



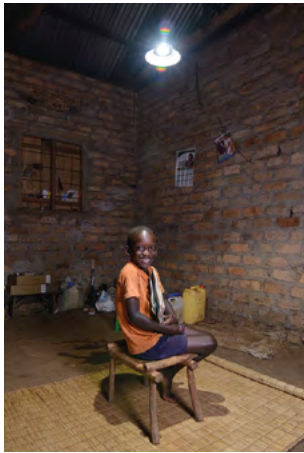
Powering Opportunity in East Africa



Proving Off-Grid Solar is a Power Tool for Change







About

GOGLA

GOGLA is the global association for the off-grid solar energy industry. Established in 2012, GOGLA now represents over 150 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

Altai Consulting

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

As the world is running out of time to reach the Sustainable Development Goals (SDGs), off-grid solar is emerging as a power tool for change. Through technology and business innovation, our industry is working hard to develop products and services that bring light and energy services to households living beyond the reach of the grid. Every day we see the positive impact that solar home systems have, and the ways in which they are providing customers with new opportunities to generate income, unlock more working hours and create jobs.

Following the first groundbreaking “Powering Opportunity” report in 2018, this latest round of research draws a detailed portrait of the social and economic impact that is a direct result of increased demand for and uptake of solar home systems across East Africa. The findings confirm what more than 245 million people already know: off-grid solar powers opportunity.

As the industry celebrates the significant number of households reached across the globe, this impact also reaffirms our belief that off-grid solar will be crucial for reaching Sustainable Development Goal 7 (SDG 7) – access to affordable, reliable, sustainable and modern energy for all by 2030. The extent of the challenge can sometimes seem daunting: in East Africa alone more than 138 million people remain without access to energy. Only fast and proven solutions will make a difference, and off-grid solar is able to provide clean energy services quickly and at scale.

Further to this, it becomes increasingly clear that off-grid solar also plays a vital role in accelerating progress towards realizing other SDGs, as it is tackling climate change and improving people’s quality of life in many ways. Households using off-grid solar products consistently report that their health improves, that they feel safer and that their children have more time to study.

While the evidence is growing, it is important to recognize that the full potential of off-grid solar can only be achieved with concerted and collaborative action from all stakeholders across the public and private sector. The off-grid solar sector is still relatively young, and companies often operate in challenging and dynamic environments. This is why continued support for the sector is crucial.

We thus call on industry, decision-makers, investors, and development partners across East Africa to come and work together to create a strong, sustainable off-grid solar sector. Only together, can we go further, faster to bring the positive economic, social and environmental impact to millions of additional people in the region and around the world.

Patrick Tonui, East Africa Representative



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Executive summary

“Powering Opportunity in East Africa: Proving Off-Grid Solar is a Power Tool For Change” provides insights into the social and economic impact of off-grid solar. It follows the “Powering Opportunity: The Economic Impact of Off-Grid Solar”¹ report which highlighted the domino effect solar home systems (SHS) are having on household economic activity, creating income and improving quality of life. This latest report confirms those findings, sheds new light on how this impact evolves over time, and explores how economic activity equates to full time equivalent (FTE) employment.

The research cited in this report took place in Kenya, Mozambique, Rwanda, Tanzania and Uganda with customers of seven leading Pay-As-You-Go (PAYGo) companies: BBOXX, d.light, Fenix International, M-KOPA, Mobisol, SolarWorks! and ZOLA Electric.

Thanks to funding from the UK’s Department for International Development (DFID), researchers were able to collect and analyze data from 1,419 customers who purchased their SHS 15 months prior, and were interviewed at the time of purchase, as well as three months later for the previous Powering Opportunity report.

The greatest beneficiaries are those most in need. These are low-income households.

A significant 59% of households that purchased SHS report earning less than \$3.20 per day and 81% less than \$5.50² per day, indicating that SHS are mainly reaching low-income households in East Africa.

Customers generate more income.

15 months after purchasing an SHS, 34% of households are more economically active. This means that either through use of the product in a business or through the ability to undertake more work hours, they have the opportunity to earn more money.

28% of households report generating additional income from this additional economic activity with the average additional income across the research reported at \$46 a month. On average, the amount generated is equivalent to 14% of the national monthly income per household³.

More work hours unlocked and jobs created.

By extending business opening hours or giving customers more free time in their day for economic activity, the SHS helps them work more hours or even start new activities. Overall, this additional work translates into 21 FTE jobs per 100 SHS sold. Job creation unlocks improved income prospects and by extension better quality of life for the informal workforce, especially in rural areas.

Significant improvement in quality of life.

15 months after purchasing their SHS, 95% of customers would recommend their product to a friend or relative. An encouraging 94% report they feel improvements to their quality of life as a direct result of using their SHS. Not only do these SHS’ open up income opportunities, they also replace dangerous kerosene lamps which have harmful effects on health. SHS also provide more time for children to do their homework with increased light hours after school and improve safety in homes and businesses.

1 GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar.

2 International Poverty Line has a value of US\$1.90 PPP. 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.

3 Based on gross national income (GNI), % of monthly income per household calculated for each household and averaged. World Bank (2018), GNI per capita: Kenya \$1,620, Mozambique \$440, Rwanda \$780, Tanzania \$1,020, Uganda \$620.



Introduction



“

I am able to extend my work hours and earn extra income with the aid of reliable bright lights

”

ZOLA Electric Customer,
Arusha, Tanzania



Key Findings



89% report their health has improved since buying the SHS

34% of households undertake more economic activities thanks to their solar home system

86% of customers say children have more time to do their homework



28% of households generate additional income once they purchase an SHS



Households create an additional \$46 per month on average

Among households generating income

SHS help households to work more hours or start new activities. Overall, this additional work translates into 21 FTE jobs per 100 SHS sold

In total, 52% of these FTEs are undertaken by women and 50% are in rural areas

91% of customers report they feel safer with off-grid solar



Introduction

1.1. Context and objective

There are little more than 10 years left to realize Sustainable Development Goal 7 (SDG 7): access to affordable, clean energy for all. The number of people without access to electricity fell to 840 million in 2017⁴, yet meeting SDG 7 remains challenging. At the current pace of electrification, 650 million people are likely to remain without access to electricity in 2030, and 9 out of 10 of these people will live in Sub-Saharan Africa⁵. Decentralized systems, led by solar off-grid and mini-grid are the most efficient solution to provide the technologies needed to reach at least 55 million households⁶. This share could be even larger if grid and mini-grid solutions do not develop at the pace required to fulfil their anticipated contribution to the electricity access goal by 2030.

Universal energy access will thus only be achieved through a mix of grid, mini-grid and off-grid solutions. Off-grid energy provides a cost-effective solution to reach remote communities, sparsely populated and low-income areas. It also provides solutions where the grid is unreliable or where connections are too expensive. For example, the 2015 Global Tracking Framework finds that, for 100,000 people with no electricity at all, solar home systems could be delivered for around \$20 million, while full grid connection with at least 23 hours supply of electricity would cost around \$150 million⁷.

The off-grid solar market is continuing to grow. Cash sales of solar lanterns provide millions of people each year with clean energy access and is the largest part of the off-grid sector⁸. Solar home systems (SHS) are proving to be a game-changing new growth area, and business model innovations, including Pay-As-You-Go (PAYGo) solutions, are transforming the way people pay for solar power. The Powering Opportunity series collects evidence of the social, economic and human impact these life-changing solutions are having.

Impact research for solar lanterns shows the positive effects of switching from kerosene to solar lanterns. Significant savings, additional study hours and health and safety benefits are consistently present – (SolarAid⁹, Harrison et al¹⁰, Aevarsdottir¹¹, Hassan and Lucchino¹²). The young sectors of SHS and the PAYGo business model have limited impact research to date, which led the United Kingdom's Department for International Development (DFID), GOGLA, the global association for the off-grid solar energy industry, and Altai Consulting to conduct a first socio-economic impact study in 2017-2018, leading to the publication of the Powering Opportunity report in 2018¹³.

Powering Opportunity illustrated that SHS greatly improve the well-being of those who used them in their homes and businesses by replacing dangerous kerosene lamps and candles, improving safety and giving them life-changing services such as phone charging. The report was an ambitious collaborative effort and the first of its kind to bring companies across a number of countries together to focus on the economic activity and income generation unlocked by SHS.

Three months after purchasing a SHS, a vast majority of customers reported using their SHS to increase their economic activity through a business, additional working hours or even new jobs. More than a third of interviewees reported that this generated additional income, on average \$35 or 9% of the monthly gross national income per household¹⁴.

The last report offered a snapshot of the impact of SHS on households but did not show whether this impact was sustainable or not. The research generated new questions, such as who the specific beneficiaries within the household were, and what type of activities are undertaken during additional hours of work unlocked by the SHS.

4 ESMAP (2019), 2019 Tracking SDG7 The Energy Progress Report.

5 ESMAP (2019), 2019 Tracking SDG7 The Energy Progress Report.

6 IEA (2017), Energy Access Outlook 2017.

7 SEforALL (2015), Global Tracking Framework.

8 GOGLA (2019), Global Off-Grid Solar Market Report: Semi Annual Sales and Impact Data, July – December 2018.

9 SolarAid (2015), Impact Report 2015.

10 Harrison et al (2016), Accelerating Access to Electricity in Africa with.

11 Aevarsdottir et al (2017), The Impacts of Rural Electrification on Labor Supply, Income and Health: Experimental Evidence with Solar Lamps in Tanzania.

12 Hassan and Lucchino (2016), Powering Education 2, Enel Report.

13 GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar.

14 Based on gross national income (GNI), % of monthly income per household calculated for each household and averaged. World Bank (2018), GNI per capita: Kenya \$1,620, Mozambique \$440, Rwanda \$780, Tanzania \$1,020, Uganda \$620.

Introduction

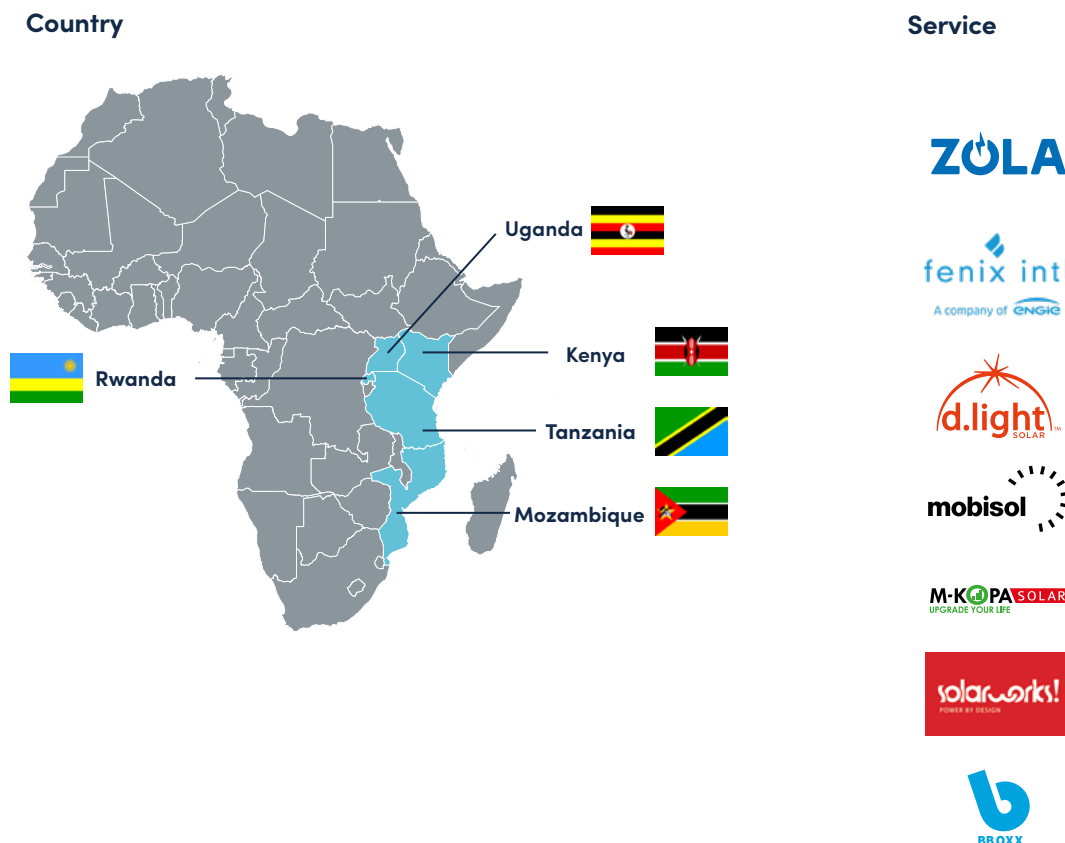
This study seeks to better understand the initial findings and assess the sustainability of this economic impact over time. The report uncovers new insights into the mechanisms behind economic impact and measures how this impact and additional work hours translates into job creation. Research was conducted with the same companies and interviewed households as in the previous research, 15 months after they first purchased their SHS.

1.2. Methodology and limitations

This research set out to talk to as many of the customers interviewed for the previous report as possible from the five countries covered. All seven companies that took part in the original research renewed their involvement: BBOXX (Rwanda), d.light (Kenya), Fenix International (Uganda), M-KOPA (Kenya), Mobisol (Tanzania) SolarWorks! (Mozambique) and ZOLA Electric (Tanzania).

SHS like those sold by the companies participating in this research are targeted to households in rural locations but also help meet the needs of households in low-income urban or peri-urban areas. In areas with unreliable grid electricity, households can turn to SHS as a back-up or even a replacement to the grid to maintain a constant level of service. Although there were no set quotas, customers were included across rural, peri-urban and urban areas enabling the research to better reflect the average impact of SHS.

SHS are first and foremost designed for households and their impact is felt by the entire household. Therefore households, rather than individuals, are the primary unit for impact measurement. However, this research also set out to uncover who within the household perceives economic benefits from the use of the system, to expand understanding of household dynamics and gender-related impacts.



Introduction

Capacity of SHS varies greatly. Differences in capacity mean differences in services provided and in cost to the consumer. In this study, the products range from 8 Wp to 200 Wp. The smallest systems provide two lights and phone charging, while the larger systems include up to ten lights, torches, multi-port phone-chargers, radios and TVs.

To best showcase the results of this research, an approach to categorization was taken which considered a) the product sizes purchased by the customers interviewed in this research and b) the broad categorizations of system sizes used widely across the sector. This led to three final categories (as noted in the table below). The 21–49 Wp category is not included as no data was collected on products in this range during the course of







the research¹⁵. There is no further split between the systems in the 50+ Wp category due to the application of the industry standard “three data point rule” (figures cannot be published unless the data comes from at least three companies).

Depending on its size, each system can provide different levels of services and power different appliances. An overview of standard capacities is provided in Figure 1.

The research comprises two elements: quantitative research conducted through phone-based interviews with the same customers as for the previous report and qualitative data collected through face-to-face in-depth interviews with customers and sales agents¹⁶ from three of the participating companies.

3-10.99 Wp	11-20 Wp	50+ Wp
<ul style="list-style-type: none"> - d.light D30 (10 Wp) - Fenix ReadyPay (8 Wp) - Fenix Home Starter LFP (10 Wp) - Solarworks! SW40 (10 Wp) 	<ul style="list-style-type: none"> - Fenix Home Comfort LFP (17 Wp) - M-KOPA 400 (20 Wp) - Zola Home (12 Wp) 	<ul style="list-style-type: none"> - BBOX Home (50 Wp) - Mobisol Family SHS (80 Wp) - Mobisol Entertainment SHS (120 Wp) - Mobisol Business SHS (200 Wp) - Solarworks! SW200 (50 Wp) - Solarworks! SW400(100 Wp) - Zola TV (50 Wp)

Figure 1: Overview of typical service level by system size

	Number of lights	Common features and appliances	Approximate repayment period
3-10 W			2 years
11-20 W			2 years
50+ W			3 years

¹⁵ Many companies were contacted to take part in the research to cover as wide a range of products and system sizes as possible. With the final seven companies that were both willing and able to participate, data collection would not have enabled enough products to be covered in the 21-49 Wp range to respect the three-data-point rule. For this reason, the category was not included. In addition, it was only possible to meet the three-data-point rule by including all systems of 50 Wp or above into one category, rather than to split this into two or more separate categories (e.g. separate 50-99 Wp and 100+ Wp categories). For this reason, the largest 50+ Wp contains systems of various sizes between 50 Wp and 200 Wp. The three-data-point 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.

¹⁶ The title and exact responsibilities of interviewees may differ from one country and company to another, but all were involved in sales and in direct contact with customers.

Introduction

Quantitative data

Each household interviewed for this report took part in three interviews, at the time of purchase, three months after the purchase and 15 months after the purchase.

To leverage existing interactions between companies and their customers, the baseline data collection was conducted by participating companies at the moment of purchase or shortly after (before product installation, or no longer than a week afterwards). Specific company training and daily/weekly data quality review was provided by Altai Consulting to ensure that the final data sets received were consistent and robust. Data was then centralized and analyzed by Altai Consulting. Follow-up data collection after three months and after 15 months was managed by Altai Consulting with their market research partner Sagaci Research conducting the phone-based interviews. Altai Consulting again provided training and continued guidance to the Sagaci in-country research teams, before centralizing and analyzing the collected data.

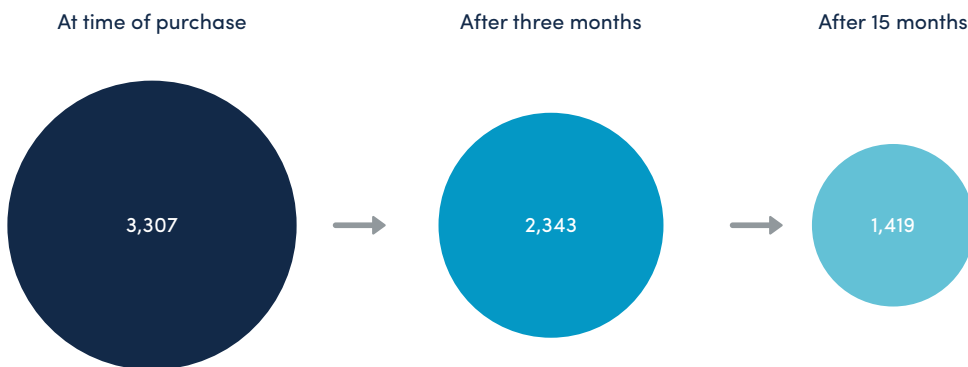
At the time of purchase, 3,307 valid interviews were conducted by the participating companies. Interviewees were sourced from a population comprising all households purchasing SHS from the seven participating companies in the five research countries in the second half of 2017. The sample size reduced to 2,343 after three months and 1,419 after 15 months (Figure 2).

Attrition reached 29% after three months and 39% after 15 months. This attrition was expected over the course of a multi-year research project and has several different reasons: refusal to participate in the survey, phone number change, unavailability of respondent at the time of the survey, poor mobile coverage, customer default, invalid or incomplete interviews.

The sampling methodology was reviewed by a statistical expert. It consists in selecting a sample from the target population (customers having purchased a SHS from one of the seven participating companies in the five surveyed countries in the second half of 2017) from which data is collected at an initial point in time and then collecting similar measurements on the same sample at two other successive dates (after three months and after 15 months). The analysis intends to take into account the response attrition across the three surveys, as not all respondents from the initial sample responded to the following interviews.

The original sample was comprised of new customers joining the companies' customer bases between September and December 2017. This methodology was used so the research would not affect participating companies' operations and constitutes a convenience sampling. Based on discussions between Altai Consulting, GOGLA and participating companies in 2017, there are no significant differences in characteristics between

Figure 2: Evolution of research sample size

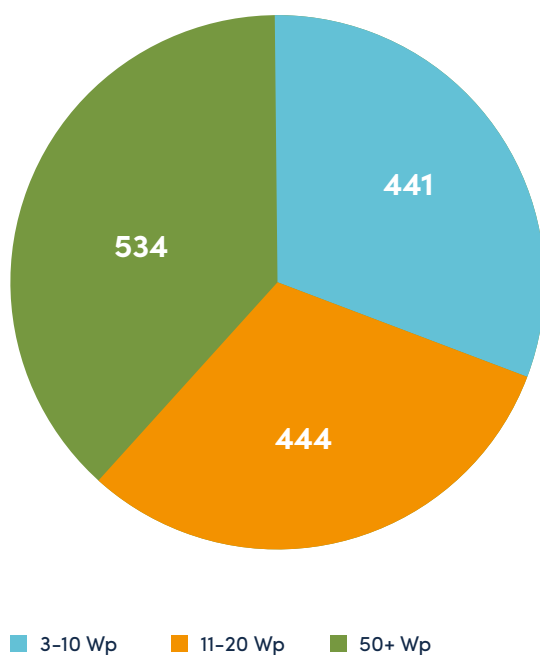


Introduction

the surveyed customers and the rest of the target population. Therefore, the assumption that the customers can be considered as having been selected randomly from the target population likely holds true¹⁷. Additionally, the impact results are homogeneous across the variety of countries, business models and system sizes. This provides confidence that the insights revealed by this research could hold true for SHS customers in the five countries of the research.

The sample size enables a margin of error of maximum 4.8% at 95% confidence level, guaranteeing the statistical significance of the analysis. Sample sizes at the system size level are big enough (Figure 3) to provide margins of error between 7.6% and 9.1%.

Figure 3: Sample size by system size



Qualitative data

To provide more in-depth understanding of the household dynamics seen in the quantitative results and illustrate case study findings, in-depth interviews were conducted with 18 customers and eight agents from three companies in three countries: BBOXX (Rwanda), Fenix International (Uganda) and M-KOPA (Kenya).

Customers were selected by Altai Consulting based on the quantitative data to focus on customer profiles that would bring research greater understanding of the changes the SHS brought to a household or business and how such change was affected by external dynamics. For example, customers were interviewed where they reported they were using their systems to support enterprise, as well as where they reported that they had stopped doing so. Location of interviewees was also taken into account to ensure the feasibility of the fieldwork (Figure 4). Agents were selected by the companies based on location and duration of employment.

Interview guidelines were designed by Altai Consulting and tailored to each interviewee. Altai consultants working on the analysis of the quantitative data travelled to the aforementioned countries to conduct the interviews assisted by local consultants.

All case studies and quotes in this report are based on this qualitative data collection unless mentioned otherwise.

Figure 4: Maps of data collection areas



¹⁷ Methodology and limitations assessed by Khalil El-Gazri, an experienced statistician who designed many statistical projects for the UN, World Bank, USAID and French Ministry of Foreign Affairs. Details provided in Methodology Annex.

Introduction

Results

One of the objectives of the research is to compare impact between the three months and 15 months points in time. Both after three and 15 months, customers were asked to compare their current situation to that before purchasing the SHS. This report uses data collected at the time of purchase, after three months and after 15 months but only for the 1,419 customers that answered all three surveys. Data from customers from the previous research that were not interviewed as part of the final dataset was not considered. This has two main implications:

- Survivor bias: although the attrition effect is taken into account in the weighting, the fact that some customers were no longer able to benefit from the system is not taken into account.
- The sample has changed compared to the previous study and therefore the results after three months presented in this report may differ from those published in the previous Powering Opportunity report.

Beyond the change of sample size, there are other alterations to the way results are presented compared with those from the previous report (which uses data gathered three months after purchase):

- The scale for the number of hours of light used by customers has changed to provide more insight into usage of the system (Figure 5). Previously the scale only provided details up to six hours of light. The current scale goes up to 15 hours of light. When comparing results after 15 months and three months, the previous scale (up to six hours) is used.
- Categories of economic impact have been altered. In the previous report, three types of economic activity were identified: businesses, additional time at work and new jobs. This report only identifies two categories: businesses and more work hours unlocked by the SHS. Qualitative data collection led to the conclusion that the distinction of the categories as presented in the previous report was not adapted to the largely informal economic activities conducted by SHS customers, with some customers referring, interchangeably, to additional time enabling a new job or more time for work.

- Where the previous research only sought to understand if a household benefitted economically from the use of the SHS or not, this study attempts to understand the number of people within households that are undertaking more economic activity as well as their gender. It measures this change in economic activity through the number of additional work hours that are unlocked by the SHS, translated into how much full-time equivalent (FTEs)¹⁸ employment it creates.

GOGLA respects a three-data-point rule when using its Member companies' data. Therefore, analyses presented in this document rely on data from at least three companies. This allows for greater reliability in the results as it means that each data point presented includes data from customers of different companies. However, it also means that certain insights cannot be shared publicly, and analyses cannot be conducted by country or company. Exceptionally, GOGLA and companies agreed to the publication of case studies that provide company-level insights.

Figure 5: Change in scale for hours of light

Baseline & after 3 months	After 15 months
Less than 1	Less than 1
1 to 2	1 to 2
2 to 3	2 to 3
3 to 4	3 to 4
4 to 5	4 to 5
5 to 6	5 to 6
6 or more	6 to 7
	7 to 8
	8 to 9
	9 to 10
	10 to 11
	11 to 12
	12 to 13
	13 to 14
	14 to 15
	15 or more

¹⁸ Details provided in Methodology Annex.

¹⁹ Commission of the European Communities, International Monetary Funds, Organisation for Economic Co-operation and Development, United Nations and World Bank (1993), System of National Accounts.

²⁰ Details provided in Methodology Annex.

Introduction

Definitions

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 territory¹⁹ (i.e. 1 FTE is equivalent to 1 full-time worker).

Pay-As-You-Go (PAYGo): refers to a business model that allows users to pay for their product via consumer financing over time. A PAYGo company will typically offer a solar product for which a customer makes a down payment, followed by regular payments for a term ranging from 6 months to 8 years²⁰. In most cases, the repayment period is close to 24 months.

Solar Home System (SHS): The SHS included in this study refer to kits of solar technologies that are made up of a solar PV panel, battery 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'. While 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. 3-200 Wp, where a distinction is being specifically made that relates to the smallest category (3-10 Wp), the specific system size is used.

System upgrade: Within the PAYGo business model, many companies provide the opportunity for valued customers who have repaid, or are on the way to repaying, to trade in their system or enhance their current product to get more power capacity, or to purchase new appliances or services.

Limitations and risk mitigation

- Data was collected at specific points in time and may have been affected by seasonal factors such as the agricultural calendar, political events, currency variations, kerosene price variations, etc. Through consultation with participating companies at the time of initial data collection, it seems no specific conditions apply to new customers joining the seven companies' customer bases during the survey period.
- Data being collected after 15 months implies a long recall period which can prove challenging for respondents. Interviewers were trained to assist customers.
- Due to the multi-country aspect of the research, cultural understanding and interpretation of certain questions may have differed. To mitigate this effect, all translations were conducted by Sagaci Research, a market research firm with extensive experience in conducting surveys in multiple African countries, including all countries covered in this research. All translations were reviewed by local staff of the participating companies to ensure the questions would be understood by their customers.
- For many questions requiring customers to quantify their answer, ranges were provided. Metrics based on these ranges were computed by using the median value of each range, the upper limit of the bottom range and the lower limit of the top range. (For example: If the range is "Between 10 and 20", the value will be 15 and if the range is "More than 50", the value will be 50).
- Data on income and expenses is reported, whether overall income and expenses or income generated from additional economic activity data. Where possible, data was cross-checked for consistency with previous data on income and expenses collected at the time of purchase as well as with other socio-demographic indicators where possible (Poverty Probability Index, main source of income)²¹.

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The SHS Customer

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The SHS Customer

2.1. Socio-demographics

The profile of a typical customer interviewed 15 months after SHS purchase is a 38-year old male living in a rural area with a wife and four other household members, generally four children or three children and one adult. However, purchasers and their households represent a variety of profiles which this section will explore in more detail.

Gender and age of purchaser

Looking at the individual identified as the purchaser, three-quarters are men (Figure 6), and most are between 25 and 40 (Figure 7). These statistics are almost entirely unchanged compared to the results after three months. Neither age nor gender has been a determining factor in attrition.

Figure 6: Gender of purchaser²²

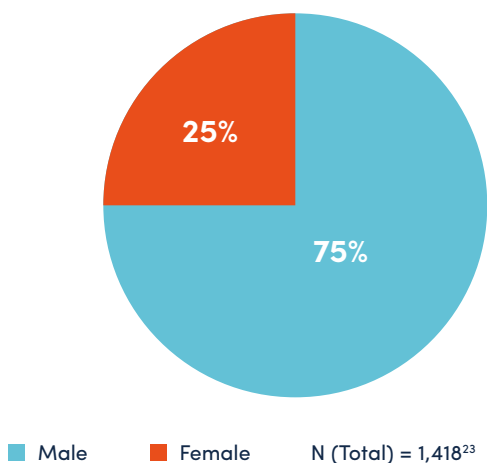
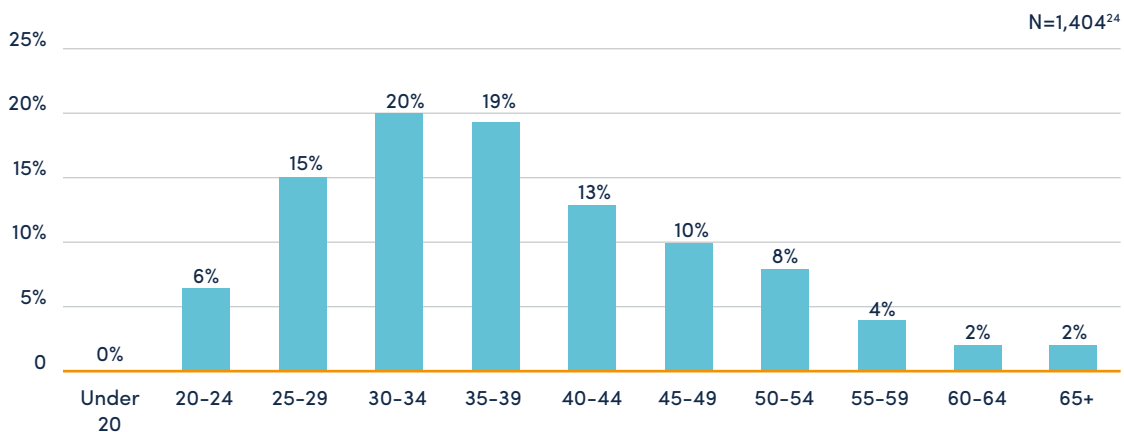


Figure 7: Age of purchasers distribution



Household size and composition

Individual purchasers are not the sole beneficiaries of the SHS. The average household size is 5.7 and each member can be considered as a beneficiary. This average size is higher than the national averages for East African nations and Mozambique, which ranges from 3.9 to 4.9²⁵. Overall, 51% of beneficiaries are children and 49% are women or girls.

Type of location of households

To understand if the location of customers affected the impact of the SHS, households were sorted between urban, peri-urban and rural locations²⁶. Overall, more than half of customers are located in rural areas, with 29% in peri-urban and 16% in urban areas. Households that purchased larger systems (50+ Wp) are more likely to live in urban or peri-urban areas than those that purchased smaller systems (Figure 8). Overall, the impacts measured in this study do not significantly depend on whether a customer is urban or rural. Data points of interest are highlighted in the report.

22 Data collected at the time of purchase.

23 Missing baseline data for one customer.

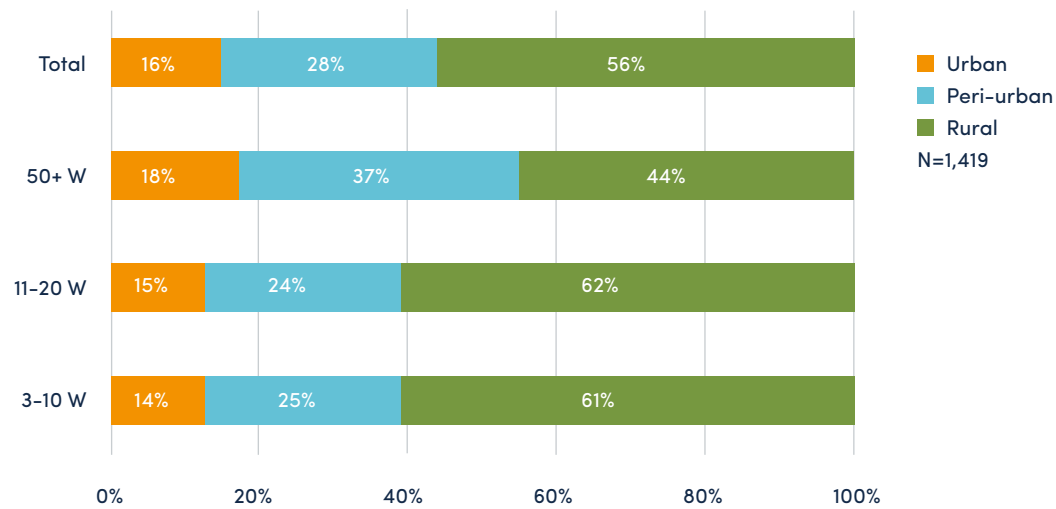
24 Missing baseline data for 15 customers.

25 UN Household Size and Composition Around the World 2017. Kenya: 3.9 (DHS 2014), Mozambique: 4.4 (DHS 2011), Rwanda: 4.3 (DHS 2015), Tanzania: 4.9 (DHS 2015), Uganda: 4.7 (Census 2014).

26 For this research location types were defined by population. Urban designates a population above 5,000, peri-urban a population between 2,000 and 5,000 and rural a population below 2,000. These definitions were respected on a best effort basis.

The SHS Customer

Figure 8: Distribution of households by type of location and system size



Level of income²⁷

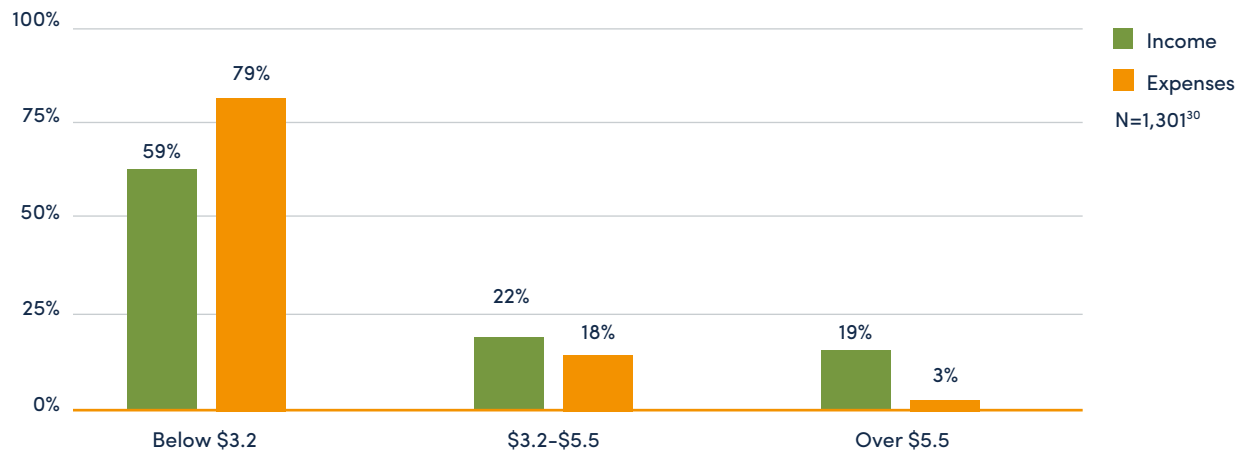
To understand the income segmentation of customers the research looked both at reported income and expenses, especially in an effort to understand poverty levels of households using SHS.

Overall, 59% of households report an income below \$3.20 per day and 81% below \$5.50²⁸ per day (Figure 9). Looking at expenses, 79% of households report spending less than \$3.20 per day and 97% less than \$5.50 per day. This indicates

that SHS in this research are mainly reaching low-income households.

The distribution of reported income is homogeneous across system sizes which is surprising given that larger SHS are more expensive. This could be due to product availability at the time of purchase, or to the possibility to have longer repayment periods for larger SHS, bringing down the daily costs and thereby making the product more affordable.

Figure 9: Reported income and expense levels²⁹



²⁷ Details provided in the Methodology Annex.

²⁸ International Poverty Line has a value of US\$1.90 PPP. 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.

²⁹ Reported after 15 months.

³⁰ Excluding customers responding "do not know" or "do not wish to answer".

The SHS Customer

2.2. Customer experience

15 months after purchasing their SHS, satisfaction with the system remains extremely high.

Value for Money

Customers' rating of the value for money of their product has slightly improved overtime from 78% considering it good or very good after three months, to 82% after 15 months (Figure 10). For larger, more expensive SHS, a smaller percentage of customers rate the system as providing very good value for money, suggesting cost is a factor (Figure 11). However, the overwhelming majority still consider larger systems as very good, good or fair value for money.

Likelihood to recommend the system to friends, family or neighbors is extremely high among customers of all system sizes and has remained stable over time. The share of customers that are likely or very likely to recommend the system was 97% after three months and 95% after 15 months (Figure 12). There is however a slight shift from very likely to recommend to likely to recommend. Like value for money, likelihood to recommend is slightly higher for smaller products (Figure 13).

Figure 10: Perception of Value for Money over time

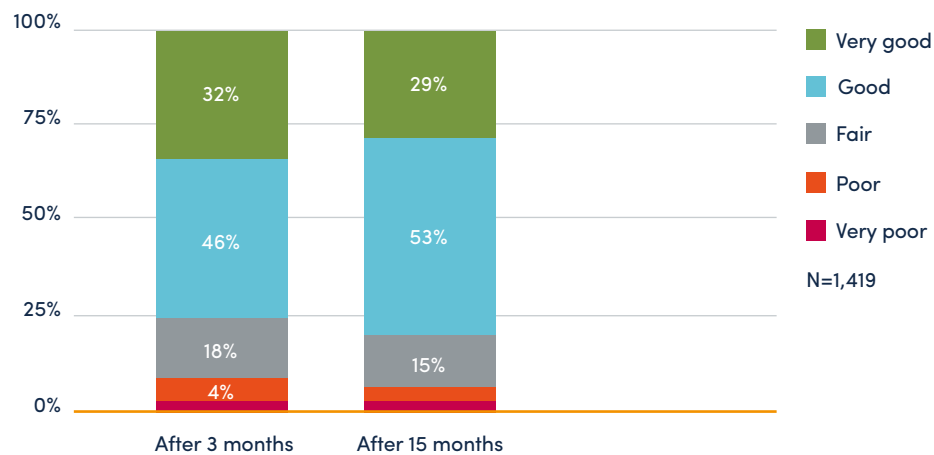
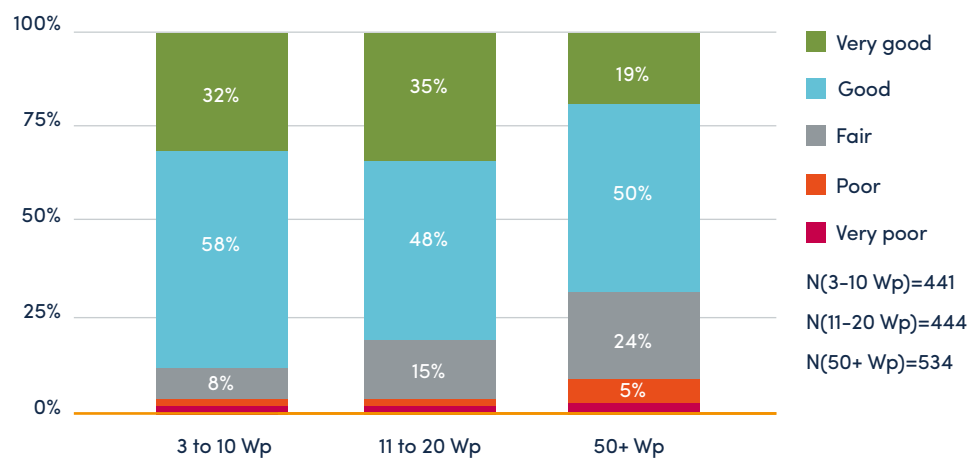


Figure 11: Perception of Value for Money after 15 months by system size



The SHS Customer

Figure 12: Likelihood to recommend over time

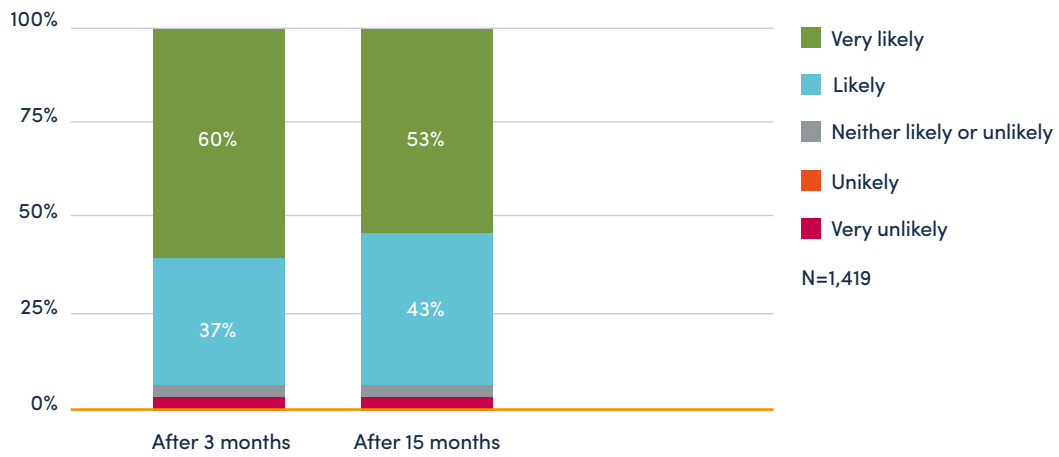
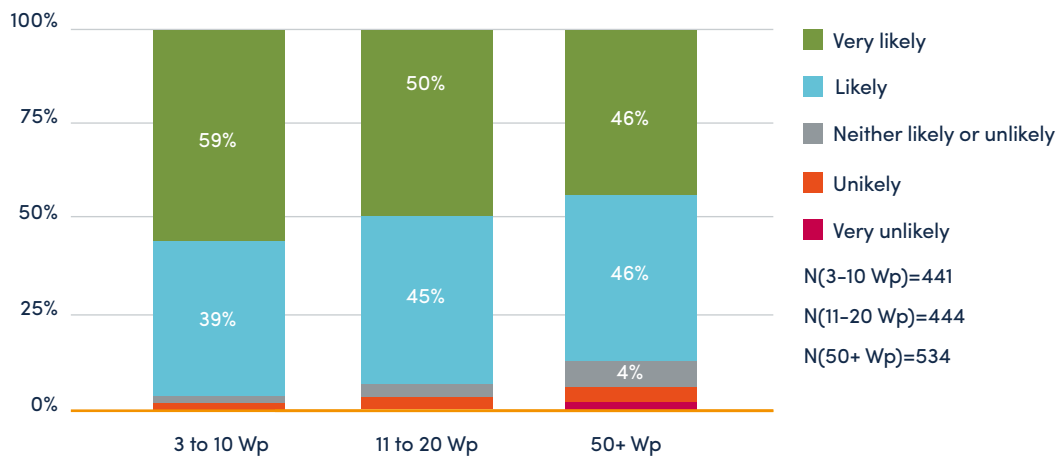


Figure 13: Likelihood to recommend by system size after 15 months



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**The Power Of
Off-Grid Solar**

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The Power Of Off-Grid Solar

3.1. Improved access to light

Use of sources of light

15 months after purchasing their SHS, 72% of customers were relying solely on the SHS as their lighting source. This means only 28% of customers are using secondary sources of light (e.g. torches, kerosene) after 15 months, down from 50% after three months. However, this figure might not fully capture households that occasionally rely on other sources of light.

Looking specifically at the main source of light used before purchasing the system, the most common sources of light were kerosene (40%) followed by solar lanterns (17%) and SHS (13%) (Figure 14). As highlighted in the previous research³¹, this indicates two narratives:

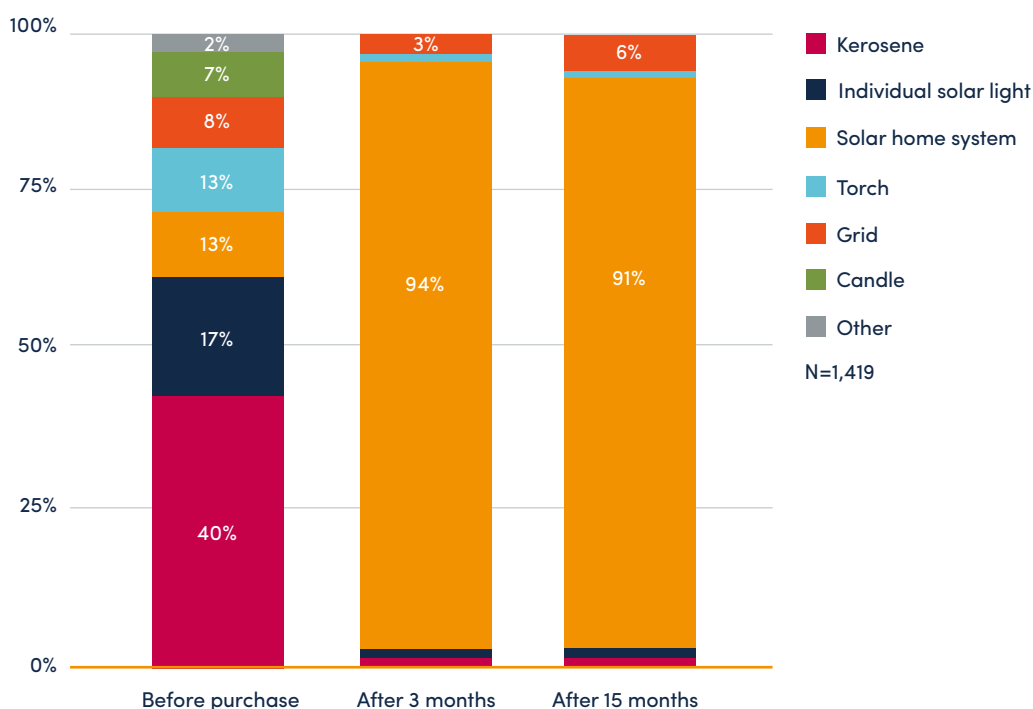
- Access to SHS is contributing to the replacement of kerosene for lighting. This is especially true of smaller SHS and in rural households. After purchasing an SHS, kerosene as a primary source of light is almost eliminated.

- Many customers are progressing along a solar staircase³² by upgrading their energy source or stacking energy solutions (e.g. combining the use of both solar lanterns and SHS). This is especially true of purchasers of the larger systems.

After 15 months, the SHS is the main source of light for almost all households. However, the share of households using the SHS as their main source of light slightly decreased between the three months and 15-month surveys, due to a small increase (3 percentage points) in the number of customers accessing the grid.

For those households that still use secondary sources of light in addition to the SHS (26%), the main reason is due to the need for more lights (for example, to cover more rooms). It is followed by the need to have a back-up when the system is off (23%) and the need for more power (17%). To meet these needs, customers stack light sources.

Figure 14: Evolution of main sources of light over time



³¹ GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar.

³² 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

When looking at those customers that did still use secondary³³ light sources, the most common source mentioned both after three months and after 15 months is a torch (11%; see Figure 15). As indicated above, at 15 months, SHS are actually the second most mentioned additional source of light (6%) as customers use it to back-up the grid.

Notably, after three months, 12% of households mentioned kerosene as a secondary source but after 15 months, only 5% do, indicating that kerosene consumption decreases further over time.

SHS replaces the use of toxic kerosene

Kerosene is a polluting fuel, and is categorized as such by the World Health Organization, which discourages its use as a household fuel³⁴. A 2018 study showed that switching from kerosene to solar lamps significantly improved air quality inside the house and reduced exposure to toxic air pollutants³⁵. Reported impacts of using kerosene for lighting include respiratory issues, coughing, eye irritation and increased risk of fire³⁶.

Before purchasing an SHS, 52% of households surveyed used kerosene for lighting, including 40% as a primary source of light. 15 months later, only 6% of households still use kerosene for lighting, nearly all as a secondary source.

Although some customers may keep their kerosene lamps as a back-up, most get rid entirely of this source of light.

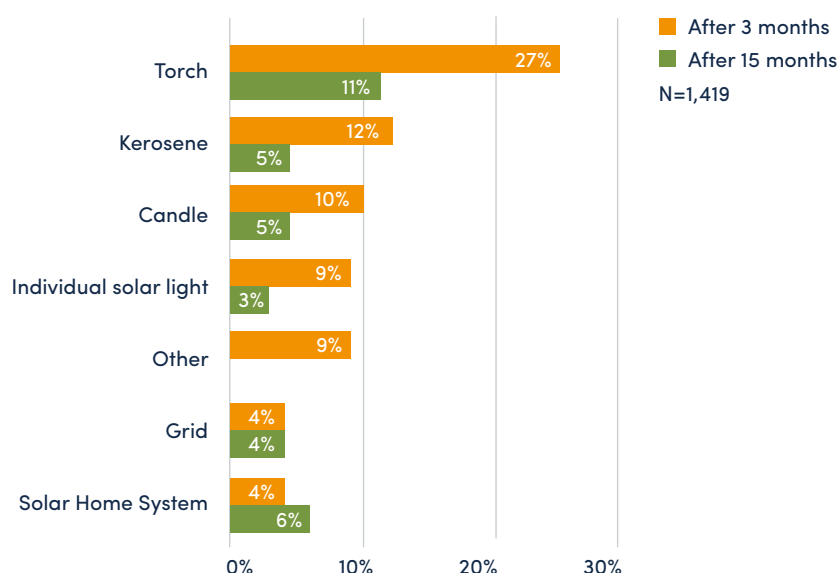
Some interviewees noticed the impact of off-grid solar alternatives on the sales of kerosene:

“You go to petrol stations and they don’t have kerosene, not because people have over-purchased, but because the demand is low so someone can’t risk stocking something that is not easily taken.”

Fenix International Agent, Eastern Uganda

Interviews confirmed that the negative effects of using kerosene lanterns, in particular in relation to health and safety, are well understood and perceived by customers, as are the benefits of switching to solar.

Figure 15: Secondary sources by share of households using



33 Customers were asked to mention to four sources of light ranked by how much they are used in the household from main to fourth. Auxiliary is comprised of the second, third and fourth sources of light when mentioned by customers.

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

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

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

The Power Of Off-Grid Solar

SHS plays a role in supplementing the grid

10% of households mention the grid as a source of light after 15 months. Among them, almost half reported new connections to the grid since the three-month survey. The share of households mentioning the grid as a secondary source of light remained stable over time between three months and 15 months. The share using the grid as a primary source grew from 3% to 6%.

Most customers that report using grid electricity are using a combination of both grid and SHS, either using solar as a secondary back-up for unreliable grid or to cover more rooms. In other cases, despite the availability of grid power, its lack of reliability means that customers still prefer to use the SHS as their primary source of electricity.

"The grid connection is available here in the market, but I have not considered getting connected because of the frequent blackouts I mentioned to you earlier. The solar home system is much better than the grid connection since I do not pay monthly electricity bills nor will I experience blackouts, provided there is sunlight."
M-KOPA Customer, Nyangweso, Kenya

Using the grid and an SHS

Assumpta is a 43-year-old woman living in a village in Rwanda near the Tanzanian border. Originally, she used the SHS to open a shop in the front room of her house. Since she bought the SHS, her shop at the front of the house has been connected to the grid but not the rest of the home. This now means she can have power throughout the building. What's more is that the SHS provides immediate back up to her business during the common black outs.

"Sometimes the grid connection is not working properly and in that case I switch to using the SHS."

Using mostly grid in the shop and the SHS at home has helped her improve lighting on both fronts. Even if she finds the SHS expensive compared to grid electricity, she recognizes that she has more money available since buying the SHS, because she has been able to save money on phone charging, to start her own business and to attract a lot of customers when there is no grid power.



The Power Of Off-Grid Solar

SHS have improved the access to lighting

Increased and improved access to light is cited as the primary reason to purchase a SHS and provides the most direct benefit. Three months after purchase, the share of customers reporting more than six hours of light per day grew from 24% to 59% (Figure 16). This figure has continued to increase, reaching 71% after 15 months.

Many households actually use their lights for more than 10 hours per day (Figure 17). Lights are often used when undertaking household chores which previously had to be done before nightfall or were done in the dark or in poorly lit conditions. The significant number of hours of use is also due to the fact that many customers leave a security light on during the night, usually outside.

Figure 16: Evolution of the number of daily hours of light available

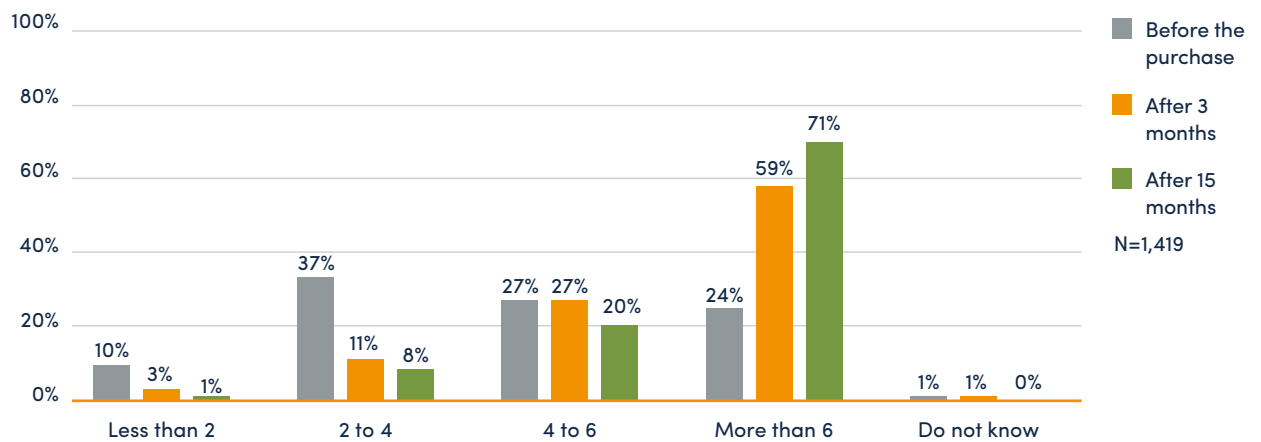
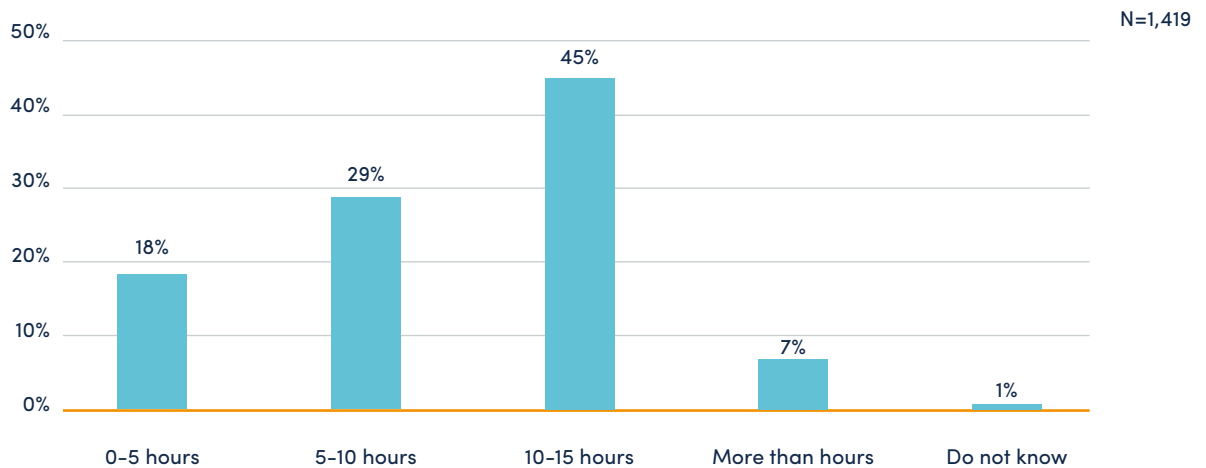


Figure 17: Daily hours of light available after 15 months



The Power Of Off-Grid Solar

3.2. Phone Charging, Radios And Televisions

Whilst light is the central feature of SHS, they also provide additional services. All the systems considered in this research include phone charging capacity. 70% include radios, 51% include torches and 32% include a TV. The most popular appliances are phone charging, radios and TVs (Figure 18). Other appliances mentioned include hair clippers and fans.

Face-to-face interviews with customers revealed further insights about how SHS and appliances are used. Unsurprisingly, the first pattern that emerges is customers tend to charge phones during the day and use the lights at night with many households leaving at least one light on during the night for safety.

“Before, my wife used to cook in the dark and it was hard to check the quality of the food while preparing. Now with the light it’s easier to check the food and maintain hygiene in the kitchen.”

M-KOPA Customer, Masaita, Kenya

Radios and televisions often used at different times and to get access to the local news or educational programs.

“All my family members use the radio to listen to news, then later switch to the television once the radio’s battery runs out. We use the television to watch agricultural shows as a family.”

M-KOPA Customer, Ainamoi, Kenya

Customer aspirations

Overall, many SHS customers seek to further improve the service they are provided by the SHS. This can be done by upgrading or adding lights or appliances. The most common requests reported to companies’ sales agents are for additional lights (especially for smaller systems). When TVs are not included in the kit, they are one of the most sought-after appliances.

Other appliances frequently mentioned by customers are refrigeration units, speakers and irons.

“I am a fisherman here on the lake. I get so much fish that needs to be preserved before transporting to the market. Solar will come in handy if it can support big freezers. That is the challenge we are facing as fishermen here on Lake Victoria.”

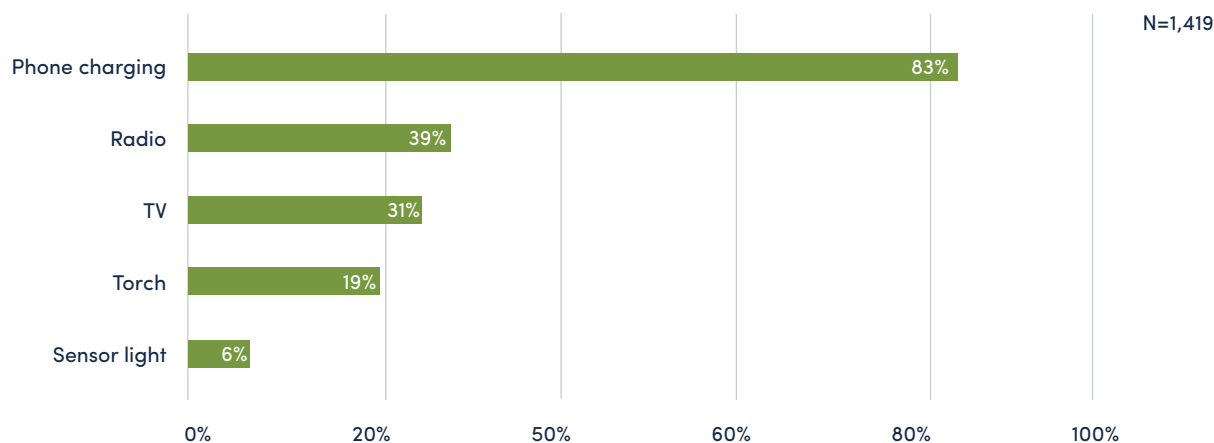
M-KOPA Customer, South Nyanza, Kenya

Agents also report that customers are aspiring to get more and more service from their off-grid systems.

“In the next few years, our customers will need better products from SHS. They will want to live in the same conditions as people living in town who are connected to the grid. They will want to be able to power the same appliances, like irons.”

BBOX Agent, Northern Rwanda

Figure 18: Appliances used by share of households using them







Economic Opportunities





Economic Opportunities

Beyond access to light and phone charging, SHS have the ability to help households seize economic opportunities and increase their income. Although not all households experience this, it can have a significant impact for those that do. This section showcases overall economic impact figures that are derived from either using the SHS in a business or being able to work more hours thanks to time unlocked by the SHS.

This section is structured around three key impact measures:

- Additional activity undertaken: the share of households reporting the SHS has helped them undertake additional economic activity (Section 4.1)
- Additional income generation: customers reporting additional income has been generated from the new or extended economic activity (Section 4.2)
- Job creation: FTE employment created through the new or extended economic activity (Section 4.3)

4.1. Additional economic activity undertaken

This study finds that more than a third of households undertake additional economic activity as a result of SHS ownership (Figure 19).

Overall, the share of households undertaking new or extended economic activities due to the SHS 15 months after purchase remains high but it has reduced when compared to the data collected three months after the purchase (Figure 20).

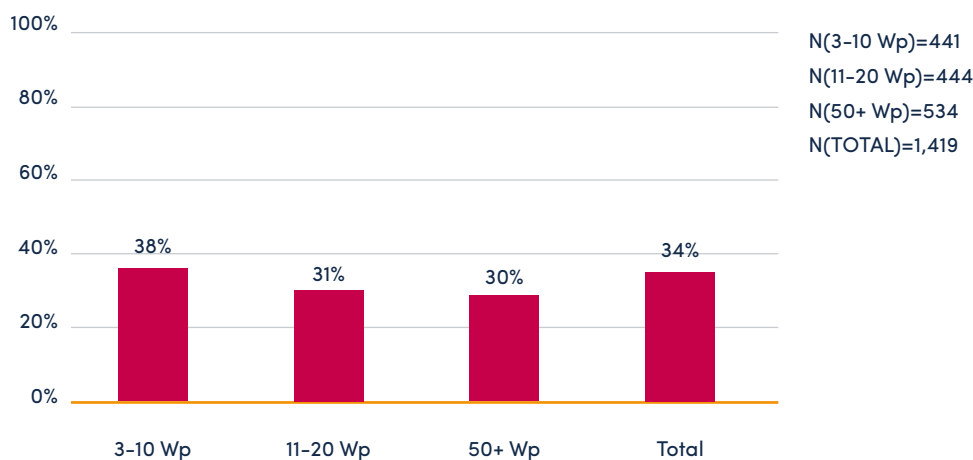
The economic activities undertaken have been classified into two categories:

- Use of the system in a business
- More work hours unlocked by the SHS

After 15 months, 21% of households report using the system to support a business, while 21% report undertaking more work (Figure 21). 8% of households report undertaking both kinds of economic activity.

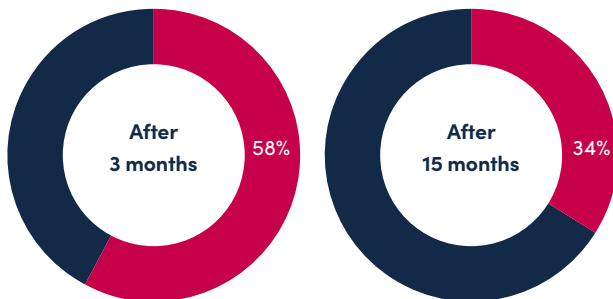
While the percentage of customers who reported that they use the system in a business has reduced only slightly between three and 15 months, those reporting they have more working hours available has dropped more significantly. After three months, 24% of households reported business usage of the system, 47% reported more work hours. 14% reported both.

Figure 19: Share of households undertaking additional economic activity after 15 months by system size



Economic Opportunities

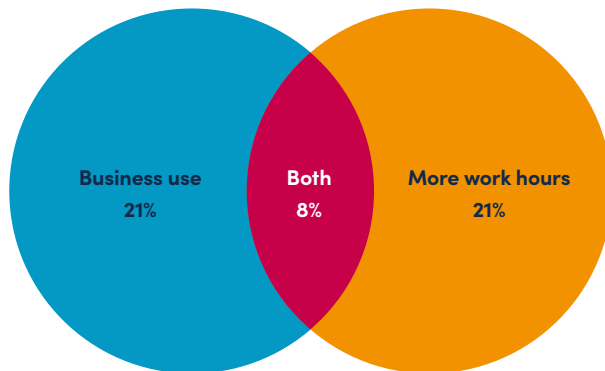
Figure 20: Share of households reporting additional economic activity since the purchase of the product after three months and after 15 months



N=1,419

Figure 21: Type of additional economic activity undertaken reported by households

Total additional economic activity undertaken: 34%



N=1,419

Several factors could explain the reduction in the share of households reporting more economic activity between the three months and the 15 months surveys:

- Households that reported that the system had unlocked additional time to work three months after purchasing their SHS may no longer report this impact due to the long recall period and, as they have become used to their new schedule.

“When the system was new, everything was very fresh in their memory. Now, when time goes by, it becomes normal to [the customers] so they cannot give you a clear picture.”

Fenix International Agent, Eastern Uganda

- Many of the activities conducted by household members are informal and depend on opportunity and external factors. Therefore, some activities reported three months after the purchase may no longer be conducted.
- Many businesses or income generating activities conducted have a low survival rate often due to a lack in entrepreneurial skills, inability to generate income or increased competition. This is confirmed by an increase in income among households that are still conducting an economic activity after 15 months (see section 4.2)

“The challenge in the business community here is that businesses don’t live past their first year. Someone starts a business but has no entrepreneurial skills so within a year, it’s over.”

Fenix International Agent, Eastern Uganda

Economic Opportunities

4.1.1. Focus on business use of the SHS

21% of SHS are used in a business or income generating activity. Smaller SHS are used slightly more frequently for business (24%) than 11–20 Wp (19%) or 50+ Wp systems (19%). This is consistent with findings from the previous Powering Opportunity report³⁷.

Among the businesses using the SHS, 52% are new businesses, while 48% existed prior to the purchase of the SHS. The most common types of businesses using the SHS are phone charging businesses (39%), shops and stalls (27%) and bars and restaurants (12%) (Figure 22). Among businesses classified as “Other”, the most common business is hair cutting. The most common ways businesses use the system are to charge phones and for lighting both inside and outside. While 39% of businesses report that charging phones for a fee is their primary

activity, 48% of businesses mention offering phone charging as a service in their business. This indicates that several businesses charge phones as a secondary activity (Figure 23). This is particularly common amongst shop owners.

After 15 months, the share of households using the SHS in a business or income generating activity is 21%. After three months, the result was slightly higher at 24%. However, the 3% drop does not constitute a significant change given the study’s margin of error and so the results are relatively stable.

More interestingly, this evolution actually hides a more complex dynamic. While the overall number of businesses using SHS is relatively stable, some businesses active a year before are no longer operating, whilst other new businesses have emerged.

Figure 22: Types of business using a SHS

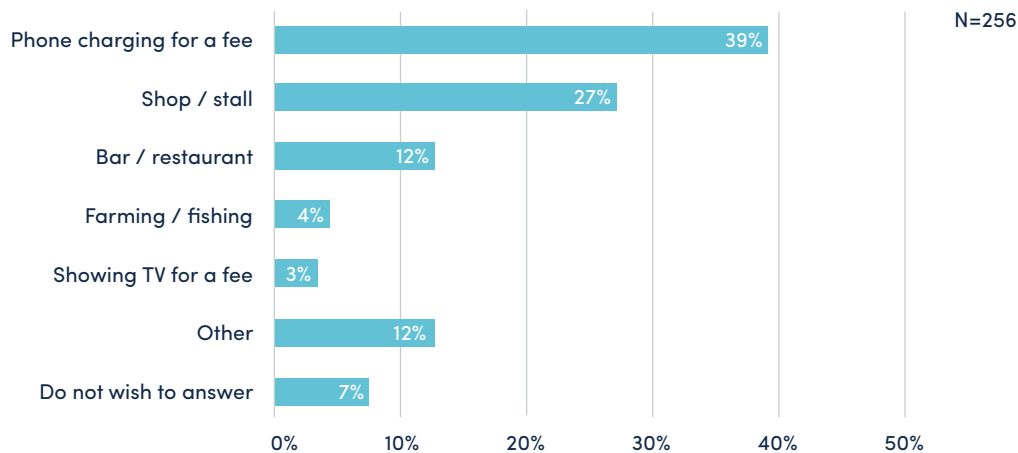
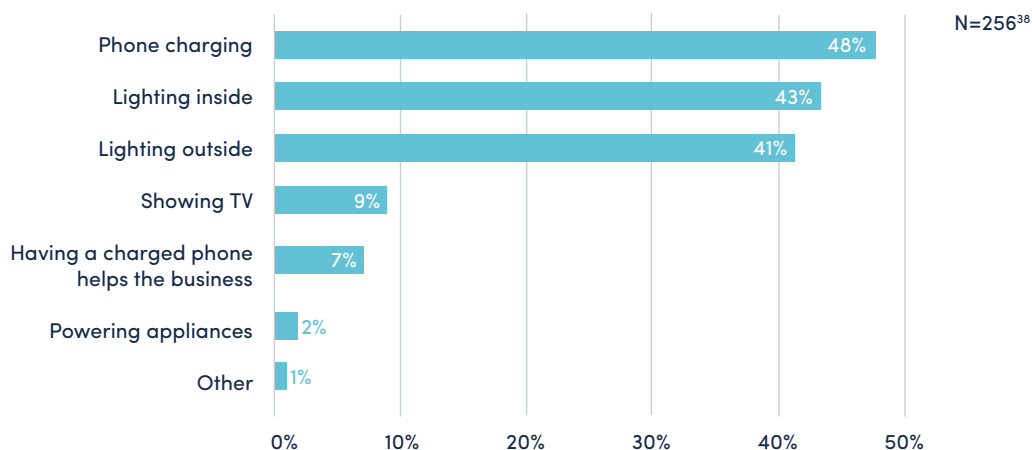


Figure 23: Ways the system is used in businesses



37 3–10 Wp (27%), 11–20 Wp (18%) and 50+ Wp (24%). GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar.

38 Multiple answer question.

Economic Opportunities

Phone charging as a business

In many cases, phone charging as a business enables households to charge their neighbors and close community's phones for a fee. As more and more members of the community acquire a SHS, the customer base disappears.

"I charge two phones every two days for ten shillings each which makes me forty shillings a week. I have fewer customers now because more and more people own a solar home system."

M-KOPA Customer, Kandege, Kenya

"Solar has now become so common that everyone charges their own phones. Those who used to bring their phones for charging now have acquired their own SHS."

Fenix International Agent, Uganda

This means phone charging for a fee is not necessarily a sustainable business for every SHS customer. However, it can also be a steppingstone towards more sustainable livelihoods.

Innocent is a 32-year-old man living in a village located in the Southern province of Rwanda. He uses the SHS at home where he used to operate a small shop. He had to stop this activity a few months ago due to illness, requiring him to go to the hospital. Still, he is planning to reopen the shop when he has reconstituted his stock. He and his wife are also farmers.

Innocent originally began his business with phone charging for a fee but then grew his business:

"After I bought the solar home system, I came up with the idea of using it in a business. The idea of business came because I was planning to charge phones for fee, so that the income generated would help me to pay back the system. Then, I found out that many people who came to charge their phones also asked me for other products. Therefore, I decided to use income from charging phones for a fee and from farming activities to open the shop."



Economic Opportunities

4.1.2. Focus on more work hours unlocked by the SHS

The use of the SHS directly to power enterprise, for example by charging phones for a fee or lighting a restaurant, is not the only way in which households benefit economically from their product. Access to electricity also enables households to work for a greater number of hours through three main ways:

- Having more light hours: additional hours of light in the evening allow household to reorganize activities to spend more time working:

"I have a BBOXX solar home system at home and my wife is selling fruits. To do so, she has to move from here to Kigali. Thanks to the SHS, she can come home late, and still have time to do household work like cleaning the house and laundry. I myself used to go home early, between 7 pm and 8 pm, in order to get time to write a report. But thanks to the SHS, any time I get home, I can switch on my computer and write it."

BBOXX Agent, Eastern Rwanda

- No longer travelling to buy light sources or charge phones: prior to purchasing an SHS, customers regularly had to buy kerosene, candles or batteries. For many households this meant significant time travelling to a point of sale. The time saved enables them to work more.

"The extra hours I used to spend purchasing kerosene are now used to stay longer at the market and getting more money."

M-KOPA Customer, Ikwanda, Kenya

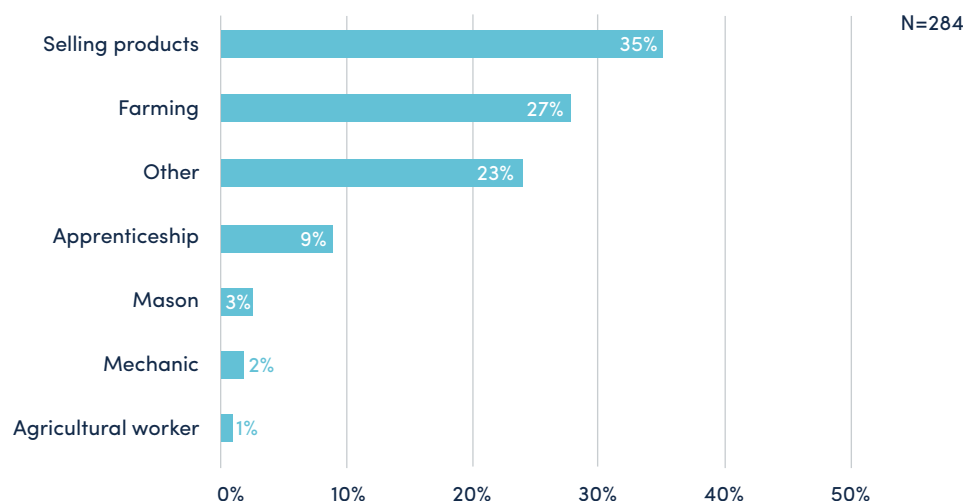
- Improved connectivity via a mobile phone: access to phone charging means users are easier to reach enabling them to seize more job opportunities.

"Being a boda-boda man³⁹, my husband's phone should always be on since most of his customers tend to call him for work. Having his phone always on because it is charged has helped him get more work thanks to solar."

Fenix International Customer, Namulamba, Uganda

21% of households reported being able to work more hours thanks to the SHS. This includes spending additional hours in an existing activity or starting a new activity. Among them, the main types of activities carried out SHS customers are selling products and farming their own land (Figure 24). Other types of activity undertaken are extremely varied and include teachers, community workers and craftsmen.

Figure 24: Main types of activities conducted through more work hours



Economic Opportunities

Amongst the 21% of customers that work more hours, the majority are doing so as they have more light hours available in the day to shift and expand their daily activities (73%; Figure 25).

After three months, 47% of customers reported spending additional work hours undertaken compared to 21% after 15 months (a 26 percentage point decrease). As mentioned above, the drop has several explanations, including:

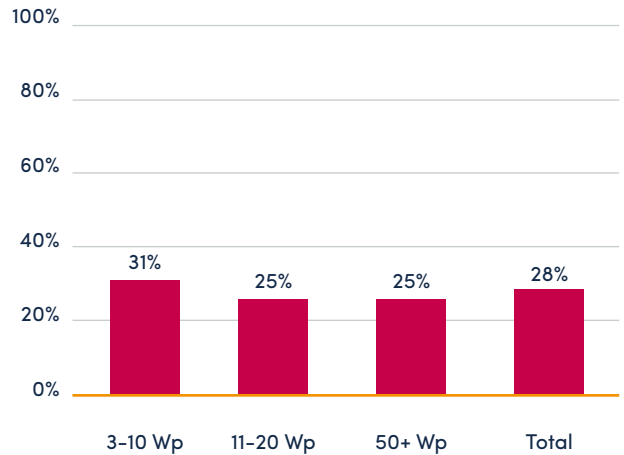
- Households that were unable to generate income from additional work are likely to have abandoned the additional activity.
- Respondents may not report the additional time unlocked any more as they have become used to the situation over the last 12 months (recall bias).

Of the 26 percentage point decrease, a small part (less than 5 percentage points) may also be attributed to a change in methodology⁴⁰.

4.2. Additional income generation

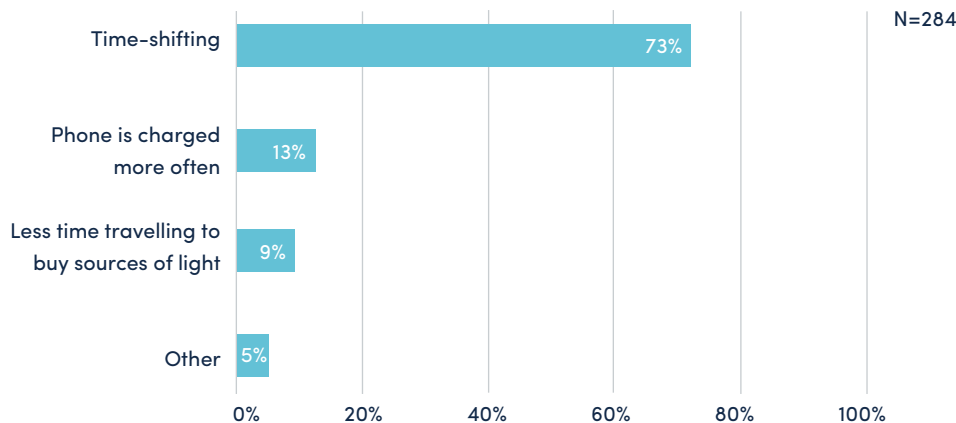
81% of those undertaking more economic activity generate additional income, which translates to 28% of households generating more income among the whole sample (Figure 26).

Figure 26: Share of households generating income thanks to the SHS after 15 months by system size



N(3-10 Wp)=441 N(50+ Wp)=534
 N(11-20 Wp)=444 N(TOTAL)=1,419

Figure 25: How the SHS generates opportunities, amongst customers who report working more hours



⁴⁰ In the previous research, certain households reported economic impacts twice. For example, a household where the SHS was used in a business might report using the system in the business but also spending additional time at work thanks to the SHS in the business. While that is not necessarily irrelevant, especially as in most households several members contribute to the additional economic activity, it did not necessarily provide a clear picture of the economic impact. To avoid this issue in the current research, the questionnaire was adapted to exclude the possibility of double counting.

Economic Opportunities

On average, this additional income comes to \$46 per month (Figure 27). On average each household generates additional income equivalent to 14% of their country's monthly gross national income per household⁴¹. Larger SHS are likely to lead to higher earnings, with 50+ Wp customers reporting an average additional income of \$57.

While there has been a reduction in the overall percentage of households reporting undertaking additional activity, the share of these households that generate additional income has increased to 81% compared to 63% after three months after the purchase (Figure 28) and the average amount of new income generated has increased from \$35 to \$46 (Figure 29)⁴³.

Figure 27: Average income generated among households generating income after 15 months by system size

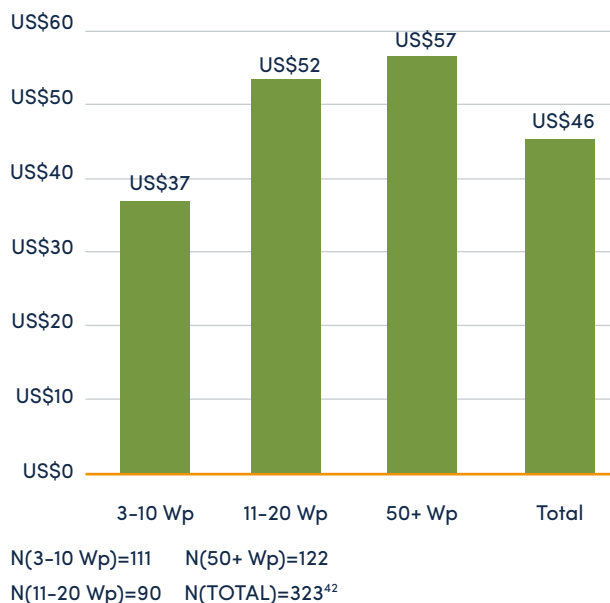


Figure 28: Evolution of the share of customers generating additional income from the reported economic activity

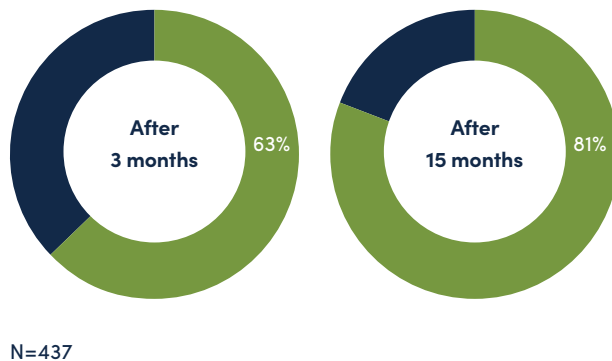


Figure 29: Evolution of the average additional income generated among customers generating income from additional economic activity



41 % of monthly GNI per household calculated for each household and averaged. Source: World Bank (2018): GNI per capita: Kenya \$1,620, Mozambique \$440, Rwanda \$780, Tanzania \$1,020, Uganda \$620.

42 To improve robustness, outliers were eliminated from the calculation of averages. Details provided in Methodology Annex. It should be noted that this study does not constitute a cost-benefit analysis. As discussed in the previous Powering Opportunity report.

43 Not all households perceive the same benefits when it comes to income generation and energy expenditure. For a significant number of customers, the SHS will have beneficial effects on their quality of life but will not enable them to generate income or save money compared to previous expenditure on energy sources.

Economic Opportunities

Access to electricity can generate entrepreneurs

Elijah is a 40-year-old father living in the Rift Valley of Kenya with his wife and his four children.

When he bought the SHS, Elijah and his wife were doing manual jobs. Elijah realized he had to come up with a new source of income to support the SHS cost. Therefore, he took the opportunity to open a restaurant in which he used the SHS for lighting and for showing sports on TV. Elijah's was also able to employ his sister to work in the restaurant. The restaurant generates around 300 KES (USD \$3) per day

His wife has also opened a hair salon right by the restaurant. Thanks to the SHS lighting, she can receive customers late into the evening and generates 500 KES (USD \$5) per day. They are both very happy that they quit their previous activities as manual workers as they now feel less tired and are generating more income than before.

Thanks to the savings made, Elijah and his wife have been able to pay for school fees. They have also been able to launch other business activities. They have hired casual workers on their farm, have purchased a motorbike and hired a man to drive it as a boda boda (motorbike taxi), which earns them another 300 KES (USD \$3) each day.

Elijah also uses the SHS for entertainment – watching sport on TV – and his children use it to do their homework. He feels his children have really benefitted from the SHS:

"To be honest my children were not performing well in school. They used to score around 40% but now they get 80%. They didn't know how to read well either but since I bought this solar home system, they come from school and are able to do their homework, which helps them catch up and perform better."

The restaurant is currently closed during the low season, but Elijah is now planning to reopen it in a more profitable location. Ideally, he wants to buy another SHS in order to keep one at home and one in the business.






Economic Opportunities

4.2.1. Focus on business use of the SHS

83% of business that existed before the SHS was purchased report the SHS enabled them to improve their income generation. 98% of new business report generating income from their activity. On average, customers using the system for business report the SHS has helped generate an additional \$34 per month. Phone charging for a fee is the most common business but it also generates lower income, on average \$16 (Figure 30). The most lucrative activity is opening a bar or restaurant or extending its business hours, which generates an extra \$52 per month⁴⁴.

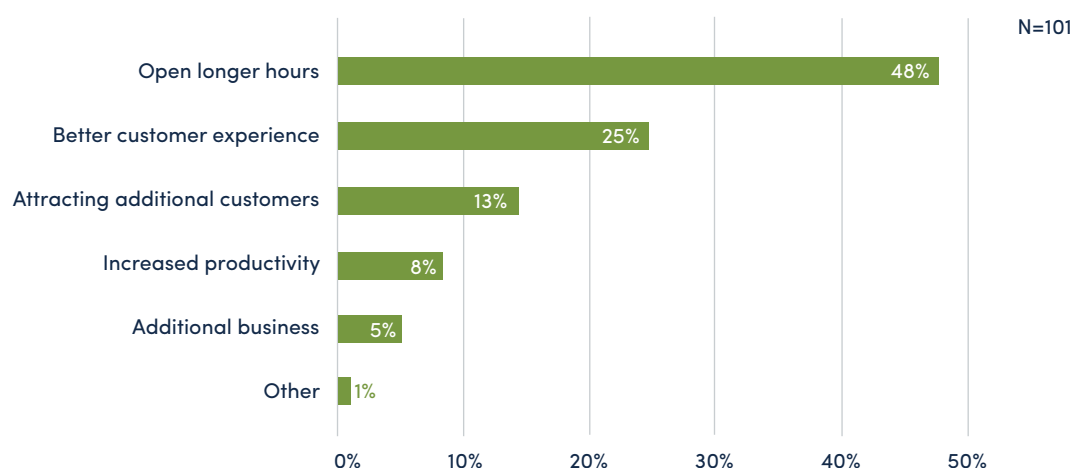
For pre-existing businesses, the most common way to improve the income generated is enabling the business to open longer hours (Figure 31). Improving the experience for customers in the second most mentioned mechanism (e.g. showing TV or playing radio in a bar or restaurant).

Figure 30: Key business types and monthly income generation compared to GDP per capita⁴⁵

	Share of business		Average income generated	
	After 3 months	After 15 months	After 3 months	After 15 months
 Phone charging for a fee	34%	39%	\$13	\$16
 Shop or stall	20%	27%	\$36	\$50
 Bar or restaurant	11%	12%	\$46	\$52

After 3 months: N(Phone charging)=179 N(Shop)=89 N(Bar)=56 After 15 months: N(Phone Charging)=93 N(Shop)=45 N(Bar)=28

Figure 31: Ways the SHS improves the income of pre-existing businesses



⁴⁴ Sample sizes for this analysis are small and results should be interpreted with caution.

⁴⁵ % of monthly GNI per household ratio calculated for each household and averaged. Source: World Bank (2018). Kenya \$1,440, Mozambique \$430, Rwanda \$730, Tanzania \$970, Uganda \$620. World Bank (2018): GNI per capita: Kenya \$1,620, Mozambique \$440, Rwanda \$780, Tanzania \$1,020, Uganda \$620.

Economic Opportunities

Supporting Micro, Small & Medium Enterprises (MSMEs)

Benter is a 34-year-old mother of five living in a village in Western Kenya. She uses the SHS at home for lighting, phone charging and watching TV. Benter is running a grocery business: she buys food products from wholesalers every evening and sells them in the market the following day.

Before switching to solar, Benter was barely able to afford kerosene and she could not afford to use any light sources to sort her stock when coming back from the wholesalers. As a result, her products (fruits and vegetables) would often spoil during the night, resulting in a daily loss of 100 to 200 KES (USD \$1 to \$2). Now that she has the SHS, Benter can calmly organize her stock each evening which enables her to prevent losses. The SHS also allows Benter to work for longer hours. Thanks to all this, Benter has seen her daily sales rise from 1,000 to 1,500 KES (USD \$10 to \$15).

"[The lack of light] made me leave my goods in an unorganized way hence incurring approximately 200 KES (USD \$2) loss every day. However, since shifting to the solar home system, I get to rearrange my goods since there is light and I don't suffer from unnecessary losses."

Benter also uses the SHS to charge her neighbors' phones and radios for a fee. This makes her generate an additional monthly income of 1,800 KES (USD \$18).

She also used to run a kiosk next to her house to sell her products. When doing so, the SHS helps her to extend operating hours up to 10 pm. She decided to close the stall to focus on her activity in the market but is planning to reopen once she finds someone reliable to help her.



Economic Opportunities

4.2.2. Focus on more work hours unlocked by the SHS

As noted above, fewer households report that a member spends more time working after 15 months than after three months. However, among those that report spending more time working at 15 months due to the SHS, the share that are able to generate income has increased, as has the amount of additional income generated. Within these households, 70% have been able to generate income, compared to 51% at three months post purchase (Figure 32).

On average, these households generated an additional \$28 per month after three months but the additional income generated at 15 months reaches \$42 a month (Figure 33). Among the main activities carried out, those working in agriculture generate an average \$46 and those selling products generate an average \$35.

Figure 32: Evolution of the share of households generating income from more time spent working

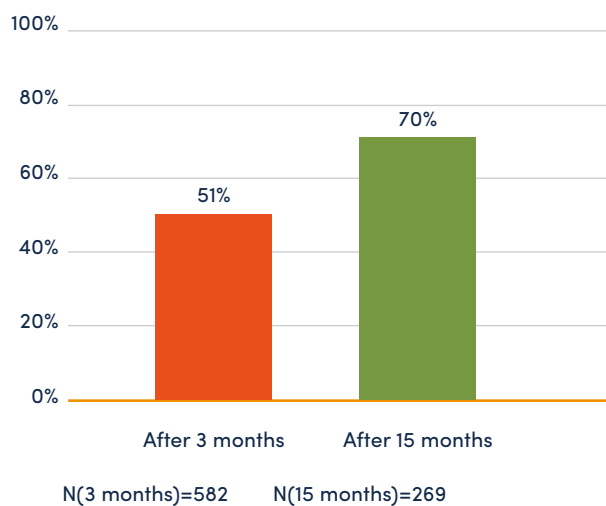
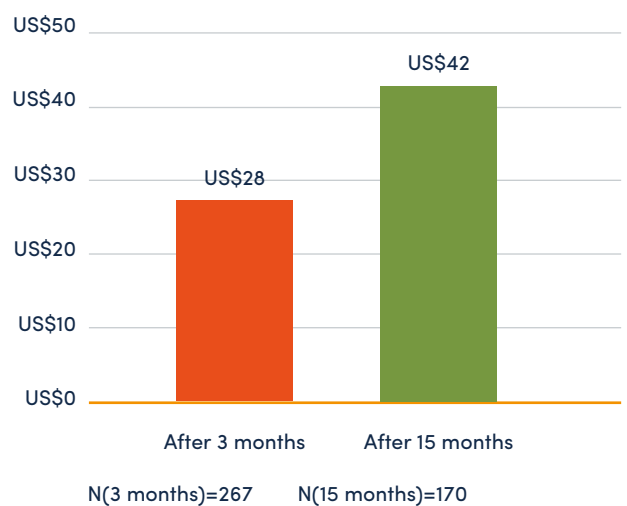


Figure 33: Evolution of the income generated by households generating income from additional hours of work unlocked through the SHS



Economic Opportunities

4.3 Job Creation

Although the number of households reporting that a member is able to spend more time working has reduced between three and 15 months, the 15 month survey aimed to explore more about this impact and so also looked into the number of people per household who are working more, and whether they are male or female. This led to several new and significant findings.

Questions posed around how many people in the household were undertaking more economic activity as a result of SHS ownership revealed that, where more economic activity is being unlocked by the SHS, this is resulting in more work hours or new employment for more than one household member. For example, in several cases, both the female and male head of the household are able to work for longer, or to take on new employment. The research also shows that in many cases, both male and female household members are able to undertake a significant amount of additional work hours.

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 of the mechanisms highlighted earlier in this research: more time working due to extended business hours and more time spent working due to increased hours of light, less time spent travelling and better connectivity.

Overall, the additional hours of work enabled by the SHS translates to a significant 21 FTEs created for each 100 SHS sold (Figure 34). Half of these FTE opportunities are created in rural areas.

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 development⁴⁶, especially in Africa where the informal sector accounts for around 40% of GDP⁴⁷.

Figure 34: Distribution of FTEs created by type of location

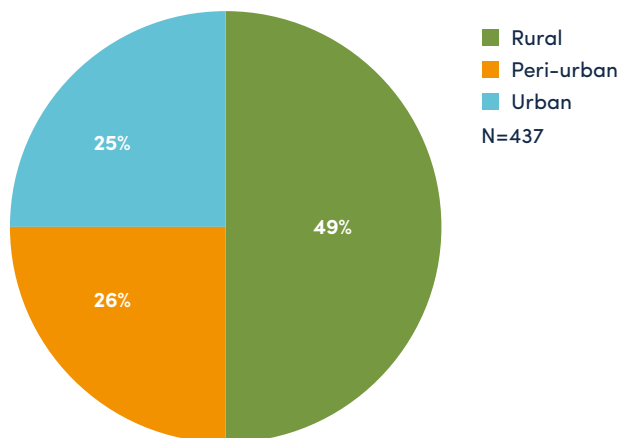
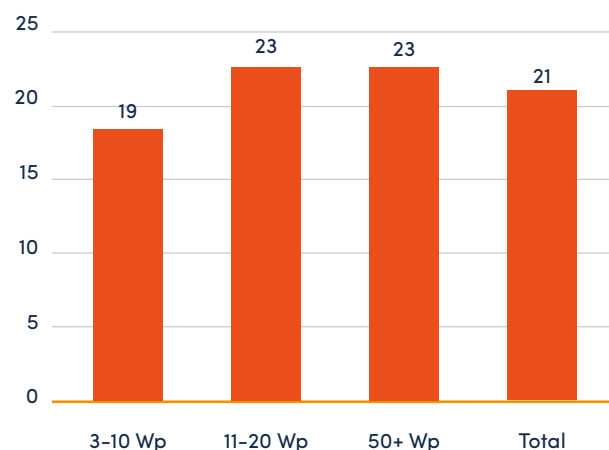


Figure 35: Number of FTEs generated by 100 SHS sold by system size



N(3-10 Wp)=441 N(50+ Wp)=534
 N(11-20 Wp)=444 N(TOTAL)=1,419

46 ILO (2018), Women and Men in the Informal Economy.

47 ODI (2018), Informal is the New Normal – Improving the Lives of Workers at Risk of Being Left Behind, Shaping Policy for Development.

Economic Opportunities

FTE Methodology

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 territory⁴⁸ (i.e. 1 FTE is equivalent to 1 full-time worker).

Within this research, FTE jobs were calculated relative to the legal working week in participating countries: Kenya 53 hours, Uganda 49 hours, Tanzania 49 hours, Mozambique 49 hours and Rwanda 46 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 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.

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.

Please note that the FTEs within this research are only calculated for the increased time spent working by off-grid solar customers and does not include any hours worked by the staff or agents of off-grid solar companies themselves. Furthermore, that a majority of jobs within off-grid solar companies, such as those for sales staff, technicians and management, are formal and full time. More details on 'sector level', rather than 'household level' jobs can be found in the report "Off-Grid Solar. A Growth Engine for Jobs"⁴⁹.

As noted above, as well as exploring changes in impact over time by undertaking surveys at three and 15 months, another aim of this research was to understand who within a household was undertaking more economic activity due to the purchase of a SHS. The survey found that in most households where additional economic activity was taking place, this was being reported by more than one member of the home; on average 1.63 household members.

In some cases, this is due to multiple members working in a family business, however, households also report different combinations of activities such as phone charging as a business and spending more time working on their land or managing a small eatery while selling products outside the home.

Among households undertaking additional economic activity (34%), when adding additional work hours undertaken by all members, these hours translate to an average of 0.74 FTE jobs per household.

48 Commission of the European Communities, International Monetary Funds, Organisation for Economic Co-operation and Development, United Nations and World Bank (1993), System of National Accounts.

49 GOGLA & Vivid Economics (2019), Off-Grid Solar. A Growth Engine for Jobs.

Economic Opportunities

SHS often enable more than one person to undertake more economic activity within a household

Felix is a 27-year-old man from a village near Nasho in Eastern Rwanda where he lives with his wife and his little brothers. He and his wife are farmers and, he also owns a shop located in the city center, which is quite far from his house.

Felix and his wife are using the SHS at home, mostly for lighting, from 6 pm to 10 pm. In addition, an outside security light remains on until 6 am to prevent robberies.

Having lights in the evening helps them to reorganize their time and to improve their business activities. Each evening, Felix, his

wife and a woman they have now been able to hire to help on the farm spend four additional hours preparing the products to sell the next day. This helps the family generate an additional monthly income of 23,000 RWF (USD \$25). By reorganizing his daily work, Felix is now able to generate more income, and was thus able to hire an employee to be in charge of the shop located in the city. Now, Felix can fully dedicate his time to his farming activities and is proud of being able to offer jobs to other people.

"I hired someone to work in the shop and I decided to take care of farming activities only. During the day, I just go to the shop to have a look and be aware of the situation. [...] All of us benefit from the time we have thanks to the SHS because the generated income improves our lives."



Economic Opportunities

4.3.1. Focus on business use of the SHS

As noted, to establish how much additional employment is created within existing or new businesses, the 15 months survey explored the hours of business operation before and after SHS purchase. On average the businesses surveyed in this research operated for 37 hours a week, with the SHS being used an average of 37 hours a week. However, despite the correlation of these numbers, the figures hide several realities. For example, some businesses only use the SHS for lighting a few hours per day in the evening to extend opening hours. Others leave an outside light on all night as a deterrent for thieves. Others use the system to power a TV during their bar's opening hours. Therefore, the impact of the system in terms of extra work hours and job creation for businesses can be difficult to measure. To meet this challenge, the research used an approach based on time spent working by household members to best represent the impact of the SHS in terms of job creation within businesses.

New Businesses

For new businesses, customers provided the list of household members working in the business and their working hours, enabling the calculation of FTEs created by each business⁵⁰. For pre-existing businesses, a more conservative approach was adopted, where extended business hours were equated to additional work hours, but these were only attributed to the main household member operating the business to compute FTEs⁵¹.

In new businesses, the average number of household members working in the business is 1.3 with a quarter of households reporting more than one member is working in the new enterprise. 55% of them are women.

With new businesses reporting they are open an average 40 hours a week, unsurprisingly 42% of individuals work full-time in their new enterprise.

Pre-existing Businesses

In pre-existing businesses, opening hours have been extended by an average 10 hours per week. This figure includes businesses that benefited from the SHS but did not extend business hours.

Number of FTEs

Taking into account both jobs created by new businesses and extended working hours from pre-existing business, each business generates 0.64 FTEs. In a broader perspective, this means that for 100 SHS sold, the use of SHS in business creates 12 FTEs⁵² (Figure 36).

Additionally, businesses were asked if they had been able to hire new employees from outside their households. 19% of businesses report doing so and on average they report hiring two employees. However, the research did not include elements enabling further qualification for these jobs or assessment of the time these employees spent at work. Therefore, although a significant finding, these additional hires were not counted towards the measurement of job creation in terms of FTEs.

4.3.2. Focus on more work hours unlocked by the SHS

The average number of additional work hours undertaken by members of households that have been able to unlock more time for economic activity is 12 hours a week, which amounts to a bit less than two additional hours per day.

Among the customers reporting these results, most have simply increased their working hours, but a few have started new jobs. This explains why, although most household members spend less than 10 additional hours per week at work, a few report full work weeks.

On average, these households report that the system has enabled more than one member of the household to spend more time working or get a new job. On average, 1.9 members, for example, both the male and female head of household. Among the beneficiaries, 49% are women.

Number of FTEs

Overall, time and opportunities unlocked by the SHS help generate additional work hours equivalent to 9 FTEs for every 100 SHS sold.

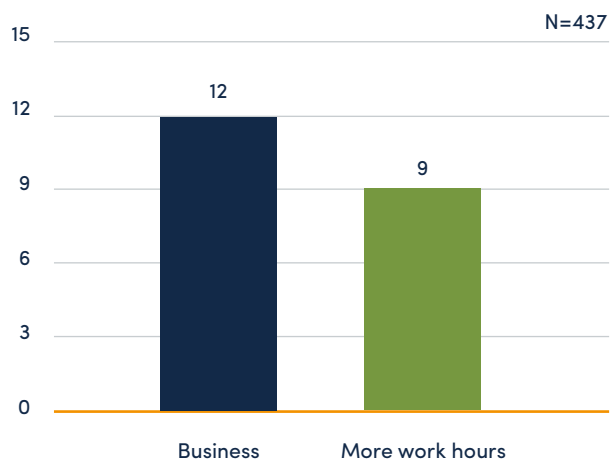
50 Details provided in Methodology Annex.

51 Details provided in Methodology Annex.

52 FTE calculations provided only include household members working in the business. 19% of businesses also report having been able to hire employees from outside their households.

Economic Opportunities

Figure 36: FTEs created for 100 SHS sold by households undertaking additional economic activity



Economic Opportunities

Empowering Women

Access to electricity through SHS can have a key role in giving women access to economic opportunities. 62% of pre-existing businesses using a SHS are run by women. 55% of household members working in new businesses are women. They also represent half of household members undertaking more economic activity. This suggests that off-grid solar can play an important role in creating opportunities for women in enterprise or to support their work. Below are the portraits of two women using the SHS in their businesses.

Pamela, M-KOPA Customer, Miyoro, Kenya

Pamela is a 41-year-old woman living in Western Kenya with her husband. She is a farmer and a community health worker. She mostly helps others who are sick, referring them to hospitals, providing HIV/AIDS testing and counselling and collecting data related to health in her community.

She uses the SHS at home for lighting from 6 pm to 11 pm, for watching TV and for powering a water tank outside her house.

Thanks to the SHS, Pamela and her husband have been able to unlock time which they dedicate to economic activities. As a community health worker, Pamela has to collect and sort data. Before the SHS, she was

having trouble working on it at night. Now that she has the SHS, she has three extra hours of lighting each evening to make sure her data is of a satisfactory quality. Thanks to this, she can get a 4,000 KES (USD \$40) bonus at the end of each month, whereas before, she only managed to get it some months of the year due to poor quality data.

She also charges phones for a fee, five a day on average, for 10 KES (USD \$0.10) per phone. The SHS helps her generate more income and save money on previous light sources.

"It has also been cost effective because we used a lot of money for buying kerosene and batteries. Right now, we can be able save up and buy essentials for the house and shopping for the children."



Economic Opportunities

Doreen, Fenix International Customer, Tororo, Uganda

Doreen is a 29-year-old woman from an area just outside the town of Tororo in Eastern Uganda. She uses the SHS in her restaurant which caters to locals as well as truckers on their way to the nearby Kenyan border. In the restaurant she employs three young women. The main benefits of the SHS have been to extend business working hours and provide flexibility. Before buying the system, the restaurant was only open during daytime and cooking was done using battery torches and kerosene. Doreen was open for breakfast and lunch. Now, she turns the light on in the early morning to cook and in the evening to light the space. She uses it for about 5 hours a day.

The light in the morning is brighter and safer and has greatly improved the team's productivity in preparing food which means they are ready earlier:

"I wake up early at 5 am and by 8 am everything is ready much faster than before with the kerosene and candles."

By having light in her business, Doreen now can open for an additional meal which is something she'd been asked to do by customers in the past but could not. Therefore, the additional light directly translated into additional business and additional income. She currently makes an extra 520,000 UGX (USD \$138) per month.

"I started cooking supper with the SHS. Before I got solar, I only used to cook breakfast and lunch but now there is light for the customers in the evening. There used to be so many customers who would ask for supper though I did not cook it. So, when I heard about the product, I decided to purchase it for the restaurant."

In addition to improved income, the SHS helps Doreen make savings as she had high expenditure on kerosene for the restaurant. The light also has other benefits for her business such as safety and security:

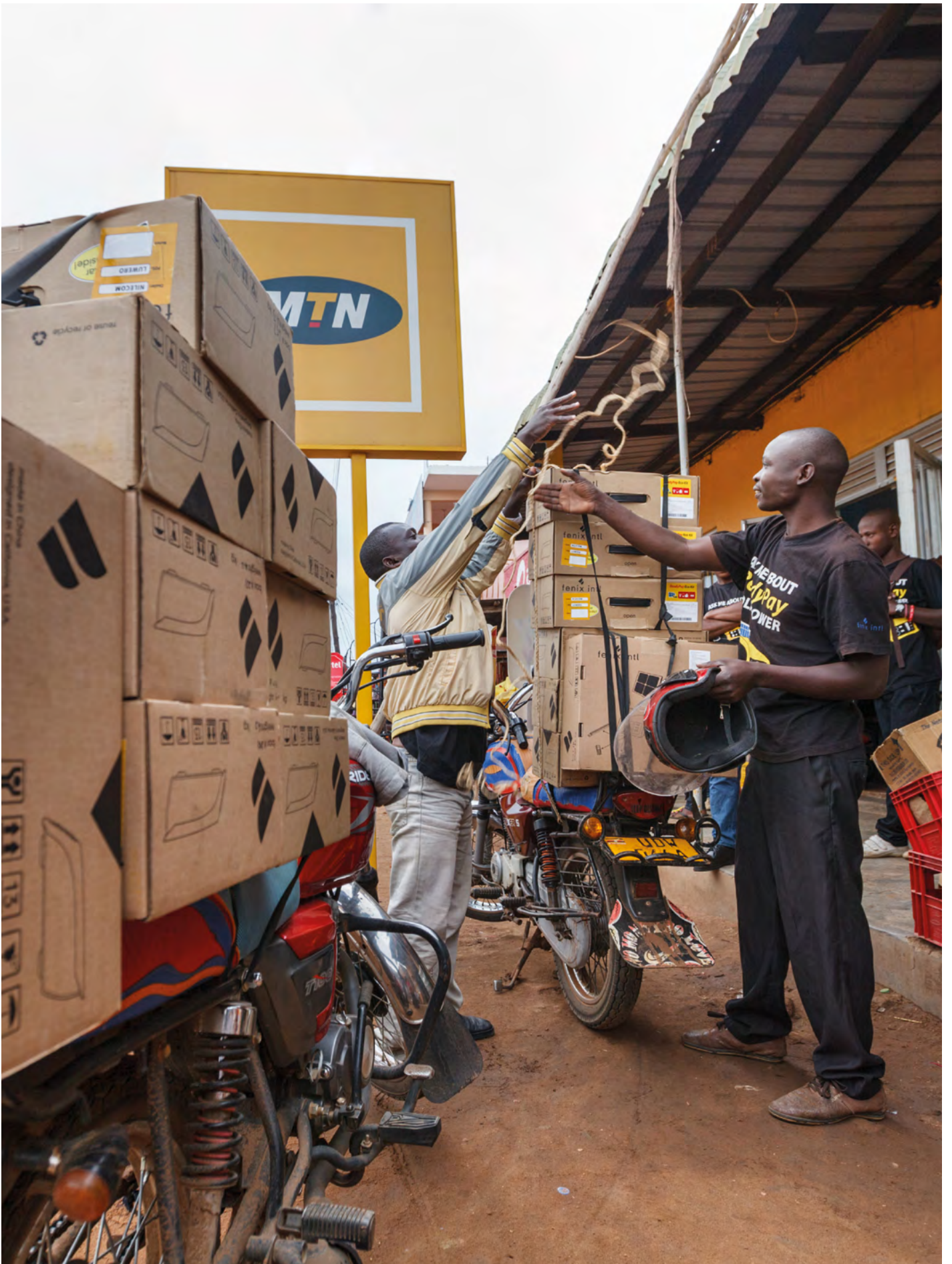
"The security light has prevented the thieves from stealing like they used to before. Also, we no longer risk burning ourselves like with the candles, we're not breathing the smoke anymore and we don't risk having leaking batteries which was dangerous, especially in a food business."



“

**Impact on
Quality of
Life**

”



Impact on Quality of Life

5.1. Improved quality of life

Improved economic situations enable households to better their living conditions. The SHS itself does a lot more to improve households' quality of life. Access to lighting, phone charging and appliances offer many immediate benefits to households, while the SHS helps customers feel safer, healthier and better connected.

After 15 months, 94% of households report the SHS has improved their quality of life. This figure has remained stable over time (95% after three months). Rural customers appear slightly more likely to report quality of life improvements (Figure 37).

Among the few customers that don't report any quality of life improvement, the main reasons mentioned are the cost of the system, the inability to use it as intended for business and technical issues.

Customers were also asked if they felt any negative effects from the system. Only 4% reported negative effects with the most common being feeling more stressed, likely related to repayments.

The three most frequently mentioned reasons for quality of life improvement are access to light (93%), improved safety (91%) and having a charged phone (90%) (Figure 38).

Figure 37: Share of customers reporting quality of life improvements by type of location

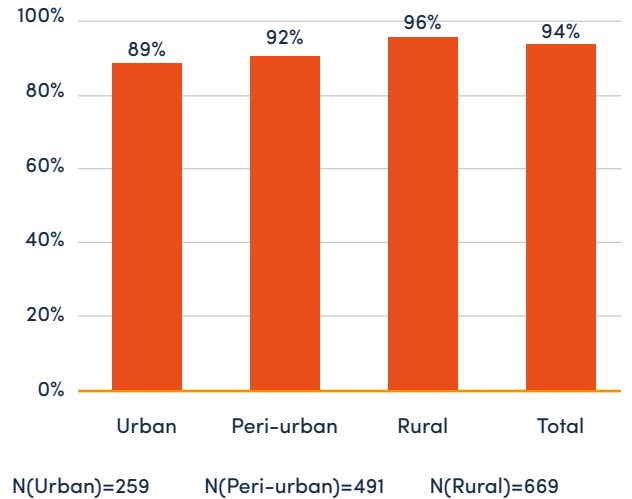
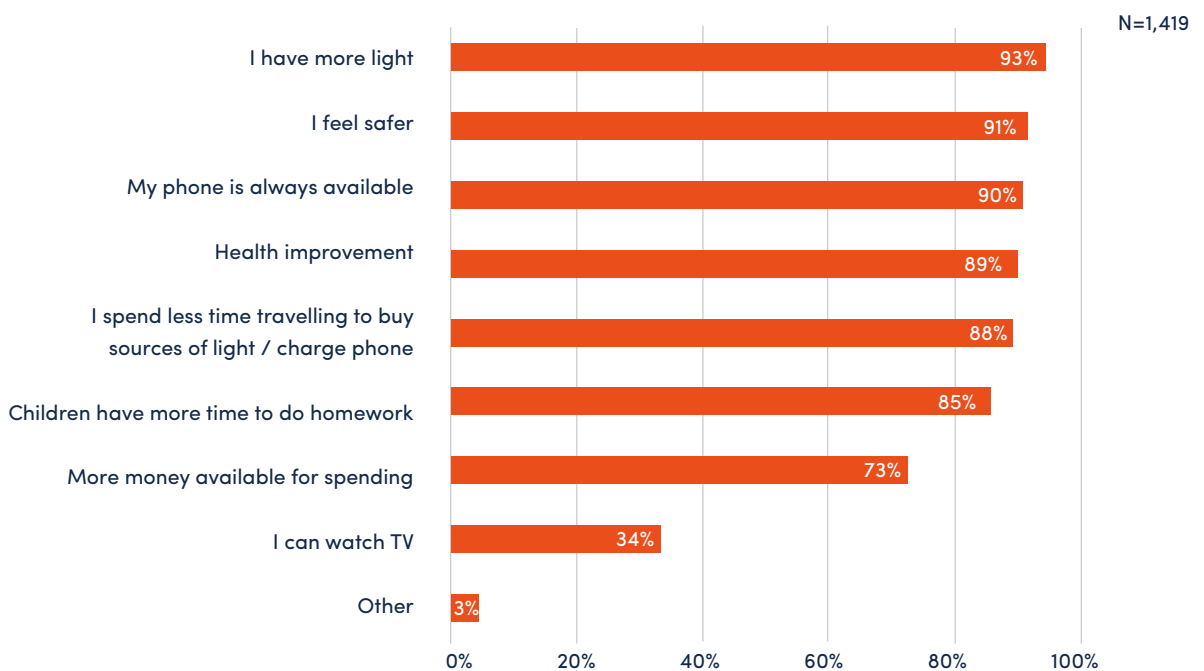


Figure 38: Share of customers reporting the following factors of quality of life improvement



Impact on Quality of Life

Access to electricity can bring multiple improvements to customers' quality of life

Daniel is a 35-year-old carpenter and bricklayer living in a village in Western Kenya with his wife and his five children. He and his wife are also farmers. He uses the SHS at home for lighting from 7 pm to midnight, for watching TV and for phone charging.

Daniel feels his quality of life has improved thanks to using the SHS. Before, his family had to use kerosene and Daniel confesses that they sometimes forgot to buy some, ending up burning some papers to light up the house. He now feels safer.

Being able to watch the news on TV, he feels connected and informed.

"We are always informed due to watching television which makes me feel like I am one of these rich people since I get access to the same information they do."

His children have more time to do their homework thanks to the light, from 8 pm to 10 pm, resulting in academic performance improvement.

"Before I purchased the system, I would let them read for an hour at most so that we could save the fuel for the following day's use."

On top of academic performance, his children's health has improved thanks to the SHS. Using kerosene lamps to read, they used to get sick and Daniel used to spend 200 KES (USD \$2) each month on medical care.



Impact on Quality of Life

Access to electricity has an positive impact on customers' social lives

In areas where access to electricity is rare, homes that have access to light soon become social hotspots attracting neighbors and children alike.

"Our light is brighter so more people come to my place for get together and children come and play football in the compound because it's the brightest place. I have gained more friends just from using solar because people come here for a chat and share ideas."

Florence, Fenix International Customer, Buikwe, Uganda

Television can also play a key role in keeping the community alive in the evenings with less people travelling to the closest center to watch TV.

"Whenever they came to visit, my two grown children hardly spent time at home after doing their chores. My son used to walk around in search of a place to watch football while my daughter used to search for a place to watch movies. These days after chores, they never leave because we have television therefore ending up spending more time at home."

Susan, M-KOPA Customer, Kilingili, Kenya

5.2. Focus on Savings

Savings are essential for low-income households to build-up assets and cope with shocks or emergencies. The ability to save prevents households from resorting to negative coping mechanisms such as reducing food consumption, selling productive assets or taking children out of school . Many customers report that SHS enable them to generate savings. Over the product lifetime, more than half of customers are expected to make savings compared to their previous expenditure on light and phone charging. This is particularly true of smaller systems (3-10 Wp). Moreover, this number does not consider other expenses that the system may eliminate such as transportation to buy energy sources or charge phones and the figure is therefore likely to be higher. However, it should also be recognized that this is not true for all customers. For a significant share of customers, purchasing the SHS entails an increase in energy expenditure. This is particularly the case for customers purchasing appliances beyond lights and phone charging (radio, TV) as they gain access to a much higher level of energy service, as well as additional products.

64% of households report that they have more money available since purchasing the SHS. Among them, the main uses of this additional budget are paying school fees (27%) and buying food (19%) (Figure 39). School fees and food are the top two categories across system sizes. While more than half of 3-10 Wp mention these categories as their main area of expenditure, 11-20 Wp SHS users are comparatively more likely to report savings while 50 Wp customers are more likely to report re-investing the money in a farm or a business.

53 CGAP (2016), The Role of Financial Services in Building Household Resilience in Burkina Faso.

54 GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar.

Impact on Quality of Life

Switching to solar home systems can help customers save money

Joseph is a 58-year-old casual laborer living and working in Kericho County, Kenya. He uses the SHS at home for lighting, phone charging, watching TV and listening to the news on the radio.

On the income side, having his phone always charged, Joseph no longer misses casual work opportunities. Moreover, he has more time available because he no longer spends time to charge his phone or to buy kerosene at the market, a round trip that takes over two hours. As a result, he works four daily jobs a week on average, whereas he used to work only two before using the SHS.

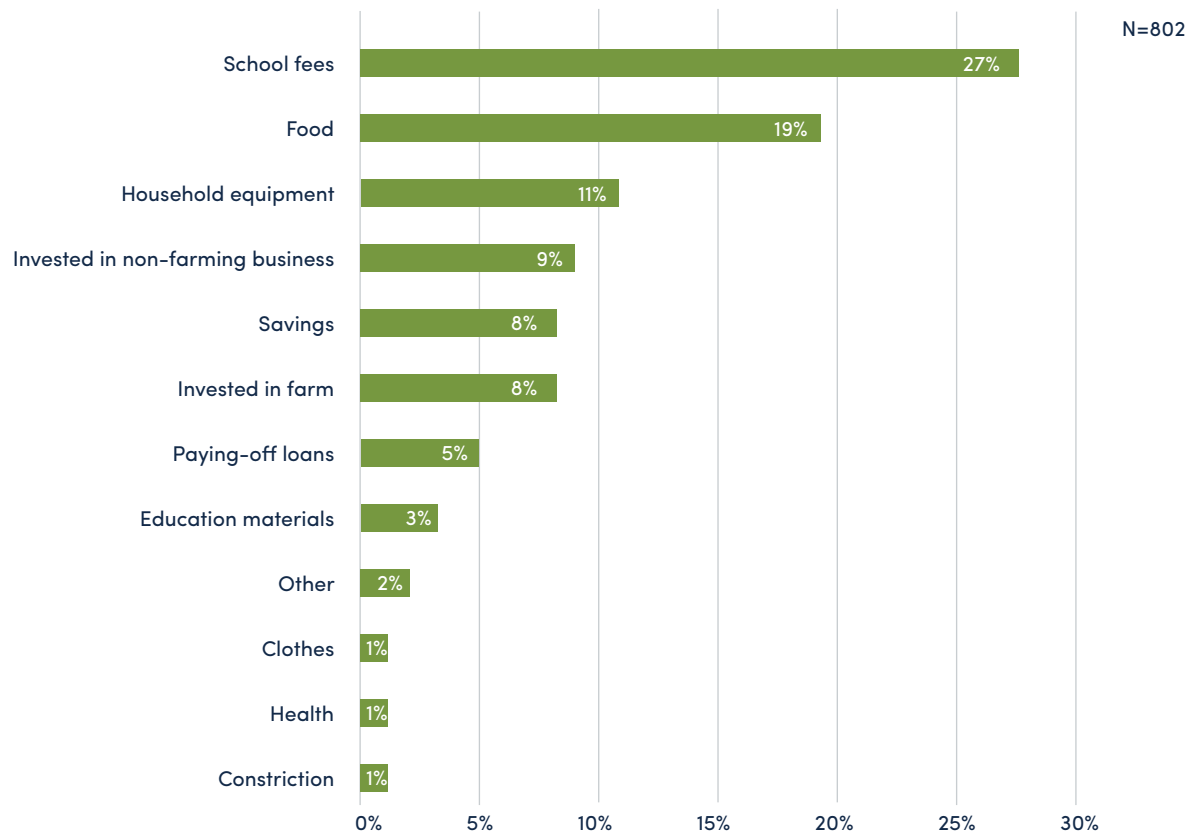
The SHS helps Joseph save money on kerosene and phone charging but also on transport. This additional money is spent on books and pens for his children.

"I used to have 2,000 shillings (USD \$20) left after deducting all my expenses but nowadays I have between 3,000 and 5,000 shillings (USD \$30 and \$50) left every month after meeting my household needs."



Impact on Quality of Life

Figure 39: Use of additional budget available since purchasing the SHS



Impact on Quality of Life

5.3. Focus on health, safety and education

Health

Health shocks such as illness and injury are among the most common forms of shocks in emerging countries and can have major financial consequences for households⁵⁵. 89% of households in this research report improvements in health conditions

since purchasing the SHS. By replacing potentially harmful or dangerous sources of light like kerosene and candles, SHS reduce the frequency and/or likelihood of health-related shocks by eliminating the risk of illness caused by fumes⁵⁶ or of burn injuries.

Eliminating harmful kerosene has an immediate impact on customers' health

Susan is a 47-year-old mother of four living in Western Kenya. She is a farmer and rears chicken. She uses the SHS at home for lighting from 7 pm until midnight, phone charging and watching news on TV.

Susan has suffered from asthma since her childhood. The kerosene fumes she was exposed to before switching to solar worsened her health condition, but she did not have a choice. As a result, she used to go to the

hospital three times a month due to asthmatic attacks. Now that she has the SHS, Susan hardly ever has attacks.

"I cannot even remember the last time I went for an injection."

Being in better health has also improved her productivity:

"I now perform better in my farming activities. This has really improved my consistency in working and increased time for working everyday thanks to the solar home system."



55 Leive and Xu (2008), Coping with Out-of-Pocket Health Payments: Empirical Evidence from 15 African Countries.

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

Impact on Quality of Life

Safety

SHS help prevent loss of assets by providing additional security to households and businesses. 91% of households report feeling safer since purchasing the solar home system:

- Outside lights provide protection for household members and livestock

"The light helps me to ensure our safety. For example, wild animals cannot come near the house when there is light."

BBOX Customer, Gasharara, Rwanda

- Lights protect households and businesses against theft of assets or produce

"I feel safer due to security lights outside and I also feel relaxed since thieves don't break into the store anymore since we've installed solar."

Fenix International Customer, Wakiso, Uganda

- No longer traveling to charge phones or buy batteries / kerosene reduces risks

"I no longer have to send the children to the center to buy kerosene which is very far. Their safety is most important for a mother."

Fenix International Customer, Kabwangasi, Uganda

Education

Education is recognized as an important vehicle for poverty alleviation. As noted by UNESCO: "Education provides people with knowledge and skills that increase their productivity and make them less vulnerable to risks. On average, one year of education is estimated to increase wage earnings by 10% – in sub-Saharan Africa, by as much as 13%. Likewise, education enables rural households to diversify their income-earning opportunities, for example through access to more lucrative non-farm work"⁵⁷. Access to safe and bright lights in the home can have a beneficial impact on education by enabling children to do their homework longer and in better conditions.

86% of customers with children report that their children have more time to do their homework since purchasing the SHS.

Having the possibility to work longer and in better conditions allows students to perform better in school and may in turn open new opportunities for them.

"My children can read comfortably. My children used to study for 30 minutes every day from 8.30 pm to 9.00 pm, whereas these days they read for 3 hours, from 7.00 pm to 10.00 pm. The one in class 8 used to be in the 18th position but now he's in the 5th position. The one in class 7 used to be in the 30th position but now he's the 7th position."

M-KOPA Customer, Ainamoi, Kenya



Conclusion

This research, along with the 2018 Powering Opportunity report, provides strong insights into how solar home systems are improving the lives of people living in low-income households. The data shows that the socio-economic impact of solar home systems on households remains consistently high over time.

Almost all customers (95%) would recommend their product to a friend or relative and a striking 94% report that their quality of life improved as they feel healthier (89%), safer (91%) or because their children have more time to study (86%). In addition, 64% of customers say they feel they have more money available since purchasing the SHS. The number of households reporting an economic impact from using the SHS is lower compared to three months after the purchase, hinting to a period of trial and error for certain customers. Overall, 34% of households report undertaking more economic activity since purchasing the SHS.

However, by digging deeper into the economic impacts of SHS, it was found that in most cases where a household is able to undertake more economic activity, more than one member of the household is doing so, earning additional income.

To more clearly demonstrate the impact of this increased economic activity, this research calculated the number of unlocked FTEs, based on the number of extra hours worked thanks to SHS ownership. Overall, the additional hours customers were able to work translate to a significant 21 FTE jobs created for every 100 solar home system used. In total, 52% of them are undertaken by women and 50% are in rural areas.

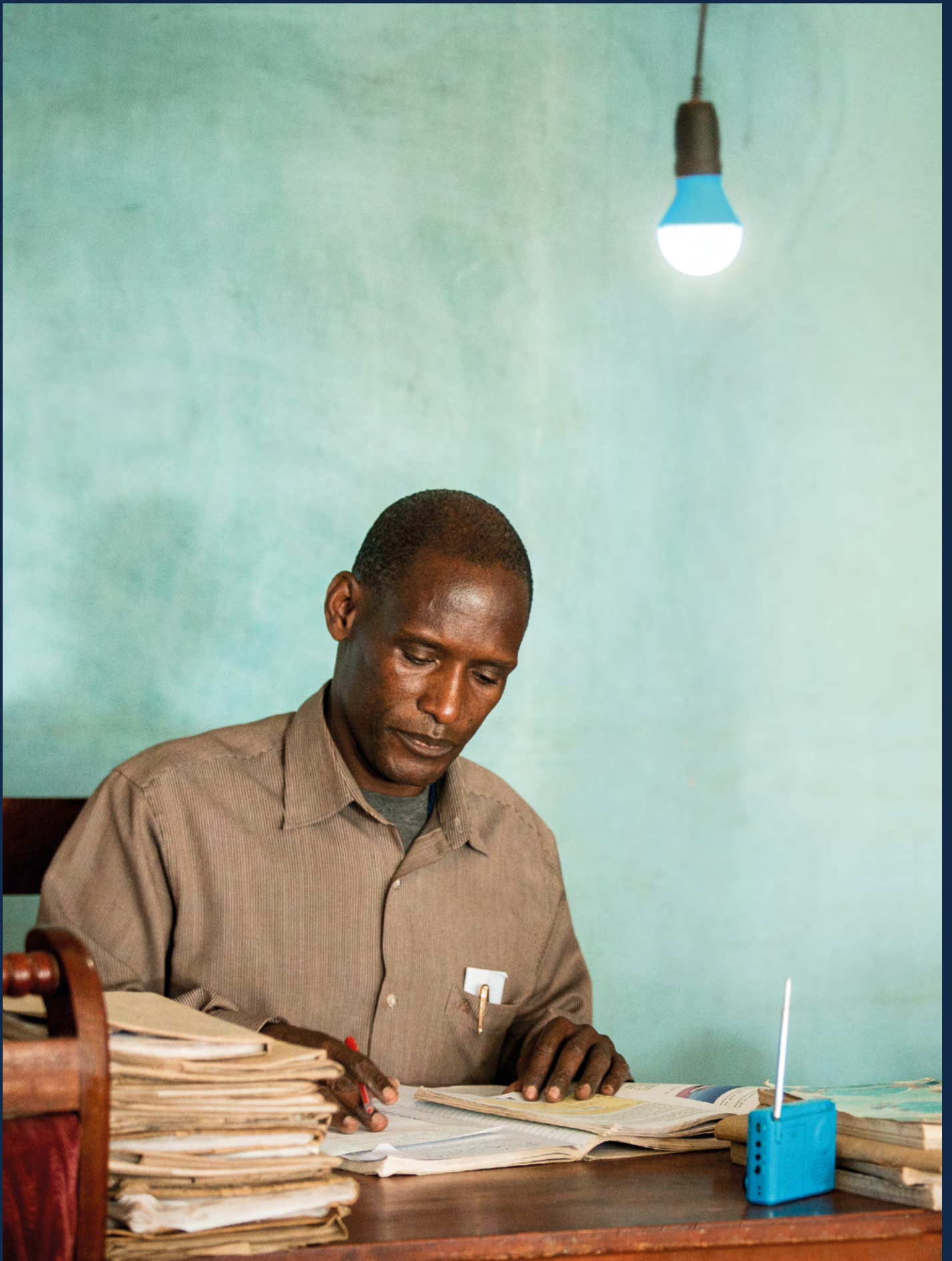
For many customers the system has proven to be a sustainable source of income generation, as 28% of all households report it helps them to generate additional income. This is especially true of customers using their product to create or enhance a business which highlights the potential of SHS to support Micro, Small and Medium Enterprises. The average additional monthly income reported by these households is \$46.

These impacts are significant, especially seeing that 59% of households report earning less than \$3.20 per day, indicating that SHS are reaching low-income households.

The findings in this report show that SHS have an untapped, transformative power. Off-grid solar is reaching low-income households in rural communities in East Africa, providing households with profound social and economic change. We hope that the Powering Opportunity series will help investors, decision-makers and those looking to support the industry to better understand how off-grid solar can impact the lives of households and can be a power tool for change.

Additional research could further support this effort. Areas for further research include:

- What is the impact of solar home systems over the product lifetime, among customers that have paid for their system in full?
- What is the economic impact of productive appliances (refrigerators, hair clippers, water pumps, etc.)?
- How can appliances for SHS support new business creation and increase the output of existing activities?
- What role have companies to play in supporting entrepreneurs?
- How can companies connect with other organizations/programs that train entrepreneurs and help them increase income by using solar?
- How can people use solar to become more resilient for external shocks like climate change and health risks?
- Is there a gender gap between those who benefit from off-grid solar electricity?





Annex





Annex

Product Annex

BBOXX Home



SolarWorks! 40



d.light D30



Fenix International ReadyPay



M-KOPA 400



Mobisol Entertainment



ZOLA Electric TV



Methodology Annex

Primary data collection

During the baseline, the target was for each of the seven participating companies to undertake 500 interviews. Data collection was conducted by the companies at the moment customers purchased the SHS or soon after (at the latest one week after the installation). This avoided the risk of relying on customers' memory for information about their prior situation. At the end of the collection and cleaning, the sample size was 3,307.

Call backs were conducted with customers who had consented to participate in the research. The final sample size after three months was 2,343 and 1,419 after 15 months. Follow up data collection was conducted by Sagaci Research, using tablets and an adapted software. This ensured traceability and enabled extensive monitoring, allowing Altai Consulting to swiftly review and address any irregularities. The quality of the interviews was further ensured through quality control by both Sagaci Research and Altai Consulting. Any irregularities or suspected irregularities in interviews led to their dismissal. Where relevant, further cleaning was conducted by Altai Consulting to ensure the robustness of the data⁵⁸.

Compensating customers for the time spent participating in the survey was at the company's discretion for the baseline and follow-up. However, any such compensation was capped at "one day of light" provided through the SHS to avoid this leading to bias in answers. During the baseline only one company chose to provide compensation, four did so after 3 months and none after fifteen months. No irregularities were noted between answers from customers that were compensated with a "day of free light" when compared to others in the sample.

Final questionnaires were designed by Altai Consulting and GOGLA (see below) and were translated into local languages by Sagaci Research. Baseline survey: Data was collected between October and December 2017.

The survey is comprised of 29 questions.

Part 1: Administrative (filled by company)

- Product information
- Purchase information

Part 2: Basic Demographics

- Purchaser socio-demographics

- Household size and composition

Part 3: Intended use

- Business use
- Home use

Part 4: Previous behaviors

- Sources of light
- Use of light sources
- Energy expenditure
- Mobile phone
- Mobile money

Part 5: Income

- Reported income
- Reported expenses

Part 6: Progress out of Poverty data (only certain companies participated)

Part 7: Conclusion

- Consent for follow-up

After three months survey: Data was collected between February and April 2018.

The survey is comprised of 49 questions.

Part 1: Administrative (filled by interviewer)

- Identifying the correct respondent

Part 2: Perceived value

- Reasons for purchase
- Value for money
- Likelihood to recommend
- Quality of life

Part 3: Current behavior

- Sources of light
- Use of sources of light
- Phone charging
- Appliances
- Energy expenditure

Part 4: Income generation

- Business or income-generating activity
- Income generated

Part 5: Changes in economic situation

- Perceived increase in available budget and use
- More time at work
- New job
- Income generated

Part 6: Perspectives on future of the SHS

- Appliances
- Upgrading

After 15 months survey: Data was collected between February and April 2019.

The survey is comprised of 54 questions.

Part 1: Administrative (filled by interviewer)

Annex

- Identifying the correct respondent
- Part 2: Perceived value
- Value for money
 - Likelihood to recommend
 - Quality of life
- Part 3: Current behavior
- Sources of light
 - Use of sources of light
 - Phone charging
 - Appliances
- Part 4: Economic activity and income generation
- Economic activity undertaken
 - Income generation
 - Time spent working
- Part 5: Income and expenses
- Perceived increase in available budget and use
 - Reported weekly income and expenses

In-depth interview guidelines: Data was collected between April and May 2019.

Guidelines were adapted to each respondent based on two models:

Guidelines for Agent interviews:

- Role as an agent
- Usage of SHS by households
- Economic impact of SHS
- Future perspectives

Guidelines for Customer interviews:

- Usage of the SHS
- Economic impact
- Income and expenses
- Perspectives

Weighting

The weighting was reviewed and updated by a statistical expert.

The sampling methodology used was that of a panel survey design⁵⁹, consisting in selecting a base sample from the target population from which we collected data at an initial point in time and then collecting similar measurements on the same sample at two other successive dates. The analysis took into account the response attrition across the measurements waves as some respondents from the initial sample didn't respond to one or both of the successive waves of interviews.

The original sample was comprised of new customers joining the companies' customer bases between September and December 2017 (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 methodology⁶⁰ 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 our findings. For this study to be representative of a larger population, the assumption that needs to be true is that the surveyed/sampled customers are selected randomly with known probability from the target population: new customers who bought an SHS between July and December 2017. Based on discussions between Altai Consulting, GOGLA and participating companies in 2017, this assumption seems likely to hold true. Indeed, no specific conditions seemed to apply to new customers joining the seven companies' customer bases during the survey period⁶¹.

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 and the non-response due to the respondents' attrition across the consulting waves.

$$\text{Weighting factor} = \frac{\text{Number of occurrences in population}}{\text{Number of occurrences in sample}} \times \text{Non-response factor}$$

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

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

61 Methodology and limitations assessed by an accredited statistician. Details provided in Methodology Annex.

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.

Margin of error

The large sample size provides a satisfactory margin of error of 4.8%. Sample sizes by system size also enable robust analysis with margins of error below (or equal to) 9.1%. In certain instances, the report uses data based on smaller sub-samples to showcase interesting results. Use of these analyses, especially for extrapolation, must be undertaken with care.

Sample	Sample size	Margin of error
Total	1,419	4.8%
3-10.99 Wp	441	7.7%
11-20 Wp	444	9.1%
50+ Wp	534	7.6%

Incomplete data

The baseline data was collected by each company with the exception of ZOLA Electric (formerly known as Off-Grid Electric) for whom data was collected by Sagaci Research in a process managed by Altai Consulting. For those companies who conducted data collection themselves, a certain flexibility was afforded. Companies could provide some of the data from their own system if they had collected it previously (socio-demographics for example) so as to shorten the survey with clients. This process was able to benefit from the initial customer interaction undertaken by all companies and to limit the impact on the customer and customer relationship. However, this led to some instances of missing data on socio-demographics and baseline sources of light, as reflected in smaller sample sizes in some analysis.

Income and expenses

The baseline survey included questions on reported total weekly household income and expenses. Out of caution, this data was not used in analysis for the first Powering Opportunity report. Results

from questions on more specific and targeted expenditure (spending on light and phone charging) and income (additional income generated) were included as these present a much smaller risk of inconsistency.

The survey conducted after 15 months included reported weekly household income and expenses. This data was considered to be more robust than that collected during the baseline by the SHS providers themselves. This was established through consistency checks. However, the data is used with caution and to a very limited extent. This caution is because reported income may not necessarily be wholly accurate. For example, informal occupations commonly undertaken in the regions covered by the research mean many customers have fluctuating income, making it difficult to fully assess, or as interviewees may not have a comprehensive knowledge of the entire household income.

Progress out of Poverty Index

Questions for the PPI were originally included in the baseline questionnaire but due to the length of the questionnaire, these were made optional and were finally collected by too few companies to be used. However, PPI results were used to triangulate the income and expenditure questions answered by customers after 15 months.

Data cleaning

Recoding

- Other: for several questions, the response "other" was possible and led to a follow-up question requiring customers' to specify the response. Wherever possible, these answers were recoded into existing pre-coded responses or if a sufficient number of specified answers were similar, a new code was created.
- Income generation: In rare cases, when a customer claimed to generate additional income but reported a \$0 amount, they were considered not to generate income.
- FTE jobs: In rare cases, when households reported economic activity but then reported 0 household members took part in the activity, this activity was excluded.
- Sources of light: In the case of two companies, interviewers did not record more than two sources of light. Follow-up data collection conducted by Sagaci enabled the research to pick-up the additional sources of light and recode them in the baseline.

Annex

Double counting

- To avoid double counting additional economic activities and income generation, only one instance of income generation was included where customers reported the same income for several economic activities.
- Customers reporting they used the system in a business and income generating activity and claiming the same income in another economic activity were considered to only have a business or income generating activity. Customers who claimed to have more time at work and a new job and earn the same amount were considered to only be spending more time at work.

Analysis

Qualitative data showed the distinction between these the “new job” and “more time spent at work” categories used in the initial Powering Opportunity report did not hold true in the context of SHS customers. As such, to better represent the impact of SHS after 15 months, these two categories were blended and considered from an additional work hours perspective, with a shift in measurement from the share of households undertaking activity to FTE jobs.

When showing data for the share of household where the SHS unlocks additional time and opportunities for economic activities, double counting has been removed.

Eliminating outliers

- A small portion of reported additional incomes were considered extreme values and were not included in the calculation of averages. The maximum monthly income was set to \$200. This was confirmed through qualitative interviews with customers and sales agents.
- For the calculation of FTEs, certain reported number of hours at work were considered extreme values and were not included in calculations. The maximum amount of time spent at work is 12 hours a day for a business and the legal working week for each country is used as an upper limit for customers reporting that they work more (see below).

Calculating FTE jobs

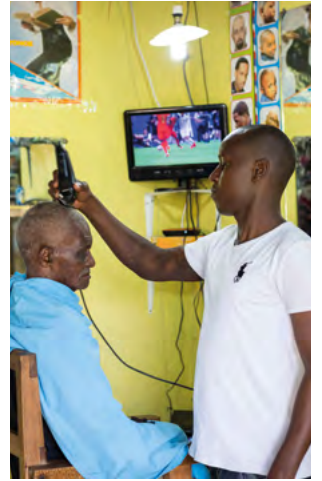
FTE jobs were calculated relatively to the legal working week in participating countries: Kenya 53 hours, Uganda 49 hours, Tanzania 49 hours, Mozambique 49 hours and Rwanda 46 hours. Customers reporting an existing business were asked to report the increased number of opening hours per week. The number 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 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.

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.







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The Voice of the **Off-Grid Solar Energy** Industry