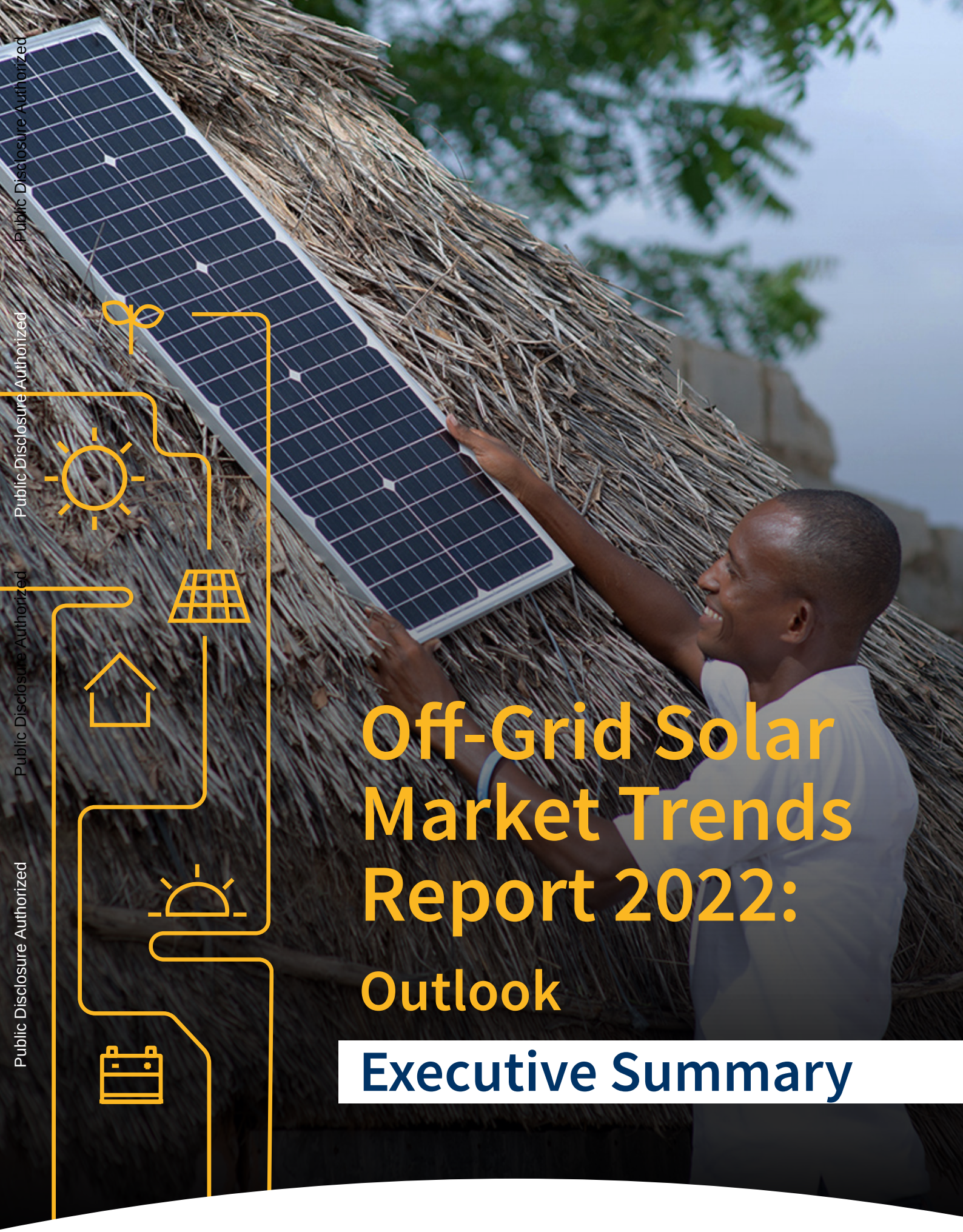


Off-Grid Solar Market Trends Report 2022:

Outlook

Executive Summary

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

Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: Outlook, Washington, DC: World Bank.

Disclaimer

The conclusions and judgments contained in this report should not be attributed to, and do not necessarily represent the views of IFC or its Board of Directors, the World Bank or its Executive Directors, Efficiency for Access, or the countries they represent. IFC, World Bank and Efficiency for Access do not guarantee the accuracy of the data in this publication and accept no responsibility for any consequences of their use. The information contained in this publication is derived from carefully selected sources that are believed to be reasonable. GOGLA and Open Capital Advisors do not guarantee its accuracy or completeness and nothing in this document shall be construed to be a representation of such a guarantee. Any opinions expressed reflect the current judgment of the authors of the relevant article or features and do not necessarily reflect the opinion of GOGLA and Open Capital Advisors, Efficiency for Access, the IFC, or the World Bank. The opinions presented are subject to change without notice. GOGLA, Open Capital Advisors, Efficiency for Access the IFC, or the World Bank accept no responsibility for any liability arising from the use of this document or its contents.

Production Credits

Production Editor | GOGLA

Designer | Future by Design (www.futurebydesign.studio); Data visualization: Future by Design Studio via Flourish

Images | Cover: Baobab+

This report is produced by Lighting Global/ESMAP, the International Finance Corporation, Efficiency for Access Coalition, GOGLA and Open Capital Advisors.

Off-Grid Solar Market Trends Report 2022

Outlook

Executive Summary

Acknowledgments

The authors would like to thank those who generously contributed their time in the consultations that have informed this report.

ESMAP/World Bank: Gabriela Elizondo Azuela, Sameer Shukla, Dana Rysankova, Johanna Galan, Maria Arango, Thomas Flochel, Bonsuk Koo, Lucie Blyth, Jennifer Lynch, Raihan Elahi

International Finance Corporation: Bill Gallery, Subrata Barman

Efficiency for Access Coalition: Makena Ireri, Leo Blyth, Jenny Corry, Elisa Lai

GOGLA: Susie Wheeldon, Sjef Ketelaars, Drew Corbyn, Laura Fortes, Oliver Reynolds, Collin Gumbu, Patrick Tonui, Rebecca Rhodes, Timona Chore, Koen Peters, Aletta D'cruz, Eva Roig

Open Capital Advisors: Andreas Zeller, Duda Slawek, Harry Masters, Tamara Kalunda, Travis Koteco, Hanna Dohrenbusch, Stephanie Onchwati, Millie Maina, Charlene Njau

Other contributors: Ed Day (Greencroft Economics), Sanjoy Sanyal (Regain Paradise)

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

IFC—a member of the World Bank Group—is the largest global development institution focused on the private sector in emerging markets. We work in more than 100 countries, using our capital, expertise, and influence to create markets and opportunities in developing countries. In fiscal year 2021, IFC committed a record $31.5 billion to private companies and financial institutions in developing countries, leveraging the power of the private sector to end extreme poverty and boost shared prosperity as economies grapple with the impacts of the COVID-19 pandemic. For more information, visit www.ifc.org

Efficiency for Access is a global coalition promoting energy efficiency as a potent catalyst in clean energy access efforts. Since its founding in 2015, Efficiency for Access has grown from a year-long call to action and collaborative effort by Global LEAP and Sustainable Energy for All to a coalition of 20 donor organizations. Coalition programmes aim to scale up markets and reduce prices for super-efficient, off- and weak-grid appropriate products, support technological innovation, and improve sector coordination. Current Efficiency for Access Coalition members lead 12 programmes and initiatives spanning three continents, 62 countries, and 34 key technologies. For more information, please see www.efficiencyforaccess.org

GOGLA is the global association for the off-grid solar energy industry. We are proud to champion one of the world's most innovative and impactful sectors. Hundreds of millions of people already benefit from affordable, high-quality, clean off-grid solar products and services. With the right support, our pioneering industry will be able to scale up rapidly to improve the lives of 1 billion people by 2030. To help make this happen, we promote, safeguard, and convene the industry, advocating for enabling policies and increased investment as well as supporting our 200+ members with effective services. To find out more, visit www.gogla.org

Open Capital Advisors is a management consulting and financial advisory firm that drives growth, enables investment, and builds markets across Africa. We help businesses, investors, development partners, and the public sector to identify opportunities and deliver unique, impactful solutions. Our mission is to advance African economies and build future generations of business leaders. Since 2010, we have completed over 1000 engagements across 25 countries in sub-Saharan Africa and raised over $1billion in capital for impactful businesses across the continent. Our locally based team of over 150 full-time staff brings experience from the world's top consultancies, private equity firms, investment banks, and development organizations. For more information, please visit www.opencapital.com

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.

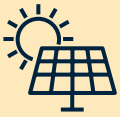
Terms	Definitions
Off-grid solar products	Off-grid solar products include both solar energy kits and off-grid solar appliances and this term is used in the report to describe the breadth of technologies that it covers. See definitions below.
Solar energy kits (SEKs)	These include solar lanterns, multi-light 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.*

Headline Trends



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 at 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.

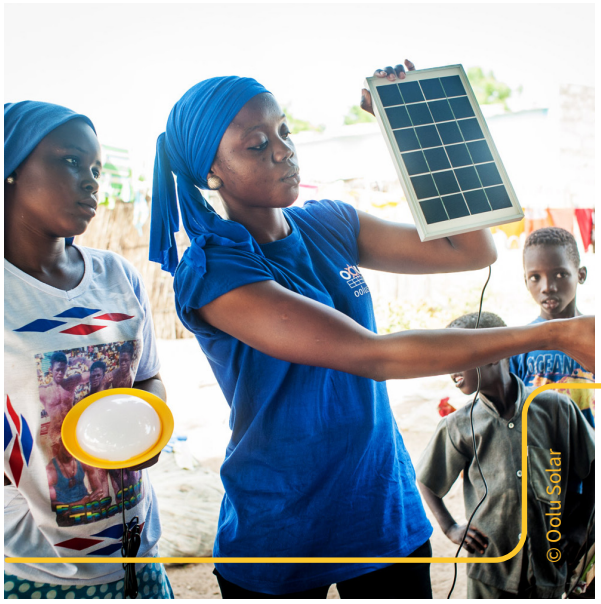
3 *Note: The universal access shortfall includes: [1] 234 million people who will remain unelectrified by 2030 and, [2] 453 million people who will be using below Tier 1 SEKs to access electricity.*

Off-grid solar (OGS) continues to be a robust market providing energy services to tens of millions of customers every year. The market is now currently valued at approximately $2.8 billion annually, and comprises a wide variety of solar energy kits (SEKs) and off-grid appliances.[4] Like other sectors, OGS was impacted negatively by the COVID-19 pandemic, with decreased sales and market turnover. This was caused by pressures on supply chains, subsequent price increases, and reduced customer incomes. But the sector has since shown early signs of recovery, with sales of solar energy kits recording a 10% increase from 2020 to 2021. [5]

OGS products remain a cost-effective solution to electrify millions of off-grid homes, businesses, and productive use appliances. By the end of 2021, the sector was serving 493 million people with access to better quality, more affordable, and reliable energy services. OGS has also been identified as the least-cost solution to provide Tier 1 electrification to 464 million additional people that currently have no access to electricity, and that predominantly reside in nascent and emerging markets.[6] With electrification rates below 50% in approximately 21 countries, the sector is increasingly recognized as vital to achieving electrification goals worldwide. 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.[7]

As a result, the OGS sector is poised to play a significant role in a clean and just energy transition in line with the goals of Sustainable Development Goal 7 (SDG7). SDG7 aims to ensure "access to affordable, reliable, sustainable and modern energy for all".[8] Beyond the access goals, SDG7 also aims to increase the proportion of renewable energy in the generation mix, and improve energy efficiency, and the proportion of power generation that is renewable energy-based in developing countries. OGS products have shown that they can support each indicator under SDG7.

The sector is also critical to supporting a host of other development goals, including those that focus on health, hunger, climate action, education and income.[9] 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 (SDGs 3 and 13), while saving $26 billion in fuel costs through switching from dirty fuels to solar lanterns and SHS (SDG1).[10] Larger-tier systems that enable productive use of energy, particularly in agriculture, health, and education, can have an even greater catalytic effect on SDGs. OGS systems now support use cases beyond household use, helping to ensure quality education and healthcare (SDGs 3 and 4), with support from initiatives like the World Bank funding of nearly $650 million to electrify public institutions using OGS and mini-grids.[11]



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

5 *Ibid.*

6 *Note: The estimate of newly connected primary OGS users is based on analysis of the Global Electrification Platform, 'Low Demand' scenarios.*

7 *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.*

8 *United Nations Department of Economic and Social Affairs, UN SDG Goals: SDG7 Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for All.*

9 *Ibid.*

10 *Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector. GOGLA (2021), Global Off-Grid Solar Market Trends Semi-Annual Sales and Impact Data.*

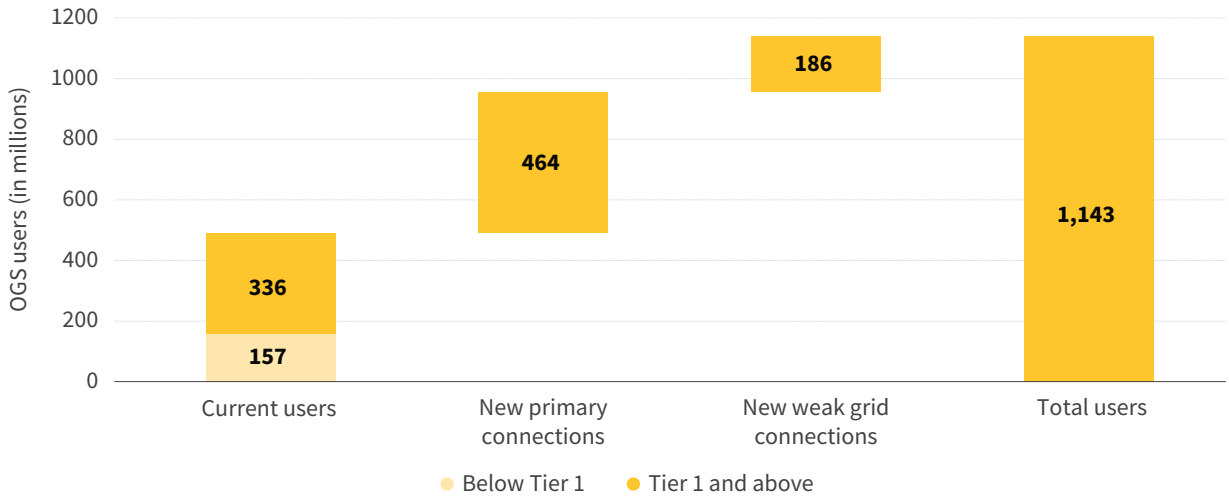
11 *Open Capital Advisors consultation with the World Bank.*

Despite progress in the sector, there is a substantial gap towards achieving SDG7. In 2020, 733 million people were still without access to electricity.[12] COVID-19 has made achieving SDG7 all the more challenging, causing job losses for many and pushing 100 million people into extreme poverty. This has impacted their ability to pay for OGS products.[13] The OGS sector has shown resilience in the face of a global pandemic, but the electrification gap remains significant.

This report considers both current and new OGS users, to estimate the sector's contribution towards achieving 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. It is also assumed that OGS will continue to be utilized by the 493 million current OGS 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.[14]

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. To date, a proportion of sales has been to weak grid customers, who experience frequent or lengthy outages of grid electricity or voltage fluctuations that can damage electrical appliances.[15] OGS companies have served these customers, improving the reliability of their electricity connections, a key aspect of the electricity 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 of 186 million new customers assumes that the current proportion of OGS users employing OGS products as a back-up power source will remain constant until 2030.[16]

Figure 1: Composition of people benefiting from Tier 1 OGS systems by 2030[17]



12 *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.*

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

14 *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.*

15 *Note: Due to data limitations, this report evaluated the proportion of OGS users who are currently using OGS as a compliment to a weak grid and assumed this to remain constant from now to 2030.*

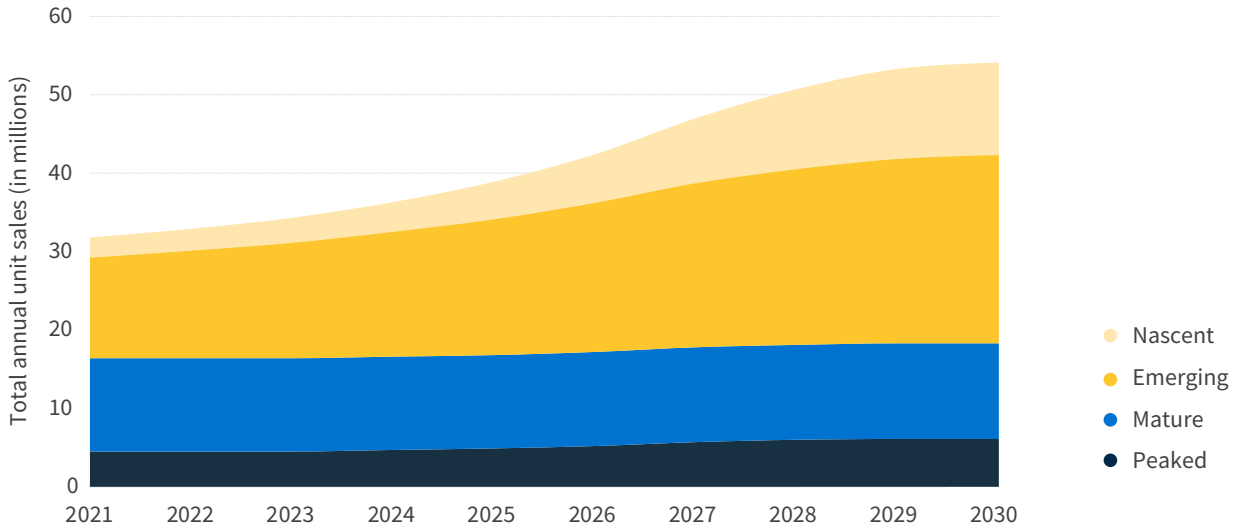
16 *Note: This report considers the proportion of weak grid consumers using OGS as a back-up highlighted in: Lighting Global/ESMAP, GOGLA, Efficiency For Access, Open Capital Advisors (2022), Off-Grid Solar Market Trends Report 2022: State of the Sector.*

17 *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.*

The sector will need to reach 1.1 billion people with Tier 1 and above OGS products by 2030 to reach SDG7, including providing first-time primary access to 464 million people, assuming grid and mini-grid also achieve their potential. To achieve this goal, total annual unit sales need to grow from 32 million in 2021 to 56 million in 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 of 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. These sales are projected solely for SEKs at the household level, but significantly more sales would be required to electrify public institutions and productive uses of energy. For example, it is estimated that tens of thousands of health centers alone across low- and middle-income countries lack electricity.[18]

Figure 2: Total annual unit sales required to achieve universal access 2021 - 2030 by market[19]



This report also estimates the investment required to reach 1.1 billion people with Tier 1 and above SEKs. First, it estimates the total sales needed in each market, the composition of companies as well as the cost of goods sold (COGS), and operating costs for companies in each market to achieve SDG7 goals. For example, serving customers through smaller distributors (typically present in more nascent or FCV countries) would require higher investments. This is 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.[20] These estimates assume universal access to Tier 1 and above SEK systems, comprising a minimum of multi-light systems and entry-level solar home systems, with an average cost of $100 per system.[21] The total investment comprises 38% debt, 34% equity, and 28% grant capital. A substantial amount in grant funding, at levels much higher than those seen historically, will be required to support market entry in nascent and emerging markets where many of the harder to reach customers live. Beyond the investment required by the sector, an additional $4.5 billion in funding is required to address the affordability gap. This can be addressed with demand-side subsidies, as well as other non-customer revenue such as carbon credits. Of the total $23.3 billion in funding required by the sector, up to $16.5 billion will be specifically for nascent and emerging markets.[22]

18 *Powering Healthcare Initiative | About us.*

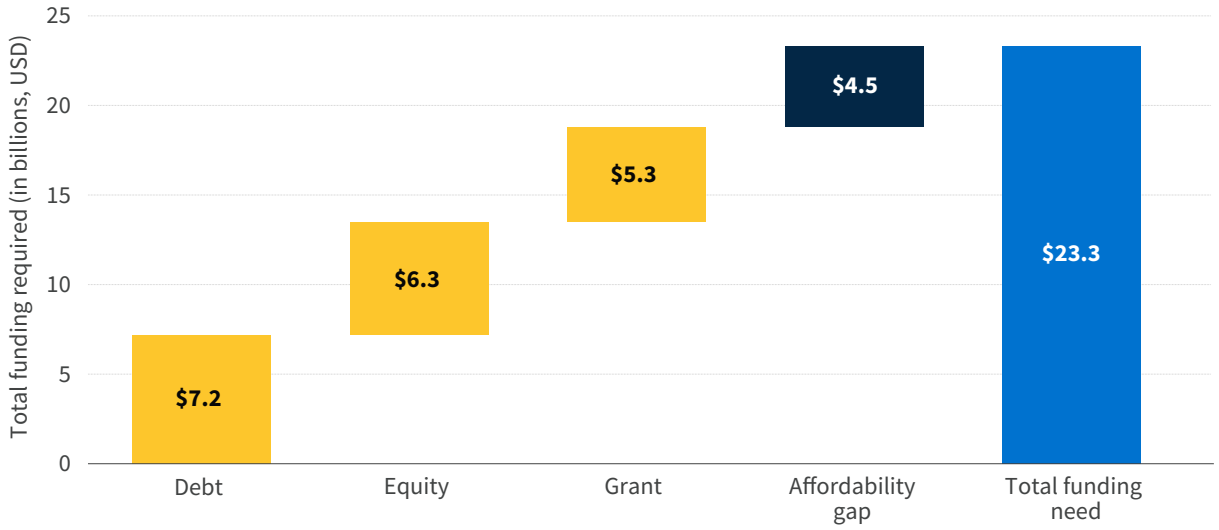
19 *Open Capital Advisors analysis of projected sales between 2022 and 2030.*

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

21 *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.*

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

Figure 3: Total funding needed to reach universal access[23]



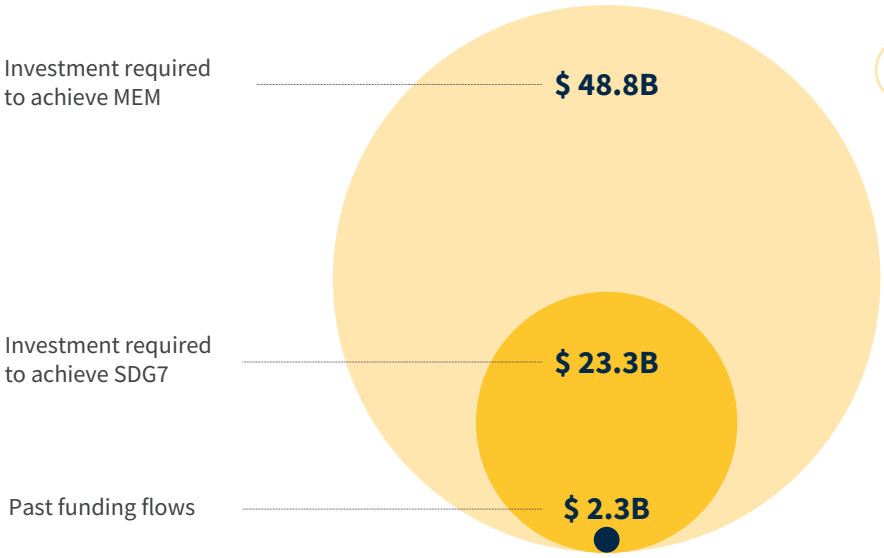
If the sector aims to achieve beyond Tier 1 electrification for households, the funding need will be much larger. Tier 1 is the minimum level of electrification needed to achieve SDG7, but it is often just the first step on the energy staircase. OGS products can support higher tiers of energy service too, which would increase funding needs: in a scenario where all users gain access to the equivalent of a Tier 2 SEK, $48.8 billion would be required helping to enable higher levels of service like the Modern Energy Minimum (MEM) benchmark for OGS users, which aims for per-household annual consumption of 300kWh.[24] 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.[25]

23 *Open Capital Advisors analysis of total funding need for the OGS sector split across debt, equity and grant.*

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

25 *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 given 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 also only considers the users to be connected under the SDG7 scenario.*

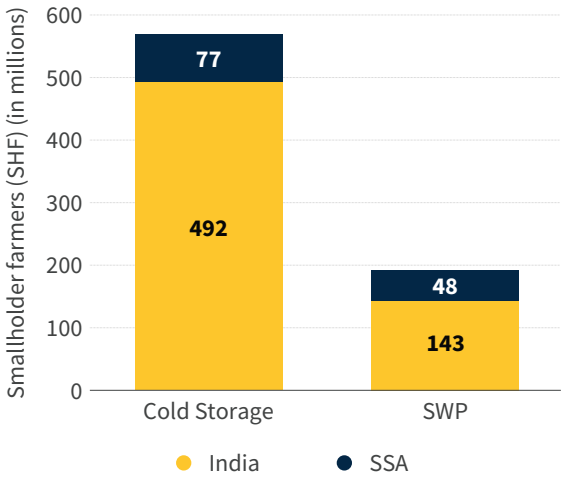
Figure 4: Comparison of funding flows to date, funding required to achieve SDG7, and funding required to achieve the MEM, excluding the affordability gap[26]



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 192 million smallholder farmers could benefit from SWPs across SSA and India by 2030.[27,28] Furthermore, with 72% of health centers and 67% of primary schools unelectrified in SSA, OGS remains a viable option to improve healthcare and learning outcomes.[29]

Figure 5: Cumulative market potential for cold storage and SWP among smallholder farmers in India and SSA by 2030[30]



26 *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 given 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 also only considers the users to be connected under the SDG7 scenario.*

27 *See Annex 3 - The methodology to estimate market potential for SWPs in SSA and India. Note: Smallholder farmers in this report are defined as small-scale farmers, pastoralists, forest keepers and fishers who manage areas varying from less than one hectare to 10 hectares.*

28 *Food and Agriculture Association (2012), Smallholders and Family Farmers Factsheet.*

29 *SEforALL (2020), Energy Access Takes Center Stage in COVID-19 Fight, Powering Africa's Recovery.*

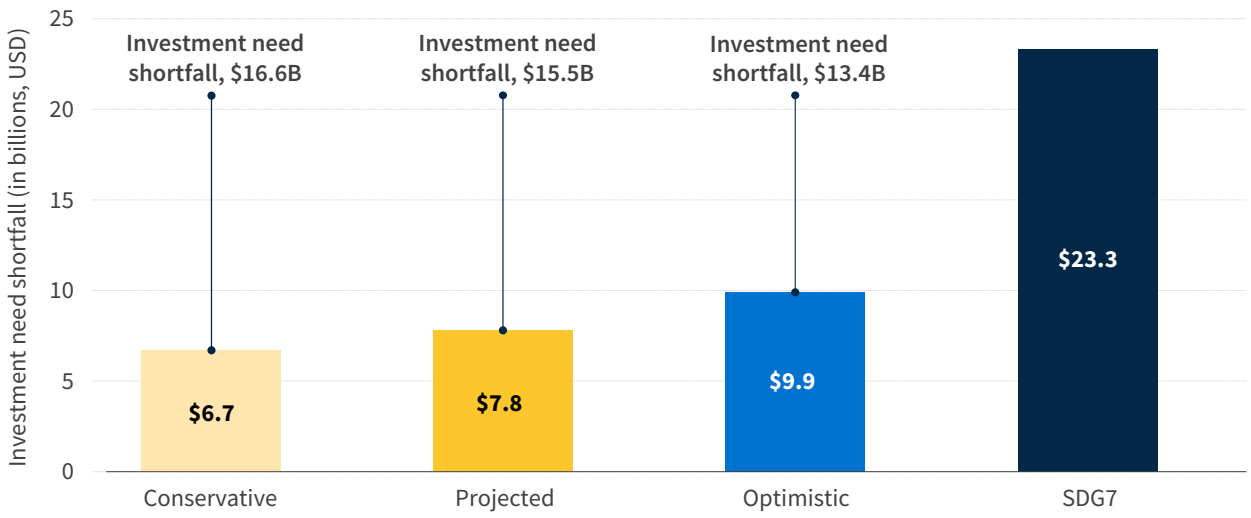
30 *Open Capital Advisors analysis of PUE market potential for cold storage and SWP in India and SSA. See Annex 3 - The methodology to estimate the market potential of SWPs and cold chain in SSA and India.*

In addition to describing the sector's contribution to sustainable development goals, this report also projects potential growth pathways for SEKs. This report presents three scenarios: 5% year-on-year, 2.8%, and accelerated growth of 7.2%, all 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).

Under the projected growth scenario, the sector could serve 624 million OGS users with Tier 1 and above electricity access by 2030, 516 million people fewer than what is needed to achieve universal access.[31] A majority of those that will remain unserved in this scenario are located in nascent and emerging markets. If interventions are not well-funded and implemented, as noted in the conservative growth scenario, as many as 606 million people may remain without access to Tier 1 and above electricity by OGS solutions in 2030.[32]

Under the current financing trajectory, which aligns to the projected scenario, the sector would raise $7.8 billion in investment and funding, representing a gap of $15.5 billion compared to the SDG7 scenario.[33] Importantly, 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. 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, which increases the cost of reaching these consumers. Also, under the current financing trajectory, large companies that are currently not operating in many of these difficult markets are expected to raise the bulk of funding, continuing the trend whereby 72% of total investment raised to date has been raised by the seven scale-up companies.[34] If this trend continues, it is likely that the currently unserved markets will remain unserved.

Figure 6: Shortfall in company financing compared to SDG7[35]



31 *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.*

32 *Open Capital Advisors analysis of sales required to achieve SDG7.*

33 *Open Capital Advisors analysis of investment required to achieve SDG7.*

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

35 *Open Capital Advisors analysis based on data from the 2022 OGS MTR 'State of the Sector', GEP 'Low Demand' scenario data on newly connected primary users, and GOGLA Investment Database data to estimate the investment need for the different scenarios between 2020 and 2030.*

Even more funding will be needed to meet the market potential of PUE in agriculture. This report estimates that SWPs and cold storage alone can benefit 192 million and 569 million smallholder farmers, respectively, in sub-Saharan Africa and India by 2030. To achieve this ambitious market potential goal of 4.5 million units by 2030, sales would need to grow by 32% annually, from a low base of approximately 223,000 annual sales in 2021.[36] While interest from investors has increased for this OGS segment, substantially more funding must flow into the sector, most importantly addressing the large affordability gap.

Additionally, billions of dollars will be needed to close the electricity gap for public institutions in sub-Saharan Africa and beyond. Currently about 1 billion people worldwide are served by healthcare facilities without reliable electricity.[37] One of every four facilities in sub-Saharan Africa has no access, and even when electricity does exist, the power supply is unreliable (approximately 28% report reliable electricity).[38] In education, approximately two-thirds of schools do not have reliable electricity access, reducing education levels and productivity.[39] Total World Bank investment in the electrification of public institutions via OGS or mini-grids is approximately $650 million across 25 countries, but the gap to close remains large.[40]

In developing sector interventions to accelerate electricity access and close the shortfall, it is important for stakeholders to acknowledge that the OGS sector serves both a commercial market and a development agenda. This tension results in companies facing affordability constraints and high operating costs, thereby serving both commercially attractive and unattractive markets while trying to operate profitable businesses. Most of the unelectrified populace now live in remote, harder-to-reach areas and have lower ability to pay, which has been further exacerbated by the COVID-19 pandemic. Furthermore, companies have recently found it increasingly difficult to secure de-risking capital due to low amounts of grant funding available for off-grid energy solutions.

To achieve the sector's ultimate development potential, targeted, game-changing interventions are needed to address several barriers to growth. Targeted action is needed to address low affordability by marginal consumers and constrained company margins due to increased costs. In addition, other market-specific barriers related to regulatory challenges and lack of consumer awareness will also need to be addressed to strengthen the sector and improve the enabling environment for OGS companies. A summary of these interventions is presented in Figure 7.

36 *Open Capital Advisors analysis of PUE market demand comprising cold chain and SWPs in India and SSA. Note: The report anticipates that the cold storage units will be utilized by multiple farmers.*

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

38 *SEforALL (2020), Energy Access Takes Center Stage in COVID-19 Fight, Powering Africa's Recovery.*

39 *Ibid.*

40 *Open Capital Advisors consultations with the World Bank.*

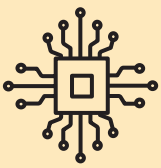
Figure 7: Summary of 2022 game changers

Finance and funding game changers

- More catalytic finance and de-risking tools are needed from donors, DFIs, and development partners to scale up early-stage companies and incentivize entry into nascent markets.
- More off-balance sheet financing is needed to scale up operations in more mature markets by unlocking more local currency working capital. Large OGS companies can leverage their high-quality receivables portfolios to successfully raise off-balance sheet financing, but small companies would require a large-scale platform that aggregates receivables for multiple players to reduce transaction costs per company and attract investors.
- Companies, with support from development partners, could more compellingly relay to climate investors how they offer a viable pathway to carbon emissions reductions and climate change adaptation, to unlock more climate finance; something not sufficiently done at the moment and hindering access to this type of capital.
- More smart supply-side subsidies, tailored to varying company sizes and market maturity, are needed to incentivize OGS companies to expand into areas left behind in more mature markets–and for faster development in nascent markets. Collaboration between governments and development partners will be crucial in increasing the scale of supply-side subsidies.
- Availability of well-designed end-user subsidies can be scaled to ensure that every household is able to at least afford a Tier 1 solar product. Governments, development partners, and donors can pool resources and leverage knowledge from new sector initiatives such as The End User Subsidy Lab to launch large-scale pilot programs to determine best practices.

Market player game changers

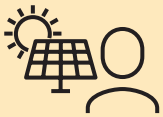
- Increased flexible and favorable financing from development partners and donors is needed for companies to expand PAYGo access. Companies can also explore alternative business models such as cash-or-airtime-based PAYGo to boost penetration and improve OGS affordability in less mature markets, where mobile money and PAYGo remain largely unavailable.
- Increased consolidation in more mature markets can result in fewer, larger, and potentially more resilient companies with improved margins and increased ability to raise capital for scaling electricity access.
- Small or local companies in less mature markets can couple value chain specialization with strategic partnerships to generate efficiencies that will strengthen the sector over time.



Technology game changers

- More companies can adopt Internet of Things (IoT) and Artificial Intelligence (AI) technologies for digitalization of processes to reduce credit risk, improve margins, and increase access to financing.
- Donors can fund more research and development on making grid-compatible OGS systems more affordable to better target all weak grid areas. OGS companies can also partner with utilities to identify better-paying customers in these areas, enabling them to make more PAYGo sales and reduce their credit risk.

- To enable widespread adoption for sector strengthening through improved margins, more companies can partner with interoperable Software as a Service (SaaS) providers and join conversations to address hardware interoperability issues around repayment risk and quality assurance.
- More companies can apply lessons from mesh-grid pilots to launch similar projects to unlock benefits of modular SHS, increase affordability, upsell beyond Tier 1 electricity access, and enable consumers to earn from energy trading and PUE appliance use.



Product and consumer game changers

- If positively applied, beyond-energy models, which involve the sale of non-OGS products, can increase company margins and profitability. This can improve overall sector performance and ability to attract more financing to expand electricity access to unserved areas.
- Increased use of PUE appliances for income generation is required for economic empowerment of consumers and can drive long-term energy affordability. To increase PUE availability and adoption, sector players can explore more financing options beyond the typical PAYGo model to make appliances more affordable.

Policy and ecosystem game changers

- Partnerships between OGS and sectors such as agriculture, healthcare, and education can increase consumer awareness and uptake of PUE appliances and SEKs for socio-economic development. To increase large-scale cross-sector partnerships, governments and development partners can collaborate to co-launch development programs as joint initiatives between sector ministries and public institutions.
- Governments can improve enforcement of favorable policies and regulations by building stronger capacities in government agencies involved in off-grid electrification. They can implement and enforce enabling policies, implement integrated electrification plans, and drive sustained private sector investments towards sustainable sector growth. In countries without robust electrification plans and high access gaps, governments and development partners can work together to integrate OGS policies into NEPs.

All stakeholders will need to coordinate efforts to implement these interventions to accelerate electricity access and attain other development goals. Stakeholders include OGS companies, governments, development partners, donors, and investors, who can support with increasing electricity access as well as bolstering company sustainability, in the following ways:

- **OGS companies:** Companies can position themselves favorably to access financing by leveraging advanced technologies that improve their credit risk management, operating margins, 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 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 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.

With less than a decade left to 2030, stakeholders must take drastic action to meet the sector's target contribution to the sustainable development goals. The private sector, governments, and donors must act now, with extreme urgency, to combine resources and coordinate to reach the common goal of SDG7. This report clearly describes the size of the remaining gap and how the sector can contribute to reach this target. It both maps the biggest challenges and guides each stakeholder towards potential high-impact solutions with specific actions that can lead to accelerated growth and development of the sector to maximize the sector's impact.

Annexes

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

Product Category	Definition	Power Range (Wp)	Indicative Price Range ($)[41]	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

41 *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[42]
    - 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

42 *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[43]
- 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[44]
- 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[45]
- 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[46]
    - 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[47]
- Leverage UN population growth projections between now and 2030 as a proxy to estimate the growth in SHFs across the key value chains[48]
- 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[49]

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

44 *UN populations data portal.*

45 *The World bank data portal.*

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

47 *Ibid.*

48 *UN Population data portal.*

49 *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[50]
- Leverage Pew research center estimates on the number of people in each household as a proxy to estimate the number of SHF households[51]
- 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[52]
- 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[53]

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[54]
- 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.)

50 *UN Population data portal.*

51 *Pew Research center: Household size.*

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

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

54 *UN Population data portal.*