INTERNATIONAL SOLAR ALLIANCE

Solar Home Systems

Picture Source: https://gh.ambafrance.org/Gaakukorpe-community-in-the-Volta-region-benefits-from-solar-energy-project

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Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
BDT	Bangladeshi Taka
BOAD	West African Development Bank
COVID-19	Coronavirus Disease of 2019
DC	Direct Current
DFID	Department for International Development
DISCOM	Distribution Companies
ECOWAS	Economic Community of West African States
FCFA	Western African CFA Franc
GEF	Global Environment Facility
GIZ	German Agency for International Cooperation
GOGLA	Global Off-Grid Lighting Association
GPOBA	Global Partnership on Output-Based Aid
IDB	International Development Bank
IDCOL	Infrastructure Development Company Limited
IEC	International Electrotechnical Commission
IEC TS	International Electrotechnical Commission Technical Standard
IFC	International Finance Corporation
INR	Indian Rupee
ISA	International Solar Alliance
IT	Information Technology
JICA	Japan International Cooperation Agency
KFW	Kreditanstalt Fuer Wiederaufbau, German state-owned bank
KOSAP	Kenya Off-grid Solar Access Project
KST	KOSAP Service Territories
LED	Light Emitting Diode
LiFePO4	Lithium Iron Phosphate
MSCF	Market Scale-up Challenge Fund
MSME	Micro, Small and Medium Enterprises
NDC	Nationally Determined Contributions
NEP	Nigeria Electrification Project
NGO	Non-Government Organisation
OBF	Output Based Fund
PAYG	Pay-as-you-Go
PO	Partner Organisation
PV	Photovoltaic
RBF	Result Based Financing
RE	Renewable Energy
REA-PMU	Rural Electrification Agency-Project Management Unit
REC	Rural Electrification Corporation
RERA	Renewable Energy for Rural Areas
RET	Renewable Energy Technology
ROGEAP	Regional Off-Grid Electrification Access Project
SELCO	Solar Electric Light Company
SHS	Solar Home System/Solar Home Systems
SSAAU	Scaling Solar Application for Agricultural Use
SSP	SHS Service Providers
TERI	The Energy and Research Institute
TV	Television
USAID	US Agency for International Development
USD	United States Dollar
WAEMU	Western African Economic Monetary Union
WHO	World Health Organization

Executive Summary

According to the World Bank Database (2019), around 10% of the total world population do not have electricity access . Of the 10% population lacking access, approximately 600 million people (79%) belong from Sub Saharan Africa alone.

While those who have access to electricity, do not have reliable power to meet their energy demands- therefore making the potential market for Solar Home Systems (SHS) significant not only in the off-grid solar market but also to provide energy security to areas which suffer from frequent power outages. In addition, the off-grid solar products are playing an essential role in the fight against the COVID-19 pandemic as well., by keeping the families safe and secure amid pandemic since SHS are a reliable source of power independent of any grid disruption. Solar home systems and efficient appliances are powering the health centers, local businesses and helping families stay connected and secure.

ISA is cognizant of the fact that the role of solar home systems is paramount in accelerating solar deployment, especially in off-grid areas with limited to no energy access and has therefore introduced SHS component under Scaling Solar Application for Agricultural Use (SSAAU) Programme. The objective of this programme among other flagship programmes of ISA is to promote rapid deployment of Solar PV at scale in ISA member countries. ISA aims to promote solar home systems to off-grid communities in least developed countries to assist them in achieving energy security as well as energy access in ISA member countries.

In this regard, this E-book seeks to provide a comprehensive knowledge repository of solar home systems covering the general aspects of SHS including the need of SHS, prevalent SHS currently being sold in the market, as well as highlights on the best international practices and case studies on SHS from the countries having majority of energy deprived population.

Context

Picture Source: https://pixy.org/5940739/

1. Context

Solar Home Systems have played a pivot role in providing reliable energy to people living in rural as well as off-grid areas. Not only it is a cleaner source of energy but also among cheaper technology among all renewable energy alternatives. This makes it affordable among many off-grid users specially after the introduction of many government schemes as well as innovative financing mechanisms such as PAYG (Pay-as-you-Go). Furthermore, SHS is beneficial in providing energy security to areas which suffer from frequent power outages, making SHS efficient systems in powering the service units such as health centers and essential businesses. ISA is cognizant of energy related challenges in least developing countries where majority of the population resides in rural areas, and is therefore envisions the role of solar home systems as paramount in accelerating solar deployment in off-grid areas with limited to no energy access. The focus of ISA's flagship programmes is to endorse and encourage rapid deployment of Solar PV at scale in ISA member countries located across 4 regions as identified by ISA, i.e., Africa, Asia Pacific, Europe, and, Latin America and Caribbean. As a part of Scaling Solar Application for Agricultural Use (SSAAU) programme, ISA also aims to promote SHS to off-grid communities especially in least developed countries to assist them in achieving energy security as well as energy access.

1.1 Solar Home Systems (SHS)

A typical Solar Home System comes with PV module, battery, charge controller, inverter, number of electrical components such as LED, TV, portable torch/lantern, etc. SHS systems are commonly utilised as a reliable source of electricity, especially in the remote areas where grid accessibility is either limited or absent. Apart from providing lighting solutions, a Solar Home System also provides product features such as radio, fan, cellphone chargers whatever is required by a rural home. In some off grid markets such SHS can also be customized as per the needs of the user.

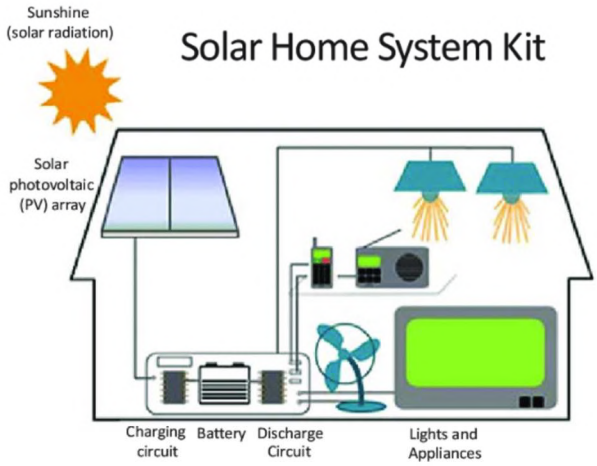

Figure 1 A typical SHS kit
(Image Source: https://www.researchgate.net/figure/Fig-1-A-small-DC-Solar-Home-System_fig1_324199648)

Working of a Solar Home System

A Solar PV module consist of an inter-connected string of semiconductor wafers (usually a silicon wafer), known as solar cells. The electricity from a solar cell is generated on the principle of Photovoltaic Effect (PV), i.e., when sunlight falls on the solar panels it gets absorbed by the solar cells (silicon wafer) and the silicon semiconductors convert the solar energy into electric energy through the release of electrons causing generation of voltage and electric current. This electric energy in the form of direct current (DC) is then used directly to charge the battery. It is advisable to use a charge controller for the batteries to protect them from over charging and deep discharge. The DC power in the battery is then utilised to power electrical loads in the night. If required, electrical loads utilize solar energy during day time. Extra power generated is used for charging of battery.

1.2 Target beneficiaries of SHS

SHS are extremely beneficial to economically backward communities that either do not have electricity supply at all or suffer from erratic and insufficient supply and still resort to environmentally unsustainable fuel for meeting their energy needs. SHS deployment is thus target to such energy deprived population since the product offering of SHS include efficient quality lighting that promote health and development; it also provides the rural population with freedom from the vicious cycle of poverty by improving their standard of living to an extent.

1.3 Advantages of SHS

i. Access to electricity at affordable prices

Most rural population are low wage earners and are unable to make ends meet with their low incomes. Moreover, the people who live in remote areas or tribal regions are deprived of grid electricity owing to the lack the financial capacity of utilities to expand their grids to isolated rural areas or due to the low potential return on investment.

SHS offers electricity at affordable prices to the rural households. With many government schemes coupled with innovative financing models have lighted many rural homes across Africa. Subsequent section highlights some case studies as examples to show how SHS have benefited rural populations with a clean as well as reliable source of energy.

ii. Improved quality of life

Inadequate lighting makes it hard for people to carry out chores effectively. Furthermore, it also brings difficulty for school going children to study in dim-lit conditions and makes medical aid also inaccessible and more challenging at night. Better living conditions is aided from the reliable access to electricity. Furthermore, it can be used to save lives by assisting health workers in effectively manage and effectively address critical life-threatening medical conditions in a well-lit facility by means of using SHS.

iii. Increased employment and entrepreneurship opportunities

With increase in productivity with efficient lighting, employment opportunities can be created for rural population by providing them training in operations, maintenance, assembling, repairing, and installation of SHS. By carrying out training and capacity building, a skill development center can be established in the region to encourage others to become solar entrepreneurs in their areas.

iv. Reduction in usage of polluting fuels such as kerosene/diesel and biomass

Energy being the fundamental commodity to humans, those living in the rural areas mostly rely on local resources to fulfill their basic requirements. Using non-environment friendly energy sources are known to create a negative impact on nature. Fossil fuels and biomass are among the heavily exploited resources of energy among humans. Biomass is abundant in most of the rural areas and is heavily utilized by the locals to meet their energy requirements. Burning of biomass not only creates pollution for the environment but also affects human health leading to respiratory problems which might aggravate causing death.

Switching to solar energy technologies such as SHS can eradicate problems associated with using pollution causing energy substitutes bringing a much cleaner and environment friendly alternative in rural and/or off-grid areas.

v. Increased resilience in terms of energy supply

Rural population that relies mostly on fuelwood and other biomass to meet their energy requirements and are known to spend substantial amount of time in collecting natural resources. In communities where labor allocation is unequal, women are the ones responsible for collection. This practice exploits time and efforts of not only women but young girls who are given this responsibility at a young age, severely affecting their education. While kerosene lamps have been the most popular energy source since many centuries, it comes at a cost to the environment as well as poor population. SHS displaces expenditure on kerosene lamps and candles, besides reducing indoor air pollution over and above fire and burn risk.

High capacity SHS (>100 W) provides at least 10 hours of backup power supply in a day, which is enough to meet the energy needs during the day as well as meet lighting requirements to carry out chores during the night hours. This leads to increased productivity among rural people. Local businesses in off-grid areas can remain open for longer hours creating more opportunities for economic growth.

vi. Lights keep rural community safe from venomous reptiles

According to the World Health Organization (WHO), around 138,000 people die from snakebites each year globally and roughly 95% of those deaths occur in poor, rural communities in developing nations. In Sub-Saharan Africa, up to 30,000 deaths are believed to occur each year from snakebites[2]. Most of these areas are deprived of reliable access to electricity, this makes it harder to spot snakes when it gets dark making people vulnerable to snakebites during the nights.

Solar Home System thus becomes extremely useful to provide lights to households in such critical regions. Moreover, the portable lamp can be used to spot the snakes in dingy areas and can be valuable solution to keep the community safe after sunset.

vii. Fulfillment of commitments laid down though the country's NDCs

In addition to many benefits of using SHS, the non-polluting, environment friendly technology of Solar PV contributes to the NDC efforts of the country in reducing national emissions and adapt to the impacts of climate change is also achieved to some extent.

[2] https://www.nationalgeographic.com/animals/article/snakebites-neglected-health-crisis-africa

SHS PREVALENT IN OFF-GRID MARKET

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2. SHS prevalent in off-grid market

As per the GOGLA Off-Grid Solar Market Report[3] it has been observed that sales of SHS, of wattage more than 11 Wp, recorded sales of over 1 million in the year 2020. Around 563,000 units and 620,000 units were sold in the first and second half of 2020 respectively. The 50-100 Wp systems were the most selling SHS category and SHS with more than 100 Wp category were among the least selling. In total solar home systems that were sold in 2020, approximately 86% were sold through Pay-as-you-go financing. This figure reflects the importance of affordable financing business model for making larger, more expensive off-grid products, affordable by many potential customers who are unable to have the funds for the upfront payment.

Table 1 Description of SHS product offerings that are currently prevalent across the globe

S.No	PV module size	Product features in SHS kit	Indicative Price (in USD)	Battery Size	Power backup
1.	10 – 12 W	• Three to four lights or light points • Torch • Mobile charging/ USB points • FM radio	~ 100	LiFePO4 3.3 – 6.4 V 12 Ah	4 hours
2.	20 – 75 W	• One or two bright tube lights (400 lumens each) • Four light bulbs with wall switches (upgradable to up to eight lamps) • FM radio, TV, and torch (optional, sold separately) • Three USB ports to charge multiple mobile devices simultaneously	~ 130 – 350	LiFePO4 11.1 – 12.8 V 6 - 18 Ah	5 – 7 hours
3.	140 – 200 W	• 2-12 light points • Portable lamp or torch • Table fan or TV (optional)	~ 500	LiFePO4 or Sealed Lead Acid 12 – 12.8 V 130 Ah	12 hours

[3] https://www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h2_2020.pdf

STANDARDS APPLICABLE TO SHS

3. Standards applicable to SHS

In June 2020, the International Electrotechnical Commission (IEC) published quality standards for pico-products and SHS kits up to 350 Wp. The Technical Standard IEC 62257-9-8 is largely built on the standards framed by Lighting Global Quality Standards.

Table 2 IEC Standards for SHS Components

S.No.	Component	Standard
1.	Solar PV Module	• IEC 61215-1:2016 • IEC 61730-1: 2016 • IEC 61730-2: 2016
2.	Battery	• IEC 62133-2: 2017 • IEC 61427-1: 2013
3.	White LED Lamps	• IEC 62612
4.	Solar Charge Controller	• IEC 62109-1: 2010
5.	DC ceiling Fans or Table Fan	• IEC 60335-2-80

IEC TS 62257-9-8 published under IEC 62257 (standards for rural electrification) defines the baseline requirements for the quality, durability, and advertising accuracy for stand-alone renewable energy products with the aim of ensuring quality of the product.
IEC 62257-9-8 is applicable to both pico-photovoltaic products, which include small, portable devices such as lanterns and flashlights, as well as solar home systems (SHS) which can be used for home lighting systems and certain appliances.
Whereas, IEC 62257-9-5 provides the detailed instructions for carrying out product sampling and testing. Many governments of several countries in Asia and Africa refer to IEC Technical Specification 62257-9-5 in their standards and/or policy.

International Initiatives

Picture Source: https://www.saurenergy.com/solar-energy-articles/rural-electrification-in-india-under-prime-minister-narendra-modi

4. International Initiatives

4.1 International Finance Corporation (IFC) World Bank Group's Lighting Global

Lighting Global is the IFC-World Bank Group's initiative launched in 2009 with first pilot project in Kenya. The objective of Lighting Global to support sustainable growth of the international off-grid solar market as a means of rapidly increasing energy access to the regions where most of the population do not have access to electricity. Lighting Global works with manufacturers, distributors, governments, and other development partners to build and grow the modern off-grid solar energy market.

As on June 2020, nearly 180 million people have benefited from using Lighting Global[4] quality verified solar products, by which more than 59 million people are able to meet their basic electricity needs. More than 44.5 million quality verified products have been sold through Lighting Global since 2009 and 44.5 million metric tons of carbon-dioxide equivalent (CO_2e) have been avoided due to the use of quality verified products instead of fuel-based alternatives.

Figure 3 Impact created by IFC's Lighting Global (as on June 2020)

(Image Source: Lighting Global, https://www.lightingglobal.org/about/our-impact/)

The Lighting Global program's approach is spread across 4 major components, these are:

i. Creation of international quality standards for solar devices and SHS to ensure quality assurance. The Program also guides manufacturers on the quality standards.
ii. Provide market intelligence by conducting market research and publish the findings, which includes extensive opportunities presented by the off-grid market, and other critical data which is valuable to manufacturers, distributors, and retailers to make informed business decisions.
iii. Facilitate access to finance for manufacturers, distributors, retailers, and consumers.
iv. Address impediments to the market's development, and work with individual firms to scale their businesses, providing on-the-ground business-to-business support and linkages to build the last mile distribution.
v. Raise consumer awareness about emerging solar products in nascent markets.
vi. Work with governments towards making a conducive environment in terms of policy. and regulatory, in order to increase access to clean energy by fostering a vibrant competitive market for off-grid energy products.

[4] https://www.lightingglobal.org/about/our-impact/

4.2 The USAID – Power Africa SHS Kickstarter program

The USAID – Power Africa SHS kickstarter program is designed to catalyze and stimulate the market in the short term over 3 years (2019 – 2021). The program in its initial stage, is planned to target the 85% of Malawian households which are currently living without electricity. Power Africa is providing financial assistance and operational support to private sector solar home system (SHS) companies in Malawi to help accelerate deployment of solar and scale off-grid product sales, bringing electricity to the underserved population in Malawi.

The kickstarter program has the following 5 key components:

i. A USD 1.5 Million Results Based Financing (RBF) Grant Facility which is aimed at stimulating the sale/provision of 150,000 new SHS off-grid connections.
ii. Access to working capital; debt and equity finance from various local financial institutions
iii. Operation Support i.e. technical assistance to SHS companies
iv. A Consumer Solar Awareness and Education Campaign.
v. Policy and Regulatory Reform initiatives including strengthening fiscal incentives and support like VAT & Duty Exemptions

4.3 Renewable Energy for Rural Areas (RERA) Programme- GIZ

The Renewable Energy for Rural Areas (RERA) programme[5] is commissioned in 2016 by the German Federal Ministry for Economic Cooperation and Development (BMZ) with an objective to support the Nepal Government in the deployment of decentralised renewable energy technologies (RETs) like mini-grids, solar home systems and biogas in rural areas. Overall term of this project is 5 years, i.e., from 2016 to 2021.

RERA Programme brings together the private sector, civil society and banking institutions, on one platform to work towards improving the supply of renewable energy (RE) services and products. RERA programme also works to ensure the after-sale-services. Additionally, the programme assists in creating a viable market for off-grid energy technologies by providing the following services:

i. Supporting the government of Nepal and Alternative Energy Promotion Centre (nodal agency for scaling up decentralized RE in Nepal) in creating a conducive policy framework for participatory and demand-led promotion of decentralised RE.
ii. Strengthening the private sector with innovative business models and technologies.
iii. Improving the access to finance for businesses and end-users to purchase and market energy products and services

[5] https://www.giz.de/en/worldwide/73840.html

Picture Source: https://www.nigeriaelectricityhub.com/2019/05/15/innovating-rural-electrification-in-uganda/

4.4 Regional Off-Grid Electrification Access Project (ROGEAP)

The Regional Off-Grid Electricity Access Project (ROGEAP) – previously known as the Regional Off-Grid Electrification Project (ROGEP)[6] – was launched as the pilot programme (Lighting Africa) of Lighting Global by the World Bank Group. The project aims to increase access to sustainable energy in the fifteen ECOWAS member countries and four additional countries (namely Cameroon, Chad, Mauritania and Central African Republic) for households, businesses, as well as public health and education facilities. The project currently holds active status and is expected to close by December 2030.

The project has two main components:

- Component 1 is focused upon developing a regional market by establishing enabling business environment and providing technical and financial capacity building support to solar entrepreneurs in 19 project countries. ECOWAS is the implementing agency for this component,
- Component 2 is focused upon facilitating access to finance for standalone solar system businesses through a line of credit and establishing a guarantee facility to eligible CFIs located in eight West African Economic and Monetary Union (WAEMU) member countries. West African Development Bank (Banque Ouest Africaine de Développement or BOAD) is the implementing agency for Component 2.

4.5 Rural Renewable Energy Development Project in Bhutan- ADB

The Rural Renewable Energy Development Project began in 2011 and was completed in 2017. The project was formulated by Asian Development Bank (ADB)[7] and designed to support Bhutan government's Rural Electrification Master Plan 2005. The project had following four components:

i. Connecting about 5,075 rural households to the Bhutan power grid by 2015 through expansion of the electrical grid distribution system in six districts: Lhuentse, Mongar, Samdrup Jongkhar, Trashigang, Trashiyangtse and Zhemgang
ii. Providing electrification to about 1,896 off-grid households through distribution and installation of SHS and rehabilitation of about 2,500 SHS by 2014
iii. Constructing a pilot wind power plant and installing three wind masts at Tshimalakha in the district of Chukha, including their connection to the grid by 2014; and
iv. Constructing about 1,600 domestic biogas plants at various households by 2014.

According to the Department of Renewable Energy (DRE), apart from achieving the targets set for each component, additional outcome of the project was as follows:

- All female headed households were connected to off-grid solar home systems.
- 153 village technicians were trained in O&M of on- and off-grid systems, of which 20% technicians were women.
- Livelihood improvement programs were extended to 269 participants including 159 (80%) women participants.
- 4,891 participants attended the awareness-raising activities which included 2,593 (53%) women.

[6] https://www.lightingafrica.org/publication/regional-off-grid-electrification-project-rogep-overview/
[7] https://www.adb.org/sites/default/files/project-documents/42252/42252-022-pcr-en.pdf

GUIDELINES ON CHOOSING THE RIGHT SHS

5. Guidelines on choosing the right SHS

With the expansion of several off-grid system suppliers, choosing the right type of Solar Home System can become complicated especially for those who are not aware about the system. Lack of knowledge and awareness among the rural households also hinder the growth of solar PV in some countries. Therefore, it is important to assess the following before selecting an SHS:

i. Assessing the basic energy requirements:

As discussed in the section above, the typical size of solar home system starts from 11 W (smaller home lighting system) to over 100 W (larger system which can support other home appliances as well); it is hence necessary to understand the requirement of the household. Although lighting is considered as basic requirement, the beneficiary can also opt for SHS which include appliances such as TV, fan, etc. as part of their SHS kit, depending upon their willingness to pay for these SHS products.

ii. Familiarize with the product offerings:

Before selecting an SHS the user must familiarize with the features the SHS product offers. This will allow the beneficiary to make an appropriate choice from the various SHS available in the market.

iii. Be wary of sub-standard products

While there are many different SHS products available in the emerging off-grid markets, they are also heavily dominated by sub-standard products that use refurbished PV panels. These products usually do not come with a 25-year performance warrant, and do not provide power backup for hours as offered by their high-quality certified counterparts. These SHS cost usually lower than the standard market price, making them financially attractive. A beneficiary should not opt for price over quality, because there could be chances where the supplier may not be offering a quality certified SHS.

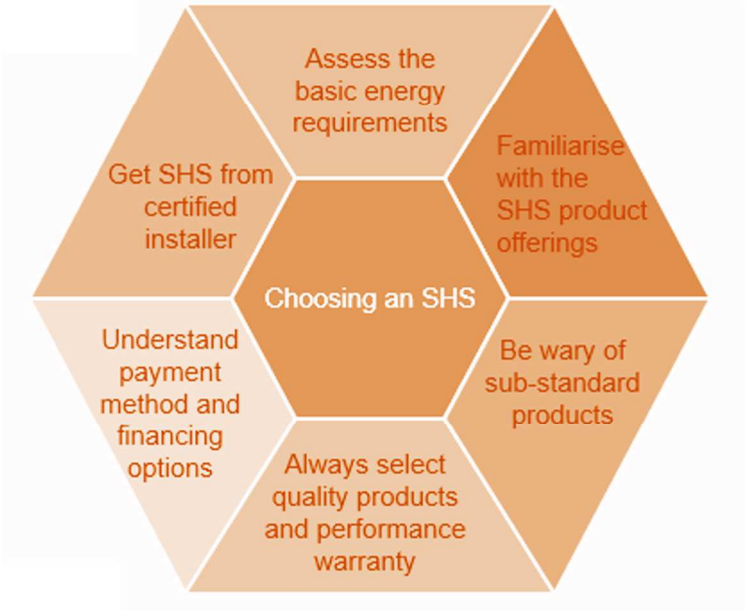


*Figure 4 **Guidelines** to choose the right SHS*

iv. Select quality certified SHS

An SHS which complies with the international quality standards set by the International Electrotechnical Commission (IEC) is called a quality certified SHS product. Such systems are durable, reliable and come with a warranty. Standards applicable to SHS are mentioned in section 3 above. These systems are known to last for 20-25 years. The batteries and other components however require replacement depending upon their consumption. A typical battery requires replacement every 3-5 years.

v. Understand payment method and financing options

As discussed in the earlier sections, the average cost of a quality certified medium sized SHS is typically around 300 USD, which might raise the challenge associated with upfront payment by many beneficiaries from rural households. To address the challenge of affordability, many suppliers/system providers allow the user to pay the amount in easy monthly installments through mode of mobile payment known as PAYG mechanism (pay as you go). Several others also enjoy government schemes which incorporates such innovative payment mechanism integrated with debt facilities and other incentives. The sections below highlights case studies where countries have deployed many SHS to accelerate energy access in off-grid areas through financial assistance and government schemes.

vi. Purchase SHS from certified system provider/supplier/installer

The job doesn't end with purchasing the SHS since it is extremely critical that the SHS is properly installed at the premises of beneficiary for it to function efficiently. A certified system provider/supplier/installer will consider all the technical steps to install the SHS. A certified system provider/supplier/installer may also offer after-sales services such as maintenance and technical inspection of the system for 2-3 years.

INSTALLATION AND MAINTENANCE OF SHS

Picture Source: https://www.insightsonindia.com/2017/12/12/insights-editorial-powering-rural-healthcare/

6. Installation, and maintenance of SHS

The most ideal location for the installation of solar PV panels is a shadow free site that receives maximum sunlight for maximum number of sunlight hours in a day.
Typically, a roof is the most desirable location for installation however, the solar panels could also be mounted on the ground provide there are no objects blocking access to the sun.
Proper safety precautions must be taken on the installation site to ensure safety during the whole installation process.
The following steps explain solar panel installation on a roof:

1. Setting up support/mounting structure:

Once the location for installation is identified, appropriate mounting structure is erected to support the panels. Proper safety precautions must be taken on the installation site to ensure safety during the whole installation process. The whole mounting structure must be tilted and have an angled as per the Latitude of the location to have maximum exposure to sunlight.

2. Install Solar Panel

After the structure is set in place, the solar panel is installed on the mounting structure in a way that it stays stable and withstand wind load.

3. Wire the Solar Panels

The next step in the installation process is to install the proper electrical wiring which is suitable to solar panels. One must ensure that all mains are switched off during this process to avoid any accidents to the personnel during the wiring installation.

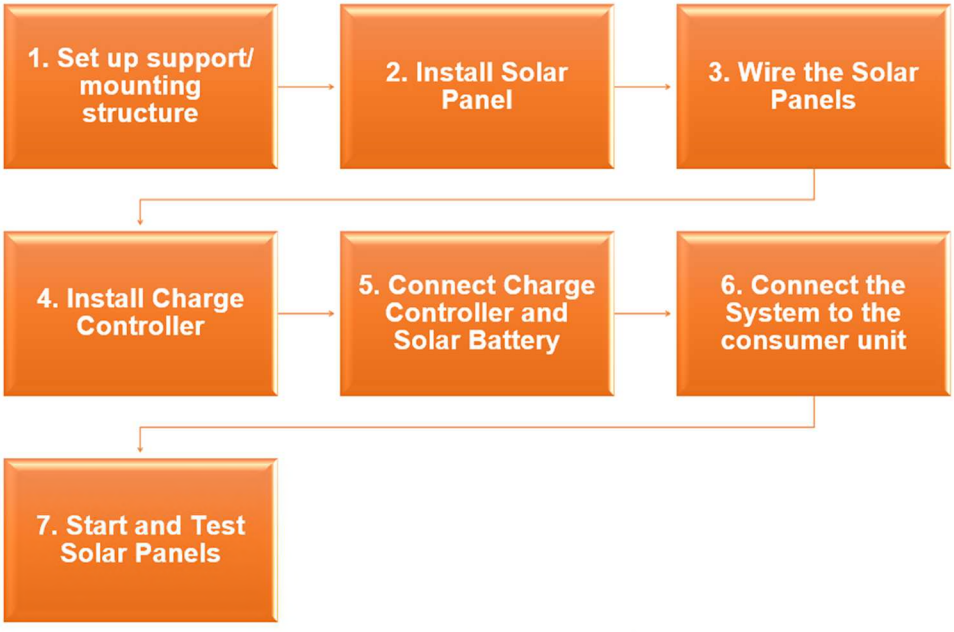


Figure 5 Steps for installation of SHS

4. Install Charge Controller

Once the wiring is done, the charge controller is connected to the system, preferably at a site which is accessible. The charge controller should be installed on a solid surface. The charge controller should be installed at a location where it can be disassembled at any time.
Charge controllers are to be installed in a cooler place with proper ventilation to ensure the optimal working environment.

5. Connect Charge Controller and Solar Battery

The next step is to connect the charge controller to the solar battery. A charge controller is installed to protect the batteries from overcharging. Make sure that the positive and negative terminals of the charge controller and batteries are properly connected. The batteries are connected in series. Electrical safety must always be followed while connecting the batteries.

6. Connect the System to the Consumer Unit

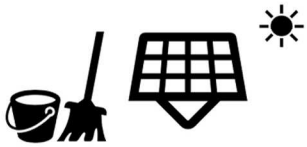
The system is then connected to the consumer unit to generate electricity. A solar generation meter is also connected to monitor the electricity produced by the solar PV system.

7. Start and Test Solar Panels

The final step in the installation process is to test the functioning of the SHS. Once approved by the installation personnel, the consumer may start using it.

Maintenance of a Solar Home System

Solar PV panels require very little maintenance. However, inspection may be done by a professional occasionally to check for any operational or safety related issues. It is important that the panels are kept clean since dust particles may hamper their efficiency to absorb the solar radiation. Therefore, frequent cleaning of the panels is necessary.



A normal garden hose can be used to wash the panels; yet one must keep water away from electrical components of the system. Ideally a solar panel should do cleaned twice a day, however it is acceptable to do it once in two days.

Current roadblocks hampering growth of SHS technology

Picture Source: https://gh.ambafrance.org/Gaakukorpe-community-in-the-Volta-region-benefits-from-solar-energy-project

7. Current roadblocks hampering growth of SHS technology

There are several challenges that are hampering the popularity of the SHS among rural consumers. Some of the challenges are listed below:

i. Low affordability among rural customers

Low-income households do not have the financial capacity to purchase the SHS upfront. Although there have been many financial grants and subsidies offered by government, some section of rural consumers show reluctance in paying for the SHS in small installments as well. Additionally, low purchasing power of rural customers makes it difficult to recover capital and operations costs of SHS from tariffs alone.

ii. Political and economic risks

Uncertainty in the market due to political and economic risks leads to the slowdown of the SHS market growth since they can cause instability to the existing legislative environment which could negatively affect the progress of project. The actual implementation gets severely impacted even if the regulatory environment is conducive, due to lack of political will to drive the SHS programme in the country. In some countries severe cutbacks in funding available for subsidising new systems and delays in awarding new tenders have also been reported, which affects deployment of energy access in off-grid/rural areas.

iii. Last mile distribution

Last mile distribution challenges in conflict areas can influence the SHS cost. The final cost of the SHS system becomes expensive than the procured cost of the system. Also, the isolated nature of the off-grid areas in which SHS's are located also creates challenges in terms of installing and maintaining systems. Connecting roads to rural households/off-grid areas are often ill-maintained and sometimes non-existent. In some cases, off-grid households are inaccessible by road and installers having to carry equipment into sparsely populated valleys.

iv. Penetration of low-cost substandard products

Illegal imports of sub-standard SHS products have penetrated many Asian as well as African markets. These are usually SHS consisting of refurbished panels which do not have long operating hours and have low operational life. Such products are often bought by rural households owing to their attractive low price. This decreases the market value of SHS as well as takes away consumer trust in SHS products. This leads to low demand among rural customers.

v. Lack of local capacity and skills

There are challenges with undertaking local maintenance in rural areas which can affect business models of concession companies as there are high costs associated with travelling long distances to remote households. Establishing skills within local communities to undertake basic maintenance could be beneficial for both customers and concessionaire's business models.

Best practices

Photograph: Alamy

8. Best practices

The case studies will be pivotal in understanding the barriers for adoption of SHS in different regions.

8.1 Kenya- Mwangaza Mashinani Scheme

The government of Kenya's Energy and Cash Plus Initiative, known as Mwangaza Mashinani[8], is an innovative pilot project funded by the Swedish Development Agency (Sida) and commissioned by UNICEF to Energy 4 Impact.

The Scheme subsidises Solar Home Systems sold by two selected providers: D.Light and BioLite. The Scheme is a part of National Safety Net Programme (called Inua Jamii), which makes cash transfers to target beneficiaries to financially assist them in paying for their basic needs. From the Mwangaza Mashinani scheme more than 1,600 systems have already been deployed in two counties in Kenya – Kilifi and Garissa – benefitting some 8,000 of the poorest people there.

Target beneficiaries

The target beneficiaries are the vulnerable population whom the government supports by giving small cash payment each month to help them pay for their basic needs. These are mainly orphans, vulnerable children, people with severe disabilities and elderly people.

Implementing Model

To make the SHS more affordable, the scheme provides grants of up to 99% of the cost of the system, which covers the upfront cost of the system as well as a monthly top-up payment towards on-going repayments, paid over 12 months. The remainder contribution is covered by the people allowing them to feel a sense of ownership. Once the full cost has been repaid the individual or household gets the ownership of the equipment.

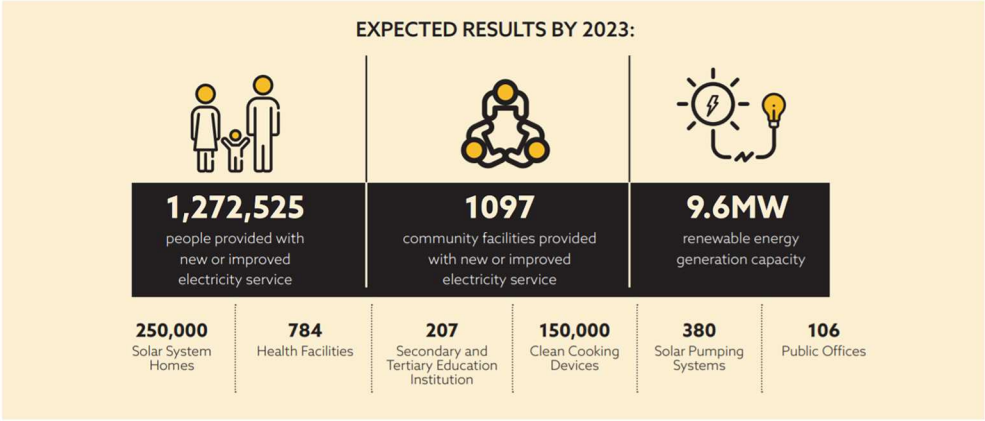
The SHS comes with a warranty for at least two years. The payment of the SHS is done by the beneficiary via mobile money which is the money paid by the government to the target beneficiaries into their bank accounts.

8.2 Kenya Off-grid Solar Access Project (KOSAP)

The Ministry of Energy (MOE), Kenya Power and Lighting (KPLC), and the Rural Electrification Authority (REA) are implementing agencies of the Kenya Off-grid Solar Access Project (KOSAP) which is categorized in 4 components and which are planned over a 5-year period (2018-2023). The component 2 under KOSEP covers Stand-alone Solar Home Systems and Clean cooking Solutions for off-grid population. The financing facilities included under the Solar Home System Solution are solar Results-Based Financing (RBF), and solar debt facility.

Target beneficiaries

The off-grid households in the 14 underserved counties of Kenya which are dispersed and require individual system solutions (Solar Home Systems- SHS). Affordability for the SHS among the target beneficiaries is ensured by allowing the households to pay for the systems over time through easy monthly installments.



[8] Solar home energy scheme brings power to poor people in rural Kenya | Energy 4 Impact
Picture Source: https://www.lightingafrica.org/wp-content/uploads/2018/12/KOSAP-1-pager.pdf

8.2.1 KOSAP Solar Debt Facility

The Solar Debt Facility brings about a total of USD 30 Million to support ongoing solar operator growth in the KOSAP Service Territories (KST). The debt facility addresses the working capital and supply chain constraints associated with getting hardware inventory to market and with providing financing to end-customer.
The Solar Debt Facility provides debt financing for Solar companies that supply SHS of high quality (preferably Lighting Global Quality Standards), provided they have demonstrated ability to sell, distribute, and provide after-sales support.in Kenya. The Debt Facility is open to any Kenyan registered business that credibly demonstrates the ability to meet the eligibility criteria[9].

8.2.2 KOSAP Solar Service Providers Results-Based Financing

The KOSAP Solar Service Providers Results-Based Financing (SSP RBF Facility) provides financing of USD 12 million to compensate SHS service providers (SSPs) for initial, ongoing incremental, and opportunity costs associated with an expansion of operations in the KOSAP Service Territories (KSTs).
The objective of the SSP RBF Facility is to establish sustainable supply chains for marketing and sales of multi-light Lighting Global approved solar-PV systems in the KOSAP Service Territories (KSTs) of Kenya using a private sector-led market-based approach[10].
Any Kenyan business or a Kenyan subsidiary of an international business including, pay-as-you-go (PAYG) businesses, over-the-counter businesses, wholesale distributors, as well as partnerships of a combination of such companies can apply to the SSP RBF facility.

8.3 Togo's CIZO Programme

The CIZO programme, launched by the government of Togo in 2017, aims to efficiently accelerate the extension of energy services in rural areas. The term "CIZO" means "light up" in Togolese language.
The Government of Togo has designed the electrification strategy to accelerate deployment of 555,000 Solar Home System (SHS) (CIZO programme), 300 mini-grids (55,000 connections), and 400,000 on-grid connections between 2018 and 2030 with the ultimate aim of reaching universal electrification by 2030[11].
The programme is implemented in collaboration with a range of authorised PAYG solar companies, which to date include: BBOXX (under a joint-venture between BBOXX and French energy provider EDF), Soleva, Fenix (now Engie Energy Access), Solergie, and Moon.
These private sector partners are responsible for operations along the value chain (e.g. kit purchase, distribution, payment collection, maintenance), while the public sector provides subsidised access, consumer awareness campaigns, and VAT exemptions.

Target beneficiaries

Rural households of Togo which are deprived of reliable energy access.

Implementing Model

Rural households with SHSs from authorised providers are able to access a monthly subsidy (CIZO Cheque) of 2,000 FCFA (USD 3.62) for the SHS payment plan over a three-year period. SHS owners can make a payment through mobile money, the mobile operator then tops up the customer's payment with the subsidy before sending it to SHS supplier.

[9] http://www.kosap-fm.or.ke/standalone-solar-systems-for-households-debt-facility/
[10] http://www.kosap-fm.or.ke/standalone-solar-systems-for-households-results-based-financing-rbf-facility/
[11] https://www.gsma.com/mobilefordevelopment/blog/smart-subsidies-and-digital-innovation-lessons-from-togos-off-grid-solar-subsidy-scheme/

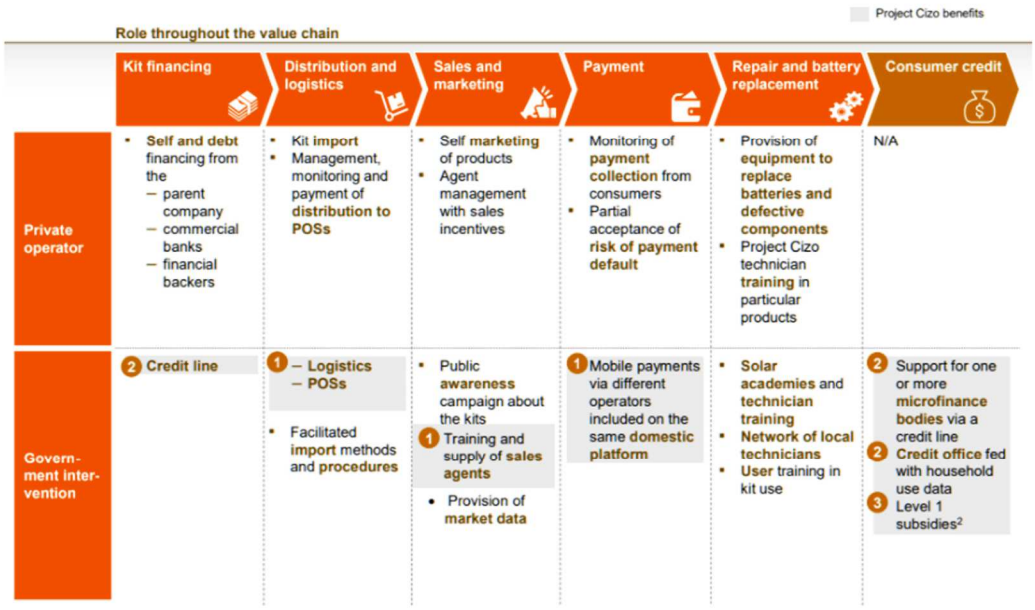


Figure 6 Role of private and public sector in Togo's CIZO Programme
(Image source: https://www.lightingglobal.org/wp-content/uploads/2018/12/Togo-Electrification-Strategy-Short-EN-Final.pdf)

8.4 Bangladesh's Solar Home System (SHS) program

Infrastructure Development Company Limited (IDCOL) of Bangladesh started the SHS program in January 2003 to fulfill basic electricity requirement of the off-grid rural people as well as supplement the Government's vision of ensuring access to electricity for all citizens of Bangladesh by 2021[12].

Till the end of January 2019, about 4.13 million SHS were installed under the program. Thus, the program has ensured supply of solar electricity to 18 million people i.e. 12% of the country's total population who previously used kerosene lamps for lighting purpose. IDCOL has a target to finance 6 million SHS by 2021 with an estimated generation capacity of 220 MW of electricity.

Target beneficiaries

Remote areas where electrification through gird expansion is challenging and costly.

Implementing Model

IDCOL initially received credit and grant support from the World Bank and GEF to start the program. Later, GIZ, KfW, ADB, IDB, GPOBA, JICA, USAID and DFID came forward with additional financial support for expansion of the SHS Programme.

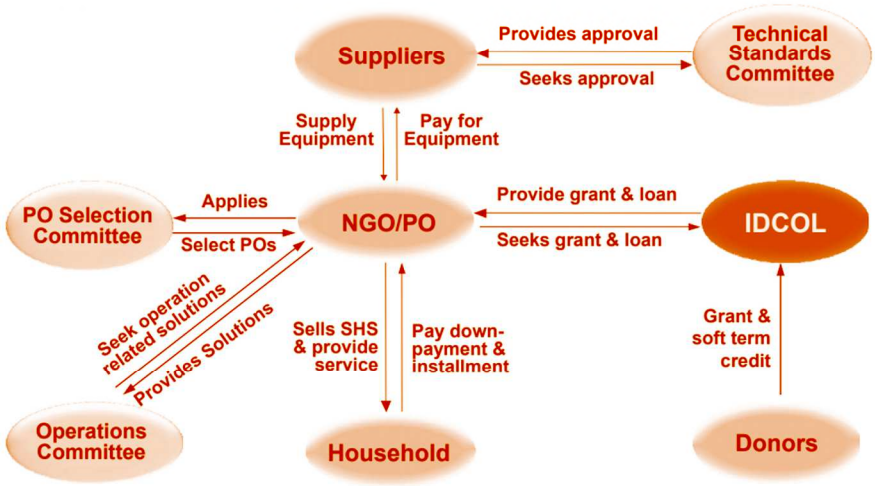


Figure 7 Implementation model of IDCOL's SHS Programme
(Image source: https://esmap.org/sites/esmap.org/files/ESMAP_SAR_EAP_Renewable_Energy_Resource_Mapping_Islam.pdf)

[12] https://idcol.org/home/solar#:~:text=IDCOL%20started%20the%20SHS%20program%20in%20January%202003,electricity%20for%20all%20citizens%20of%20Bangladesh%20by%202021

IDCOL provides grant and soft loans as well as necessary technical assistance to the Partner Organizations (PO). PO select customers, extend loan, install the systems, and provide after sale service. IDCOL's total investment under the program is BDT 52,240 million (USD 696 million) out of which loan USD 600 million and grant USD 96 million.
The program has so far saved consumption of 1.14 million tons of kerosene worth USD 411 million approx. In addition, in the next 15 years already installed 4.1 million SHS will save consumption of another 3.6 million tons of kerosene worth USD 1,300 million. Moreover, around 75,000 people are directly or indirectly involved with the programme.

8.5 Off-grid Solar Home System Programme South Africa

The Off-grid Solar Home System Programme[13] falls within the government's Integrated National Electrification Programme (INEP) which has a target of access to electricity for all formal households by 2025 The objective of programme is to provide energy access to remote areas far from the national grid which are technically and/or economically difficult to electrify. To date the programme has achieved approximately 30,000 installations in rural households.

Target beneficiaries

The project is aimed at providing rural, non-electrified households with access to solar home systems for lighting and other basic electrical needs.

Implementing Model

Remote rural areas that do not have any electrification plans for the next 3 years are identified and granted as concessions to private companies who are given exclusive rights to operate in those areas. The concessionaire acts like a small local utility that provides an electricity service to households.
The programme is a fee-for-service model whereby households pay a monthly fee to cover maintenance and costs of replacing the batteries. Government decided on this choice of model (rather than outright sales) to ensure that concession companies retained a local presence in the area and would provide after sales service and maintenance. The programme also requires the concessionaire to establish their local presence through establishing rural energy stores or office and to address the thermal needs of households as well by supplying fuels such as liquid petroleum gas (LPG) and kerosene and improved cook stoves at the local level.

8.6 India's Saubhagya Scheme

The Saubhagya Scheme was launched by the Prime Minister of India on 25th September 2017, with an objective of providing free electricity connections to all households in rural areas (above as well as below poverty line) and poor families (below poverty line) in urban areas. Rural Electrification Corporation (REC) has been designated as its nodal agency for providing electricity under the Saubhagya Scheme[14]. Smooth facilitation of on-the-spot filling up of application forms including release of electricity connections to households by the electricity distribution companies (DISCOMs) is also included in this scheme. DISCOMs as well as state power departments are directed to report real time information on the release of electricity connections via dedicated web portal.

Target beneficiaries

All un-electrified households located in rural and urban areas, where grid extension is not feasible or cost-effective. Only economically poor un-electrified households in urban areas are considered and non-poor urban households were excluded from this scheme.

[13] https://energy-access.gnesd.org/projects/29-1-sarah-best-sustainable-development-advisors-for-the-international-institute-for-environment-and-development-2011-remote-access-expanding-energy-provision-in-rural-argentina-through-public-private-partnerships-and-renewable-energy-a-case-study-of-the-per.html
[14] https://www.recindia.nic.in/saubhagya

Implementing Model

Under the Saubhagya Scheme, SHS of 200 to 300 Wp (with battery bank) with a maximum of 5 LED lights, 1 DC Fan, 1 DC power plug etc. are provided to un-electrified households located in remote and inaccessible villages/habitations along with the provision of Repair and Maintenance (R&M) for 5 years. For households that are in fairly accessible areas, financial assistance to set up grid electrification is provided by the government to the DISCOMs including Private Sector DISCOMs, State Power Departments and RE Cooperative Societies. The electricity connections include provision of service line cable, energy meter including pre-paid/smart meter, single point wiring. According to the funding structure under this scheme[15], the maximum grant by government of India (including additional grant on achievement of prescribed milestones) is 90% for Special Category Indian States[16] and 75% for other States.

8.7 Nigeria Electrification Project (NEP) SHS Component

Nigeria Electrification Project (NEP) SHS component[17] aims to help capable solar providers reach more rapidly underserved Nigerian households and micro enterprises (MSMEs) and provide access to better energy services at lower cost than their current service.

Target beneficiaries

The target beneficiaries are those that lack connection to energy services and do not expect a connection in a timely manner or suffer from unreliable and expensive power and do not anticipate improvement in service.

Implementing Model

The NEP provides grant support to leverage other sources of finance such as: company's own equity, equity from investors, and facilitate access to credit by reducing risk to lending entities. The NEP SHS program consists of two investment instruments:

i. Output Based Fund: providing fixed incentive payment per SHS system installed.
ii. Market Scale-Up Challenge Fund: providing lump sum grants against strongest business plans and other investor co-funding for rapid scaleup.

8.7.1 Output Based Fund (OBF)

The OBF fund will provide fixed incentive grants in the range of 20% of the retail cost of the system to the grantees, per each eligible system installed and verified. This support will enable the firms to finance the required investment in people, training, advertising, processes, and logistics inclusive of gender workforce integration and disaggregation as informed by the NEP gender program. The grant amount will be fixed for each system size/level of service category and revised periodically aiming to continually reduce it over the life of the program.

An Independent Verification Agency will be engaged by REA-PMU (rural electrification agency-project management unit) to carry out the verifications of claims submitted by the participating solar companies. The companies can submit claims as frequently as once per month by logging the required information on the online platform (details to be provided to successful applicants). The minimum threshold requirement is sales of at least 150 systems per month.

[15] https://www.recindia.nic.in/saubhagya
[16] As per Ministry of Home affairs, 11 states namely, Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and Uttarakhand are granted special category status.
[17] https://rea.gov.ng/solarhomesystems/

8.7.2 Market Scale-up Challenge Fund (MSCF)

The MSCF offers up-front grants to a small number of strongest and most capable solar providers, paid against robust business plan milestones and co-funding requirements, to accelerate their capacity to reach and serve Nigerian households and small enterprises at scale. The purpose of the grants is to reduce the risk to investors and be used to provide additional direct working capital to enable faster investment in the inventory and expanding distribution. The MSCF is not aimed at supporting small, early growth stage companies that might hold such ambitions but do not yet possess the capacity to achieve it in a comprehensive way. However, it may support companies who are quickly emerging to become established market leaders.

A rigorous evaluation process will emphasize a robust business plan of international standards; a senior management team that is capable across all key disciplines, including consumer marketing, consumer finance, IT, logistics, financial management, business process management; commitment to high sales targets or rapid growth in monthly sales; and a credible pathway to mobilizing the substantial capital required to grow. Only companies that demonstrate this higher level of capacity will be eligible for a full evaluation under the Market Scale-up Challenge Grants. The solar companies that receive grants from the Market Scale-up Challenge Fund remain eligible to claim the Output Based Grants as well.

8.8 SELCO India's Basic Energy Access Solution to rural areas

SELCO India (SELCO) is a for-profit social enterprise which was established in 1995 and works towards building a strong service network in the rural areas for solar systems and other energy service. SELCO operates via 25 service centers established across Karnataka and Gujarat states of India, and has played a pivotal role in linking commercial and rural banking institutions with beneficiaries to develop innovative and sustainable financial models that match the cash flow of the target client base.

Target beneficiaries

The underserved and un-served areas of India in terms of energy access.

Implementing Model

SELCO business model involves establishment of strong innovative linkages between end users, energy services, technology and financing. SELCO adopts a two-way approach of door-step service and door-step financing. SELCO customizes the solutions[18] that fits best to the needs of the end user. SELCO has therefore adopted a bottom to top approach that can cater to the expectations and needs that could empower the lives of underserved or un-served households and small-scale businesses.

SELCO through field visits, to understand the need and issues of potential customers, and offers a customized solution to address their energy needs. SELCO then connects the beneficiaries to the partner rural banks and facilitates a relationship between the two such that the loans are made accessible to them. SELCO also helps instill a sense of financial confidence in the rural people by creating awareness to loan facilities for affordable financing.

[18] https://selco-india.com/what-we-do/#offering1

Way Forward

Image source: Chris Daniele via OffGridWorld

9. Way Forward

International Solar Alliance (ISA) can assist the member countries in mitigating the challenge associated with energy access in off-grid areas through promotion of Solar Home Systems (SHS). For the project initiation ISA can start by offering its action oriented, member-driven, collaborative platform as well as large-scale capacity building initiative under SHS component under SSAAU flagship programme of ISA.

According to ISA's Theory of Change, ISA aims to address the issues of energy access, energy security and energy transition by implementing upon three strategic goals:

1. Reduce cost of technology
2. Reduce cost of finance
3. Mobilise USD 1 trillion of investments for solar by 2030

To achieve these goals, ISA will work towards providing the following support:

I. Advocacy

- ISA can provide an anchor platform to facilitate partnership and coordination in target countries. Having a strong network of national focal points in member countries, ISA can help engage with multiple stakeholders.
- ISA can conduct pre-feasibility assessments to gain country insights, improve market data and understanding.
- ISA can support in undertaking in-country missions and stakeholder consultations to identify priority areas which can be targeted for project implementation.
- Through a combination of needs assessment questionnaire and demand validation, ISA can assist in technical studies including preparation of pre-feasibility reports.

II. Policy and regulatory support

- ISA can also work in coordination with the government to refine the regulatory framework to create a conducive environment for SHS as well its components.
- ISA can also provide backstopping to government in developing aggregated purchase frameworks to overlay a range of financing support, as well as price discovery tenders for reducing the price of SHS in target areas.
- Implementation

III. De-risking of investments

- ISA shall facilitate affordable finance for Solar Home System to attract private sector players to invest.
- ISA can assist in shortlisting of viable business model options for project implementation.

IV. Institutional and capacity building

- ISA can assist the member country in capacity building & training for key stakeholders.
- ISA through knowledge dissemination can assist in preparation of relevant project documents in consultation with appropriate stakeholders, which will further assist in their scale-up strategy.