GOGLA

The Voice of the Off-Grid Solar Energy Industry

Powering Opportunity
The Economic Impact of Off-Grid Solar

UKaid from the British people

altai consulting

About

GOGLA
GOGLA is the voice of the off-grid solar lighting and electrification sector. Established in 2012, GOGLA now represents over 130 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. Altai's teams operate in over 50 developing countries in Africa, the Middle East and South Asia.

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Foreword

When GOGLA was established six years ago, its mission was to create a thriving off-grid solar market to help millions living in energy poverty access clean, affordable electricity. This mission was based on the fundamental understanding that access to energy changes lives. We presented ourselves with a significant challenge: to accelerate the speed at which we reach one of the key sustainable development goals, Access to Energy.

Since then, the notion that the private sector can deliver off-grid solar and accelerate energy access has been well proven.

Off-grid solar lighting and electrification products sold by GOGLA's 130 members have now reached over 100 million people worldwide. This success has been the result of a combined effort, from pioneering companies to forward thinking decision makers and bold investors. Yet what really propels this new market forward are the millions of customers who recognise that off grid solar can help them to save money, breathe cleaner air and light up their homes.

Yet the scale of progress is still not nearly enough. Success remains limited to too few companies in too few countries. Too many potential customers cannot yet be reached, with one billion still without access to energy. We will need to go further, faster. The call for a more targeted focus on off-grid solar must be heard louder and clearer. The success stories must be shared wider. And particularly, the evidence of the profound impact of this success needs to be shown convincingly and forcefully.

For this reason, we worked with seven pioneering industry partners to gain new insights into the transformational impact of solar kits and solar home systems. The aim of this research was to gather measurable proof of the stories these companies were hearing every day from their customers: that solar home systems are catalysing economic activity, powering businesses and improving quality of life.

'Powering Opportunity: The Economic Impact of Off-Grid Solar' highlights how a seemingly small intervention, bringing a solar system into a home, can unlock out-sized gains in welfare, productivity, and income generation. Off-grid solar has the potential to lift millions of households across Africa and Asia out of energy poverty and to open-up new economic opportunities for the next generation.

Today, our mission remains as important as it was six years ago, but what has fundamentally changed is that we now have unequivocal evidence on the impact of the off-grid solar industry. This report should be used as a meaningful force to propel us towards greater and faster action. By working together to support off-grid solar, we can power enterprise, boost well-being and bring clean energy access to all.

Koen Peters, *Executive Director, GOGLA*

Table of Figures

Table of Contents

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Executive Summary

'Powering Opportunity: The Economic Impact of Off-grid Solar' provides powerful insights into the benefits of off-grid solar power. Namely, that solar home systems (SHS) are catalysing economic activity, creating income and improving quality of life.

It is well-known that off-grid solar can deliver benefits to wellbeing and the environment, but until now, the impact of off-grid solar on economic activity, such as improved access to jobs and business opportunities, has been less clear. This research provides quantifiable evidence that, for a majority of households, solar home systems are being used to power enterprise and unlock working hours – with many reporting an immediate increase in income.

Thanks to funding from the UK's Department for International Development (DFID), researchers were able to collect and analyse data from over 2,300 new off-grid solar users in Kenya, Mozambique, Rwanda, Tanzania and Uganda. Together, these five countries represent around 45%[1] of the global off-grid SHS market. Seven leading Pay-As-You-Go (PAYG)[2] companies participated in the research, the first time such a large number of companies have joined forces to gather customer insights and impact knowledge.
The research found that nearly 60% of off-grid solar customers undertook more economic activity within just three months of purchasing a solar home system; whether gaining a new job, using their system directly within a business, or being able to work for longer.

For more than a third of customers, this access to electricity has already enabled them to increase their monthly income by $35 a month, more than half the average monthly GDP per capita[3].

In addition, over 90% of households that replaced toxic kerosene lamps with solar alternatives report that they have experienced improvements in both health and feelings of safety.

Off-grid solar is recognised as a fast and affordable alternative for scaling up energy access across the globe, delivering a wide range of improvements to quality of life. This research clearly shows that off-grid solar can also scale up economic opportunities for customers and catalyse enterprise and employment in off-grid communities.

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1 Based on H2 2017 sales figures collected by GOGLA
2 Pay-As-You-Go (PAYG): refers to a business model that allows users to pay for their product via consumer financing. A PAYG 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 years. Source: Off-Grid Solar Market Trends Report 2018, Lighting Global
3 Average GDP per capital in Kenya, Mozambique, Rwanda, Tanzania and Uganda (World Bank, 2017). https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=KE-TZ-RW-UG-MZ

To create a robust data-set, interviews were undertaken with 2,343 solar home system customers.

Customers from seven companies were surveyed both at the time they purchased their system (baseline) and three months later (follow-up). Interviews took place in five countries.

Countries

- Kenya
- Mozambique
- Rwanda
- Tanzania
- Uganda

Companies

BBOXX, d.light, mobisol, solarworks!, fenix intl, ZOLA, M-KOPA SOLAR

Data showed that for a majority of households (58%), the SHS has helped unlock new economic activity.

These activities have been classified into three categories: spending more time at work, using the SHS in a business and getting a new job. 15% of households are benefitting from more than one activity.

After only three months, 36% of households already generate more income. On average, these households make an additional $35[4,5] per month.

Calculated over the lifetime of the product, additional income could exceed $2,000[6].

44% **The SHS enables a household member to spend more time at work**

24% **The SHS is used in a business or income generating activity**

7% **The SHS enabled a household member to get a new job**

4 This figure includes households combining additional incomes through more than one activity
5 All monetary amounts in this report expressed in USD unless specified otherwise
6 Expected product lifetime is computed using the warranty and a standard multiplier: Warranty * 1.5. Source: GOGLA

Solar home systems unlock additional work hours

Improved access to light and power unlocks previously unproductive hours: allowing 44% of users to be more flexible with their daily activities and spend more time at work.

Almost half of these customers have already found these extra work hours enable them to make more income: on average, an additional $25 per month.

Off-grid solar creates new job opportunities

In 7% of households the SHS had enabled a member to get a new job, with 69% of these households reporting an immediate increase in income.

On average, customers who have been able to take on a new employment make an additional $28 per month.

SHS can enhance business revenue

13% of customers use the SHS to support a business they operated prior to purchasing their system: primarily shops, stalls, bars or restaurants.

11% of customers started a new enterprise after purchasing the SHS. The most common being a phone charging business.

Overall, 24% of customers use their system to support their business, with 89% seeing this reflected in increased revenues. On average business owners generate an additional $29 per month.

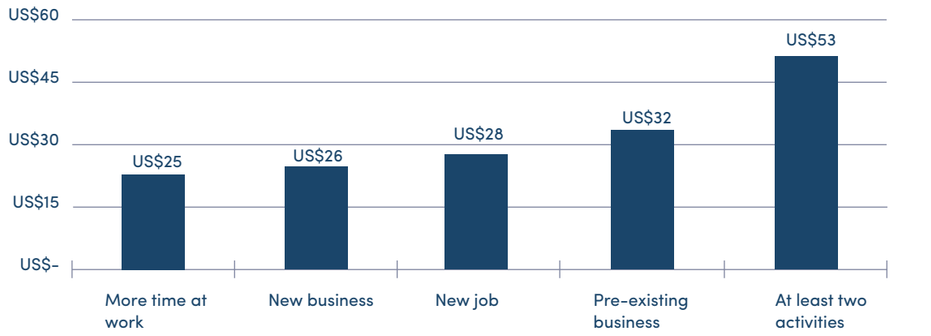
Although phone charging for a fee is the most common activity overall, the biggest returns are seen in retail shops, which increase their revenue by an average of $36 per month.

As well as uncovering the extent of economic activity enabled by the SHS across all households, results on the use of the system in existing businesses, or to start a new business, show a strong potential for use in Micro, Small and Medium Enterprises (MSME).

Customers combining two or more of these economic activities are creating the largest increase in income: on average $53 per month.

Average additional monthly income generated by type of economic activity

N (More time at work) = 359
N (New business) = 220
N (New job) = 99
N (Pre-existing) = 220
N (At least two activities) = 236



A solar lantern is the first step on the 'energy staircase', with many customers then moving to SHS.

Nearly a quarter of customers climbed further up the clean energy staircase – from a solar lantern to an SHS: indicating that, for many, lanterns are paving the way for greater levels of energy access. All customers surveyed now have mobile charging in their home, and 38% have gained access to television. 89% of customers use their phone more since purchasing the SHS, while 86% of TV owners watch it every day.

Viewed through the Sustainable Energy for All Tiers of energy access[7] 31% of households surveyed have been able to reach Tier 2.

Solar home systems have an overwhelmingly positive impact on welfare and well-being.

94% of households report that their SHS has improved their quality of life and 96% would recommend it to friends or family – testifying to their high satisfaction with their system. This improvement in quality of life is due to a number of factors, including:

Cleaner air

91% of households that previously used kerosene for lighting report their health has improved since they bought the SHS. In these households, SHS replaced an average of 1.7 kerosene lamps - reducing or eliminating the indoor pollution they generated and its detrimental consequences on health and the environment[8].

Improved safety

In addition, 91% of households feel safer since purchasing the SHS, with safety encompassing a variety of elements. For some customers it is a reduction in injuries related to kerosene burns or falling in the dark[9], while others say the light helps them to ward off thieves, attackers or wild animals at night[10].

More study-time

Lastly, additional hours of light in the home led to more study time for children. 84% of households with children report that they now have more time to do their homework.

These results highlight how off-grid solar can drive economic activity, create new business opportunities and enable households to increase their income. Data also confirms that access to off-grid solar leads to significant improvements in quality of life and welfare. The research finds that solar home systems can act as a catalyst for more resilient and sustainable economies and can further efforts to meet several UN Sustainable Development Goals.

7 SE4ALL Multi-Tier Framework approach to measuring energy access:
Tier 1: Defined either by a minimum power capacity of 3W or 12Wh or by a service of lighting of 1,000 lmhr/day with a minimum availability of 4 hours per day
Tier 2: Defined either by a minimum power capacity of 50W or 200Wh or by a service of electrical lighting, air circulation, television and phone charging are possible with a minimum availability of 4 hours per day
8 Lam, Nicholas & R Smith, Kirk & Gauthier, Alison & Bates, Michael. (2012), "Kerosene: A Review of Household Uses and their Hazards in Low- and Middle-Income Countries". Journal of toxicology and environmental health. Part B, Critical reviews. 15. 396-432. 10.1080/10937404.2012.710134.
9 Graham and Tevosyan, Perceived Health Benefits of Off-Grid Products: Results of an End-User Survey in Uganda, unpublished draft (2018), https://www.finca.org/wp-content/blogs.dir/1/files/2014/02/Perceived-Health-Benefits-of-Off-Grid-Products_White-Paper.pdf
10 See ZOLA Electric Case Study, Chapter 6

10 KEY FINDINGS

1

58% of housholds undertake more economic acitivites thanks to their solar home system

2

36%

of housholds generate additional income once they purchase an SHS

3

Housholds create an additional $35 per month on average

Amoung households generating income

4

44%

of customers can spend more time at work

As they have more light hours and time due their SHS

5

11% of customers started a new business

6

In **7%** of households, owning an SHS enabled someone to get a new job

7

89%

of customers report they use their phone more since using their SHS

8

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

9

91% report their health has imporved since buying the SHS

Among households that used kerosene

10

84% of customers say children have more time time to their homework

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1. Introduction

1.1 Context and objectives

1.1 billion people do not have access to electricity[11]. In 2017, the International Energy Agency (IEA)[12] estimated that to meet the Sustainable Development Goal 7 of energy access for all, almost half of the households to be electrified need to be reached via decentralised renewable solutions[13]; for which off-grid technologies will need to provide access to 55 million homes.

However, off-grid solar is still often overlooked in energy access and development planning and financing. Only a quarter of governments[14] in 'access deficit' countries[15] have strong regulatory frameworks for off-grid solar solutions in their energy access plans, and only $1 out of every $1,000[16] invested into sustainable energy goes to off-grid solutions.

Where a supportive environment has enabled the sector to grow, off-grid solar is already enhancing lives, by replacing dangerous kerosene lanterns and candles and providing access to services such as phone charging, television and productive use appliances. Worldwide, over 100 million people have benefitted from improved energy access through off-grid solar technologies[17].

Although rapid expansion of the off-grid solar market was initially driven by sales of solar lanterns, between 2013 and 2017 innovation in multi-light kits and solar home systems enabled sustained market growth for products offering capacities beyond lighting only: these products now represent a quarter of annual volumes[18]. The growth of the SHS system segment has largely been driven by PAYG volumes which grew at an average annual rate of 140% between 2013 and 2016 to reach 80% of solar home systems sold in 2016[19]. With PAYG, customers can pay for their system or service in instalments, allowing them to access previously unobtainable technology and levels of energy.

The PAYG business model has also been a catalyst for investment. 85% of funds raised in off-grid solar from 2012 to 2017 have been raised by PAYG businesses[20].

Yet, while several research efforts highlight the transformative impact of switching from kerosene lamps to solar lanterns – including significant savings, additional study hours and health and safety benefits – (SolarAid[21], Harrison et al[22], Aevarsdottir[23], Hassan and Lucchino[24]) less evidence has been collected on the impact of this growing segment of SHS, or about the effect of these systems on jobs, income, business creation, time spent in productive work, etc.

To fill the data gap, this research sought to build on the current body of work and explore the impact of SHS, from multi-light and phone charging kits (3-10.99 Wp) to larger SHS (11 – 200 Wp). In particular, it aimed to understand whether these systems are contributing to increased productivity, and to uncover the extent to which they are helping to meet the energy needs of off-grid households. For these reasons the research focuses on the effect that solar home systems have on economic activity and quality of life.

Companies selling many different sizes of products, as well as a variety of accompanying appliances, took part in the research (see Annex 1). This also allowed for analysis across system sizes, providing unique insights into the impacts created by different product categories.

11 IEA (2017), Energy Access Outlook 2017, https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
12 The IEA is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 29 member countries and beyond
13 IEA (2017), Energy Access Outlook 2017
14 World Bank (2016), RISE Report 2016, http://documents.worldbank.org/curated/en/538181487106403375/pdf/112828-REVISED-PUBLIC-RISE-2016-Report.pdf
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16 Financing the Future: Accelerating investment in inclusive, sustainable energy systems—the Ashden International Conference 2018 https://medium.com/william-joseph/financing-the-future-accelerating-investment-in-inclusive-sustainable-energy-systems-the-e578809a3195
17 GOGLA (2017), Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data January-June 2017, https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth12017_def.pdf
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23 Aevarsdottir et al (2017), The impacts of rural electrification on labor supply, income and heath: experimental evidence with solar lamps In Tanzania, 2017, https://www.tessabold.com/uploads/7/0/1/0/70101685/welfare_effects_of_solar_power_september_2017.pdf
24 Hassan and Lucchino (2016), Powering Education 2, Enel Report, https://www.enelfoundation.org/content/dam/enel-foundation/download/poweringeducation/PoweringEducation%202%20-%20Final%20Paper%20-%20Enel.pdf

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1.2 Methodology

This research set out to talk to as many off-grid solar customers as possible, from the widest range of countries and companies.

Seven PAYG solar home system providers, operating in several countries, joined the research effort: BBOXX (Rwanda), d.light (Kenya), Fenix International (Uganda) M-KOPA (Kenya), Mobisol (Tanzania), SolarWorks! (Mozambique) and ZOLA Electric (Tanzania). Companies supported the research by providing access to their customers for data collection and, in most cases, by gathering baseline data in their initial interaction with the customer – either at the point of sale, or shortly afterwards.

Solar home systems such as those sold by the companies participating in this research are primarily targeted to households in remote and 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 solar home systems as a back-up or even a replacement to the grid to maintain a constant level of service. Customers were included from a range of different locations, ensuring that the research reflects impact across rural, peri-urban and urban areas.

As the impact of off-grid solar systems is felt by a whole household, this is used as the primary unit of measurement.

SHS are first and foremost addressed to households, therefore, assessing how an SHS affects an individual person would only provide a limited understanding of its impact. As a result, this research focuses on the household, and uses the households as a unit of measurement in nearly all cases, even when the SHS is used for business purposes.

SHS vary greatly in power capacity and therefore in the services they provide and in their cost for the consumer. This research aims to understand the variations in impact between different system sizes.

The products in this study range from 8W to 200W. The simplest systems include two lights and phone charging, the most complete systems include more than ten lights, torches, multi-port phone chargers, TVs and radio.

The variety of different services available across the products included in this study also comes at different costs. This range of system sizes and accompanying appliances meets the different needs, aspirations and budgets of off-grid customers. One of the objectives of the research is to explore the impact of SHS based on their system size (as denoted by the panel size).

To support this aim, an approach to categorisation was taken which considered a) the product sizes purchased by the customers interviewed in this research and b) the broad categorisations 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 research[25]. 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" (see more details on the next page).

The research includes responses from customers located in urban, peri-urban and rural regions.

Countries

- Kenya
- Mozambique
- Rwanda
- Tanzania
- Uganda

3-10.99 Wp	11-20 Wp	50+ Wp
d.light D30 (10 Wp)	Fenix Home Comfort LFP (17 Wp)	BBOXX Home (50 Wp)
Fenix ReadyPay (8 Wp)	M-KOPA 400 (20 Wp)	Mobisol Family SHS (80 Wp)
Fenix Home Starter LFP (10 Wp)	ZOLA Electric Home (12 Wp)	Mobisol Entertainment SHS (120 Wp)
Solarworks! SW40 (10 Wp)		Mobisol Business SHS (200 Wp)
		Solarworks! SW200 (50 Wp)
		Solarworks! SW400 (100 Wp)
		ZOLA Electric TV (50 Wp)

Each system size can power different appliances and provides different levels of service as shown in Figure 1. Additional information on the products in the research are available in the Annex.

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

Approach

The joint approach between GOGLA and Altai Consulting was conducted in several steps:

Planning and preperation → **Baseline data collection** → **Initial analysis** → **Follow-up data collection** → **Analysis and reporting** → **Iteration and dissemantion**

25 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.

Data collection maximised the benefit of company interactions with their customers, as well as the expertise of dedicated in-country research teams.

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 centralised and analysed by Altai Consulting. Follow up data collection was managed by Altai Consulting with their market research partner Sagaci Research conducting phone-based interviews. Altai Consulting again provided training and continued guidance to the Sagaci in-country research teams, before centralising and analysing the collected data. Data collection was conducted using tablets and an adapted software to ensure traceability and enable 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 data[26].

Follow up data collection was undertaken three months after baseline interviews.

This timeframe enabled customers to have used their system for several weeks before they were asked whether, and how, the SHS had impacted their economic activity or quality of life.

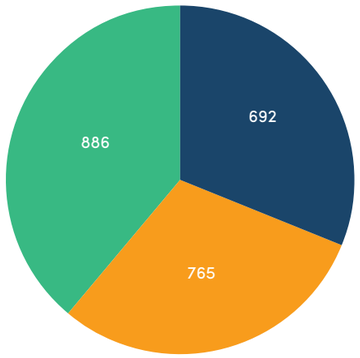
Overall, baseline and follow-up interviews for 2,343 customers composed the final dataset

The sample size enables a margin error of maximum 3.8% at a 95% confidence level, guaranteeing the robustness of the analyses. Data sets for each of the system sizes are large enough to provide margins of error between 6% and 7%. Each includes results from over 690 customers.

To ensure representativeness, the final database was weighted based on H2 2017 sales of each product by company and country. Results also comply with the industry standard "three data-point rule".

GOGLA respects a three-data-point rule when using its Member company's 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 one case study per company that may provide company-level data.

Figure 2: Sample size by system size



System size	3-10 Wp	50+ Wp	50+ Wp
Interviews	692	765	886

Definitions

Solar Home System: SHS are 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. SHS are often defined as 11 Wp and larger, while systems between 3-10.99 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 (3-10.99 Wp), the specific system size, or the term 'multi-light kits' will be used.

Pay-As-You-Go (PAYG): refers to a business model that allows users to pay for their product via consumer financing. A PAYG 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 years[27].

Energy expenses: For the purpose of this research, energy expenses simply refer to the sum of lighting and phone charging expenses. Other expenses such as transportation costs to purchase combustibles, or where customers used to pay to watch TV elsewhere etc. are not considered.

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

Limitations and risks

There are a number of limitations and cautions to the use of this data and analysis and users are asked to note that:

- 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.
- Given the variety of business models and products[28], results may be more representative of the customer base of the participating companies rather than the off-grid sector in East Africa as a whole. However, the research revealed the same impacts for all companies and, although some differences exist between system sizes, the overall results are homogeneous. This suggests the results of the research can be confidently extrapolated to East Africa and Mozambique.
- This study relies exclusively on data from East African nations and Mozambique. Whilst a strong homogeneity was seen in results, given that there is limited impact research in other geographies, caution should be used when extrapolating the results of this study beyond East Africa.
- 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. Additionally, 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).

26 Details provided in Methodology Annex
27 Details provided in Methodology Annex
28 Details provided in Methodology Annex

2. The Solar Home System Customer

2.1 Socio Demographics

The typical purchaser of the SHS is a 37-year-old male living in a rural area with a wife and three children. However, there is a wide variety of purchasers and types of household that use SHS which this section will explore in more detail.

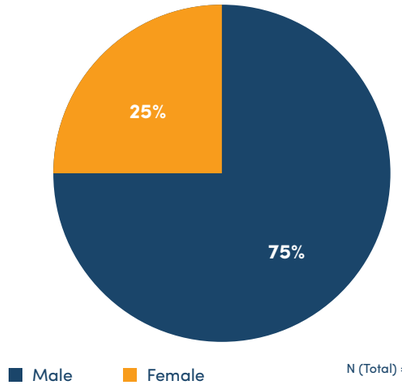
Typical SHS Purchaser

Household size

The households that purchased the solar home systems are relatively large with an average of 5.6 members, slightly higher than the average for East African nations and Mozambique[29].

The average household hides a wide variety of profiles with 4% of households comprising just one adult living alone while 8% of households have ten or more members. 11% of households have no children and 17% have five children or more. The typical household has two or three adults but 18% of households have four or more adults.

Figure 3: Gender of purchaser split by system size



N (Total) = 2,340[30]

Overall, 51% of individuals benefitting from the systems are children and 50% are women or girls.

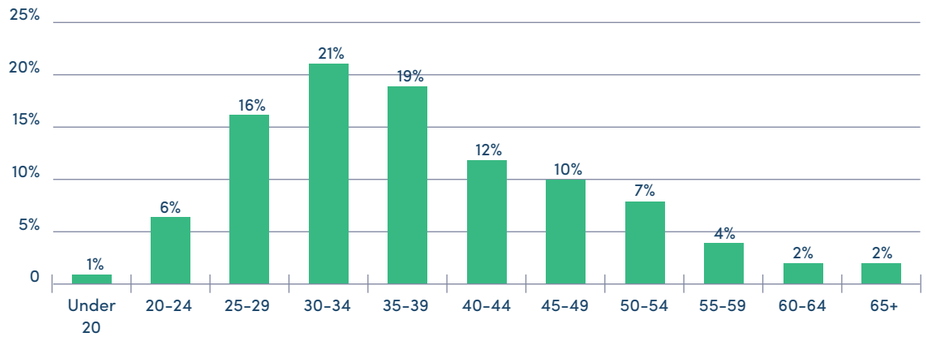
Gender and age

Looking more specifically at the household member identified as the purchaser, three-quarters are men, with only a quarter women (see Figure 3).

Most purchasers are between 25 and 40 years old (see Figure 4), with only 15% of customers over 45.

Figure 4: Age distribution of purchasers

N (Total) = 2,316[31]



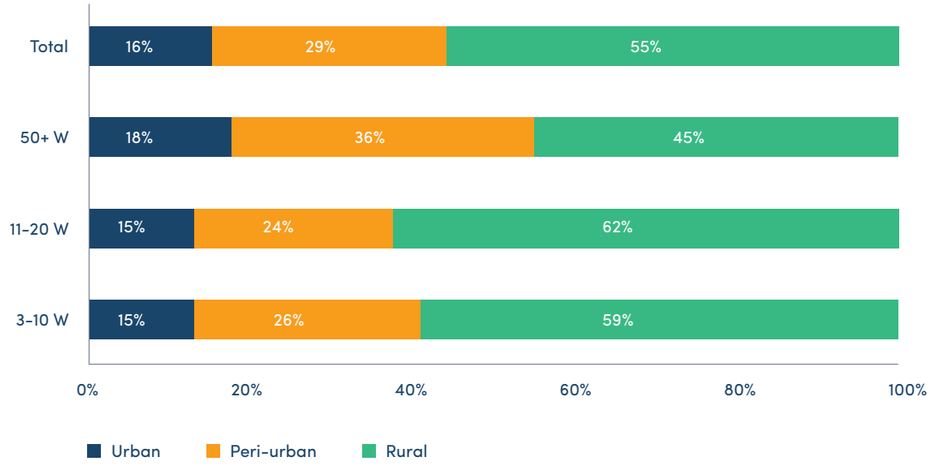
Type of location

Households energy needs also depend on their type of location. Within this research, locations were classified as either urban, peri-urban or rural based on the population of the locality they inhabit[32]. For the two smaller system sizes, up to 20 Wp, approximately 60% of customers live in a rural setting, 25% in peri-urban areas and 15% in towns. Customers of larger systems (50+ Wp), are likely to be more urban with a majority living in an urban or peri-urban setting (see Figure 5).

It should be noted that these location types are specific to the customers interviewed in this research and have not been weighted to reflect the wider customer base of participating companies.

Figure 5: Customer distribution by type of location split by system size

N (Total) = 2,343



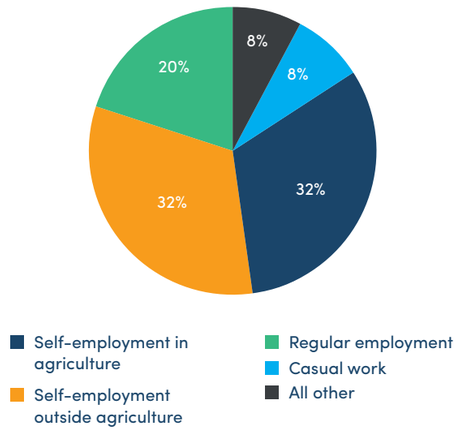
Source of income

Despite a majority of customers living in rural areas, agriculture is the main source of income for only about a third of customers, on par with self-employment outside agriculture.

Only a fifth of customers report having regular employment. Most customers are likely to rely on irregular or seasonal sources of income and to have multiple revenue streams. As we will see in this research, the SHS can play an active role in diversifying and increasing revenue streams for these households.

Figure 6: Distribution of customers by main source of income

N (Total) = 2,343



29 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)
30 Missing baseline data for three customers
31 Missing baseline data for twenty seven customers
32 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

What is the income level of households purchasing SHS?

Collecting accurate data on total individual or household income is always challenging, especially in emerging markets where income is often irregular and depends on several sources. While efforts were made to assess these aspects through survey questions on: reported average income per week, reported average expenses per week and, where possible, the Progress out of Poverty Index (PPI), customers were not always able to provide an accurate picture of their full range of weekly, or monthly expenditure. For this reason, total income and expenditure data captured has not been used for the analysis within this report.

Results from questions on more specific and targeted expenditure (spending on light and phone charging) and income (additional income generated) have been included as these present a much smaller risk of inconsistency, the quality of responses was high, and as there was significant homogeneity in results – underlining their validity.

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2.2 Customer experience

For nearly three quarters of customers, the main reason to purchase a solar home system is to gain reliable access to light (74%), with the second most common driver being the ability to charge mobile phones (42%) – both are foundational services provided by all sizes of solar home system (see 7 Figure).

When looking at both customers primary and secondary reasons for purchase, the possibility to purchase a TV was the third largest driver (9% of all mentions), with this rising to nearly a quarter (23%) when looking at only those customers who purchased a TV with their system. Other motivations reported by customers were linked to benefits gained through use of the system, including safety (6%), security (5%) and the ability to make savings (5%).

Customer Motivation – by System Size

When looking at the reasons for purchasing the SHS by system size (see Figure 8), it appears that customers with a 3–10.99 Wp system are slightly more likely to mention savings as a driver, they also seem to value the phone charging capacity more. The possibility to get a TV is particularly important for 11–20 Wp system customers. However, 3–10.99 Wp system purchasers also mention this as a driver which could indicate that some customers hope to be able to upgrade to a larger system in the future.

Figure 7: Two main reasons for purchasing the solar home system

N (Main) = 2,343 N (Second) = 2,285[33]

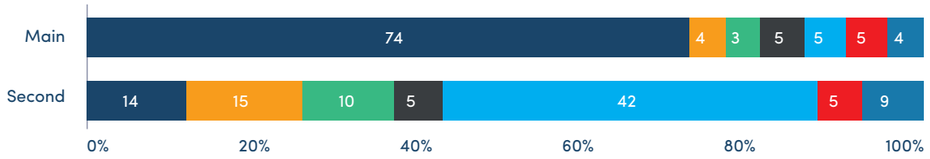
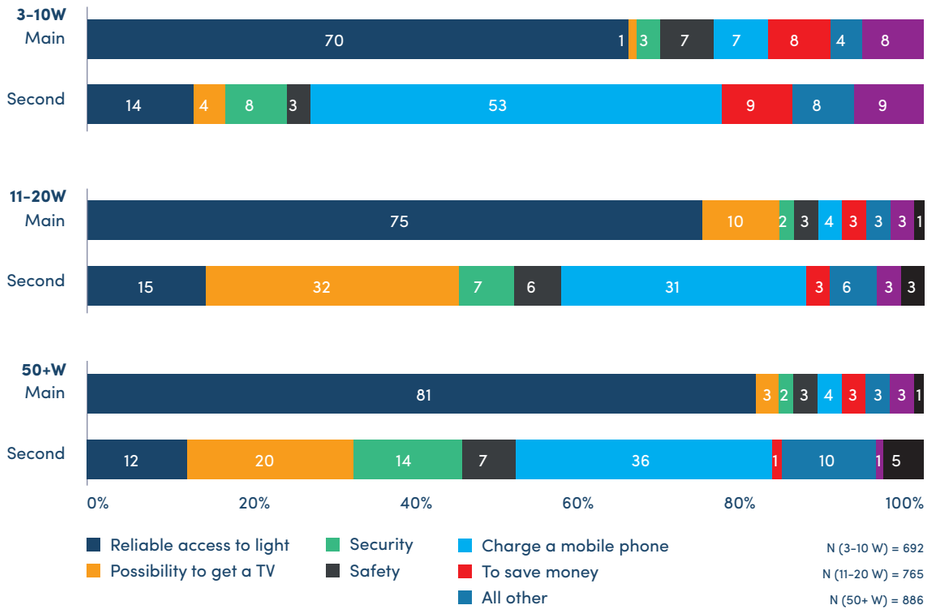


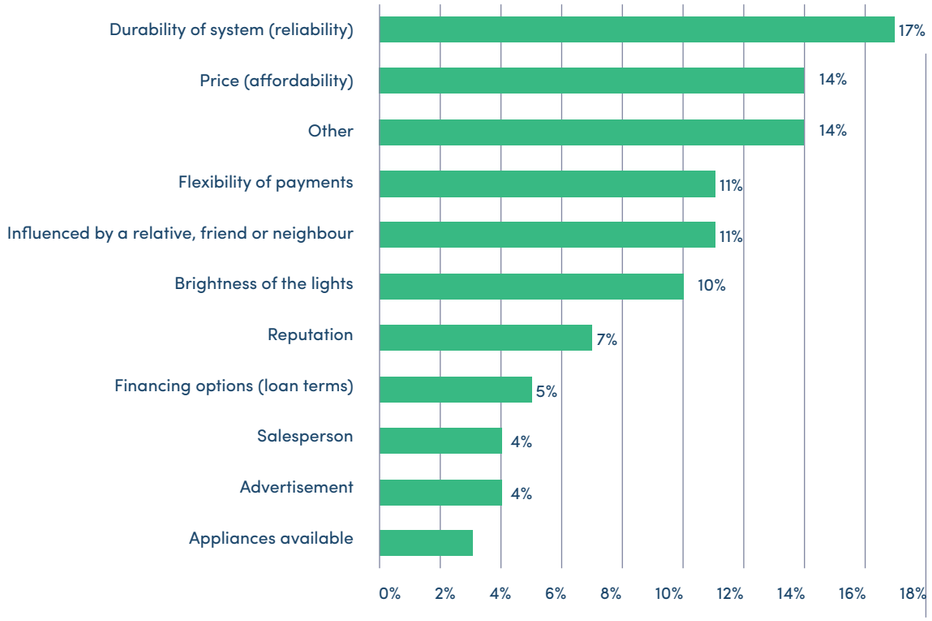
Figure 8: Two main reasons for purchasing the solar home system split by system size



33 Some customers only provided one reason

Figure 9: Drivers of brand or product choice

N (Total) = 1,165[34]



Other includes a broad set of responses of which a few stand out: customer services, warranty, product aesthetics and promotions.

58% of customers reported that they were aware of other, similar products in their market alongside the SHS they chose.

To better understand the drivers of purchase, we asked these customers why they picked their SHS above other products available. The key criteria for favouring one product over another were highlighted as the durability of the system (17%) and its price (14%) (see Figure 9). In making their choice of system, many customers also mention the flexibility of payments (11%) and the influence of relatives, friends or neighbours (11%).

Criteria for product choice – by system size

Flexibility of payment appears as a key criterion for 3-10.99 Wp system purchasers. This could potentially indicate that the ability to pay for their system in instalments was a key factor in allowing these customers to access solar products.

Interestingly, 50+ Wp system customers are more likely to mention affordability as a reason for choosing the system they purchased (see Figure 10).

This may be as customers of larger SHS are slightly more likely to be located in urban or peri-urban areas and may see purchasing the SHS as an alternative to grid connection. Grid connection can often include a very high upfront cost, even before the daily cost of energy or the purchase of appliances. For example, in Tanzania, a grid connection for an urban home can cost up to $300 before any other expenses[35].

Figure 10: Top 5 drivers of brand or product choice

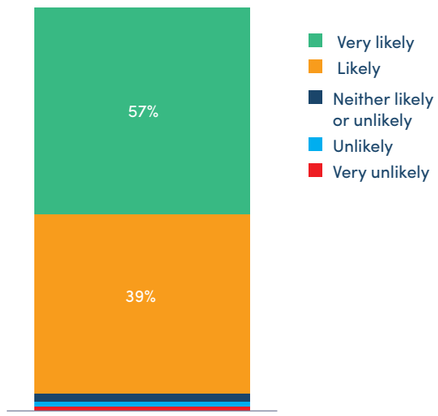
N (3–10 W) = 367
N (11–20 W) = 309
N (50+ W) = 489

34 Among customers aware of similar products in the market
35 http://www.tanesco.co.tz/index.php/customer-service/service-line-application

Likelihood to recommend the system

Overall, customers seem very satisfied with the products they have purchased as demonstrated with the high likelihood to recommend the SHS across the board: 96% of customers are likely or very likely to recommend their product (see Figure 11). The figure even reaches 98% for the 3-10.99 Wp systems.

Figure 11: Likelihood to recommend



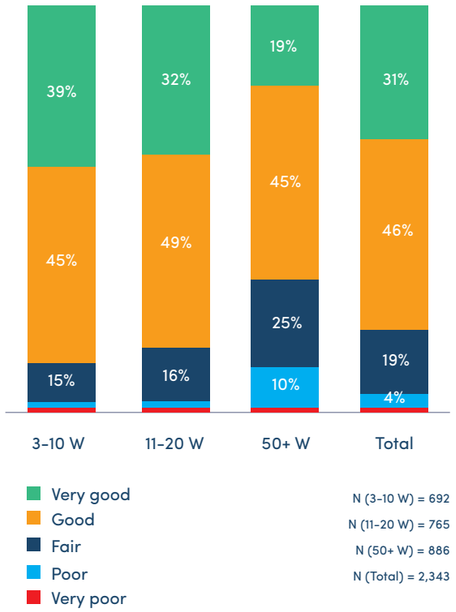
N (Total) = 2,343

Value for money

While still very positive, the perceived value for money is slightly more varied (see Figure 12). Although there are still over three quarters of customers (77%) who feel the value for money is good or very good, almost a fifth (19%) categorise this as fair, and a few customers feel it is poor (4%) or very poor (1%).

Viewing this by system size, it is notable among households having purchased a larger 50+ Wp system that the share of customers perceiving the value for money as low or very low is highest (11%) suggesting that, when compared to smaller system sizes, the additional expense is a factor. However, it is interesting that, despite this, nearly all 50 Wp customers claimed they were either likely or very likely to recommend the product and reported quality of life improvements as very high (see Section 5). This suggests that, even for those who find the system is expensive, the wider access to power is still having a very positive effect overall.

Figure 12: Perception of value for money by system size



N (3-10 W) = 692
N (11-20 W) = 765
N (50+ W) = 886
N (Total) = 2,343

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3. The power of off-grid solar

3.1 Improved access to light

As evidenced from the analysis of purchase drivers, access to light is the most immediate benefit felt in the household.

Purchasing the SHS allows many customers to access bright and reliable light for the first time. For others who have already replaced traditional energy sources, such as kerosene or candles, with solar lanterns, the improvement is more incremental, and the value of the solar system is delivered through the additional services it provides.

Previous sources of light

To understand these different narratives, customers were asked to cite up to four main sources of light they used before purchasing the SHS (see Figure 13).

Across the board, kerosene was the most commonly used source of light and was the primary source of light for almost 40% of customers.

The smaller the size of the purchased SHS, the more likely customers were to have been using kerosene as a primary source of light before purchasing their SHS. More than half of 3-10.99 Wp customers relied on kerosene as their primary source of light compared to just 15% of 50+ Wp customers.

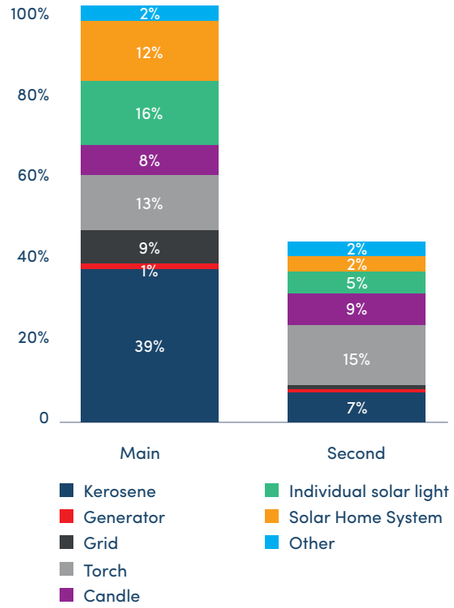
Solar products were already quite common. 28% of all customers used a solar product as a primary source of light with 16% using a solar lantern and 12% using some form of solar home system[26].

Customers purchasing larger systems were more likely to have had solar products beforehand, with 38% of 11-20 Wp and 43% of 50+ Wp customers already relying mainly on solar energy as a lighting source. This data would tend to confirm the notion that some customers progress along an energy staircase[37], upgrading their energy service or stacking energy solutions (e.g. combining the use of both solar lanterns and SHS). 60% of all customers reported using only one source of light before they purchased the SHS. However, among households using two sources or more, the most popular auxiliary sources were torches and candles. 11-20 Wp system purchasers were more likely to report previously using more than one source of light.

It should be noted that the sources of primary and secondary lighting used by a household were, and continue to be, influenced by the common lighting sources used in a specific country or region, as well as the maturity of the market for solar products.

Figure 13: Main sources of light used before purchasing the SHS[38]

N (Total) = 2,343



	3-10 W	11-20 W	50+ W
Most common primary source	Kerosene	Kerosene	Solar lamp
Share of users	53%	41%	30%
Second most common primary source	Grid	Solar lamp	Torch
Share of users	12%	20%	21%
Most common auxiliary source	Torch	Torch	Torch
Share of users	16%	36%	14%

Current sources of light

Overall, the SHS have been widely adopted as the primary source of light. Among the few who use a different primary source of light, the most common is the grid. Three months after their purchase, 50% of households still use auxiliary sources. The most popular remains torches which could be explained by the need for transportable light outside the home and as a torch remains an asset the household is unlikely to throw or give away. 3-10.99 Wp and 11-20 Wp customers who were generally more reliant on kerosene prior to their purchase are also more likely to still use kerosene, albeit as an auxiliary source of light.

Increased access to light

The first and foremost benefit of the SHS for customers is an increase in the number of hours of light available to them on a daily basis (see Figure 14). Most customers now have more than six hours of light per day when only a quarter had that level of service before purchasing their SHS. Purchasers of systems that are 50 Wp or more are even more likely to report having more than six hours of light per day (see Figure 15).

By unlocking more time, additional hours of light can lead to a wealth of opportunities for households to improve their quality of life and access economic opportunities (see Case Study: Through the Lens).

For the vast majority of customers, the SHS also means a consequential improvement in the brightness of light.

Indeed, while the average lumen output for a kerosene lamp is 20[39], the lumen output of products in this research, based on the middle setting (of low-mid-high), ranges from 110 to 720[40], and can be up to 40x brighter.

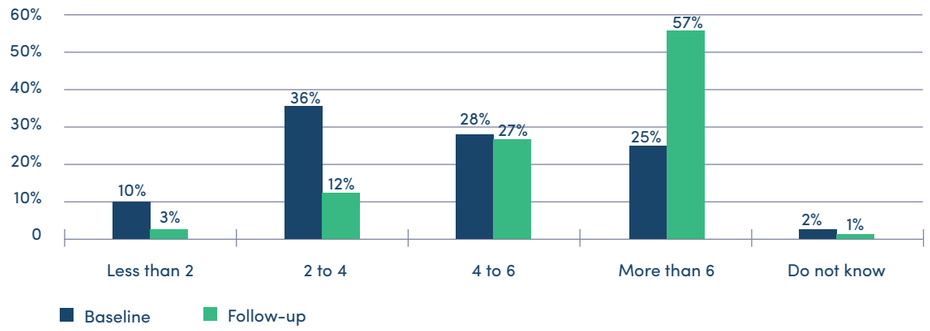
Households are using their lights for longer than six hours

On average, customers had 4.2 hours of light previously and now have 5.3 hours per day. Customers perceived an increase of at least an hour of light. Households primarily using torches or candles before their purchase of an SHS felt the highest increase at 1.7 hours.

However, it is important to note that the increase of over an hour of light seen in this research is most likely an underestimation, as the exact number of hours above 6 hours is not known[41]. Companies usage data suggests that customers may commonly use lighting for more than 6 hours, and several accounts suggest that families often use one of the solar lights as an over-night security light. This is especially true of larger systems of 50Wp or above.

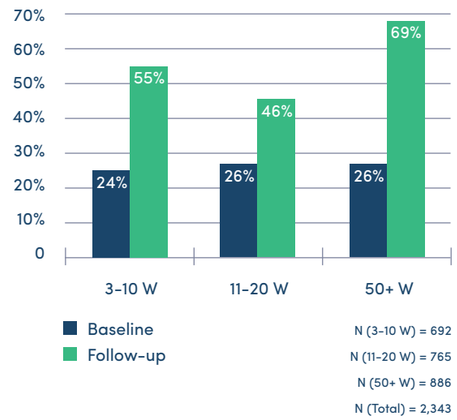
Figure 14: Evolution of number of daily hours of light available

N (Total) = 2,343



36 The definition of solar home system was purposely quite broad to capture customers using unbranded products
37 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 recognises 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.
38 The graph shows the main and second sources of light mentioned by users. Some users mentioned up to four sources of light
39 GOGLA Standardised impact metrics for the off-grid energy sector, 2016
40 Based on Mid-Lumens settings data provide by participating companies to GOGLA
41 Details provided in Methodology annex

Figure 15: Share of customers with six hours of light or more by system size



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BBOXX affords its customers more time[42].

A majority of BBOXX customers surveyed in this study report increasing their number of hours of light per day by almost 3 hours. This additional light can have a transformative impact on people's day to day lives and on their livelihoods. To highlight this, the company shared an excerpt from the project 'Through the Lens: Energy Access Stories of Solar Home System Users in Rwanda', part of Iwona Bisaga's PhD, conducted at University College London in collaboration with BBOXX.

Through the Lens: Energy Access Stories of Solar Home System Users in Rwanda
Relying on kerosene lanterns and battery-powered torches for lighting one's house makes it challenging to perform even basic activities, like cooking, reading or socialising. Holding a lantern or a torch and still getting sufficient light around you is not easy, neither is it cheap, convenient or comfortable, especially if you need to do it every day, or rather - every night. And the night in Rwanda always falls at the same time: by 6:30pm it's completely dark. That's at least four hours spent in darkness or a poorly lit environment if you don't have access to a reliable, bright light source. Deo from Musanze was well aware of all those challenges, having experienced them for years. Until one evening when he was working on the porch of his house, from where he runs his tyre cutting business. A BBOXX Sales Agent was passing his compound and spotted Deo and his co-workers toiling in the dark, with only a dim light flickering somewhere among them. It was that Agent who told Deo about a solar home system and how it could make it easier for him, his family and co-workers to perform activities after dark, including those involved in the business. Soon after that conversation, Deo decided to subscribe to BBOXX's services. His words reflect the changes that have occurred since, in his family and in his business:

"There is a big difference, for example I always keep the lights on and we don't get switched off. Even when we want to work until 11:00 pm, we can do it without any problem, unlike when we were using torch batteries because we used to fear that the batteries would get drained. My torch batteries used to drain so fast and it was so expensive. But now I can watch TV, listen to the news all over the world. My wife is also able to cook and help the kids to take a shower in the evening. Before, it used to be very difficult because the lantern brightness could not reach all the places of the house. But with the system she can do all the activities from whichever side she wants. She can also wash dishes in the evening, all this because of the brightness of the lights. Many things have really changed that drove me to get rid of kerosene."

It has now been over two years since Deo adopted his system. Extended hours with a bright light has been one of the major benefits for him and his family members. He has also grown his business as he can now cut more tyres and do it more precisely, increasing productivity. With the growing demand, he had to employ more workers. His family can also do various activities after dark which were not possible or limited before, including watching TV and enjoying dinner in a bright place. Having light might be the most basic of one's energy needs, but it can also be one of the most transformative. And, as not all lights are the same, those that are bright, clean, last longer, and are convenient to use can make a big difference not only for a family's well-being, but for their livelihood as well.

DEO AND HIS CO-WORKERS ON THE PORCH OF HIS HOUSE WHERE HE RUNS HIS BUSINESS.

© Iwona Bisaga

42 Through the Lens: Energy Access Stories of Solar Home System Users in Rwanda (2018) Iwona Bisaga

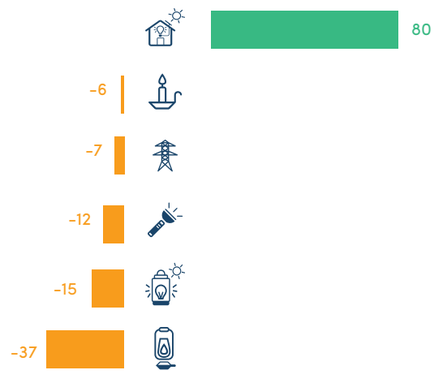
Sources of light evolution

As illustrated by the baseline sources of light, purchasing the SHS can have different effects on households depending on which sources of light are used less or abandoned in favour of the solar home system. Figure 16 gives an overview of the evolution of primary sources of light. Unsurprisingly, with the adoption of the SHS, all other sources of light are used less.

Among the 7% of customers who do not use the SHS as a primary source of light, the most common explanation is that they are connected to the grid and are using the system to provide a backup supply of electricity (23%). This is followed by customers experiencing technical issues (21%) and customers who have not paid their fees (12%). Finally, a few customers mention different reasons for favouring other sources, such as needing more lights (10%), more power (9%) or finding other sources cheaper (5%).

Figure 16: Evolution of primary sources of light expressed in percentage points (pp)

N (Total) = 2,343



From the analysis of the sources of light evolution, two specific narratives emerge:

Kerosene replacement

In many households, the main impact of the SHS is the reduction of kerosene use. Kerosene as a primary source of light is nearly eliminated dropping from 39% to 1%.

77% of households using kerosene before purchasing the SHS have abandoned the use of kerosene altogether rather than using it at as a back-up light. Therefore, the share of households using kerosene as a secondary source did not increase much, growing from 9% to 12%.

Across all households previously using kerosene, the solar home system replaced an average of 1.7 kerosene lamps with the following split by system size:

It is important to note that, while larger systems tend to eradicate more kerosene lanterns in an individual household, households that purchased 50+ Wp systems are also less likely to be using kerosene on average (as they are more likely to already use solar products such as solar lanterns or grid electricity in their homes). This means that, while a larger system may replace more kerosene lamps than a smaller system at the individual household level, overall, more kerosene is replaced by smaller systems.

Reducing or eliminating the use of kerosene as a source of light is one of the ways SHS can have a transformational impact, not just at a household level through improved quality of life and safer living conditions, but on a large scale due to the detrimental effects of kerosene lamps on health and the environment.

Energy staircase

For some households, purchasing the SHS is their first access to solar products, but others are moving up from solar lamps to solar home systems and many are gaining access to additional energy services through the ability to power appliances.

Overall, 65% of SHS customers were new to solar, 22% already had a solar lamp and 13% already had a SHS (see Figure 17).

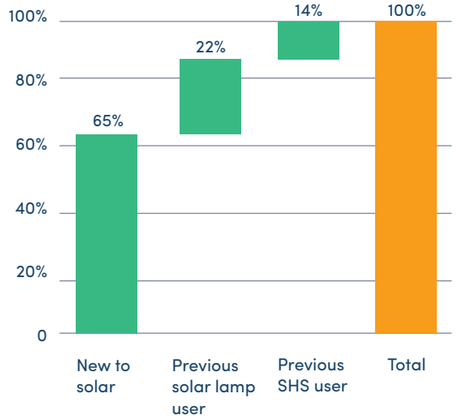
Another way to look at improvement in energy access is through the lens of the SEforALL Multi-Tier Framework[43].

31% of the customers interviewed moved up from Tier 0 or 1 to Tier 2 which is defined either by a power capacity above 50Wp (or 200Wh) or by the capacity to provide electrical lighting, air circulation, televisions and phone charging with a minimum duration of four hours per day.

The share of customers accessing Tier 2 for the first-time is 96% in the 50 Wp category. Those who did not gain access to Tier 2 by purchasing the SHS were already considered to be accessing Tier 2 as they reported having access to the grid when they purchased their solar home system. However, by augmenting grid power with SHS, these customers may in practise be reaching a higher Tier of energy access.

Figure 17: Energy staircase

N = 2,343



Reducing toxic black carbon through off-grid solar

In a recent study (Lam et al. 2018), researchers examined the effects of introducing solar lamps into kerosene lamp using households on air quality and exposure to air pollutants[44]. Using a suite of sensors to measure pollution and lamp use, they were able to show that the use of solar lamps coincided with large reductions in kerosene lamp use, particulate matter (PM2.5) concentrations in rooms, and exposure to PM2.5 of household members. The largest benefits were experienced by children – who often used kerosene lamps late into the night – for whom average PM2.5 exposures fell by an average of 70%. PM2.5 is often considered the most reliable pollutant indicator for assessing disease risk, and observed reductions were suggestive of health benefits for all members of the house.

In addition to the health impacts of reducing kerosene at the household level, there are also benefits for the climate. A characteristic of the particles emitted by millions of kerosene lamps is that they are rich in 'black carbon', a strong climate warming pollutant. From a previous study, it was estimated that the effect on climate from the black carbon emitted from kerosene lamps globally was equivalent to about 4.5% of the United States' carbon dioxide emissions and 12% of India's[45].

As Dr. Lam explains: *"the fact there is evidence that solar lighting can meaningfully reduce reliance on kerosene lamps with the potential for significant health and climate benefits is extremely encouraging. There are often many trade-offs and challenges facing the transition to a low carbon energy system, but this is the closest to an all-round win as I've ever seen."*

43 SE4ALL Multi-Tier Framework approach to measuring energy access: https://www.seforall.org/sites/default/files/Beyond-Connections-Introducing-Multi-Tier-Framework-for-Tracking-Energy-Access.pdf . MTF classifies energy services in five tiers. Tier 0 is no service, tier 5 is full service. Tier 0: no access to electricity, Tier 1: Defined either by a minimum power capacity of 3W or 12Wh or by a service of lighting of 1,000 lmhr/day with a minimum availability of 4 hours per day. Tier 2: Defined either by a minimum power capacity of 50W or 200Wh or by a service of electrical lighting, air circulation, television and phone charging are possible with a minimum availability of 4 hours per day

44 Lam et al (2018), Exposure Reductions Associated with Introduction of Solar Lamps to Kerosene Lamp-Using Households in Busia County, Kenya, Indoor Air 2018, 28 (2), 218–227

45 Lam et al (2012), Household Light Makes Global Heat: High Black Carbon Emissions from Kerosene Wick Lamps, Environ. Sci. Technol. 2012, 46 (24), 13531–13538.

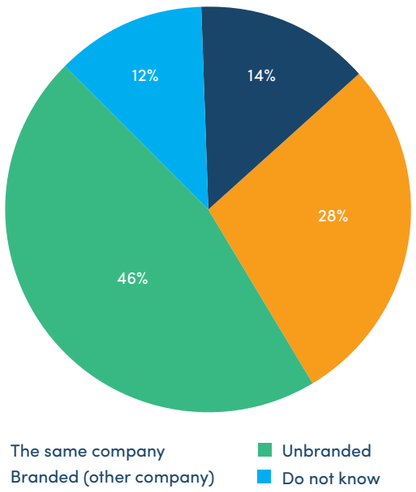
The Customer-Company Journey

Just under half of the solar products used by customers before they bought the SHS covered by this study were unbranded (see Figure 18). The fact that durability is the most common driver of purchase[46] of the specific SHS in this research indicates the quality of these branded products is well understood. In this context the switch from unbranded to branded solar products could result from customers having a first experience with solar but now seeking higher quality. In addition, over 40% of customers were already using a branded product before they bought their SHS. Amongst them, a third moved to the same brand.

In the 3-10.99 Wp category, these are mainly households moving up from a solar lamp to an SHS (see d.light Case Study below) while the 11-20 Wp category includes more people upgrading from a previous SHS. While this study did not explore the energy staircase through a lens of brand-loyalty, this indicates that some customers are responding to the opportunity to upgrade or access a larger product through their current customer-company relationship and value the brand.

Figure 18: Origin of solar products used by households before purchasing the SHS

N (Total) = 948[47]



d.light enables its customers to climb the energy staircase[48]

Close to a third of d.light's customers used solar products before purchasing the SHS. For almost half of them this was a d.light solar lamp, showcasing the company's ability to attract PAYG customers from its existing base of solar lantern users.

"We spend a lot of time connecting with our customers to understand how they use their products, and how we can best meet their needs – helping us to continuously improve our service. This was why, after years directly selling solar lanterns, we began to offer PAYG products to our customers. For as little as $5, d.light has helped millions of off-grid households move from toxic kerosene to clean solar lanterns. With PAYG, we can now offer our customers an affordable way of bringing even more energy into their homes through our solar home systems — along with all of the benefits that come with them." Douglas Gavala; Regional Research Manager Africa; d.light

46 Among customers aware of similar products available in their market
47 Among households using solar products before purchasing the SHS
48 Quote provided by d.light

A maturing market

The data in this research on repeat sales of solar products from the same brand shows signs of a maturing market, where customers have already accessed solar products before and know their benefits or, in some cases, have already repaid a PAYG product or upgraded. The data also suggests there is brand awareness in the surveyed market as more than 40% of customers knew their previous solar product's brand.

As more and more PAYG customers reach the end of their product repayment period, we are likely to see more households transitioning to purchase new appliances or upgrade to larger SHS. With certain companies, customers are also able to access PAYG financing for other products such as clean cookstoves or bicycles[49].

As markets and business models continue to evolve, it will be informative to explore the impact of this customer relationship on greater access to energy, appliances and other services. More details on the products customers would like to purchase in future can be found in Section 6.

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49 M-KOPA (2015), Affordable, clean energy: a pathway to new consumer choices, http://www.m-kopa.com/wp-content/uploads/2015/10/Affordable-Energy-Lightbulb-Series-Paper1-6.pdf

3.2 Phone charging, radios and television

Solar home systems go beyond lighting and provide the capacity to power or charge appliances. Customers no longer need to rely on others to charge their phone and have access to information and entertainment in their homes.

Phone charging

The most commonly included feature in SHS is phone charging capacity. Prior to their purchase of their system, the vast majority of customers paid to charge their phones. This implies that most customers had to leave their home to charge their phone and charging came at an additional cost, resulting in significant periods of time when the phone might be switched off.

Since purchasing the solar home system, 93% of households no longer pay for phone charging (see Figure 19) and 89% report they can use their phones more (see Figure 20).

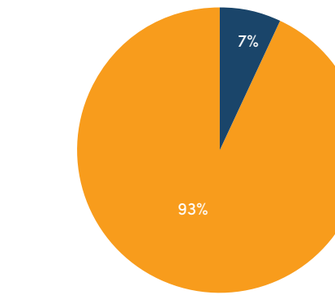
On average, each household has 2.3 mobile phones. As we will see further on, having a phone charger and more reliable access to a mobile phone comes with several benefits including savings and economic opportunities.

Among the 7% of households still paying for phone charging, almost a fifth of customers mention that this is because they are spending many hours away from home during the day, while another fifth highlights a lack of power or incompatibility between the phone and system. However, the most common explanation from customers who still pay for phone charging is that this is because they are having technical issues with their SHS or have not paid their fees.

In almost all cases where more power is now available, customers use the opportunity to charge their phones and stay connected. In a few cases, phone availability directly impacts a household's livelihood. For example, 2% of customers mention that having their phone charged more often is the main reason they able are to work more (see Section 4).

Figure 19: Share of customers no longer paying for phone charging

N = 2,343



The Power of Connectivity

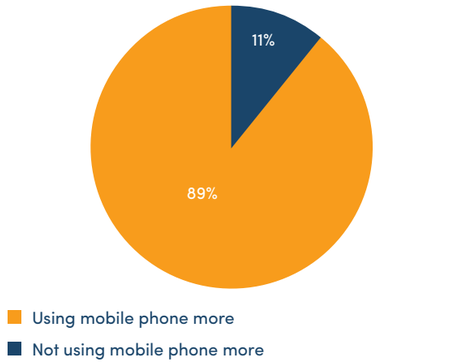
Findings from several pieces of research by GSMA show the breadth of impacts created by increased mobile phone access and PAYG technology.

As Michael Nique, Director of Research & Insights for the GSMA M4D Utilities program, explains:
"The links between access to energy and greater connectivity are clear. If you have access to local power solutions, you can keep your phone charged and benefit from the value of connectivity, i.e. stay in touch with family and business contacts, get information for your work or community and increasingly, get access to mobile financial services. With the emergence of mobile value-added services aiming to improve agricultural, health and education outcomes, the opportunities are far-reaching.

With PAYG technology, evidence suggests that mobile energy payments can also drive greater financial inclusion for unbanked households, especially in rural areas. By building alternative credit scores based on customers' mobile energy payments, PAYG providers are able to provide larger solar systems and/or appliances, such as DC TV, to enable customers access to broadcasted programs. More energy, more connectivity and more informed, inclusive communities is a powerful and transformative combination."

Figure 20: Increased phone usage since purchasing the SHS

N = 2,343



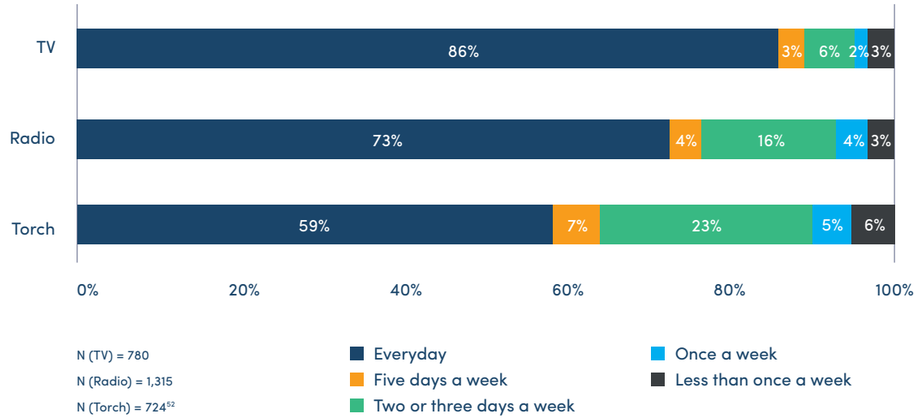
Appliances

The solar home systems encompassed in this research also frequently include appliances such as torches, radios and TVs. Overall, radios are the appliances most commonly included with an SHS and therefore the most commonly used appliance. However, when looking at the utilisation rate of appliances, TVs are the most popular.

Additionally, frequency of use data confirms the popularity of television, with 86% of TV users reporting they watch it every day (see Figure 21). Recent research by M-KOPA[50] finds similar results and reports that customers average three hours of television use a day. Their research also highlighted that televisions have the potential not only to inform but to increase political awareness. Other studies also highlight the educational role that TV can play in highlighting social issues or disseminating best practices on topics such as health or financial inclusion[51].

The popularity of TV is further confirmed by the fact that it is the most sought-after appliance for customers who do not currently own one (see Section 6).

Figure 21: Frequency of use of appliances among appliance users



N (TV) = 780
N (Radio) = 1,315
N (Torch) = 724[52]

50 Tuned-in, Television and civic engagement in off-grid society, M-KOPA, 2017
51 Global Leap, The State of THE Global Off-Grid Appliance Market
52 Among households using the appliance with their SHS

3.3 Energy expenditure

Understanding how the purchase of the SHS affects a household's energy expenditure is complex. This report provides insights into what the repayment fees represent in relation to previous expenditure on lighting and phone charging and attempts to showcase the financial impact for the customer over the life-time of the product.

This research is not a fully-detailed cost-benefit analysis. Many costs incurred by off-grid customers accessing energy-based services are not included (transport, paying to watch TV, etc.) and the acquisition of additional products purchased with the solar home system, such as radio, multiple lights and television, are not directly comparable to prior costs.

Nonetheless, the data collected and analysed does provide a key narrative which will be further explored in this section: during the repayment period, most customers will spend more money on energy on a regular basis than they did previously, but the system brings them a lot of added-value and the majority of them will make savings over the life-time of the product.

Energy Spending Evolution

On average, before they purchased the off-grid solar systems covered by this study, households reported spending $2.4 per week or $124 per year on energy, which is defined here as lighting and phone charging. Differences by system size were relatively small, ranging from $2.3 per week for those who bought a 50+ Wp system to $2.5 for purchasers of the 3-10.99 Wp systems.

After their purchase, most households experience a significant decrease in their energy expenditure when excluding the fees for the solar home system. 60% of households no longer spend money on lighting and 93% no longer spend anything on phone charging.

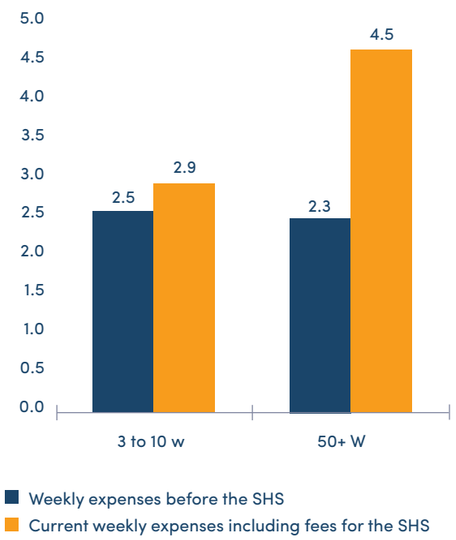
When including SHS fees however, the weekly energy expenditure is usually higher than previously (see Figure 22). On average, households spend an extra $1.1 per week. While for smaller systems this increase is lower than $0.4, households using 50+ Wp systems see a more than $2 increase in weekly energy expenses (see Figure 23).

Despite this, 18% of customers make weekly energy savings that are large enough to cover their weekly fees for the SHS. This is true for 21% of 3-10.99 Wp customers and 12% of 50+ Wp customers.

Please note that, due to limitations in data collection and the application of the three-data-point rule, results for 11-20 Wp category cannot be expressed on the topic of expenditure (in Sections 3.3 and 4.2).

Figure 22: Evolution of weekly energy expenses since purchasing the SHS (USD) N = 1,677[53]

Figure 23: Weekly energy expenses evolution (USD) by system size N = 1,677



This comparison is only indicative as many other costs could be considered such as transportation expenses, time spent travelling or informal costs linked to accessing certain sources of light.

In addition, the off-grid systems generate many other benefits: access to radio, TV or other appliances, more lights, and opportunities to improve the household's quality of life and economic situation. This research advises that the comparison between the SHS and previous expenses on light and phone charging do not uncover the whole picture, and that full cost benefit analysis would be needed to assess the true impact of this change. Moreover, as is explored later in this section of the research, energy expenditure over the lifetime of the SHS paints a different picture – with significant savings being seen by a majority of households.

Focus on lighting expenses

Before purchasing the solar home system, households spent an average $1.4 per week on lighting, with a small majority (51%) of customers paying less than $1 per week (see Figure 24).

Average lighting expenses do not vary much from system size to system size but the diversity of previous sources of light means expenditure varies a lot from household to household leading to surprising results. For example, the 50+ Wp category includes a significant share of customers (13%) who spent more than $2 per week, in part due to a small portion of customers using generators as a primary source of light and spending upwards of $10 per week. At the same time, 34% of 50+ Wp system users spent less than $0.5 on lighting compared to just 17% in the 3 - 10.99 Wp category. This is because 50+ Wp customers were also more likely to have solar lamps before purchasing their SHS. While these customers would therefore be paying nothing for lighting on a day-to-day basis (most solar lamps are sold upfront in cash), many 3 - 10.99 Wp customers were relying on more expensive kerosene.

Fluctuating kerosene prices

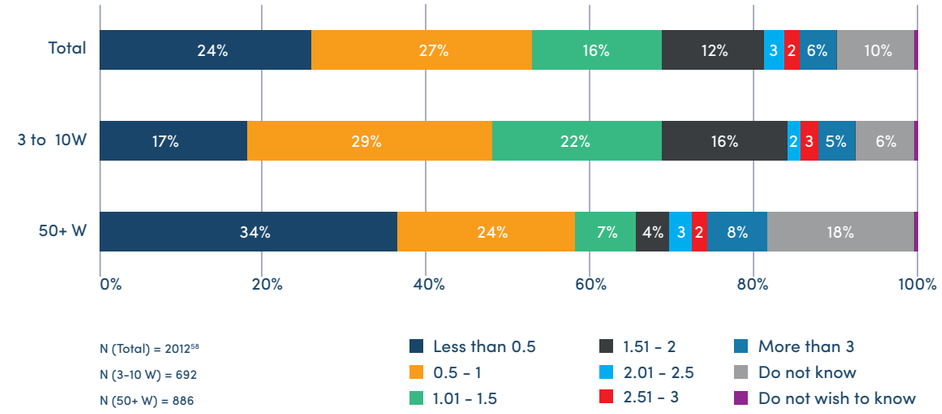
Being the most common source of light before purchasing the SHS, how the cost of kerosene evolves has a strong influence on the financial benefits of the SHS for the households. During the baseline data collection for this research, the price of a barrel of crude oil was fluctuating between $50 and $60[54]. In this period, customers using kerosene as a primary source of light reported spending an average of $5.9 on light per month. 22% of these customers began making energy savings once they had purchased their SHS.

By the time follow-up interviews were being collected, the barrel prices had risen to between $60 and $70. Based on these prices[55], the same households' previous light expenditure would have reached approx. $6.5 per month, meaning that 25% of them could have been making energy savings[56].

If oil prices return to the $100 level they often reached between 2010 and 2014, those same households would have been spending $10 per month on lighting[57] and 41% would be making savings on a regular basis by purchasing an SHS.

53 Excluding data from one of the seven companies and customers who answered "do not know" for lighting expenses, phone charging expenses or number of phone owners in the household. Details provided in Methodology Annex
54 Crude oil barrel price: $58.55 (November 1st 2017)
55 Crude oil barrel price: $65.46 (March 1st 2018)
56 For simplicity, projections assume an increase in crude price translates into an increase in kerosene price in the same proportion
57 This model does not account for any behavioural change

Figure 24: Distribution of customers by previous lighting expenses (USD), split by system size

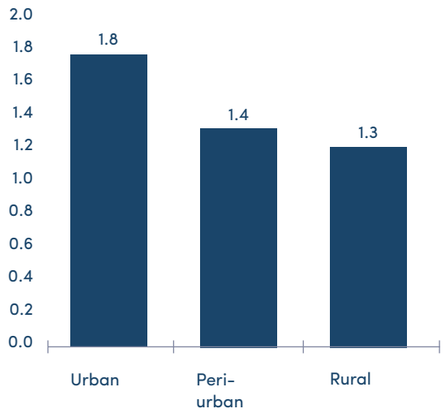


The difference in lighting expenditure varies more significantly by type of location, with urban customers previously having an average lighting expenditure of $1.8 compared to $1.4 for peri-urban customers and $1.3 for rural customers (see Figure 25).

Analysis of previous lighting expenditure by energy type shows that, on average, customers using solar products before had the lowest lighting expenses ($1-1.1), with those using the grid reporting the highest ($1.5, see Figure 26).

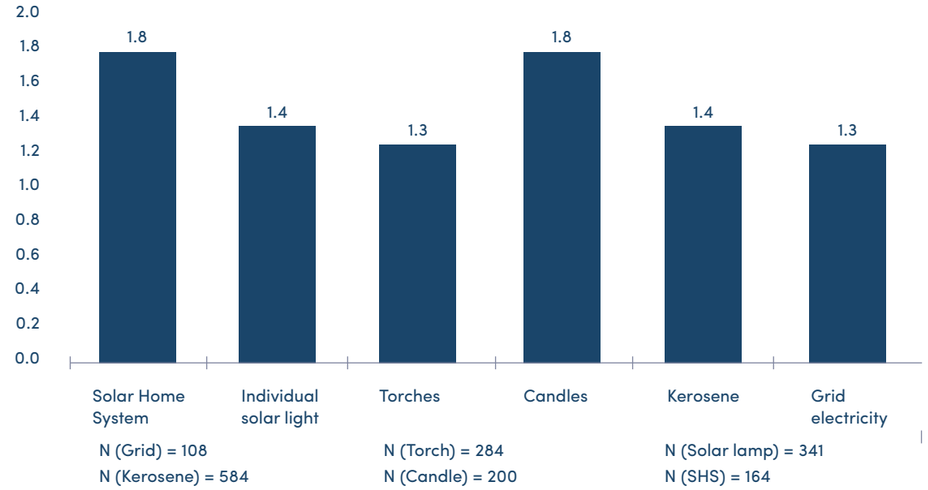
Figure 25: Average expenses on lighting (USD) before purchasing the SHS by type of location

N (Urban) = 347
N (Peri-urban) = 609
N (Rural) = 785[59]



58 Includes six companies data only. Please refer to Annex.
59 Includes six companies data only. Please refer to Annex.

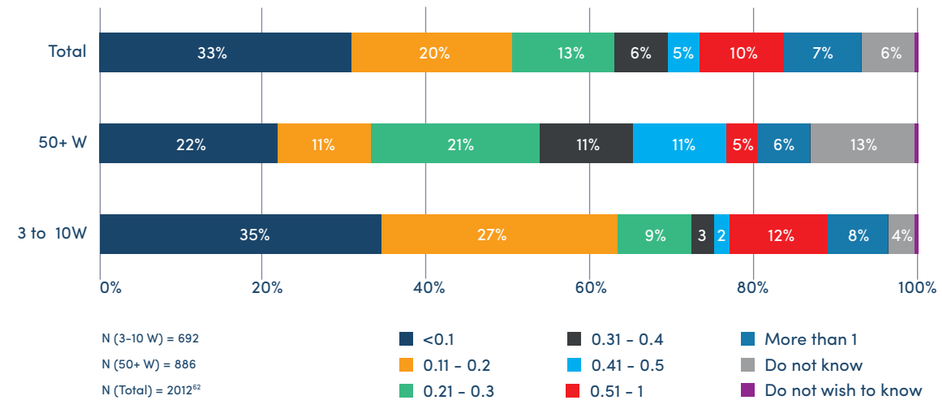
Figure 26: Average prior expenses on lighting (USD) by previous primary source of light[60]



Focus on phone charging

In addition to lighting expenditure, customers spent an average $0.4 per week on phone charging per head, which amounts to an average of $1 per household. Again, differences in previous energy expenditure can be seen between purchasers of the smaller and larger system sizes. A majority of 3 - 10.99 Wp customers spent less than $0.2 per person before they purchased their SHS, while only a third of the 50+ Wp system customers did so (see Figure 27). On average, individual phone charging expenses are equivalent to 28% of expenses on phone credit[61] which means almost a fifth (19%) of what individuals spend on their phone goes to phone charging.

Figure 27: Customer distribution by previous individual phone charging expenses (USD), split by system size



60 Includes six companies data only. Please refer to Annex. Categories "Diesel Generator" and "Other" excluded due to sample size
61 ARPS (Average revenue per unique subscriber). GSMA, 2017
62 Includes six companies data only. Please refer to Annex.

Energy expenditure over the SHS's lifetime

Although on a weekly basis the products do not enable savings for most households, when analysing lighting and phone charging expenditure, this snapshot does not reveal the full financial value of the product to the customer. Looking at the energy spending over the product's expected lifetime[63] shows that 55% of households will make savings on energy expenditure compared to previous energy expenditure[64] (see Figure 29).

When broken down by system size, purchasers of the smaller systems will save $125, while 50+ Wp customers will end up spending $108 more (see Figure 28); however, these customers will be gaining a far greater energy service, and many are additionally including televisions, radios and multiple light fittings with their PAYG purchase.

Figure 28: Average savings over the SHS's expected lifetime, split by system size

N (Total) = 1,575[65]
N (50+ W) = 692
N (3-10 W) = 527

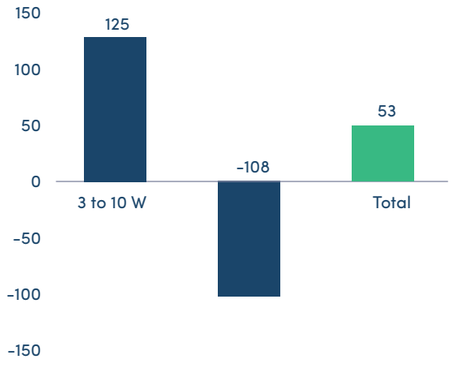
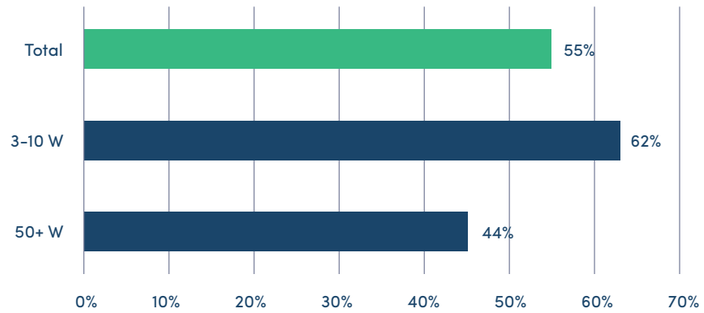


Figure 29: Share of households making savings over the SHS expected lifetime, by system size

N (Total) = 1,575[66]
N (50+ W) = 692
N (3-10 W) = 527



63 Expected product lifetime is computed using the warranty and a standard multiplier: Warranty * 1.5. Source: GOGLA
64 Savings are computed using the following formula: Savings = (Previous energy expenditure * Expected product lifetime) - (Current energy expenditure excl. fees * Expected product lifetime + Total cost of SHS)
65 Excluding customers who answered "Do not know" in the baseline and/or follow-up. Includes six companies data only. Please refer to Annex.
66 Includes six companies data only. Please refer to Annex.

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4.Economic opportunities

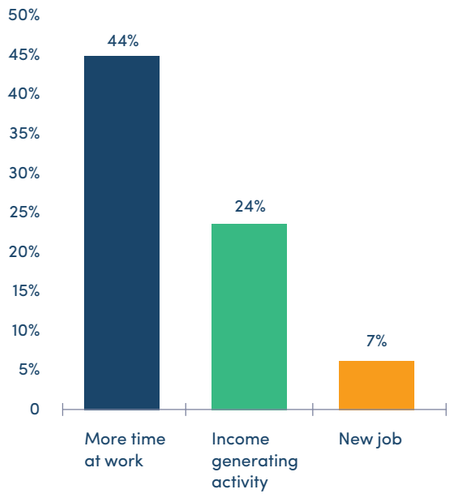
4.1 Undertaking more economic activities

The SHS ability to provide economic opportunities to the households that use it brings a potential for transformative impact. More hours of light provide more time and flexibility to users, who can use the extra light hour(s) to work or to shift the order of their day around to undertake more productive activities. SHS and their accompanying features or appliances can also be used directly to enhance a business or to create income.

Economic opportunities were a central focus of this research. Overall, the study found that 58% of households undertake more economic activity due to their purchase of a solar home system. These activities followed three main pathways, with 15% of customers following more than one pathway to increased economic activity.

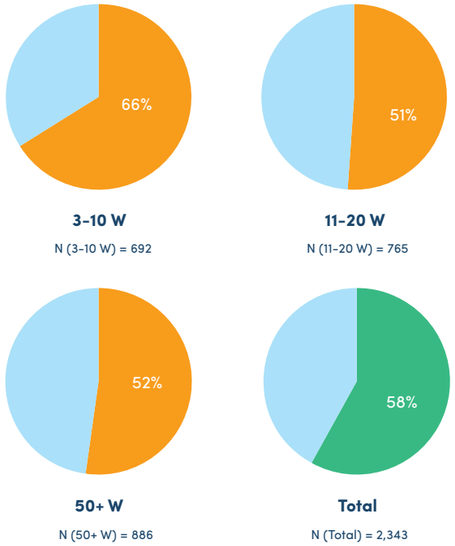
Figure 30: Share of customers undertaking economic activities

N=2,343



Of the three system sizes, customers that purchased a 3-10.99 Wp system proved most likely to undertake economic activity (see Figure 31). Rural customers are also slightly more likely to do so (63%) than urban (50%) and peri-urban (53%) customers.

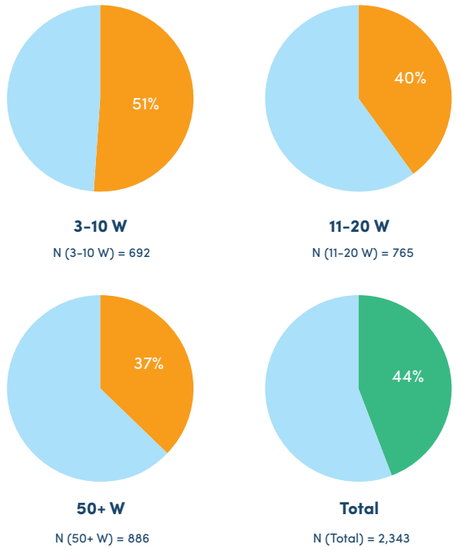
Figure 31: Share of customers undertaking some form of economic activity, by system size



Increased working hours

The most common way in which households undertake more productive activity is by being able to spend more time at work since purchasing the SHS (44%, see Figure 32). Among households where a member is able to spend more time at work, two-thirds claim they were able to do so through task-shifting: moving activities at home from the daytime to the evening to be able to work longer hours (see Fenix International Case Study). Other factors that enabled users to spend more time at work were spending less time travelling to purchase kerosene, batteries or to charge their phone (17%) and having a phone which is charged more often (5%).

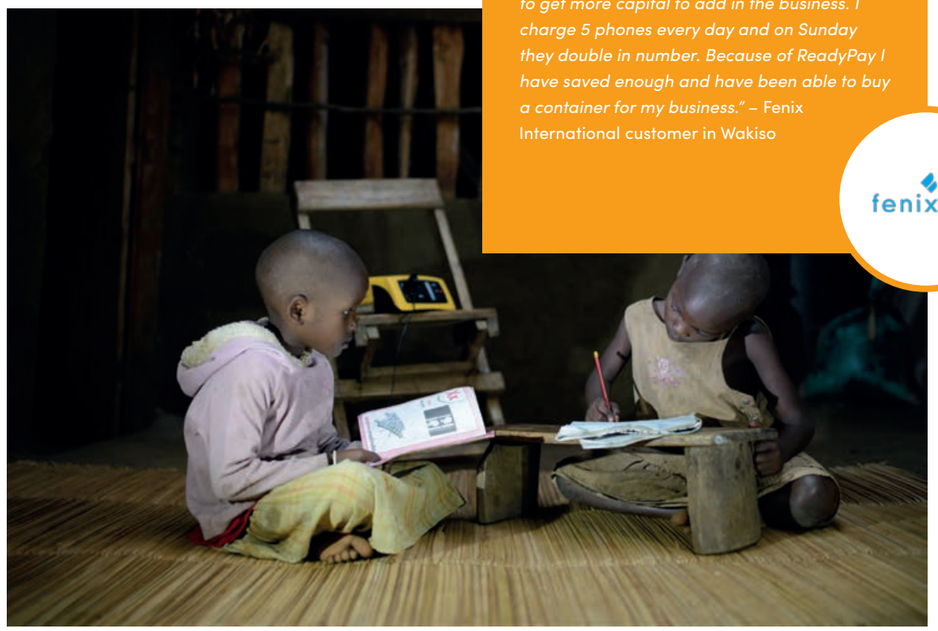
Figure 32: Share of households where at least one member is able to spend more time at work thanks to the SHS, split by system size



Fenix customers were able to spend more time at work thanks to the system

A majority of Fenix customers report spending more time at work since purchasing their SHS. Among them, two-thirds do so by reorganizing their activities and shifting their time towards the night hours.

"Before buying ReadyPay solar, I was operating in a small stall made of wood and was using Kerosene for lighting which was expensive since I had to buy kerosene of 1000 UGX daily ($0.26). It was dim, having to return the children home early to do their homework but they would arrive home late, so we would just go to bed which forced me to wake them up early to do it. With all these challenges I earned less and made many losses since the paraffin would pour on the groceries like tomatoes most of the time which forced me to throw them. With the RP solar, I work until 11pm, the security light is bright enough and it has encouraged other people to come and sell from there and to rest. I'm also running a phone charging business that has enabled me to get more capital to add in the business. I charge 5 phones every day and on Sunday they double in number. Because of ReadyPay I have saved enough and have been able to buy a container for my business." – Fenix International customer in Wakiso



© Fenix International

Using the system directly to support a business or income generating activity

24% of customers use the power and service from their SHS directly in a business or to support an income generating activity. The most common activity is phone charging for a fee (34%) followed by using the SHS in a shop to power lights or appliances (20%) as seen in Figure 33. In a majority of cases (59%), this activity is not the household's main source of income and is conducted from home (80%).

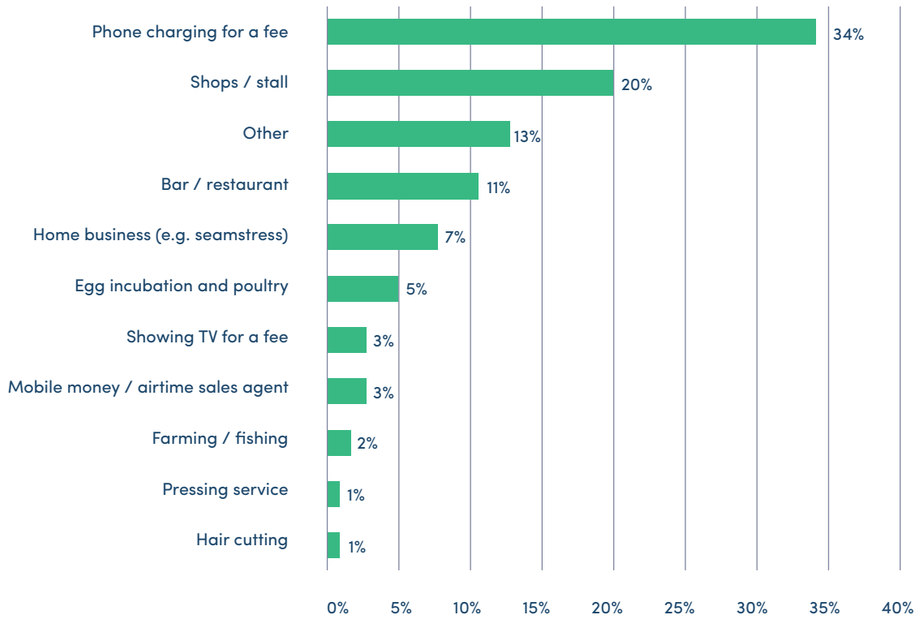
A small majority of these activities were already running before the purchase of the SHS. These are most often shops or food related businesses such as bars and restaurants

The rest, 44% of the subset, or 11% of all households, started a new business since purchasing the SHS (see Figure 34). The most common new business established is charging phones for a fee. A few customers also start showing TV for a fee. Across all households whose system included a TV, 12% are using the TV to generate income.

Looking at system sizes, households with 3-10.99 Wp SHS are slightly more likely to use their system for a business or income generating activity (see Figure 35).

Figure 33: Types of business and income generating activities

N = 521[67]



67 Among customers using the SHS in a business or income-generating activity

Figure 34: New income generating activities

N = 2,343

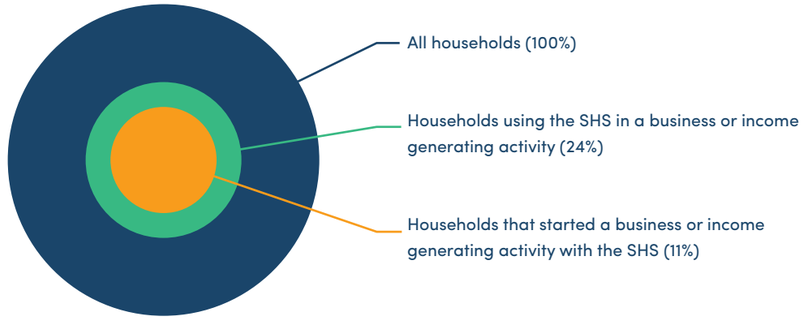
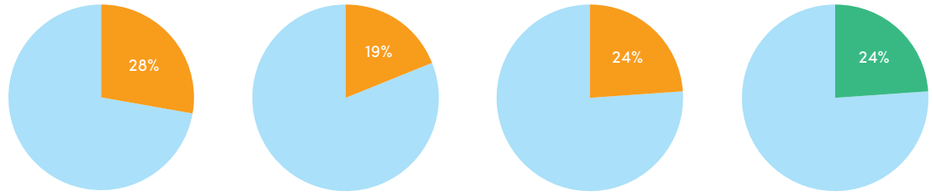


Figure 35: Share of customers using the SHS directly for business or income generating activities split by system size



3-10 W
N (3-10 W) = 692

11-20 W
N (11-20 W) = 765

50+ W
N (50+ W) = 886

Total
N (Total) = 2,343

New jobs

Finally, 7% of customers report a member of their household has been able to get a new job since purchasing the SHS. A figure which is stable across system sizes and socio-demographic indicators. Among these households the majority mention the additional time offered by having more hours of light as the enabling factor. A few households using the SHS in a business or income generating activity also report that they have hired new employees. However, the nature of the jobs created is not well understood and additional research is required to fully explore this topic.

4.2 Creating income

36% of households who purchased a solar home system reported generating income through its use, whether directly (use in a business) or indirectly (task-shifting).

Creating income – by economic activity

Of the three economic pathways defined previously, almost all households using the system in a business or income-generating activity report making additional income, and 69% of those who got a new job.

However, among customers who have been spending additional time at work, only 47% report having created additional income, suggesting that the relationship between greater time spent working and increased income is more complex. Several factors may explain this phenomenon. First, it is not necessarily surprising that additional income has not yet been reported as the follow-up interview with customers in this research was only three months after they purchased their system and it may be too early for an effect to be seen. Secondly, the work may lead to reward in-kind, rather than cash, and therefore households may not be able to provide a currency amount. Typical examples could be additional time spent working in agriculture where the fruit of labours might be reaped over a longer time-period and may lead to more produce, rather than a monetary reward, or where a household is diversifying their income rather than augmenting it.

Figure 36 shows these figures as a proportion of all households while Figure 37 shows which economic activities are undertaken by households generating additional income, including those combining activities.

Figure 36: Share of households generating additional income by type of economic activity

N (Total) = 2,343

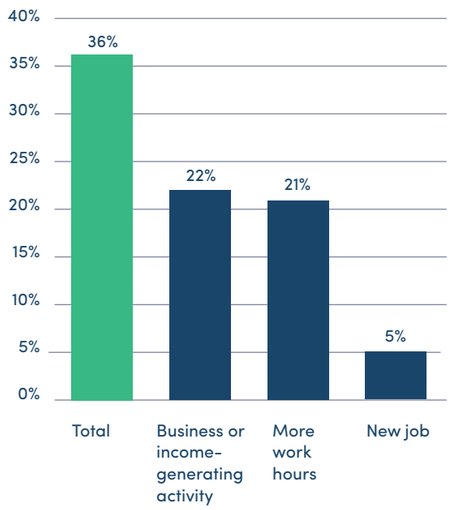
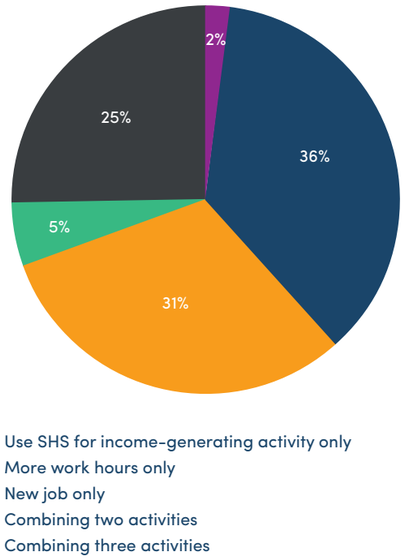


Figure 37: Economic activities undertaken among households generating additional income

N (Total) = 740[68]



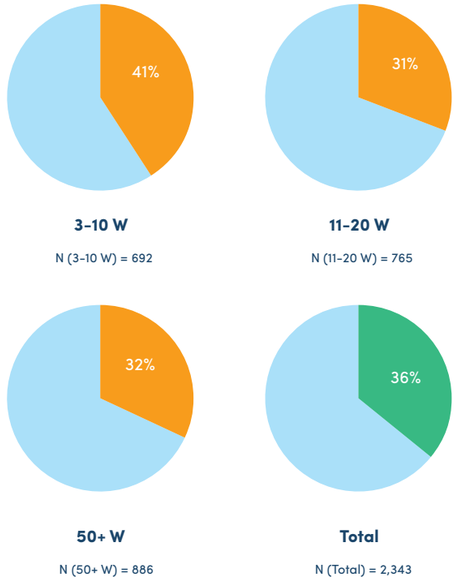
68 Among households generating additional income

Creating income – by system size and type of location

Across system sizes, the share of households generating income from their economic activity is similar. However, as slightly more customers in the 3-10.99 Wp range use their system to undertake economic activity, this leads to slightly higher results for that system size overall (see Figure 38).

This is also true when looking at customers' type of location, with rural customers slightly more likely (39%) to be generating income.

Figure 38: Share of households generating income split by system size

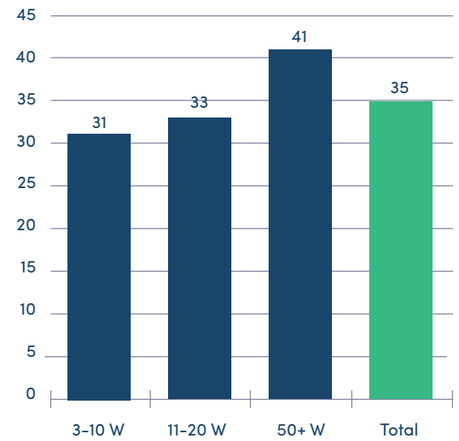


New income generated – by system size and type of location

While results found that the largest systems (50Wp+) are used slightly less frequently than smaller systems to create income, it also found that, when they are used for business or income generation, the 50+ Wp systems led to slightly higher returns ($41) compared to the smallest systems ($32), (see Figure 39 and Mobisol Case Study). This amount includes households cumulating sources of additional income.

When looking at types of location, rural customers tend to generate the highest income with $42 in comparison with $35 for urban and $26 for peri-urban households.

Figure 39: Income generated split by system size



N (3-10 W) = 223
N (11-20 W) = 193
N (50+ W) = 281
N (Total) = 697[70]

The average additional income created by households undertaking more economic activity is $35[69] per month.

69 For methodology on elimination of outlying values, see Methodology Annex
70 Among households generating income, excluding outlying values

Mobisol's larger systems enable households to generate significant additional income[71]

The Mobisol systems in this research range from 80W to 200W and therefore provide more power than most others studied. The research found that, for those Mobisol customers that generated more income, the average increase was $65. Interestingly, between Mobisol systems, as in the broader research, the larger the system, the higher the average income generated.

A good example of how Mobisol's larger systems can be used for income generation is entrepreneur Mbonny Kyando from Kidomole, a small village close to the coastal town of Bagamoyo in Tanzania.

Mbonny (59 years old) lives with her two children and three grandchildren. In her younger years, Mbonny worked in agriculture but has now taken the opportunity to establish a small village cinema in the house she built with her husband twenty years ago. Having been on her own with her children for the past two decades, she has found several ways to generate a basic income for her family, but ever since she bought a Mobisol system, this has been much easier.

Starting with a small mobile phone charging business for the community, her children expressed the wish to invite their friends over to watch TV. Mbonny wanted the system with highest capacity to ensure the TV could be used for several hours, so she chose a 200W system. Using the LEDs for outside lighting as well, her house has become a social hub where friends and neighbours come to talk and charge their phones. The 2018 World Cup provided a great possibility for charging a small fee to every visitor of the cinema in her living room. These fees are typically between $0.10 and $0.25.

© Global Leap

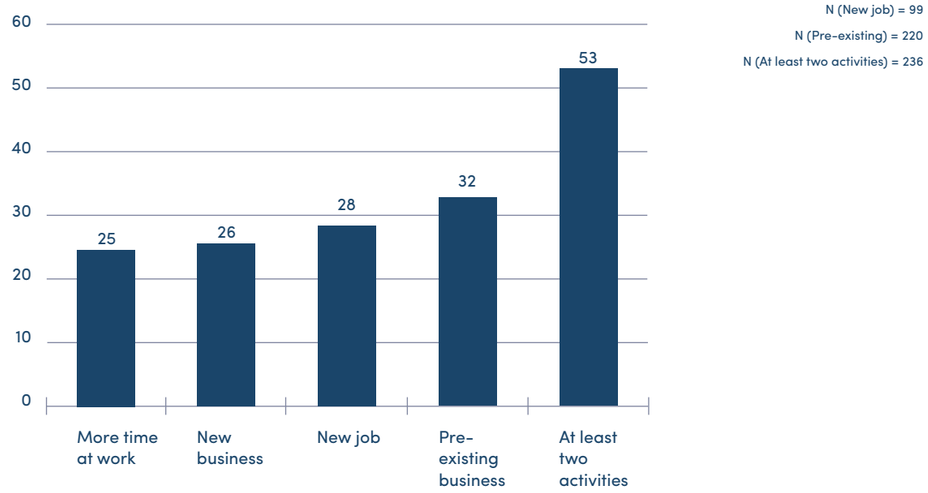
71 Customer information provided by Mobisol

New income generated – by economic activity

Of the main paths to income generation covered in this research – excluding households that undertake more than one new income generating activity –, the most rewarding appears to be using the system in an existing business, with an additional income of $32 on average[72] (see Figure 40). When households undertake more than one type of income generating activity, the average new income created per month is in excess of $50.

Among income-generating activities in which the SHS is used, although phone charging for a fee is the most common, it generates modest revenues compared to more established enterprises such as shops and restaurants (see Figure 41). The few households using the SHS to show TV for a fee generate four times more income than those charging phones, confirming that larger systems provide opportunities to generate higher revenues. Use of the SHS in a shop/stall or bar/restaurant generates respectively six times and ten times more additional income than phone charging. These figures show a strong potential for the use of SHS in MSMEs[73].

Figure 40: Monthly income generated by type of income generating activity undertaken



Powering Productivity

When reviewing outcomes from this study alongside findings from research into the impact of the Rwandan grid roll out programme, the majority of businesses supported by the SHS are the same types of businesses that are supported by the grid[74]. This suggests that off-grid solar can play a similar role to the grid in enhancing enterprise. The only differences between the types of businesses being supported were where grid-electricity was used for milling and welding. However, while off-grid solar for productive use appliances was not covered in this study, it is worth noting that several off-grid companies are now piloting or offering solar water pumps, welding equipment, and other agricultural and cold storage products[75].

72 Details provided in Methodology annex
73 Among households generating income. A same household may be represented in more than one category
74 Lenz et al. 2017, Does Large Scale Infrastructure Investment Alleviate Poverty ? Impacts of Rwanda's Electricity Access Roll-Out Program
75 https://plugintheworld.com/, http://sunculture.com/ , https://futurepump.com/ , http://ecozensolutions.com/

Figure 41: Comparison of key income generating activities using SHS[76]

	Share of business	Average income generated	% of monthly GDP per capita
Phone charging for a fee	34%	$12.8	19%
Shop or stall	20%	$36.4	62%
Bar or restaurant	11%	$46.4	69%
Showing TV for a fee	3%	$43.5	57%

N (Phone charging) = 179
N (Shop) = 89
N (Bar) = 56
N (Showing TV) = 28[77]

Income generated over the expected lifetime of the SHS

Projecting these income generation figures into the future, over their product lifetime, customers who are currently generating income could hope to generate more than $2,000[78] on average, while users of 50+ Wp systems could hope to create more than $3,000 (see Figure 42).

Looking through the lens of the different economic activities, having extra light and power from an SHS in a pre-existing business appears to be the most rewarding, with an average of over $2,000 created over the expected product life (see Figure 43).

Different businesses, different benefits

To provide some perspective, let's compare a typical 3–10.99 Wp system user who started a phone charging business to a 50+ Wp system customer using his system in a shop he already ran.

The 3–10.99 Wp system user who started a business charging mobile phones for a fee will generate an average $500 over their product's expected lifetime. Although this may seem significantly lower, the average total cost of the system for this user is around $180 meaning she will not only generate enough income to pay for the product but also generate an additional revenue of $300 over approximately three and a half years.

The 50+ Wp system in the shop will help generate an average of $1,500 additional income over the product lifetime. The total cost of the system for this customer is on average $550. The system will generate enough income to cover the cost, and create close to $1,000 more, over an average of seven years.

76 % of monthly GDP per capita ratio calculated for each household and averaged. Source: World Bank. Kenya $1,455, Mozambique $382, Rwanda $703, Tanzania $877, Uganda $580. Please note, small sample sizes mean results may not be statistically significant.
77 Among households using the SHS for these businesses or income generating activities
78 No discount rate has been applied to the income generated over the product lifetime. The projection does not reflect any potential market or behaviour changes. Includes combining several economic activities.

Figure 42: Average additional income generated over the product lifetime by system size

N (3–10 W) = 223
N (11–20 W) = 193
N (50+ W) = 281
N (Total) = 697[79]

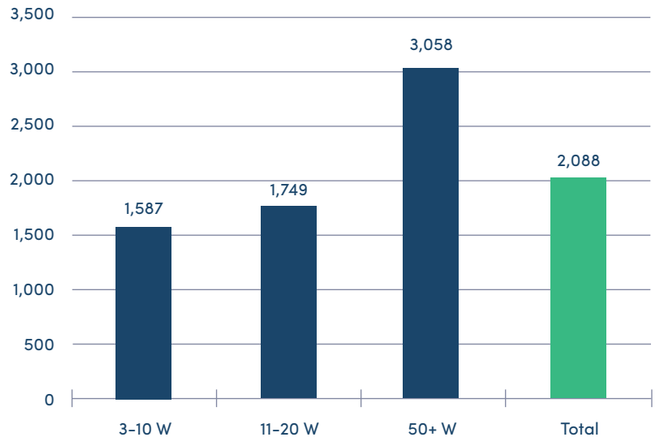
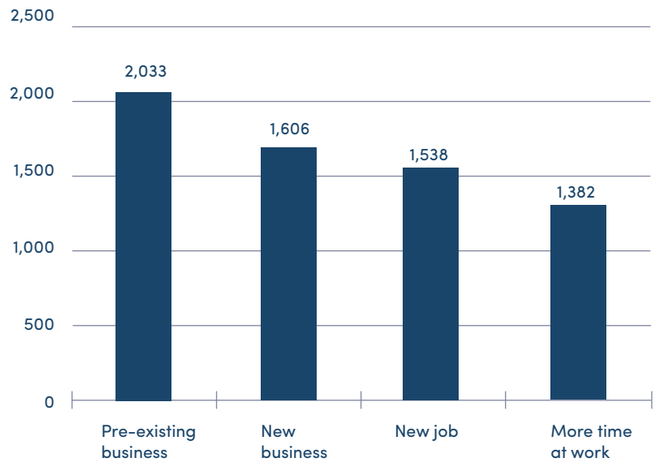


Figure 43: Average additional income generated over the product lifetime by economic activity

N (Pre-existing business) = 220
N (New business) = 220
N (New job) = 99
N (More time at work) = 359[80]



79 Among households generating income
80 Among households generating income. A same household may be represented in more than one category

New income generated and savings over the product expected lifetime

In the short-term, energy savings and additional income generation mean that over 40% of customers are able to off-set the additional monthly costs that are incurred by the system purchase (see Figure 44). This is true for 81% of customers that report generating additional income.

While 59% of customers do see an average increase in costs by $1 per week, this is ultimately recouped over the lifetime of the solar system for the vast majority of customers. 70% of users will end up at least covering the total cost of the SHS through savings on energy and/or income generated (see Figure 45); and most will make gains.

When looking at this figure across all customers surveyed, users gain an average surplus of $825.

Figure 44: Share of customers able to cover system fees by cumulating energy savings and income generation

N = 2,343

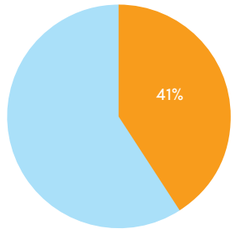
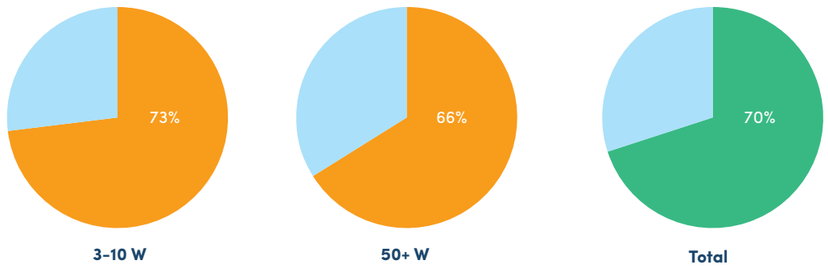


Figure 45: Share of households, covering the total cost of the system, or more, with energy savings and/or income generated

N (3-10 W) = 512
N (50+ W) = 869
N (Total) = 1,770[81]



81 Excluding customers who answered "Do not know" to expenses questions. Excluding outlying values for income

© Mobisol

5. Impact on quality of life

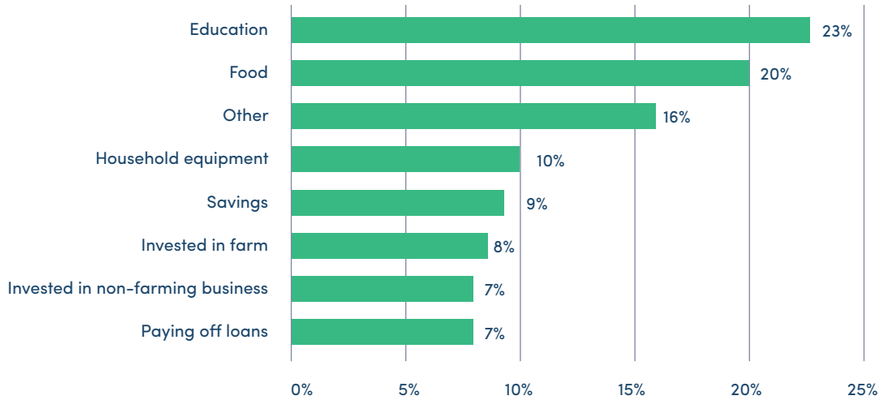
Through economic opportunities, households can improve their living standards but the system itself does a lot to improve quality of life through a variety of factors such as feelings of better health, safety and increased availability of household budget.

Use of additional budget

For example, two thirds of households report they have more money available to spend since buying the SHS. This figure potentially hints at the real number of household generating savings on a monthly basis when comparing fully-loaded costs. These households claim their main use of this additional budget is expenditure on education – most likely school fees - and food (see Figure 46).

Figure 46: Uses of additional available budget

N = 1,395[82]



Empowering women to accelerate energy access

Several research efforts suggest that quality of life benefits from increased energy access (welfare, access to information, etc) are felt most keenly by women, who often spend more time in the home[83, 84]. However, as noted on the following page, women do not always seem to be involved in energy related decision-making.

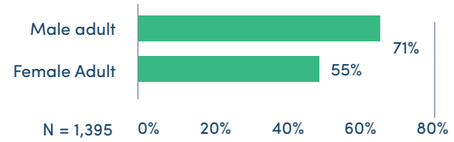
This suggests there is an opportunity to engage women further with energy access via off-grid solar. Indeed, engaging women in the sale, distribution and maintenance of off-grid solar has been shown to create even greater benefits for women and has been linked to improved energy access outcomes. For example, Solar Sister has supported thousands of women to become solar sales agents enabling them to create an income as well as uplift their position within the community[85]. While data gathered by Fenix International shows that female customers play a leading role in recommending their peers purchase an SHS and do so more often than men[86].

82 Among households reporting to have more money available to spend since buying the SHS
83 Miller Center for Social Entrepreneurship (2016), Turning on the Lights: Transcending Energy Poverty Through the Power of Women Entrepreneurs
84 Ashden (2012), Does energy access help women? Beyond anecdotes: a review of the evidence
85 Miller Center for Social Entrepreneurship (2016), Turning on the Lights: Transcending Energy Poverty Through the Power of Women Entrepreneurs
86 Power Africa (2018), Women: Champions of African Off-grid Solar Energy, www.medium.com/power-africa/women-champions-of-african-off-grid-solar-energy-41126d596779

Decision-making power

Exploring who makes decisions on spending additional budget (male adult, female adult, both or other) results revealed that women played a role 55% of the time and men 71%. Added to data on the gender of the system purchaser (75% male; 25% female) this suggests an imbalance in energy-related decision-making. However, it is worth noting that, as most interviewees were men, this picture may not fully capture decision-making dynamics.

Figure 47: Members of the household involved in the decision process for spending additional available budget by share of mentions (multiple answer)



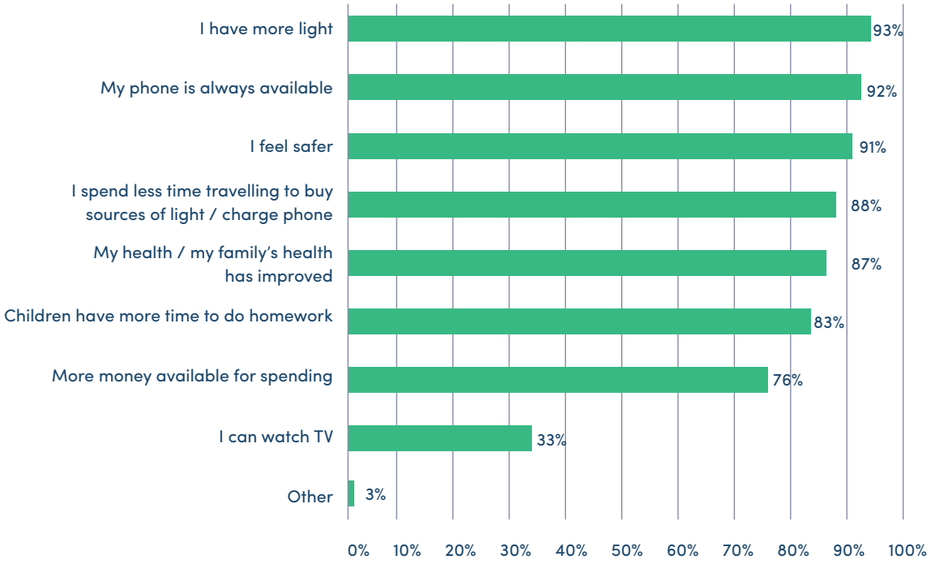
Quality of Life Improvements

Beyond these economic improvements, 94% of households report an improved quality of life. Looking further into the notion of quality of life to explore what this means to individual customers, the research revealed that this improvement can be due to an array of different benefits: from children having more time to do homework to a reduction in exposure to toxic kerosene fumes.

Among the most commonly agreed factors of improvement are access to light and the availability of users' mobile phones (see Figure 47). Similarly, households whose system includes a TV see access to this medium as a strong factor. However, a lot of the benefits of system ownership are more indirect. For example, 93% of customers report being able to spend more time with their family since purchasing the SHS – likely to be linked to the enhanced lighting enabling them to do more together in the evening, or due to the TV drawing the family into the household rather than outside to seek external sources of entertainment.

Figure 48: Factors of quality of life improvement (multiple answer)

N = 2,171[87]



87 Among households reporting an improvement in their quality of life since purchasing the SHS

M-KOPA helps its customers improve their quality of life[88]

95% of M-KOPA's customers told us that their quality of life had improved thanks to the SHS. Insights shared by M-KOPA highlight some of the many ways the SHS is improving well-being.

In Jackson Onyango's case, this is because he is now able to spend more time with his wife and children. The Kisumu resident explained: *"I am happy to share a meal with my family. We get to catch up on our day's activities after dark, without worrying about the lights going off."*

For Daniel Okumu and his wife, Eunice, it is their access to television that has enabled them to gain new insight into the world around them: *"At the touch of a button, we can now see the world right from the comfort and safety of our home".*

Three key areas of quality of life improvement call for a deeper understanding:

Safety: 91% of interviewees report feeling safer thanks to the SHS. This notion of safety can mean a variety of things to different purchasers (see ZOLA Electric Case Study). Access to quality lighting means less incidents linked to tripping or bumping into objects inside the household, outdoor lights mean reduced risk of robbery or encounters with wild animals and fewer kerosene lights mean less fire related incidents or injuries.

Health: 91% of households that used kerosene in the baseline report they feel their health, or that of their family, has improved since purchasing the SHS. Through their toxic fumes and incidents of fire and poisoning[89], kerosene lamps have a demonstrated detrimental effect on the health of households using them as a source of lighting (see Health Case Study).

Education: Finally, lack of light in schools or in homes can be a hurdle for education. 84% of households with at least one child report that their child or children have more time to do their homework thanks to the SHS. In the long run, this could equate to better performances in school and potentially improved economic opportunities.

88 Quotes and pictures provided by M-KOPA
89 Graham and Tevosyan, Perceived Health Benefits of Off-Grid Products: Results of an End-User Survey in Uganda, unpublished draft (2018), https://www.finca.org/wp-content/blogs.dir/1/files/2014/02/Perceived-Health-Benefits-of-Off-Grid-Products_White-Paper.pdf

ZOLA Electric customers' feel safer[90]

Since purchasing their SHS, almost all of ZOLA Electric's customers feel safer. When exploring the different ways that customers were using their system, ZOLA Electric spoke to Letura Lesupei from Kertalo near Ngorongoro in Tanzania. Letura is a nomadic herder and like a quarter of ZOLA Electric customers' he mainly uses his lights outside, which help to provide safety for his herd: *"Before having lights, my sheep were eaten by hyenas, but since the day I installed solar they stopped entering in my cattle's pen",* he explained.

As a business owner of a small retail shop in Soitsmbu, Arusha, Simon Vitalis also finds that the light helps to protect his livelihood. Simon explained that, for him, safety is protecting his business from thieves: *"The security around my business environment has increased to a great extent because now I am not worrying about my product to be stolen without me seeing it due to the darkness while I am busy serving my customers".*

Evidence from Uganda of kerosene's effect on health

FINCA International's recent study[91] (2018) paints a stark picture of health and safety in an energy poor household: *"Life is... dangerous and unhealthy. In Uganda, single-wick lanterns are responsible for 70% of fire incidents and 80% of burn injuries. Kerosene, a clear fluid in plastic bottles, spoils food and is accidentally ingested by children. Meanwhile, fuel combustion releases hundreds of pollutants into the air, including carbon monoxide, formaldehyde and benzene, along with a myriad of other damaging particles."*

Responses from over 790 of their Ugandan customers go on to describe the array of health improvements felt after they switched from kerosene to off-grid solar, including fewer burns and eye problems, reduced toxicity and respiratory problems and less diseases caused by rats and pests. As in this research, health benefits were reported by over 90% of SHS customers in the FINCA study.

A spotlight on education

An increase in study time as a result of access to off-grid solar is also seen in several other research efforts (SolarAid[92]; Hassan & Lucchino[93]; Kudo et al.[94]) and has been linked to better exam performance (Hassan & Lucchino), increased school attendance (Kudo et al.) and better motivation (SolarAid).

However, improved educational outcomes have not been found in all studies (Kudo; Furukawa[95]), suggesting that an environment conducive to improved learning and performance is also vital if the benefits of these additional light hours are to be unlocked. For example, the support of experienced teaching staff, peer-to-peer learning and access to educational resources.

90 Quotes provided by ZOLA Electric
91 Graham and Tevosyan, Perceived Health Benefits of Off-Grid Products: Results of an End-User Survey in Uganda, unpublished draft (2018), https://www.finca.org/wp-content/blogs.dir/1/files/2014/02/Perceived-Health-Benefits-of-Off-Grid-Products_White-Paper.pdf
92 SolarAid (2015). Impact Report 2015, https://solar-aid.org/wp-content/uploads/2016/09/SolarAid-IMPACT-REPORT-2015.pdf
93 Hassan and Lucchino (2016), Powering Education 2, Enel Report, https://www.enelfoundation.org/content/dam/enel-foundation/download/poweringeducation/PoweringEducation%202%20-%20Final%20Paper%20-%20Enel.pdf
94 Kudo, Y., Shonchoy, A., Takahashi, K. (2017) Can Solar Lanterns Improve Youth Academic Performance? Experimental Evidence from Bangladesh. The World Bank Economic Review
95 Chishio Furukawa (2014), Do Solar Lamps Help Children Study? Contrary Evidence from a Pilot Study in Uganda, Journal of Development Studies, Taylor & Francis Journals, vol. 50(2), pages 319-341, February.

6. Looking to the Future

As part of our research, we tried to understand what aspirations customers had regarding their solar home system. Customers are interested in further improving their access to electricity either through new appliances or through an SHS upgrade.

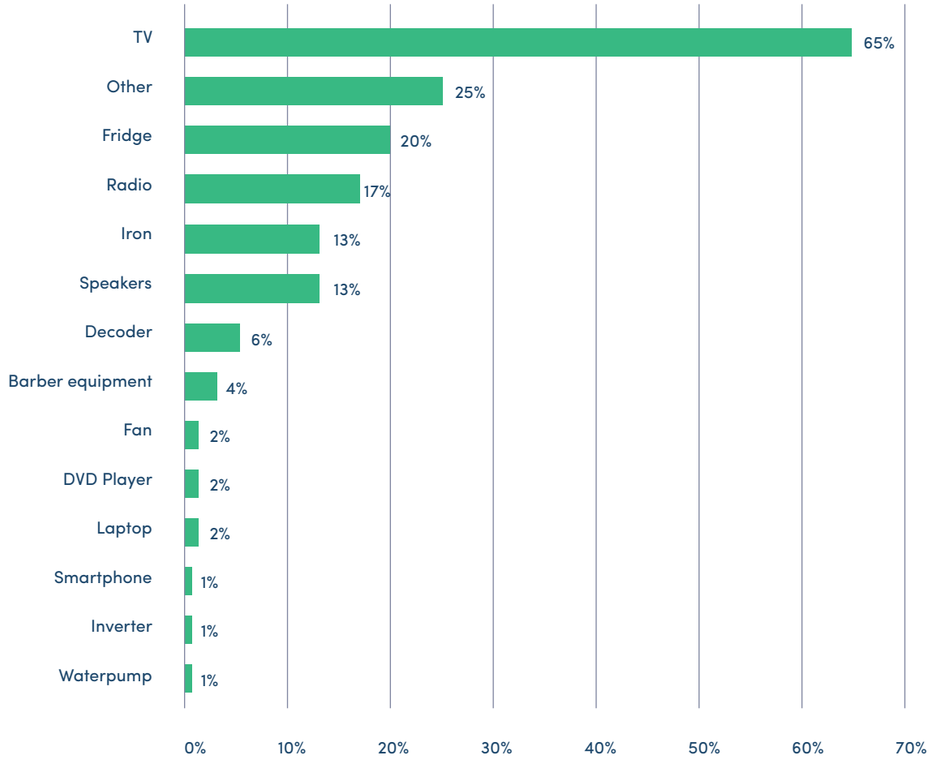
real appetite for better access to energy services and the ambition of customers to upgrade to larger systems and appliances in the future. Among customers already owning a TV, many advised they wanted a larger TV, a decoder or a DVD player.

Appliances

80% of customers would like to have additional appliances. TVs are by far the most popular with 65% of customers mentioning them (see Figure 49). Among 3-10.99 Wp users, none of whom have a television, 91% mention that they would like to buy one – indicating a

Figure 49: Appliances customers would like to have ranked by share of mentions

N = 1,797[96]



Other includes a wide array of responses. The most frequent is additional lights. Several customers mention products unrelated to solar such as cookstoves, water tanks and motorcycles testifying to the potential for PAYG providers to provide other products and services to their customers.

96 Among customers who would be interested in other appliances than those included in their system

SolarWorks! customers have an appetite for large appliances[97]

Almost all of Solwarworks! customers are interested in acquiring appliances. They are particularly interested in large appliances with close to half hoping to purchase a fridge. Rosa Juvencio Nhaule is one of those Solarworks! customers in Mozambique. Rosa lives with her family in the Xai-Xai district, about three hours north of the capital Maputo, where she has her house and a small patch of land for cattle.

She's been a customer for about a month. She has a 115Wh system, with a 19" DC TV, on a 3-year payment plan, but would love to have a freezer to help ice-cream sales in her small shop. She already sells ice-creams, but currently uses ice cubes to keep them frozen. This is a big risk for her; if people don't buy her ice creams within a few hours, everything will have melted, which means that she can throw away all her stock of ice cream and will not generate the expected income.

"As a company, we are very keen to start offering refrigeration to our customers. To that end, we are currently testing several fridges in terms of performance and energy consumption. At the same time, we are doing customer research (by actively calling our customers) to understand what kind of refrigeration people want, and how they would use it." Thomas de Wijn; Operations Director; SolarWorks!

97 Quote, customer information and picture provided by Solarworks!

The emerging opportunity for off-grid refrigeration

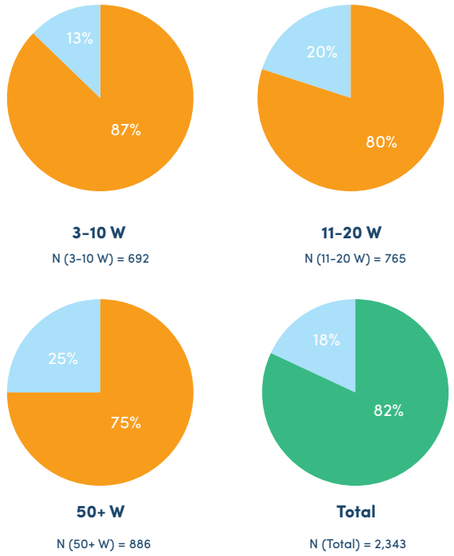
"Refrigerators increase revenues for businesses and enable diversification of existing business through for example sale of cold drinks, attracting more customers and/or increasing the business' competitive edge. Despite these benefits, entrepreneurs face challenges of quality, lack of grid access or unreliability, efficiency, cost and service delivery. This creates a great opportunity for manufacturers to deliver off-grid technologies to address this challenge. With recent innovations, and improvements in the cost, service and efficiency of off-grid refrigeration, it is an opportunity that is already beginning to be realised — with exciting potential for the future." Nyamolo Abagi; Senior Associate; CLASP

Upgrading

Beyond appliances, customers' aspirations to reach better energy access also transpire through the fact that 82% mention they would like to upgrade their system in the future with the figure, unsurprisingly, slightly higher for smaller systems (see Figure 50).

The most common motivation for wanting to upgrade is to own a TV. This is the main reason for 38% of users (see Figure 51) and 51% of 3-10.99 Wp users. A desire to access other appliances and get a bigger system for income generation are also important factors. 26% of users of 50+ Wp systems mention the latter as a driver for upgrade compared to only 13% among 3-10.99 Wp system users.

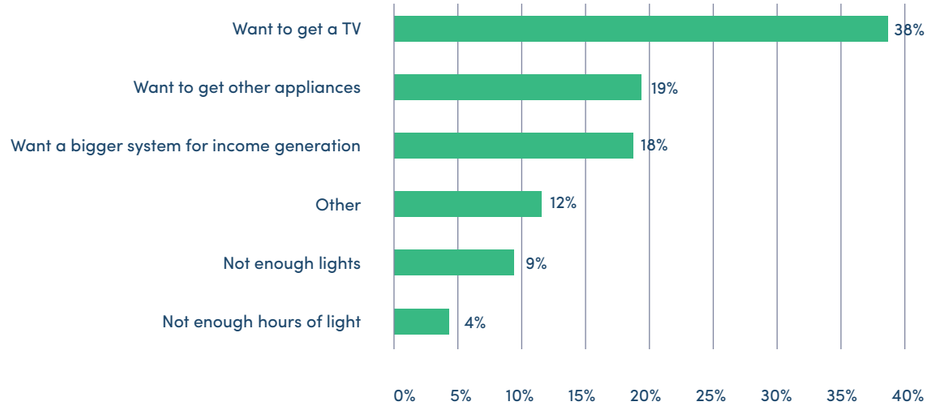
Figure 50: Share of customers willing to upgrade split by system size



© Mobisol

Figure 51: Reasons to want a system upgrade ranked by share of mentions

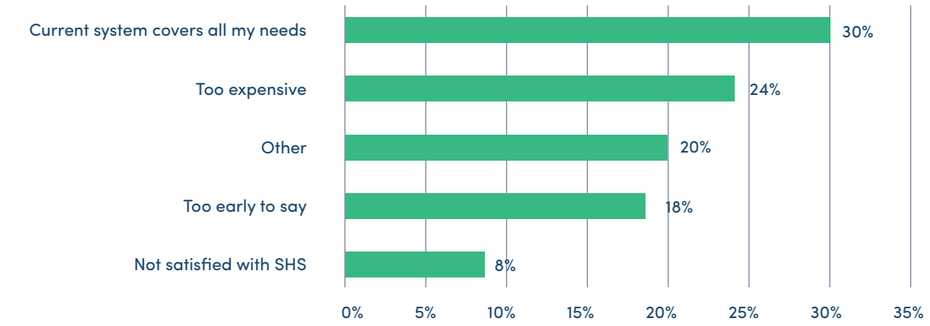
N = 1,842[98]



Among the 18% of users who do not plan to upgrade their system, 30% report that this is because their current system covers all their needs (see Figure 52). While the second most common answer is that it would be too expensive (24%); this is particularly noted by customers of the 50+ Wp systems (34%).

Figure 52: Reasons not to plan on upgrading ranked by share of mentions

N = 391[99]



98 Among customers planning to upgrade their system
99 Among customers not planning to upgrade their system

© ZOLA Electric

7. Conclusion

This research contributes powerful insights on the many ways that SHS are used to drive economic activity, create income and improve quality of life, providing valuable, quantified evidence for those looking to support or invest in the off-grid industry.

In a majority of households, SHS are unlocking more time for work and boosting enterprise. Customers using their systems to open new businesses, and existing business owners reporting more income, highlight the potential for off-grid solar to support and strengthen MSMEs. This data can help decision-makers gain a more complete picture of the ways that off-grid solar is driving economic activity and the value it can bring to off-grid communities.

Companies and researchers can also work to deepen this body of knowledge and consider how these economic benefits could be optimised. Areas for further research include:

- What level of economic activity takes place over a longer time-period?
- What is the long-term impact of an SHS on new/existing businesses, and how can this be maximised?
- What type of additional work is being undertaken, and which types of jobs are being created?
- How does a change in economic activity affect agricultural households?
- How does access to productive use appliances affect economic activity and income generation?

In addition to findings on business, jobs and income, results showed that over a third of those purchasing a SHS previously owned a solar product, primarily a solar lantern, and 18% of customers owned an unbranded solar product before buying a branded system. While many households are still switching to off-grid solar from kerosene, candles, and torches, this shows that customers are also moving up the 'energy staircase' from smaller or unbranded solar products to larger, branded ones, indicating a correlation between access to 'entry-level' products and high quality PAYG solar home systems.

Improvements in welfare and economic opportunity also confirm that access to off-grid solar products can help to meet many SDG targets, not only SDG7 – energy for all. For example, higher incomes and long-term energy savings will help to reduce poverty (SDG1), while more economic activity, connectivity, enterprise and employment will support the goal of decent work and economic growth (SDG8). Better air quality, safety and more time spent with family will contribute to health and well-being targets (SDG3), while more study time will play a role in reaching the educational targets of SDG4. Eliminating the use of toxic kerosene also provides a win-win contribution to meeting global climate goals (SDG13).

Together these impacts show the transformational potential of off-grid solar products and the catalytic role they can play in achieving national and international development goals. Off-grid solar has the ability to lift millions out of darkness, this research shows it can play another vital role: powering opportunity.

Products Annex

This Annex shows some of the solar home systems and appliances purchased by customers surveyed for this research. One image has been included per company.

BBOXX Home

d.light D30

Fenix Home Starter

M-KOPA 400

Mobisol Entertainment

SolarWorks! 40

ZOLA Electric TV

© ZOLA Electric

Methodology Annex

Primary data collection
During the baseline, the target was 500 interviews for each of the seven participating companies. 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. The final sample size is 2,343.

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 for the follow-up. 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 behaviours
- 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

Follow-up 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 behaviour
- 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

Weighting
For the aggregate data, 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. Every interviewee was assigned a weighting factor by which the corresponding data was multiplied. The factor is determined by the number of occurrences in the population divided by the number of occurrences in the sample:

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

For example:

$$\text{Weighting factor (SHS model 1)} = \frac{\text{Number of SHS model 1 sold in target country in H2 2017}^{100}}{\text{Number of SHS model 1 in sample}}$$

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 low margin of error of 3.8%. Sample sizes by system size also enable robust analysis with margins of error below (or equal to) 7%. In certain instances, the report uses data based on smaller sub-samples to showcase interesting results. Use of these analysis, especially for extrapolation must be undertaken with care.

Sample	Sample size	Margin of error
Total	2,343	3.8%
3-10.99 Wp	692	6.1%
11-20 Wp	765	7.0%
50+ Wp	886	6.0%

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, and irregular data for one company in respect of previous lighting expenses. This is 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 final report. Results from questions on more specific and targeted expenditure (spending on light and phone charging) and income (additional income generated) were favoured as these present a much smaller risk of inconsistency.

Progress out of Poverty Index
Questions for the PPI were originally included in the questionnaire but due to the length of the questionnaire, these were made optional and were finally collected by too few companies to be used.

Data cleaning
Recoding:
- Other: for several questions, the response "other" was possible and led to a follow-up question requiring 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: If a customer claimed to generate additional income but reported a $0 amount, they were considered not to generate income.
- 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.

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:
Reported additional income generation, extreme values:
- 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 $150 or $5 a day – Kenya's GDP per capita per day is approx. $4[101]. Due to the differences in capacity between system sizes, this limit was increased to $200/month for 11-20W systems and $300 for 50+W.

100 Sales data was not directly shared with Altai consulting but was extrapolated from proportion of sales within surveyed companies
101 GDP per capita Kenya: $1,455 (World Bank Data)

GOGLA

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