainable Energy Project. World Bank, "Philippines: World Bank Approves Two Projects to Expand Electricity Access for Poor, Remote Households," news release, May 12, 2016, https://www.worldbank.org/en/news/press-release/2016/05/12/philippines-world-bank-approves-two-projects-to-expand-electricity-access-for-poor-remote-households.

561 Tom Kenning, "EU Provides €60 Million for Remote Off-Grid Solar in the Philippines," PV Tech, November 8, 2018, https://www.pv-tech.org/news/eu-provides-60-million-for-remote-off-grid-solar-in-the-philippines.

562 Open Capital Advisors and Vivid Economics consultations.

Appendix B: Consultations for the MTR 2020

This report is produced by Lighting Global, GOGLA, and ESMAP, in collaboration with Vivid Economics and Open Capital Advisors.

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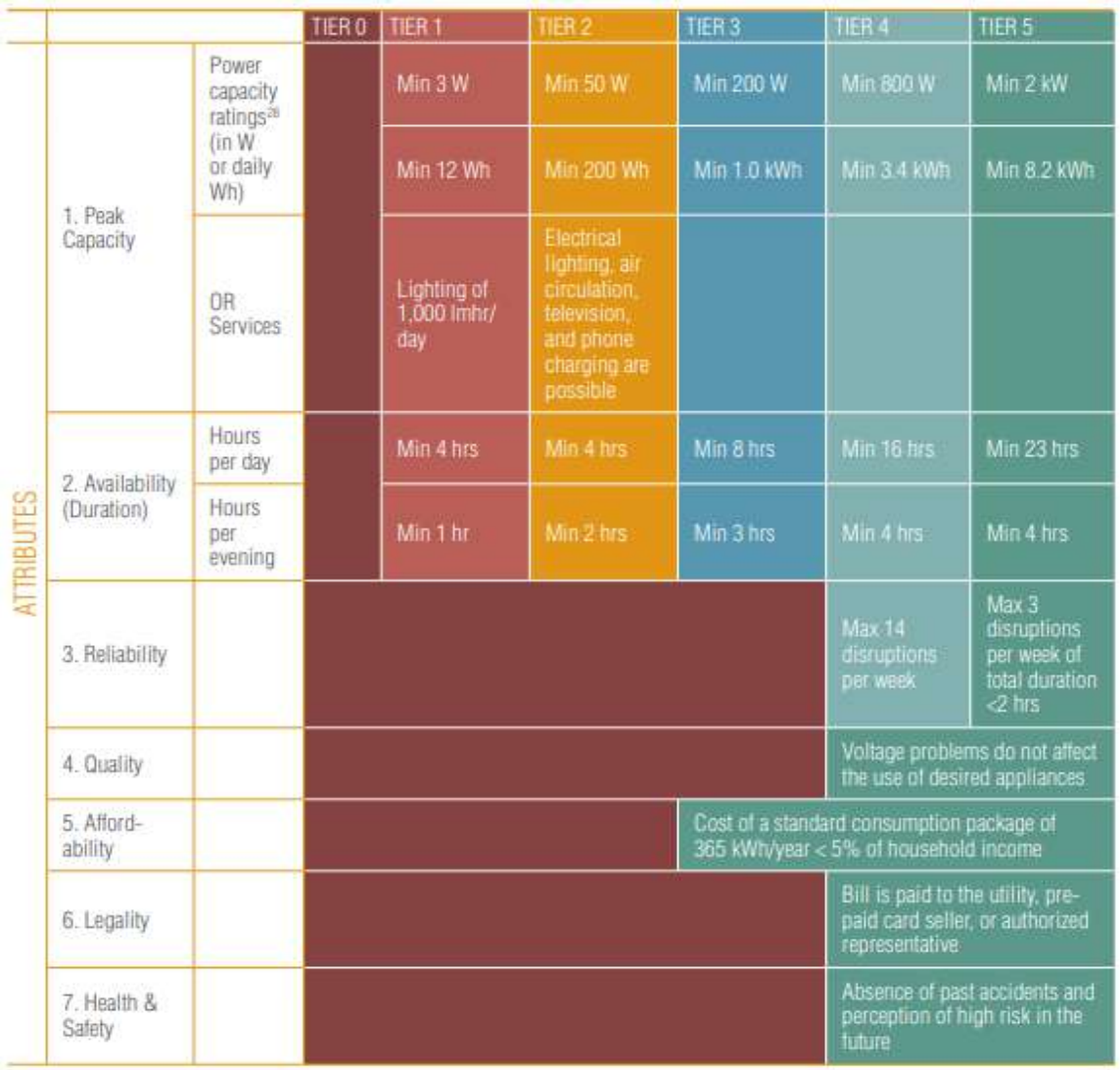
Appendix C: The Multi-Tier Framework

Figure 95: Multi-tier Matrix for Measuring Access to Household Electricity Supply



Source: Mikul Bhatia and Nicolina Angelou, Beyond Connections: Energy Access Redefined

Appendix D: Methodologies

Box 26: Methodology used to estimate the total market size for off-grid solar products

1. **Estimate total off-grid product penetration by country:** From MTF household data on solar product ownership and census data on population and household demographics, estimate total solar product penetration at the national level.
2. **Estimate total live pico and SHS systems per country:** Use MTF data on solar panel wattage to categorize household products into two main segments: pico (<11 Wp) and SHS (11+ Wp).
3. **Estimate live affiliate products per market:** Obtain data from GOGLA on live affiliate products per country; calculate live pico and SHS affiliate products per country.
4. **Estimate annual affiliate vs. non-affiliate proportions of sales:** Compare live affiliate products (from Step 3) to total live solar products estimated from the MTF database to calculate the share of affiliate products in each market.
5. **Triangulate market share estimates with known sources (where available):** Use reports such as Lighting Global / Ipsos market research reports, country-specific market reports, Bloomberg New Energy Finance (BNEF) 2016, and the 2018 market trends report to verify estimates.
6. **Calculate global estimate:** Use the percentage affiliate market share estimate to scale affiliate pico and SHS sales figures to total global products sold.

Appendix E: Lighting Global Quality Assured Product List (January 2020)

For over a decade, Lighting Global has supported the global market for modern off-grid energy through its widely adopted, rigorous Lighting Global Quality Assurance framework for pico-PV products and SHS kits. The Lighting Global Quality Standards and quality verification process form the internationally-recognized baseline for product quality and integrity that all market actors can trust. **The following products have met the Lighting Global Quality Standards.**

As the off-grid energy market has matured beyond lighting, so has the need for quality assurance. To meet the needs of this fast-growing sector, Lighting Global announced the launch of VeraSol, an evolved program of Lighting Global Quality Assurance, in February 2020. VeraSol maintains the strong foundation for quality assurance laid by the World Bank Group, providing quality verification services, comparable product data, and technical assistance to governments and institutions. To better serve consumers, companies, governments, and the market, VeraSol has expanded the technical foundations for appliances and productive uses and plans to extend these services in the future.

VeraSol imagines quality assurance as a broad foundational platform owned by a collective group of stakeholders. Under the operational leadership of CLASP and its long-time partner, the Schatz Energy Resource Center, VeraSol will build collective ownership across an expanded group stakeholders. Foundational support is provided by the World Bank Group's Lighting Global program, UK DfID, IKEA Foundation, and others.

Over a one-year period, all quality assurance services, including verification and product listings, will be transitioned and operated under VeraSol. To minimize confusion and market disruption during this transition, the VeraSol program will be co-branded with Lighting Global. Lighting Global will remain a program of the World Bank Group and continue to operate all market and business development services.

For more information please visit VeraSol.org

A4&T

Voltze Escort G3 Solar Power Lantern

AL Furaat Solar Tech Manufacturing P.L.C.

Solar Light System

All Solar Lights

All Solar Lights

All Solar Lights Family

Amped Innovation PBC

WOWsolar Family

WOWsolar TV

WOWsolar 60

Azuri Technologies, Ltd.

10W Quad Solar Home System

Azuri 50W TV120 Solar Home System

Azuri Quad 15W Solar Home System

Barefoot Power Pty Ltd.

Connect 3000 Li

Go 250 / Go 255

BBOXX

bPower

bPower50

BeeBeeJump Technology Co., Ltd.

P1T Solar Energy Storage System

BioLite Inc.

Solar Home 620

Bright Products

Bright Move

Bright Move Smart

Bright Start and Bright Start +

SunTurtle

SunBell 2.0Y

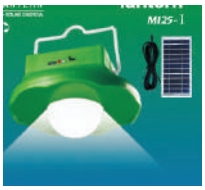
SunBell Smart and SunBell Smart PAYG

SunBell SmartY

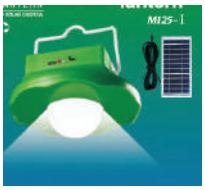
Chaohu Venus Solar Technology Co.

Solar Home Light Kit (VEK-8L)

Solar Lantern M125-I



Solar Lantern M125-II



VEK Family

d.light design

A2 Solar Lantern

d.light design cont.

D1XX Family

D30

D330

D3XX Family

S3 Solar Lantern

S30 Solar Lantern

S500

S50X Family

SHS Family

Solar Home System D100

Solar Lantern S200

Solar Lantern S600 / S610

Solar Lantern S670

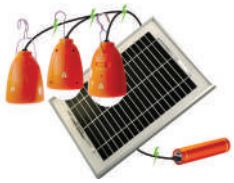
Solar Lantern T200

T2XX Family

X850

EcoZoom

EcoZoom Multi Light



EMEL Solar Solutions Limited

EMEL Solar G3 Solar Power Lantern

Engie Mobisol GmbH

Mobisol Bright Future 200W SHS - 32″TV

Mobisol Family SHS

Mobisol Solar Television System Family

Solar Television System

Fenix International

SmartLife

Fosera Group

Fosera Mobile One

LSHS 10500

LSHS Family

Pico Solar Home System (PSHS) Family

Pico Solar Home System 7500

Freeplay Energy

Radiance Solar Lantern

Frontier Markets

Solar Rakshak Plus

Greenlight Planet

SSun King Boom

Sun King Charge/ Sun King Pico 50

Sun King Home 120/ Home 120 Easybuy

Sun King Home 400 Family

Sun King Home 400 easybuy

Sun King Home 40Z

Sun King Home 60 / Home 60 Easybuy

Sun King Home Family

Sun King Pico Plus

Sun King Pro 2

Sun King Pro 200

Sun King Pro 300

Sun King Pro 400

Sun King Pro All Night

Sun King Pro Easybuy

Sun King Pro X Plus

Havell India

Enviro SL36

JUA Energy

Free Light L1

Home Mate Family

Home Mate H1 / Home Home Mate H1G

Home Mate H2G

Lagazel

Lagazel Kalo 600

Lagazel Kalo 1500

Lagazel Kalo 3000

Little Sun GmbH

Little Sun Diamond

Little Sun v.4

Charge 4400

Micergy Company Limited

Micergy Powerlink Series MP1T

M-KOPA Solar

M-KOPA 5

Namene Solar Light Company

SM100 Solar Light

Ningbo Zhengzheng Electric Appliance Co., Ltd.

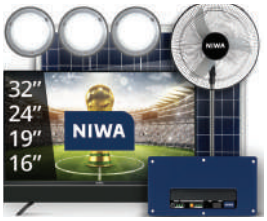
Solar Lighting System

NIWA - Next Energy Products Ltd.

Energy 50

Multi 300XL

Product Family Name: Energy 50



Starlight ONE

Starlight ONE (rev0)

Uno 50

NOTS Solar Lamps

MUTIMAX Solar System (MSS)

Nova Lumos, Ltd.

Solar Power Station

NRS Relief FZE

Enlight Essential

Solar Smart All-in-one/Solar Shelter Kit

OffgridSun

Energy Station Family

Energy Station Plus

Omnivoltaic Energy Solutions Co. Ltd.

L190 Solar Lantern

LUMN L500

LUMN M600

LUMNS Family

ovCamp HS2-144_LB2244

ovCamp HS2-36_LB1122

ovCamp Solar Home Systems

ovCatch Fishing Lamp

ovSolar Power Company Limited

Home Power

HP30B

ovBeacon MB2 – 200

ovBeacon MB2 – 290

ovBeacon MB2 – 380

ovBeacon MB2-160

Panasonic Corporation

Solar Lantern

Philips

LifeLight

Poly Solar Technologies (Beijing) Co., Ltd.

10 W Solar Home System (PL-10-H-W)

SHS Family

Solar Home System

Solar Power Supply System

Power Equation

G1 Solar Power Lantern with Phone Charger

G3 Solar Power Lantern

Qingdao Leff International Trading Ltd.

Solar Lighting Kit (SLF-01)

Solar Lighting Kit (SLF-02)

Qotto SAS

Solar Home System

Rahimafrooz Renewable Energy Limited

SUNFLO Pico PV System (SF-P0830)

SUNFLO Pico PV System (SF-P1030WR)

SUNFLO Family

Renewit Solar Limited

G1 Solar Power Lantern with Phone Charger

G3 Solar Power Lantern

Large Home Power Station for SolarTV

Solar Homework Light

Schneider Electric Industries SAS

MobiyaTS170S andTS170L

Mobiya Lite

Shanghai EASY Renewable Energy Co.

Solar Lantern M125-I

Solar Lantern M125-II

Solar Home Light Kit (VEK 8L)

VEK Family

Venus SHS Family

Venus Solar Home System

Shenzhen JCN New Energy Technology Co., Ltd.

Solar BT Speaker System

Shenzhen LEMI Technology Development Co., Ltd.

10 W Solar Home System

30 W Solar Home System

SHS Family

Shenzhen Solar Run Energy Co. Ltd.

Apollo 9 Solar Home System

Apollo Family

Solar 4 Bulbs Home Lighting and Charging System

Solar Home Lighting System (SR05)

Solar Home Lighting System (SR06)

Solar Reading Lamp

Solar Torch

SR06 Family

YelloBox Family

YelloBox Solar Home System

YelloBox T1 Solar Home System

Sinoware Technology Co., Ltd.

SunAce II

SunAce II Family

Smarter Grid International Ltd.

Smarter Catch

Smarter Home HS2-36_LB1122

Smarter Home Family

Smarter Home HS2-144_LB2244

Solar Panda Corporation

Solar Panda Family

Solar Panda Home Kit

The Solar Warehouse Ltd.

savvy solar lighting kit (slk6020)

savvy solar lighting kit (slk6050)

savvy solar lighting kits-family

Total

Family Sunshine

Home Sunshine Family

Home Sunshine

Little Sunshine

Villageboom GmbH

Villageboom High Power +

Villageboom Family

Zimpertec

Litio SHS Kit / LS7000-K020

Zimpertec SHS Family

CHAPTER 8
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