



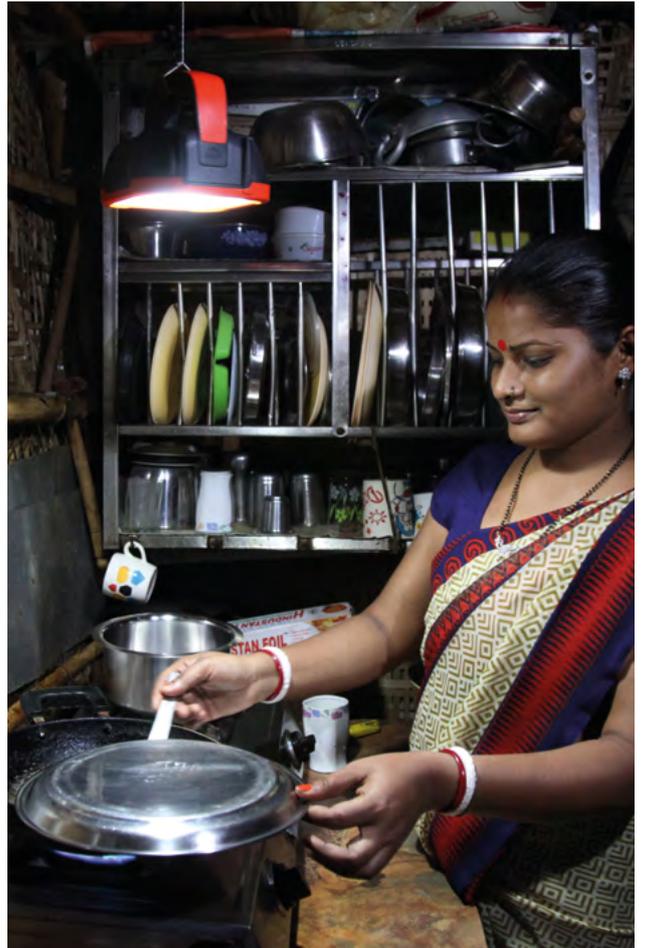
# Powering Opportunity



Energising Work, Enterprise and Quality of Life with Off-Grid Solar







# About

## **GOGLA**

GOGLA is the global association for the off-grid solar energy industry. Established in 2012, GOGLA now represents over 180 members as a neutral, independent, not-for-profit industry association. Its mission is to help its members build sustainable markets, delivering quality, affordable products and services to as many households, businesses and communities as possible across the developing world. The products and solutions that GOGLA members sell transform lives. They improve health and education, create jobs and income opportunities and help consumers save money.

To find out more, go to [www.gogla.org](http://www.gogla.org)

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Altai Consulting provides strategy consulting & research services to private companies, governments and public institutions in developing countries. Our teams operate in over 50 developing countries in Africa, the Middle East and South Asia.

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# Foreword

## A Call to Action

The data and results profiled in this report were gathered during 2018-19, before the COVID-19 pandemic. Yet, as the world grapples with the crisis, profiling the impact and potential of off-grid solar solutions becomes even more timely. Not only are these solutions providing an essential service to homes, businesses and institutions across the developing world today, they will play a critical role in (re)building sustainable economies in the post-COVID recovery tomorrow. We urge governments, investors and the donor community to join us in protecting this vital industry and ensuring its impact is not lost but enhanced in the challenging months ahead.

It comes as no surprise that gaining clean light and power in a home previously filled by darkness, or the smoke of a kerosene lamp, is beneficial. Yet the off-grid solar sector is often asked whether the energy it provides is powerful enough, or if the products it sells create meaningful change. This three-year research project, which draws from over 7,400 interviews across 11 countries, answers those questions unequivocally: yes. Off-grid solar solutions may appear to be simple devices, but they are having an outsized impact on quality of life.

This final report in the Powering Opportunity series finds that, whether in East Africa, West Africa or South Asia, **nearly all** customers report improvements in their quality of life after they buy a solar home system (SHS). It further shows that improvements are maintained across time and that these benefits are not dependent on the size of the system purchased. Moreover, the research found that the majority of people benefitting from off-grid solar solutions live in low-income, rural households, and through these solar home solutions, are gaining access to clean energy for the first time.

Providing households with cost effective solar power – enough to light up a home and keep a family in touch with each other and the world around them – has wide-ranging impacts.

In East Africa, where kerosene is commonplace, and in West Africa, where many households use diesel generators, the study shows that 89% and 86% of people respectively perceive health benefits and 91% and 98% report feeling safer. Even in South Asia, where many SHS in the region are used as a back-up to the grid, 94% of people

say that the solar powered systems have enhanced their well-being, including two thirds of families who find that children have more time to study.

For many households, turning the power on is proving transformational. For many businesses, too.

Solar home systems are often overlooked as products that can be used to enhance economic activity, for example by powering businesses, creating new jobs and increasing productivity. Yet, here too, the products are providing far more impact than many realise.

This research shows that one third of the solar home systems purchased in East Africa are used to extend the working day or boost enterprise. This is increasing earnings by an average of \$46 per month, equivalent to a 14% increase on average income in the region. The cumulative additional time spent working as a result of these systems is equal to 21 Full-Time-Equivalent (FTEs) for each 100 SHS sold. With 4.8 million solar kits and home systems sold in East Africa since 2016, an estimated one million FTEs have been introduced to the economy<sup>1</sup>. 52% undertaken by women.

Although results related to economic activity are more modest in West Africa, they still reveal that an impressive eight FTEs are created for every 100 SHS sold, and an additional four FTEs are created per 100 SHS in South Asia. Given the size of the off-grid solar markets in India, Bangladesh and Pakistan, these results translate to huge numbers of FTEs unlocked by the sector over the last decade. While in the emerging markets of West Africa, they highlight a great opportunity to enhance the use of SHS for enterprise with the right national and regional support.

1. Calculation undertaken using FTE data in conjunction with GOGLA Global Off-Grid Solar Sales and Impact data (2020).

## Foreword

Indeed, we urge decision-makers from around the world – policymakers, investors and the international development community – to take note of the fast and cost effective impacts that are being created by the off-grid solar sector and to **work with us**.



Our industry is maturing. We know more than ever what works and what does not work when we try to connect people to clean modern energy. We know more than ever what it is that our customers want, and how we can help them. And we know with certainty that we will create far more, and far more rapid, impact if we work together with governments, multilateral donors, and stakeholders from all sides of energy access work. This research reminds us just how important it is.

**Radhika Thakkar**, President, GOGLA

A handwritten signature in black ink, appearing to read 'Radhika Thakkar'.



We urge decision-makers from around the world to take note of the fast and cost effective impacts that are being created by the off-grid solar sector and call on them to **work with us**.

Radhika Thakkar  
GOGLA President



# Key Findings

## Energy access

Customers report significant increases in the hours of light available. For example, before their purchase, two thirds of East African customers had less than 6 hours of light a day. Now, 53% have more than 10 hours



The SHS helps users to stay connected as they can charge their phones more often; many also access radio, TVs and fans

## Economic activity

34% of households in East Africa, 19% in West Africa and 12% in South Asia report that at least one member is undertaking additional economic activity due to the SHS



Additional economic activity translates into 21 FTEs per 100 SHS sold in East Africa, 8 in West Africa and 4 in South Asia

Of the hours of extra work undertaken by customers, 52% are undertaken by women in East Africa, 38% in West Africa and 22% in South Asia



# Key Findings

## Income generation

28% of households in East Africa report generating additional income thanks to the SHS. This is also true for 14% of households in West Africa and 11% in South Asia



The average income generated per month by those households is \$46 in East Africa, \$31 in West Africa and \$65 in South Asia



64% of customers in East Africa, 75% in West Africa and 25% in South Asia report they feel they have more money available since purchasing their SHS



## Quality of life

Nearly all SHS customers report quality of life improvements; 94% in East Africa, 97% in West Africa and 94% in South Asia

## Safety

91% of customers in East Africa, 98% in West Africa and 90% in South Asia report feeling safer



## Health

89% of customers in East Africa perceive health improvements in their household. This is also true for 86% in West Africa and 37% in South Asia



# Key Findings

## Education

85% of households in East Africa, 91% in West Africa and 66% in South Asia report that children have more time to do their homework thanks to the light provided by the SHS



## Reduced inequalities

SHS are reaching low-income households who might otherwise be left behind. 59% in East Africa and 42% in West Africa report earning less than \$3.20

Most customers live in rural areas: 55% in East Africa, 70% in West Africa and 90% in South Asia

## Climate

In East Africa, use of kerosene as a main source of light among customers shrunk from 39% to almost zero, reducing polluting emissions



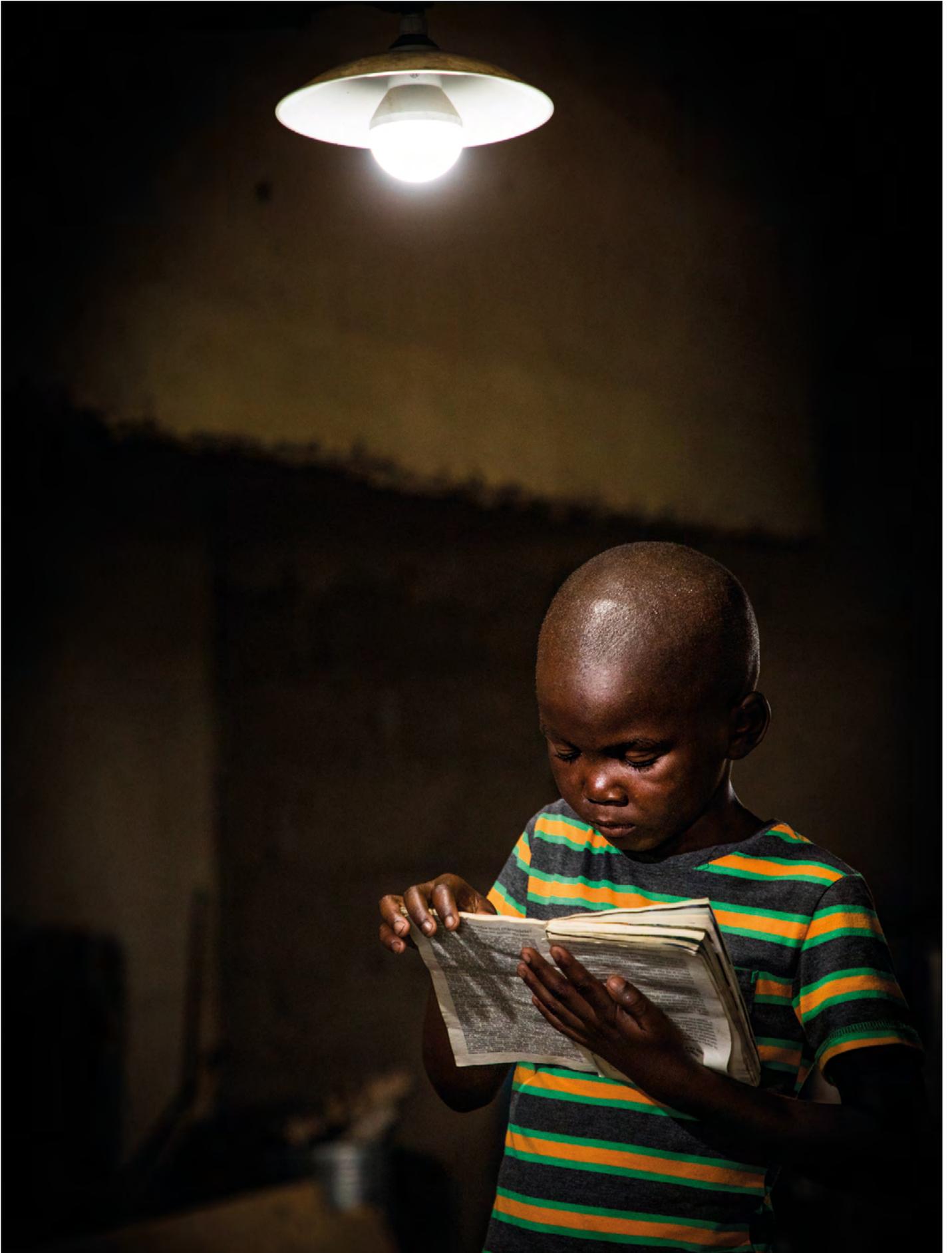
In West Africa, use of diesel generators as a main source of light decreased from 14% of customers to 4%





# Introduction





# Introduction

## 1.1 Context

Despite progress in reaching Sustainable Development Goal 7 (SDG7) - affordable, reliable, sustainable and modern energy for all - 840 million people still live without access to electricity<sup>2</sup> and two billion more are estimated to live with unreliable supply<sup>3</sup>. Electrification remains lowest in Sub-Saharan Africa with over 50% of the population living without access - 573 million people - while worldwide, rural areas lag behind urban areas with 79% of the rural population having access to electricity versus 97% of the urban population<sup>4</sup>. According to the International Energy Agency (IEA) and other agencies tracking SDG 7, off-grid solutions provide the fastest and most cost-effective way to reach millions of people who are unconnected, particularly those in rural areas<sup>5</sup>.

To help meet this challenge, the off-grid solar industry has taken great strides over the last decade. Since 2010, solar lantern sales have reached hundreds of millions, while larger products and appliances are now commonplace. In 2018, sales of solar home systems (SHS) and multi-light kits broke the two million a year barrier and sales of solar powered TVs, fans, refrigerators and water pumps reached record highs<sup>6</sup>. Overall, the off-grid solar sector is now a \$1.75 billion annual market serving 420 million users worldwide<sup>7</sup>.

In addition to the technical efficiencies that have enabled off-grid solar to become affordable for millions of low-income households, the emergence of the PAYGo business model, which allows customers to buy solar products in instalments, has been a key driver of market growth. However, in 2017 when the 'Powering Opportunity' research began, limited research into the impact of solar home systems and the PAYGo business model was available. This led the UK Department of International Development to commission GOGLA and Altai Consulting to explore the socio-economic impact of PAYGo SHS through a series of regional studies: two in East Africa, one in West Africa and another in South Asia. This report is the culmination of the three-year project and includes data points from interviews with over 7,400 customers and 11 PAYGo SHS providers across 11 countries.

The Powering Opportunity series is an important contribution to research on the impacts of off-grid solar, in particular on economic activity and income generation, providing evidence for policymakers, donor agencies and impact investors looking to support the sector. This global report includes data from all three regional Powering Opportunity research activities to create a one-stop-shop for key findings and geographic insights. Furthermore, it is designed to highlight how off-grid solar solutions are not only driving SDG7 but making significant contributions to a further seven SDGs.



2 IEA, IRENA, UNSD, World Bank, WHO (2019), Tracking SDG 7: The Energy Progress Report 2019.

3 More than two billion people are living with blackouts, summing up to more than 100 hours a year. IFC (2019), The Dirty Footprint of the Broken Grid: The Impacts of Fossil Fuel Back-Up Generators in Developing Countries.

4 Ibid.

5 Ibid.

6 GOGLA (2019), Global Off-Grid Solar Market Report. Semi-Annual Sales and Impact Data January – June 2019.

7 Lighting Global, GOGLA, ESMAP (2020), Off-Grid Solar Market Trends Report 2020.

# Introduction

## 1.2 Geographic scope

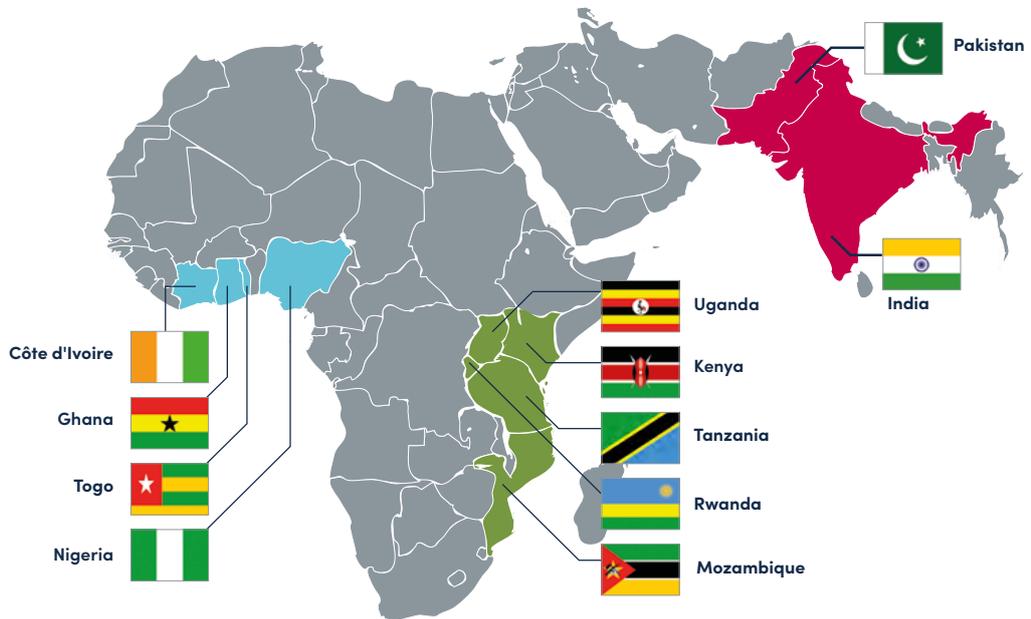
The Powering Opportunity research led to interviews with 7,402 customers from 11 PAYGo SHS providers in 11 countries over three regions (Figure 1 & Figure 2).

This final report leverages key insights from the entire research to produce an understanding of the impacts SHS can have at a global level, through the comparison of three key regional markets.

**Figure 1: Research timeline and regional focus**



**Figure 2: Scope of the research**



# Introduction

## 1.3 Regional overviews

Although all three regions have been central to the growth of the off-grid solar (OGS) sector, the state of the OGS market varies significantly in each. This section highlights some factors common to each region. However, it should be noted that the information provided refers primarily to the countries in the scope of this research (Figure 2), rather than to the regions in a broader sense.

### East Africa

In East Africa, electrification rates are relatively low with exception of Kenya (64%). Among other countries covered in this region, rates vary from 22% in Uganda to 34% in Rwanda<sup>8</sup>. This implies a huge potential for off-grid solar in East Africa with large unconnected populations. The region has been the centre for innovations in SHS and PAYGo technology. The success of PAYGo in East Africa was in part due to the popularity of mobile money, especially in Kenya, with digital payments acting as a key enabler. Markets across the region have reached different levels of maturity but are overall among the most mature for SHS and PAYGo and there is fierce competition between providers in the region. In the first half of 2019, almost three quarters of SHS sales reported by GOGLA worldwide took place in East Africa<sup>9</sup>.

### West Africa

In West African countries covered in this research, electrification rates are usually higher than in East Africa, ranging from 48% in Togo to 79% in Ghana<sup>10</sup>. However, grid electrification does not always imply a reliable access to energy for end-users, as demonstrated by the heavy reliance on back-up generators in West Africa and especially Nigeria<sup>11</sup>. Off-grid solar has a lower-penetration in the region than in East African countries in this research but has seen significant growth,

especially for SHS where sales in the first half of 2019 doubled compared to sales in the second half of 2018. The off-grid sector in the region has also begun to benefit from institutional support. The World Bank is providing over \$200 million in financing for the Regional Off-Grid Electrification Project for 15 ECOWAS and four Sahel countries<sup>12</sup>. In Togo, the government is providing subsidies for PAYGo SHS sales under the CIZO program<sup>13</sup>.

### South Asia

In South Asia, grid electrification is on average higher than in Sub-Saharan Africa. In India, the World Bank estimated that 92% of the population had access in 2017, with the electrification rate estimated at 71% in Pakistan<sup>14</sup>. In Pakistan, this rate has been stable for over a decade. In India, electrification has been continuously increasing and the recent successful Saubhagya scheme, aiming to connect 26 million households in rural villages, has played a significant role in bridging the last gap. This means that SHS are more commonly used as a back-up or complement to the grid. Historically, South Asia as an off-grid solar market has been dominated by cash-based sales and solar lanterns, which continue to play a significant role in the market and in providing benefits to customers. However, in both India and Pakistan a number of companies, as well as Microfinance institutions (MFIs) are selling PAYGo SHS, and the ability of larger systems to power fans and appliances are providing added value for customers. As the market matures many organisations are also exploring the potential of solar water pumps and refrigeration. It is worth noting that, although no companies from Bangladesh were included in this research, the country's extensive IDCOL SHS scheme has also been a key driver of off-grid solar activity in the region.

8 World Bank data (2017), <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=KE-RW-UG-TZ-MZ>

9 GOGLA (2019), Global Off-Grid Solar Market Report. Semi-Annual Sales and Impact Data January – June 2019.

10 World Bank data (2017), <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=CI-GH-TG-NG>

11 IFC (2019), The Dirty Footprint of the Broken Grid: The Impacts of Fossil Fuel Back-Up Generators in Developing Countries.

12 World Bank (2019), Press Release: <https://www.worldbank.org/en/news/press-release/2019/04/22/world-bank-provides-2247-million-to-help-increase-access-to-electricity-in-west-africa-and-the-sahel-region>

13 Ministère des Mines et des Energies, Agence Togolaise d'Electrification Rurale et des Energies Renouvelables (2019), Projet d'Electrification Rurale CIZO : Résumé du cadre de gestion environnementale et sociale, Rapport Final, Juillet 2019.

14 World Bank data (2017), <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=IN-PK>

# Introduction

## 1.4 Research approach

### Data collection

In West Africa and South Asia, the research set out to conduct two-rounds of interviews with customers, while in East Africa, three sets of interviews were undertaken (Figure 3).

In South Asia, challenges with the fieldwork<sup>15</sup> led to methodology adjustments. The main impact of these adjustments is that the research was unable to interview the same customers twice, leading to two independent data sets referred to as Pre-purchase and Post-purchase rather than Baseline and Follow-up.

Attrition was also seen between the baseline and follow-ups (due to refusal to participate in the survey, phone number change, unavailability of respondent at the time of the survey, poor mobile coverage, etc.)<sup>16</sup>. The final samples and project timeline are described in the table below.

### Analysis

This report leverages analysis of the data for each region, to compile and insights on the profile of customers, energy mix, usage of SHS and impact on the lives and livelihoods of customers in East Africa, West Africa and South Asia. In each region, the data was weighted to balance the quota effect and ensure the highest degree of representativity possible<sup>17</sup>.

Figure 3: Research approach



Figure 4: Sample sizes<sup>18</sup>

	East Africa	West Africa	South Asia
Baseline / Pre-purchase	3,307	2,375	894
Follow-up 1 / Post-purchase	2,343	1,678	949
Follow-up 2	1,419	-	-

<sup>15</sup> Please see the Methodology Annex for more information.

<sup>16</sup> Please see the Methodology Annex for more information.

<sup>17</sup> Please see the Methodology Annex for more information.

<sup>18</sup> In South Asia, both phases are independent, which explains why the sample size for Post-purchase is bigger than for Pre-purchase.

# Introduction

## 1.5 PAYGo Solar Home Systems

The Powering Opportunity series focuses on PAYGo solar home systems (SHS) which are sold through different types of business models.

GOGLA defines companies as PAYGo providers if they sell their solar products through a form of consumer financing. Companies often use rent-to-own and energy-as-a-service business models or partner with Microfinance institutions (MFIs). The technology that allows companies to remotely lock a system to ensure customers pay for their product is also referred to as PAYGo technology, or it is said that a product is PAYGo enabled. However, a product can be sold as PAYGo without the technology being included in the product.

### Business models

The vast majority of products in the research were sold on a rent-to-own basis. A company will typically offer a solar product for which a customer makes a down payment, followed by regular payments for a term usually ranging from 6 months to 3 years. This means customers need to repay on a regular basis and within a limited amount of time. However, most companies offer flexibility to customers both on regularity of payments and length of repayment period.

BBOX products studied in this research are sold on a different basis. In BBOX's energy as a service model, customers pay a fee for access to energy during a period fixed by contract. Any accompanying appliances are sold on a rent-to-own model. For customers this means energy payments continue over a longer amount of time but so do the warranty and servicing contract.

The MFI model functions as an asset financing model with a financial institution as an intermediary between the SHS provider and final customer. Rather than paying the provider of the SHS in instalments, the customer takes out a loan at a microfinance institution to finance the system. This model is particularly common in South Asia and within this research is carried out by Greenlight Planet in India.

### System sizes

Off-grid companies in this research all sell quality verified products<sup>19</sup> but with a great variety of offers in terms of system size, features and included appliances. The table below shows the different product size categories and the features and appliances each system size typically includes in this research.

Different system sizes also have an impact on the price paid by the customer. Larger systems provide more power and access to more services and appliances but are more expensive and therefore tend to have higher down payments and longer repayment periods.

Figure 5: System sizes

Size range	Commonly included appliances
3-10 Wp	 
11-20 Wp	  
21-50 Wp	   
50+ Wp	    

19. Quality verified products meet the VeraSol Quality Standards. For more information please see <https://verasol.org/>



Before I bought the SHS, I used to charge my phone at my friend's house. Over time, I got tired of having to walk long hours to and from his house just to do that. This pushed me to get my own. I am now able to sit at home and charge my phone while having the added benefit of light at night and a TV to watch.

PEG Customer  
Kintampo, Ghana



With the SHS we can light our home during the evening. It makes it easier for us to cook food, and we can now sit together and talk after dark, which was not possible before.

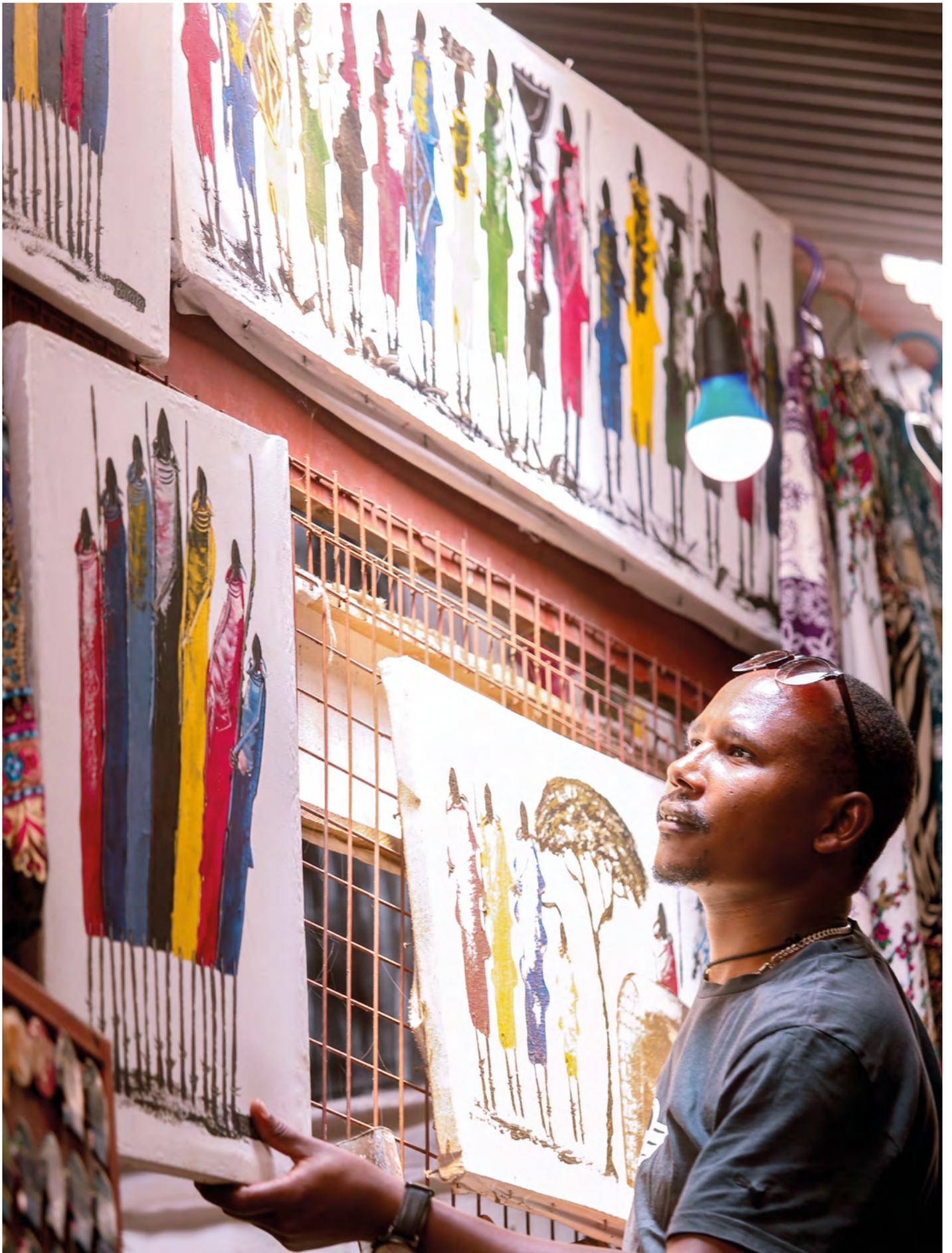
EcoEnergy Customer  
Tahar, Pakistan



“

**The Solar  
Home System  
Customer**

”



# The Solar Home System Customer

## 2.1 Customer profile

The research shows SHS reach a broad variety of customers (Figure 6). Although they are predominantly bought by off-grid rural low-income customers, they also provide significant benefits to wealthier, urban grid-connected customers.

SHS are reaching low-income households in all regions. In East Africa, 59% of customers report earning less than \$3.20 per day. This figure is 42% in West Africa and 18% in South Asia. In all three regions, the majority of customers report earnings below \$5.50 a day<sup>20</sup>.

The vast majority of customers live in rural areas. 55% of customers in East Africa live in rural locations, 70% in West Africa and 90% in South Asia. Other customers live in urban or, more often, peri-urban areas.

Across the research, the typical purchaser is a man in his thirties. However, women and children are also beneficiaries of SHS installed in the home. In all three regions, around 50% of beneficiaries are women or girls and around 50% of beneficiaries are children.

Average household sizes range from 5.6 in East Africa to 7 in West Africa, meaning that SHS are benefitting several people in each home. In all countries and regions, the average size of households with off-grid solar are larger than the national average<sup>21</sup>.

## 2.2 Customer experience

### Reasons to purchase the system

Across all regions, and unsurprisingly, reliable access to light is the main reason for customers to purchase an SHS. Phone charging also appears as a key factor for purchase (Figure 7).

In East Africa, access to TV, a key driver of SHS sales in the region, is highlighted. Security and safety is also a motivation to purchase a SHS, which is likely linked to the fact that many customers previously relied on dangerous kerosene lamps (see section III. The Power of Off-Grid Solar).

In West Africa, most reasons for purchase reported are related to lights and appliances, but a significant number of customers also mention the PAYGo payment model. The fact that more

Figure 6: Typical purchaser profile per region<sup>22</sup>

	East Africa	West Africa	South Asia
Gender of purchaser	Male	Male	Male
Age of purchaser	35-40 years old	35-40 years old	30-35 years old
Household size	5.6	7	6.9
Type of location	Rural	Rural	Rural
Monthly income level (USD)	\$80-100	\$120-140	\$140-160

N(East Africa)=2,343 N(West Africa)=1,618 N(South Asia Post-Purchase)=949

20 Lower Middle Income Class Poverty Line has a value of US\$3.20 PPP. Upper Middle Income Class Poverty Line has a value of US\$5.50 PPP.

21 UN Population data: Côte d'Ivoire: 5.1, Ghana 3.5, India 4.6, Kenya 3.6, Mozambique 4.4, Nigeria 4.9, Pakistan 6.8, Rwanda 4.3, Tanzania 4.9, Togo 4.6, Uganda 4.5

22 Monthly income level corresponds to the median income interval of incomes reported by customers. Income was reported on a weekly basis in Africa except Mozambique (monthly) and on a monthly basis in South Asia.

# The Solar Home System Customer

**Figure 7: Top five reasons to purchase a SHS per region**

	East Africa	West Africa	South Asia
1	Reliable access to light	Reliable access to light	Reliable access to light
2	Mobile phone charging	Mobile phone charging	More lights
3	Security & safety	Access to appliances	Mobile phone charging
4	Access to TV	More lights	Grid back-up
5	Saving money	PAYGo payment	Business usage

N(East Africa)=2,343 N(West Africa)=1,618 N(South Asia Post-Purchase)=949

customers mention the payment terms more often in West Africa than in East Africa may be due to customers in East Africa being more familiar with PAYGo, as the model is more widely adopted and the market more mature.

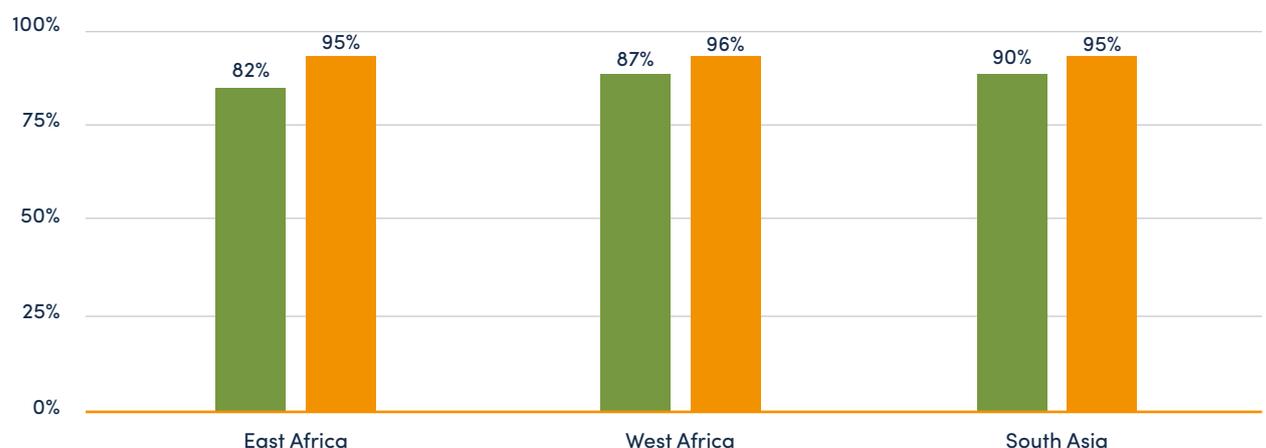
In South Asia, having a back-up to the grid is one of the most commonly cited reasons to get a SHS. Unlike in Africa, a majority of SHS customers in South Asia in this research (61%) are grid-connected (see section III. The Power of Off-Grid Solar).

## Customer satisfaction

In all three regions, satisfaction with the products is very high, with more than 80% of customers rating the value for money of their system as good or very good and at least 95% of customers saying they are likely or very likely to recommend their product to a friend (Figure 8).

Data from East Africa shows that these figures are stable over time. Surveys with customers were undertaken at both three months post-purchase and 15 months post-purchase. In that time the positive value for money rating grew from 78% to 82%, and the likelihood to recommend rating changed from 97% to 95%.

**Figure 8: Share of customers rating the value for money as 'good' or 'very good' and reporting they are 'likely' or 'very likely' to recommend the product to friends and relatives**



■ Value for money  
■ Likelihood to recommend  
 N(East Africa)=1,419  
 N(West Africa)=1,618  
 N(South Asia Post-purchase)=949



We used to use kerosene for lighting which produced a lot of smoke that caused coughing especially for the children, but with solar, that has stopped.

Fenix International Customer  
Namulamba, Uganda



We were in the dark at night, but not anymore since we started using the SHS. My children are able to study after sunset and the light makes it safer to step out of the house in the evening. The fan is also great, as it helps us sleep and cook more comfortably.

Simpa Networks Customer  
Bhagabatipur, India



## The Solar Home System Customer



“

**The Power Of  
Off-Grid Solar**

”



# The Power Of Off-Grid Solar

## 3.1 Evolution of light sources

Sources of light used by households before they get their SHS vary greatly from one region to another. With significant differences also appearing within regions and even within countries. However, a few key trends appear<sup>23</sup>.

In East Africa these are notably the switch from kerosene to solar and the fact that customers appear to be progressing along a 'solar energy staircase'<sup>24</sup>, from smaller solar products like lanterns to larger and larger SHS capable of powering more appliances.

In West Africa several trends emerge, in part due to more heterogeneous results from one country to another. In urban areas, SHS are acting as a back-up to the grid and competing with generators as a source of light. In rural areas, the main sources of light before the SHS are torches and other solar technologies. Many customers who already had solar lanterns or solar kits are complementing them with their new SHS. As in East Africa, this seems to confirm the emergence of a solar energy staircase.

In South Asia, while many are getting access to a modern energy source for the first time, the most significant feature is that a majority of customers are using their SHS to back or complement a grid connection.

Each of these trends is explored in this section.

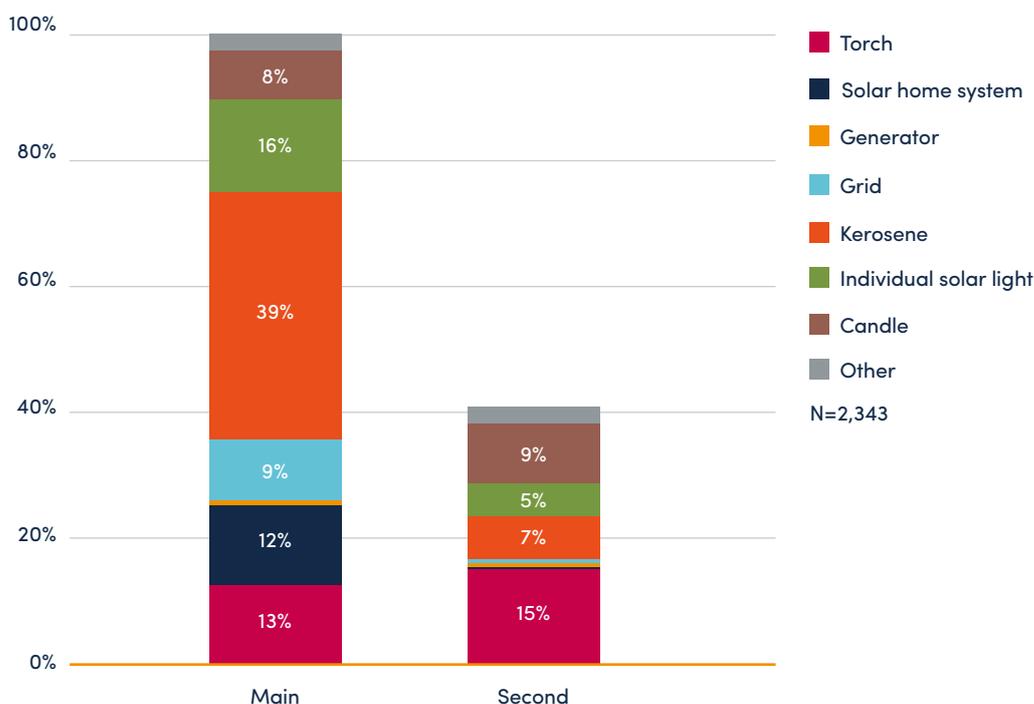
### East Africa

Prior to their purchase of the SHS, almost 40% of customers in East Africa relied on kerosene to light their homes. After the adoption of the SHS, kerosene as a source of light is almost eliminated altogether (Figure 9). On average, SHS in the research eliminated 1.7 kerosene lamps per household. This has major benefits both for households and for the environment.

### Reducing kerosene use

Cutting kerosene use for lighting makes households safer and healthier. Kerosene lamps put users at risk of fires that can cause injury and destroy homes or assets. Kerosene is a polluting fuel and is categorized as such by the World Health

**Figure 9: Previous sources of light used in East Africa**



<sup>23</sup> Country-level data cannot be shared due to GOGLA's three-data-point rule. Please see the Methodology Annex for more details.

<sup>24</sup> Previous discourse suggested the emergence of an 'energy ladder', where off-grid customers move from a solar lantern to a small solar home system and then on to larger products and more appliances. However, a more recent narrative has emerged that additionally recognizes that many customers do not move in a linear fashion from one product to another but may stack products (e.g. they may own several solar lights, or a solar home system as well as solar lanterns). The energy ladder concept is now often replaced by reference to the 'energy staircase', to allow for this stacking whilst maintaining the upward energy access trajectory and allowing for product to product movement.

# The Power Of Off-Grid Solar

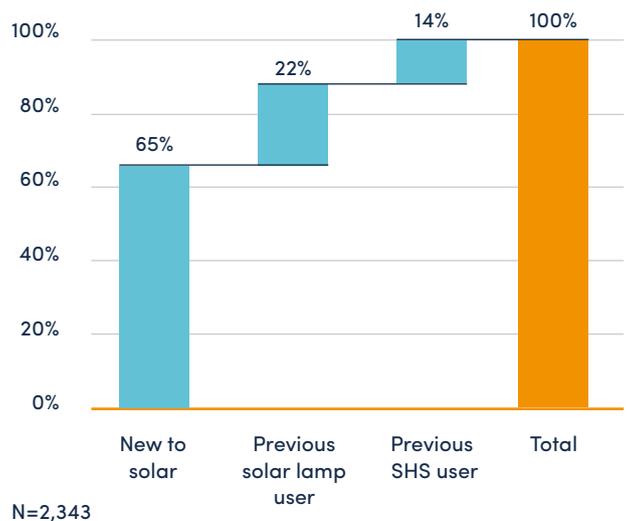
Organization, which discourages its use within the home<sup>25</sup>. A 2018 study showed that switching from kerosene to solar lamps significantly improved air quality inside households and reduced exposure to toxic air pollutants<sup>26</sup>. Reported impacts of using kerosene for lighting include respiratory issues, coughing and eye irritation<sup>27</sup>. Kerosene has further been linked to increased risk of pneumonia<sup>28</sup> and tuberculosis<sup>29</sup>. In this research, in East Africa, 91% of customers report feeling safer since purchasing the SHS and 89% perceive health improvements in their household.

Systemically replacing kerosene with solar also reduces greenhouse gas emissions by reducing the burning of fuel. The United Nations Environment Programme (UNEP) estimates that eliminating all fuel-based lamps would reduce emissions by 90 million tonnes of CO<sub>2</sub> per year<sup>30</sup>. Additionally, kerosene lamps produce black carbon, a particle that has a warming effect vastly superior to CO<sub>2</sub>. The warming effect of black carbon from usage of kerosene lamps worldwide is estimated to be equivalent to 240 million tonnes of CO<sub>2</sub><sup>31</sup>.

## Climbing the energy staircase

35% of customers already had solar products before purchasing their SHS: 22% had a solar lantern and 13% a SHS (Figure 10). This is consistent with the idea that customers move up an energy staircase from solar lanterns to larger SHS.

Figure 10: Energy staircase



25 World Health Organization (2016), Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children.

26 Lam et al (2018), Exposure Reductions Associated with Introduction of Solar Lamps to Kerosene Lamp-Using Households in Busia County, Kenya.

27 Graham and Tevosyan (2018), Perceived Health Benefits of Off-Grid Products: Results of an End-User Survey in Uganda.

28 Bates et al (2013), Acute Lower Respiratory Infection in Childhood and Household Fuel use in Bhaktapur.

29 Pokhrel et al (2010), Tuberculosis and Indoor Biomass and Kerosene Use in Nepal: A Case-Control Study.

30 United Nations Environment Programme (UNEP) – Global Environment Facility (GEF) en.lighten Initiative.

31 The Brookings Institution (2013), Black Carbon and Kerosene Lighting: An Opportunity for Rapid Action on Climate Change and Clean Energy for Development.

# The Power Of Off-Grid Solar

## West Africa

### Climbing the energy staircase

Overall, torches were the main source of light used by SHS customers in West Africa before they bought their product, especially in rural areas. This means many households, purchasing the SHS provided them with access to high quality, sustainable lighting in their home for the first time.

In rural areas, more than a quarter of customers used solar as their main source of light before they purchased their new product, including many who already owned an SHS. In this context, the SHS already being used by the household may be a non-quality verified product or component-based product, with the customer aiming to enhance their quality of electricity supply<sup>32</sup>.

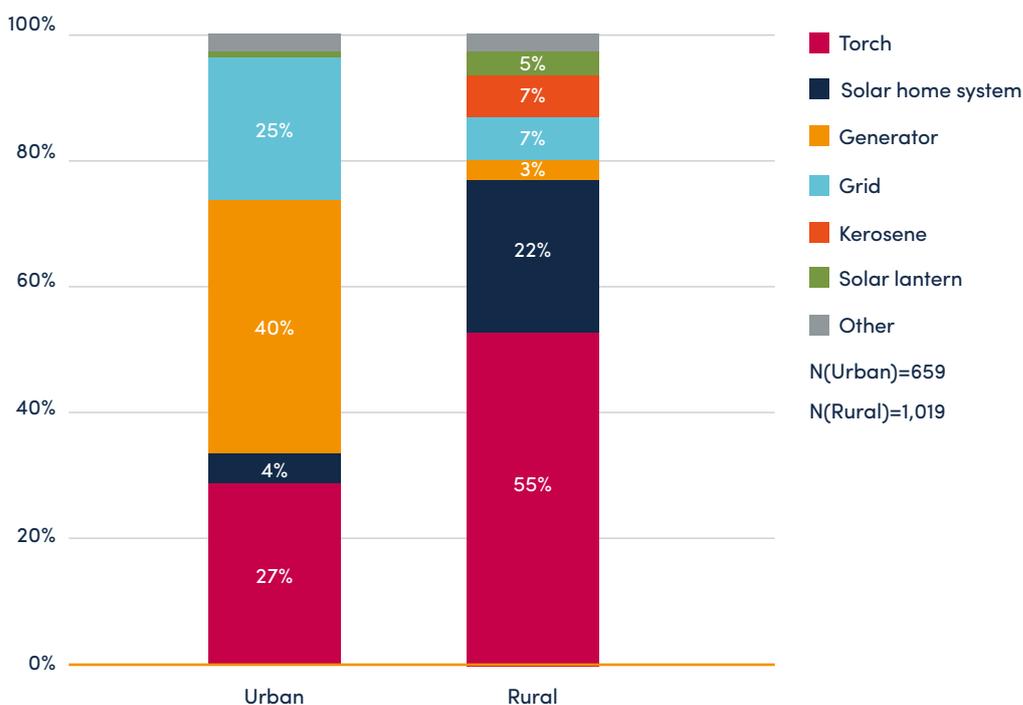
### Replacing generators

In urban areas, the most common source of light used previously by SHS customers is a generator. This is unsurprising, as an estimated 40% of annual electricity consumption in West Africa comes from generators<sup>33</sup>. SHS offer a clean alternative to generators where they can provide a similar capacity. They can replace generators as a main source of light or provide a back-up to the grid.

As with kerosene, the shift away from fossil fuel generators can have several positive effects. For households it can remove high levels of expenditure on fuel, while on a broader scale, generators are also a major cause of pollutant emissions. In Sub-Saharan Africa, back-up generators are estimated to release 15% of the region's total nitrogen oxide (NOx) output, equivalent to emissions from 35% of the transport sector in the region<sup>34</sup>.

Overall, after three months, 86% of households have adopted the SHS as their main source of light (Figure 12).

**Figure 11: Previous sources of light used in West Africa by type of location**



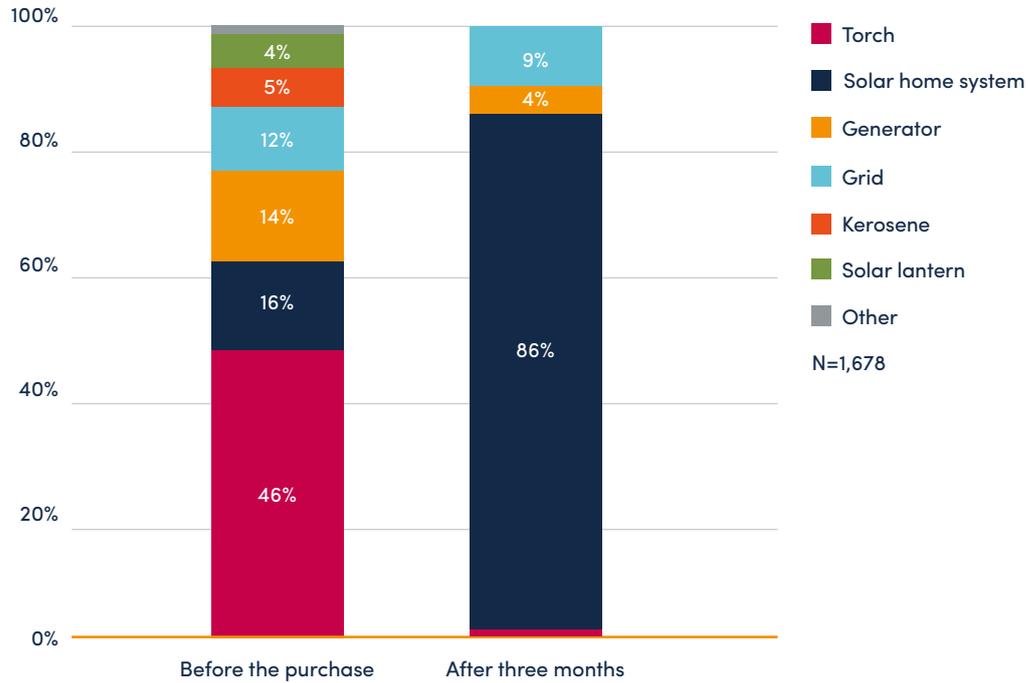
32 Non-quality verified products are defined by opposition to products that have been tested and meet the standards set by VeraSol and are therefore quality verified. Component-based products refer to products for which customers buy a solar panel, a battery box and other components separately, rather than in a kit.

33 IFC (2019), The Dirty Footprint of the Broken Grid: The Impacts of Fossil Fuel Back-Up Generators in Developing Countries.

34 Ibid.

# The Power Of Off-Grid Solar

**Figure 12: Main source of light evolution in West Africa**

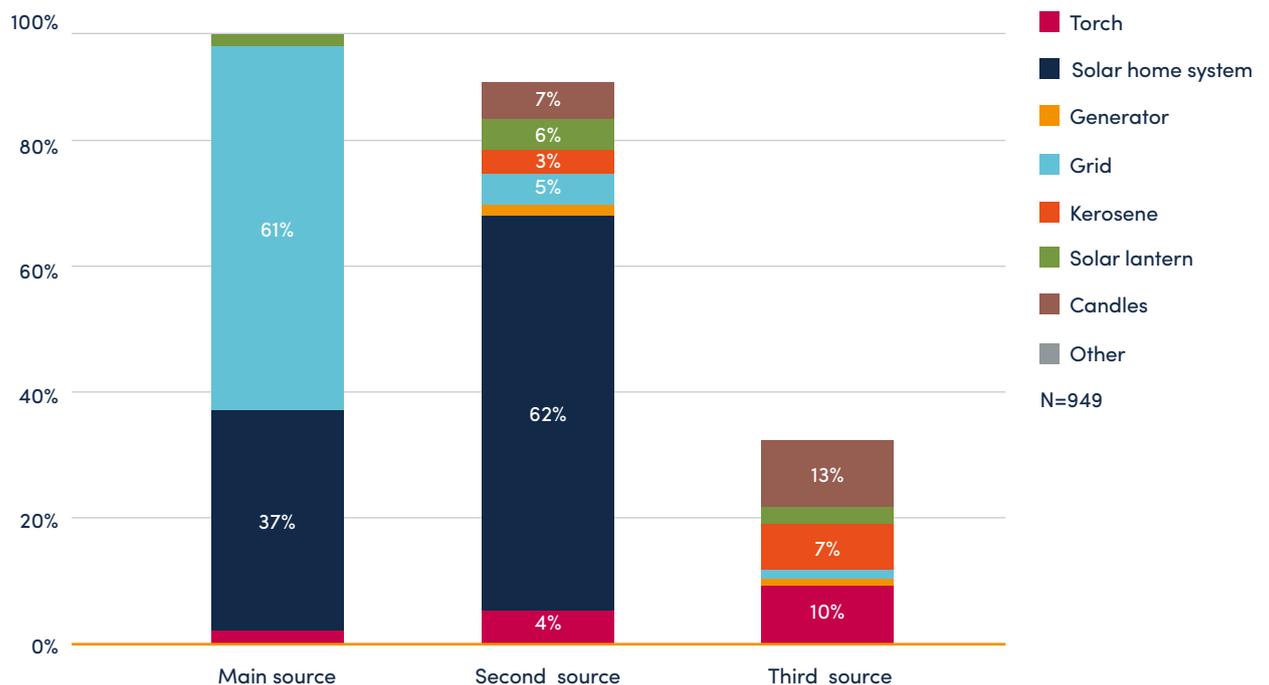


## South Asia

In South Asia, while many are gaining access to a modern energy source for the first time, a majority of customers surveyed are using their SHS as a back-up or an addition to the grid. Despite the fact this makes the SHS a secondary source of

electricity for 61% of customers, 88% claim to use their SHS every day. This indicates that, even in areas of high grid penetration, SHS have a role to play in providing greater consistency and security of supply – and the impacts that come with it.

**Figure 13: Current sources of light used in South Asia**



# The Power Of Off-Grid Solar

## 3.2 Improved access to light

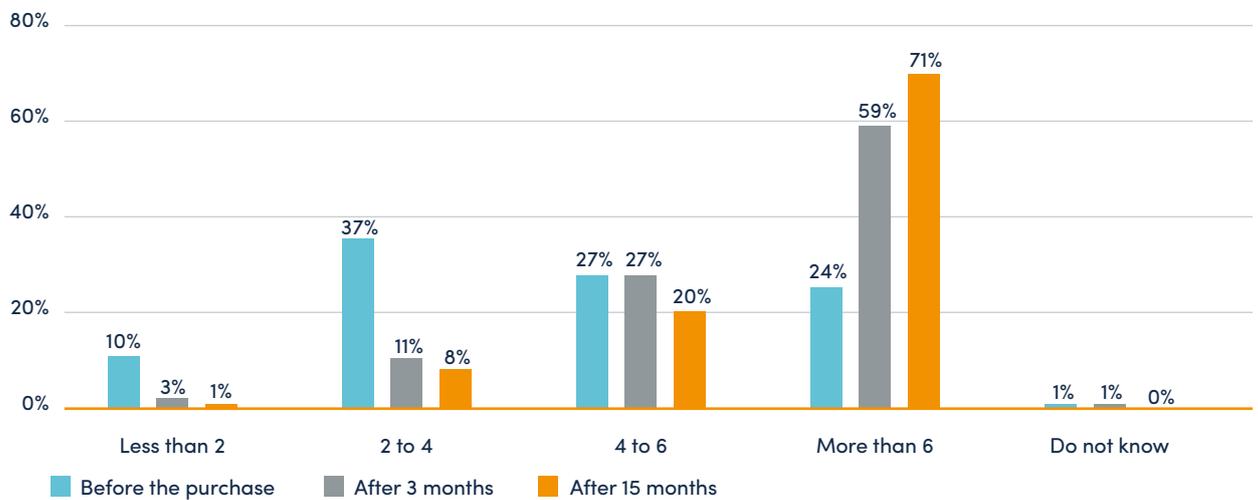
In Africa, use of the SHS led to a significant increase in hours of light available per day for most customers. For South Asia, data on the evolution of light hours is unavailable due to data collection challenges<sup>35</sup>. However, for those gaining first time access to modern energy in that region, a greater number of light hours following the purchase of the SHS is likely given evidence provided in existing research<sup>36</sup>.

### Hours of light evolution

The charts below provide the evolution of hours of light from all sources of light used in East and West Africa<sup>37</sup>.

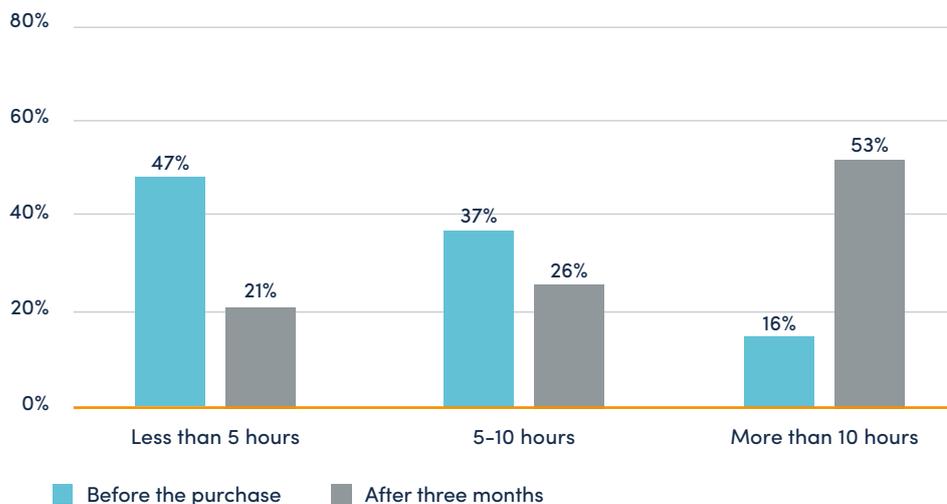
**Figure 14: Evolution of hours of light in East Africa**

N=1,419



**Figure 15: Evolution of hours of light in West Africa**

N=1,652



35 Please see the Methodology Annex for more information.

36 Lighting Asia (2018), Impact of Solar Off-Grid Lighting Solutions on Rural Households in the States of Uttar Pradesh and Bihar in India.

37 The scale used in the original East Africa research only went as far as 'More than 6 hours', while this scale was increased to 'More than 10 hours' in the second round of research in East Africa and in the West Africa research. Therefore, data from East and West Africa are presented using different scales.

# The Power Of Off-Grid Solar

## Hours of light available to SHS users

After purchasing the SHS, customers in East and West Africa report very similar access to light with over 50% in both regions reporting more than 10 hours of light per day (Figure 16). This indicates that, as well as using their system in the evening, a number of households additionally use the system to improve light in the daytime, or to provide a security light at night. In South Asia, despite access to the grid and use of the SHS, most customers report using less than five hours of light per day.

## Quality of life improvements

Improved access to light creates a number of positive effects within a household. Across all regions, an overwhelming majority of customer report the purchase of the SHS lead to improvements in their quality of life. This is true for 94% of customers in East Africa, 97% in West Africa and 94% in South Asia.

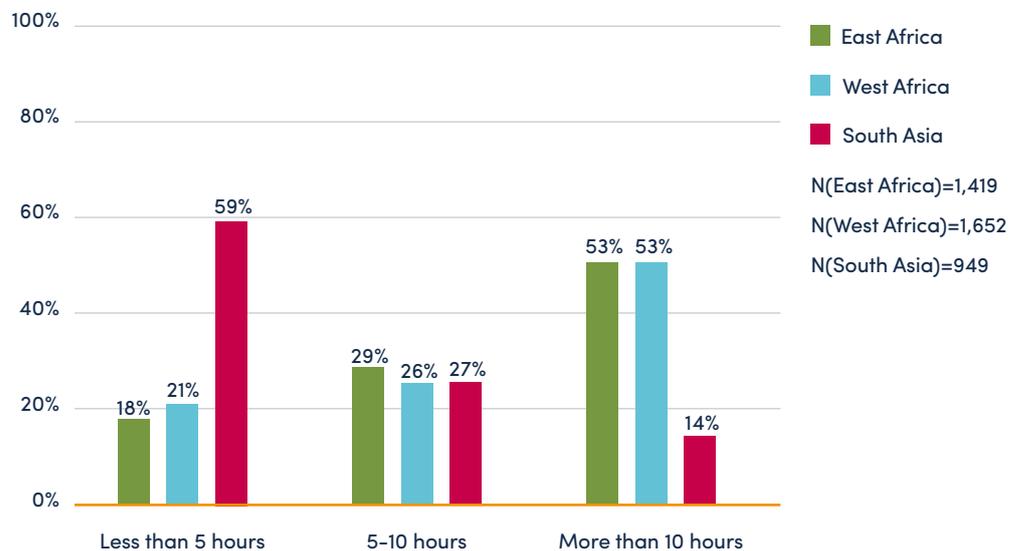
Three key areas of quality of life improvement are safety, health and education.

In East Africa, 91% of customers report feeling safer, 89% report perceiving health improvements and 85% report children have more time to do homework.

In West Africa, 98% report feeling safer, 91% report children have more time for homework and 86% report perceiving health improvements.

In South Asia, 90% of customers report feeling safer, 66% report children have more time for homework and 37% report perceiving health improvements. Health improvements are likely to be lower in South Asia as many households are using the SHS as a backup to the grid, whereas many customers in Africa are using it to replace dangerous or polluting kerosene, candles or diesel generators.

Figure 16: Hours of light per day across all three regions



# The Power Of Off-Grid Solar

## 3.3 Phone charging and appliances

### Phone charging

Access to phone charging is one of the most commonly mentioned reasons to purchase the SHS across all regions. And indeed, access to phone charging can be linked to several benefits.

First and foremost, the availability of phone charging increases the amount of time cell phones can be switched on and used. Many customers, especially in Africa, report using their phone more (East Africa: 89%, West Africa: 93%, South Asia: 30%) which can have several benefits such as improving cohesion within dispersed families and increasing users' broader sense of inclusivity<sup>38</sup>.

Second, cell phones can help users seize more economic opportunities and increase their income (see section IV. Economic Opportunities).

Finally, mostly in Africa, customers may have previously relied on others to charge their phones. In many cases this means they pay a fee for this service or travel significant distances to charge their phone. Therefore, having phone charging capacity at home can save customers considerable time and money.

### Appliances

The most commonly included appliances in the SHS in the research are radios, TVs and fans. Fans are most common in South Asia<sup>39</sup>.

TVs are playing an increasing role in driving sales of larger SHS, especially in East Africa<sup>40</sup>. Beyond their commercial appeal, TVs – and radios – also come with several benefits for households. In particular, these products enable access to educational information – such as programmes that share valuable information on health, financial inclusion<sup>41</sup> or agriculture – and can also lead to improved political awareness<sup>42</sup> and knowledge of current affairs<sup>43</sup>.

Fans can also significantly improve households' wellbeing. This is particularly true in areas such as Sindh and Uttar Pradesh, areas covered in this research, where temperatures seasonally exceed 45°C.

### Future perspectives

Beyond appliances bought with the SHS at the time of purchase, customers are often interested in getting more from their products. This is true of 80% customers in East Africa, 83% in West Africa and 45% in South Asia.

Where they are not already included in their solar home system package, TVs are a sought-after appliance in all three regions. Fridges and radios are among the more popular appliances in Africa, while fans are the most desired appliance in South Asia and second most popular in West Africa (Figure 17).

Customers also mention a desire to purchase smartphones, internet access, water tanks, cookstoves and other appliances that are not typical SHS appliances and features. However, many of these can be provided on a PAYGo basis<sup>44</sup> and some off-grid solar companies are already providing or exploring ways to offer these services<sup>45</sup>.

38 GSMA (2006), The Economic and Social Benefits of Mobile Services in Bangladesh and Goodman (2005), Linking Mobile Phone Ownership and Use to Social Capital in Rural South Africa and Tanzania.

39 This is true for this research, but also for the appliance market in general. For more information, please see GOGLA (2019), Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data January – June 2019.

40 GOGLA (2019), Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data January – June 2019.

41 Efficiency for Access Coalition (2019), The State of the Global Off-Grid Appliance Market Report.

42 M-KOPA (2017), Tuned-in, Television and Civic Engagement in Off-Grid Society.

43 Efficiency for Access Coalition and 60 Decibels (2020), Use and Impact of Solar TVs: Lean Data Insights from Kenya, Rwanda, Tanzania, Uganda.

44 Mastercard (2018), Pay-As-You-Go and the Internet of Things: Driving a New Wave of Financial Inclusion in the Developing World.

45 These companies include Baobab+, Biolite, Brightlife, Fenix International, Greenlight Planet, M-KOPA and PEG Africa.

# The Power Of Off-Grid Solar

Figure 17: Top five most wanted appliances and features per region

	East Africa	West Africa	South Asia
1	 TV	 TV	 Fan
2	 Fridge	 Fan	 TV
3	 Radio	 Fridge	 More lights
4	 Iron	 Radio	 Smartphone
5	 Speakers	 More lights	 Water pump

N(East Africa)=1,797 N(West Africa)=1,420 N(South Asia)=414

Our research confirms and highlights many of the impacts that SHS can have on the quality of life of customers. It also raises new questions on certain impacts that have been scrutinised less by research efforts to date. Some recommendations for future research areas include:

- To inform companies in their product design and educational material - What are the different facets of safety and security that the SHS affects in the life of users?

- To inform governmental and health authorities - How can the many improvements in health reported by customers when they switch from kerosene to solar be better understood in relation to specific health outcomes?
- To inform organisations focussed on improving digital inclusion - To what extent do SHS improve customers connection to others and the world through access or better access to phones, radios, televisions and the Internet? What impacts does this create and how can any positive benefits be expanded?



# Economic Opportunities







It was hard for me to work as a tailor in the dark using a kerosene lamp; if you don't burn your client's clothes, it's snakes that will come and bite you. The SHS helped me to deliver my clients on time and to work safely. Not only do I have more clients, but I was also able to hire more apprentices.

BBOXX Customer  
Aneho, Togo



The extra hours I used to spend purchasing kerosene I now use to stay longer at the market and earn more money.

M-KOPA Customer  
Ikwanda, Kenya



# Economic Opportunities

Beyond access to light and phone charging, SHS can help households seize economic opportunities and increase their income. Although not all households use their SHS in this way, it can have a significant impact for those that do.

This section showcases a key focus of this research: economic impact figures that are derived from either using the SHS in a business or being able to work more hours with the extra time unlocked by the SHS – for example due to more light leading to greater time for productive activities.

This section is structured around three key impact measures:

- **Section 1: Additional economic activity undertaken**, the share of households who report that the SHS has helped them undertake additional economic activity
- **Section 2: Additional income generation**, customers who report generating additional income from the new or extended economic activity
- **Section 3: Job creation**, FTE employment created through the new or extended economic activity

## 4.1. Economic activity

In this research, economic activity includes a) use of the SHS in a business or b) additional work hours enabled by the SHS<sup>46</sup>.

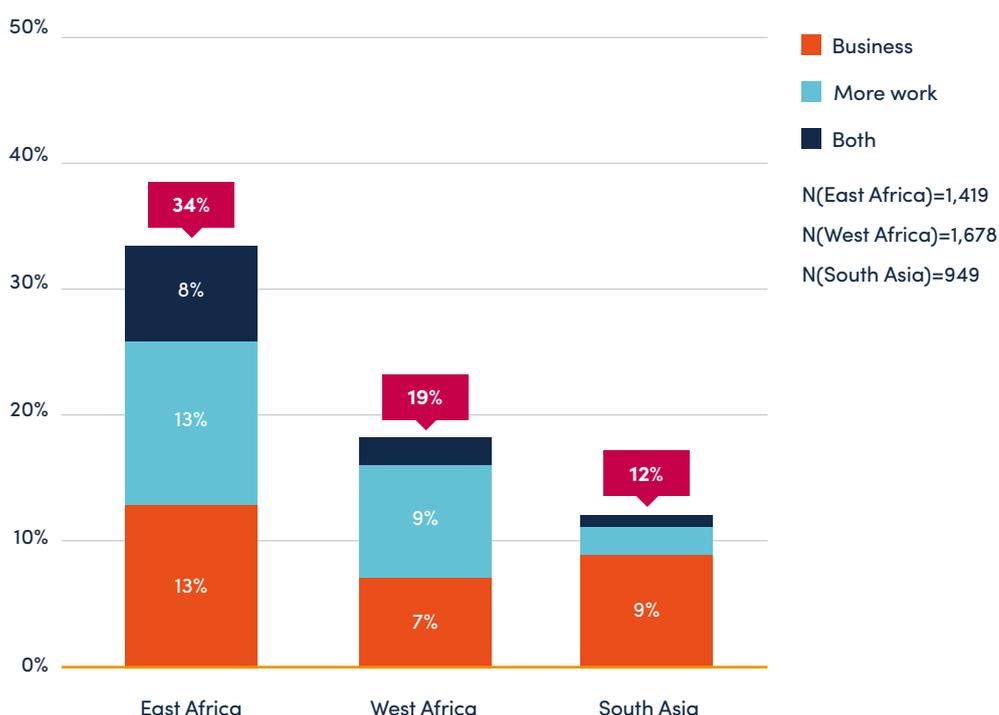
In East Africa, 34% of customers report undertaking additional economic activity, 19% do so in West Africa and 12% in South Asia (Figure 18).

Among customers reporting additional activity, several households report that the SHS is used to both carry out a business activity and that it enables at least one household member to work more.

### More time for work

This economic activity indicates where one or more household member can work additional hours thanks to the SHS. Generally, this is enabled through time shifting. Time shifting is made possible by the additional hours of light made available after dark by the SHS, allowing customers to spend more time at work, especially outside the home. This is most often a result of household members adjusting their time so that they carry-out household activities and chores in the evening, freeing up time in the day.

Figure 18: Economic activity by region split by type of economic activity



46 Additional work hours in the business in which the SHS is used are not included to avoid double counting.

## Economic Opportunities

Other enabling factors are the availability of mobile phones to manage activities or seize opportunities and the ability to dedicate the time previously spent travelling to purchase sources of light or charge phones to productive activities.

In many cases, the additional time spent working adds up to fewer than ten hours a week, but a small number of customers are able to start new activities or more significantly increase the number of hours they spend working.

The most common activities undertaken in these additional work hours are, by some margin, farming and selling products.

### Business usage

Several types of activities can be supported by the SHS, with the system used within these activities to different extents. For example, some customers in Africa use their SHS to start a phone charging business in which the SHS is the tool that enables the entire enterprise to operate. Others might use the SHS to improve an existing business by providing lighting for a shop or installing a TV in a bar or restaurant.

In East Africa, the most common type of business enabled by the SHS is phone charging for a fee. This is followed by the use of the system within a shop. In West Africa, SHS are most often used in shops, followed by restaurants. In South Asia, the main type of businesses using the SHS are also shops (Figure 19).

### 4.2 Income generation

Among customers reporting undertaking more economic activity due to the SHS, most report this has helped them improve their income. Overall, 28% of customers in East Africa, 14% in West Africa and 11% in South Asia report additional income (Figure 20).

The additional income reported can represent a significant increase, especially for low-income households. Indeed, on average the income reported by each household in the East Africa research represents 14% of the average monthly income per household in their country. In West Africa, this figure reaches 8.5% and in South Asia it is 10%<sup>47</sup>.

Figure 19: Share of key business types per region<sup>48</sup>

	East Africa	West Africa	South Asia
 Phone charging	39%	14%	8%
 Shop / stall	27%	27%	50%
 Restaurant / bar	12%	19%	1%
Other	22%	40%	41%

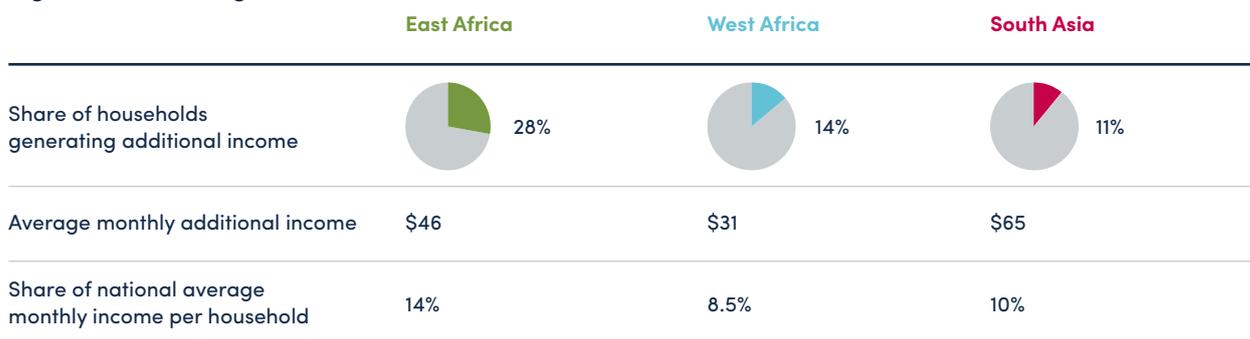
N(East Africa)=256 N(West Africa)=181 N(South Asia)=105

47 Based on gross national income (GNI), ratio of additional income/GNI calculated for each household using country data before computing the average. World Bank (2018), GNI per capita: Côte d'Ivoire \$1,610, Ghana \$2,130, India \$2,020, Kenya \$1,620, Mozambique \$440, Nigeria \$1,960, Pakistan \$1,580, Rwanda \$780, Tanzania \$1,020, Togo \$650, Uganda.

48 'Other' includes a broad variety of economic activities, including home businesses such as tailoring, showing TV for a fee (in a video club / hall) or agricultural activities such as egg incubation.

# Economic Opportunities

**Figure 20: Income generation**



N(East Africa)=1,419 N(West Africa)=1,678 N(South Asia)=949

## Business usage

SHS can help improve a household income either by allowing them to start a new business or by enabling to improve the income of an existing business.

For existing businesses, the most common way the SHS can help improve income is by enabling households to extend opening hours. Other common benefits are improving customer experience through lighting or entertainment and improving productivity.

## Perceived increase in household budget

Across the research, customers were asked if they felt they had more money available since purchasing the SHS. 64% of customers in East Africa, 75% in West Africa and 25% in South Asia report that it is the case.

In East Africa, customers mentioned that this additional budget is mostly spent on education. The main area of expenditure in West Africa is food and in South Asia it is spent on non-productive household equipment such as cooking material (Figure 21).

Food is the first or second area of expenditure across the three regions. This indicates that SHS may be helping to improve the quantity or range of food products purchased by low income households.

In all regions, education is also cited as a key area of additional expenditure, suggesting that the SHS is helping some parents to unlock funds for items such as school fees, books and materials.

**Figure 21: Top five areas of expenditure mentioned by households reporting saving money since purchasing the SHS**

	East Africa	West Africa	South Asia
1	Education	Food	Household equipment
2	Food	Investment in farm / business	Food
3	Investment in farm / business	Savings	Savings
4	Savings	Paying off loans	Clothes
5	Paying off loans	Education	Education

N(East Africa)=802 N(West Africa)=1,178 N(South Asia)=309

# Economic Opportunities

## 4.3 Job creation

Additional questions were asked to households that reported undertaking more economic activity, in order to understand a) how many household members were working more, b) whether they were male or female and c) how this additional activity affects employment.

Customers reported that, often, more than one household member was able to work more hours or find new employment and that commonly this included a female member of the household. To more clearly demonstrate the impact of this increase in economic activity, this research uses a calculation of FTEs, based on the number of extra hours worked thanks to the SHS. This FTE calculation includes the additional time that is spent working via all the mechanisms mentioned earlier:

- more time spent working due to extended business hours,
- more time spent working due to increased hours of light,
- less time spent travelling, and
- better connectivity

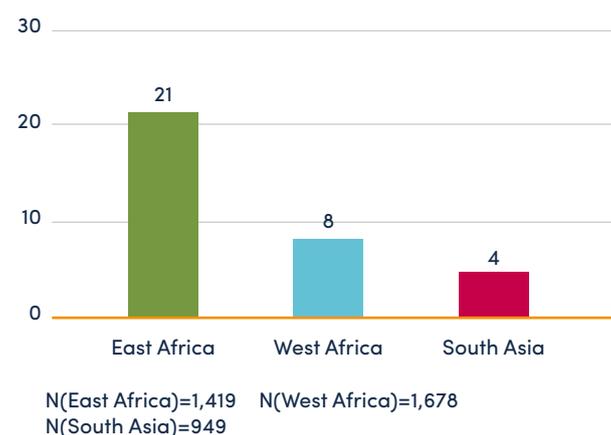
The term 'job creation' refers to the creation of FTEs<sup>49</sup>.

The number of FTEs created for 100 SHS sold is 21 in East Africa, 8 in West Africa and 4 in South Asia (Figure 22).

In East Africa, 50% of FTEs are created in rural areas and 52% are undertaken by women. In West Africa, 69% of FTEs are in rural areas and 38% are undertaken by women. Finally, in South Asia, 22% of FTEs are undertaken by women<sup>50</sup> (Figure 23). Although the data collected in South Asia does not profile whether these jobs were created in urban or rural areas, the vast majority of SHS sales in the region were in rural areas (90%), enabling a strong assumption that the majority of FTEs are also located in rural regions.

While this additional activity is extremely significant in demonstrating the opportunities created by the simple addition of light and power into a home or business, it should be noted that new jobs or work hours created due to the SHS are likely to be informal (e.g. where additional hours are spent working in a small shop, or a household member is able to take on more part-time work) and may not be as secure as more formal activities. However, improving the lives of the informal workforce is an important part of economic development, especially in Africa and South Asia, where more than 80% of the employed population are in the informal economy<sup>52</sup>.

**Figure 22: FTEs created per 100 SHS sold**



49 Please see the Methodology Annex for more information on the FTE calculation.

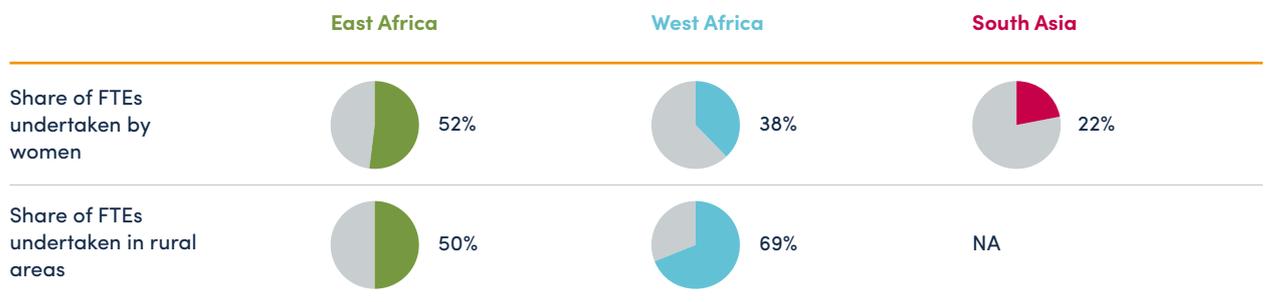
50 Data on type of location unavailable in South Asia. For more information, please see the Methodology Annex.

51 Data on type of location unavailable in South Asia. For more information, please see the Methodology Annex.

52 ILO (2018), Women and Men in the Informal Economy: A Statistical Picture.

# Economic Opportunities

**Figure 23: Distribution of FTEs by type of population in each region<sup>51</sup>**



N(East Africa)=437 N(West Africa)=337 N(South Asia)=132

The research conducted for the Powering Opportunity series revealed to what extent SHS could be a tool for customers to seize opportunities, undertake more economic activity and increase their income. However, the results also raised questions that would benefit from further research.

To inform governments, businesses and development actors focused on supporting enterprise, some recommendations for future research areas include:

- What is the exact nature of the additional activities and businesses that operate thanks to the SHS? How does the SHS enable the households to increase their income through these levers?
- SHS appear to be a tool for entrepreneurship, yet this potential is not always realised or at least not to the same extent. What are the enablers and obstacles to entrepreneurial use of SHS? Should entrepreneurship among SHS users be fostered? If so, how can stakeholders effectively support entrepreneurship among customers?

## Conclusion

**The Powering Opportunity research series provides evidence of the social and economic impact of SHS on customer households in three key regional markets: East Africa, West Africa and South Asia.**

Each of the reports published for this research showed how and to what extent solar home systems improve households' quality of life and empower them to seize economic opportunities. This report compiles results from all three regions and highlights that, across the board, PAYGo SHS are reaching rural and low-income customers, with the majority of customers reporting earnings below \$3.20 per day. Most households buying off-grid solar are also larger than the national average, so the benefits of the SHS are felt by many within each home.

The research also shows how SHS enter the local energy mix and provides useful information for policymakers and planners in both countries with extensive grid infrastructure and without. In East Africa, the most notable trend is the switch from kerosene to solar energy which has positive impacts on households' health and on the environment. In West Africa, SHS play a variety of roles, commonly supplementing unreliable grid electricity, replacing smaller torches and solar lanterns or replacing expensive diesel generators. In South Asia, SHS most commonly act as a back-up or complement to the grid in rural areas, with the security of supply they provide leading to significant benefits.

Customers in all three regions feel the benefits of using the SHS strongly, with over 95% of customers willing to recommend their product. Additionally, 94%- 97% of customers report the SHS has improved their quality of life, with the main areas of improvement being access to light and phone charging, safety and study time for children. In Africa, where customers are more likely to be replacing harmful kerosene lamps with the SHS, health improvements are also mentioned by a large share of users. Importantly, a second phase

of research in East Africa, one year after the initial impact study, showcased that these effects are sustainable over time.

For many customers – 34% in East Africa, 19% in West Africa and 12% in South Asia – the SHS is also providing a tool to boost economic opportunities. The SHS are supporting businesses and enabling additional time for work, with more than one person in each household often able to benefit. To demonstrate the impact of this increased economic activity, this research calculated the number of FTEs unlocked thanks to the SHS – based on the number of extra hours worked. The number of FTEs created for 100 SHS sold is 21 in East Africa, 8 in West Africa and 4 in South Asia.

For most households that undertake additional activity, this has already translated into additional income. The average additional income generated per month is \$46 in East Africa, \$31 in West Africa and \$65 in South Asia. If these increases can be sustained in the long run, they have the potential to have a transformative effect on households' livelihoods.

By providing access to affordable and clean energy (SDG7), solar home systems act as a catalyst to reach seven other SDGs.

SHS are helping reduce inequalities (SDG 10) by providing electricity access to low-income and rural households. They are helping improve the quality of life of families across Africa and Asia by increasing their comfort and, in many cases, by reducing their exposure to toxic fumes from kerosene (SDG 3). By replacing kerosene and generators, SHS are also playing a role in the reduction of emissions (SDG 13). Additionally, the light provided by the system is helping children spend more time on their homework (SDG4).

For many households, the SHS also has an impact on their economic activity by allowing them to seize new opportunities or improve the way they conduct their businesses (SDG 8). This translates into additional hours of work, including a significant share for women (SDG5). In most cases these households increase their overall income through this additional activity (SDG1).

Sustainable energy has been termed 'the golden thread that connects economic growth, increased social equity and an environment that allows the world to thrive'<sup>52</sup>. This study finds that off-grid solar is playing just such a role in communities around the globe.



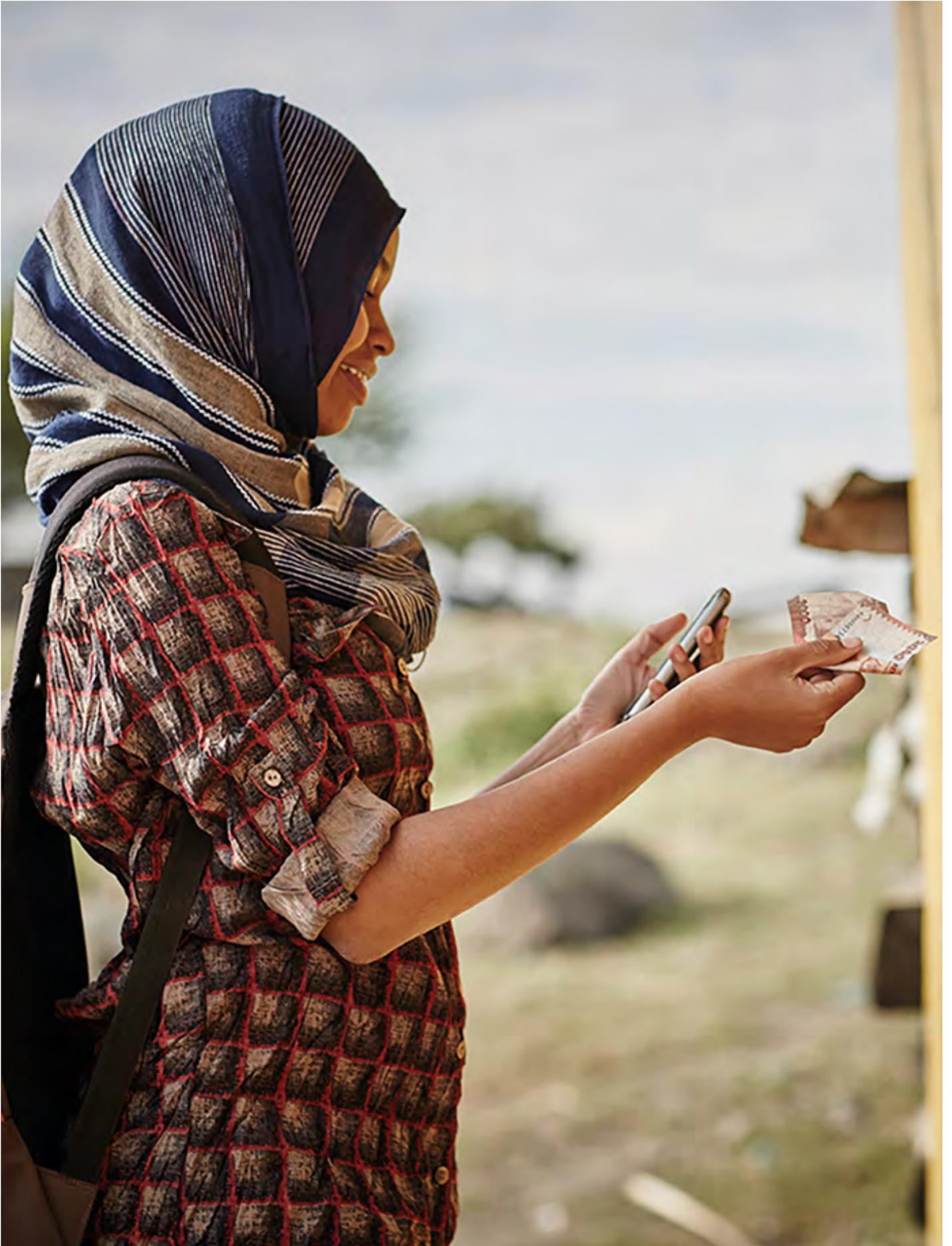
© Greenlight Planet

52 Quote from Ban Ki Moon at the Clean Energy Ministerial in Seoul, during his time as the UN Secretary-General: <https://www.un.org/press/en/2014/sgsm15839.doc.htm>



# Methodology Annex





# Annex

## Data collection in East and West Africa

### Baseline data collection

Baseline data was collected by participating companies after receiving training from Altai Consulting, using a questionnaire designed by GOGLA and Altai Consulting. This approach enabled the study to leverage points of contact between the company and customers while minimising the impact on operations. The survey was conducted at the moment of purchase or soon after. This avoided relying on customers' memories for information about their situation prior to purchasing their SHS.

**East Africa sample size: 3,307**

**West Africa sample size: 2,375**

### Follow-up data collection

Follow-up data collection was conducted by Sagaci Research, an experienced pan-African market research firm. The questionnaire was designed by GOGLA and Altai Consulting and training for the data collection was provided by Altai Consulting.

Sagaci Research conducted the data collection using tablets with software to ensure traceability and enable extensive monitoring. Monitoring was continuously conducted by both Altai Consulting and Sagaci Research to address all potential issues. Any irregularities or inconsistencies in interviews led to their dismissal.

Sagaci Research attempted to interview all baseline interviewees. However, attrition was expected (due to refusal to participate in the survey, phone number change, unavailability of respondent at the time of the survey, poor mobile coverage) leading to smaller sample sizes for the follow-up compared to the baseline.

**East Africa sample size: 2,343**

**West Africa sample size: 1,678**

In East Africa, a second follow-up was conducted a year later following the same methodology and led to a **final sample size of 1,419**.

## Data collection in South Asia

### Pre-purchase data collection

Baseline data was collected by participating companies after receiving training from Altai Consulting, using a questionnaire designed by GOGLA and Altai Consulting. This approach enabled the study to leverage points of contact between the company and customers while minimising the impact on operations. The survey was conducted at the moment of purchase or soon after. This avoided relying on customers' memories for information about situation prior to purchasing the SHS.

**South Asia sample size: 894**

### Post-purchase data collection

Post-purchase Data collection was conducted by third-party companies Market Cube in India and IPSOS in Pakistan. The questionnaire was designed by GOGLA and Altai Consulting and training for the data collection was provided by Altai Consulting.

Monitoring was continuously conducted by both Altai Consulting and the third-party companies to address all potential issues. Any irregularities or inconsistencies in interviews led to their dismissal.

Due to challenges in Pre-purchase data collection and difficulties in reaching customers by phone, the Post-purchase data collection was conducted through a mix of face-to-face and phone-based interviews to enable to reach a maximum number of customers over the project timeframe. Additionally, the number of complete Pre-purchase interviews was too low to rely only on those customers as interviewees for the Post-purchase data collection. Therefore, third parties were provided with phone numbers of other customers having purchased their SHS during the same time period.

**The final sample is composed of 949 interviews**, including 123 for which both Pre-purchase and Post-purchase data are available.

## Analysis

### Incomplete data

For the baseline data collection, flexibility was given to the participating companies as to how to collect the data. Some data was gathered from data previously collected by the company rather than asked to customers and in some cases, questions were excluded all together because companies feared they might be perceived as too intrusive. This is reflected in smaller sample sizes for certain analyses.

### Data cleaning

To ensure the robustness of the data, additional cleaning and recoding was conducted by Altai Consulting.

This was particularly the case for questions where ‘Other, please specify’ was a possible answer as this enabled to create new codes when a specific answer was given by a sufficient number of respondents.

Recoding was also used to eliminate inconsistencies when they could be verified with Sagaci Research.

### Weighting

Weighting for the analysis was based on the panel survey design<sup>53</sup> used for the East Africa research which was reviewed by a statistical expert<sup>54</sup>.

The sampling methodology consisted of selecting a base sample from the target population from which data was collected at an initial point in time and then collecting similar measurements on the same sample at a later date.

The original sample was comprised of new customers joining the companies’ customer bases during the half-year when the data was collected (target population). This methodology was used to enable the research to coexist with the participating companies’ operations and constitutes a convenience sampling.

The total number of new buyers of SHS during the period of interest were provided for all companies in all participating countries. This stratified information (by countries and by companies) on

the target population, under the assumption that the convenience sampling could be considered as a clear random sampling, allowed to produce estimators with statistical precision and develop a weighting methodology<sup>55</sup> to address the unequal selection of respondents and to address the non-response due to the respondents’ attrition across the consulting waves.

Aware that the sampling is subject to assumptions on the probabilistic design of the base sample, limitations exist to extrapolate the findings. For this study to be representative of a larger population, the assumption that needs to hold true is that the surveyed/sampled customers are selected randomly with known probability from the target population: new customers who bought a SHS during the half-year period when the data collection took place.

Weighting has been used to balance the quota effect and adjust the data collected to better represent the population from which the sample was drawn. The weighting methodology developed addresses the unequal selection of respondents.

$$\text{Weighting factor} = \frac{\text{Number of occurrences in population}}{\text{Number of occurrences in sample}}$$

### Margin of error

The following table presents the margins of error at 95% confidence level.

Research	East Africa I	East Africa II	West Africa	South Asia
Margin of error	3.8%	4.8%	4.1%	4.3%

53 Kasprzyk et al (1989), Panel Surveys, Volume 227 of Wiley Series in Probability and Mathematical Statistics.

54 Khalil El-Gazri – Independent Statistician.

55 Chen et al (2012), Weighting Adjustments for Panel Nonresponse.

## Annex

### **Full-Time Equivalentents (FTEs)**

FTE jobs were calculated relatively to the legal working week in participating countries: Côte d'Ivoire 40 hours, Ghana 40 hours, India 48 hours, Kenya 53 hours, Mozambique 49 hours, Nigeria 40 hours, Pakistan 48 hours, Rwanda 46 hours, Tanzania 49 hours, Togo 40 hours and Uganda 49 hours.

Customers reporting an existing business were asked to report the increased number of opening hours per week. The number of hours was attributed to only one household member and compared to a full week as described above.

Customers reporting a new business were asked how many household members worked in the business and how many hours they worked in the business. FTEs were calculated for each individual and summed at the household level.

Customers reporting new jobs or additional time at work were asked how many household members undertook additional work and for how many hours a week. FTEs were calculated for each individual and summed at the household level.

Although several businesses reporting gaining new employees, this data was not used within the FTE job calculation as data was not obtained on the number of additional hours worked by these employees.

### **Eliminating outliers**

Income generation: to eliminate extreme values from average calculations a minimum (\$0.5) and maximum (\$200 in Africa, \$400 in South Asia) amount were defined.

Full-Time Equivalentents (FTEs): to eliminate extreme values in the number of working hours, a maximum of 12 hours a day was considered for businesses, and the legal working week for each country was defined as the upper limit for additional time spent working (see above).

### **Three-data point rule**

This rule followed by GOGLA dictates that data can only be published if at least three separate companies have reported data for any single data point. When there are less than three responses, no results are shown. This protects the proprietary interests of the companies who have supplied data in support of this report and reduces the influence of any one company's data.

## Glossary

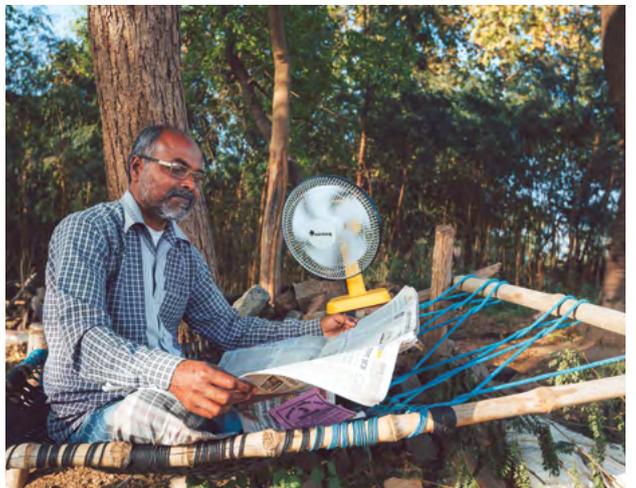
**Full Time Equivalent (FTE):** Unit of measurement of the workload of an employed person. It is calculated as the total hours worked divided by the legal maximum week full-time jobs within each economic territory<sup>56</sup> (i.e. 1 FTE is equivalent to 1 full-time worker).

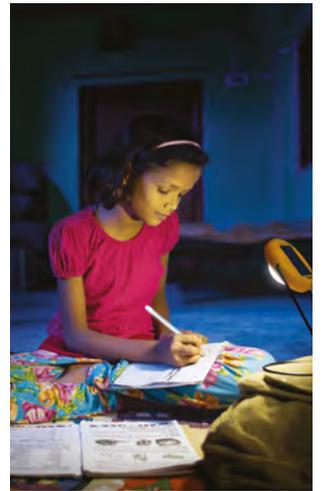
**Household:** Group of people living under the same roof and sharing the same food. Households are the main unit of measurement for this report. They are referred to as 'households', 'customers' or 'users' indiscriminately.

**Pay-As-You-Go (PAYGo):** GOGLA defines companies as PAYGo providers when the customer pays for the product in instalments over time or pays for use of the product as a service - this includes products sold by distributed energy service companies (DESCOs) and microfinance institutions (MFIs), as well as those sold as lease-to-own.

**Solar Home System (SHS):** The SHS included in this study refer to kits of solar technologies that consist of a solar PV panel, battery pack and LED lights which provide light and power to a household or business. These products are sold in many countries that have large populations living off-grid. The size of SHS can vary, as can the appliances they are sold with, although all are sold as 'plug and play' kits. SHS are often defined as 11 Wp and larger, while systems between 3-10 Wp are referred to as 'multi light and phone charging kits'. However, it should be noted that the term 'SHS' will often be used in the descriptive information in this report to refer to the whole range of systems covered, e.g. 3-315 Wp. Where a distinction is being specifically made that relates to the smallest category (3-10 Wp), the specific system size is used.

**Watt peak (Wp):** The capacity of a solar installation is expressed in watt peak (Wp). This is the maximum electrical capacity that a solar cell can yield under ideal circumstances: solar collector directed towards the sun in a cloudless sky.





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