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Off-Grid Solar Market Trends Report 2022:

Outlook

LIGHTING GLOBAL
Catalyzing markets for modern off-grid energy

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

ESMAP
Energy Sector Management Assistance Program

GOGLA

EFFICIENCY FOR ACCESS

Open Capital

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Off-Grid Solar Market Trends Report 2022

Outlook

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Lighting Global is the World Bank Group's initiative to rapidly increase access to off-grid solar energy for the 733 million people living without electricity world-wide. Managed by the Energy Sector Management Assistance Program (ESMAP), we work with governments, the private sector, development partners, and end-users, continually innovating to unlock key market barriers and enable access and affordability to those that would otherwise be left behind. Our support has expanded to technologies that go far beyond lighting, including systems to power the needs of households, businesses, schools, and health centers. We operate with funding gratefully acknowledged from ESMAP and their donors. For more information, please visit www.lightingglobal.org

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Abbreviations

ACE	Africa Clean Energy
AGG	Africa Go Green Fund
AI	Artificial intelligence
B	Billion
BoP	Bottom of the pyramid
CaaS	Cooling-as-a-Service
CO2e	Carbon dioxide equivalent
COGS	Cost of goods sold
DFI	Development finance institution
D-REC	Distributed Renewable Energy Certificate
EforA	The Efficiency for Access Coalition
ESMAP	The Efficiency Sector Management Assistance Program
EUS	End-user subsidy
FCV	Fragility, conflict, and violence
GDC	The Global Distributors Collective
GCF	The Green Climate Fund
GHG	Greenhouse gas
IoT	Internet of things
kWh	Kilowatt-hour
LED	Light-emitting diode
LMD	Last mile distributor
LPG	Liquefied petroleum gas
M	Million
M&A	Mergers and acquisitions
MCA	Micro carbon avoidance
MEM	Modern energy minimum
MTF	Multi-Tier Framework
MTR	Market Trends Report
NDC	Nationally Determined Contributions
NEP	National Electrification Plans
OGS	Off-grid solar
PAYGo	Pay-as-you-go
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Scheme
PUE	Productive use of energy
REC	Renewable Energy Certificates
RBF	Results-based financing
R&D	Research and development
SaaS	Software-as-a-Service
SDG7	Sustainable Development Goal 7
SEA	Southeast Asia
SEK	Solar energy kit
SHS	Solar home system
SIDA	The Swedish International Development Cooperation Agency
SPV	Special purpose vehicle
SSA	Sub-Saharan Africa
SWP	Solar water pump
$	United States Dollars
T	Trillion
UNICEF	The United Nations International Children's Emergency Fund
VAT	Value added tax
W	Watt
Wp	Watt-peak

Context & Key Definitions

For more than a decade, the biennial Off-Grid Solar (OGS) Market Trends Report (MTR) has been the anchor of the World Bank Group/GOGLA franchise of market data and trends reports, which are the go-to source of OGS sector information for investors, industry members, policymakers, and other stakeholders. The series includes semi-annual reports that track sales and impact results by country, region, and worldwide for VeraSol quality-verified products and other branded solar devices sold by GOGLA affiliates. The MTR is where we step back and dive deep into trends in the sector, alongside new research and data, to further understanding among market players and illuminate the pathway forward.

Terms	Definitions
Off-grid solar products	Off-grid solar products include both solar energy kits and off-grid solar appliances and this term is used in the report to describe the breadth of technologies that it covers. See definitions below.
Solar energy kits (SEKs)	These include solar lanterns, multi-light kits and solar home systems (SHS). • **Solar lanterns** are typically packaged as a simple, one-light lantern with an LED light, an embedded 0.5–3.0 Watt-peak (Wp) solar panel, and an internal rechargeable lithium-ion (Li-ion) battery. Some models include USB charging for mobile phones. • **Multi-light systems** include up to three or four LED lights with a standalone solar panel rated up to 10 Wp and a rechargeable Li-ion battery with most models including USB charging for mobile phones. • **Solar home systems (SHS)** have a solar panel rated from 11 Wp to usually up to 350 Wp and provide multiple electricity functions, such as lighting and powering a wide range of appliances such as TVs and fans. SHS are offered plug-and-play (PnP) or based on open-market components. In this report, SHS refers to both plug-and-play and component-based systems unless specified.
Off-grid solar appliances	These include solar-powered appliances which are energy-efficient and powered by direct current (DC), and include both household/small business appliances and productive use of energy (PUE) appliances. • **Household and small business appliances** are typically used within a home and include televisions, fans, refrigerators and radios. In some cases these products are used in small businesses, such as refrigerators in a shop. Note: a significant majority of solar-powered TVs and a proportion of fans are typically sold bundled with SHS especially in sub-Saharan Africa. • **Productive use of energy (PUE) appliances** are appliances that leverage solar energy to enable improved or new income generating activities, often in agriculture. These products include solar water pumps, refrigerators/cold rooms or agro-processing equipment.
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 (SEforALL) 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. The MTF redefines electricity 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 considers additional aspects, such as reliability and affordability. Electricity access is measured on a tiered spectrum, from Tier 0 (no access) to Tier 5 (the highest level of access).
Rural	Encompasses all population, housing, and territory not included within an urban area.
Urban	Encompasses all population, housing, and territory included within an urban area.

Terms	Definitions
Unconnected households	Households that are not connected to national grids.
'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.
Households with unreliable/weak 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.
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 report analyzes 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 (typically solar home systems and multi-light kits) 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-Verified	'Quality-Verified' products meet VeraSol (formerly Lighting Global) Quality Standards, which are minimum requirements for off-grid lighting product quality, durability, truth-in-advertising, warranty, and lumen maintenance.[1] VeraSol provides Quality Standards for both solar lanterns and multi-light systems and SHS up to 350 W, and compliance is required to participate in VeraSol support programs. Quality Standards are one component of the VeraSol Quality Assurance Program. The International Electrotechnical Commission (IEC) has adopted the VeraSol testing methods as Technical Specification 62257-9-5. 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 VeraSol 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 VeraSol quality standards, but stakeholders assume that all products affiliate companies produce are of reasonably decent 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.
Modern Energy Minimum (MEM)	Modern energy minimum is a benchmark that envisages annual per capita household energy consumption of 1000kWh, inclusive of 300kWh household consumption and 700kWh for non-household consumption.[2]

1 *Verasol (2022), Answering Your Frequently Asked Questions About VeraSol. Note: Verasol Quality Standards were previously referred to as Lighting Global Quality Assurance Standards.*

2 *Rockefeller (2021), The Modern Energy Minimum: The Case for a New Global Electricity Consumption Threshold.*

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1.1B people need to be electrified by OGS to reach SDG7

1.1 billion people need to be electrified by off-grid solar (OGS) systems to reach SDG7. This includes 493 million current OGS users who are expected to continue replacing and upgrading systems, 464 million new OGS customers who will use OGS products as their main energy source, and 186 million new OGS customers who will use their products to complement grid electricity. 416 million of the 464 million new OGS users will reside in nascent and emerging markets, primarily in sub-Saharan Africa.

516M people will not be reached under projected sector growth

Given sector growth trends, 624 million people are projected to be connected to Tier 1 and above electricity access by 2030 via OGS solutions – this is 516 million fewer than the SDG7 scenario.[3] Under this projected scenario, the sector is expected to grow by 5% annually. Depending on sector interventions, the sector could grow as fast as 7.2% annually or as slow as 2.8%.

A projected $15.5B funding shortfall of what is needed to reach SDG7

Based on historical sales and investment trends, the sector is projected to raise $7.8 billion between now and 2030 – this is $15.5 billion short of what is needed to reach SDG7. Significant capital is needed to seed companies, foster growth in new markets, and promote the transition to Tier 1 access for users currently below the minimum threshold of electrification. Crucially, this investment must be deployed alongside game-changing sector interventions to achieve SDG7.

$4.5B will be needed to address the affordability gap

$4.5 billion is needed just to close the affordability gap to be able to reach SDG7. Studies confirm that end-user subsidies can be successfully disbursed to improve affordability, but given the persistent affordability challenge of the large underserved populace, an increase in the scale of well- designed and funded end-user subsidy programs is needed, particularly in underserved markets. Other non-customer revenue sources such as carbon credits could also help companies to bridge this affordability gap.

More supply-side subsides are needed for harder-to-reach markets

Stakeholders must develop interventions that acknowledge both the development agenda of the sector and the commercial potential. An increase in supply-side subsidies and concessional finance is needed to support the OGS sector's contribution to universal access by 2030. Despite an uptick in results-based financing disbursements, more supply-side subsidies are needed alongside private investment so that companies can serve the hardest to reach while also operating viable businesses.

3 *Note: The universal access shortfall includes: [1] 234 million people who will remain unelectrified by 2030 and, [2] 453 million people who will be using below Tier 1 SEKs to access electricity.*


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Introduction

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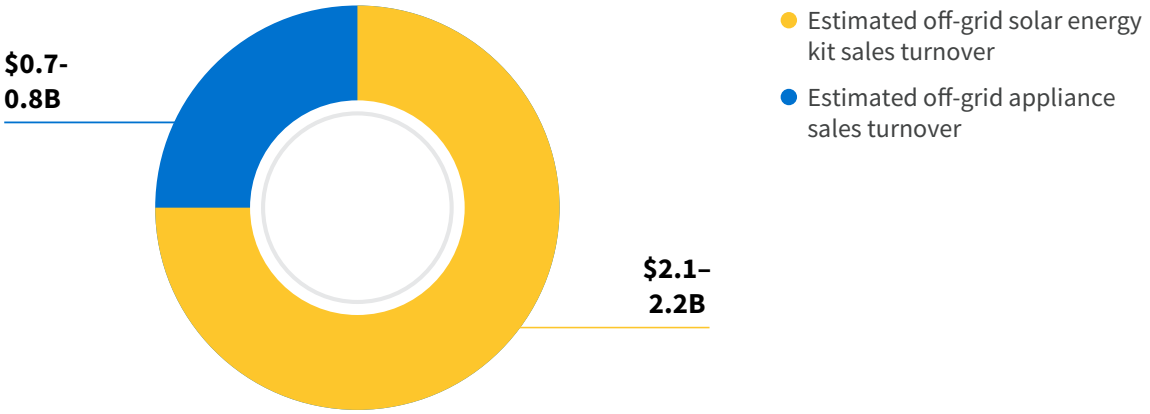
Introduction

The OGS market provides energy services to 493 million people. The market's annual turnover is now approximately $2.8 billion, covering a wide range of SEKs and off-grid appliances. The SEK market now has a $2.1 billion annual turnover, while the off-grid appliance market now has a $0.7 billion annual turnover.[4] Given that the sector's early business models developed just over a decade ago, these figures reflect a substantial and growing market.

Figure 1: Estimated off-grid solar energy kit and appliance market turnover, annual (2021)[5]



Estimated off-grid solar kit sales turnover includes ~4% worth of TVs & fans sold bundled with solar home systems in sub-Saharan Africa.

The OGS sector remains robust, with 493 million people currently using off-grid solar technologies as their primary source of electricity, for back-up connections, and for productive use.

Like other sectors, the OGS sector was impacted negatively by the COVID-19 pandemic, resulting in decreased sales and market turnover. COVID-19 response measures limited company movements, pressured supply chains that resulted in price increases, and lowered income levels for consumers. As a result, unit sales of SEKs declined 21% from 2019 to 2020, while market turnover decreased by 14%. Year-on-year, appliance sales volumes and turnover also decreased, with declines especially in cash sales of appliances.[6]

Since 2021, the sector has shown early signs of recovery. Solar energy kits recorded a 10% increase in sales from 2020 to 2021 and a 7% increase in market turnover, with a correspondingly faster rebound in the sales of lower-cost single light with mobile phone charging and multi-light systems, compared to sales of higher-cost SHS. Cash sales for SHS products also remain depressed, negatively impacting the sector's market turnover.

Despite a slowdown of OGS sales, total financing commitments for the sector since 2012—comprising debt, equity, and grants—surpassed $2 billion. From 2016 to 2020, yearly investment volumes plateaued between $300 and $350 million, but investment reached $457 million in 2021, driven mainly by debt financing for the industry's largest companies.[7] Productive Use of Energy (PUE) companies, representing a relatively new market segment,

4 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

5 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector.'*

6 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

7 *Ibid.*

attracted almost 10% of total investment volume in 2021 ($44.9 million).[8] 2022 will likely be another record year in terms of investment volumes.

In line with affordability levels of target customers, a single light with mobile phone charging as well as multi-light systems still comprise the vast majority of sales in the sector, though uptake of higher-capacity systems continues to grow. The COVID-19 pandemic widened the affordability gap for many and has accelerated the trend whereby companies increase sales of higher-tier systems to ensure the health of their loan portfolios and protect their bottom lines. Sales of larger SEK systems (Tier 1 or higher) and sales to populations with weak grid connections highlight the importance of the sector to support customers as their energy needs increase over time, to enable productive uses of energy, and also to improve reliability of electricity access.

The OGS sector is a major contributor to SDG7, providing access to solutions that provide a wide range of energy services.

OGS products remain a cost-effective solution to electrify millions of off-grid homes and businesses. OGS has been identified as the least-cost solution to electrify 464 million more people, including a portion of the 733 million people currently without access as of 2020, and accounting for population growth between now and 2030.[9]

The sector is increasingly recognized as vital to achieving global electrification goals. OGS products can be deployed faster than main grids and mini-grids, and can more cost-effectively service smaller loads. As a result, they are estimated to be the most cost-effective and feasible solution for 55% of new household electricity connections over the next five years (estimates from 2020 to 2025).[10] This has become evident over the last 2 years, as at least 12 additional governments have incorporated OGS into their integrated electrification plans, and many more have launched rural electrification initiatives.[11]

As a result, the OGS sector is poised to play a significant role in achieving the electricity access goals under Sustainable Development Goal 7 (SDG7). SDG7 aims to ensure 'access to affordable, reliable, sustainable and modern energy for all', and includes five specific targets for 2030.[12] Beyond these access goals, SDG7 also aims to increase the proportion of renewable energy in the generation mix and improve energy efficiency, with indicators for funding flows, and the proportion of renewable energy-based generation for developing countries.

Besides providing primary electricity access, the OGS sector also plays a significant role providing backup solutions to weak grid customers, supporting the reliability of access under SDG7.[13] As of 2020, an estimated 775 million people globally are connected to grids that provide low levels of availability or reliability, causing hundreds of hours of outages that impact daily lives and hinder economic activity.[14] OGS will continue to play an important role to customers of these weak grid connections, customers that already comprise a significant share of OGS sales in some markets.

The OGS sector can provide end users with a range of systems that provide differing "Tiers" of electricity access. SDG7 considers Tier 1 electricity access as the minimum bar for electrification, which in practice equates to an SEK product that is at least a 3 Watt-peak multi-light system.[15] Tier 1 access, however, is just the first step in moving people onto the energy staircase. As electricity demand grows over time and people gain access to larger systems, they move towards higher levels of services (see Figure 2).

8 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

9 *Estimate based on analysis of the Global Electrification Platform, 'Low Demand' scenarios.*

10 *Ibid.*

11 *United Nations, United Nations Framework Convention on Climate Change Secretariat (n.d.) NDC Registry. Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector. ESMAP (2022), Tracking SDG7: The Energy Progress Report: Access to Electricity.*

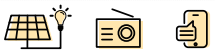
12 *United Nations, United Nations SDG Goals: SDG7 Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for All.*

13 *Note: This report defines unreliable grid as frequent or lengthy outages of grid electricity or voltage fluctuations that can damage electrical appliances.*

14 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector. Note: This is an estimate of back-up OGS users and potential SEK customers.*

15 *IEA (2022), Tracking SDG7: The Energy Progress Report.*

Figure 2: Level of service provided for different Tiers of electricity access[16]

Tiers	Medium peak capacity	System Availability (Hours)		Products
		Day	Night	
Partial Tier 1	Below 3W			
Tier 1	3W	4	2	
Tier 2	50W	4	2	
Tier 3	200W	8	3	
Tier 4	800W	16	4	
Tier 5	2kW	23	4	

Note: [1] The icons represent possible product options that could be powered in the different tiers of energy access depending on the users' needs. For example, in Tier 3 a user could have a refrigerator or a solar water pump. [2] Tiers, as highlighted in the graphic, describes either the minimum peak capacity or the system availability.

The OGS sector is critical to support a clean and just energy transition, as well as other sustainable development goals.

Beyond supporting SDG7, OGS can also support the attainment of a host of other development goals including SDGs for health, hunger, climate action, education and income.[17] For example, many OGS systems today are being used to generate income and increase food production (SDGs 1 and 2), and to date, the sector has contributed to avoiding 190 million metric tonnes of CO2e emissions (SDG13), and saved fuel costs of $26 billion by switching from dirty fuels to solar SEKs (SDG1).[18]

Larger-tier systems that enable the productive use of energy, particularly in agriculture, can unlock more economic activities. For example, solar water pumps reduce domestic labor, which can save time for the 14 million women in sub-Saharan Africa (SSA) who spend an average of 30 minutes a day fetching water, contributing to SDG5 (gender equality) and SDG10 (reduced inequalities).[19] They also increase productivity, with 96% of farmers reporting more productivity due to their SWP in a survey across six countries, thus contributing to SDG2 (zero hunger), SDG10 (reduced inequalities) and supporting increased incomes.[20] Furthermore, solar cold chains could save up to 14% of global food production supporting food security for nearly 950 million people annually.[21] By meeting the potential market for SWPs and cold storage, the sector can enhance food security, create jobs, reduce fuel expenditure and avoid millions of tons of CO2 emissions as consumers replace non-solar powered appliances.[22,23]

16 World Bank Group, Global Energy Survey: Applying Multi-Tier Framework for Measuring Energy Access.

17 UN SDG Goals: SDG7 Ensure access to affordable, reliable, sustainable and modern energy for all.

18 Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.

19 UNICEF (2016), Collecting Water is often a Colossal Waste of Time for Women and Girls.

20 Efficiency for Access Coalition and 60 Decibels (2021), Uses and Impact of Solar Water Pumps; International Food Policy Research Institute (2019), Solar-powered Cold-storages and Sustainable Food System Transformation: Evidence from Horticulture Markets Interventions in Northeast Nigeria; GOGLA (2021), Powering Opportunity: Energising Work, Enterprise and Quality of Life with Off-Grid Solar.

21 Efficiency for Access, Creating a More Resilient Food System Through Sustainable Refrigeration.

22 *Efficiency for Access (2022), Impact Assessment Framework V2.*

23 *Note: CO2e emissions avoided only consider SWP pumps directly replacing diesel pumps.*

Another major benefit of higher-tier systems is providing cost-effective electricity for education. Research shows that nearly 60% of children born today increase their productivity by 50% with better access to quality education and healthcare.[24] Children in SSA are therefore at a major disadvantage, as only 33% of primary schools in the region have access to electricity, in some cases contributing to low-quality education.[25] OGS could electrify these schools, contributing to better learning outcomes by providing lighting, and powering better tools for teachers, such as laptops and the internet.

Healthcare facilities could also benefit from widespread electrification using OGS. Only about 28% of health centers have access to reliable electricity.[26] OGS, especially higher-capacity SHS, provides an effective alternative to power these health centers and free up resources to focus on the quality of care; research shows that OGS costs nearly five times less than operating a diesel generator.[27] OGS-powered refrigeration of medical supplies, including vaccines, and powering of medical equipment can also improve outcomes. In India, nearly 20-25% of temperature-sensitive health products–including vaccines– are spoiled due to insufficient cold storage.[28]

Funding for healthcare centers can help reduce wastage of health supplies and improve healthcare outcomes. The total addressable market for last-mile, off-grid solar vaccine storage alone is estimated at $811 million; however it is likely billions are needed for the whole sector.[29] Some development partners are already funding projects in this space. The World Bank alone has contributed nearly $650 million across over 25 countries to support electrification of public institutions using mini-grids and OGS solutions.[30] Development partners have also funded cold storage; for example, the World Bank provided $80,000 through the World Bank's Health Emergency Preparedness and Response (HEPR) trust fund to establish a storage warehouse equipped with five solar direct drive refrigerators in Sao Tome and Principe, contributing to approximately 75% fuel and operations cost savings compared to diesel generators.[31] The project led to better health outcomes for expectant women and children under age 5 due to safer and more reliable vaccine storage, and building on this success, the Sao Tome and Principe government is poised to receive additional funding from ESMAP and Green Climate Fund to scale the project.

The OGS sector also has major potential to support climate mitigation and adaptation goals in emerging markets (SDG13). Between 2020 and 2022, at least eight countries seeking to meet and/or surpass their climate change commitments either updated or revised their nationally determined contributions (NDCs) to include increased access to off-grid energy solutions.[32] By replacing kerosene and diesel, the sector has enhanced climate mitigation and adaptation for climate-vulnerable populations, contributing to a just energy transition.[33]

Despite progress in the sector, there is a substantial shortfall in achieving SDG7. In 2020, 733 million people still lacked access to electricity.[34] COVID-19 has made achieving SDG7 more challenging, causing job losses for many and pushing 100 million people into extreme poverty in 2020 alone.[35] The OGS sector has shown resilience in the face of the global pandemic, but the electrification gap remains large.

This report aims to survey the outlook for the off-grid solar market and interventions needed for the sector to achieve its full potential impact. Chapter 2 discusses what it will take for the sector to achieve its primary development goals, including both access to electricity and a host of other development goals enabled by electricity access. Chapter 3 assesses the gap between that

24 World Bank (2018), If Countries Act Now, Children Born Today Could Be Healthier, Wealthier, More Productive.

25 Power Africa (2020), Power for All Factsheet: Decentralized Renewables: Improving Children's Welfare.

26 *World Bank and WHO (2022), Electrifying Health Centers Report (unpublished).*

27 Lumos (2020), How Solar is Supporting Education in Africa.

28 Intellecap (2021), Off-Grid Solar Refrigeration: Cure to the Growing Vaccine Wastage Crisis.

29 *Ibid.*

30 *Open Capital Advisors consultation with the World Bank.*

31 *Ibid.*

32 United Nations, United Nations Framework Convention on Climate Change Secretariat (n.d.) NDC Registry.

33 GOGLA (2022), How to Make Climate Finance a Game-Changer for the Off-Grid Solar Industry.

34 Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector. *Note: This report reflects similar electricity access figures as those reported in the SDG7 tracking reports. The SDG7 tracking reports apply the following methodology; [1] Access to electricity service from Tier 1 to Tier 5 is considered in instances where surveys based on the Multi-Tier Framework have been conducted, [2] In instances where surveys have not been conducted, electricity access is calculated by a binary measure of "connected population" or "unconnected population" derived from existing household surveys, such as the DHS and LSMS.*

35 World Bank Group (2020), Poverty and Shared Prosperity 2020: Reversals of Fortune.

benchmark and the sector's current trajectory. Chapter 4 will discuss the game changers that are needed to propel the sector to ultimately reach its development potential.

Finally, Chapter 5 will summarize the roles of key sector stakeholders in actualizing those game changers to achieve universal access.

02

Reaching the Sector's Potential: SDG7 and Beyond

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This chapter focuses primarily on how the sector can improve access to reliable, modern energy services and how much funding is required. While focusing specifically on access to Tier 1 electrification, the chapter also discusses the additional impact and investment required if the sector were to provide higher levels of electricity access, for example those envisioned under the Modern Energy Minimum (MEM) benchmark for OGS users, which aims for a per household annual consumption of 300kWh. This chapter details the required connections per market type, the sales required to achieve those connections, and the funding required.

1.1 billion people need to get access to reliable, modern, and affordable energy by 2030 under the SDG7 scenario: 89% of the 464 million to-be newly connected OGS users live in nascent and emerging markets.

This report considers both current and new OGS users to estimate the sector's needed contribution towards SDG7. The Global Electrification Platform (GEP), under the 'Low Demand' scenario, considers 464 million people to be best electrified using OGS technologies between now and 2030. The report then assumes that OGS will continue to be utilized by the 493 million current users over the next 8 years, with those currently using below Tier 1 SEKs expected to upgrade to a Tier 1 or above system by 2030.[36]

Apart from primary OGS connections, this report also assumes that 186 million new weak grid customers will use OGS as a complement to a weak grid. The global weak grid population is today estimated at nearly 775 million projected to grow to just under 1 billion people by 2030 as a result of population growth and grid expansion.[37] To date, a proportion of sales has been to these weak grid customers, who experience frequent or lengthy outages of grid electricity or voltage fluctuations that can damage electrical appliances.[38] OGS companies have served these customers, improving the reliability of their energy connections, a key aspect of the access goals under SDG7.

The sector is expected to continue serving urban and easy-to-reach customers that have unreliable grid connections, and the estimate assumes that the proportion of OGS users employing OGS products as a back-up power source will remain constant until 2030.[39]


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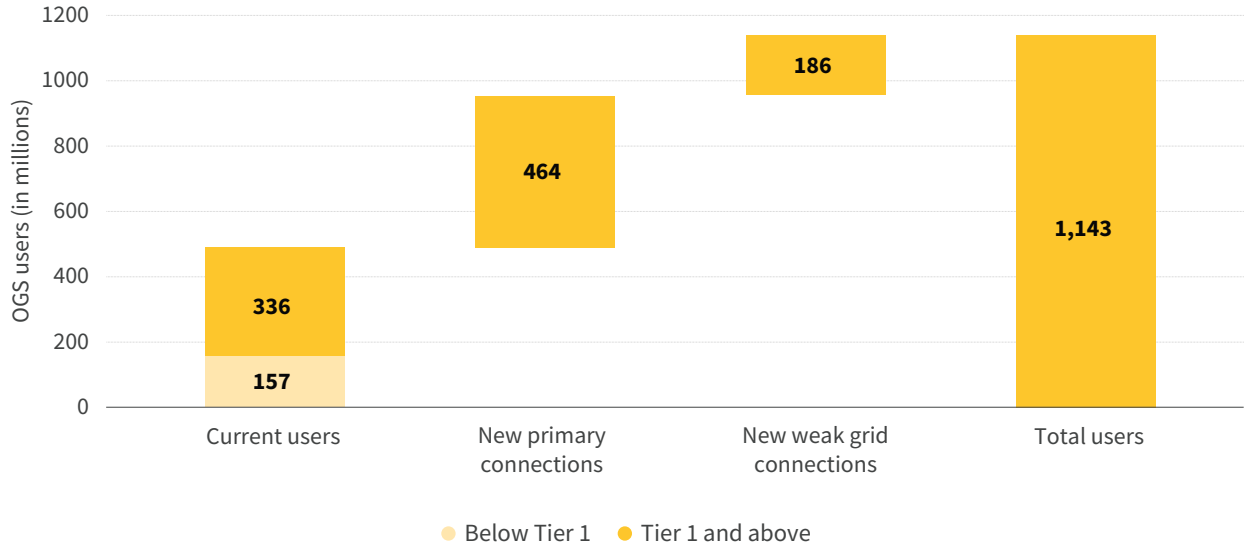
36 *Note: This assumption is made on the basis that while grid and mini-grid development might be planned to connect some of the current users, grid and mini-grid rollout has historically remained slow and power provision issues have persisted.*

37 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

38 *Note: Due to data limitations, this report evaluated data on the proportion of SEK users who are currently using SEKs to complement weak grid connections and is assumed this to remain constant from now to 2030.*

39 *Note: This report considers the proportion of weak grid consumers using SEKs as a back-up highlighted in the 2022 OGS MTR 'State of the Sector.' There is currently limited data for this exercise, and more data could be helpful in informing stakeholders about the weak grid market.*

Figure 3: Estimated composition of people that need to be reached with Tier 1 OGS systems to achieve SDG7[40]



Ultimately, the sector will need to reach 1.1 billion people with Tier 1 and above OGS products by 2030 to reach SDG7, assuming grid and mini-grid also achieve their potential for electrification.[41] Among them, 650 million people could be first-time OGS users, including the 464 million people who will use OGS as a primary electricity solution, and the 186 million people who will use it to complement a weak grid, as noted above. Though it is assumed that the current 493 million users will continue to use OGS solutions with all customers upgraded to at least Tier 1, in practice some may stop using OGS if other connections, for example grid or mini-grid, are available, reliable, and cost-effective.[42]

This report estimates the total number of new connections as well as sales required by type of market. Market classifications include peaked, mature, emerging, and nascent, according to the classification in the *2022 OGS MTR 'State of the Sector'*.[43] The market classifications are based on the electricity access gap in each country, OGS product penetration, and OGS sales growth rates.

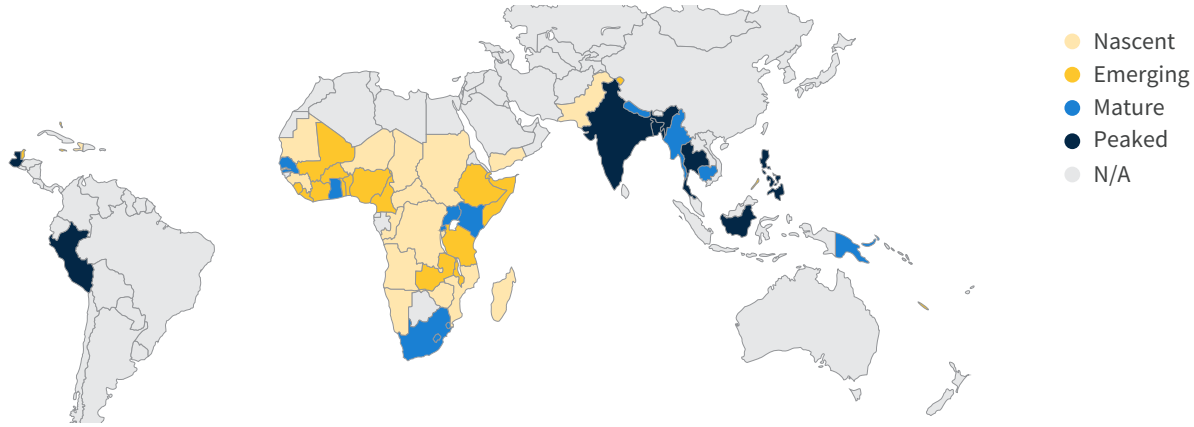
40 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector,' GOGLA data and GEP data. Note: [1] The 493 current SEK users are assumed to continue to use an SEK through to 2030, with users currently using below Tier 1 systems expected to update to a Tier 1 or above system, though it is possible that some of these people may also get new grid or mini-grid connections in which case they may still use an SEK as a back-up, [2] The 464 million additional people using SEK as their primary source of electricity access is based on the GEP 'Low Demand' scenario, [3] The 186 million additional people using SEK alongside a grid or mini-grid connection is based on the current proportion of SEK sales which are deployed as backup systems. This number could be significantly larger given the scale of the potential market identified in the 2022 OGS MTR 'State of the Sector.' [4] The current users include both below Tier 1 and Tier 1+ users.*

41 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector,' GOGLA data and GEP data.*

42 *Ibid.*

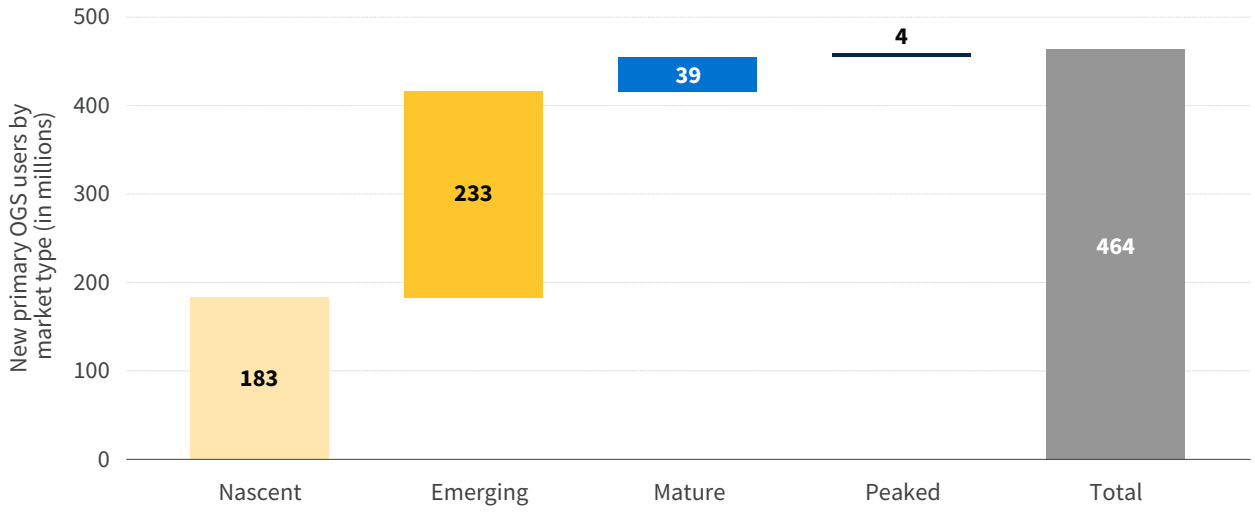
43 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

Figure 4: Market classifications[44]



Under this universal access scenario, 416 million of the 464 million people needing Tier 1 access as a first-time primary connection (89%) reside in nascent and emerging markets, primarily in SSA.[45] These markets have the least-developed OGS sectors. Some are characterized by a degree of fragility, conflict, and violence that hinders off-grid solution providers from operating there without incentives, which has limited sales to date. While a number of these markets have substantial electricity access needs, they also consist of low-income target populations which presents a less attractive commercial potential for OGS companies.

Figure 5: New primary OGS users by market type under the universal access scenario[46]



The Democratic Republic of Congo (DRC) and Nigeria will make up the largest share of the 464 million new primary OGS users in nascent and emerging markets. The largest proportion of new connections in emerging markets (30%) will be in Nigeria, driven by Nigeria's large unelectrified population. Nigeria also has major issues with grid reliability, creating demand for SEK products as a secondary source. The DRC is a key nascent market for currently unconnected primary OGS users and will make up 26% of new connections in this market type.

44 *Note: [1] Market classification is based on a combination of cumulative sales penetration and recent sales growth rates as outlined in Chapter 5.1 of the 2022 OGS MTR 'State of the Sector.' [2] The energy access gap in countries for which GOGLA members do not report sales data accounts for less than 1% of the remaining energy access gap to achieve SDG7.*

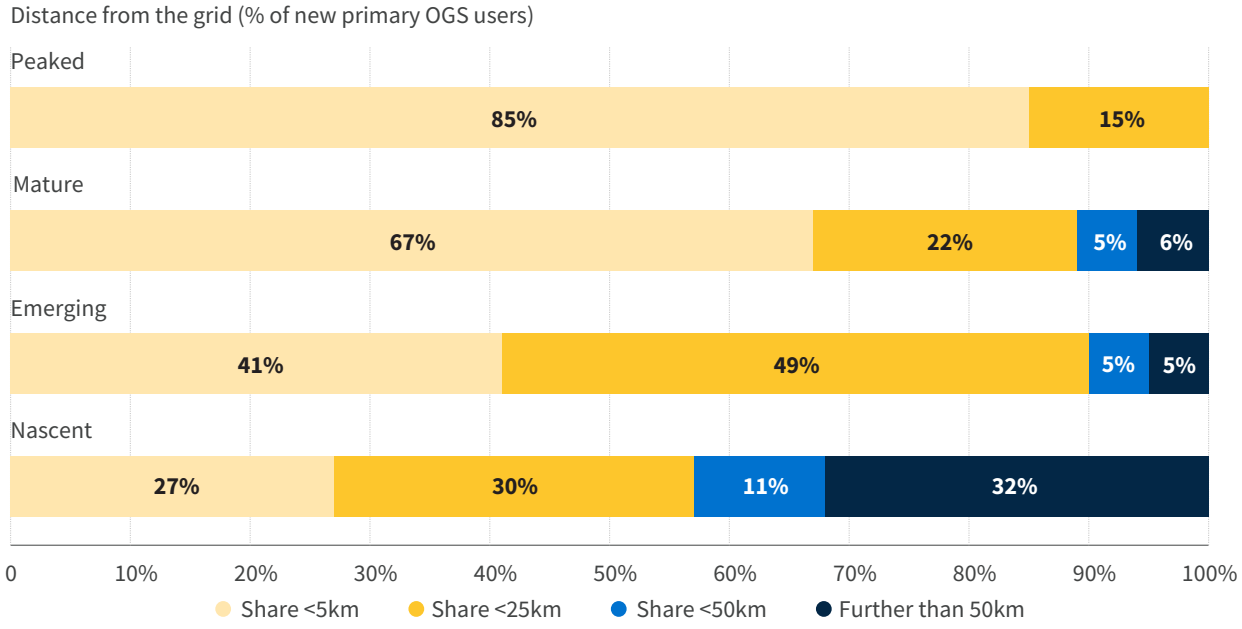
45 *Note: This classification excludes ~2% of total reported sales to GOGLA from countries that are not within the regions considered in this report, such as in Europe.*

46 *Note: Market classification is based on a combination of cumulative sales penetration and recent sales growth rates as outlined in Chapter 5.1 of the 2022 OGS MTR 'State of the Sector.'*

Only 43 million (9%) out of the 464 million new primary OGS users live in mature and peaked markets.[47] These countries are located primarily in South Asia, Southeast Asia, and East Africa, and have relatively favorable economic conditions and conducive enabling environments compared to nascent and emerging markets. As a result, 64% of total sales since 2016 have been in these markets.[48] Governments in mature and peaked markets have not only made great strides to increase electrification through OGS, but have also increased grid connections through grid expansion and densification, though many grid customers experience frequent outages; OGS as a back-up energy service can help improve these reliability issues. As a result of this progress, there are only a few remaining new connections to achieve universal electricity access, mostly in relatively hard-to-reach areas. Beyond these new connections, the OGS peaked and mature markets will continue serving current OGS users.

Most of the 464 million new primary OGS users will be located far from medium voltage (MV) grid lines. Particularly in nascent markets, 73% of new SEK users utilizing OGS as a primary source of electricity access will be located farther than 5 km from the MV grid lines.[49] However, given how remote some of these currently unconnected communities are, reaching them with SEK distribution networks could be very costly.

Figure 6: Distance of new primary OGS users from the existing grid[50]



For the weak grid portion of the market, rapid urbanization is anticipated to continue as one of the key drivers for back-up sales due to increased grid connectivity. Over the last 10 years, rapid urbanization has created a need to improve grid connections. The urbanization rate in SSA has grown steadily to reach 44% in 2021.[51] Rapid urbanization is assumed to continue over the next 8 years due to high population growth and the large number of young people reaching working age each year, and migrating to urban areas in search of employment opportunities. With their large populations and unreliable, expensive grid connections, Nigeria, the DRC, and Bangladesh are assumed to account for the largest share of people accessing OGS as a backup between now and 2030, at 23%, 14%, and 11%, respectively, of the total population that uses OGS solutions for back-up.[52]

47 *Note: This classification excludes ~2% of total reported sales to GOGLA from countries that are not within the regions considered in the scope of this report, such as Europe.*

48 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

49 *Note: This is based on GEP analysis on how far from the grid new people live to gain access to OGS from 2022 to 2030.*

50 *Ibid.*

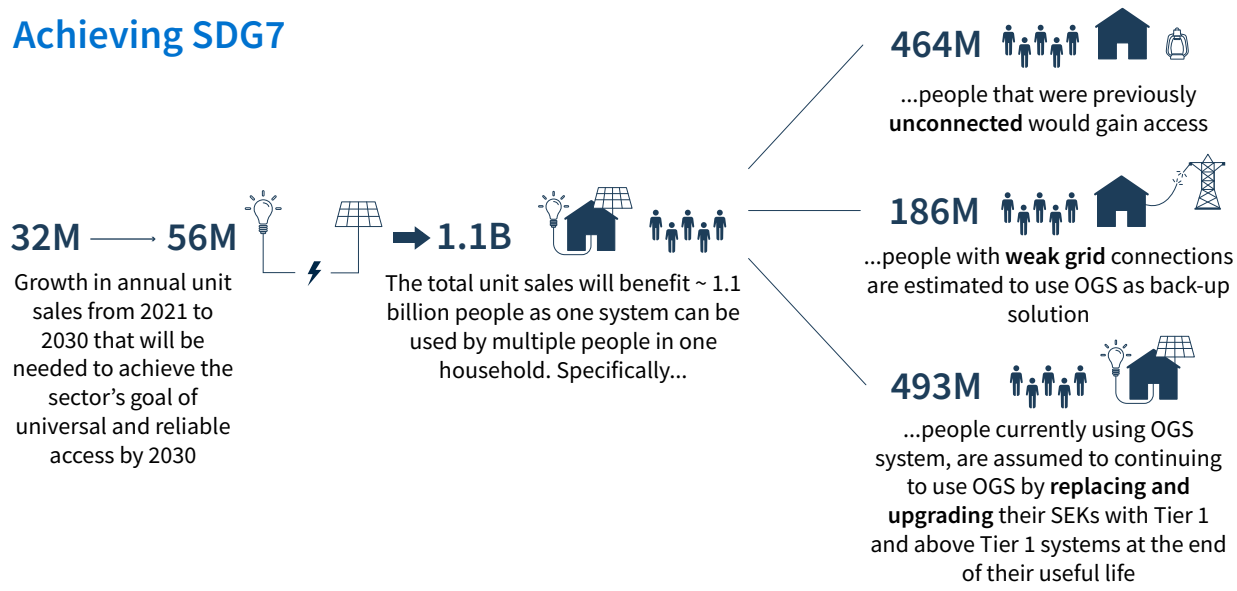
51 *Statista (2022), Urbanization Rate in Africa from 2000 to 2025.*

52 *Open Capital Advisors analysis of sales required to achieve universal access to electricity by 2030.*

To reach the goals of universal and reliable access to electricity under SDG7, annual unit sales need to grow from 32 million units in 2021 to 56 million units in 2030.

To achieve the goal of 100% access to affordable, reliable, and modern energy, total annual unit sales need to grow from 32 million in 2021 to 56 million in 2030, assuming that grids and mini-grids also achieve their potential. This estimate includes sales to new consumers who use OGS as their primary source of electricity, sales to customers who use SEK products as a backup to weak-grid connections, and replacement and upgrade sales to existing consumers.[53]

Figure 7: Sales and connections needed to achieve SDG7[54]

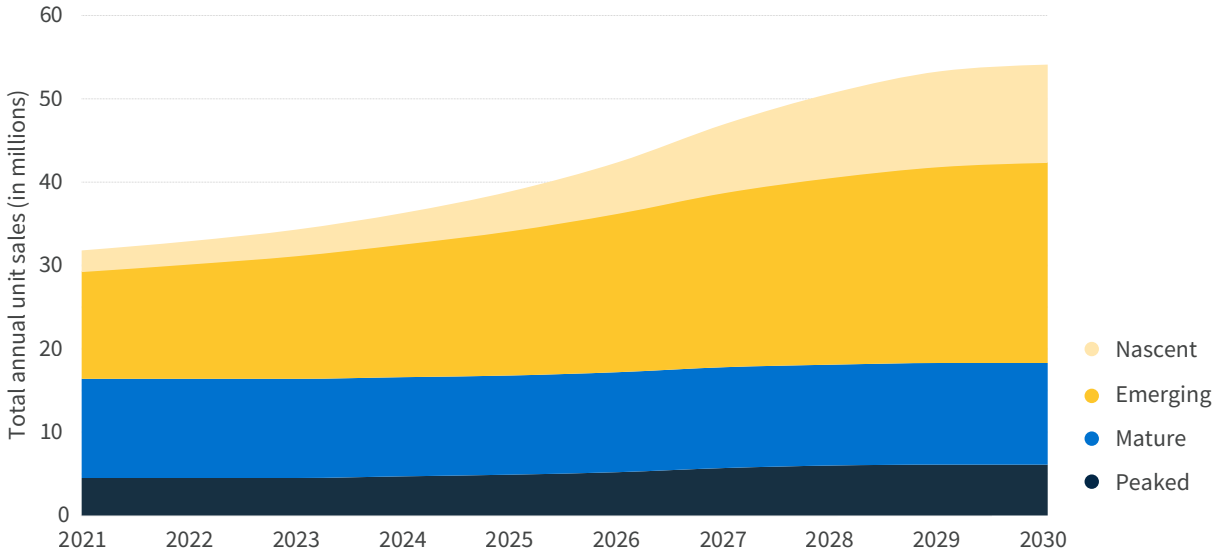


Sales in nascent and emerging markets would need to grow more rapidly in earlier years to close the electricity access gap by 2030. 58% would be needed in nascent and emerging markets driven primarily by sales to currently unconnected populations while the 42% in mature and peaked markets would be driven primarily by replacement sales to current users–including those who will upgrade from below Tier 1 to Tier 1 and above SEKs–and sales to weak grid users. While sales are anticipated to remain relatively stable in mature and peaked markets, sales in nascent and emerging markets will have to dramatically increase between 2022 and 2027, before stabilizing as it approaches the SDG7 target, to avoid a cliff-edge as soon as SDG7 is achieved.

53 *Ibid.*

54 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector,' GOGLA data and GEP data.*

Figure 8: Total annual unit sales required to achieve universal access 2021 - 2030 by market[55]



Beyond the 56 million annual sales needed for household electrification to achieve SDG7, significantly more sales are likely required to meet the needs of PUE and public institutions.[56] The above estimates exclude sales of PUE appliances –such as those in agriculture– and sales of OGS solutions to public institutions including schools or health institutions. Overall sales in the sector could therefore be significantly higher. Healthcare institutions, for example, could significantly benefit from OGS, since nearly 1 billion people worldwide are served by health centers without access to electricity.[57] Cumulative sales may be even larger if the roll-out of planned grid and mini-grid connections takes longer than anticipated under GEP projections, which could make OGS an attractive interim solution.

Realizing the sales required to achieve SDG7 goals will require $18.8 billion of external investment plus $4.5 billion in additional funding to address the affordability gap.

This report also estimates the investment required to reach 1.1 billion people with Tier 1 and above SEKs. First, it assumes the total sales needed in each market (as in the previous section), and the composition of companies to meet those sales. It then estimates the cost of goods sold (COGS), and operating costs for those companies in each market. This gives a total estimated figure for the funding needed to achieve SDG7 goals. Differences exist across markets, which is reflected in the analysis. For example, serving customers through smaller distributors typically present in more nascent or FCV countries, would require higher investments due to higher COGS and operating expenses driven by lower economies of scale, tougher operating environments, and lower levels of digitalization.

The OGS sector requires $18.8 billion in investment to fund company operations and $4.5 billion in additional funding to address the affordability gap between now and 2030.[58] These estimates assume universal access to Tier 1 and above SEK systems, comprising at a minimum multi-light systems and entry-level solar home systems with an average cost of $100 per system.[59] The sector will require a mix of debt, equity, and grants, as outlined below, as well as subsidies and other non-customer revenues. Companies' financing requirements will differ ultimately by market and level of maturity. For example, companies in nascent and emerging markets require more start-up or market-entry grant capital compared to large companies serving mature markets.

55 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector,' GOGLA data and GEP data.*

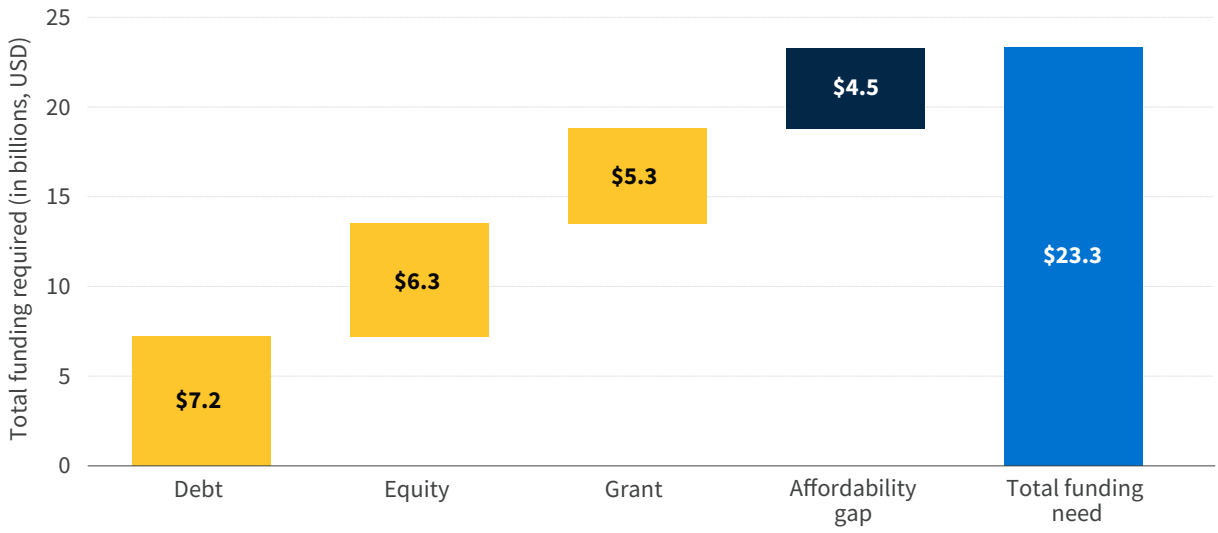
56 *Powering Healthcare Initiative | About us.*

57 *World Health Organization (2022), Accelerating Access to Electricity in Health Care Facilities.*

58 *See Annex 3 - The methodology for estimating the investment needed to achieve SDG7 and projected investment.*

59 *Open Capital Advisors analysis of product prices based on a review of Mangoo marketplace, company websites, consultations with off-grid companies and chinese manufacturers, and industry reports such as the Ipsos market studies in Kenya, Ethiopia, and Tanzania.*

Figure 9: Total funding required to reach universal electricity access[60]



Debt comprises nearly 38% of the total external investment required by the sector. Companies in the sector have large working capital requirements for both inventory and receivables, with the latter a particularly acute need for PAYGo companies. Small, last-mile distributors will require term loans or revolving working capital facilities, while larger companies will look for larger-ticket debt, both on- and off-balance sheet.

Equity comprises 34% of the external investment required. Equity investments fund core operations and position a business for growth. Growing businesses also require equity to shore up their balance sheets before taking on more debt financing. Eventually, businesses may grow to the point that they can shift their more mature lines of business off their balance sheets (see section 4.1.2).

A substantial amount of grant funding, at levels much higher than historic levels, will be required to support market entry in nascent and emerging markets where many of the harder to reach customers live.[61] This estimate, 28% of the external investment needed, is much larger than the proportion raised in the past. Catalytic supply-side grant capital would be allocated to companies of all sizes expanding into nascent and emerging markets to connect first-time users or to support PUE. Such financing might include market-entry grants, RBFs, and innovation competitions, whether based on milestones or otherwise.

Beyond the investment required by the sector, an additional $4.5 billion in funding will be required to address the affordability gap, and can be addressed with demand-side subsidies as well as other non-customer revenue such as carbon credits. The affordability gap represents the difference between the commercial price of a Tier 1 SEK and the ability to pay for the 464 million people who would need access to an SEK as their primary form of electricty access by 2030. This affordability estimate assumes PAYGo accounts for 30% of the unit sales reaching otherwise unconnected households and that unconnected households are concentrated among the lowest income strata in each country.[62] This estimate does not include the current affordability gap for the 157 million people that have below Tier 1 access with OGS products. The affordability gap therefore is likely larger than presented.

Accelerating availability of the PAYGo business model could significantly reduce the magnitude of the affordability gap. Without end user finance – that is, if all SEKs were sold cash over the counter – the affordability gap would rise to $5.9 billion. If PAYGo were deployed for all sales, the affordability gap would fall to $1.3 billion. However, there may be important market segments where deployment of PAYGo business models at scale may be challenging, such as those in fragile and conflict-affected settings. These markets may have infrastructure gaps or logistical or security challenges that hinder cash repayment collections from what are likely to be relatively low-income, vulnerable households. Where feasible, programs that support the expansion of PAYGo would help further reduce the affordability gap, though such programs

60 *Open Capital Advisors analysis on total funding needed to reach universal access split across debt, equity and grant.*

61 *Note: Non-dilutive funding refers to any capital that a business receives that does not require them to give up ownership or equity. Saratoga Investment Corp (2022), Non-Dilutive Funding 101 & Why You Should Consider It.*

62 *Note: PAYGo accounted for around 8% of unit sales and 34% of the value of sales in 2021, as PAYGo is typically used for larger SEKs.*

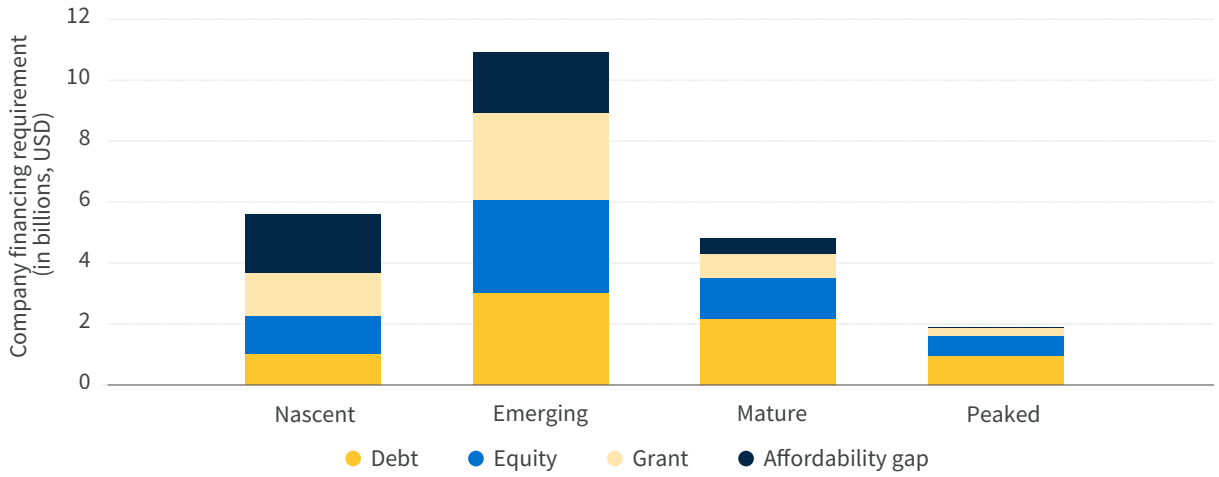
should take care to promote good PAYGo portfolio quality and ensure consumer protections.

Demand-side subsidies and climate funding could also play a major role in bridging the affordability gap. Demand-side subsidies specifically reduce the cost of systems below commercial rates, whether using 'pro-poor'-style RBF, conditional cash transfers, or other mechanisms. Certain forms of climate funding could also help bridge the affordability gap. Carbon credits, for example, could provide an additional form of subsidy to companies on a per-unit basis, which can improve company margins but can also reduce the affordability gap if prices are reduced by the amount of the carbon credit.[63]

Of the total $23.3 billion in funding required by the sector, up to $16.5 billion will be required just in nascent and emerging markets.[64] The electricity access gap is much greater in these markets compared to mature and peaked markets, with 89% of new primary connections occurring here, especially in large markets like Nigeria and the Democratic Republic of Congo. A significant amount of funding here will therefore go towards reaching currently unconnected populations with primary OGS connections. In many of these markets, the cost of serving customers will be higher than in mature and peaked markets, necessitating more grant funding. Emerging and nascent markets are also anticipated to have a large share of small and mid-sized companies in the sector, which have higher COGS and lower operating margins compared to established companies, and which have attracted limited investment in the past. Unable to generate sufficient revenue to finance their operations, these companies need to raise money from external sources to finance their operations and growth.

$1.9 billion and $4.9 billion of the anticipated $23.3 billion would flow to peaked and mature markets, respectively.[65] These markets have a lower electricity access gap, making up approximately 9% of the to-be newly connected OGS users by 2030. The investment needed in these markets is therefore primarily needed to replace existing Tier 1 systems, upgrade systems that are not Tier 1, and serve back-up users, though some funding will be needed to connect the currently unelectrified population. The affordability gap is much lower in these markets: $0.5 billion of the total $4.5 billion affordability gap (11%). In peaked and mature markets, established companies are anticipated to have a larger market share, given their existing presence and customer base.

Figure 10: Company financing requirement by market type[66]



The total investment figure of $18.8 billion is likely a conservative estimate for the sector. This total investment need assumes universal access only to Tier 1 products. However, in reality, companies will continue to offer a diversified portfolio of products providing different Tiers of electricity access. This is especially important for households with higher energy needs, and to support business activities and the energy demand of public institutions, including schools and health centers. Furthermore, in practice a part of the investment will flow towards non-energy products that will not contribute directly to achieving SDG7.

63 *D-REC Initiative (2020), Creating a New Global Mechanism for the Certification of Distributed Renewable Energy.*

64 *See Annex 3 - The methodology for estimating the investment need to achieve SDG7 and projected investment.*

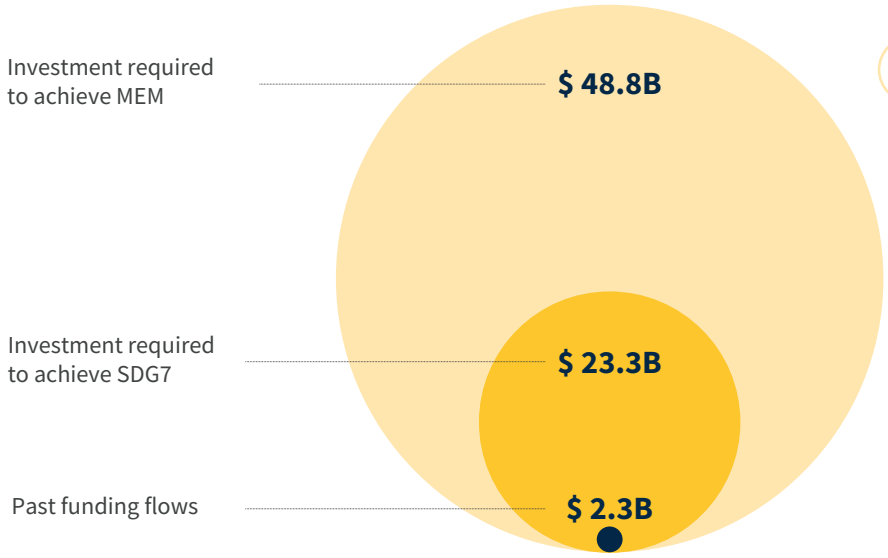
65 *Open Capital Advisors analysis of investment required to achieve universal access.*

66 *Open Capital Advisors analysis of total financing requirement for the OGS sector split across debt, equity and grant across the different market categories.*

Providing access to higher-tier systems that enable more productive uses of energy could increase the funding requirements to a minimum of $48.8 billion.

If the sector aims to achieve beyond Tier 1 electrification for households, the funding need will be much larger. Tier 1 is the minimum level of electrification needed to achieve SDG7, and it is often just the first step on the energy staircase. OGS products can support higher tiers of energy service too, which would increase funding needs: $48.8 billion would be required to help enable higher levels of service like the MEM benchmark for OGS users, which aims for per-household annual consumption of 300kWh, equivalent to Tier 2 access at a minimum.[67] Given that there already exists a large affordability gap to ensure universal access to Tier 1 electrification, and that Tier 2 systems would supply more electricity than is currently demanded by the majority of low-income and unelectrified users, the affordability gap to reach Tier 2 access for all would be substantial, and is not included in the $48.8 billion funding need.[68] Consumer financing will address affordability challenges, but even with consumer financing, a large majority will still not be able to afford the products, requiring much higher subsidies in turn.

Figure 11: Comparison of funding flows to date, funding required to achieve SDG7, and funding required to achieve the MEM[69]



The $48.8 billion does not include the substantial amount of funding required to address the affordability gap.

Beyond electrifying households, OGS can also play a critical role in providing electricity to power productive uses of energy, particularly in agriculture, and also in providing electricity for public institutions in healthcare and education. Nearly 569 and 192 million smallholder farmers (SHF) could benefit from cold storage and solar water pumps (SWPs), respectively, in India and SSA combined between now and 2030.[70] The two most developed PUE use cases, from a technical and business model standpoint, are SWPs for irrigation, and cold storage facilities for agricultural produce. Other use cases for agriculture are less developed, so this report estimates

67 *Rockefeller (2021), The Modern Energy Minimum: The Case for a New Global Electricity Consumption Threshold.; Note: The average selling price assumed for these systems is $250 per unit.*

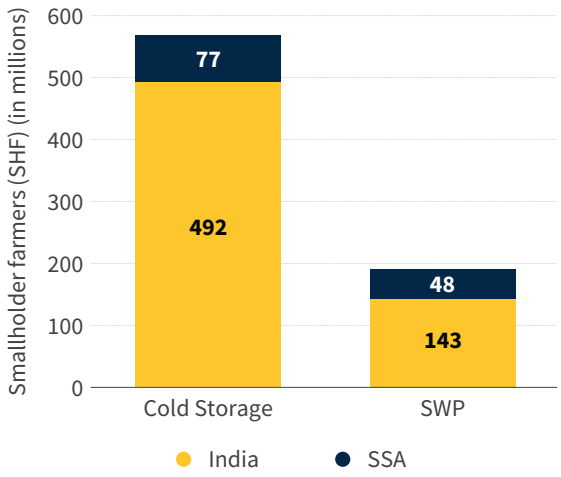
68 *See Annex 3 - The methodology for estimating the investment need to achieve SDG7 and projected investment.*

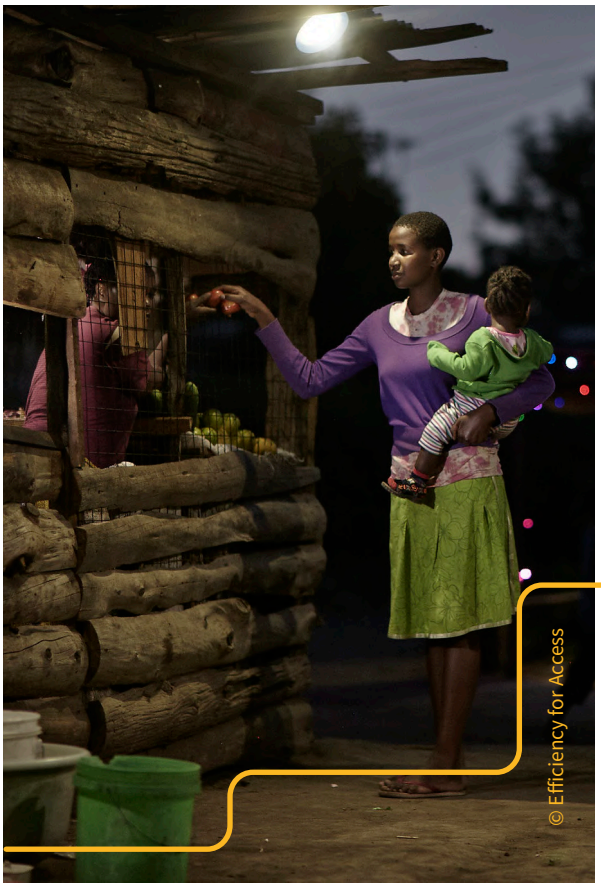
69 *Open Capital Advisors analysis of past funding flows from the GOGLA Investment Database, investment required to achieve SDG7 and higher levels of service like the MEM. Note: [1] The amount described in this report to achieve higher levels of service like the MEM does not account for the funding required to address the affordability gap, which is expected to be substantial based on the high cost of Tier 2 systems relative to income levels for populations in these markets, [2] 300kWh has been equated to a minimum of Tier 2 system capacity and the investment need only considers the users to be connected under the SDG7 scenario.*

70 *Note: The 569 and 192 million smallholder farmers relates to individual farmers and not smallholder farmer families.*

only the potential for solar water pumps and cold storage. The large potential market consists of smallholder farmers in value chains with the greatest potential for cold storage and irrigation including horticulture and dairy (see methodology section in Annex 3). While strides have been made to increase electrification levels and its reliability in these regions, there is still a huge potential to increase electrification of the agriculture sector.

Figure 12: Market potential for cold storage and SWPs in India and SSA by 2030[71]





71 *Open Capital Advisors analysis of market potential of PUE split across cold storage and SWPs in India and SSA.*

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03

Measuring the Gap

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Over the past decade, the OGS sector has experienced fluctuating growth, with periods of growth between 2015-2019, a decline in 2020 due to COVID-19, and a recent uptick in sales as the sector recovers. As the sector continues to rebound from COVID-19, it is important to consider how the sector might grow by 2030 and what is needed to close the remaining gap to universal access.

Despite sector-wide efforts, up to 606 million people may remain without Tier 1 electricity access in 2030.[72]

Beyond describing the sector's contribution to sustainable development goals, this report also projects potential growth pathways for SEKs. Based on analysis of historical sector growth, this report estimates sector growth of 5% year-on-year while also presenting scenarios with more conservative growth of 2.8% and accelerated growth of 7.2%. These figures are based on analysis of historical trends for below Tier 1, Tier 1, and above Tier 1 SEK sales (see the methodology section in Annex 3). This report assumes that the sector will continue to serve both Tier 1 users, and those above and below Tier 1, as it has done in the past, with more sales of Tier 1 expected by 2030 in an optimistic scenario of 7.2% growth compared to a 2.8% conservative growth.[73]

Under the projected growth scenario, the sector could reach 624 million OGS users cumulatively with Tier 1 and above electricity access by 2030, 516 million people fewer than what is needed to achieve universal access.[74] This growth is based on historic trends observed between 2015 and 2021, and represents the midpoint of the conservative and optimistic scenarios. Assuming 5% annual growth in sales, the sector will connect 624 million people with Tier 1 and above systems, but leaving 516 million people with below Tier 1 or no access.[75] A majority of those that will remain unserved in this scenario are located in nascent and emerging markets. The sector would also avoid 412 million MT of CO2e emissions and enable $108 billion in cumulative savings. This scenario assumes a steady economic recovery from COVID-19, with a corresponding increase in consumer incomes, continued, and only minimal impact on pricing.

In the optimistic growth scenario, the sector will grow 7.2% year-on-year until 2030, reaching 928 million people cumulatively with Tier 1 solutions by 2030. This growth, while unlikely, matches trends observed between 2015 and 2019. This period experienced steady macro-economic growth and coincided with the rapid uptake of PAYGo and major financial investments in the sector. The optimistic scenario assumes that supply chain challenges are resolved; real consumer incomes return quickly to pre-pandemic levels and then continue to grow; the effects of negative shocks on key markets are limited; and sector support programs are rolled out effectively, playing a major role particularly in nascent and emerging markets.[76] With a 7.2% annual growth rate, the sector could connect approximately 928 million people with Tier 1 and above Tier 1 SEKs between now and 2030. However, the universal access goal would still be missed by 232 million people who would be using below Tier 1 SEKs by 2030. The sector would also achieve 433 million MT CO2e emissions avoided and $134 billion cumulative savings.

If interventions are not well funded and implemented, the sector would grow at a much more modest 2.8% annually, in line with the conservative scenario, reaching 534 million people cumulatively with Tier 1 and above solutions by 2030. This growth rate is based on trends observed between 2016 and 2021, when already high inflation and food prices impacted end consumer incomes, then further exacerbated by COVID-19. This conservative growth scenario could happen if consumers' ability to pay stagnates and faces a slow recovery to pre-COVID-19 levels in major OGS markets, or if supply chain shocks continue to put upward pressure on prices. At this growth rate, the sector is assumed to only connect 534 million people cumulatively with Tier 1 and above Tier 1 SEKs. Under the conservative scenario the SDG7 targets would be missed by 606 million people, including 251 million people with

72 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector,' GOGLA data and GEP data. Note: This shortfall represents both new primary users, back-up users and includes people currently using below Tier 1 SEKs as these do not constitute universal access.*

73 *See Annex 3 - The methodology for estimating projected global off-grid solar sales.*

74 *Open Capital Advisors analysis of sales required to achieve SDG7. Note: The shortfall includes, [1] Population that will remain without access to electricity by 2030 and, [2] People who will be using below Tier 1 SEKs to access electricity by 2030. See Annex 3 for more details on the methodology.*

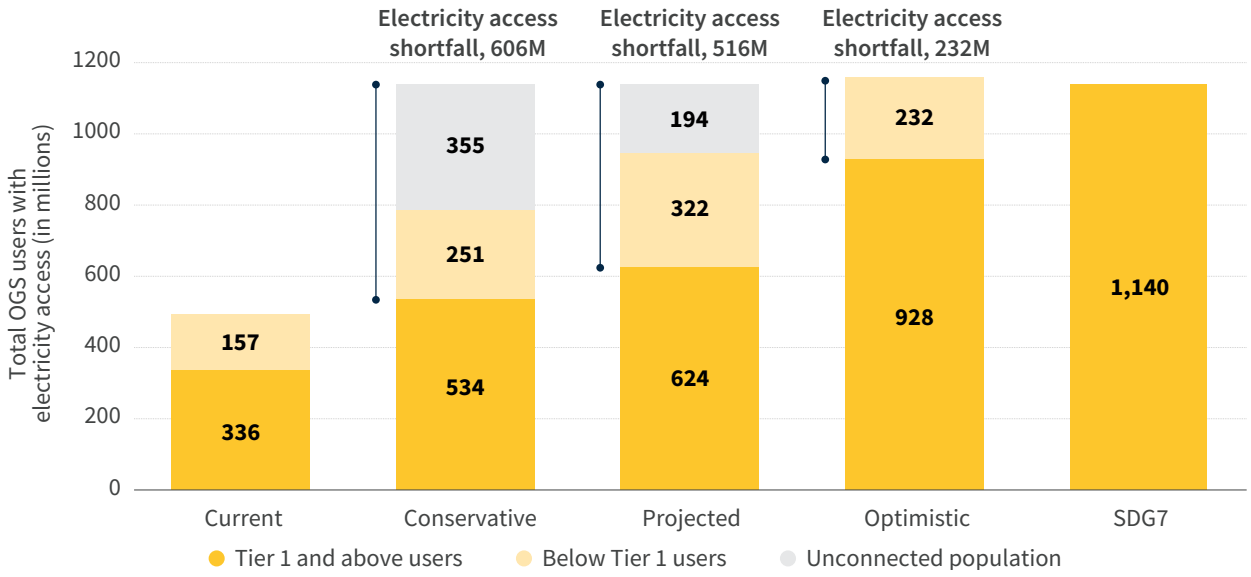
75 *Note: This shortfall represents both new primary users, back-up users and includes people currently using below Tier 1 SEKs as these do not constitute universal access.*

76 *See Annex 3 - The methodology for estimating projected global off-grid solar sales.*

insufficient, below Tier 1 SEKs.[77] The sector would achieve 390 million MT CO2e emissions avoided and $88 billion cumulative savings.

A range of major risk factors could trigger slower growth rates, including a global recession, high levels of inflation, and conflict. While this report assumes that the sector will continue to recover from COVID-19, other external macroeconomic factors, such as high inflation; external shocks, such as a resurgence of COVID-19 and increasing global food prices; or extreme weather events might negatively impact the sector's development. Such external factors could lower disposable incomes of target customers and/or obstruct company operations. These risks are also likely to most affect already fragile and conflict-affected states, which account for the majority of the potential SEK users in nascent and emerging markets.

Figure 13: Projected shortfall from achieving SDG7[78]



To connect the 624 million users under the projected scenario, the sector is projected to raise ~$7.8 billion between now and 2030, a funding shortfall of $15.5 billion.

Under the current financing trajectory, the sector would raise $7.8 billion in investment and funding, representing a gap of $15.5 billion compared to the SDG7 scenario.[79] Much of the anticipated financing will be used to fund replacement sales, or sales to new customers that are relatively easy to access, rather than electrifying hard to reach new customers, therefore the SDG7 scenario assumes sales of more, higher cost Tier 1 systems. Also, the unserved population is anticipated to reside mainly in nascent and emerging markets, which are characterized by high poverty levels, and in some cases, fragility and conflict. This increases the funding required to reach consumers compared to those in mature and peaked markets. Finally, the projected S-curve of the SDG7 scenario necessitates a faster ramp-up in sales in the shorter term - so as to avoid a cliff-edge in sales in 230 - which also requires more financing for replacement systems before 2030.

In this scenario, large companies are expected to raise the bulk of funding. This continues the trend in which 72% of total investment raised to date has been raised by the seven scale-up companies.[80] These companies are currently not operating in many of the most difficult markets, and if this funding pattern continues, it is likely that currently unserved markets will remain unserved.

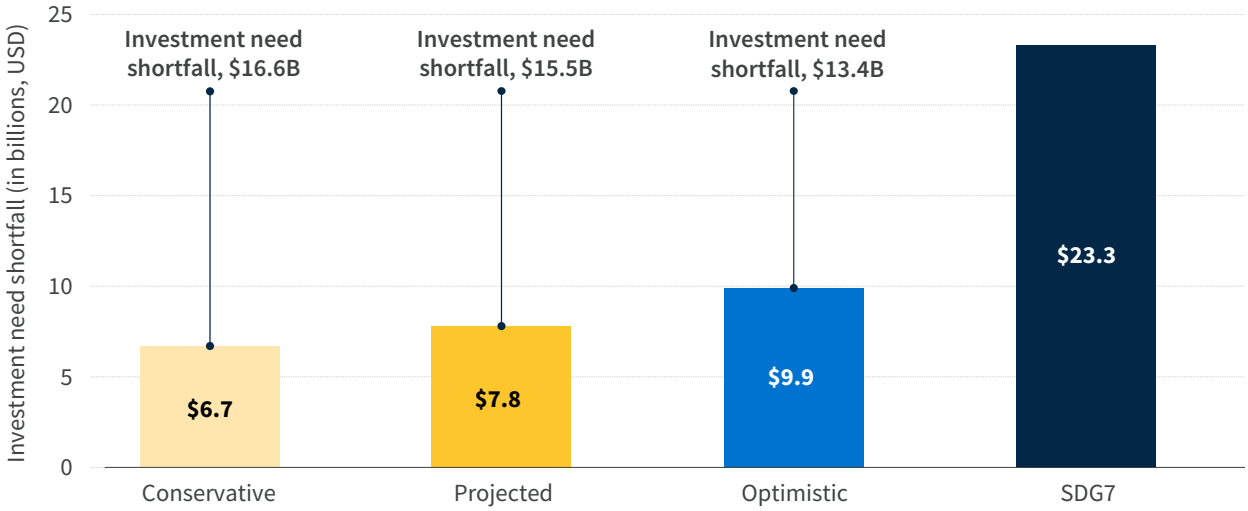
77 *See Annex 3 - The methodology for estimating the projected global off-grid sales. Note: This shortfall represents both new primary users, back-up users and includes people currently using below Tier 1 SEKs as these do not constitute universal access.*

78 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector,' GEP data, and GOGLA data on different potential scenarios between 2020 to 2030. Note: The proportion of below Tier 1 and Tier 1+ users is based on the sales split by Tier in 2030.*

79 *Open Capital analysis of investment required to achieve SDG7.*

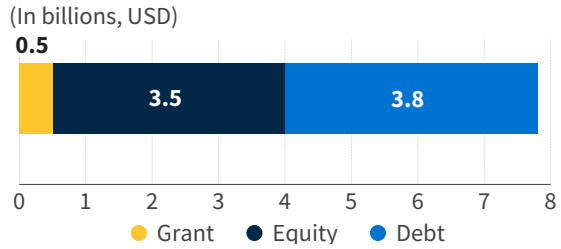
80 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

Figure 14: Total company financing projections by scenario[81]



In the projected scenario, total investment of $7.8 billion reflects the sector's current supply and demand-side constraints. The investor landscape and appetite, as well as the inability of smaller and mid-size companies to attract and absorb larger amounts of funding, are the largest anticipated inhibitors of funding for the sector.

Figure 15: Total company financing anticipated under the projected growth scenario (in billions, USD)[82]



Debt is anticipated to make up the largest proportion of external financing needs, at a total of $3.8 billion. In line with recent financing trends, debt is expected to take up the lion's share of investment, financing PAYGo portfolios and other working capital needs. Both large and small companies are anticipated to continue raising debt, though there are more options for larger companies since there are several sector-focused debt funds that serve the sector, each of which have minimum requirements that exclude smaller companies.

Equity is anticipated to make up $3.5 billion of the total financing under the projected scenario. Equity will be needed to shore up the balance sheets for continually larger debt raises. Most of this equity investment in the short term is likely to focus more on mature and established markets into companies that are already present. More equity funding may potentially be made available to drive consolidation via the acquisition of medium-size players, as well as for some geographical expansion if grants are also available to de-risk new markets. Some smaller, more local distributors already exist in such markets, underscoring the importance of supporting those companies to succeed as much as those with major scale potential.

Grants, including RBF schemes, are anticipated to make up 500 million of the total investment under the projected scenario. This figure, which is much less than required under the SDG7 scenario, includes market-entry and scale-up grants, with RBFs anticipated to account for ~$0.35 billion of the total grant investment. Grants are projected to fuel the expansion not only of smaller companies, but also of established companies into harder-to-reach customer segments, particularly through RBFs. Other anticipated uses of grants include assistance to companies to continue to enhance their product offerings into higher-capacity SEK and PUE assets.

While unlikely to occur, in a more optimistic scenario approximately $9.9 billion could flow into the sector,

81 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector,' GEP data, and GOGLA data on financing needs for the different scenarios between 2020 to 2030. Note: Importantly, the projected, optimistic, and conservative scenarios follow historical trends in investment, whereas the SDG7 scenario estimated the need to fully reach all with Tier 1 access at a minimum, representing two different methodologies.*

82 *Open Capital Advisors analysis based on data used in the 2022 OGS MTR 'State of the Sector,' GEP data, and GOGLA data on financing needs for the projected growth scenario.*

supporting sales growth of 7.2%. Under this scenario, investment would start to address some of the major capital gaps for small and medium-sized companies, and investors will be more risk tolerant, with new funds launched to target the sector specifically, and that customer income levels and affordability rebound to pre-pandemic levels. However, to reach the SDG7 goals, substantially more investment is required to: i) seed or incentivize companies to both enter nascent and emerging markets as well as serve them in a cost-effective manner, such as with large amounts of subsidies; ii) upgrade the 343 million of users that have below Tier 1 OGS products, while ensuring that all new customers are Tier 1 and not below; and iii) provide adequate financing to the small- and medium-sized companies where there currently exists a major gap.

As little as $6.7 billion in investment could flow into the sector which, together with other macroeconomic risks, could result in the more conservative annual growth rate of only 2.8%. This pessimistic scenario assumes a continuing decrease in deals for small and medium-sized companies, hindering these companies from raising debt in any substantial amount. It also assumes that grant funding and subsidies, including RBFs, will be not well-coordinated or deployed too late to catalyze markets before 2030. Finally, the scenario anticipates that the seven scale-up companies have reduced the need to raise external financing as they reach maturity.

Across all growth scenarios in this report, it is anticipated that hard-to-reach markets will require substantial amounts of concessional capital. Many potential customers in these markets have low incomes, which is a barrier to market entry, and some of these markets are smaller in terms of their potential given their smaller populations. These issues are exacerbated in markets that also experience conflict and violence, which make it even more difficult to operate. Hard-to-reach markets exist not only in nascent, national-level markets but also in certain areas of countries often characterized as mature markets, such as several counties in Northern Kenya.

Although donor interest in the PUE sector continues to grow, the gap to reach the market potential is even starker for PUE appliances.

In 2021, sales of PUE appliances were estimated at nearly 223,000 units, driven largely by refrigerator and SWP sales.[83] SWPs have dominated PUE sales, constituting 62% of cumulative PUE sales over the past four years, compared to 38% for refrigerators.[84] Despite increasing awareness of the benefits of PUE appliances, affordability challenges still prevent many smallholder farmers from accessing valuable products. For example, with 698 million people in SSA living below the poverty line of $1.90 a day, upfront SWP prices of $400–1,000 remain unaffordable for many.[85] The sales estimates to date include household-size refrigerators, but this report assumes that the true use case to accommodate agricultural cold storage for smallholder farmer needs will be satisfied by larger cold storage units.

To achieve the market potential for SWPs and cold storage alone in India and SSA, as described in Chapter 2, unit sales would need to grow by 32% annually.[86] To ascertain the required sales, this report estimates both the potential market size in 2030, and the growth rate in sales, starting from a base of historical sales, required to reach those levels. In this scenario, unit sales would reach 4.5 million in 2030, compared to 223,000 in 2021. This growth rate is therefore not an estimate of expected sales, but of the growth needed to reach the target market size by 2030. It is also important to note that the current base of sales is quite low, which contributes also to the large growth rate needed. India is a large anticipated market for PUE sales, as a large share of farmers there grow horticulture and perishable crops, producing nearly 50% more fruit than SSA.[87] India also has a large proportion of rainfed land, along with government subsidy schemes that lower the cost of SWPs.

83 *Open Capital Advisors analysis of sales volumes and market trends for PUE appliances based on the 2022 OGS MTR 'State of the Sector.'*

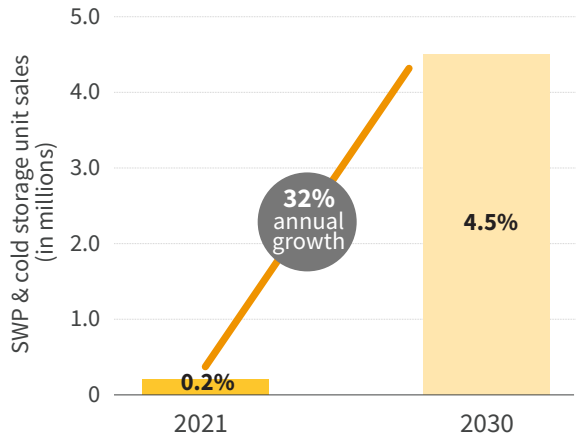
84 *Ibid.*

85 *Development Initiatives (2021), Poverty trends: Global, Regional and National; Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

86 *Open Capital Advisors analysis on total unit sales required to achieve the market potential of SWPs and cold storage units in SSA and India.*

87 *FAO (2020), FAOSTAT: Value of Agricultural production.*

Figure 16: Comparison of SWP and cold storage unit sales in 2021 and market potential by 2030[88]



Larger cold storage units are anticipated to make up the lion's share of cooling solutions used in the agriculture sector, pending ways to address affordability challenges. To truly achieve sales in line with the market need for cold storage, stakeholders will have to address the affordability gap. Upfront prices for refrigerator systems can reach several thousand dollars, while larger walk-in cold storage units typically reach costs in the tens of thousand. Companies will have to refine innovative business models such as Cooling as a Service (CaaS), especially for smallholder farmers, and stakeholders must improve links to offtake markets to maximize the value of cold-stored produce.

Box 1: Case study on SokoFresh CaaS initiative in Kenya on off-grid solar refrigeration

SokoFresh, an off-grid solar refrigeration company based in Kenya, developed a CaaS initiative that provides cold storage services to farmers, while providing access to markets through a digital market linkage solution. Currently, it has nine 5MT cold storage units in operation which have contributed to significant post harvest loss reductions and increased farmer incomes by 40% on average.[89] This initiative provides cold storage services at the farm level under a pay-as-you-store model which provides farmers and traders a risk-free opportunity to maintain the quality of their produce and increase their incomes. SokoFresh aims to have 190 operational cold storage units by 2023.[90]

SWP sales will continue to comprise the majority of unit sales of PUE appliances for agriculture. While the Indian government has plans to downsize its subsidy program by 50% by 2030, the greater focus on PUE from investors and donors is likely to continue to bolster system sales, both in India and SSA.[91] Addressing the affordability gap is also important for SWPs, as noted previously. While PAYGo and other consumer finance solutions may help solve the problem, it will be equally important that companies providing these services focus on loan portfolio health and risk diversification.

The PUE segment will ultimately require substantial funding for these higher value assets. PUE assets have a higher COGS, so finance requirements will be relatively high compared to SEKs on a per-unit basis. Patient capital will be needed for companies to explore business models and identify suitable customers, particularly given the nuances of different agricultural value chains in different markets. Donors and impact investors are already interested in this sector, with ~75% of grant capital for the sector in 2020–2021 earmarked for PUE.[92] Governments, too, have shown interest, with Bangladesh and India deploying subsidies to ramp up sales. Despite these promising examples, the sector remains in its infancy and significantly more sales are required to electrify public institutions and PUE. For example, it is estimated that tens of thousands of health centers alone across low- and middle-income countries lack electricity.[93] Consequently, much more funding will be required to support electrification of public institutions such as schools and health centers.

88 *Open Capital Advisors analysis of unit sales in 2021 and market potential of SWPs and cold storage units in SSA and India by 2030 based on the 22022 OGS MTR 'State of the Sector.'*

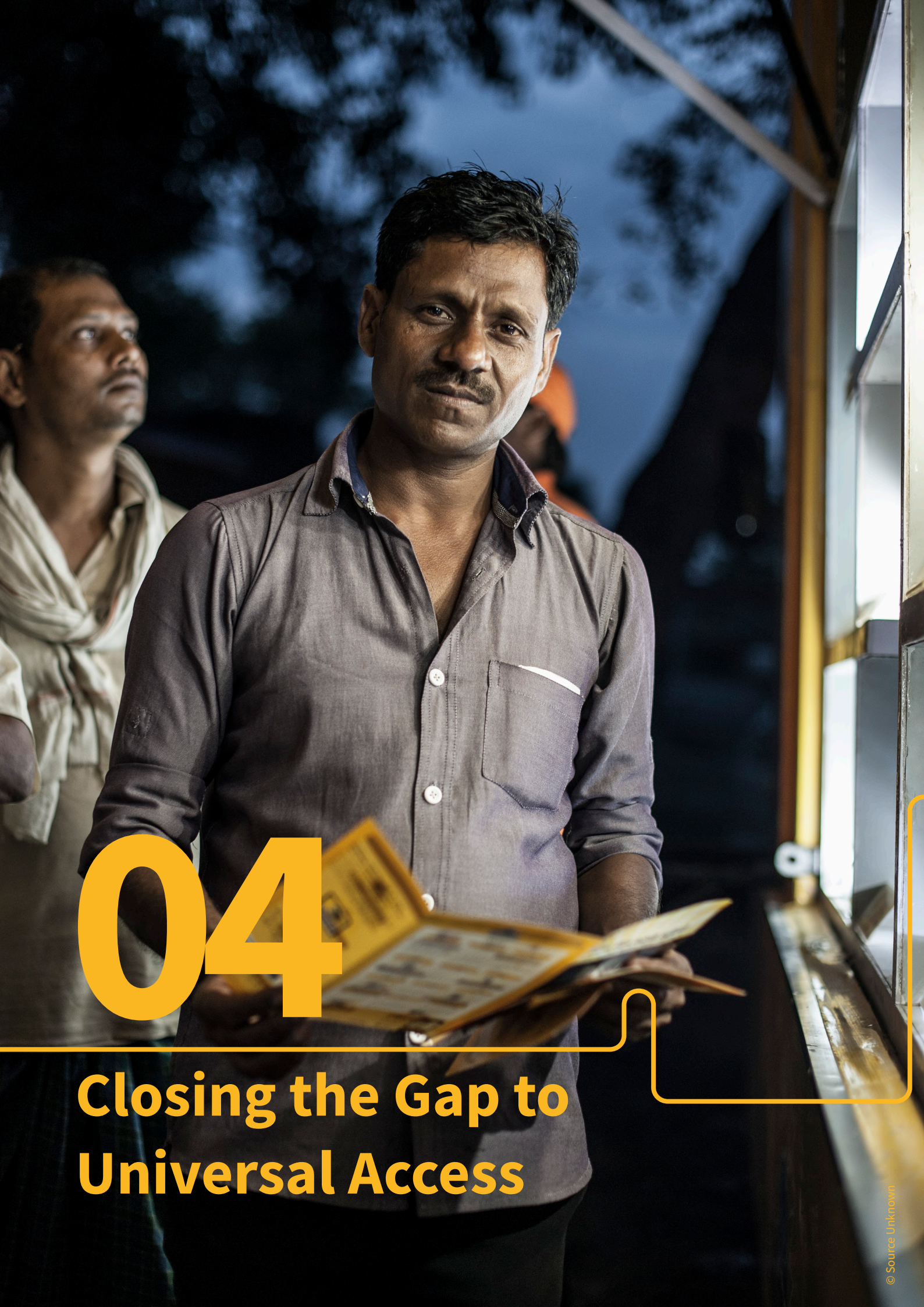
89 *CaaS Initiative, Off-grid cold storage for farmers in Kenya.*

90 *Ibid.*

91 *Efficiency for Access (2019), Solar Water Pump Outlook Report.*

92 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

93 *Powering Healthcare Initiative | About us*



04

Closing the Gap to Universal Access

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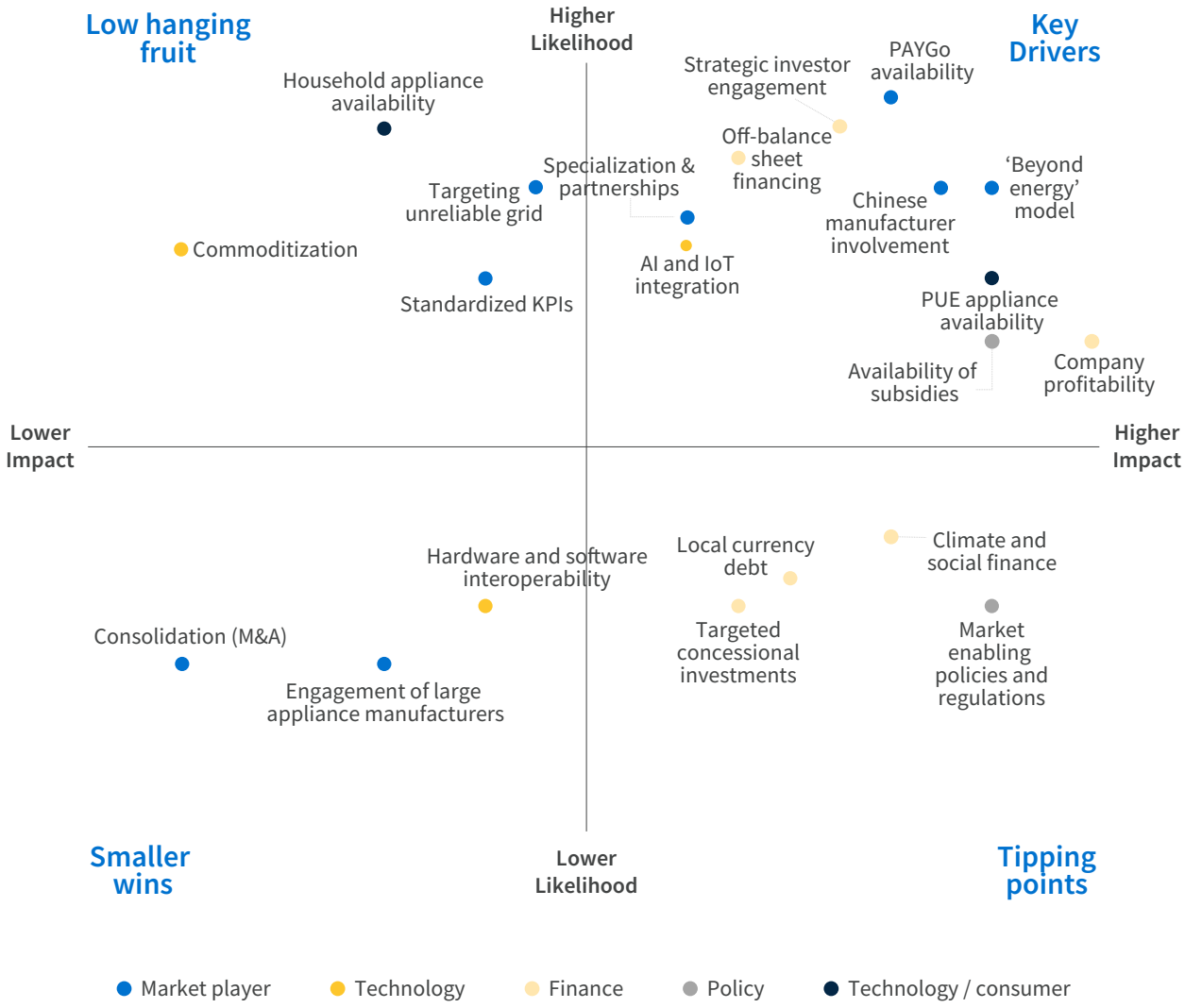
The OGS sector has strong growth potential; targeted interventions are needed to address key barriers to growth and close the electricity access gap.

To achieve its potential, the OGS sector requires game-changing interventions to address existing barriers to growth. As outlined in chapter 2, the sector will need to reach 56 million unit sales in 2030 from 32 million in 2021 to meet its target contribution towards SDG7: serving 1.1 billion people, including 464 million newly connected primary OGS users. Given the range of growth rates discussed in chapter 3, the sector may still miss its target by up to 606 million people, as in the conservative scenario. Therefore, targeted action is needed to close the gap.

The last several iterations of this report have assessed potential game changers. The *2020 Off-Grid Solar Market Trends Report (MTR)* classified and prioritized OGS sector game changers based on relative impact and likelihood of influencing the sector's growth trajectory. "Low-hanging fruit" and "Smaller wins" were noted as having relatively lower impact on the market, with differing levels of likelihood. "Tipping points" were assumed to be high-impact factors that stakeholders needed to support to close the electricity access gap while "Key drivers" were considered more likely to occur, with similarly high levels of impact (see Figure 18).

Figure 17: Recap of relative ranking of 2020 game changers for the OGS sector[94]



94 *The 2020 Off-Grid Solar Market Trends Report.*

This version of the *MTR* will continue this approach, reviewing the progress of key game changers, and presenting those that are needed to accelerate sector growth. Each of the sub-sections below details briefly the progress for each game changer since 2020, defines what is needed to achieve each, and how stakeholders can support those efforts.

Addressing key barriers such as low affordability, higher costs, and narrow company margins can drive first-time access and accelerate the pace towards SDG7.

The OGS sector serves both a commercial market and a development agenda. Meeting development goals means ensuring that all households and institutions are electrified, requiring companies to serve both commercially attractive and unattractive markets. Most of the unelectrified populace now lives in nascent and emerging markets.[95] Several of these are FCV markets, and many other potential customers live in remote, harder-to-reach areas, including those yet to be electrified in more mature markets.

Given the development agenda, many OGS companies will face major affordability constraints and other impacts depressing company margins. Customers that remain unelectrified may have lower ability to pay, and the cost to close the electricity access gap in nascent or harder-to-reach emerging markets is often higher than the cost of serving existing OGS customers, narrowing company margins.

These constraints have been further aggravated by the challenges of COVID-19 and shifts in the donor community. For example, global supply chain disruptions have raised component costs and reduced consumer incomes. However, companies have recently found it increasingly difficult to obtain the de-risking capital needed to provide access for all households due to the finite amounts of grant funding available for off-grid energy solutions.

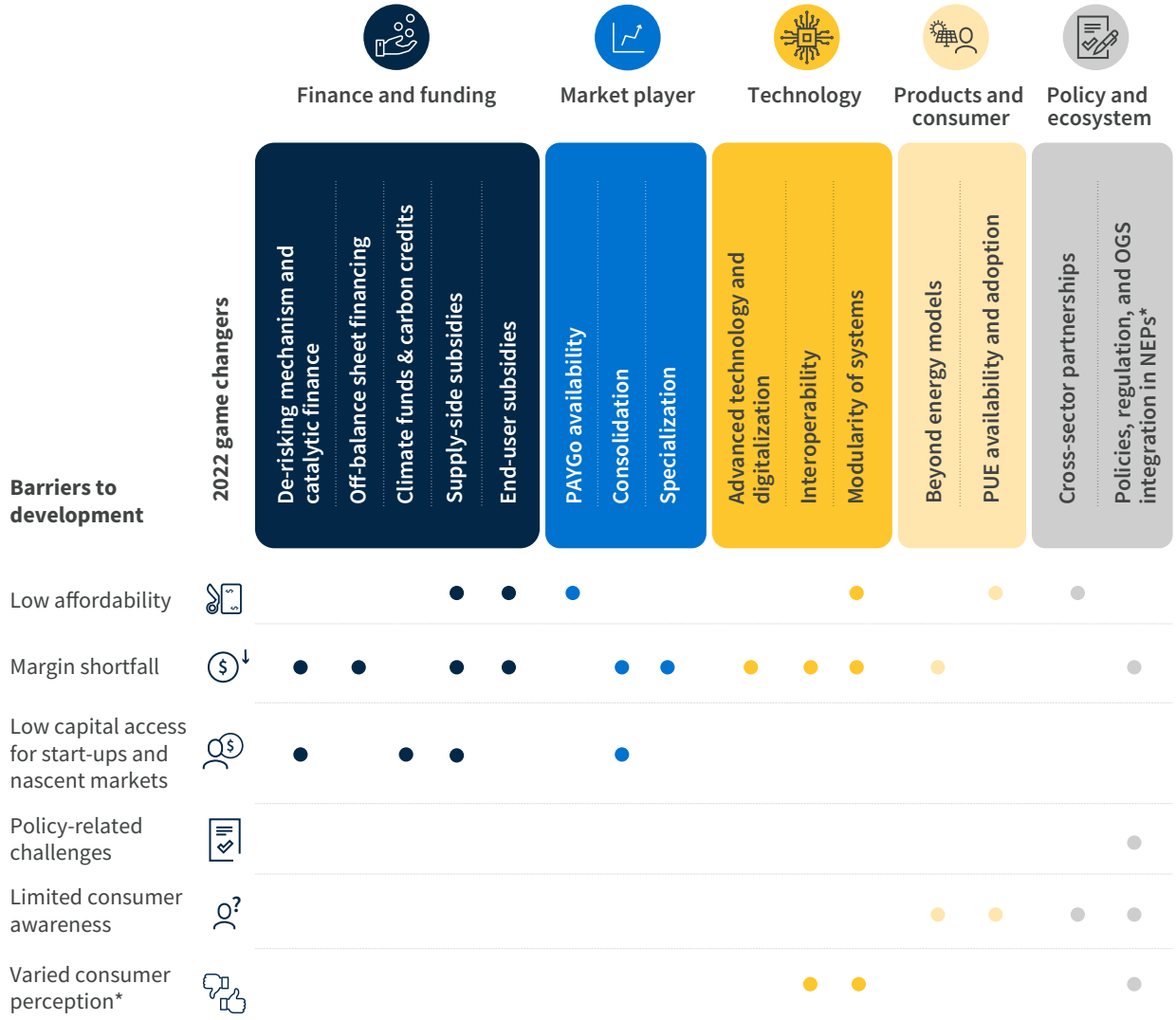
Most game-changing interventions, therefore, will have to focus on affordability and company margins. The most critical interventions are those that directly scale up first-time access and increase affordability to help achieve SDG7. De-risking mechanisms, off-balance sheet and catalytic finance, climate finance, and supply-side subsidies can reduce the cost of reaching the unelectrified in commercially unattractive markets. Cheaper and more efficient technologies and hardware interoperability can reduce direct costs and increase company margins, while digitalization, strategic value chain partnerships, and beyond-energy models can create operational efficiencies that also improve margins. System modularity, another technology game changer, can also lower costs and enhance affordability of OGS products and greater availability of PAYGo and demand-side subsidies can both then directly bring down the cost for customers. Lastly, though consolidation has potential to increase market concentration, it allows companies to achieve economies of scale, attract more capital, and expand PAYGo offerings to consumers.

Addressing market-specific barriers will support efforts towards universal access by improving the enabling environment to further unlock the sector's potential.

Other market-specific barriers still exist, including policy or regulatory challenges and lack of consumer awareness. Enabling policies and regulations that are simple to implement, consistent, and well-enforced, along with strategic cross-sector partnerships, can improve the operating environment and promote consumer awareness to accelerate sector development. In particular, awareness of the benefits of PUE appliances across many markets remains low, so awareness campaigns for these (as well as SEKs) are still needed in diverse markets. This will increase adoption rates, driving impact beyond electricity access, such as poverty reduction and climate change adaptation.

95 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

Figure 18: How 2022 game changers for the OGS sector address key barriers to development[96]



These and several additional game changers are discussed in more detail below. This section covers specifics on how each can be leveraged to support the sector's goals of reaching SDG7.

96 *Open Capital Advisors analysis. Note: *[1] NEPs - National Electrification Plans, [2] Varied consumer perception refers to the challenge whereby many consumers are yet to perceive OGS as a viable energy solution capable of providing reliable electricity to power multiple items. It differs from limited consumer awareness that covers consumer knowledge of existence and benefits of OGS products, especially PUE appliances.*

4.1 Finance and Funding Game Changers

4.1.1 De-risking Mechanisms and Other Catalytic Finance

More catalytic finance, including de-risking tools, are needed to scale early-stage companies and incentivize entry into nascent markets.

De-risking mechanisms and other catalytic finance are often used to facilitate commercial investment into seed and start-up companies or to incentivize companies to start operations in markets considered 'high-risk.' De-risking mechanisms, which include collateral buy-back agreements, match-funding, and first-loss guarantees, reduce the probability of financial loss for commercial investors by having a third party absorb most of the liability in case of a loss. Other catalytic mechanisms offer companies more favorable financing terms, including instruments such as upfront grants, repayable grants, patient capital, and low-interest loans with a grace period.[97]

Foundations, philanthropic investors, DFIs, and development partners have historically been key sources of catalytic finance in the OGS sector. An example demonstrating the importance of first-loss guarantees for companies entering or operating in nascent FCV markets is the Facility for Energy Inclusion's Off-Grid Energy Access Fund's (FEI-OGEF LP) $5.9 million guarantee to back debt invested in BBOXX DRC in 2021. This was provided alongside a separate guarantee by MIGA, part of the World Bank Group, backing quasi-equity investments in BBOXX DRC, Kenya and Rwanda.[98] Earlier on, in 2018, the company also received a 60% guarantee from the Swedish International Development Cooperation Agency (SIDA), allowing it to secure crowdfunded debt from TRINE to expand operations in Kenya and Rwanda.[99] A different example, showing that guarantees are just as important for scale up of start-up and seed companies, is Pawame's 2017 debt raise through TRINE. This was secured by two guarantees, jointly totalling 50% of the principal. Despite Pawame's recent financial difficulties, Pawame honored its debt obligations and managed to raise additional debt after demonstrating traction following this financing.[100]

More catalytic finance is needed to mobilize new capital for nascent markets and unlock the long-term growth needed to achieve SDG7. Covered under "targeted concessional investments" in the *2020 MTR*, catalytic finance remains critical in addressing the significant gap between capital mobilized for established versus nascent markets, and in reducing the cost of electrifying harder-to-reach areas in more mature markets.[101] Catalytic finance can include both funding for early-stage companies to support their initial growth in markets they are operating in and funding for larger companies entering new markets or testing new models.

Foundations, philanthropic investors, DFIs, and development partners will play a crucial role in providing more catalytic finance and de-risking instruments. To ensure progress towards SDG7, they can partner with funds to specifically support companies willing to penetrate tougher markets or seed and start-up companies in those same areas. Pooling concessional capital with more than one funder providing upfront grants or first-loss guarantees to de-risk a partner fund's investments will share risk among participating organizations. Partnerships with fund managers early during concessional fund design can enable partner funds to successfully raise additional capital before closure and deployment.


© Power Africa

97 ESMAP (2020), Funding the Sun | New Paradigms for Financing Off-Grid Solar Companies.

98 AFSIA (2021), MIGA Support Helps Bboxx Deliver Clean Off-Grid Solar Energy in Central and East Africa.

99 ESMAP (2020), Funding the Sun | New Paradigms for Financing Off-Grid Solar Companies.

100 *Note: For more information on Pawame's struggles through the COVID-19 pandemic, please refer to the 2022 OGS MTR 'State of the Sector'.*

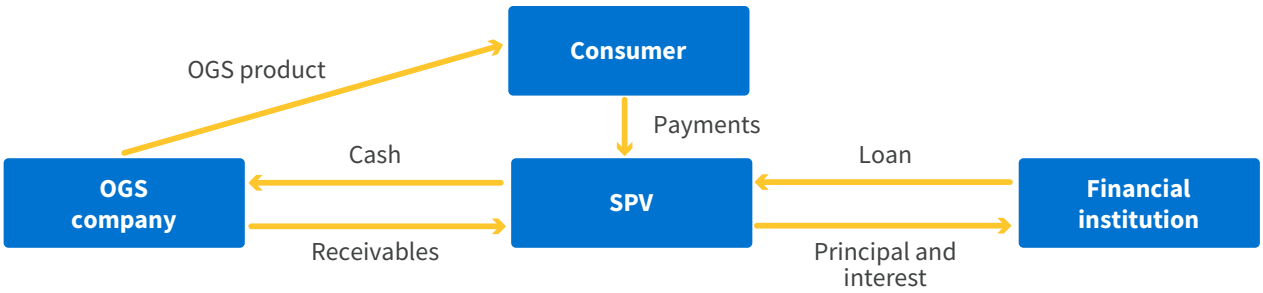
101 ESMAP (2022), Designing Public Funding Mechanisms in the Off-Grid Solar Sector.

4.1.2 Off-Balance-Sheet Financing

More off-balance-sheet financing is needed to enable larger OGS companies to scale operations in more mature markets.

Off-balance-sheet financing offers an innovative way for larger OGS companies to raise flexible working capital to finance growth beyond equity and on-balance-sheet debt financing. Off-balance-sheet financing structures allow companies to sell their receivables through a separately established special purpose vehicle (SPV). The financing is recorded on the SPV's balance sheet, allowing the company to utilize debt funding, without affecting its leverage ratios. Typically, higher implied collateral is required (or an equivalent higher interest rate) compared to traditional debt to account for higher credit risk, since investors into an off-balance-sheet SPV often have no recourse to the originating OGS company's receivables not transferred to the SPV (see Figure 20).

Figure 19: Example of an off-balance-sheet SPV structure[102]



Off-balance-sheet financing is mostly suitable for larger companies given the scale of receivables needed to justify the high transaction costs incurred during the creation of securitization vehicles. Securitization structures are complex, attracting high transaction costs that are too expensive for small companies. Furthermore, small companies have less of a credit track record, which increases their riskiness and the cost of their receivables. As such, there have been few off-balance-sheet financing rounds in the OGS sector, and most transactions have been led by larger scale-up companies like BBOXX (2015) and d.light (2020 and 2022).[103] The potential impact of off-balance-sheet financing is still considered high, as it was in the *2020 MTR*, despite the limited transactions to date.

Large OGS companies can leverage their large, relatively high-quality receivables portfolios to successfully raise off-balance-sheet financing.[104] To prepare for such a raise, companies can ensure receivables are strategically carved out during prior debt raises so that on-balance-sheet lenders have no recourse on receivables that are to be sold during an off-balance-sheet financing. Companies can also demonstrate lengthy track records for their PAYGo operations in an existing market–around 12 months–before raising off-balance-sheet financing for that specific market. Since most vehicles are successful when they sell quality receivables, companies can prepare by incorporating credit risk assessment and management practices early to limit default risk for the selected pool of receivables.

An off-balance-sheet financing platform that aggregates receivables from multiple small companies in more mature markets could help unlock more working capital in local currency. The scale from such a model could justify the fund's set-up costs, solving the challenge faced by individual companies with small PAYGo portfolios. Development partners and donors could fund the establishment of an off-balance sheet financing platform to make this type of funding economically feasible for small companies. Foundations and philanthropic investors could provide buy-back guarantees for the first round to reduce risk and encourage investors to participate; once the first round is successful, subsequent rounds may require less de-risking. Financiers, both local and international, can

102 *Open Capital Advisors analysis and consultations; GOGLA (2016), Off-Grid Solar Investment Academy.*

103 *Greentech Media (2015), The World's First Securitization of Off-Grid Solar Assets; Global Private Capital (2020), d.light and Solar Frontier Capital Announce $65 Million Local Currency Receivable Financing Facility for Kenya; African Energy Live Data (2021), Kenya: Norfund Invests in d.light Receivables Vehicle; d.light (2022), d.light and SFC Announce Industry-Leading $238 Million Multi-Currency Receivable Financing Facility.*

104 *Open Capital Advisors analysis and consultations.*

take part as either senior or subordinated debt partners to make local-currency financing available for these companies. An SPV arranger with OGS sector experience would be appointed to manage the platform. In addition to planning and fundraising, the arranger would also verify receivables quality. Companies could then join the platform on a cost-share basis, and technical assistance could be provided to support onboarding and compliance. Sector stakeholders are already exploring similar platforms, such as Solaris Offgrid's PaygOps Disruptive Receivables Finance Project.[105]

4.1.3 Climate Funds and Carbon Credits

OGS companies can better communicate the positive climate benefits of the sector to unlock more climate finance.

Climate finance refers to funds set aside to support projects that curb the effects of climate change, either through mitigation or adaptation, in line with SDG13.[106] Climate funds, such as the Green Climate Fund (GCF), make debt or equity investments directly or indirectly (through other funds) into companies or projects that meet set climate objectives.[107] Carbon credits, another mechanism of climate finance, are verified emissions-reduction certificates awarded for projects that can be traded as permits that allow the holder to offset a specified amount of GHG, thus providing an additional revenue stream for companies that have earned the credits by enabling the avoidance of GHG emissions.[108]

Though OGS products offer a viable pathway to reducing carbon emissions and adapting to climate change, the sector has not tapped into much climate finance. The bigger barrier is that companies do not sufficiently communicate the sector's positive impact on climate change. A few OGS companies that sell SEKs have marketed climate mitigation benefits to climate finance providers, but PUE companies have been less successful, despite often offering climate change mitigation and adaptation benefits.[109] On the supply side, investors are often deterred by the limited pipeline of projects and relatively small ticket sizes. Furthermore, the traditional private institutional investors who dominate the climate finance space are not yet as familiar with the OGS sector and its potential to accelerate SDG7 and SDG13 goals, and they are often looking for investment opportunities that can offer higher liquidity and returns compared to current opportunities in the OGS sector.[110] In addition, companies struggle to raise funding through carbon credits due to the currently expensive monitoring and verification requirements. Overall, accessing both types of climate finance remains a high-impact game changer, as was the case in the *2020 MTR.*

Several initiatives have been launched to overcome challenges such as the expensive measurement and verification processes for carbon credits and to aggregate the impact of many SEKs monitored by company PAYGo systems to increase ticket sizes. The Distributed Renewable Energy Certificate (D-REC) initiative, for example, was launched by multiple stakeholders to draw climate revenue to the sector, by enabling the generation and trade of Renewable Energy Certificates (RECs) from distributed renewable energy projects, including in OGS. The initiative hopes to raise $100 million annually and is anticipated to be instrumental in replacing the use of kerosene and small-scale fossil fuel-powered generators with OGS products.[111] Solstroem has also launched a carbon credits program that offers OGS companies access to carbon markets through the generation and sale of Micro Carbon Avoidance (MCA) certificates.

Moving forward, more OGS companies can leverage platforms that allow them to monetize their positive impact on climate change, unlocking a new source of non-customer revenue and improving company margins. The Solstroem and D-REC initiatives discussed above make it easier and more affordable for companies of all sizes to access financing from carbon markets. So far, mostly larger, vertically integrated companies in SSA and Southeast Asia,

105 *PaygOps | PaygOps Disruptive Receivables Finance Project.*

106 *UNFCCC | Introduction to Climate Finance.*

107 *UNHCR | Carbon Financing.*

108 *SouthPole | Carbon Offsets Explained: What Are Carbon Credits and How Do They Work?*

109 *Note: SWPs and solar refrigeration appliances in particular have direct climate benefits through enabling increased adaptation and resilience to their users in the face of increasing harsh climatic conditions as well as improving mitigation through harnessing renewable solar power in place of climate-harming fossil fuel powered generators to reduce emissions from fuels and reduced food waste. For more information, please refer to the 2022 OGS MTR 'State of the Sector.'*

110 *GOGLA (2022) How to Make Climate Finance a Game-Changer for the Off-grid Solar Industry.*

111 *The D-REC Initiative | About the Initiative.*

such as Sun King, ZOLA Electric and ENGIE, have registered as program partners and are already receiving payments.[112] More companies in these markets need to utilize these platforms to gain access and benefit from financing raised.

To draw additional climate financing to the sector, OGS companies can better communicate their climate change mitigation and adaptation impact stories to investors. Companies, investors, and development partners need to collaborate to improve and standardize the measurement and verification of climate change adaptation impact to allow companies to demonstrate this benefit convincingly. Companies can then work with industry associations, including GOGLA and local bodies, to improve data transparency, so climate investors and donors can make more informed decisions.[113]

4.1.4 Supply-Side Subsidies

More smart supply-side subsidies tailored to varying company sizes and market maturities are needed to close the electricity access gap.

Supply-side subsidies, such as zero-interest loans, grant windows, and supply-side RBFs, incentivize companies to serve harder-to-reach, underserved markets by de-risking companies' investments. Supply-side RBFs — which involve payments to companies based on set performance in underserved markets — and grant windows are the most commonly disbursed supply-side subsidies, given their track record of successfully incentivizing entry into new, high-risk, or high-cost markets.[114]

The number of supply-side subsidy programs increased significantly over the last two years, as governments worked with development partners to increase the pace of OGS electrification. Nearly 50% of RBF funding disbursed (or in ongoing disbursement) to the sector since 2013 was committed in 2020 alone, as the need to accelerate electricity access increased during the pandemic. Governments including Madagascar, Nigeria, Mozambique, and the DRC launched supply-side subsidy programs, some with a mix of instruments to develop different market segments and some focusing on both SEK and PUE product segments (refer to the *2022 OGS MTR 'State of the Sector'* for more analysis). These subsidies continue to be a high priority for the sector.

Despite an uptick in RBF disbursements, more supply-side subsidies, tailored to company size and market maturity, are needed so that companies can serve the hardest-to-reach customers while also operating a viable business. Supply-side subsidies, particularly zero-interest loans and non-repayable grant windows, are needed to incentivize companies to enter and unlock underserved markets. This includes not only nascent country-level markets, but also underserved communities in mature and peaked markets.[115] Grant windows are required for all companies in nascent markets, regardless of size, whereas in more mature markets, zero-interest loans or supply-side RBFs that include upfront payments may be better suited for smaller OGS companies that lack sufficient working capital to pre-finance installations. Last Mile Distributors (LMDs) will be critical in reaching remote areas with poor infrastructure and low population density and therefore are likely key funding recipients. In general, programs should adopt different incentives for differently sized companies, based on the goals of the program and the ecosystem of potential beneficiaries of the funding because regularly structured RBFs alone may not unlock nascent markets or support growth of small companies.[116]

A combination of increased supply-side support and public procurement may be needed to accelerate electricity access in FCV countries, depending on specific market characteristics. Consultations with larger firms show that supply-side subsidies in FCV markets may fail to incentivize their market entry as fragile economies and difficult operating environments leave these markets at the bottom in terms of market attractiveness.[117] Nurturing existing local private sector companies that know how to navigate the tough environment would be a better alternative in these markets and this would require more supply-side subsidy designs that incorporate at least upfront payments. Besides supply-side subsidies, public procurement may also be a suitable option to provide electricity access in such markets where the unelectrified

112 *Solstroem | Projects.*

113 *Next Billion (2022), The Growing Urgency of Funding Off-Grid Solar: Exploring the Multi-Billion Dollar Investment Opportunity in Achieving Climate and Energy Access Goals.*

114 *ESMAP (2020), Funding the Sun | New Paradigms for Financing Off-Grid Solar Companies; ESMAP (2022), Designing Public Funding Mechanisms in the Off-Grid Solar Sector.*

115 *Ibid.*

116 *Open Capital Advisors game changers workshop.*

117 *Open Capital Advisors analysis and consultations.*

population targeted is small, sparse, largely remote, and extremely poor, or where the level of insecurity is so high that markets fail to function properly.[118]

Collaboration among governments and development partners is crucial in increasing the scale of supply-side subsidies available to OGS companies. These stakeholders can partner to design and launch pre-funded subsidy programs and crowd-in additional funding from other donors or development partners. Notably, governments can deploy public funds in addition to capital provided by donors and development partners to increase budgets for subsidy programs. A combination of different mechanisms can be used to reach more areas and consumer groups.[119]

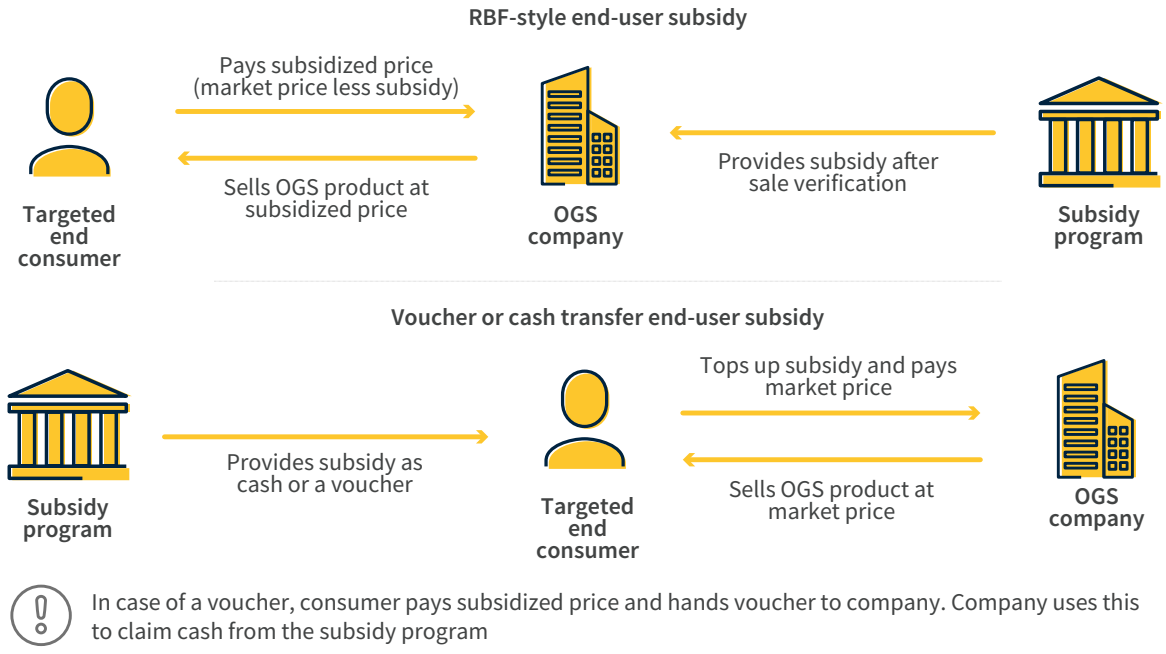
Furthermore, program managers and OGS companies can also play a crucial role by leveraging existing technology to improve the RBF verification process, and attract more funding into subsidy programs. Leveraging Internet of Things (IoT), and existing PAYGo software for RBF impact monitoring and verification can improve the accuracy of the process. This instills greater confidence in funders and shortens the verification and fund disbursement timelines to encourage company participation.

4.1.5 End-user Subsidies

Availability of well-designed end-user subsidies can be scaled up to ensure that every household can afford a Tier 1 solar product.

End-user subsidies are funding instruments designed to overcome the affordability barrier by directly reducing the purchase price of OGS products for end consumers. Subsidies can be disbursed through RBF – where companies sell OGS products to targeted consumers at a discount and receive the subsidy amount to fund that discount – or vouchers, as well as through direct cash transfers to qualifying consumers (see Figure 21). Delivery through cash or vouchers to end-consumers is often preferred when governments and companies consider it particularly important for beneficiaries to know that prices have been subsidized.[120] Such subsidies often target the lowest-income, most-vulnerable populations who risk being left behind in the push to universal access.

Figure 20: End-user subsidy disbursement options[121]



118 *ESMAP (2022), Designing Public Funding Mechanisms in the Off-Grid Solar Sector.*

119 *ALER (2021), The Mozambican Off-grid Energy Market Gave a Sign of Great Dynamism and Growth Potential Reflected in the Investment Portfolio of the BRILHO Program; ESI Africa (2020), Fund Open for Proposals to Accelerate Off-grid Solar in Madagascar.*

120 *ACE TAF and Open Capital Advisors (2020), Demand-Side Subsidies in Off-Grid Solar: A Tool for Achieving Universal Access and Sustainable Markets.*

121 *Ibid.*

End-user subsidies, however, can distort the market, so they must be designed carefully. The direct reduction of end-user prices can negatively affect market pricing dynamics during the program and upon completion if and when the private sector resumes sales at prevailing market prices.[122] Clear communication of program terms, including end dates, is important to the exit strategy. Careful targeting and verification using country-level data is also important to ensure that the target beneficiaries receive the benefit, avoiding "leakage" of program funds.

Recently, more pilot studies have been launched by companies and governments, confirming that end-user subsidies can be successfully disbursed via PAYGo companies to improve affordability and access.[123] Both ENGIE and SolarAid ran pilot end-user subsidy programs in Uganda and Zambia, respectively, between 2019 and 2022, where they sold products at a 20–25% discounted price. Key lessons learned include: (i) that the subsidized fee had a higher impact on the livelihoods of the poorest households compared to other low-income households and (ii) that the lowest-income households achieved affordability if the subsidy was introduced for PAYGo-enabled products to reduce the installment payments to either match or fall below their regular energy spend. Successful nationwide programs and pilots have also been run in Togo and Rwanda, with important lessons learned and analyzed (see the *2022 OGS MTR 'State of the Sector'* for details). Given the persistent affordability challenge of the largely underserved populace, end-user subsidies are as critical to achieving SDG7 as they were in 2020.

An increase in the scale of well-designed, substantially-funded end-user subsidy programs is therefore needed. In the immediate short term, more pilot programs are required to inform program design and obtain impact results that can attract more funding. End-user subsidies should be targeted at improving the affordability of basic, Tier 1 OGS products for the poorest unelectrified households - an estimated $4.5 billion is needed to bridge the affordability gap (see Chapter 2 for the SDG7 analysis). End-user subsidies are also needed to provide access to income-generating PUE appliances.

Governments, development partners, and donors can pool their resources to launch both new pilots and large-scale, multi-year programs. Though data drawn from company-led pilots is helpful, the programs are often small-scale and impact limited. To design and launch more pilots, as well as larger programs, stakeholders can leverage knowledge shared from new initiatives such as The End User Subsidy Lab created by ESMAP/Lighting Global, EnDev, GOGLA, and Africa Clean Energy (ACE) that shares lessons from ongoing and upcoming pilots. One design element that can be explored to improve targeting and impact outcomes is the establishment of a centrally-managed citizen database, with technology leveraged for more accurate qualification, verification, and payment disbursement. The databases can be built on data from existing safety net programs that already target vulnerable citizens. The Kenya Energy Cash Plus / Mwangaza Mashinani programme (MMP) pilot, for example, used data from the existing National Safety Net Programme (NSNP) to achieve this.[124] Finally and importantly, program implementation must have a clear exit strategy to ensure the overall sustainability of funding for electricity access.

4.2 Market Player Game Changers

4.2.1 PAYGo Availability

Increased capital for PAYGo expansion and innovation of PAYGo business models at the country level are needed to boost PAYGo penetration and improve affordability of OGS products.

PAYGo has accelerated OGS electrification, especially in SSA, by making SEKs and PUE appliances more affordable. Of the two models in existence, the most common is the rent-to-own model that eventually transfers ownership to the consumer whereas the rental or energy-as-a-service model is less common (see the Abbreviations & Key Definitions section for PAYGo definition).

Affiliate PAYGo sales showed resilience despite the COVID-19 pandemic, but PAYGo remains largely unavailable in less mature markets. This is due to a reliance on mobile money and limited funding available. Affiliate PAYGo sales increased in 2021, demonstrating resilience of the business model in the face of depressed incomes even though some PAYGo companies received financial support from development partners and funds to

122 *Ibid.*

123 *GOGLA (2022), End User Subsidies Lab Webinar Series: Innovative Industry Models to Increase Affordability by Subsidizing End User Prices.*

124 *End User Subsidies Lab (2020), Case Study: Conditional Cash Transfers in Kenya for Off-Grid Solar Energy Cash Plus / Mwangaza Mashinani Programme.*

extend payment holidays to customers and revise payment terms. PAYGo availability, however, is still concentrated in East Africa and other markets where mobile money is available (see the 2022 OGS MTR 'State of the Sector' for details), and limited financing to fund PAYGo working capital requirements has also limited growth in new markets.

Companies can leverage alternative payment solutions and networks to increase PAYGo availability in riskier markets with underdeveloped mobile money networks. OGS companies can adapt the PAYGo model to fit their country's infrastructure in countries where mobile money is unavailable. In Nigeria, LUMOS partnered with MTN to offer airtime-based PAYGo, whereas Sun King (formerly known as Greenlight Planet) built a cash-based PAYGo network of retailers who act as cash collection centers for customer payments and provide customers with 'unlock codes' for their systems.[125] These examples demonstrate that PAYGo is possible without mobile money, and can be made available in nascent and emerging markets.

Development partners and donors can provide flexible, favorable financing to increase PAYGo availability in less mature markets and for the poorest customers. To achieve universal access, dedicated concessional debt financing, preferably in local currency, can support PAYGo companies, alongside fiscal incentives such as tax and subsidy exemptions, to lower the cost of scaling PAYGo companies. For nascent and emerging markets, start-up grants can support local LMDs to develop their PAYGo business model, particularly where large companies lack interest in the market. Funding can also be channeled to PUE companies that partner with micro-finance institutions to co-offer PAYGo-type agreements to lengthen the payment period or further reduce the amount per installment to make PUE appliances more affordable.

Government institutions can introduce finance- and technology-related policies that enhance the enabling environment for increased PAYGo availability in markets where mobile money is unavailable. Central banks can introduce or amend policies to allow non-financial institutions, such as mobile network operators, to offer financial services. This will enable companies to easily expand the PAYGo model to new markets, using the preferred mobile-money payment method. Governments can also introduce tax exemptions for mobile phones to increase affordability and penetration. This will enable growth in mobile money access and increase PAYGo availability.

Increased consolidation in more mature markets and specialization, with strategic partnership, in less mature markets can drive operational efficiency and improve company margins, strengthening the OGS sector.

4.2.2 Consolidation

Consolidation often occurs in an industry's life-cycle as it grows towards maturity, resulting in fewer but larger and potentially more resilient companies. In some instances companies willingly merge or acquire others to realize synergies, and in others companies are acquired when one is struggling financially. Companies that emerge stronger from consolidation often operate at a larger scale and benefit from operational efficiencies and improved margins, enabling them to attract capital for growth. Consolidation through acquisitions by larger companies may also help to increase PAYGo availability, by replicating their refined models to regions where acquired companies operate.

However, consolidation can increase market concentration and resulting companies may still not target BoP households or FCV markets. Consolidation can thereby reduce competition, and there is no guarantee that consolidated companies will aim to serve customers with the greatest need for electrification. Without a clear, long-term commercial opportunity, short-term financial incentives may not be enough to convince companies to enter these markets, even with the larger companies' experience with the PAYGo model.

There are already mergers and acquisitions (M&A) taking place in the sector driven by the need to strengthen company operations. In January 2022, Solar Panda and Azuri Technologies partnered through an agreement that increased Solar Panda's customer base by 50%, demonstrating an ability for the company to quickly scale its reach.[126] Solar Panda subsequently raised $8 million in July 2022.[127] In September 2022, BBOXX acquired PEG Africa to scale up operations, widening its geographical presence in West Africa, and potentially supporting the company in attracting more investment for its growing

125 *Signify Foundation and Intellecap (2019), Mapping the Off-grid Solar Market in Nigeria; GSMA (2016), Mobile for Development Utilities Lumos: Pay-As-You-Go Solar in Nigeria With MTN; Shell Foundation (2019), Greenlight Planet Nigeria: Pilot Learnings: 2017-2019; PUNCH (2021), Greenlight Has a Bright Future in Nigeria – Tuga Omoyemi, PAYG Business Leader at Greenlight Planet.*

126 *Solar Panda (2022), Solar Panda and Azuri Technologies Announce Servicing Agreement.*

127 *CEO Business Africa (2022), PAYG Startup Solar Panda Secures US$8m Series A Funding to Increase Product Offering.*

portfolio.[128] LMDs are also consolidating to strengthen operations. For example in May 2022 Solar Sister in Nigeria and Tanzania merged with LivelyHoods in Kenya to jointly supply SEKs and other climate-friendly products to last-mile consumers.[129] In 2020, consolidation was viewed as low-impact and low-likelihood but is now considered both high-impact and high-likelihood.

While consolidation may occur naturally over time, driven by prevailing global economic conditions that affect company performance, companies and strategic investors can seek out lucrative opportunities to accelerate the process in more mature markets. Companies can find opportunities to acquire or merge with other businesses that align with their long-term strategies while more strategic investors could enter the market to take advantage of opportunities to conglomerate complementary companies into a stronger, cohesive group, as ENGIE did with Mobisol and Fenix International.

4.2.3 Specialization

Specialization involves focusing on one product segment or part of the OGS value chain to gain a competitive edge in the market. Product segment specialization is a popular strategy for PUE companies while value chain specialization is common among small or local distribution companies without the financial muscle or capacity to operate along the entire value chain, or for companies choosing to offer a niche service along the value chain, such as software.

Specialization is an ongoing trend in the OGS sector with companies now cropping up to provide niche services that cut across all sector players. Over the last two years, companies have cropped up to provide specialized services to OGS companies, such as e-waste management, after-sales services including warranty, repairs and maintenance, and digitalization to improve credit risk management and the customer experience. Specialization is still considered a high-impact game changer.

PUE companies can continue to build specialist expertise in their respective niches. PUE appliances are complex and often require a much more technical team to provide product-specific advice on sales or after-sales support. Due to this, most companies offer one or few types of appliances, such as solar cooling or solar water pumps. This additional complexity with PUE also makes it difficult for traditional, SEK-focused companies to simply add PUE appliances to their product portfolios without requiring specialized sales teams for distribution.

Small or local companies in less mature markets can consider value chain specialization and adoption of common international product standards to encourage strategic partnerships. Though the vertically integrated model is good for nurturing new technologies, specialization enables companies to maintain leaner, efficient businesses with reduced market exposure.[130] Coupled with partnerships across the value chain, companies can efficiently serve a wider range of customers while offering better quality products and services. With common standards, adopted widely, companies will be able to comfortably unbundle value chain processes, specialize in one or two segments, and form meaningful partnerships with other players across the value chain.

4.3 Technology Game Changers

4.3.1 Advanced Technology and Digitalization

Companies can adopt technological advances such as Internet of Things, and system interoperability and modularity to unlock benefits that strengthen sector development.

Internet of things (IoT) and Artificial intellige (AI) are technologies that enable OGS companies to capture data that can be analyzed to increase operational efficiency and improve services whereas grid-compatible OGS systems enable power source optimization for weak-grid consumers. IoT is a network of sensors that enables exchange of consumer data between OGS devices that companies analyze to predict customer behavior and improve PAYGo company payback outcomes, after-sales services, and predictive maintenance. Subsidy program managers can also use the data for remote

128 BBOXX (2022), Bboxx Consolidates its Market Leading Position by Acquiring Solar Energy Frontrunner PEG Africa.

129 Solar Sister (2022), Better Together! Solar Sister Announces Merger With Livelyhoods Kenya.

130 UNEP DTU Partnership & Strathmore University Energy Research Centre (2021), Local value Capture From the Energy Transition: Insights From the Solar PV Industry in Kenya; Global Distributors Collective (2021), The Growth and Fundraising Journeys of Last Mile Distributors (LMDs).

verification.[131] Closely related is AI, the simulation of human intelligence by machines, that OGS companies use to digitize processes, optimize product performance, assess consumer credit risk, and improve pricing.[132] Grid-compatible systems, another advancement in technology, are those that allow for OGS integration with the national grid through inverter-based networks to improve power supply quality and reliability in unreliable-grid areas.[133]

Application of these technologies is still fairly new but is already playing a critical role in driving sector growth by improving credit risk management processes and reducing operational costs. Large companies such as BBOXX, M-KOPA, and SunCulture, to name a few, are applying IoT and AI to better understand consumer behavior for improved credit risk assessment and management, and to optimize inefficient processes, while LMDs are doing the same through outsourced digitalization services from specialized Software-as-a-Service (SaaS) companies (refer to the *2022 OGS MTR 'State of the Sector'* for more details).[134] IoT has also been a key feature in management of grid-compatible OGS systems, enabling the system to communicate with the grid to optimize energy source utilization depending on the state of grid power supply or weather conditions affecting OGS power supply. AI and IoT integration remains high-impact for the sector and targeting unreliable-grid areas is now considered high-impact, compared to 2020.[135]

More companies can adopt AI and IoT technologies to digitalize processes that reduce credit risk, improve margins, and increase access to financing. With investor focus now clearly on PAYGo credit portfolio health, companies can leverage AI and IoT technologies to better assess and manage credit risk before and after client onboarding. The same technologies can also be applied to making operational processes such as after-sales service and sales management, more efficient to improve company margins. With healthy credit portfolios and rising margins, OGS companies will be in a better position to attract investment for serving new customers.

Subsidy program managers can work with companies to leverage IoT for more accurate impact monitoring and faster verification. IoT allows for remote verification, which can expedite the claims process for subsidy programs like RBFs, making these programs more compelling for companies and funders to participate, given the positive impact on company cash flows and impact monitoring.

Donors can fund more research and development on making grid-compatible OGS systems more affordable to better target all weak grid areas. Setting up such systems is expensive and not yet accessible at scale. Since many weak grid areas are rural, where ability to pay is often lower than in urban areas, it is vital to bring down costs and increase affordability. OGS companies can also partner with utilities to identify better-paying customers and consumer profiles in these areas, enabling them to make more sales through PAYGo and reduce their credit risk.

4.3.2 Interoperability

Interoperability refers to standardization of connectors and digital protocols which allow consumers to pair SEKs and appliances from different companies and enable companies to save on research, development, and manufacturing costs. This increases consumer choice by reducing switching costs from one company to another and fosters healthy competition that drives market efficiency and growth as OGS companies will have to maintain active and relevant competitive strategies to sustain customer loyalty.[136] However, for interoperability to deliver these benefits, adoption needs to be widespread.

While software interoperability is in its early stages of adoption, hardware interoperability is yet to take off due to concerns around repayment risk and quality assurance. SaaS providers of PAYGo platforms - including Angaza, PaygOps (by Solaris Offgrid), and Paygee - are pioneering adoption of software interoperability. However, use of the standardized universal plug developed by the 'Connect Initiative' to promote hardware interoperability is not yet common.[137] OGS companies continue to develop proprietary hardware and software applications, citing risks that guaranteeing a high level of after-sales service and quality of systems performance may be difficult if they were to make their products interoperable. There is also a perceived risk that PAYGo customers may also fail

131 *Oracle | What is IoT?*

132 *Dalberg & The World Bank (2022), Africa Energy Access Flagship report (forthcoming). TruQC | Digitization vs. Digitalization: Differences, Definitions and Examples; Note: 'Digitalization' refers to the use of digital technologies to transform business processes, creating efficiencies and potentially increasing margins. It differs from digitization, which is simply converting processes from analog to digital form.*

133 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

134 *GDC | Digital Service Catalog.*

135 *Dalberg & The World Bank (2022), Africa Energy Access Flagship report (forthcoming)..*

136 *GOGLA (2021), The Connect Initiative Whitepaper.*

137 *Solaris Offgrid (2020), PaygOps, Paygee and Angaza are Becoming Interoperable!*

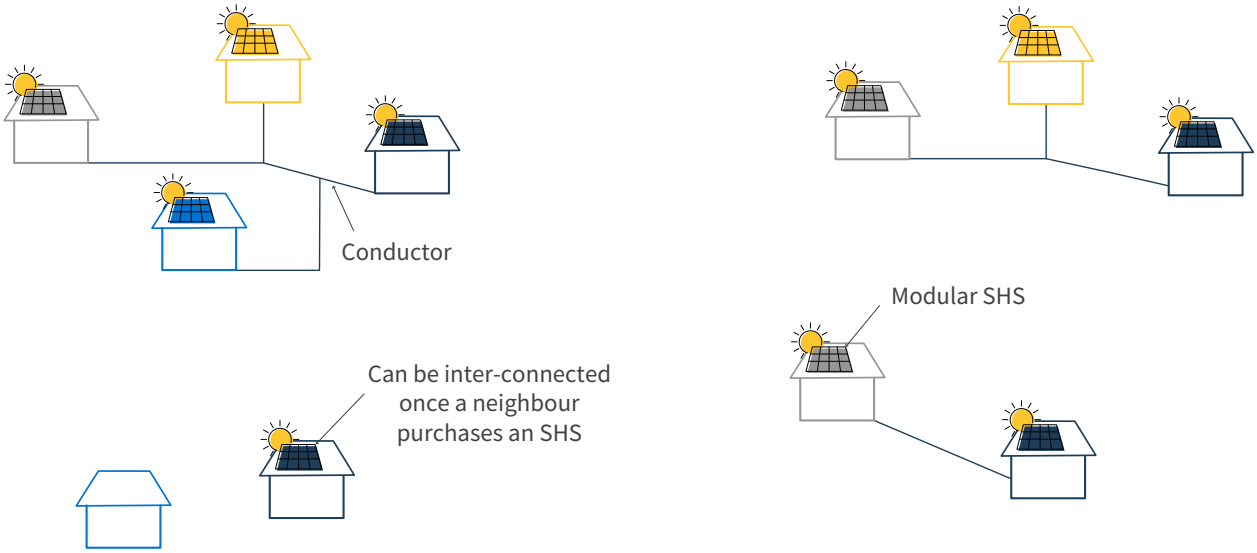
to complete payments (refer to the *2022 OGS MTR 'State of the Sector'* for more details).[138] Unlike in 2020 where interoperability was viewed as a 'small win', it is now seen as a lever to increase company margins and OGS electrification demand by improving consumer perception.

More OGS companies can partner with interoperable SaaS providers and further consider hardware interoperability. 18 brands that already utilize services of the three aforementioned interoperable SaaS PAYGo platforms will adopt software interoperability as soon as the SaaS companies officially become interoperable; more companies can easily adopt software interoperability by using any of these three platforms to make adoption more widespread. OGS companies, through industry association-led programs such as the 'Connect Initiative', can find solutions to the concerns around hardware interoperability, to improve consumer choice while also reducing risks to their brands and loan books.

4.3.3 Modularity of Systems

Modularity is a technology feature that makes it possible to increase the capacity of SHS or PUE appliances by adding battery and PV module capacity.[139] System modularity can enable consumers to climb the energy staircase with rising incomes and greater energy needs. Paired with PAYGo, this can increase affordability of electricity access beyond Tier 1 and enable consumers to see OGS as more than just a temporary electricity solution before grid arrival. Further, leveraging modular SHS to create a mesh-grid, a system of connected SHS that enables energy sharing and trading, could also enhance community-wide benefits of solar systems (see Figure 22).[140]

Figure 21: Illustration of mesh-grids leveraging modular SHS in an off-grid community[141]



Availability of modular SHS has increased impressively over the last few years while modularity among PUE appliances remains nascent. Companies selling modular SHS include SolarworX, Solar Kiosk (selling Solego products from SolarworX), Solaris, Niwa, Fosera, SolarNow, among others, while Okra Solar and SolarworX have successfully set up mesh-grid projects in Cambodia, Nigeria, Haiti, Philippines, Zambia, and Cameroon.[142]

138 *GOGLA (2020), Connectors: The Low-hanging Fruit for Interoperability.*

139 *Everything About Solar Energy (2015), Modularity.*

140 *Okra Solar (2022), Do the Costs of Mesh-Grids Weigh Up? 18 Months Later for Steung Chrov; SolarworX | DC Microgrid.*

141 *Okra Solar (2022), Mini-Grids vs. Mesh-Grids;* Note: *Image inspired by OKRA Solar mesh grid.*

142 *InnoEnergy, Modular Solar Home and Business System; Angaza (2020), Angaza and Solarworx Bring Modular Solar Solutions to Africa; Solar Kiosk, Solar Solutions for Frontier Markets; Solaris Offgrid (2017), Eternum Energy becomes Solaris Offgrid; Niwa (2014), Niwa – Next Energy Products Releases Family of Modular Solar Systems; Angaza (2018), Fosera GSM Solar Home System is Angaza Pay-As-You-Go Ready; Business Call to Action | Case Study, Solar Now: Affordable Solar Home Systems; Okra Solar (2022), Do the Costs of Mesh-Grids Weigh Up? 18 Months Later for Steung Chrov; SolarworX (2021), DC Microgrid Successfully Piloted in Zambia; Okra Solar | Projects; SolarworX (2022), Solarworx Launches DC Microgrid in North Cameroon.*

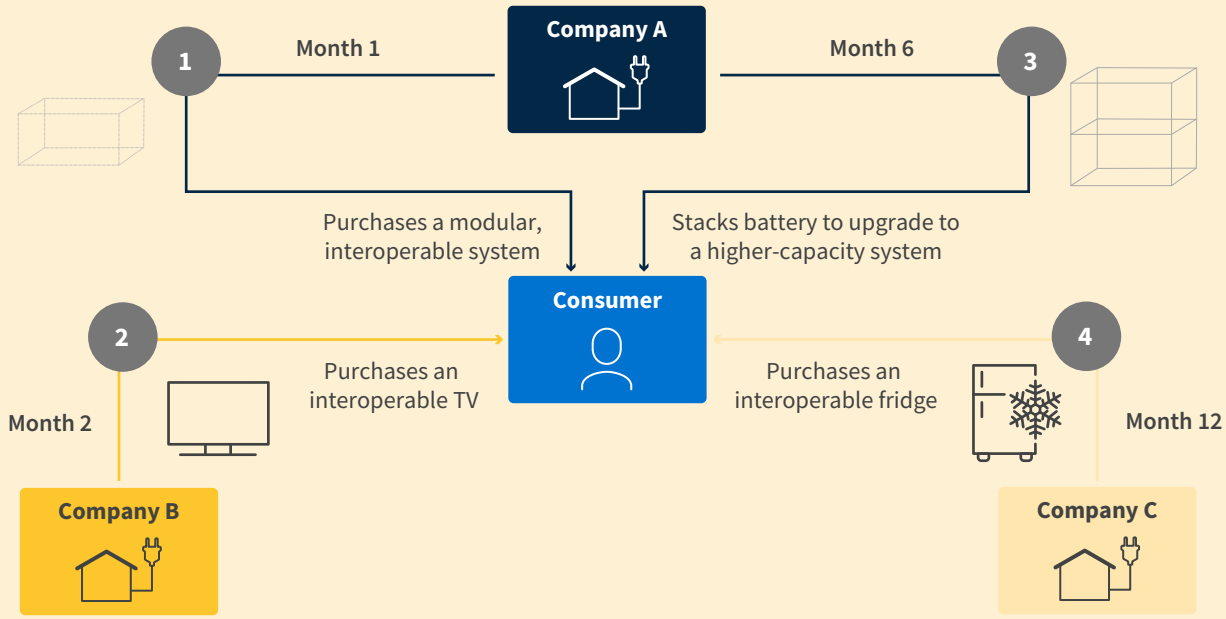
Most companies that sell modular units on PAYGo allow customers the flexibility of adjusting their PAYGo agreements once they increase capacity. Modular agro-processing appliances like solar rice hullers are available in Southeast Asian markets but generally, sales of such PUE appliances have largely been bespoke, based on needs of the purchaser.[143] Modularity of systems is a newly added game changer in this report.

More SEK companies can apply lessons learnt from mesh-grid pilots to explore similar projects, unlocking enhanced benefits of modular SHS to increase affordability and upsell beyond Tier 1 electricity access. Since modular SHS are now fairly available, more companies can consider leveraging this technology to create mesh-grids that enable these benefits for electricity access beyond Tier 1. Consumers can earn an income through the sale of excess energy to neighbors and from PUE appliances powered through the higher energy capacity made available.[144] With these added benefits to consumers, as well as modularity making gradual system capacity upgrade possible without having to replace existing installed systems, companies can more easily and affordably upsell higher-Tier systems.

PUE manufacturers, funded by development partners and donors, can accelerate the commercial availability of modular PUE appliances. With concessional financing, companies can conduct and conclude research and development, and produce and distribute modular technologies to enable the sector to benefit from modularity in PUE.

Box 2: A world with widespread adoption of interoperability and modularity

Applied together, interoperability and modularity can more easily enable a transition to higher Tier systems in more mature markets. Systems that combine both interoperability and modularity can allow consumers to increase the capacity of their SHS from "Company A" and use it to power an appliance purchased from "Company B" or "Company C," and so on. This could be a gamechanger for consumers if, for example, Company B's appliances were more affordable for the same level of quality or if Company C sells appliances that Company A does not have. The fact that most PAYGo platforms allow for remote activation and deactivation of SHS, and appliances can help mitigate the risk of failure to complete payments by PAYGo customers. Companies could benefit from being able to upsell systems and appliances to consumers who were not their first-time customers, which could increase competition and drive innovation that could lead to further company growth and sector development.[145]



143 Engineering FOR CHANGE | Solar PV Rice Huller.

144 Okra Solar (2021), What Productive Power Looks Like.

145 PaygOps | Open PAYGo Link.

4.4 Products and Consumer Game Changers

4.4.1 Beyond-Energy Models

Positively-applied beyond-energy models can strengthen the sector by helping companies to continue to supply OGS products and services as a result of improved overall margins and profitability.

Beyond-energy models involve the sale of non-OGS products as a way to improve company margins for profitability, thus strengthening the sector. This model is already common in more mature markets where market penetration among core, commercial customer segments is nearing saturation. Companies leverage their existing PAYGo infrastructure, sales agents, and distribution networks to sell non-OGS products as a means of income diversification and growth, but continue to serve the OGS market as achieving universal access remains their core goal.

More companies have adopted beyond-energy models in the last two years to explore new growth avenues, sources of funding, and potential pathways to sustainable profitability. Scale-up companies such as BBOXX and M-KOPA as well as LMDs have begun (i) selling smartphones, LPG gas and other clean cooking solutions, and electric motorcycles on PAYGo; (ii) partnering with telecommunications and media companies to sell complimentary services like cable television and internet access; and (iii) selling financial services like health insurance and education loans. This has enabled them to diversify income streams, optimize use of distribution channels in the hope of improving margins, and unlock other forms of financing. For instance, in 2022 BBOXX received debt financing of $5.5 million from the Africa Go Green Fund (AGG) to expand its PAYGo-enabled LPG gas offering and mitigate approximately 760K tonnes of CO2 emissions.[146] The beyond-energy model is a potential game changer in supporting company sustainability. However, for it to be game-changing the expansion in product mix must not come at the expense of reaching unserved populations.

Positive application of beyond-energy models is needed to improve company margins and sector performance, while also continuing to reach unserved areas. By opening up their established distribution networks for sale of other products in response to consumer demand, companies can increase profit margins. Better performance attracts the investment necessary to scale operations and provide electricity to previously unelectrified households. For better chances of successfully incorporating these models, companies need to ensure that they: (i) opt for highly demanded products, (ii) can leverage new products to access additional sources of financing such as clean cooking appliances and e-bikes for climate finance, and (iii) onboard specialized technical sales agents to effectively distribute complex products such as e-bikes.

4.4.2 PUE Availability and Adoption

Increased use of PUE appliances for income-generation is required for economic empowerment of consumers and can drive energy affordability in the long-term.

PUE, in this report, entails the use of electricity from OGS to power appliances for income-generating activities. PUE adoption can increase consumer incomes, for example for farmers that increase productivity and yield with a solar water pump or for farmers, dairy herders, fisherfolk, wholesalers, and retailers that increase incomes while reducing food loss with cold storage. These two solutions ranked highest in potential to boost economic development and reduce poverty in the short term, according to an Efficiency for Access Coalition (EforA) survey.[147] Increased income results in higher disposable incomes, which can improve the affordability of electricity access.

146 *BBOXX (2022), Africa Go Green Fund Signs a $5.5 Million Loan With BBOXX to Support the Rollout of Renewable Energy and Clean Cooking Systems Across Africa.*

147 *GOGLA (2019), Productive Use of Offgrid Solar: Appliances and Solar Water Pumps as Drivers of Growth; Efficiency 4 Access Coalition (2017), Global LEAP: Off-Grid Appliance Market Survey.*

Across most markets, rising demand has driven more companies to sell PUE appliances, and multiple efforts have been made to increase their availability and adoption. For instance, 35% of the Global Distributors Collective (GDC) members (LMDs) reported selling PUE products in 2021, up from 6% in 2019, and another 21% expressed their interest to start, with SWPs being the most popular appliance.[148] Sales volumes of SWPs and cold storage appliances remain low but recent initiatives have been launched to increase access to OGS for productive uses, such as (i) PUE innovation competitions such as Powering Renewable Energy Opportunities in SSA, (ii) tailored financing mechanisms targeting PUE such as Acumen's Pioneer Energy Investment Initiative Phase II, (iii) programs to promote PUE awareness and adoption such as EnDev's Promotion for Solar for Productive Use, and (iv) government-led subsidy programs for PUE appliances such as PM-KUSUM in India (see the *2022 OGS MTR 'State of the Sector'* for more details). Increasing availability of PUE appliances continues to be a high-impact Game Changer.

Increasing access to and uptake of PUE appliances is critical in raising income levels of BoP households and consequently energy affordability. PUE appliances have potential to increase incomes and often increase savings by reducing use of expensive fossil fuels. They also can improve reliability, eliminating reliance on unreliable grid connections, and reducing exposure to fluctuating fossil-fuel prices. However, any solar-powered appliance's availability is dependent on the solar resource. Higher incomes can be channeled to various uses, including potentially higher energy budgets and demand.

To increase PUE availability and adoption, sector players can explore more financing options beyond the typical PAYGo model to make appliances more affordable. Companies can explore providing PAYGo with longer payment tenors or that account for seasonal variations in income. Proving out models in different country contexts will require grant funding from development partners. End-user subsidies, provided by governments and development partners, can also increase affordability for lower income groups. Entrepreneurship training and support for building off-take markets can also help ensure that PUE appliance operators are successful in generating steady, long-term income. On the supply-side, donors can avail more capital to fund R&D that can make products cheaper in the long run.

4.5 Policy and Ecosystem Game Changers

4.5.1 Cross-Sector Partnerships

Partnerships between the OGS stakeholders and those in other sectors such as agriculture, healthcare, and education can increase consumer awareness and uptake of PUE appliances and SEKs.

Cross-sector partnerships, in this context, refer to collaborations that encourage clean and reliable electricity access through OGS in addition to development goals in other sectors. Agriculture, healthcare, and education are some of the important sectors that, in addition to generating huge demand for energy services, could mutually benefit from these partnerships as (i) the majority of farming activities take place in rural areas where electricity access is limited, and (ii) many off-grid healthcare centers and schools also lack access to electricity.

Cross-sector partnerships between OGS, and agriculture and healthcare sectors have continued to strengthen in SSA and Southeast Asia, largely involving PUE appliances. Governments in India, Bangladesh, and Togo have supported the uptake of SWPs among off-grid farmers and solarized existing diesel powered pumps, reinforcing the potential for cross-sector partnerships.[149] Companies such as Ecozen in India, ColdHubs in Nigeria, and Savana Circuit and Baridi (by Tree_Sea.mals Ltd.) in Kenya are also building informal partnerships by working with farmers and traders across different agriculture value chains to provide complementary services such as online marketplaces, collect feedback to improve appliances, and conduct trainings to improve appliance utilization and reduce food loss.[150] In 2020, governments and development partners helped foster healthcare

148 *The Global Distributors Collective (2022), State of the Last Mile Distribution Sector 2022; The Global Distributors Collective (2022), Webinar: Selling Productive Use of Energy (PUE) Products at the Last Mile: Top Tips and Common Pitfalls.*

149 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

150 *Ecozen Solutions | Home; ColdHubs | Home; Savanna Circuit Technologies | About Us; Baridi | Product.*

partnerships by launching programs for OGS companies to provide solar cooling solutions for vaccines and other medications. One example is UNICEF's Solar Direct Drive Refrigerators and Freezers program.[151]

OGS electrification of remote schools, clinics, and government buildings has also been a key development area, reinforcing partnerships with education and healthcare sectors, and government institutions. In 2022, the Ghana Mini Grid and Solar Photovoltaic Net Metering project was launched, targeting institutional electrification of 400 schools, 1,100 public buildings, and 200 health centers, through SHS and mini-grids.[152] Currently, several projects have been approved under the World Bank Group's Lighting Africa Program, such as the Regional Off-Grid Electrification Project (ROGEAP) approved in 2019 to electrify public institutions, schools, and health centers beyond households and businesses in West Africa and the Sahel region, using OGS solutions.[153] This game changer is new to this report, as a newly identified enabler of public institution electrification, PUE, and higher-tier electricity access.

Development partners can launch more cross-sector partnerships to increase beyond-household electricity access. PUE companies have leveraged smaller scale partnerships for years. Large-scale partnerships are now needed. Development partners from both the energy and agriculture, education or health sectors can partner and co-develop programs that can achieve mutual goals. Companies would ultimately benefit from larger volumes of sales, as these partnerships open up more potential markets with use cases such as solar irrigation to improve production, cold storage to reduce food losses, and health center and school electrification improving health and education outcomes.

Government ministries can co-fund programs that develop multiple sectors simultaneously. One example is the recent collaboration between Zambia's ministries of health and energy, whereby a joint action plan was drafted to electrify health centers that lack reliable electricity access; the plan provided both for energy systems and PUE appliances.[154] Cross-ministerial collaboration is essential, requiring that ministries no longer operate in silos.

Companies, governments, and industry associations can also create awareness on benefits of partnerships between two sectors. For PUE appliances, awareness is still a major barrier. More funding is needed to build awareness on topics including the benefits of solar-powered products over diesel or grid-powered alternatives. Agriculture-focused PUE companies could also improve awareness and product servicing by partnering with agriculture-based organizations that already have a wide reach of end users who work in agriculture.

151 UNICEF (2020), Cold Chain Support Package: The Solar Direct Drive Refrigerators and Freezers.

152 AfDB (2022), Ghana Signs Grant Agreement With African Development Fund, Government of Switzerland, to Support Development of Mini-grids and Solar PV Net Metering.

153 Lighting Africa (2019), Press Release: World Bank Provides Over $200 Million to Help Increase Access to Electricity in West Africa and the Sahel Region.

154 Sun-Connect (2022), Zambia Charts New Path for Powering Unelectrified Health Facilities With Solar to Improve Delivery of Essential Services.

4.5.2 Policies, Regulations, and OGS Integration in NEPs

Consistently implemented and enforced policies and regulations favorable to OGS sector development can drive sustained private sector investment and enable sector growth.

Enabling policies and regulations such as inclusion of OGS targets in NEPs, favorable tax and duty exemptions, and quality standards are directives by country governments that, if introduced, encourage private sector participation to improve electricity access. The key objective of government policies and regulations is to increase market participation while encouraging competition, with the goal of providing minimum cost, quality electricity access to citizens. One way of doing this is to incentivize the market entry or scale-up of OGS companies by reducing costs through tax and duty exemptions for reliable and quality assured products.[155] Leveraging international quality standards ensures that customers have a favorable experience with OGS products and that funds are well spent. Market-enabling policies and regulations are still seen as vital as they were in 2020, and specific needs vary on a country by country basis.

A growing number of countries have recently introduced enabling policies and regulations but inconsistency of implementation is high. Many governments, mainly in nascent and emerging markets, have recently introduced tax and duty exemptions, or adopted international quality standards or included OGS targets in their NEPs. This indicates positive progress in global OGS sector development.[156] However, this progress has also been impaired by instances of poorly communicated revocation of tax and duty exemptions, and of unsatisfactory enforcement of quality standards due to capacity constraints. For instance, in 2020 Kenya unexpectedly reintroduced and increased VAT on solar equipment, driven by a government commitment to raise tax revenue, then reintroduced elements of exemptions in 2021, while Zambia voided exemptions given in previous years, which required OGS companies to pay taxes retrogressively from multiple years back (see the *2022 OGS MTR 'State of the Sector'* for more details). These changes were not well-communicated and created uncertainty in the OGS market.

In countries without robust electrification plans, governments, supported by development partners, can show strong commitment to electricity access by integrating OGS policies into NEPs. It is best practice to ensure that NEPs are adequately resourced, and that implementing agencies and ministries have adequate capacity to deliver on set OGS targets. Such actions can improve investor confidence to channel more financing to scale electricity access in those countries.

Governments can improve enforcement of favorable policies and regulations, as simply introducing them is insufficient to enact change. Governments can improve enforcement by conducting capacity building across government bodies involved in implementation of off-grid electrification policies and regulations, from ministries to specialized agencies, tax and customs agents, and bureaus of standards, to ensure that they have enough well-trained agents for consistent enforcement. In addition, though regulations need to be firm and consistently applied; national electrification plans can allow for some flexibility, both in their implementation and for future updates, to accommodate changing market dynamics and other unforeseen developments. The plans can be dynamic, for example using OGS as pre-electrification for areas that are scheduled to be grid-electrified at later stages. Lastly, policies need to be simple to interpret and execute by companies to improve compliance.

155 ESMAP (2022), Designing Public Funding Mechanisms in the Off-Grid Solar Sector.

156 The 2020 Off-Grid Solar Market Trends Report; RISE 2020 data and Open Capital Advisors analysis.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Conclusion

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Closing the electricity access gap requires coordinated action by OGS sector stakeholders. Addressing barriers to growth by actualizing the game changers is vital.

2030 is fast-approaching, and the OGS sector must accelerate sales to achieve its development goals. In 2020, 733 million people were still without access to electricity, and this report estimates that the sector will need to grow unit sales from 32 million in 2021 to 56 million in 2030 to provide electricity access to 1.1 billion people and meet its target contribution towards SDG7, including providing first-time primary access to 464 million people.

All stakeholders will be required to make a coordinated push to implement game-changing interventions that accelerate electricity access. This includes OGS companies, governments, development partners, donors, and investors. These interventions help to increase both Tier 1 and higher levels of electricity access, while supporting overall sustainability of the sector.

- **OGS companies:** Companies can access financing by positioning themselves favorably and leveraging advanced technologies that improve their credit risk management, operating margins, and monitoring and demonstration of climate impact. They can also leverage beyond-energy models and subsidies to improve company margins, while reaching new electricity users. In markets where PAYGo is limited, they can work with other stakeholders to pilot and rollout innovative forms of PAYGo. Finally, companies can seek out opportunities to build long-term, cross-sector partnerships to increase the adoption of PUE appliances.
- **Governments:** Governments that have not yet done so, and that still have high electricity access gaps, can adopt OGS as a component of their national electrification plans and international quality standards for OGS products. Once policies and regulations are in place, they can focus on adequate enforcement. Where support is needed, together with development partners, governments can also launch supply-side and end-user subsidy programs, making it a national priority to deploy public funding alongside donor funding for electricity access. In addition to co-funding subsidy programs, governments can also promote private investment, for example by taking on some up-front risks through catalytic grants and guarantee schemes; or by funding consumer awareness programs. To increase electrification of public institutions and promote PUE appliance growth and associated increases in incomes, governments can coordinate across ministries to jointly finance and then administer projects between the energy sector and other sectors, such as agriculture, education or health.
- **Development partners and donors:** As frequent sources of catalytic grants, de-risking mechanisms, and subsidy programs, these partners can collaborate to ensure that funding reaches currently underserved markets; operating in nascent markets requires a higher risk-tolerance than currently exhibited by many development partners. They can also provide concessional capital to innovative funds that crowd-in the commercial investments needed to drive sector growth. Development partners and donors can support governments through co-funding and technical assistance to pilot, launch, and successfully execute national electrification plans, as well as specific initiatives such as subsidy programs.
- **Impact investors, development finance institutions, and other financiers:** These financiers can actively create innovative financing mechanisms, such as an off-balance sheet financing platform, alongside development partners. They can actively manage or participate in those opportunities. They can also seek to work more with de-risking capital allowing them to support early stage companies. Companies cannot rely on grant funding alone to achieve scale.

There is an urgent need to accelerate electrification with OGS, particularly in currently underserved markets. The sector now has over a decade of learnings, in that time developing high-quality and affordable products, demonstrating successful business models, and identifying adequate policies and regulations needed at the country level to help the sector flourish. Significant investment will be required to reach the sector's development goals, but the path to success is clearer than it has ever been.

Annexes

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Annex 1 - Definitions of Key Household Product Segments and MTF level

Product Category	Definition	Power Range (Wp)	Indicative Price Range ($)[157]	MTF Level	Example
Portable lanterns	Single light only	0-1.49	$4 - 40	Enables Tier 0 (or partial Tier 1) Electricity Access for an individual person	 d.light S3
	Single light & mobile charging	1.5-2.99	$6 - 51		
Multi-light systems	Multiple light & mobile charging	3-10.99	$37 - 208	Enables Tier 1 Electricity Access for at least one person and up to a full household	 SunKing Home 200X
Entry-level SHS	Three to four lights, phone charging and powering a radio	11-20.99	$33 - 333	Enables Tier 1 Electricity Access for a household	 BBOXX Flex 40
Basic-capacity SHS	As above, plus power for a television, more lights, appliances & extended capacity	21-49.99	$40 - 686	Enables Tier 2 Electricity Access for a household when coupled with high-efficiency appliance	 StarTimes Solar S100
Medium-capacity SHS	As above, but with extended capacities	50-99.99	$50 - 1100	Enables Tier 2 Electricity Access for a household even using conventional appliances	 BioLite SolarHome 620
Higher-capacity SHS	As above, but with extended capacities	100+	$248 - 2862	Enables Tier 2 Electricity Access for a household, even using conventional appliances	 JUA H4G-300

157 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

Annex 2 - Definitions of Key Household and Productive Use Appliance Segments

Household / small business appliances			
Product Category	**Application**	**Indicative Price Range ($)**	**Example**
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.	$34 - 325	 NIWA Solar ELED TV 23.6”
Fans	Fans improve household comfort, especially during hot seasons.	$14 - 65	 fosera. POWER LINE Standing Fan 12V
Refrigeration units (up to 300L capacity)	Off-grid refrigeration units reduce the risk of food contamination and preserve perishable produce and beverages for both households and small shops in rural, remote communities.	$72 - 1817	 Koolboks Refrigerator
Other	Other, smaller appliances include radios for households and multi-port phone chargers for small businesses.	Variable	 Sun King Radio

Annex 3 - Methodology

Methodology for Estimating the Projected Global Off-grid Solar Sales

- Determine the growth rate required to achieve the SDG7 scenario
  - Determine a target number of people using SEKs by 2030. This assumes that Tier 1 is the minimum threshold for electrification, so system sizes below Tier 1 are not eligible. This figure comprises:
    - The number of people needing a first-time SEK energy connection, based on analysis from the Global Electrification Platform (GEP) "Low Demand" scenario
    - An estimate of the share of SEKs that will be serving as backup systems alongside the main grid, based on data on historical share of weak grid users and scaled across different market types[158]
    - Maintaining the access of current SEKs users by replacing systems as they reach the end of their asset life
  - Starting from the current split of SEK sales by system size, mapped to the ESMAP Tiers, project the expected evolution of sales by three system sizes: (1) below Tier 1, (2) Tier 1, and (3) Tier 2+. The target SEK users number is used to set a sales trajectory that would reach all of the target population with a Tier 1 SEK by 2030, accounting for different asset lives of systems of different sizes (Tiers). The assumed mix of sales by 2030 in this case (comparable to the below projected scenarios), is: 70% of SEK sales would be Tier 1, 30% above Tier 1
- Determine growth rates for the other scenarios: projected, optimistic, and conservative
  - Project plausible growth in both (1) unit sales and (2) evolution of the relative shares by system, size, based on historical trends in SEK sales
    - To determine the 'projected' unit sales growth rate this report uses the average of the growth rate of affiliate sales between 2015-2019 and 2016-2021
    - To determine the upper bound 'optimistic' unit sales growth rate, this report uses the growth rate of affiliate sales between 2015 and 2019 as these years experienced fast growth
    - To determine the lower bound 'conservative' unit sales growth rate, this report uses the growth rate between 2016 and 2021 as these years experienced accelerated growth, a decline due to impacts from COVID-19, and then a rebound in growth in 2021
  - In each scenario, project the evolution in the sale of units by size, which are based on historic affiliate sales:
    - In the 'projected' scenario: by 2030, 30% of SEK sales would be above Tier 1, 36% Tier 1, and 34% below Tier 1
    - In the 'optimistic' scenario: by 2030, 35% of sales would be above Tier 1, 45% Tier 1, and 20% below Tier 1
    - In the 'conservative' scenario: by 2030, 25% of SEK sales would be above Tier 1 43% Tier 1, and 32% below Tier 1
  - Carry out these unit sales projections for the total SEK market, and for nascent, emerging, mature and peaked markets separately

Methodology for Estimating the Investment Need to Achieve SDG7 and Projected Investment

To estimate the global investment need for the off-grid solar sector to achieve SDG7

- Classify companies into small distributors, mid-sized companies, and scale-up companies, and determine the proportion of each in nascent, emerging, mature and peaked markets
  - Assume splits between small distributors, mid-sized companies and scale up companies in each type of market
- Determine the proportion of debt, equity, and grant that each type of company may require to finance its operations
  - Assume splits of debt, equity and grant for each type of company and market type

158 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

- Determine the prices charged by different companies, the costs incurred, and operating margins
  - Assume a constant price across all company types
  - Assume lower COGS and higher operating margins for larger companies
- Calculate the revenues and costs to determine the investment need based on projected sales

To estimate the projected investment

- Following the approach taken in the Off-Grid Solar Market Trends Report 2020, estimate the historic investment raised (recorded by GOGLA Deals database), and compare this to the unit sales recorded by GOGLA. This gives an investment raise of $17 per unit sold
- Next, to account for both changes in unit volumes and changes in the type (size) of SEK sold in the future, convert the above factor to an investment raise per dollar of value sold in 2022, the starting year of projections, which comes to around $0.23 investment needed for each $1 of sales
- Next, use the estimated prices of below-Tier-1, Tier 1 and Tier 2 systems from the *2022 OGS MTR 'State of the Sector,'* and apply these to our projected unit sales pathways, to estimate a value of sales between now and 2030
- Then, apply the investment multiplier ($0.23 per $1 of sales) to estimate the investment that would be required to achieve the projected sales turnover
- Finally, determine the composition of debt, equity and grant based on historical trends

Methodology for Estimating the Affordability Gap

The approach to estimating the affordability gap for off-grid solar products is based on the approach described in *2022 OGS MTR 'State of the Sector'*. The approach is summarized again here, focusing on the adjustments and assumptions made to project the affordability analysis forward to represent the period 2022-2030

- Estimate the affordability gap for all new primary electricity access connections needed from off-grid solar technologies, for the projected population in each country that would be best served by OGS as their primary form of electrification between now and 2030 (described earlier in this annex)
- Estimate the ability to pay on a country-by-country basis for all countries with a remaining electricity access gap. For each country:
  - Obtain the distribution of consumption expenditure for each country from the latest available year of data in The World Bank's PovcalNet, which gives us the shape of a demand curve for each country
  - Obtain an estimate of the total income across each national population, using GNI per capita (GNI, Atlas method, current $) for 2020
  - Aggregate per capita demand into household demand, using household size per country from the Population Research Bureau
  - Extrapolate these values forward to 2026 as a representative mid-period year, by using the latest IMF GDP growth forecasts per country, and adjust for population growth projections from the UN Population forecasts
- Estimate the affordability gap based on an allocation of 5% of monthly consumption expenditure to off-grid solar products based on two approaches to provide an upper and a lower bound:
  - Conservative - bottom up: assumes the electricity access gap between 2022 and 2030 is concentrated among the poorest strata of the population. For example, for a country with 100 million people, of which 20 million still lack access to energy, the demand curve is based on the estimated income of the poorest 20 million people only
  - Maximum - nationwide income distribution: here the national income distribution is used, so the customers (and therefore ability to pay for off-grid solar products) are evenly distributed across the nationwide income distribution
- Compare these two demand curves ("conservative" and "maximum") for each country to the price of accessing a Tier 1 off-grid solar product. This is assumed to be around US$ 95, an estimate for the current estimated price of an off-grid solar product achieving full Tier 1 electricity access for a household

- Finally, assume that 30% of sales offer PAYGo end-user financing, while 70% are cash over-the-counter sales. While PAYGo can significantly boost ability to pay by spreading payments over for example 12 to 24 months, it is both costlier (increasing total cost of ownership) and may not always be practical in the context of customers who do not currently have electricity access, many of whom live in fragile and conflict affected regions. To provide a reasonable estimate of the affordability gap, in each country it is assumed that 30% of the sales will be made using PAYGo

Methodology for Estimating the Market Potential for Cold Storage in Sub-Saharan Africa and India

To estimate the total potential market size for cold storage in SSA

- Estimate the number of rural SHF households in SSA in 2021: 33 million SHFs based on data from the International Fund for Agricultural Development[159]
- Estimate the number of SHF households across the horticulture, dairy and fish value chains. This is a conservative estimate and assumes that SHFs in these value chains have the greatest demand for cold storage. Leverage UN population growth projections between now and 2030 as a proxy to estimate the growth in SHFs across the key value chains[160]
- Estimate the number of SHFs who will require a cold storage unit by 2030 across the key value chains by:
    - Assuming the potential demand for cold storage will comprise the off-grid SHF population in those value chains
    - Leveraging World Bank data on the proportion of rural population with access to electricity to estimate the off-grid rural population, assuming this proportion to remain constant from now to 2030[161]
- Determine the potential number of cold storage units required by the off-grid SHFs by:
    - Leveraging World Bank data on the proportion of rural population with access to electricity as a proxy for the off-grid SHFs
    - Leveraging data from a sample of CaaS companies on the number of farmers that each cold storage unit can serve

Estimate the total potential market size for cold storage in India

- Estimate the number of rural dairy SHF households in India in 2021; 70 million rural dairy SHFs based on estimates from the Indian National Investment Promotion and Facilitation Agency[162]
    - This is a conservative estimate on cold storage demand based on the assumption that the dairy segment of the agricultural sector in India has the highest demand for cooling services given its highly perishable nature[163]
- Leverage UN population growth projections between now and 2030 as a proxy to estimate the growth in SHFs across the key value chains[164]
- Estimate the number of SHFs who will require a cold storage unit by 2030 across the key value chains by:
    - Assuming the potential demand for cold storage will comprise of the unorganized SHF population (Note: Larger organized farmers are assumed to have access to reliable grid and thus access to cold storage solutions)
- Determine the potential number of cold storage units required by the off-grid SHFs by:
    - Estimating the number of farmers in each dairy cooperative by leveraging data from the National Investment Promotion and Facilitation Agency of India[165]

159 *IFAD (2021),The IFAD Field Report.*

160 *UN populations data portal.*

161 *The World bank data portal.*

162 *National Investment Promotion and Facilitation Agency NIPFC (2021), The Indian Dairy Landscape.*

163 *Ibid.*

164 *UN Population data portal.*

165 *National Investment Promotion and Facilitation Agency NIPFC (2021), The Indian Dairy Landscape.*

Methodology for Estimating the Market Potential for SWPs in Sub-Saharan Africa and India

Estimate the total potential market for SWPs in SSA

- Estimate the total number of SHF households in SSA by:
  - Leveraging UN population growth projections as a proxy to estimate the growth in SHFs households[166]
- Leverage Pew research center estimates on the number of people in each household as a proxy to estimate the number of SHF households[167]
- Estimate the number of off-grid rural SHFs
- Leverage the World Bank estimates on the share of rural households and population with access to electricity as a proxy to estimate the number of off-grid households[168]
- Estimate the number of SHFs that would be best served by SWPs by 2030 by:
  - Assuming the number of SHFs growing cash crops and with access to water as we consider these are the target consumers for irrigation by leveraging data from The Market Opportunity for PULSE in sub-Saharan Africa report by Lighting Global on the proportion of SHFs cultivating cash crops in SSA[169]

Estimate the total potential market size for solar irrigation pumps in India

- Estimate the number of smallholder farmers in India
- Leverage UN population growth projections between now and 2030 as a proxy to estimate the growth in SHFs[170]
- Estimate the number of SHFs that would be best served by SWPs by 2030 by:
  - Assuming the number of SHFs in rainfed areas and are growing high priority/value crops that require irrigation
    - Assuming the proportion that would actually use SWPs by considering the utilization of SWPs by users. (Note: These SHFs are likely to attain greater benefits from irrigation services given that access to water is the main driver for irrigation.)

166 *UN Population data portal.*

167 *Pew Research center: Household size.*

168 *World bank data portal: Rural population (% of total population) in SSA.*

169 *Lighting Global (2019), The Market Opportunity for PULSE in Sub-Saharan Africa.*

170 *UN Population data portal.*


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