GOGLA

The Voice of the Off-Grid Solar Energy Industry

Off-Grid Solar. A Growth Engine for Jobs

Off-grid solar: on the level, nature and wider impact of employment opportunities in the off-grid solar sector

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

:vivideconomics

List of tables and figures

Tables

Figures

Table of Contents

Executive summary

The off-grid solar industry is generating thousands of employment opportunities in emerging markets. These opportunities have crucial impacts on individual livelihoods, on rural and urban development, and on other sectors in the economy.

Across East, West and Central Africa, and across South Asia, it is estimated that the off-grid sector currently supports 370,000 full time equivalent (FTE) jobs. South Asia accounts for around 260,000 of these jobs, representing the largest market for employment amongst the four regions. This employment opportunity is driven by a large volume of sales which is expected to maintain a strong growth trend in coming years.

By 2022, the off-grid solar sector could support up to 1.3 million FTE jobs by 2022 across these four regions. South Asia will remain the largest market for employment, accounting for 740,000 FTE jobs, largely driven by an increase in the volume of cash-based off-grid solar technology sales. As the second largest market, East Africa will account for 350,000 FTE jobs predominantly generated by the rapid and ongoing growth of the pay-as-you-go (PAYGo) service delivery model in the region (Figure 1)[1].

The off-grid solar sector is generating a wealth of new employment opportunities across the value chain, ranging from entry-level to highly skilled positions. The scale and nature of these jobs will continue to evolve. Technological innovation will also drive an expansion in job opportunities, with larger off grid solar systems supporting a wider range of complex consumer goods.

Of these jobs, the majority will be in rural areas, supporting job creation and diversification among often economically disadvantaged and vulnerable communities. There is also a strong representation of women among workers in the off-grid solar sector, which is expected to rise. Wages in the industry are in line with, or higher than, average national wages and many companies are also supporting the expansion of skills and capacity of their staff through training and development programs.

This study follows on from the flagship publication *Powering Opportunity, the Economic Impact of Off-Grid Solar*[2]. It builds on this work by focusing on the economic opportunities presented by jobs generated both 'upstream' in the off-grid solar value chain, and 'downstream' by customers putting off-grid solar products to productive use. There is very limited existing research on the employment impacts of the off-grid solar, and this paper represents an important contribution to building the evidence base.

The findings of this study are based on quantitative modelling building on survey evidence from nearly 40 GOGLA and Lighting Global affiliate solar companies. Companies shared information on the number of pay-roll and agent employees along the value chain, as well as qualitative information collected through interviews with seven GOGLA members[3].

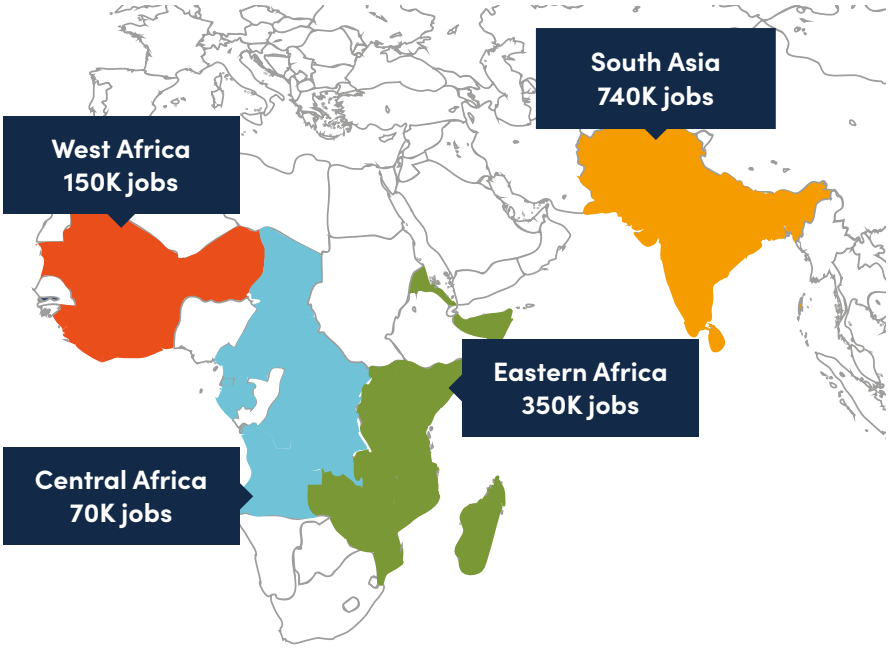
This report was authored by Vivid Economics, commissioned by GOGLA.

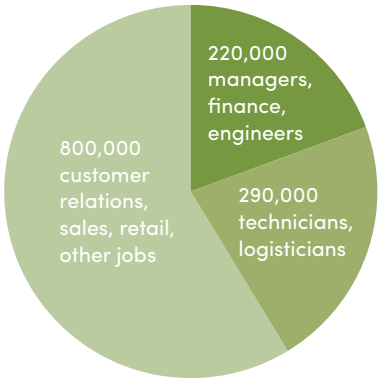
This research has been funded and supported by the German development agency, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

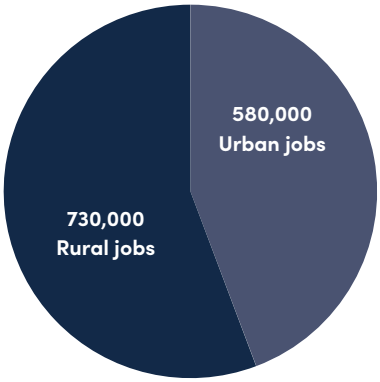
1 See Section 2 for a description of the PAYGo service delivery model.
2 GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar.
3 The authors are indebted to all companies that participated in this research and most particularly to the representatives of organizations who shared their experience of the evolution of the labor force, the insights of which provide the context behind the numbers. GOGLA and Lighting Global affiliates include GOGLA members or companies which sell Lighting Global quality verified products.

Figure 1 - Summary of Findings – Jobs potential by 2022 by regions, location, skill levels and gender

1.3 million jobs
Across four regions



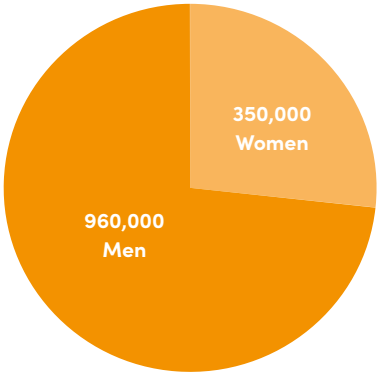




Lower skill
Secondary education
Minimal experience

Medium skill
Graduate degree
1-3 years experience

High skill
Graduate or postgraduate degree
3-5 years+ experience



Source: Vivid Economics

Introduction

The global market for off-grid solar has grown rapidly in emerging markets over the last decade, reaching an impressive cumulative sales volume of 130 million devices in 2017. The market is expected to continue to grow annually by 25% between 2018 and 2022[4].

However, with almost one billion people worldwide lacking access to a reliable electricity connection[5], off-grid solar sales have, as yet, only penetrated around 17% of the global potential market[6], leaving a vast potential market remaining and, correspondingly, a vast potential for employment creation. The off-grid solar sector has already spurred a range of new job opportunities and can continue generating thousands more if this potential market is realized.

This report examines the level and nature of employment opportunities generated by the off-grid solar sector, and how this employment is projected to grow and change as the market evolves. It then sets out a conceptual framework to capture the wider set of benefits that could be generated by employment created in and beyond the off-grid solar value chain.

This report focusses on four emerging regions: East Africa, West Africa, Central Africa and South Asia. These account for some of the largest existing markets for off-grid solar products, and regions where there is a currently a sizeable unaddressed market of customers without access to a reliable source of energy.

The next sections of the report are structured as follows:

Section 1
- Introduction to the scope of this report

Section 2
- Describes the evolution of the off-grid sector
- Explains key service delivery models in the off-grid sector
- Outlines the off-grid solar value chain

Section 3
- Sets out the methodology used in this report
- Sets out the data sources used in this report

Section 4
- Explores the potential scale of employment associated with the off-grid solar value chain in the coming years.
- Describes the trends in sales of the off-grid solar sector, and the service delivery models to deliver off-grid solar technologies to customers
- Projects the potential impact of sales on direct employment opportunities in each of the four regions: East Africa, West Africa, Central Africa and South Asia[7].

Section 5
- Investigates the nature of jobs across the off-grid solar value chain
- Analyses the demand for various types of skilled labor needed in the off-grid solar value chain
- Sets out the linkages between the off-grid solar sector and other sectors in the economy

Section 6
- Describes the range of productive use of energy (PUE) applications of off-grid solar products
- Provides a case study on the role of PUE – specifically solar water pumps (SWPs), on income and employment opportunities for recipients and users of off-grid solar products
- Summarizes the technical potential of SWPs across each of the four emerging regions

Section 7
- Describes a conceptual framework for estimating the net impact of the off-grid solar value chain on employment opportunities economy-wide
- Discusses the potential wider impacts of the off-grid solar value chain on socioeconomic development

Section 8
- Draws conclusions and sets out key barriers to realizing the full potential of employment that policy could seek to address

4 Dalberg and Lighting Global (2018), Off-Grid Market Trends Report.
5 IEA (2018), World Energy Outlook.
6 GOGLA (2017), Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data.
7 This report builds on a series of three briefing notes, presenting interim findings of this research and released between November 2018 and May 2019. For the briefing notes, please see Vivid Economics (2018), Employment Opportunities in an Evolving Market. Off-Grid Solar: Creating High-Value Employment in Key Markets; Vivid Economics (2019), Energizing Job Creation: Employment Opportunities Along the Off-grid Solar Value Chain and Vivid Economics (2019), Productive Use of Off-Grid Solar: Appliances and Solar Water Pumps as Drivers of Growth.

Introduction

© GOGLA/Jeffrey M. Walcott

Evolution of the off-grid solar sector

Off-grid solar energy provides a safer, cheaper and reliable alternative to access energy for millions worldwide. The nearly one billion people who lack access to a reliable electricity[8], spend about USD 27 billion each year on lighting and mobile phone charging[9]. The use of traditional solutions like kerosene, candles, battery torches or other fossil fuel-powered transitional technologies are expensive, harmful to health, hazardous and polluting. Clean off-grid solar energy products provide an alternative that is beneficial to individual consumers and society, directly contributing to SDG 7.1 – the goal to ensure access to affordable, reliable, and modern energy for all by 2030 and indirectly contributing to several other SDGs.

Access to off-grid solar has grown substantially over recent years, with decentralized renewables making up 6% of new electricity access since 2012[10]. This growth has been combined with significant market entry and private sector engagement from an increasingly diverse, global pool of manufacturers and distributors. Total sales value generated by the off-grid solar sector has exceeded USD 3.9 billion[11], raising increased interest and commitments from investors, including commercial debt and equity players.

Products have evolved from smaller solar lanterns and multi-light kits (pico products) to larger, 'plug-n-play' solar home systems (SHS) often sold with efficient appliances such as TVs, fans and radios[12], bringing increasing levels of energy service to customers. The combination of declining costs for solar and decentralized solutions, and cheaper and more efficient lighting and appliances, has increased the number of available solutions to cater to those currently without electricity access.[13] As a result, off-grid energy has been transforming the energy access landscape, especially in rural areas.

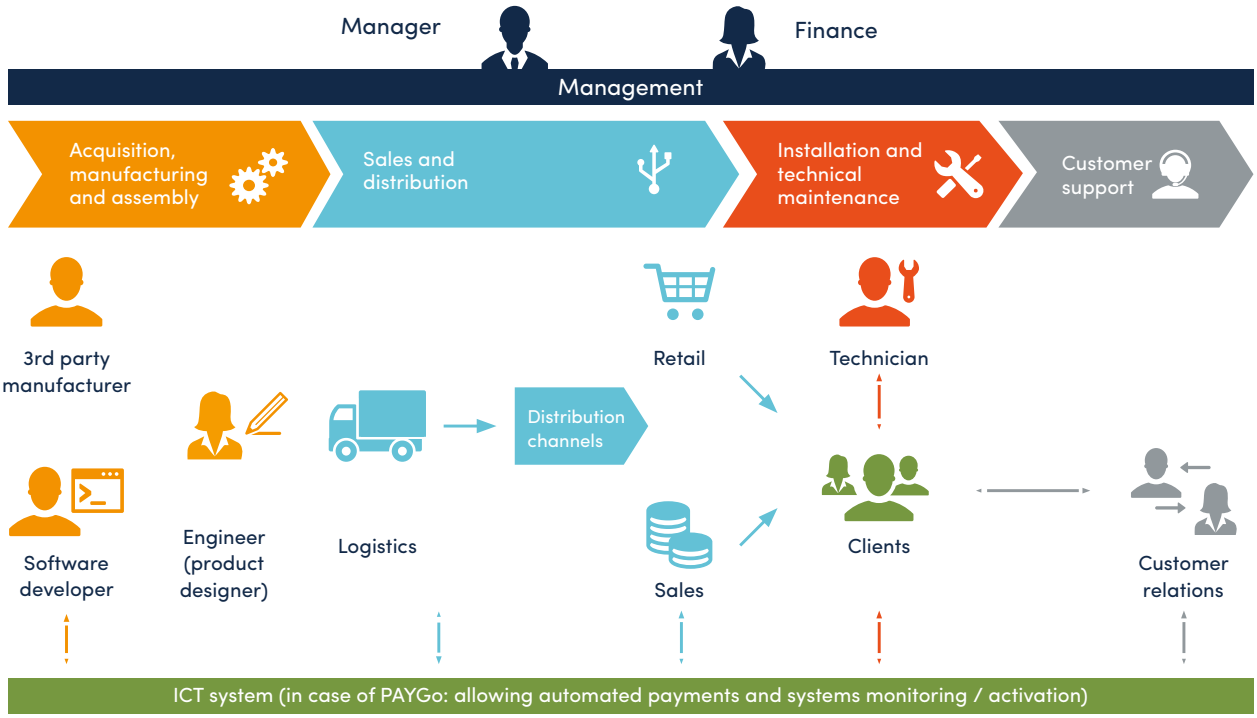
Two distinct service delivery models have emerged, cash-based versus pay-as-you-go (PAYGo). The solar lantern market is still dominated by cash sales and is becoming increasingly commoditized, with differentiation among players being substantially based on price. Recently, new service delivery models making use of digital, mobile-enabled platforms, such as PAYGo have allowed customers to buy larger SHS. These business models have seen substantial growth, especially in countries with a mature mobile money market. PAYGo allows households to pay for clean and reliable off-grid solar products in small instalments: instead of requiring upfront payments for a system, customers can pay for the system in small amounts. Customers typically make a down-payment of about 10-20% of the total cost of the SHS. Following the initial down-payment, customers make regular payments, using a mobile wallet, mobile money, or scratch cards receiving tokens for the equivalent of units paid for. Of the off-grid solar products sold by GOGLA Member companies in the first half of 2018, 80% were sold on a cash basis and 20% via PAYGo service delivery models.

For both of the main off-grid solar delivery models, there are four main aspects to the value chain, from initial technology acquisition and manufacturing, to sales and distributing of products, to technical installation, through to customer support and after sales services. Depending on the sales model and the chosen distribution channel, the proportional number of jobs within each category will change in line with the requirements of service delivery. Figure 2 provides an illustrative example of the value chain for the off-grid solar sector, displaying the different types of jobs generated along the off-grid solar products' journey to the customer, and after sale services.

8 IEA (2018), World Energy Outlook.
9 Lighting Global (2018), Off-Grid Energy.
10 IEA (2017), Energy and the Sustainable Development Goals.
11 Dalberg and Lighting Global (2018), Off-Grid Market Trends Report.
12 Pico-PV products include lanterns and simple multi-light systems of 0-10.999 Watt peak (Wp). Plug-n-play solar home systems are all-in-one packaged solar home system kits of 11+ Wp, typically powering several lights as well as energy-efficient appliances.
13 IEA (2017), Energy and the Sustainable Development Goals.

Evolution of the off-grid solar sector

Figure 2 - The off-grid solar product journey creates different types of employment across the whole value chain



The International Energy Agency (IEA) has recognized that decentralized energy systems could provide the most cost-effective way to reach 70% of energy poor households in rural areas[14]. Global market projections suggest there will be steady overall growth of the off-grid solar sector by 25% per annum over 2017-2022 and an 87% growth for the SHS segment, which is overwhelmingly driven by PAYGo[15]. From 2012-2018, PAYGo companies have raised just over USD 961 million to reach new customers, equal to about 75% of all funds raised[16]. This suggests that investors have high expectations of how fast a relatively small group of PAYGo companies can grow[17].

However, several challenges remain to scaling up off-grid solutions, both for the individual consumer and the off-grid companies. For the individual consumer, affordability remains a critical barrier. Even though traditional off-grid energy sources such as kerosene and candles make up a substantial part of household costs for people without electricity access (off-grid households in Africa pay 20 times more per kWh than households with a connection to the grid[18]), the upfront costs for off-grid systems may still be higher than most consumers are willing or able to pay. For off-grid solar suppliers, a key challenge is to decide on the most appropriate service model to deliver technologies to end consumers in an increasingly competitive market. This will require businesses to continue to innovate in their service offering, and how they provide those services across the value chain; from assembling products, to delivering technology platforms and, increasingly, extending the range of services offered to consumers.

14 IEA (2017), Providing Energy Access for all by 2030.
15 Dalberg and Lighting Global (2018), Off-grid Market Trends Report.
16 GOGLA (2019), Investment Database.
17 Dalberg and Lighting Global (2018), Off-Grid Market Trends Report.
18 Africa Progress Panel (2015), Africa Progress Panel Report: Power, People, Planet.

Methodology

This report draws on an Employment Survey (2018) carried out by GOGLA, gathering data from close to 40 off-grid solar companies. This included information on the types and levels of jobs across the off-grid solar value chain, such as management positions, technical roles, HR, and customer services. A full description of the job categories used is provided in Annex 2. This employment information has been aggregated and anonymized and used to estimate industry-wide employment using current industry sales data, and projections of future sales.

Market data research was then validated and expanded upon with seven interviews carried out with GOGLA industry members operating across the four regions covered in this report. The authors are indebted to all companies that participated in this research and most particularly to the representatives of seven organizations who shared their experience of the evolution of the labor force, the insights of which provide the context behind the numbers.

Gross employment estimates for PAYGo and cash-based sales across the four regions are based on sector sales data and sales growth projections. Specifically, the three main sources of data are used to generate employment estimates:

- Employment factors for emerging regions, developed through recent GOGLA market research and interviews carried out with GOGLA industry members. This data includes information on the types and level of employment in different positions across the company. These employment factors represent the proportional relationship between sales and employment generation. Applying them to sector wide data on sales therefore generates an estimate of how many jobs are created according to the magnitude of sales.
- Industry sales data to benchmark the current size of regional markets for solar lanterns, multi-light kits and SHS[19]. This sales data is used to apply the proportional relationship derived from the employment factors. Sales data from GOGLA and Lighting Global affiliates is scaled to estimate total off-grid solar market sales (i.e. including non-affiliates) in each region. The proportions are based on an estimate of non-affiliate sales comprising 30% of global sales for PAYGo and 71% for cash[20].
- Projections of future sales, which are used to generate changes in employment profiles by 2022. The projected growth of the sector is based on the latest market insight[21].

To generate evidence of the nature and type of jobs created, data was provided through GOGLA from the Employment Survey[22], and supplemented by structured interviews with sector players. Data on the number and nature of jobs provided by companies was used to estimate the potential scale of the employment opportunities, and how this is likely to be split by part of the value chain as the sector evolves.

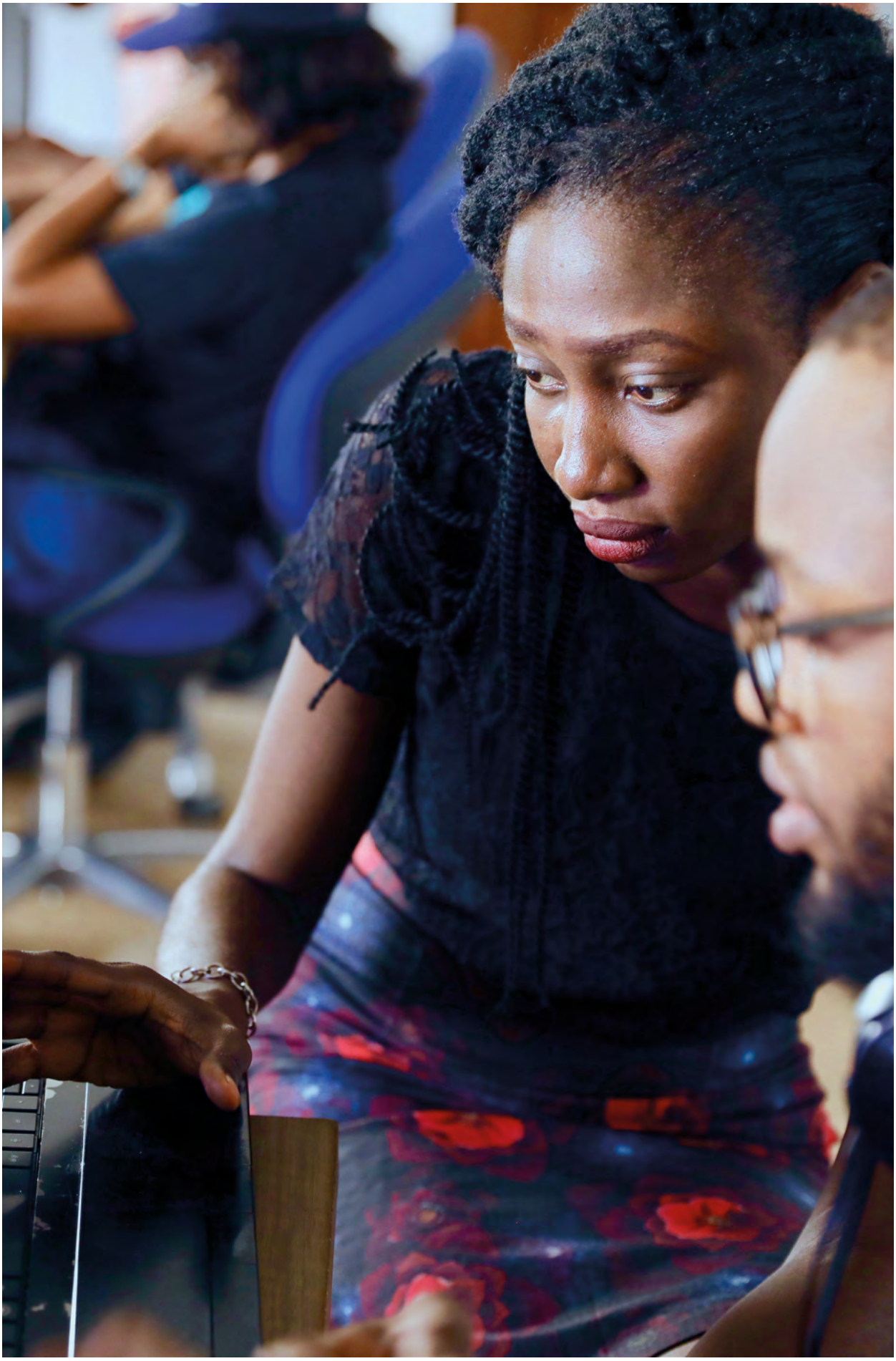
A more detailed methodological outline is provided in Annex 1.

To determine the potential size and impact of the solar irrigation market, the technical potential for solar water pumps was calculated. This calculation was based on a number of characteristics. For example, the share of agriculture in employment and GDP, weather conditions, existing modern irrigation, and the extent to which farms are in areas not well served by a reliable national grid. The methodology used to estimate the technical potential for SWPs in this section is presented in Annex 2.

A framework to measure the indirect and induced employment effects from the off-grid solar sector, and broader socioeconomic benefits, is set out in Section 7.

19 GOGLA (2018), Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data.
20 Dalberg and Lighting Global (2018), Off-Grid Market Trends Report. Growth rates provided are general for the off-grid solar sector. Estimates may not take into account regional differences in growth rates which could shape employment demand.
21 Dalberg and Lighting Global (2018), Off-Grid Market Trends Report.
22 The GOGLA Employment Survey of all GOGLA industry members was conducted in September 2019, with nearly 40 members contributing data to this research.

Methodology



Off-grid solar drives employment and income

The off-grid solar sector has already spurred a range of new employment opportunities and, as the off-grid solar market matures, the scale and nature of these jobs will continue to evolve. In the emerging markets with significant energy deficits included in this study, with supportive policies and investment environments, the off-grid solar value chain could generate up to 1.3 million full-time equivalent (FTE) jobs by 2022, excluding manufacturing[23].

These job opportunities include high-skilled, high value-add labor to support both over-the-counter cash sales, and the sales of systems through instalments under the PAYGo service delivery model, including finance and management roles. The PAYGo business model in particular also creates skilled positions in sales and after-sale services, and for technicians and engineers for installation and maintenance of the products over their lifetime.

4.1 Service delivery models and employment generation

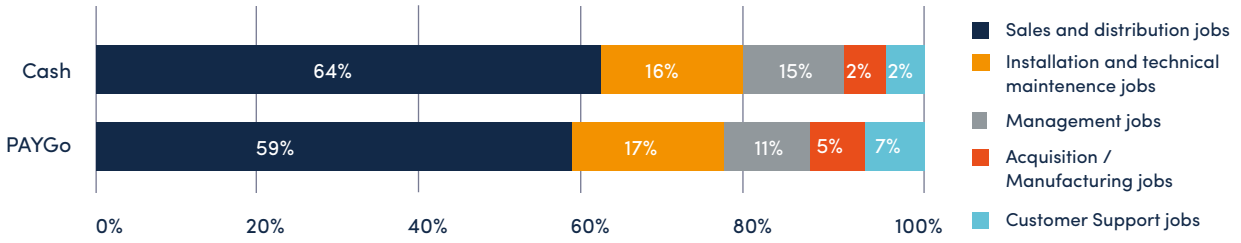
The total employment generated by sales and the prevalence of different job types is dependent on the service delivery model through which the technology is sold. This study differentiates between two service delivery models: cash sales and PAYGo.

The PAYGo model is relatively more labor intensive than the cash-based sales model due to additional roles needed for supporting installation, long-term technical assistance, and customer support as shown by Figure 3. For every unit sold through PAYGo, the number of people employed by an off-grid solar company tends to be higher than for cash-based sales. Cash sales, on the other hand, employ a larger proportion of employees under the sales and retail portion of the supply chain. Regions with relatively more sales under the PAYGo model will typically see larger employment effects directly within the solar value chain and are likely to see a slightly higher concentration of skilled work, given the higher proportion of jobs in after-sales services.

The PAYGo service delivery model places a stronger emphasis on ongoing customer support and long-term service value offering. In contrast to cash-based sales, the PAYGo model establishes a long-term connection to the customer stemming from the payment structure of the service. Since customers are expected to make regular payments, the PAYGo company must ensure that the quality of the service remains constant. Furthermore, under the PAYGo model, the company is providing an ongoing service which requires enabling, and collecting payment from customers, as well as initial credit checks. PAYGo companies therefore have a larger proportion of customer support jobs as well as installation and maintenance jobs.

Cash sales companies dedicate a higher proportion of their employees to sales and distribution as they focus on maximizing their customer base. For cash-based sales, the transaction with the customer is a one-off exchange so a company with this service delivery model can make better use of resources with a larger network of sales points and expansive distribution network. As a result, they have a higher proportion of employees in management positions needed to manage the large pool of sales agents and distribution employees.

Figure 3 - The split of employment across total jobs in the supply chain will differ according to the PAYGo and over the counter cash sales



23 This section sets out the potential scale of employment opportunities across the off-grid solar value chain in the five years from 2018.

Off-grid solar drives employment and income

To date, the services shown in the value chain have often been delivered by a single, vertically integrated business. However, alternative delivery models are already developing, with businesses providing only part of the services in the value chain and forming partnerships and links to other companies who provide other services. These partnerships can generate indirect employment across other complimentary sectors – discussed further in Section 5.

4.2 How the off-grid solar sector generates jobs and income

Employment opportunities are created and will evolve as the market develops in four key ways.

First, as markets grow and sales volumes increase, employment in the off-grid solar sector will also increase. As new sales are generated, more staff will be needed to distribute the products, and to support before- and after-sales services.

Second, as the service delivery models evolve, employment opportunities will also change in scale and in nature. In particular, as described above, an increasing share of PAYGo sales will both generate more jobs per sale and affect where these jobs are located in the value chain. The PAYGo model employs more people related to after sales customer relations, as well as technical jobs such as software design and logistics. In contrast, cash-based models will invest in effective and extensive sales networks, translating in a higher proportion of sales jobs across emerging regions.

Third, as the industry matures, the type of jobs associated with both the PAYGo and cash service delivery models may evolve. For example, an emerging trend is for customers to purchase larger multi-light systems and SHSs, often accompanied by appliances such as televisions and fans. With more complex and extensive products and services, companies may have to expand the number of employees focused on technical and customer support. Similarly, cash sales-based service delivery models may also have to innovate to compete against attractive PAYGo financing models. This may translate into more jobs in technology developments, as well as customer and technical support[24].

Fourth, some off-grid energy solutions will enable increased access to employment and income opportunities. This is explored in the recent *Powering Opportunity* report, where survey results showed that customers in 7% of households that purchased a SHS reported that this enabled them to get a new job[25]. This is explored further in Section 6 of this report.

In addition to these direct impacts on the value chain, the evolution of the off-grid solar sector will also respond to and trigger employment effects in related sectors. The projections presented in this report do not consider how related sectors, such as mobile money, technology sectors, or sales of appliances and services enabled by access to an off-grid solar product, will grow in response to increasing demand. Typically, growth in one sector will generate 'direct' employment (that is considered here) as well as 'indirect' employment in sectors linked to the value chain through 'forward' (up the supply chain) and 'backward' linkages (down the supply chain). Finally, there may be an 'induced' employment effect, as the income generated by new jobs is spent elsewhere in the economy, generating a multiplier effect on employment in other sectors. This can be positive – where activity is stimulated in other sectors in the economy, or negative – where activity is displaced from other sectors in the economy. The indirect employment effects are further explored in Section 7.

In this study, only the direct employment through sales of solar lanterns, multi-light kits and solar home systems is modelled. The numbers presented do not include any employment that may be associated with the use of off-grid solar products, employment created by the sale of off grid productive use appliances, such as solar irrigation pumps, captive power for agriculture or industry, or the future employment that would be created in associated sectors as the sales of off-grid solar products grow. For example, jobs catalyzed through the sale of appliances or increased use of mobile phones and mobile money.

The value chain for off-grid solar products is international – sales in one region will generate employment both in that region and in other regions. For example, manufacturing

24 This effect has not been modelled because of lack of data. However insight from Dalberg and Lighting Global (2018), Off-grid Market Trends Report, leads to that qualitative conclusion.

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

of components often takes place in a different location to assembly or sale of the final product – and the organization of the supply chain will differ from one region to another in this regard. The data available for this study does not allow us to unpick this global value chain – indeed it can only link sales in a particular region to employment in that region. As noted in Section 4.1, the estimates do not include manufacturing employment opportunities.

Table 1 - Summary of pico and plug-n-play million sales by region projected to 2018 and 2022.

	2018 (projected)		2022 (projected)	
	Cash sales	PAYGo sales	Cash sales	PAYGo sales
East Africa	5.4	2.4	7.6	12.2
West Africa	1.8	0.6	2.7	3.4
Central Africa	1.1	0.1	1.9	1.3
South Asia	10.3	0.2	21.9	4.4
Total	18.6	3.3	34.1	21.3

NOTE 'Sales' represents new product sales in-year, not cumulative sale. Sales are in millions rounded to one decimal point and therefore totals may not add up to the sum of individual regions.

The volume of product sales in each region is projected to 2022, as are the shares of PAYGo and cash sales. For this study, all regional markets are assumed to grow at a cumulative annual growth rate of 25% per year to 2022[26]. PAYGo sales are expected to grow faster than cash sales as the market evolves, by a factor of five[27].

The estimates of new sales in each year are then converted into an estimate of the number of active products on the market, which continue to generate employment across the value chain. In particular, this note assumes that employment in some parts of the value chain are only generated by sales in the same year, while other parts of the value chain are supported by sales in the current year, and in the preceding years. Specifically:

- Sale, retail, and customer relations are only generated by sales in the current year;
- Maintenance, logistics, engineers, technicians, software developers, finance, management are generated by products sold in the current year, and the previous four years[28].

Employment factors are used to estimate sales in each region. These employment factors are used to generate estimates of employment creation by region and by element of the value chain using projected product sales in 2018 and 2022[29]. Further explanation of how these factors were generated and used in this report is presented in Annex.

4.3 Employment in the off-grid solar sector by region

In East Africa employment across the value chain is estimated to rise from 75,000 in 2018 to 350,000 in 2022[30]. East Africa is already a large market, with a relatively large proportion of PAYGo sales. These PAYGo sales are projected to make up 62% of total products sales in the market by 2022, with cash sales comprising only 38%. This large proportion of PAYGo sales is expected to help drive this strong increase in employment opportunities.

Whilst remaining the largest region for employment overall, job growth in South Asia is expected to be somewhat slower than in East Africa, up from 260,000 in 2018 to 745,000 in 2022. This is as the majority of sales in the region are cash based, which generates relatively fewer jobs, as described above. However, sales growth is expected to continue at a rapid rate, catalyzing hundreds of thousands of new jobs. This effect is boosted by a steadily increasing share of PAYGo sales in the market, which are estimated to increase from 2% in 2018 to 17% in 2022[31].

Given their earlier stage of market growth, the West African and Central African regions show a smaller number of off-grid solar jobs in 2022 relative to East Africa and South Asia. However, the numbers still rise significantly from 25,000 and 7,000 jobs in 2018 to 150,000 and 65,000 in 2022

26 Following the estimate set out in Dalberg and Lighting Global (2018), Off-Grid Market Trends Report.
27 Calculation based on Dalberg and Lighting Global (2018), Off-Grid Market Trends Report, which expects PAYGo sales to grow by 87% per year, and cash sales by 16%, that is a factor of 5.4.
28 Assuming an average asset life of five years over which the product is serviced.
29 Employment factors were calculated using in-country sales data, as well as in-country employment. Therefore, these factors do not take into account the effects on international supply chains and are limited to the direct effect of sales employment on the region in which sales tool place. The employment factors used in the current study are comparable to those in the wider literature.
30 All job figures are given in full time equivalent (FTE) units.
31 Projected sales data from GOGLA (2018), Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data.

Off-grid solar drives employment and income

in West and Central Africa respectively. As in East Africa, the emergence of a robust PAYGo sector is anticipated to drive much of this employment growth.

Table 2 - East Africa represent the largest job market for the off-grid solar sector in 2022, followed by South Asia.

Region	East Africa	West Africa	Central Africa	South Asia
Gross jobs	350,000	150,000	67,000	745,000
Management	12%	11%	10%	14%
Acquisition / manufacturing	5%	5%	5%	2%
Sales and distribution	57%	58%	61%	64%
Installation and maintenance	19%	18%	16%	16%
Customer support	7%	7%	8%	4%

NOTE Jobs are shown in full-time equivalency (FTE). The total number of jobs created is therefore much larger than this.

The nature of potential employment in the off-grid solar sector

The off-grid solar sector is generating a wealth of new employment opportunities and well-paid jobs, ranging from entry-level roles to highly skilled positions. The industry is also maturing. New products, services and business models are being brought to market and new companies, partnerships and sector support organizations established to service the sector's growing needs. As the industry evolves, so too the scale and nature of the employment opportunities it generates.

5.1 An emerging sector and its evolving workforce

As set out in Section 4, by 2022, the off-grid solar sector could support up to 1.3 million full-time equivalent (FTE) jobs across the four regions. The roles that are being created are primarily in sales, retail, customer relations, management, finance, logistics, engineering, technical support and software development[32]. These jobs support the sale and distribution of solar lanterns, home systems and appliances, as well as the ongoing technical and maintenance needed to service these products. Sales via the PAYGo business model, where products are sold in instalments, also lead to additional job creation in customer service and finance.

Market growth is also leading companies to adopt different business models and product offerings. While some companies remain focused on basic energy access, others are moving toward more complex solar-powered appliances and agricultural equipment, proprietary software, non-energy loans, digital financial and internet services. This expansion of the sector will see increasingly diverse products and services being offered, and subsequently, an increasingly diverse range of employment opportunities.

As well as the jobs created within off-grid solar companies, the off-grid solar industry supports employment in other sectors through partnerships and links to complementary service providers. One example is partnerships with mobile phone companies, where products are sold via mobile phone retail outlets, helping to boost sales and sales positions.

In addition, indirect jobs are being created in other sectors through linkages with local suppliers for services such as transport, construction, recruitment, insurance and telecoms. GOGLA members in Sub-Saharan Africa and South Asia report that logistics, marketing and communication companies have benefitted in particular from the boost in demand created by the off-grid sector[33].

5.2 Well-paid and highly skilled jobs are being created across the value-chain

To support this growing industry, the off-grid solar sector is projected to generate 510,000 medium and highly skilled jobs and 800,000 lower skilled roles by 2022 (Figure 4)[34]. The available data does not disaggregate these roles into full-time versus part-time positions, although interviews with GOGLA members suggest that most formal employees are employed on a full-time basis.

Many of the positions created by the off-grid solar sector will also deliver substantially higher wages than the average wage of the country in which they are created. Even amongst the lower skilled positions in the sector, incomes are typically above countries' respective minimum wages, and often above the average national wage[35]. Additionally, in lower skilled positions, there is often opportunity for quick progression and wage increases due to training opportunities and the rapid growth of companies.

Well-paid and highly skilled jobs created by the off-grid solar sector may also have wider positive economic impacts. Not only do these competitive wages directly benefit employees and their families, but they may provide an indirect boost to local economies through increased spending and increased government revenue via employee-employer related taxation and social security benefits. The boost to training and skills that the sector provides will also provide long-term benefits for the wider economy. This is further explored in Section 7.

32 GOGLA Employment Survey of all GOGLA industry members was conducted in September 2019, with nearly 40 GOGLA and Lighting Global affiliates contributing data to this research, and Vivid modelling.
33 Interviews with GOGLA members.
34 These figures are given in full-time equivalent (FTE) units, and relate to projected employment in East Africa, West Africa, Central Africa and South Asia.
35 Interviews with GOGLA members.

The nature of potential employment in the off-grid solar sector

Figure 4 - The off-grid solar industry will support around 220,000 high skill jobs, 290,000 medium skill jobs and 800,000 lower skill positions by 2022.

High skill	Medium skill	Lower skill
Graduate or postgraduate degree 3-5 years+ experience	Graduate degree 1-3 years experience	Secondary education Minimal experience
220,000 Managers, finance, software developers and other engineers	**290,000** Technicians, logisticians	**800,000** Customer relations, sales, retail, other jobs

NOTE Units are in full time equivalent (FTE) jobs.

5.3 Off-grid companies are building the skill-sets of local employees

Off-grid solar companies are hiring educated workers to undertake highly skilled positions, but they are also building their workforce through training and capacity building. Many of the staff on off-grid solar company payrolls have at least 2-4 years of post-secondary education, depending on their level of responsibility. Managerial and finance positions require on average 3-6 years of experience and are often sourced from candidates with post-graduate level education; while the average level of professional experience for jobs in retail, logistics and technical services is around 1-2 years. For more technical roles such as technicians and software developers, experience specifically related to off-grid solar is more important and will become increasingly vital as products evolve into more sophisticated services.

As the industry advances, there will be an increasing demand for these high-skilled management, strategic and technical roles to support growth into new product spaces, and to enable consumers to benefit from a wider range of consumer goods. In addition, as companies in the off-grid solar sector scale up, more and more skilled employees will be needed to drive business growth into new regions and ensure reliable, consistent and high-quality customer service. This in turn will create more jobs and contribute to wider economic and social benefits.

To make the most of this growing employment opportunity, support for relevant skills training is key. However, given the youth of the sector, there is currently limited specialized training offered by educational organizations across the four regions reviewed.

> As we scale in different markets, we will need much stronger managerial, soft and analytical skills. Those are the skills that will take the business to the next level.
>
> BBOXX, East Africa

The nature of potential employment in the off-grid solar sector

Off-grid solar companies have therefore taken the initiative to build up their own workforces through in-house training and support for employee's personal development. On-the-job training is used to adapt existing skill sets to the specific requirements of the sector, particularly for managerial, sales and logistics roles; while many companies establish their own formal local training programs for logistics and sales staff[37] and invest in external training for their management and technical staff.

5.4 The off-grid sector creates employment opportunities across the economy but especially in rural areas

The off-grid solar sector has rapidly expanded, creating new, well-paid, employment opportunities. Over half of these jobs (56%) are being created in rural areas where employment opportunities are often limited (Figure 5)[38&39].

This reflects the nature of an industry for which a strong majority of unelectrified households, the primary audience for off-grid solar products, are situated in rural areas. Rural job roles in the off-grid solar sector are largely focused on sales and distribution and typically pay well above the minimum wage of the respective country, or in line with average wages[40]. For a majority of these positions, companies employ payroll staff on long-term contracts, with opportunities for progressing in line with business growth (see Boxes 2 and 3). Where sales or other part-time roles are commission-based, they provide flexible ways for rural staff to augment other job roles and opportunities to boost their household income.

The benefits of employing staff in local communities is not only felt by the employees but also the companies they work for. Companies are increasingly gaining from the direct personal knowledge that their team have of a community's needs. This can create a virtuous circle where strong sales can lead to new employment opportunities for local staff.

The off-grid solar industry presents good employment opportunities for women – and these opportunities are increasing as the technologies and business models evolve

Approximately 27% of total FTE jobs in the off-grid solar sector are filled by women, and this percentage is expected to rise as the market evolves. This is almost 20% higher than female employment in other energy sectors such as oil and gas, where the number of women only make

Box 1 - Filling the Skills Gap

While the education and skill level of applicants for roles in the off-grid solar sector is high, finding and training a network of sales and after-sales contact points for the most dispersed rural communities is a particular challenge. 'Last-mile' sales are often delegated to agents with limited prior experience when they are first recruited into the role. In addition, as off-grid companies expand into new regions with less experience of off-grid solar, there is a need for more skilled employees to undertake key roles.

Several off-grid solar companies highlighted the skills gap in rural areas as a potential limitation on future business growth[36]. A focused effort on increasing capacity would help to underpin the emerging sector and encourage its expansion into new countries and regions.

36 Interviews with GOGLA members.
37 See for example: Mobisol - Let There be Power: Mobisol Engages in Business in Africa with Mobile Solar Systems; ZOLA Electric - https://unfccc.int/climate-action/momentum-for-change/financing-for-climate-friendly/off-grid-electric and Green Light Planet's EduMe - https://www.edume.com/blog/spotlight-on-greenlight-planet.
38 GOGLA Employment Survey of all GOGLA industry members was conducted in September 2019, with nearly 40 GOGLA and Lighting Global affiliates contributing data to this research, and Vivid modelling.
39 Rural is generally defined as outside towns of 5,000 inhabitants or more.
40 Interviews with GOGLA members.

The nature of potential employment in the off-grid solar sector

Box 2 - Jean Luc, IT Support Officer BBOXX Africa

Jean Luc joined BBOXX in 2015, after working in quality assurance for 3 years where he was already earning well above the national Rwandan average wage of RWF 100,000 (USD 110) per month.

Jean Luc changed roles four times in four years, as he progressed in a fast-growing company. He spent eight months as a Customer Service Call Centre Supervisor, with a salary 40% higher than his previous job. Leveraging the skills he acquired as a supervisor, he transitioned into a Sales Agent Administrator, overseeing the work of Sales Agents business processes in Rwanda and Kenya. Under this position his salary doubled, in line with the new degree of responsibility. After 18 months in this position, he was promoted to a Sales Agent Network Deputy position in the same area but with a higher wage. After a further year, Jean Luc transitioned into being an IT Support Officer, where he is now responsible for providing IT support to all nine countries where BBOXX operates. His salary is significantly higher when compared to his starting salary, and in the same range of salaries paid in similar positions in other sectors (RWF 900,000 to 2.2 million (USD 990 to 2400) per month).

Joining a fast-growing company allowed Jean Luc to quickly develop new skills and pursue additional development opportunities. Jean Luc has accompanied BBOXX's rapid growth over the last few years, including expansion to six new countries. He has gained project and business process management skills and technological knowledge, and is still looking to develop further, as he is currently completing his MSc with his dissertation focused on the off-grid solar sector. He sees his experience at BBOXX as providing him with the set of skills and opportunities needed for career progression.

up 22%[41]. As business models such as PAYGo become more widespread[42], they are likely to generate greater employment opportunities for women in the off-grid sector, who often undertaken customer service roles associated with the business model.

Furthermore, in emerging economies, women are traditionally more closely involved in fulfilling the household's energy needs and are often responsible for the procurement and use of energy[43]. They therefore have a close perspective of how to engage a key customer demographic. A recent pilot study by Value for Women found that, when women were provided the right training on product demonstration and sales techniques, their performance rose to surpass that of their male counterparts – generating 45% more sales and 52% more revenue than male agents[44]. As the share of women in off-grid solar employment grows, this can continue to have positive feedback loops, encouraging more women to both adopt off-grid solutions and gain the skills to enter and participate in the sector[45]. The Solar Sister network provides a strong example of this opportunity, where female sales agents not only engage other women as purchasers of socially beneficial solar products, but inspire them to join the network as sales agents themselves[46].

41 IRENA (2019), Renewable Energy: A Gender Perspective.

42 As discussed in Briefing Note 1 in this series (Vivid Economics (2018), Employment Opportunities in an Evolving Market. Off-Grid Solar: Creating High-Value Employment in Key Markets), the PAYGo market is expected to grow relatively quicker than cash-based sales across emerging regions.

43 Smith (2000), Solar-Based Rural Electrification and Microenterprise Development in Latin America: A Gender Analysis; UNDP (2013), Geder and Climate Change. Asia and the Pacific. Gender and Energy.

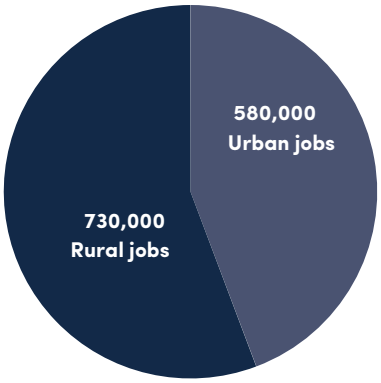
44 Value for Women (2018), A Business-First Approach to Gender Inclusion: How to Think about Gender Inclusion in Small and Medium Enterprise Operations.

45 See for example:
- The Solar Sister model of using female solar entrepreneurs to distribute solar lanterns, enabling entrepreneurs to gain business knowledge, experience, and access to capital.
- The Barefoot College trains women from rural communities as solar engineers, innovators and educators who then spread the knowledge through their local networks, boosting self-sufficiency and energy access.

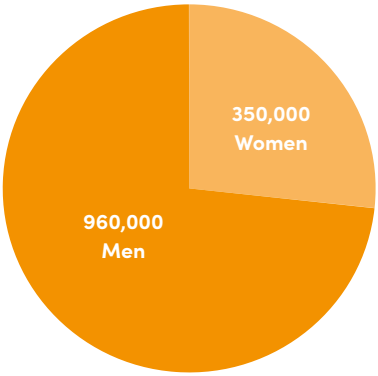
46 Miller Center for Social Entrepreneurship (2017), Turning on the Lights: Transcending Energy Poverty Through the Power of Women Entrepreneurs.

The nature of potential employment in the off-grid solar sector

Figure 5 - Projected number of jobs for employees in rural areas and women in 2022



1,310,000
total FTE jobs created



1,310,000
total FTE jobs created

Box 3 - Pascal Kipkemoi, Software Test Manager M-KOPA

Pascal Kipkemoi joined M-KOPA in 2013 as M-KOPA was first taking off as a start-up business. After working in customer care for one year, where he was already earning well above the national Kenyan average wage of Ksh. 35,000 (USD 346), Pascal was then seconded to a solar company in West Africa (PEG – Persistent Energy Ghana) as a temporary consultant for two months.

Pascal spent just over one year as a Customer Service Call Center Agent, and as his experience in this department grew, so did his salary. Pascal's background education was in finance, but due to the breadth of opportunities available within M-KOPA, he soon realized that his passion is in technology. Combined with his experiences as a consultant with PEG and his interest in technology, Pascal became a Software Test Analyst. Software Test Analysts work in teams to ensure the quality of software for production releases. With this new position and new responsibilities, Pascal's salary tripled. After a year in this position, he was promoted to a Software Testing Lead, enjoying greater responsibility in leading the testing team, and a commensurate increase in his wage. After a further year, Pascal transitioned into being a Software Test Manager, where he now monitors in-house and outsourced systems development for quality before systems go into mainstream production. To expand his skill-set even further, Pascal enrolled in a technology course at a local University in Nairobi and is set to graduate by end of 2019.

Joining a fast-growing off-grid sector company allowed Pascal to discover his career passion and to develop his knowledge and skills in a variety of professional roles.

The nature of potential employment in the off-grid solar sector

We employ from the communities within which we work – which we believe has a very positive impact on the community through training and income.

Mobisol, East Africa

© Lagazel

Employment potential from productive use of off-grid solar technology

The off-grid solar sector is increasingly enabling the productive use of off-grid solar appliances. Productive use of energy (PUE) can support livelihoods through income generation, employment opportunities, and diversification of economic activities. Off-grid solar products can increase productivity by providing more hours of light and offering a reliable electricity connection for small businesses in all stages of the production process[47]. Raising productivity of existing work in, for example, the agriculture sector helps raise incomes among the rural poor, while new appliances can also create new value chains and generate new employment opportunities.

A range of PUE products are becoming increasingly common in emerging markets. These include the use of solar in shops and stalls, bars and restaurants and to power a whole range of appliances that support agri-business.

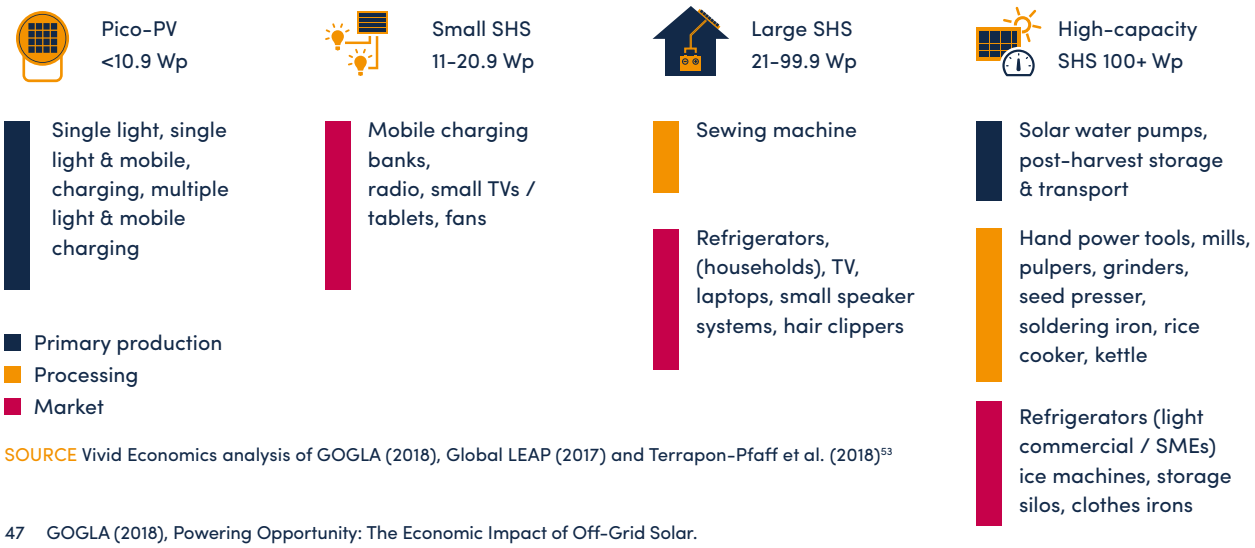
A key agricultural PUE appliance is the solar water pump. Solar water pumps (SWPs) are increasingly becoming a viable alternative to diesel pumps and offer an attractive method of access to irrigation for smallholder farmers who currently lack access to electricity and are reliant on rainfed agriculture. SWPs can be cost-competitive with diesel alternatives[48], with significant savings created across the product lifetime, whilst pay-as-you-go technology helps make them more affordable for smallholder farmers by avoiding the upfront costs[49].

Increasing the number of smallholder farms that benefit from solar irrigation will transform crop yields, boost incomes and catalyze employment.

6.1 Putting off-grid solar products to productive use of energy (PUE)

As the off-grid solar market expands, the range of products and applications is increasingly being put to productive use[50]. These range from use of small solar systems in households for mobile phone charging, to lighting, sound and television in bars and restaurants, refrigeration and cooling, to SWPs for irrigation, agri-processing, and various industries such as carpentry, tailoring, welding and looming (Figure 6)[51]. PUE provides another market for off-grid solar alongside domestic use, drives income increases through improved productivity, and supports job creation and economic diversification[52].

Figure 6 - Productive use of off-grid solar appliances ranges from mobile phone charging in households to large-scale industrial applications



SOURCE Vivid Economics analysis of GOGLA (2018), Global LEAP (2017) and Terrapon-Pfaff et al. (2018)[53]

47 GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar.
48 Open Capital Advisors & Shell Foundation (2017), Promoting Productive Uses of Energy in Uganda.
49 Guardian Labs (2018), Water From the Sun: How Solar Powered Pumps can Energise a Whole Community.
50 Productive use can be defined as "agricultural, commercial and industrial activities involving electricity services as a direct input to the production of goods or provision of services" (GIZ (2011), Productive Use of Energy – PRODUSE: A Manual for Electrification Practitioners). Off-grid solar energy supports wider welfare benefits like improving health and opportunities for education, but this briefing note focuses on productivity benefits only.
51 GIZ (2011), Productive Use of Energy – PRODUSE: A Manual for Electrification Practitioners
52 GIZ (2011), Productive Use of Energy – PRODUSE: A Manual for Electrification Practitioners.
53 Appliances for productive use and categorisation derived from: GOGLA (2018), Standardised Impact Metrics for the Off-Grid Solar Energy Sector; Global LEAP (2017), Off-Grid Appliance Survey Summary; and Terrapon-Pfaff et al. (2018), Productive Use of Energy – Pathway to development? Reviewing the Outcomes and Impacts of Small-Scale Energy Projects in the Global South.

Employment potential from productive use of off-grid solar technology

Off-grid solar products can increase productivity by providing more hours of light and offering a reliable electricity connection for small businesses in all stages of the production process. The study Powering Opportunity: The Economic Impact of Off-Grid Solar found that 58% of households undertake more economic activity due to their purchase of a solar home system (SHS), either by unlocking additional work hours, using the system in a new or existing businesses or enabling SHS-owners to get a new job[54]. A recent study reviewing the impacts of small-scale PUE applications in emerging economies found that 38% of the evaluation sample generated additional employment opportunities, while other users reported income or productivity increase[55]. Off-grid solar products have the potential to create and upgrade agricultural value chains, for example by increasing production volume or providing storage of products. Moreover, they allow for diversification of economic opportunities and increase communities' resilience to economic shocks[56], for example through reducing dependency on fluctuating fuel prices or by making farmers less dependent on unreliable rainfall and frequent episodes of drought[57]. Of the larger off-grid solar products, household and commercial/small to medium enterprise (SME) refrigeration, televisions and fans are highest in demand, while SWPs, agriculture cold chain refrigeration, and commercial/SME refrigeration are ranked highest in terms of their potential short-term contribution to socioeconomic development and poverty reduction[58].

The uptake of off-grid solar for productive use also boosts direct job creation across the off-grid solar supply chain itself both from increased sales and from the growth of a more extensive product support sector.

6.2 A closer look at solar water pumps, productivity and livelihoods

Agriculture continues to be the world's largest employer, sustaining the livelihoods of 40% of the world's population[59]. Improved irrigation is an important mechanism in generating increased income, employment and rural development[60]. Moving from rainfed irrigation to SWPs for irrigation can lead to significantly higher agricultural productivity and increased or diversified harvest, which in turn leads to higher income for farmers. Alongside income improvements, access to SWP makes communities more resilient to variable climate conditions by enabling production of a wider range of crop types or by allowing farmers to diversify their income sources, for example by selling excess water to their neighbors or surplus energy to the grid[61]. A recent study in India reports that 45% of farmers saw an increase of 50% or more in their annual incomes compared to rainfed irrigation[62]. This is corroborated by recent global research by FAO, where 90% of the respondents agreed or strongly agreed that changes in income were significant after the installation of SWPs for irrigation[63]. Moreover, a study in Zimbabwe reports an increase in income of 47% for middle income groups, and substantially higher increases for lower income farmers[64].

As well as their potential to improve irrigation on rainfed farms, solar water pumps represent a clean, reliable alternative to diesel-based pumping systems[65], and to grid-based electricity where this is not available or is of poor quality.

54 GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar. The research focuses on the impact of SHS, from multi-light and phone charging kits (3-10.99 Wp) to larger SHS (11-200 Wp). Of these 58% of households undertaking more economic activity, 36% of households generate additional income of, on average, $35/month once they purchase an off-grid solar device.

55 Terrapon-Pfaff et al. (2018), Productive Use of Energy – Pathway to development? Reviewing the Outcomes and Impacts of Small-Scale Energy Projects in the Global South.

56 GIZ (2011), Productive Use of Energy – PRODUSE: A Manual for Electrification Practitioners.

57 FAO (2018), The Benefits and Risks of Solar Powered Irrigation.

58 Global LEAP (2017), Global LEAP Off-Grid Appliance Market Survey.

59 United Nations (2015), Food Security and Nutrition and Sustainable Agriculture, Sustainable Development Knowledge Platform

60 While supporting SWP for irrigation at scale, adequate efforts for water conservation measures would be essential to reach sustainable rural development, particularly in areas with constrained ground water resources. Apart from economic incentives, some technical knowledge or service infrastructure to ensure systems are run and maintained effectively is crucial to avoid unsustainable water use, as low energy costs can lead to wasteful water use, over-abstraction of groundwater, and low field application.

61 FAO (2018), The Benefits and Risks of Solar Powered Irrigation.

62 SSAEL (2018), Evaluation and Impact Assessment of the Solar Irrigation Pumps Program in Andhra Pradesh and Chhattisgarh.

63 FAO (2018), The Benefits and Risks of Solar Powered Irrigation.

64 IRENA (2016), Solar Pumping for Irrigation: Improving Livelihoods and Sustainability; Burney et al. (2009), Solar-Powered Drip Irrigation Enhances Food Security in the Sudano–Sahel. The UK Aid funded Low Energy Inclusive Appliances program (LEIA) and Acumen will publish an SWP impacts

65 FAO (2018), The Benefits and Risks of Solar Powered Irrigation. Beyond increasing productivity, welfare gains include CO2 reduction, reducing time needed to fetch water (mostly by women) and reducing farmers' vulnerability to changing rainfall patterns and fuel price fluctuations.

Employment potential from productive use of off-grid solar technology

The life cycle costs of a solar water pump are 22-56% of the life cycle costs of diesel pumps, enabling a payback period of 2 year[66]. Replacing conventional pumps with solar water pumps reduces daily fuel costs and operation and maintenance costs. Diesel-powered pumps are typically characterized by a lower initial cost but high operation and maintenance costs, while SWPs are the opposite, with a higher initial cost but very low ongoing operation and maintenance costs[67]. On average, the life cycle costs of a solar water pump are 22-56% of that of diesel pumps, which means a payback period of 2 years is possible. As the price of petroleum products increases and the cost of SWPs has rapidly fallen in recent years, it is likely the life cycle costs for SWPs compared to diesel pumps will decrease further. Furthermore, SWPs generally have a longer operational life than diesel-powered pumps as they require less maintenance[68].

SWPs have the potential to stimulate labor demand by promoting the use of modern agricultural techniques, which can increase the number of seasonal harvests and crop area coverage. Using SWPs for irrigation can stimulate jobs in the agricultural sector through '*within-crop*' and '*across-crop*' effects[69]. The first effect is directly due to the introduction of a second harvest which raises labor demand relative to the benchmark of one harvest. The second effect is due to the expansion of crops over areas previously dedicated to less-labor intensive activities, which also tends to increase labor demand. For example, by switching from soy (one of the least labor-intensive agricultural activities), to other cereals like rice, wheat or maize, or to seasonal crops[70]. Furthermore, as set out in Section 4, off-grid solar products like SWPs create jobs directly as well. Recently, a 3-year program in Rwanda was launched with the aim to provide energy access to 77,000 people in rural communities through mini-grids and solar-powered irrigation. Altogether, it is expected to create 7,000 jobs, especially for women and youth[71].

SWP significantly boost broader welfare gains. Welfare gains range from individual benefits such as reducing time needed for water collection and higher food security, to societal benefits like reduction of CO2 emissions. Furthermore, SWPs can have significant benefits for women, since women produce two-thirds of the food in most developing countries and are predominantly responsible for fetching water for food production[72].

66 Open Capital Advisors & Shell Foundation (2017), Promoting Productive Uses of Energy in Uganda. Payback period depends on: (i) initial capital costs (type and size of system, cost of shipping and installation); (ii) recurring costs (costs relating to operation and maintenance, labor and fuel); (iii) ensuing economic benefits (fuel savings, yield increases); and (iv) current energy expenditure.

67 Solar Electric Light Fund (2018), A Cost and Reliability Comparison Between Solar and Diesel Powered Pumps; Open Capital Advisors & Shell Foundation (2017), Promoting Productive Uses of Energy in Uganda.

68 IRENA (2016), Solar Pumping for Irrigation: Improving Livelihoods and Sustainability; Solar Electric Light Fund (2018), A Cost and Reliability Comparison Between Solar and Diesel Powered Pumps.

69 FAO (2018), The Benefits and Risks of Solar Powered Irrigation.

70 Bustos et al. (2015), Agricultural Productivity and Structural Transformation. Evidence from Brazil.

71 IRENA (2017), Renewable Energy and Jobs - Annual Review 2017, International Renewable Energy Agency.

72 IRENA (2016), Solar Pumping for Irrigation: Improving Livelihoods and Sustainability.

Employment potential from productive use of off-grid solar technology

Box 4 - A Solar Water Pump Customer
Vincent Onyango, Kenya

Vincent started Kolik tree nursery in 2014 together with his brother. To irrigate the farm, they tried everything; buckets from the nearby swamp, a treadle pump, a petrol pump but each came with unpredictable costs of temporary laborers and fuel. In August 2016, to overcome these volatile costs, Vincent purchased a Futurepump solar pump using financing.

Since then, the brothers have expanded their nursery and also started growing kale and local vegetables. They keep 5% of the vegetables for themselves and sell the other 95% on the local market. With their extra income they have been able to become farmers on a full-time basis and have brought on a permanent employee.

To expand their income even further, they also lend and rent the solar pump - either for farming (at $4 a day) or construction (at $10 a day), which has enabled Vincent to pay off the loan on the solar pump in less than a year. With these additional funds Vincent has improved life for his family, while at the same time, the pump is bringing benefits to friends and neighbors.

Case Study: Futurepump; Photo Credit: Martin Wright, Ashden

Employment potential from productive use of off-grid solar technology

6.3 The future role of SWPs across emerging regions

The potential size and impact of the solar irrigation market depends on a number of characteristics. For example, the share of agriculture in employment and GDP, weather conditions, existing modern irrigation, and the extent to which farms are in areas not well served by a reliable national grid.

Agriculture remains of significant importance across emerging regions in terms of GDP and employment. In Sub-Saharan Africa, more than 95% of farmed land relies on seasonal rains to meet irrigation needs. West Africa's access to modern irrigation is especially low, at only 1%. As a result, almost 700 million ha of agricultural land is not equipped with modern irrigation. Currently, 62% of the farms are smaller than 1 hectare (ha) and operate close to 19% of the farmland[73]. Enabling more smallholders to access solar irrigation would be transformative for agriculture and economic opportunities across the continent[74]. Of the customers currently benefitting from an off-grid solar device, about a third report agriculture as their main source of income[75].

While supporting solar water pumps for irrigation at scale, adequate efforts for water conservation measures would be essential to reach sustainable rural development, particularly in areas with constrained ground water resources. Apart from economic incentives, some technical knowledge or service infrastructure to ensure systems are run and maintained effectively is crucial to avoid unsustainable water use, as low energy costs can lead to wasteful water use, over-abstraction of groundwater, and low field application.

The technical potential for SWPs on smallholder farms (<1 ha) is at least 130 million across West, Central and East Africa, and 33 million in South Asia[76]. As the world's population rises and supplies of freshwater decrease in the context of climate change, the demand for irrigation due to the need for higher food production increases rapidly[77]. The potential for SWPs to meet this need is determined by the proportion of currently non-irrigated agricultural land farmed by small-holder farmers (<1 ha land). The actual potential for SWPs will be higher as this takes only the market potential for new pumps into account, whereas SWPs can also replace existing diesel or grid-connected pumps.

In South-Asia, the current potential for SWPs is 33 million units. In South Asia, there has been a fast development of irrigation infrastructure in recent years, resulting in 33% of agricultural land using modern irrigation[78]. However, this has contributed to the agricultural sector consuming 23% of India's power from the over 20 million grid-powered irrigation pumps[79] and driven up emissions, as nearly nine million water pumps in the country are powered by diesel generators. To address the overconsumption of grid-based energy for irrigation and polluting diesel pumps, as well as to create more opportunities for the 67% of farmers without modern irrigation, India's Ministry of New and Renewable Energy (MNRE) has issued supportive policies for SWPs. It aims to grow the use of SWPs by a minimum of 100,000 per year, to reach a total of 1,000,000 pumps by 2020-21[80] and has recently announced the introduction of the KUSUM scheme, which aims to install a further 2.75 million SWPs through the use of capital subsidies[81]. Alongside environmental and agricultural benefits, this will help to create thousands of jobs in the SWP supply chain.

73 FAO (2016), The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide.

74 Nevertheless, it is important to stress again that SWPs for irrigation, if not adequately managed and regulated, bear the risk of supporting unsustainable water use as there is no financial incentive for farmers to save on fuel or electricity for water pumping. This can lead to wasteful water use, over-abstraction of groundwater, and low field application efficiency. Furthermore, SWPs are a high risk investment, especially if the roll-out programs do not adequately address onsite ownership, making them inaccessible for smallholders (FAO (2018), The Benefits and Risks of Solar Powered Irrigation). Recognizing these risks and addressing those from the beginning will be crucial to ensure the sustainable use of SWPs.

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

76 The technical potential for SWPs is determined by the proportion of currently non-irrigated (rainfed) agricultural land and the irrigable area a SWP can cover, which is typically only a small garden area of 0.3 to 1 ha (FAO (2014), Irrigation Techniques for Small-Scale Farmers). This is only the market potential for pumps to connect farmers who are not currently using modern irrigation, i.e. supplying SWPs where currently only rainfed irrigation is used. In general, grid-based irrigation is much cheaper than SWPs or diesel-powered irrigation, which is why farmers that have a reliable grid connection are assumed to not be potential customers for SWPs. Calculations are based on country-level World Bank development indicators. The analysis further assumes that all currently non-irrigated agricultural land of <1 ha can be irrigated by SWPs, and that all small-holder farmers will have only 1 SWP per farm.

77 FAO (2018), The Benefits and Risks of Solar Powered Irrigation.

78 Vivid Economics calculations based on country-level World Bank Development Indicators.

79 Energy Efficiency Services Limited, a Joint Venture of public sector undertakings under the Indian Ministry of Power.

80 SHAKTI (2018), Impact assessment of the National Solar Pumps Programme.

81 CEEW (2018), Solar for Irrigation: A Comparative Assessment of Deployment Strategies.

Employment potential from productive use of off-grid solar technology

Figure 7 - Agriculture remains of significant importance across emerging regions, with a substantial contribution to national GDP and a large proportion of the population employed in agriculture

	Agriculture share of employment	Agriculture share of GDP	Rural electricity access
South Asia 12% land irrigated of 33% potential Technical potential - 33 million SWPs	44%	18%	88%
West Africa 1% land irrigated of 19% potential Technical potential - 50 million SWPs	55%	31%	21%
Central Africa 3% land irrigated of 18% potential Technical potential - 24 million SWPs	58%	22%	28%
Eastern Africa 5% land irrigated of 18% potential Technical potential - 57 milion SWPs	64%	25%	27%

NOTE Agricultural share of employment, agricultural share of GDP and rural electricity access percentages are averaged across regions based on World Bank country-level data.

SOURCE Vivid Economics[82]

The employment opportunities resulting from the use of modern irrigation services are huge and remain largely untapped or informal. In emerging economies, only a fraction of agricultural land is irrigated, while the agricultural sector remains the main sector of employment across sub-Saharan Africa (Figure 7). Similarly, across the three African regions in this study, grid connectivity is low, and off-grid solutions for small scale agriculture could play an important role in improving employment and livelihoods for off-grid communities.

In South Asia, grid connectivity is much higher, but nonetheless off-grid solar appliances for PUE have become widely used, and there is a large potential to expand this market. PUE appliances and SWPs present a huge and emerging opportunity for employment and the off-grid sector. An opportunity that, if supported, will also boost employment opportunities and welfare for millions of the world's poorest people.

82 Based on World Bank World Development Indicators. Values are averaged across regions from available country-level data. For Central Africa there was no data available for irrigated land (as a percentage of agricultural land), so an average of the percentages of West and Eastern Africa was used.

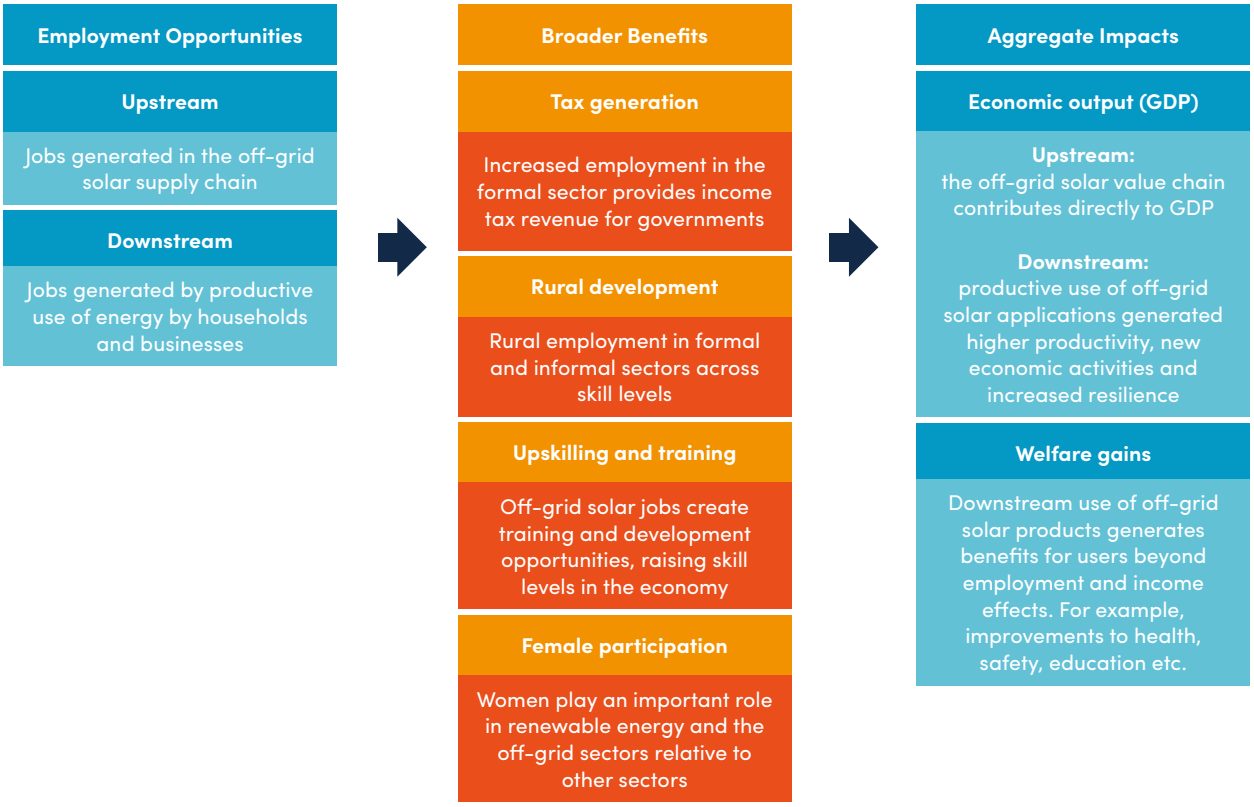
Wider economic benefits associated with employment in the off-grid solar value chain: Opportunities for further research

Employment in the off-grid solar sector could generate a range of wider benefits in emerging markets, reaching beyond finding new or higher income jobs. While the previous sections have focused on the role of the off-grid solar sector in generating new employment opportunities, and the nature of these opportunities, this section discusses the role of employment the off-grid solar sector in generating a wider set of secondary benefits, as set out in Figure 8. In particular:

- Increased revenue from income tax from increased employment in the formal sector
- Supporting rural development through economic diversification in regions where employment opportunities are typically more limited
- Generating high value employment and training programs to develop a higher skill workforce
- Increasing female participation in the workforce

Further research is required to quantify these wider economic benefits, however the outline below provides examples and existing evidence of these benefits.

Figure 8 - Wider benefits of employment opportunities generated by the off-grid solar value chain



Wider economic benefits associated with employment in the off-grid solar value chain: Opportunities for further research

7.1 Increases tax revenue and government resources

Given the relatively low share of employment in the formal economy in many regions, and particularly across much of Sub-Saharan Africa[83], the off-grid solar sector can make an important contribution to boosting formal employment. This has a range of benefits for employees, including increased economic resilience of employees who are on stable contracts, and social security, in the form of access to pensions and national insurance.

Employment in the formal economy will subsequently generate income tax revenue for governments. Given the paucity of public resources for governments in emerging regions, this can make an important contribution to the finances needed to implement national development plans. Where public money is spent effectively, it has a multiplier effect in the economy, stimulating development and economic growth.

The contribution of the off-grid solar sector to the tax base could be estimated by the number of workers employed under formal contracts. The contribution to the tax base would then be the number of workers on formal contracts, multiplied by their average wage, and the respective national income tax rates. Given the share of high-skilled labor (discussed below), this contribution could be relatively important. The amount of tax generated by formal employment in the off-grid sector would require further study and data collection.

7.2 Raising skill levels and generating high value employment

The creation of highly skilled jobs in the off-grid solar value chain will support demand for highly skilled, highly educated workers, which may have a positive impact on attracting and retaining talent in a country. As mentioned in section 5.2, the expansion of the off-grid solar sector has the potential to generate higher skilled jobs for technicians, software developers and managers. Links to other high skilled sectors, such as information technology and logistics (explored in section 3.2), may also spur demand for high skilled employees. These jobs could provide attractive opportunities for existing high-skill labor and contribute to training and development through in-house programs to raise the skills level of employees.

Increase in demand for higher skills will also boost employment in training and educational sectors for experts with off-grid solar technology specific skills. Off-grid solar companies typically provide in-house training for workers to get them up to the required expertise[84]. In some cases, there may be skills shortages, particularly in rural areas, which will provide further training opportunities and technical courses for lower skill workers.

Since supply will respond to demand, one way of measuring this impact is through the extent to which educational institutions increase their offering of technical and management courses. An increase in the number of graduates and skilled labor finding employment in local markets could be measured through further research in collaboration with educational institutions that regularly conduct alumni surveys. Additionally, industry players could share information on the training and development of their employees.

83 ILO (2018), Women and Men in the Informal Economy.
84 Interviews with GOGLA members – see Section 5.3.

Wider economic benefits associated with employment in the off-grid solar value chain: Opportunities for further research

7.3 Female participation in the workforce

While research on the impact of the off-grid solar sector on female employment is limited, studies are starting to develop this evidence base. Section 5.4 presents an overview of the potential role of the off-grid solar sector in generating employment opportunities for women. Other evidence includes:

- Evidence that access to electricity is also an enabling factor to a latent pool of female entrepreneurs. In a study conducted on the impact of a mini-grid in Ghana, there was a recorded increase of 29% in women entrepreneurial ventures after they gained access to electricity[85].
- Evidence that suggests women communicate with customers more effectively given their sensitivity to the household's energy needs, stemming from women being the primary users of energy in the household[86]. Companies are beginning to leverage this advantage after recording the positive effect on sales and customer perception[87].
- Evidence that access to modern energy and increased light hours has the potential to decrease women's 'time poverty'[88]. With less time spent collecting resources for energy provision, women have more time to seek paid activities or gain the necessary education to secure a productive future[89].

Gender-focused data collection can provide further insights to ensure that the off-grid solar sector continues to expand employment and economic opportunities for women.

7.4 Rural jobs and economic diversification

As discussed in Section 3.1, off-grid solar job creation has the potential to boost employment and skills in rural areas. Over half of job creation is linked to rural employment given the importance of last mile distribution and customer engagement. Section 2.1 outlines how the largest proportion of employment for both PAYGo and cash-based delivery models is under sales agents and employees.

The up-skilling and expansion of rural employment will additionally have a positive impact on earnings and security of rural employment. On the one hand, the informal economy continues to represent a major share of economic output in emerging markets[90], and across Africa accounts for around 40% of GDP[91]. Improving the lives of the informal workforce is an important part of economic development[92], and growth in off-grid solar employment opportunities in rural areas will improve the quality of informal jobs. As the off-grid solar sector expands, the opportunities to transition from highly informal to more formal employment as regular wage workers and micro-entrepreneurs will also expand, creating opportunities for workers to move to higher income positions, and to gain access to formal employment opportunities over time.

As well as jobs created directly and indirectly within the off-grid sector, increased energy access has the potential to create for downstream employment effects. Recent findings from the off-grid solar sector reveal that there are important income generating effects from the use of off-grid solar appliances across emerging regions[93]. In one study, 11% of households surveyed started a new business due to access to a solar home system, and 7% reported that someone in their household was able to take on a new job role. Some of those operating small enterprises also noted that the business benefits created by the SHS had enabled them to employ additional workers. As noted in Section 6, the expansion of off-grid productive use appliances and solar water pumps will also lead to new economic opportunities in agriculture and associated sectors.

Additional research could help to uncover and quantify the wider economic benefits of off-grid solar products on rural enterprise and employment.

85 Energicity (2018), Solar Mini-Grids Boost Women Entrepreneurship.
86 IRENA (2019), Renewable Energy: A Gender Perspective.
87 Winther et al. (2018), Solar Powered Electricity Access: Implications for Women's Empowerment in Rural Kenya.
88 Understood as having limited time to spend on self or paid activities due to time spent on housework and unpaid activities. World Bank (2006), Gender, Time-Use and Poverty in Sub-Saharan Africa.
89 UNDP (2013) Gender and Climate Change. Africa. Gender and Energy.
90 The informal economy encompasses those sectors where jobs lack basic social or legal protections or employment benefits (ODI (2018), Informal is the New Normal - Improving the Lives of Workers at Risk of Being Left Behind. Shaping Policy for Development).
91 ILO (2018), Women and Men in the Informal Economy.
92 ODI (2018), Informal is the New Normal - Improving the Lives of Workers at Risk of Being Left Behind. Shaping Policy for Development.
93 GOGLA (2018), Powering Opportunity: The Economic Impact of Off-Grid Solar.

Wider economic benefits associated with employment in the off-grid solar value chain: Opportunities for further research

7.5 Measuring indirect and induced job creation

The main focus of this report has been to provide evidence on the 'direct' jobs generated by the off-grid solar value chain, and the potential to stimulate employment opportunities in other sectors of the economy. However, to provide a full understanding of employment opportunities would require additionally taking into account indirect and induced job creation, as well as any negative employment impacts that result from the growth of the off-grid solar sector (e.g. due to job reductions amongst kerosene or diesel sellers).

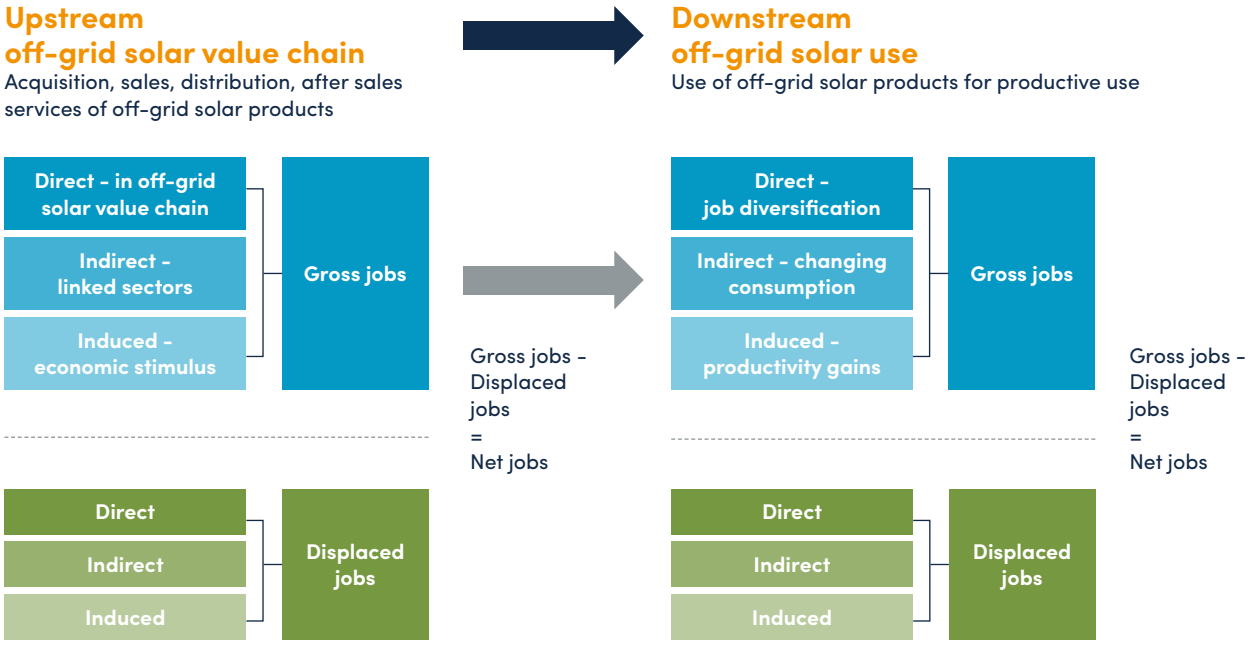
To uncover the broader employment picture, three categories of jobs should be considered:

- **Direct jobs:** jobs that are created directly by economic activity in the off-grid solar value chain and its applications;
- **Indirect jobs:** jobs that are created in linkages between the off-grid solar value chain and other sectors of the economy. For example, through increased demand for input materials required to deliver products, or through increased onward demand for telecoms products to enable consumers to access PAYGo products;
- **Induced jobs:** jobs that are created because of increased purchasing power from direct and indirect jobs. For example, as incomes are raised when productivity increases and new jobs are generated in the off-grid solar value chain, this additional income is spent in other areas of the economy, which stimulates jobs in other sectors

As shown in Figure 9, there will be employment effects both from employment in the off-grid solar value chain (the left panel) and for customers who now have access to energy and the opportunities it provides. This study focusses on the former.

Employment in the off-grid solar sector may have positive 'stimulus' employment impacts, and/or negative 'displacement' effects through delivery of the supply of products chain, and through application of off-grid solar products by consumers. These impacts through the supply chain are shown in the left 'upstream' panel of Figure 9. Jobs generated through the use of off-grid solar systems is shown in the right 'downstream' panel. A brief methodology to estimate each of these impact mechanisms is discussed in the paragraphs below.

Figure 9 - Net jobs in the off-grid solar sector are determined by direct, indirect and induced jobs for gross (new) jobs and displaced jobs in other sectors



NOTE For illustrative purposes a positive net impact is shown here (negative net job impacts are also possible depending on the scale of displaced jobs).

SOURCE Vivid Economics

Wider economic benefits associated with employment in the off-grid solar value chain: Opportunities for further research

A. Direct jobs in the off-grid solar value chain

Direct employment impacts in the off-grid solar value chain are those generated within the companies delivering services to off-grid solar customers. These range across the off-grid solar value chain, including manufacturing and assembly, importation, marketing, distribution, retail, after-sales service, financing, market research, and monitoring and evaluation[94]. An estimate of gross employment can be collected through survey data from operators – as is presented in Section 4.

To get to net direct employment effects, the gross employment number needs to be adjusted for jobs that are displaced by the off-grid solar sector. For example, if competing sectors shrink, such as the market for domestic fossil fuel (i.e. kerosene or diesel), these activities will see a reduction in sales (and potentially employment) as a result of growth in the off-grid solar sector[95]. This can be done through the use of either partial equilibrium, or general equilibrium models.

B. Indirect jobs linked to the off-grid solar value chain

Indirect employment related to the off-grid solar sector stems from linkages to other sectors in the economy. For example, links to suppliers of intermediary products and onward distribution of final products by other businesses, which are not captured in firm-level direct employment statistics. Examples of these activities are given in Section 5, and include production of raw materials and components, outsourcing some employment through third party providers and agent networks, and partnerships with for example microfinance providers.

These 'forward' and 'backward' linkages of employment effects are typically estimated using social accounting matrices. These matrices provide versions of country input-output tables, which provide a static picture of the links between sector-level supply chains in a national economy. These can then be used to estimate the expected knock-on of increased economic activity in one sector on other sectors of the economy – which may be positive or negative. However, they do not account for 'general equilibrium' effects, which would require a macroeconomic equilibrium model (such as a computable general equilibrium model).

C. Induced jobs stimulated by growth in the off-grid solar value chain

Induced employment can be estimated through applying multipliers based on empirical evidence. Induced employment is brought about as increased purchasing power from the direct and indirect employment opportunities generated that is (at least partly) spent within the economy. For example, new retail jobs are created as sales agents hired as part of the off-grid solar value chain spend their wages in shops. Induced employment is generally estimated using macroeconomic modelling techniques, which use an induced job multiplier. The obvious pitfall here is under- or overestimation of the jobs induced, both in terms of gross jobs and displaced jobs. Macroeconomic models encompass a wide range of probability models for macroeconomic time series analysis and estimation and inference procedures. However, they often have insufficient detail of the microeconomic structure of the economy, and lack in their ability to provide sufficient detail on the distributional and efficiency effects of exogenous changes.

Research to explore indirect and induced employment, as well as direct job creation within the sector, would provide more comprehensive insights on the broader impact of the off-grid solar industry on economic development.

94 Evan Mills (2016), Job Creation and Energy Savings Through a Transition to Modern Off-Grid Lighting.
95 SolarAid (2015), Research Findings - Baseline and Follow-up Market Research in Kenya, Tanzania & Zambia.

Wider economic benefits associated with employment in the off-grid solar value chain: Opportunities for further research

© ZOLA Electric

Conclusion

The off-grid solar sector already generates a range of employment opportunities in emerging regions, and this is expected to grow in the coming years. By 2022, across East, West and Central Africa, and South Asia, the off-grid solar sector could employ up to 1.3 million FTE jobs, with South Asia representing the largest region for employment, accounting for 740,000 of these. The nature of these jobs is evolving as the sector develops more complex service delivery models, and as technological innovation drives employment opportunities associated with larger systems and a wider range of complex consumer goods.

© Futurepump/Jeffrey M. Walcott

Several challenges remain to unlocking the full employment potential of the off-grid solar sector solutions, both for the individual consumer and the off-grid companies. These are set out in GOGLA's 'Providing Energy Access through Off-Grid Solar: Guidance for Governments'[96]. Key messages in respect of catalyzing job creation, are summarized here:

- Robust partnerships between the public and the private sectors in pursuit of energy access goals can provide significant benefits for job creation. From the perspective of employment opportunities, this includes development of education and training programs to ensure the skills required by an increasingly complex off-grid solar sector can be locally sourced wherever possible.

- Public funding to support growth of the off-grid solar sector will also drive the growth of formal and informal jobs, many in rural areas and for women. Recognizing the role of the off-grid solar sector in providing employment both in the value chain, and for users of off-grid solar products by households and businesses is an important step in understanding the impact that public finance can have by investment in the off-grid sector. This will be particularly effective if it is used to catalyze private sector finance and project development.

- Providing a supportive policy environment, including an appropriate taxation policy, to stimulate the sector will not only generate greater development and employment benefits but, ultimately, lead to increased government revenue. While VAT and import duties are often cited as a constraint to developing commercial service delivery models – VAT and import tariffs on solar products can be as high as 40% of the cost of goods[97] limiting market growth and the benefits created by access to off-grid solar products and services. Providing a tax regime that supports development of the off-grid solar sector will help to rapidly expand the off-grid sector and create an opportunity to improve tax revenues from other sources, in particular where employment opportunities are generated in the formal sector.

96 GOGLA (2018), Providing Energy Access through Off-Grid Solar: Guidance for Governments.
97 GOGLA (2018), Providing Energy Access through Off-Grid Solar: Guidance for Governments.

Annex 1 – Employment factors

The market research carried out by GOGLA generates total employment factors for cash and PAYGo sales for each region. That is, a separate employment factor for total full-time equivalent jobs associated with each product sale are used for each region. These were derived the GOGLA Employment Survey which contains a sample of close to 40 GOGLA and Lighting Global affiliate solar companies that shared information on the number of pay-roll and agent employees, as well number of employees along the value chain. This generates different employment factors for agents and pay-roll employees, as well as for employment along the value chain.

Employment factor for agents and pay-roll employees corresponding cash-based and PAYGo sales are used to generate gross employment across the three African regions. Presented in Table 3, gross employment was calculated by adding employment figures from agents and pay-roll employees generated by employment factors.

For South Asia, the employment factor was derived from separate regional research on off-grid solar employment and sales[98]. The employment factor for South Asia is a weighted average of employment factors derived for India and Bangladesh, the largest off-grid solar markets in South Asia. These were derived from the total number of people employed in the off-grid solar sector in those countries and country sales data[99]. The two factors were then weighted by the relative size of employment. Due to limited data, the same employment factor was applied to cash-based and PAYGo sales in South Asia.

Table 4 presents the employment factors along the value chain that were used to calculate proportional employment along the value chain per region. These employment factors were only available at the emerging regional level for PAYGo and cash-based sales. That is, there were no region-specific employment factors available. Therefore, to generate regionally specific results, the same employment factor was applied across all four regions. This generates the same proportional split of employment across the value chain per region for cash-based and PAYGo sales. However, it was possible to differentiate proportions of overall (cash-based and PAYGo employment combined) employment across the value chain across regions since each region has a different proportional split of PAYGo and cash-based sales.

Table 3 - Employment factors generate agent and payroll employment estimates for cash-based and PAYGo technology.

	Cash			PAYGo		
	Agents	Payroll	Total	Agents	Payroll	Total
Eastern Africa	1.34	0.83		10.90	16.17	
West Africa	0.04	0.26		16.83	27.79	
Central Africa	0.09	0.13		21.87	29.94	
South Asia			24.69			24.69

NOTE Employment factors represent the number of jobs created per 1,000 units sold.

SOURCE Vivid Economics

98 Data collected from the GOGLA Employment Survey was not sufficient to generate an employment factor for South Asia.

99 Employment data was sourced from the IRENA Employment Database. Sales data for India was sourced from GOGLA (2018), Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data, and units deployed in Bangladesh was sourced from IDCOL data on the Solar Home Systems Program.

Annex 1 – Employment factors

Table 4 - Employment factors for employment along the value chain generate proportional employment along the value chain for each region.

	Cash		PAYGo	
	Agents	Pay-roll	Agents	Pay-roll
Managers		0.116		1.074
Technician	0.004	0.189	0.807	1.656
Software Developer		0.014		0.340
Finance		0.065		0.501
Customer relations	0.001	0.096	0.084	2.474
Sales	1.707	0.968	11.90	6.374
Retail	0.002	0.033	0.002	0.584
Logistics	0.001	0.073	0.072	0.601
Other engineers		0.008		0.377
Other				0.062

NOTE Employment factors along the value chain were only available at the emerging region level. Employment factors represent the number of jobs created per 1,000 units sold.

SOURCE Vivid Economics & Altai Consulting

Annex 2 – Definition of jobs along the value chain of off-grid solar companies

Role	Definition from GOGLA employment survey
Managers	Managers plan, direct, coordinate and evaluate the overall activities of enterprises. Cross-cutting 'senior' management positions across the value chain -- which operate at various stages of the business. Can be further broken down into e.g. Sales Manager, Product Manager, Retail Manager, Customer Service Manager, Portfolio Management Business intelligence and insights etc.
Technician	Technicians and associate professionals perform technical and related tasks. This includes engineers, installers, repairmen, etc.
Software Developer	Software and applications developers and analysts conduct research; plan, design, write, test, provide advice on and improve information technology systems such as hardware, software and other applications to meet specific requirements.
Finance	Company finance and customer finance employees.
Customer relations	After-sales services workers such as call-center employees
Sales	Commission-based sales agents active during the last six months. An agent is active if he/she reported at least one sale in the last six months.
Retail	Employees working at the point of sale.
Logistics	Logisticians analyze and coordinate an organization's supply chain—the system that moves a product from supplier to consumer. They manage the entire life cycle of a product, which includes how a product is acquired, allocated, and delivered.
Other engineers	Industrial and production engineers conduct research and design, and coordinate the work regarding the technicians and the installations.
Other (incl. HR)	All employees that cannot be assigned to the previous categories. Includes other business functions such as HR and training

Annex 3 – Methodology for estimating potential for solar water pumps

The technical potential for SWPs is determined by the proportion of currently non-irrigated (rainfed) agricultural land[100] and the irrigable area a SWP can cover. To get a general idea of the potential scale of SWPs in emerging regions, the technical potential of SWPs is estimated for West Africa, Central Africa, Eastern Africa and South Asia, using the following steps:

- The total agricultural land area was determined by applying the percentage of agricultural land to the total land area of the four regions, using the World Development Indicators[101]. Using available country-level data, this was determined per country and then summed up per region
- The irrigated land as a percentage of total agricultural land was applied to the total agricultural land at country level (using World Development Indicators). The percentage of irrigated land was then applied to the summed up regional agricultural land area. For Central Africa there was no data available for irrigated land (as a percentage of agricultural land), so an average of the percentages of West and Eastern Africa was used
- The non-irrigated land was calculated for each region as follows: (1 - percentage of irrigated land) * total agricultural land
- The proportion of this non-irrigated land farmed by small-holder farms was determined by applying the proportion of farmland worked by <1 ha farms[102] to the total non-irrigated land area, assuming that SWPs for irrigation can only cover an area up to 1 ha[103], and
- To determine the SWP potential (number of units), it was assumed that that all small-holder farmers are potential SWPs for irrigation customers, and that farmers with farmland of <1 ha will employ 1 SWP for that land, which translates in: SWP potential = Non-irrigated agricultural land farmed by small-holder farms (ha) / 1.

100 The potential for irrigation is not only defined by amount of land suitable for irrigation, but also by availability of water resources, cropping patterns, and other local considerations like government policies, environmental context and cost. However, for the sake of this analysis it is assumed that all small-holder farmers are potential SWPs for irrigation customers.

101 World Development Indicators.

102 The proportion of farmland worked by <1 ha farms for Sub-Saharan Africa and South Asia was obtained from: FAO (2016), The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide.

103 Assumption based on: FAO (2014), Irrigation Techniques for Small-Scale Farmers.

Arthur van Schendelstraat 500A
3511 MH Utrecht
The Netherlands

info@gogla.org
+31 304 100 914

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