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Study to Investigate the Difficulties for Household Solar Systems in SAARC Region

SAARC Energy Centre

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Foreword

Acknowledgement

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List of Abbreviations

Acronym	Meaning
AC	Alternating Current
ACEP	Afghanistan Clean Energy Program
ADB	Asian Development Bank
AEDB	Alternate Energy Development Board
AEPC	Alternate Energy Promotion Center
AGM	Absorbent Glass Mat
Ah	Ampere hour
AMC	Annual Maintenance Contract
ARE's	Alternate Renewable Energies
ASPIRE	Accelerating Sustainable Private Investments in Energy
AU	Administrative Unit
BEA	Bhutan Energy Authority
BoQ	Bill of Quantities
BPCL	Bharat Petroleum Corporation Limited
BPCL	Bhutan Power Corporation Limited
BPDB	Bangladesh Power Development Board
BRAC	Building Resources across Communities
BRAC	Bangladesh Rural Advancement Committee
BREB	Bangladesh Rural Electrification Board
CAREC	Central Asia Regional Economic Cooperation
CBSL	Central Bank of Sri Lanka
CDC	Community Development Council
CFL	Compact florescent lamp
CRE	Center for Renewable Energy
CSC	Customer Service Centers
CSR	Corporate Social Responsibility
DANIDA	Danish International Development Agency
DC	Direct Current
DDA	District Development Council
DDG	Decentralized Distributed Generation
DDP	District Development plan
DDUGJY	Deen Dayal Upadhayay Gram Jyoti Yojana
DFID	Department for International Development
DoE	Department of Energy
DSM	Demand Side Assessment
EA	Executing Agency
ERDA	Energy for Rural Development Afghanistan
ESCO	Energy Service Company
ESD	Energy Services Delivery
ESD	Electricity Service Divisions
FYP	Five year plan
GEF	Global Environmental Facility

GEF	Global Environment Fund
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoB	Government of Bolivia
GoN	Government of Nepal
GoSL	Government of Sri Lanka
GPOBA	Global Partnership on Output Based : Aid
HH	Household
HPCL	Hindustan Petroleum Corporation Limited
IA	Implementing Agency
IDA	International Development Association
IDB	Inter – American Bank
IBP	International Bidding Process
IDCOL	Infrastructure Development Company Limited
IDEA	Institutional Development for Energy
IDTR	Decentralized Infrastructure for Rural Transformation
IEA	International Energy Agency
IFC	International Finance Corporation
IREDA	Indian Renewable Energy Development Agency
JICA	Japan International Cooperation Agency
JLG	Joint Liability Group
Kwh	Kilo watt hour
LDC	Least Developed Country
LED	Light emitting diode
LFL	Light Fluorescent Bulb
LT	Low tension
MEA	Maldives Energy Authority
MEW	Ministry of Energy and Water
MFI	Micro Finance Institutional
MGP	Mera Gao Power
MHP	Micro Hydro Power
MHP	Micro Hydro Project
MIS	Management Information System
Mn	Million
MNRE	Ministry of New and Renewable Energy
MoEA	Ministry of Economic Affairs
MoFP	Ministry of Finance Portal
MoP	Ministry of Power
MRRD	Ministry of Rural Rehabilitation and Demand
MSC	Medium Service Contracts
MW	Mega watt
NABARD	National Bank for Agriculture and Rural Development
NABDP	National Area Based Development Program
NABDP	National Area Based Development Programme
NBFI	Non-bank financial institutions
NEP	National Energy Policy
NEPQA	Nepal Photovoltaic Quality Assurance

NG	National Grid
NGO	Nongovernmental organizations
NGO	Non-Profit Organization
NHB	National Housing Bank
NRREP	National Rural and Renewable Energy Programme
O&M	Operation and Maintenance
PAYG	Pay As You Go
PCRET	Pakistan Council of Renewable Energy Technologies
PCI	Participating Credit Institutions
PERZA	Renewable Energy for Rural Zones Program
PIT	Product Introduction Testing
PO	Partnership Organizations
POISED	Preparing Outer Island for Sustainable Energy Development
PPAF	Pakistan Poverty Alleviation Fund
PSU	Public Sector Undertaking
PV	Photovoltaic
PVPS	PV power systems
RE&T	Rural Electrification & Transmission
REB	Rural Electrification Board
REC	Rural Electrification Company
RED	Renewable Energy Department
REMP	Rural Electrification Master Plan
ReND	Rural Energy Department
REREDP	Rural Electrification and Renewable Energy Development Project
REREDP	Renewable Energy for Rural Economic Development Project
RESCO	Renewable Energy Service Company
RETS	Renewable Energy Test Solution
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RGoB	Royal Government of Bhutan
RRB	Regional Rural Bank
RRES	Renewable and Renewable Energy Strategy
RSF	Rural Services Foundation
RST	Random Sample Testing
RVEP	Remote Village Electrification Programme
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SEA	Sustainable Energy Authority
SEC	SAARC Energy Center
SEED	Sarvodaya Economic Enterprise Development
SEMEN	Solar Electric Manufactures Association Nepal
SHG	Self Help Groups
SHS	Solar Home System
SIA	Solar Industries Association
SL	Solar Lamp
SLSEA	Sri Lanka Sustainable Energy Authority
sq. km	Square kilometers

SREDA	Sustainable Energy Development Authority
SREP	Scaling – Up Renewable Energy Program
SSHS	Small Solar Home Systems
SSL	Solar Street Light
TAT	Technical assistance team
TSC	Technical Standard Committee
UNDP	United Nations Development Programme
UNDP	United Nations Development Program
USAID	United States Agency for International Development
USD	United States Dollars
VEETs	Village Electrical Entrepreneurs and Electrical Technicians
VHP	Village Hydro Projects
VLE	Village Level Entrepreneur
WHO	World Health Organization
Wp	Watt - peak

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Executive Summary

It is widely acknowledged that access to affordable and reliable energy services is fundamental to alleviating poverty, improving health, increasing productivity, and promoting economic growth. Yet, as of 2016, nearly 1.2 billion people worldwide – one in six of the world's population – do not have access to electricity. Around 80 percent of these reside in rural areas. Among the SAARC member states, India, Pakistan, Bangladesh and Afghanistan account for the larger off-grid population. Most of the off-grid households largely depend on conventional fuels (mainly kerosene) that are inefficient, polluting and damaging to both health and the environment. As majority of these households are in remote areas and have a low ability to pay for energy services, it is a challenge for the government to provide them with grid-connected power.

Hence most SAARC member states have looked at other alternatives, such as Solar Home Systems (SHSs) that provide better cost-performance and are healthier, safer and environment friendly. It is a decentralised energy generation mechanism based on standalone solar PV and is designed to meet the electricity demand of a single rural household. It acts as a convenient source of electricity for lighting and running small appliances (e.g. Lamps, CFL, small television set, radio, and mobile phone charger) for about 3–5 hours a day, using energy from sunlight. The initiatives for installing SHSs had been started by the governments of various member states, over different time periods in the past decade, and have met with varying levels of success. While in some countries like Bangladesh and Bhutan, the initiatives have been driven majorly by the government and developmental agencies through grants and subsidies, in countries like India and Sri Lanka, there has been active involvement of both the government as well as private companies. In Pakistan and Afghanistan, there have been periodic installations based on region based initiatives and aids, but a sustained SHS program led by the government is yet to take place.

Considering that all SAARC member states have high solar potential and constant technology innovation is resulting in falling prices, SHS still holds a lot of promise and potential. Hence it's important for member states to identify the challenges and shortcomings related to technical, financial, institutional and social issues. Technical and implementation barriers related to substandard equipment, inadequate maintenance and after sales service and limitations in distribution models have been prevalent in most member states and have created a negative perception in the minds of the end users. While end user affordability issues do exist, access to finance, subsidies on conventional fuels, and failure to develop or leverage on microfinance industry, have held back the growth in countries like Afghanistan, Pakistan and, to a lesser extent, in India. Raising awareness levels and providing adequate knowledge to end users is also a major challenge for all member states. In a number of cases, the lack of knowledge by adopters has resulted in improper usage, constant tampering and inability to maintain the systems. Success of the SHS program has also been influenced by the institutional set up and enabling policies present in each member state.

Understanding the factors behind the major success of the SHS program in Bangladesh holds potentially valuable lessons for the other member states. The unique financing and service scheme employed, in which technical and financial services were provided via the same entity (Partnership Organization) ensured that customers did not have to worry about system performance and maintenance while debt collection for the entity went on smoothly. A robust quality assurance framework was also set up that ensured stringent adherence to component testing, regular monitoring via field inspections of selected installed systems and strong and enforceable warranty

requirements. Significant investments were also made for capacity building, providing technical assistance to the Partnership Organizations and conducting regular awareness and promotional campaigns for the rural population.

Our analysis of country wise challenges reveals that almost all the member states face majority of the enlisted issues, albeit, having different impact levels. Most of the issues are interrelated and hence cannot be solved independently from each other.

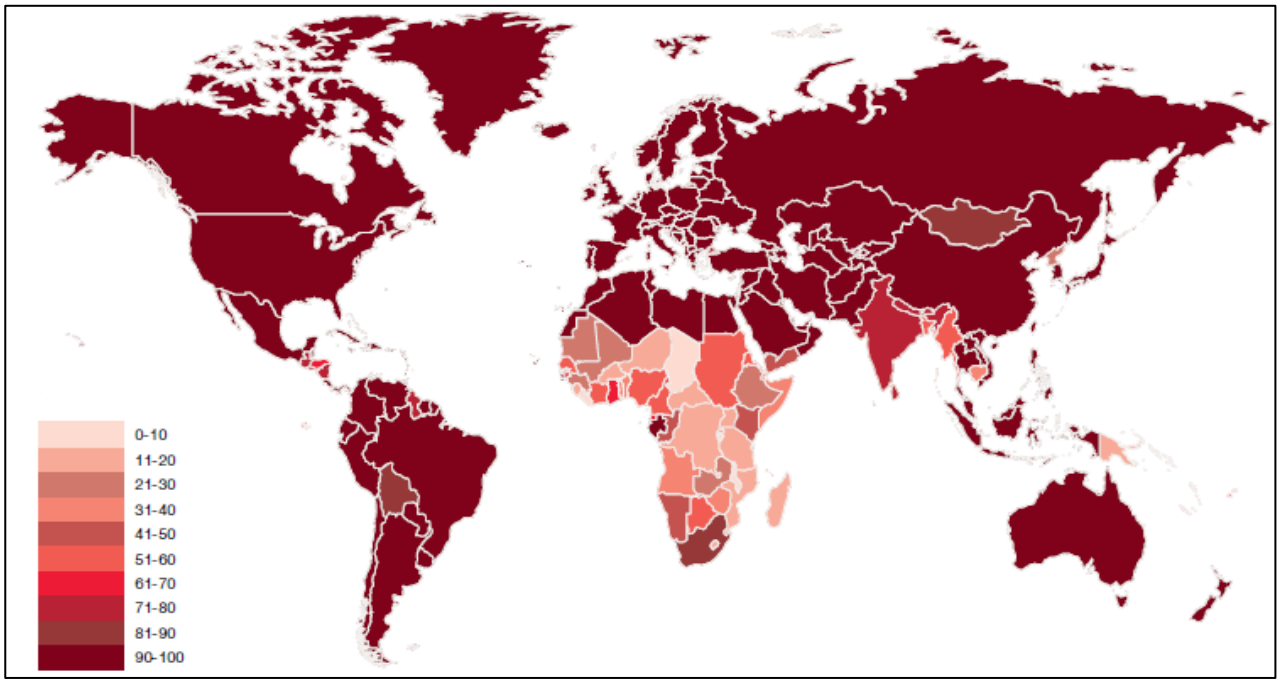
Finally, with our firm understanding of the socio-economical, technical, financial and institutional aspects of Solar Home Systems, and the progress so far in the member states, we have proposed a broad list of recommendations for the future. While some recommendations and probable steps provided are applicable for all member states, some have been tailored to suit the country-specific challenges.

1. Introduction

1.1. Background – Emphasis on Electricity for All

Access to electricity is a key driver for growth and human development leading to better education and health, more opportunities for businesses and jobs and safer communities. This vital role played by electricity in boosting productivity, living standards and human capital has been widely acknowledged worldwide by governments as well as development agencies. Hence SDG #7: "Ensure access to affordable, reliable, sustainable and modern energy for all" by 2030 is a core component of the 17 Sustainable Development Goals (SDG) committed to by over 194 member countries of the United Nations (UN). Additionally, provision of electricity is also a recognized development agenda item and one of the key pillars of the Sustainable Energy for All (SE4ALL) Initiative of the United Nations.

Emphasis on achieving such initiatives are imperative considering that an estimated 1.2 billion people – 16% of the global population – do not have access to electricity as of 2016, according to International Energy Agency (IEA). Most of these people reside in the 20 developing countries of Asia and Sub-Saharan Africa, and about 80 percent of them live in the rural areas, which are beyond the reach of the current grid system. In the developing countries of Asia, there are an estimated 526 million people without electricity, India and Bangladesh being the most notable ones in terms of - numbers[1].



Source: World Bank data

Figure 1: Access to electricity around the world[2]

[1] International Energy Agency, Energy Access Database, 2016
[2] PwC global power & utilities, Electricity beyond the grid, 2016

1.1.1. Electricity: A Key driver for Poverty Alleviation and Socio-Economic Development

> ***Energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive***
> ***Baan Ki Moon***
> ***(Former UN Secretary-General)***

Access to electricity has direct linkage with economic development as countries with low access to electricity are also economically the most under developed. There is a close correlation between income levels and access to modern energy: countries with a large proportion of the population living on an income of less than $2 per day tend to have low electrification rates[3]. The World Bank states that inclusive economic growth is the single most effective means of reducing poverty and boosting prosperity, and that most economic activity is impossible without adequate, reliable and competitively priced modern energy[4]. In developing countries, access to affordable and reliable energy services is fundamental and acts as a critical enabler in reducing poverty, improving health, increasing productivity, enhancing competitiveness and promoting economic growth.

The chart below depicts the role of the energy sector and the role of energy services. It clearly demonstrates that electricity is essential to combat poverty and foster sustainable development.

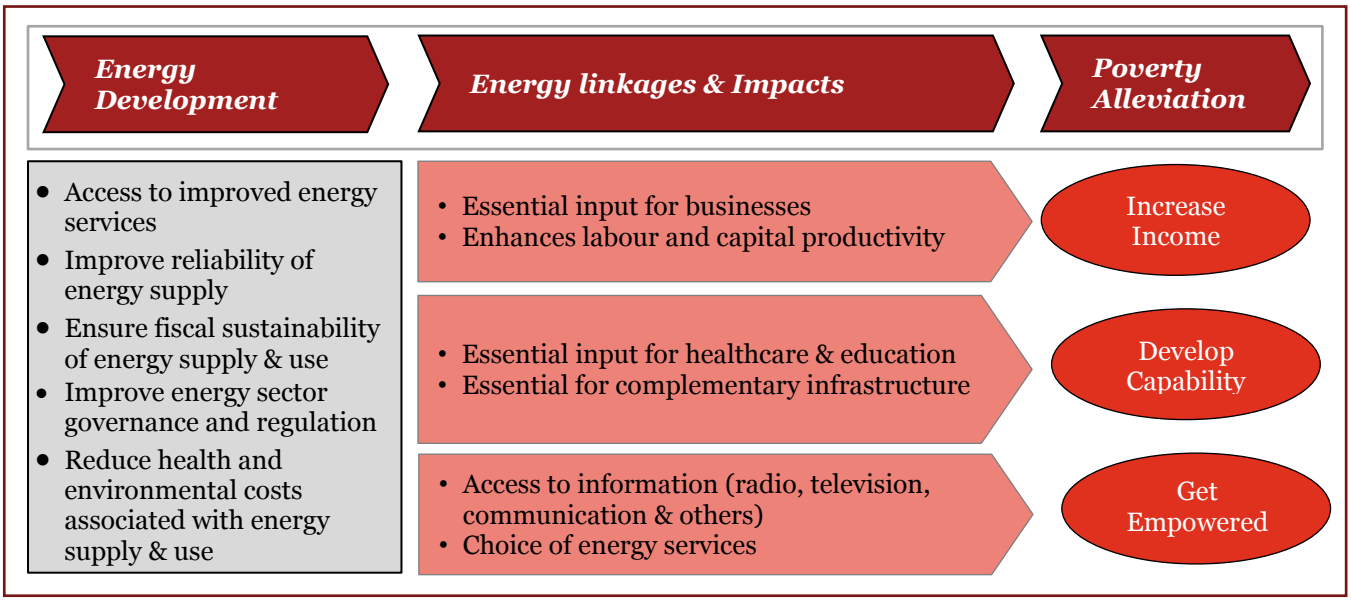


Figure 2: Energy - Poverty Framework[5]

Access to basic electricity is going to play a central role in achieving economic, social and environmental objectives of sustainable human development. However, despite the awareness, more than a billion people still continue to live without basic access to energy services. While numerous solutions exist to meet the needs of these

[3] International Energy Agency, Modern energy for all: why it matters
[4] The World Bank, What you need to know about energy and poverty
[5] USAID & BearingPoint, M.W. Addison

people, providing access to electricity in rural areas which are not connected to the national grid still remains a key challenge.

1.1.2. Off Grid Solutions: Providing Electricity beyond the Grid

For populations living within a reasonable distance from the grid, extension of the central power grid remains the most cost-effective solution. The cost of supplying grid-based electricity is less than the cost of alternative off-grid options in most situations where transmission and distribution lines are nearby. But beyond a certain distance, the cost to serve becomes prohibitive. With an estimated 80% (as per IEA Energy Access Database) of people without access to electricity living in rural areas, many of them with no nearby grid, it is clear that grid extensions can't be seen as the sole, or even the primary, answer to provision of electricity for all.

Hence, there is an impending need to drive universal energy access by adopting a more comprehensive approach and embracing the new starting points for energy provided by standalone systems and mini grids. This is also reiterated by IEA which states "for the large rural population that is distant from power grids, mini-grid or off-grid systems provide the most viable means of access to electricity."[6] In practice, detailed local energy-sector mapping is required to identify the most cost-effective route in particular locations. But the importance of off-grid solutions was borne out by a study conducted in Senegal that found that only 20%, to at most 50%, of the unconnected rural population could be most efficiently reached through grid extension investments.[7] Off-grid electrification is the most realistic option for the remainder.

Decisions about choice of off grid technology are driven by a range of factors, with cost, technology and resource availability and sustainability being foremost among them. Considering the lower running costs, abundant availability and emphasis on sustainable energy, renewable sources have become the more preferred choice over diesel based generation. Additionally falling solar module costs have led to solar playing a center-stage role in providing households with a first rung on the energy ladder with the spread of solar lanterns and small standalone solar home systems. New business models are also emerging to support this development. The different types of Off Grid energy systems are given in the Figure 1-3 below. While mini grids[8] have been used for electrifying rural villages for at least two decades, standalone systems such as Solar Home System have become far more common in the recent past.

1.1.3. Solar Home System (SHS) in SAARC Region

The South Asian Association for Regional Cooperation (SAARC) comprises eight countries namely, Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. The countries in the region have had one of the highest number of households who have no access to electricity. Apart from Maldives, Sri Lanka and Bhutan households in the other countries in the SAARC region have less than 75%-80% electricity access[1]. The effects of this have been grave. Medical and educational opportunities and services have been severely constrained, health risks have been critical owing to use of unclean lighting alternatives and opportunities for income generating activities have been reduced. Providing grid electricity access to such households is challenging, considering that

[6] International Energy Agency, World Energy Outlook, 2014
[7] Africa Progress Panel, Africa Progress Report, 2015
[8] Mini Grids – In this report we choose to use the term mini grid to refer to any grid that is not linked to the main central grid in the country or territory in which it is located.

most of them are poor and typically have limited access as well as limited ability to pay for such energy services. The respective governments have been well aware of the situation and the need for introducing clean, sustainable and affordable products to bring light to these households. Keeping this objective in mind, initiative for installing Solar Home Systems had been introduced by the respective governments over different time periods in the past decade. The initiative has either been introduced as a dedicated programme or as part of different renewable energy schemes or projects that have been running in the respective countries. It has met with varying levels of success. While it has been extremely successful in some countries like Bangladesh, the impact has not been effective in some other countries like Pakistan and Afghanistan on account of various issues and challenges. However, considering that the SAARC member states are endowed with high solar irradiation and advances in technologies such as solar PV and LED lighting have resulted in falling prices, SHS still holds promise and potential to provide basic electricity access in SAARC region. Hence it is essential to look at factors that have been key in determining success or failure and learn from the best practices to provide solutions to the existing challenges.

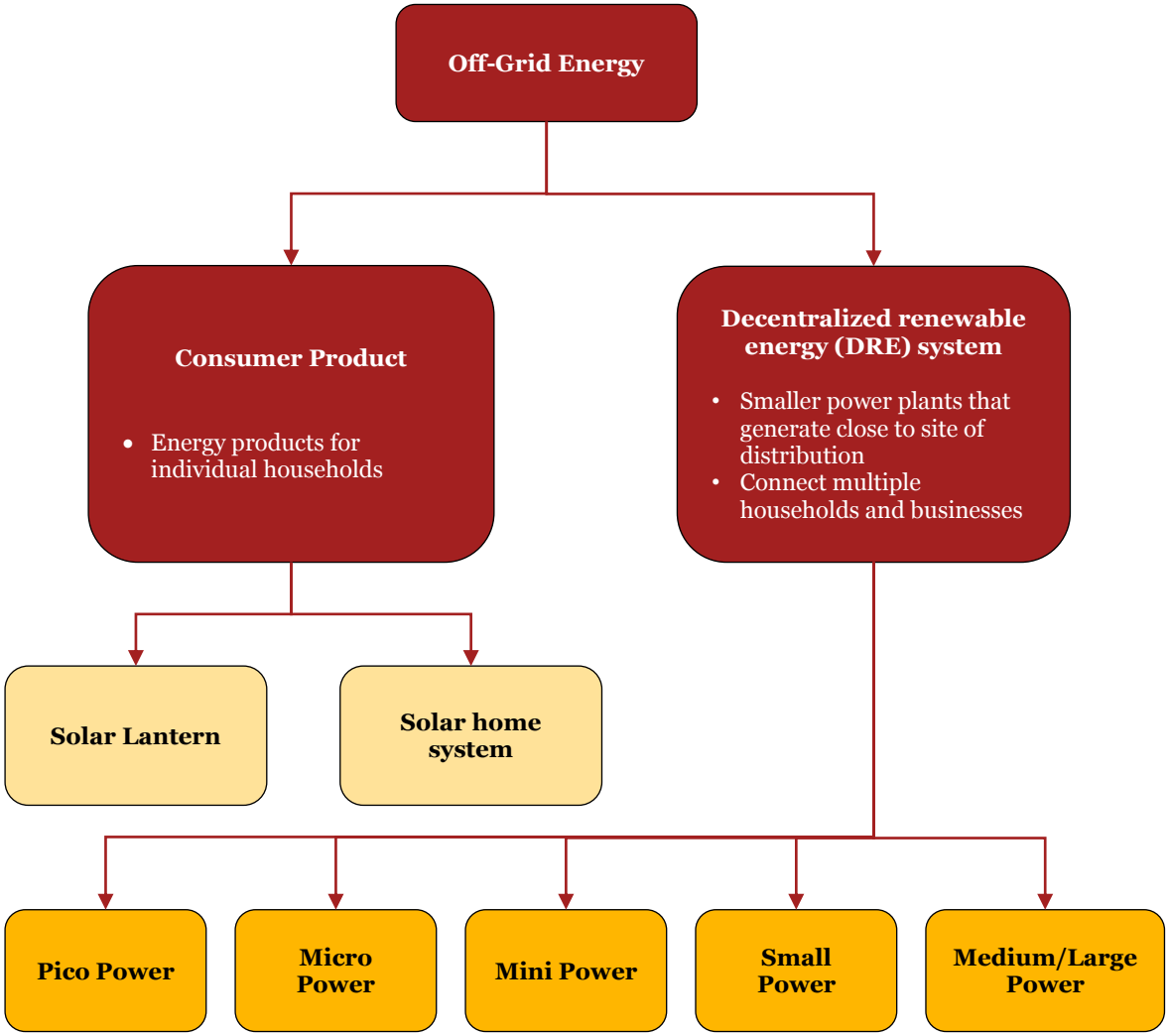


Figure 3: Types of Off-Grid Systems[9]

[9] The Climate Group, Off-Grid Business Models, 2015

1.2. Objective of Study

Solar energy is a promising solution to meet the demand for electricity services of rural households in remote locations across the developing countries. The SAARC region witnesses a large amount of solar radiation and hence many areas within this region have apt conditions to utilize the available solar energy through Off-grid solar PV systems. Hence various programmes of household Solar Home Systems (SHSs) had been launched by the SAARC Member States. However, after some early success, several doubts have arisen about the effectiveness and suitability of small PV systems for rural development. There have been many organizational, financial and technical problems that hindered progress of various programmes. SAARC Energy Centre (SEC), has proposed this study on Solar Home System under "Study to Investigate the Difficulties for Household Solar Systems in SAARC Region" with the following objectives:

- Review the already completed household Solar Home System programmes and Projects implemented by the Member States including the degree of satisfaction experienced by the users of SHSs
- Identify and investigate barriers and constraints in SHS implementation and suggest measures for the promotion and development of Solar Home Systems in the SAARC Region.

1.3. Scope of the Study

This report covers following broad topics for investigating the Difficulties for Household Solar Systems in SAARC Region:

- Understanding Solar Home Systems and review the deployment status in each SAARC Member State
- Identification and investigation of barriers and challenges with respect to growth of SHSs (country-wise)
- Understanding and summarizing the lessons learnt from success stories of SHS Developments in the World
- Suggesting measures to overcome barriers and provide recommendations to improve situation of SHS deployment (country-wise)
- Identification of benefits and outcomes of SHS deployment (country-wise)

1.4. Methodology of Study

The broad approach and methodology has been outlined below.

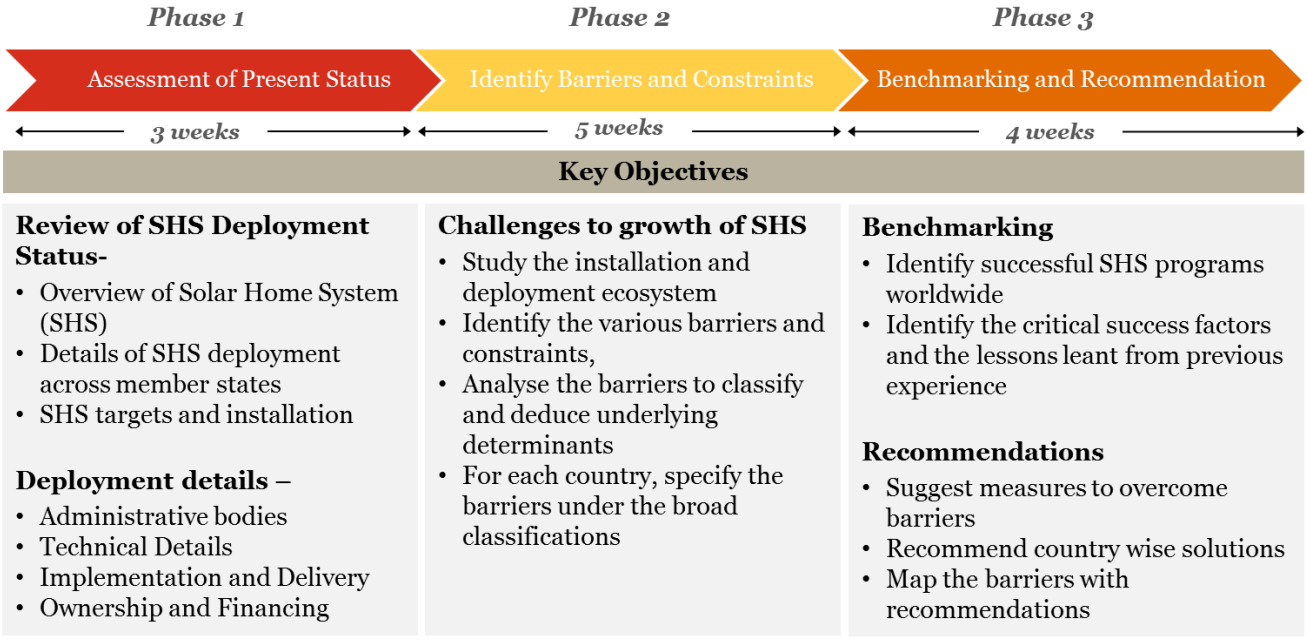


Figure 4: Approach and Methodology

1.5. Limitations of Study

- The analysis and data collection is based on public sources of information such as industry reports, journals, publications and various research databases;
- The study undertaken is primarily from secondary sources and discussions. No primary research would be undertaken only when necessary and after discussions with SAARC Energy Centre in the context of the scope of work. All primary efforts to seek information would need to be facilitated through SEC; and
- During the course of analysis and benchmarking widely acceptable norms have been relied upon in case the actual information is unavailable.
- The scope does not include any investment related advice or strategy
- Site visits and technical study is not part of the scope of the engagement

2. Solar Home Systems and Deployment Status

2.1. Overview of Solar Home Systems

2.1.1. What is a Solar Home System (SHS) -

Solar Home System (SHS) is a decentralised energy generation mechanism based on standalone solar photovoltaic system which is designed to meet the electricity demand of a single household. The primary purpose of SHS is to provide a cost effective means of supplying basic electricity access to communities or households which are not connected to the grid. It acts as a convenient source of electricity for lighting and running small appliances (e.g. Lamps, CFL, small television set, radio, and mobile phone charger) using energy from sunlight. SHS can be designed and sized based on the consumer's requirement and usage pattern. Thus the operation time can range from 3 hours to even 12 hours in some cases. As electricity generated by a solar panel is DC (Direct Current) in nature, SHS is generally used for powering DC appliances. However, an inverter can be included or configured in the system to enable AC (Alternating Current) appliances or equipment to be operated. This is usually seen in rural electrification programmes in developing countries.

2.1.2. Components of a Solar Home System -

The primary components of a Solar Home System are -:

1. Solar Modules
2. Battery
3. Charge Controller
4. Mounting Structure
5. Cables and Connecting devices
6. CFL's (Compact fluorescent lamps) or LED (Light-emitting diode) lights
7. an Installation kit that may contain a universal outlet for charging cell phones and small appliances
8. Inverter (optional)

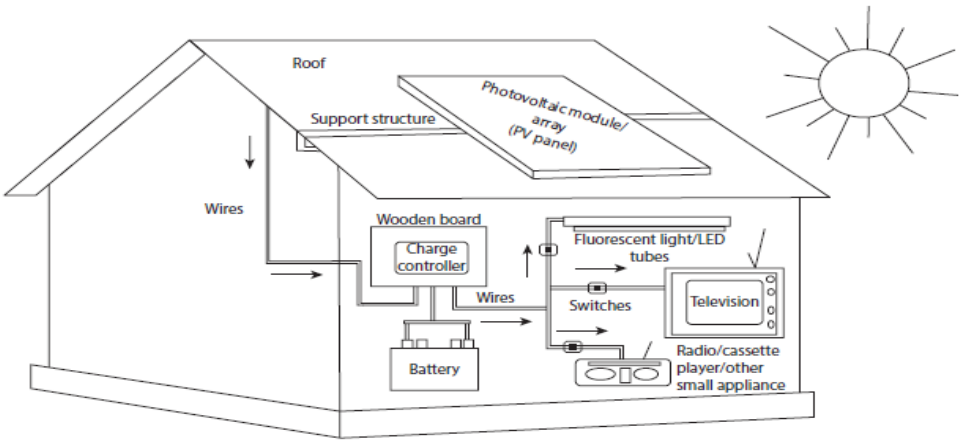


Figure 5: Typical Components of a DC Solar Home System

For each of the above technical components, there are a minimum set of requirements and recommended practices that should be followed during the design and installation stages. *Listing down the design specifications and recommended practices for each component is beyond the scope of this report*.

However it would be important to note that these requirements and practices are extremely important and should be given due consideration as they help in ensuring adequate levels of safety, performance, reliability and system lifetime. Each of these parameters play a key role and are critical in ensuring successful impact from SHS installation.

2.1.3. Brief description of how SHS works –

The **solar modules** which form the most important part of the SHS are made up of photovoltaic cells that collect energy from the sun and turn it into DC electricity. The modules are usually installed on the roof using appropriate **mounting structures**, and are placed at an angle that is optimal to collect maximum sunlight. The modules are connected to the charge controller which in turn is connected to the battery. The charge controller controls the energy flow of the entire system and assures controlled charge of the battery. It protects the battery against overcharging and discharging (prevents deep discharge by switching off the load) to ensure optimal battery maintenance in all situations. The **battery** installed are rechargeable in nature and are used to store the excess electricity generated during the day and also provides the adequate voltage needed to run the appliances. If the SHS is intended to be used for operating appliances that work on DC, the system does not require an inverter. However, for running AC appliances an **inverter** is required to be configured with the system for converting the DC electricity produced by the solar panels into AC electricity.

The capacity of the SHS can be varied according to the consumer's choice and demand by increasing or decreasing the number of solar modules. SHS systems are usually available in a broad range of capacities – 10 Watts to sometimes over 250 Watts. While the basic lower capacity systems are enough for one or two lights, the standard systems (40 W to 80 W) can power up to two to three lights, a DC fan and one or two DC appliances. Provision for inverters are usually available for higher capacity SHS systems which are capable of running AC appliances

2.2. Stakeholders and parameters related to SHS program

A well-structured SHS program should comprise of a coordinated network of partners with well-defined roles and responsibilities. Hence important parameters/stakeholders that play a crucial role in disseminating various functions necessary for efficient execution of SHS programme have been identified. *In order to compare and review the status of Solar Home Systems in each member state, it is necessary to define who/what these parameters/stakeholders are and then analyze them for each member state.* This will help in evaluating the end to end SHS execution process being followed in each country and in the process determine the unique challenges, past mistakes as well as the critical success factors that are unique to each member state.

- **Technical details** – It is important to define technical specifications with respect to configurations, capacity, application, cost etc. for each component of SHS, as the end users have little or absolutely no technical knowhow. Additionally, the viability as well as end user satisfaction from the programme is extremely dependent on the fact that the SHS installed should be of optimum size and design. The design and size should account for weather conditions, solar insolation, module degradation factor, battery life and performance factors, charge controller efficiencies and aging of components over time. Along with the above, quality, performance and warranty standards are also an extremely important consideration when providing services to rural households where service and support is difficult.

- **Policy & administrative intervention**– Various Central, State and local Government bodies and entities play a crucial role in the efficient execution of SHS programme. They are directly or indirectly engaged in formulating policies, financing schemes, electrification plans as well as implementation and monitoring. The extent of government involvement may vary from country to country, but the importance of their role and diligence cannot be overstated.

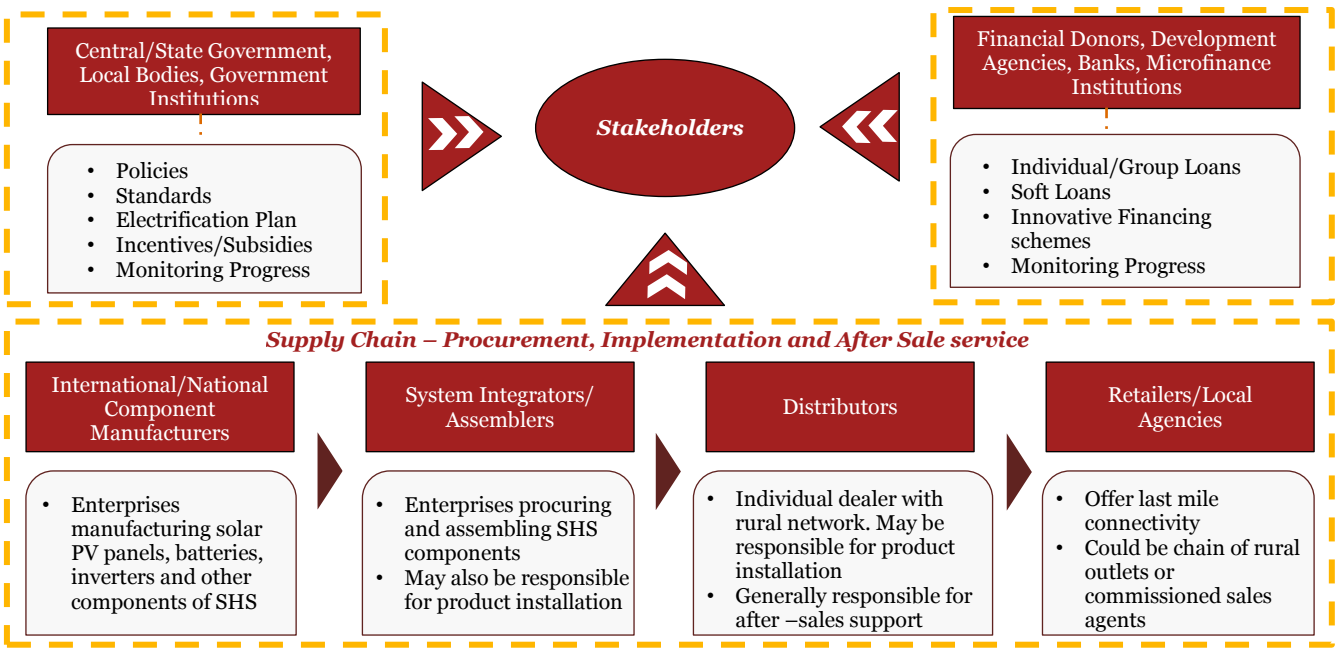


Figure 6: Stakeholders involved in Solar Home Systems

- **Implementation and Delivery** – Implementation and delivery entails a number of functions right from procurement, assembling, distribution, execution and after sales service. This provides ample opportunities for a varied number of implementation and delivery models that are in existence across various member states. Each of these models would have its own unique advantages, disadvantages, suitability issues and limitations. Hence selection of adequate model for adoption has to be analyzed in detail. Additionally due to the large number of functions, implementation and delivery requires involvement of a number of local as well as national level agencies and organizations. Hence well-defined responsibilities and proper collaboration between all stakeholders also plays an important part.

- **Ownership and Financing** – Given the large ticket size of SHSs and the financial limitations for rural (target) customers, consumer financing options play an integral part of SHS product offering. Hence, governments, implementing agencies as well as financing institutions in member states have developed various ways of supporting consumer purchases in the form of innovative financing schemes, refinancing, subsidies, ownership models etc. Donor and development agencies have also supported the SHS programme in a number of member states by providing grants and soft loans. It is important to identify and analyze the impact of various financial or ownership models and determine the suitability and limitations of each.

2.3. Solar Home System deployment status across Member States

2.3.1. Afghanistan

Energy Profile – A brief country Energy Profile has been represented in the table below:

Table 1: Energy Profile - Afghanistan

Parameter	Unit	2016
Installed Capacity	MW	566[10]
Solar Installation	MW	1[10]
Solar Contribution	percent	0.17%
Rural Population	Mn	24.38#[11]
Total Population	Mn	33.4[12]
Grid Connected Electricity Access (Country level)	percent	28.9&[10]
Grid Connected Electricity Access (Rural Level)	percent	11[10]
Per capita consumption of Electricity	kwh	176*[10]
Solar Irradiance	kWh/m2/day	5.5 [13]

#73 percent of the Afghan population lives in rural areas ; & 89% of urban and around 11% of rural population has access to electricity
* Value for 2014

[10] CAREC, Investment Opportunities in Energy Sector in Afghanistan, 2016
[11] World Bank, Rural Population (% of total population), 2016
[12] World Bank, South Asia Economic Focus, Spring 2017
[13] MEW and MRRD, Afghanistan Rural Renewable Energy Policy, April 2011

Country Overview –

Afghanistan has a total population of about 33.4 million, and with a total area of 652,860 sq. km[14], it has a population density of about 51 people per sq. km, which is one of lowest population densities in Asian region. Out of the established population, 24.3 million live in rural areas and the remaining 27% in urban parts of the country. It has great solar potential; the average annual solar irradiance is about 5.5 kWh/m2/day, but varies geographically and is highest in the south.

Most of the energy demand in Afghan rural households is fulfilled through traditional sources like fuel wood and kerosene. Diesel generators provide energy for the basic services in health clinics; although sometimes diesel expenses are too high to afford. Rural schools often operate without any power at all. The country is largely dependent on imported electricity from its neighboring countries to supply electricity to urban and industrial centers. The high transmission and distribution cost of electricity for such low energy consumption in rural areas makes it infeasible to extend the utility grid. The ACEP PV stand-alone solar systems for SHS, SSL, SL, rural solar clinics and schools provide cost-effective basic electricity and make an important contribution for development of Afghan rural areas.[17]

Administrative/Coordinating Bodies -

The Renewable Energy Department (RED) of the Ministry of Energy and Water (MEW) is the main body responsible for Afghanistan's available renewable energy resources. The RED has been established by the MEW to increase affordability and access to renewable energy services and accelerate market development for renewable energy technologies by reducing existing barriers (regulatory, technological, capacity building, economic/financial). [15]

In order to identify priorities for the implementation of the renewable energy services and programs, and to provide strategic sustainable energy solutions, four management units, namely Solar Energy, Wind Energy, Biomass Energy and Micro Hydro Power (MHP), have been created within RED. In addition, a Technical Assistance Team (TAT), comprising four renewable energy experts, has also been formed to support the four management units in achieving the strategic objectives set by the RED. The main focus of the TAT is to assist the RED in fulfilling its mandate and carrying out its mission effectively and efficiently, according to the Terms of Reference developed.

The Ministry of Rural Rehabilitation and Development (MRRD) was established to develop and implement programs promoting responsible social and financial growth in rural areas, primarily in the non-farm sector. It has employees in all 34 Provinces of Afghanistan, and delivers a wide range of programs funded both by the Ministry itself and the International Community.

MRRD launched the Energy for Rural Development Afghanistan (ERDA) which is embedded in the project document of the third phase of National Area Based Development Program (NABDP) with UNDP's support in

[14] World Bank, Country Snapshot – Afghanistan, October 2017
[15] MEW, Renewable Energy Department

2009. The program was a major part of Sustainable Livelihoods through Rural Infrastructure Services under component 2 during the project proposal preparation and project document. The NABDP mid-term review, carried out during 2010, recommended rural energy as a separate component under NABDP, and thus it started as a separate component in the NABDP strategic document prepared in early 2011 under the name of Rural Energy Department (REnD). In 2013, Rural Energy was elevated to major program status.

REnD promotes the use of solar photovoltaic systems to meet the demand of rural households, specially related to evening lighting, operating small radios and charging mobile phones. Support will be provided to individual households and also cover demands of the community in a cluster settlement, while also incorporating the recommendations of the corresponding CDC (Community Development Council) and DDA (District Development Council). The minimum number of SHSs in a settlement should be 10. As far as possible, one project will cover all the requirements of one CDC. REnD will support a system size of 20-100 Wp per household depending upon the requirement and system design to meet it.[16]

The demand of SHSs will be received from the DDP (District Development plan) prepared by a DDA or directly requested from the communities to the provincial, regional or ministry leaders. REnD will conduct feasibility studies and prepare a detailed design of the system with its cost estimate and necessary BoQ. Community interest, participation and willingness to pay are the main basis for support and implementation in the selected area. Sustainability issues will be taken into consideration with quality standardization of products, encouraging the private sector to train local people as well as providing after sales services to the community. REnD will also conduct the necessary awareness raising and capacity building activities at the community, DDA and provincial levels. A separate solar photovoltaic implementation guideline will be prepared by REnD for Solar PV implementation.

Technical details –

The SHS consisted of 80 W Premiere Solar PV module made in India, and a 150 Ah deep-cycle maintenance free-sealed AGM battery. The system provided two CFL and one high intensity LED light. A dc-dc converter was also provided for cell phone charging and radios. Most SHSs in Afghanistan were installed with undersized batteries for the PV module.[17]

Implementation and Delivery –

There are still over 25 million Afghan people who lack electricity to meet basic power needs and stimulate economic growth. Most of these people live in rural areas with limited access to health care, education, or a reliable income. These rural Afghan people typically live in small villages, often scattered over challenging mountainous or desert terrain. There is little likelihood for most of them to ever receive electricity from the conventional electric grid in the coming decades. Only through photovoltaic (PV) technologies can a majority of these rural Afghan villages hope to enjoy basic electricity service.[17]

[16] MRRD, Rural electrical implementation guidelines, 2013
[17]Robert E. Foster and Alma D. Cota, Afghanistan Photovoltaic Power Applications for Rural Development, 2012

The Afghanistan Clean Energy Program (ACEP) was launched in September 2009 with a goal to provide basic electrification services primarily through PV technologies to villages not connected to the power grid. Winrock International provided engineering technical support while USAID was the primary sponsor. ACEP benefitted over one million Afghans and installed 500 kW of PV power systems (SHS included) for villages, clinics, schools, and farms in 21 Afghan provinces. Many systems were installed in difficult areas under trying circumstances. In a few instances work crews were kidnapped by the Taliban, or jailed by corrupt local authorities; all were fortunately released unharmed. A few systems in the south were stolen or sabotaged by Taliban elements. However, ACEP persevered and was able to complete all its PV projects, which contributed to local improvements in health, education, nutrition, and income.

As part of the program, ACEP installed 717 small SHSs across 7 villages in the Almara District of Khost Province. The SHSs were of superior quality because many of the past systems installed in Afghanistan had been plagued by problems due to undersized solar panels, use of inappropriate batteries (e.g., automobile), and undersized wires. This had led MRRD to ban PV systems in their programs. In the past issues related to incorrect module tilt and orientation had also been faced. Hence installers were taught to provide a proper PV module tilt and orientation which was verified by independent evaluators after installation.[17]

There are very few private companies in Afghanistan that are involved in SHSs. Masdar is one of the largest players. It has installed SHSs in more than 2 dozen villages in Afghanistan. Which is enhancing the lives of more than 3000 people who had no access to electricity. The installations include 545 houses and 55 public facilities such as schools, mosques and clinics. Masdar also provided training to the users on how to operate and maintain their SHSs.[18]

Ownership and Financing –

The Afghanistan Clean Energy Program (ACEP) was a US$22 million funded program from September 2009 to March 2012 primarily focused on solar energy and has been the single largest United States Agency for International Development (USAID) funded solar energy initiative to date.

SHS Installation Status -

As per Afghanistan Rural Renewable Energy Policy, 2013, MRRD has installed over 100,000 solar home systems (SHSs) in various parts of the country. However, MRRD discontinued the program due to quality related issues[13].

[18] Masdar Clean Energy, Masdar Special Projects: Solar Home Systems in Afghanistan

2.3.2. Bangladesh

Energy Profile – A brief country Energy Profile has been represented in the table below:

Table 2: Energy Profile - Bangladesh

Parameter	Unit	2016
Installed Capacity	MW	11,765[19]
Solar Installation	MW	17
Solar Contribution	Percent	0.0%
Rural Population	Mn	103[20]
Total Population	Mn	161[20]
Grid Connected Electricity Access (Country level)	Percent	76.7%*[20]
Grid Connected Electricity Access (Rural Level)	Percent	67.6%[20]
Per capita consumption of Electricity	Kwh	281[19]
Solar Irradiance	kWh/m2	4-6.5[21]

*92.9 % of urban and 67.6 % of rural population have access to electricity

Country Overview –

Bangladesh is spread over an area of 147,610 sq. km and with a population of 161 million (2016) people. It is among the most densely populated countries in the world. More than 60 percent of the total population reside in the rural areas. As of 2015, around 92.9 percent of urban population and only 67.6 percent of rural population have access to electricity[20]. For the country as a whole the percent of population with electricity connection stands at 76.7 percent. Majority of the rural household who do not have access to electricity use kerosene lamps for lighting their homes. Bangladesh also has a rate of energy consumption that is amongst the lowest of any country in the world, consuming just 281 kWh per capita annually.

The total installed capacity in the country as of 2015-16 is around 11.8 GW with a very small amount attributable to renewables and solar. However the country enjoys ample solar radiation with average value of irradiance varying from 4-6.5 kWh/m2/day. The government plans to provide electricity to all by 2021.[22] However, this electrification target cannot be met by the rural grid expansion alone due to inaccessibility and low consumer density in many rural areas, as well as financial constraints. To reach the government's vision of universal

[19] Bangladesh Power Development Board, Annual Report, 2015-16
[20] Bangladesh Bureau of Statistics, Statistical Year Book Bangladesh, 2017
[21] Md. Tasbirul Islam, S.A. Shahir, T.M. Iftakhar Uddin, A.Z.A Saifullah, Current energy scenario and future prospect of renewable energy in Bangladesh

[22] World Bank, Bangladesh: Ensuring a Reliable and Quality Energy Supply, October 2016

electrification, renewable energy sources, in particular solar energy will have to play a vital role for off-grid electrification.

Administrative/Coordinating Bodies -

The Rural Electrification Board of Bangladesh was established in 1977 to oversee rural electricity access in Bangladesh. However no concrete progress had been made under the same which was pointed out in the National Energy policy (NEP) of 1996, which stated "adequate attention has not been given to meet the total energy needs of rural areas"[23]. This prompted institutions like Grameen Shakti, BRAC Foundation, and several other nongovernmental organizations (NGOs) to launch their own solar programs with emphasis on providing off grid electricity access to rural areas using solar power. From 1997 to 2003 approximately 11,000 SHSs were established by these institutions. In 2002, an updated version of NEP was released by the government with plans to electrify entire Bangladesh by 2020 and focus on decentralized electrification solutions based on renewable energy. It stated that priority will be given to the rural areas where national grid expansion is expensive.

In this backdrop, the SHS Program was launched in 2003 as a part of the Rural Electrification and Renewable Energy Development Project (REREDP) funded by the World Bank and the Global Environmental Facility (GEF) to ensure access to clean electricity for the off-grid rural areas of Bangladesh. Under REREDP the SHS program was planned to be implemented by two different institutions - Infrastructure Development Company Limited (IDCOL) and the Rural Electrification Board.

IDCOL - IDCOL was established in 1997 by the Government of Bangladesh and was licensed by the Bangladesh Bank as a non-bank financial institution (NBFI). It plays a major role in bridging the financing gap for developing medium to large-scale infrastructure and renewable energy projects in Bangladesh. It is governed by an independent board of directors drawn from the government and the private sector.

The implementation of the SHS program was planned by two parallel approaches. While BREB pursued a fee-for-service approach, IDCOL's approach was based on an ownership model.[24]

In the **fee-for-service** model, an energy service company (ESCO) carries out the investment in SHS and sells the electricity produced at a fee to the consumer. The ESCO remains the owner of the hardware and is responsible for installation, maintenance, and repair including the replacement of components. The end user pays a connection fee and a regular fee—usually monthly. The end user pays as long as the energy service is delivered and never becomes the owner of the system. However, the end user usually owns the wiring, lamps, and appliances, which are covered by the connection fee.[24]

In the **ownership** model, a supplier sells the SHS to the end user, who enters into a credit arrangement with the supplier. The ownership of the system is transferred to the consumer when the loan is completely repaid. The suppliers are in charge of maintenance and repairs, which guarantees a higher level of technical expertise. [24]

IDCOL believed that the ownership model was much more sustainable due to closer involvement of the consumers through their actual ownership of the systems. They reached the aim of 50,000 SHSs almost three

[23] Government of Bangladesh, National Energy Policy
[24] Global Delivery Initiative, Solar Home Systems in Bangladesh, September 2015

years ahead of schedule. On the other hand, BREB got stuck in lengthy procedures of coordination and procurement but managed to achieve the goal of 14,000 SHSs by June 2008.[24] However once the REREDP program was completed BREB did not continue its SHS program while IDCOL continued on the basis of the ownership model and with the support of several additional donors over the years such as ADB, DFID, GPOBA, JICA, KfW etc.

In 2008, Bangladesh enacted the Renewable Energy Policy (REP) which also emphasizes the role of renewable energies for rural electrification, and in 2013 the new Sustainable and Renewable Energy Development Authority (SREDA), whose task is to support the implementation of the REP. SREDA envisions to achieve the targets for developing renewable energy resources to meet 10 percent of the total power demand by 2020.[25]

Technical details –

IDCOL has designed a rigorous Quality Assurance (QA) framework for the SHS program in Bangladesh that combines standards with inspection and monitoring. It combines testing of SHS components, financing for approved packages, field inspections of selected installed systems and strong and enforceable warranty requirements. The SHSs are required to be sold in pre-approved configurations set by IDCOL. As per the framework and arrangement, the components of SHSs must be tested and approved before they can be used in an IDCOL financed SHS. The components must be configured into a package that meets IDCOL system design requirements and must be sold with a warranty that meets IDCOL's requirements. Compliance of SHSs with IDCOL specifications is then assured through extensive monitoring, technical audits, field inspections, and the enforcement of financial penalties.

Table 3: Sample SHS packages - Bangladesh[26]

Capacity	Total Load	Operating Hour	Cost
20 Wp	Lamp: 2 (5W each) Mobile Charger: 1	4-5 Hours	140 USD
50 Wp	Lamp: 4 (7W each) Black & White TV: 1 Mobile Charger: 1	4-5 Hours	380 USD
85 Wp	Lamp: 9 (7W each) Black & White TV: 1 Mobile Charger: 1	4-5 Hours	580 USD
135 Wp	Lamp: 11 (7W each) Black & White TV: 1 Mobile Charger: 1	4-5 Hours	940 USD

[25] SREDA, Renewable Energy Policy, 2015
[26] United Nations Practioner Network, Rural Electrification: the success story of Bangladesh

Component Standards and Warranty – There is an independent Technical Standard Committee (TSC), which maintains a "Technical Specifications for Solar Home Systems" document that defines the technical and warranty specifications that systems and components must meet in order to be financed under the IDCOL SHS program. Components must be approved by the TSC and included on IDCOL's lists of approved SHS equipment. The TSC maintains approved component lists for batteries, charge controllers, compact florescent lamps (CFL), LED lamps and lanterns, photovoltaic (PV) modules, DC-DC converters, and appliances. To get the component approved, the component supplier has to submit a number of documents to the TSC and pay the associated approval fee. Documents required include: a letter to IDCOL, a test report from a local authorized testing institution, certification that the component meets certain international standards related to quality and environmental health and safety, a specification sheet, a warranty certificate, agreements, an audit report and a company profile.

The TSC defines the technical specifications that components must meet to be approved. Suppliers provide their components to a local authorized testing institution that evaluates the components against the specifications. Once testing has been completed, the resulting test report is provided to the TSC. Each testing institution charges its own set of fees for conducting the tests which are in addition to the fees charged by IDCOL.

The minimum required warranties for the respective components are given below –

Table 4: Component wise warranty requirement - Bangladesh[27]

Component	Warranty
PV module (power output)	20 years
Pole mount module supporting structure	10 years
Battery (in systems sized above 30 Wp)	5 years
Battery (in systems sized 30 Wp and below), charge controller, DC-DC Converter, energy meter, LED lamp / tube light / bulb, cables used for wiring, switches-socket and other accessories-appliances	3 years
PV module (defects and/or failures)	2 years
CFL / fluorescent lamp, built-in rechargeable battery for LED lantern	1 year
System-integrated parts and labor	6 months

Implementation and Delivery –

The mainstay of the SHS program implemented by IDCOL are a network of Participating Organizations (POs) which are private organizations, mainly comprising of NGOs. IDCOL provides financing to these POs using grants and loans it receives from various donors and the POs pass on the financing to the consumers in the form of micro-credit scheme to purchase the SHS. IDCOL is in charge of overall project management and monitoring, defining the regulations for loan disbursement to the POs, and setting the technical standards for SHS

[27] Lighting Global, Quality Assurance for Off-Grid Solar Home Systems, February 2015

components and installations. The POs play the key role of procuring and installing the SHSs, providing after-sales service and maintenance, as well as installment collection of the loan given to the consumers. The users themselves have to make a down payment, usually 10 percent of the total cost of the SHS.

The program structure and implementation is shown below –

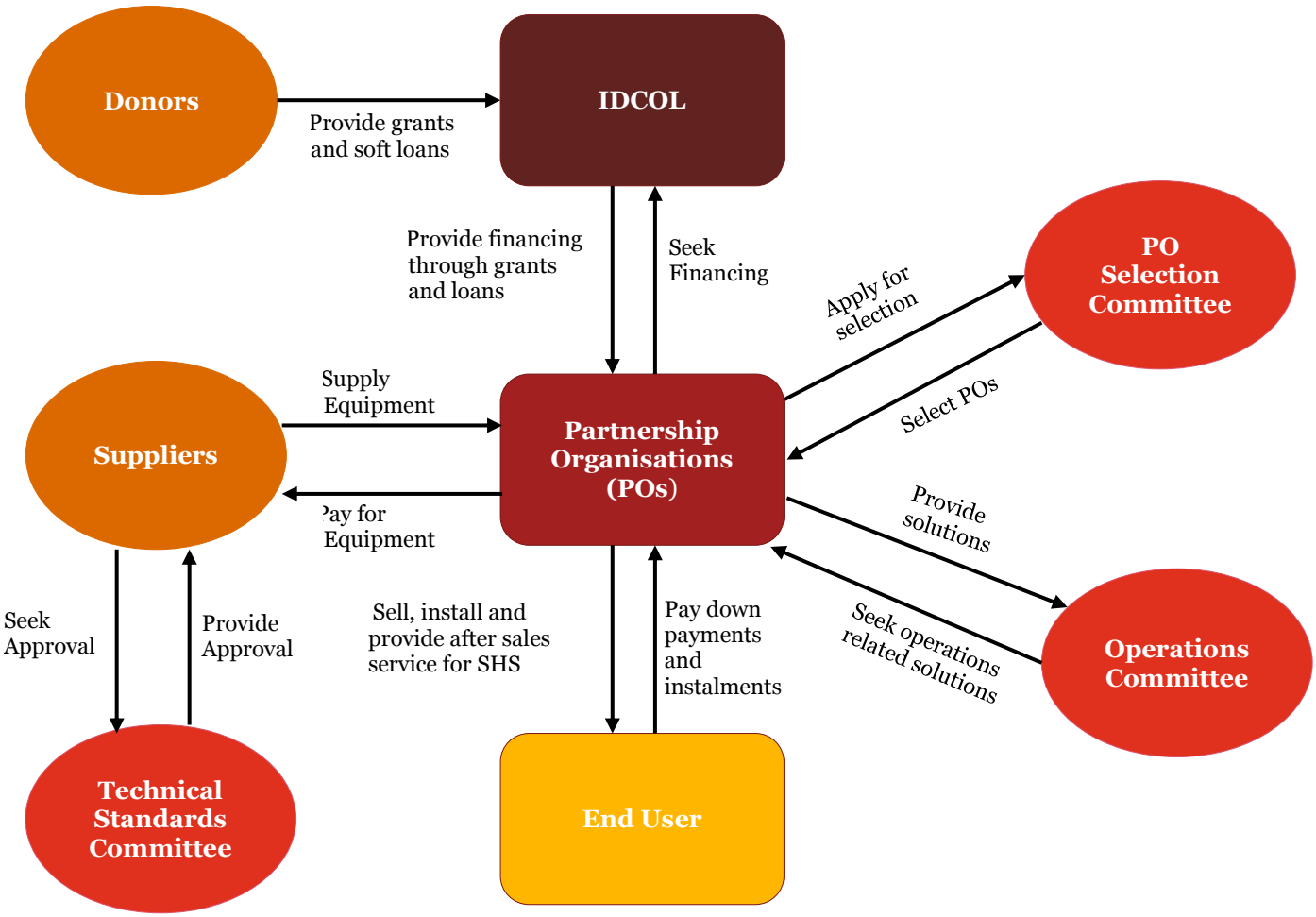


Figure 7: IDCOL SHS program structure and implementation - Bangladesh

Since IDCOL is in charge of project planning and monitoring it has to ensure that all implementation challenges should be adequately tackled. For this purpose it has set up three important committees which ensure that capable POs are selected, technical and quality standards for SHS are maintained and adequate procedures are followed. The POs are selected by a **PO selection committee** which comprises of representatives from IDCOL and government ministries and organizations. The committee selects the POs based on their rural presence, microfinance experience and financial strength. The **Technical Standards committee** comprising of technical experts from universities, government engineering departments and IDCOL staff are responsible for defining the technical and quality standards of the components, approving appropriate equipment which meet the standards and selecting the suppliers of the equipment based on relevant credentials. The **Operations committee** looks after the procedural and operational aspects of the programme. It is made up of representatives from IDCOL and project heads of all POs.

The implementation of the programme is based on the following steps:

1. The POs select eligible and willing consumers for purchase of SHS. The consumers either purchase through cash or make a down payment of at least 10 to 15 percent of the system cost—net of subsidy. The remaining amount is financed through loan at market rates. The POs assist the consumers in obtaining the loan.
2. On receipt of the down payment, the POs enter into a sale or lease agreement with a mandated supplier. The POs receive three months' credit from the supplier and their representatives install the systems.
3. After installation, the PO applies to IDCOL to refinance the loan and grant. IDCOL inspectors inspect the households to verify that the system has been installed properly. IDCOL then provides a grant to the PO equal to the entire amount of the subsidy. On receiving the funds from IDCOL, the PO pays back the credit received from the supplier. IDCOL also refinances 60 percent to 70 percent of the loan amount
4. IDCOL then claims the funds used for financing from the World Bank, ADB, or IDB, and the grant from GPOBA, KfW, or GTZ.
5. Post implementation, the POs provide any required maintenance free of charge throughout the duration of the loan. They also collect the monthly instalment payments from the consumers

IDCOL has also put in place a number of checks and balances related to **Inspection and Monitoring** in order to protect the interest of the consumers.

- *Technical inspectors* – There are more than 150 technical inspectors/engineers based in 12 regional inspection offices of IDCOL. Originally, funds were only disbursed by IDCOL to POs after each new SHS installation had been inspected. As the program has grown substantially, the inspectors are now just required to inspect 5% of newly installed SHSs before funds are disbursed. Information on inspections is entered into a central database. If an inspector determines that a SHS does not meet the technical specifications, then the responsible PO is advised to fix the problem within a certain time. Future disbursements against the SHS are withheld by IDCOL until the problem is resolved. Re-inspection checks of inspected systems are also carried out by IDCOL officials. Inspections are also intended to be carried out by representatives of POs who are responsible for collecting monthly installments. IDCOL has advised that more than 50% of installed systems have actually been inspected and the cost of the inspections is less than $1 per system. The cost of the inspections is divided evenly between donors (50%) and IDCOL (50%).
- *Call Center* - IDCOL has set up a call center for receiving complaints directly from customers. The call center numbers are provided to the customers during the installation of the SHS and printed in big lettering on charge controllers. The call center is operated by two full-time staff members. The reported problems are relayed to the respective PO who are also advised on how to fix the problem. Future disbursements to the PO for the affected SHSs are withheld until the problem is resolved. IDCOL verifies the status of the problem by calling the customers directly.

- *Independent technical audits* - A technical audit of system components is periodically carried out by a third party. This is intended to occur at least once a year and involves inspecting and testing products from individual households and collecting samples from POs and suppliers. The audit process takes 6-7 months and the results of the audit are shared with the respective POs as well as the suppliers. IDCOL follows up on whether the problems identified through audits have been addressed. POs and suppliers can be penalized as a result of the audit.

- *Training Programs* - IDCOL provides training programs for inspectors, PO trainers and staff, customers, and technicians in order to ensure proper installation, operation and maintenance of SHSs.

Up to May 2017, about 4.12 million SHSs have been installed under the program[28]. At present, 56 POs are working under IDCOL SHS program[28]. The monthly average installation of SHS under the program is 50,000 SHS[29]. The POs vary largely in size. However there are four POs which account for most of the SHSs installed so far – Grameen Shakti, Rural Services Foundation (RSF), BRAC foundation and Srizony.

Ownership and Financing –

The IDCOL SHS programme follows a micro credit scheme through which it facilitates the purchase of SHS by consumers. Using the grants and loans that IDCOL receives, it provides financing to the Partnership Organizations (POs) who pass on the financing to the consumers in the form of micro-credit scheme to purchase SHS. The flow of funds is as given below:

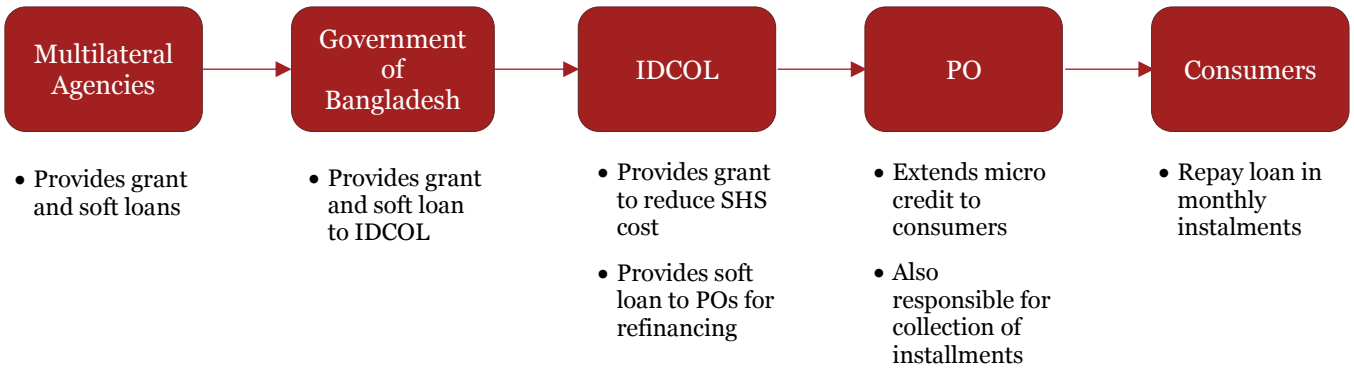


Figure 8: IDCOL SHS Program flow of funds - Bangladesh

While the IDCOL SHS programme was started with funding from World Bank and GEF, various other donor organizations have lent their support to the program over the years such as GIZ, ADB, DFID, GPOBA, IDB, JICA, KfW, and USAID[28]. A separate account is maintained for each participating donor in order to keep the individual contributions well separated. While disbursing grants and loans to the POs, the respective funds are recorded under the corresponding donor account. All POs are obliged to report their installation figures and financial details, such as collection efficiency and overdue collection rates, to IDCOL on a monthly basis in order to maintain financial transparency.

[28] IDCOL, Solar Home System Program
[29] IDCOL, REoI and ToR for Automation of IDCOL Solar Home System Program

The contributions from donor agencies have been in the form of grants and soft loans. The grants provided have been in the form of buy down grant to lower initial investment cost of SHS and Institutional Development Grant for capacity building of the SHS program and institutional development of POs. When the IDCOL program first started in 2003, the capital buy down grant was $90 per system. However, over the years both the components of grants have declined as the markets have expanded and become commercially viable. The grant is now only available for smaller systems.

Table 5: Phase out of SHS subsidy over the years - Bangladesh[30]

(In $)	2003	2004~05	2006~07	2008~09	2010~11	2012	2013~14
Capital buy down grant	70	55	40	40	25	25	20*
Institutional Development Grant	20	15	10	5	3	0	0

* For systems < 30wp only

The soft loans or concessional credit provided by donor agencies is passed on by the POs to the end consumers. This is used for refinancing of the loans by providing a longer tenure and concessional rates for the loans. Over the years even these have been gradually reduced.

Table 6: Concessional credit given by donor agencies for refinancing SHS loans - Bangladesh[30]

(In $)	2003~08	2009	2010	2011	2012	2013	2014
Loan tenure (years)	10	6 – 10	6 – 8	6 – 8	5 – 7	5 – 7	5 – 7
Interest rate (%)	6	6 – 8	6 – 8	6 – 8	6 – 9	6 – 9	6 – 9
Percent of loan refinanced (%)	80	80	80	80	70 - 80	70	70

Till December 2016, IDCOL has disbursed USD 631 million (BDT 41,587 million) as credit and channeled USD 186 million (BDT 5,983 million) as grant to all POs[31]. In addition to grants for POs, donors also provide grants for project implementation cost which includes; monitoring, supervision, marketing, physical verification of SHS, technical audit, capacity building of POs, consultants' fees, etc.

At the time of purchase of SHS, the consumers have to make a down payment to IDCOL of around 10 to 15 percent of the SHS cost post subsidy. The remaining cost is financed by micro-credit, with PO contributing around 20 to 30 percent and IDCOL providing 70 to 80 percent. POs are also made to contribute towards the loan in order to assume a part of the financial risk and instill the feeling of commitment. The entire credit is passed to the consumer who can opt for a 24- or 36-month loan period. The loans are given at 10 to 12 percent interest rate. The SHS itself is used as collateral in case the loans are not repaid. The SHS is installed by the PO, post which

[30] ADB, Making Renewable Energy a success in Bangladesh, December 2015
[31] IDCOL, Annual Report, 2016

IDCOL inspects the installation. Once it is approved, the PO approaches IDCOL for refinancing of the credit given to the consumers. [30]

An example of the mode of financing is given below:

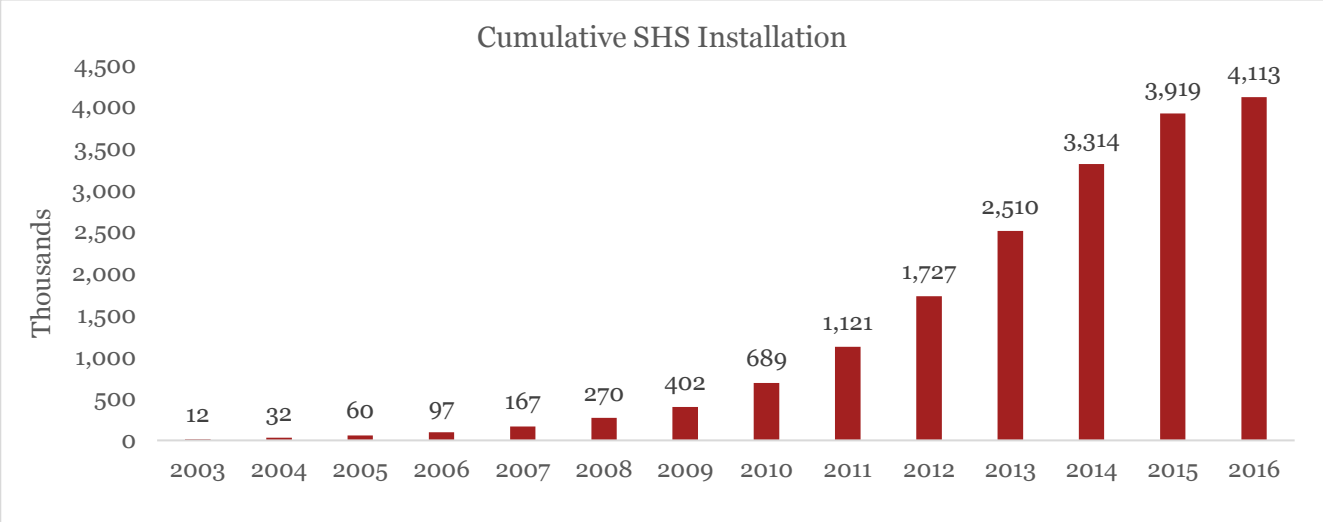
Table 7: Example of mode of financing SHS - Bangladesh

S No.	Mode of Financing	Parameters
1	System cost of a 40 Wp SHS	$ 336
2	Buy down grant or OBA subsidy	$ 0
3	System cost net of grant [(1) – (2)]	$ 336
4	Down payment by consumers [15% of net cost (3)]	$ 50
5	Credit from PO [20% of net cost (3)]	$ 67
6	Credit from IDCOL [65% of net cost (3)]	$ 219
7	Total loan payable by consumer to PO [(5) + (6)]	$ 286
	Loan Tenure (years)	3[32]
	Annual Interest Rate (%)	12[32]
	Monthly Installment	9.5
8	Refinancing of loan [70 % of loan (7)]	$ 200
	Loan Tenure (years)	5 ~ 7 [32]
	Annual Interest Rate (%)	6 ~ 9[32]

SHS Installation Status -

Started in 2003, the IDCOL SHS program had an initial target of financing 50,000 SHSs by June 2008. However they were able to achieve the target almost three years before schedule by September 2005. Subsequently, IDCOL set itself a target of financing 1 million SHSs by 2012. They were again successful in achieving this target by July 2011. IDCOL has now set a target of financing 6 million SHS by 2018 with an estimated generation capacity of 198 MW of electricity. They are well on course to achieving the same with more than 4 million installations already done by May, 2017[28].

[32] Nazmul Haque – Director (Investment) & Head of Advisory, IDCOL, presentation on IDCOL SHS Program



Source: IDCOL Annual Reports

Figure 9: Cumulative SHS Installation - Bangladesh

2.3.3. Bhutan

Energy Profile – A brief country Energy Profile has been represented in the table below:

Table 8: Energy Profile - Bhutan

Parameter	Unit	2016
Installed Capacity	MW	1614#[33]
Solar Installation	MW	0
Solar Contribution	percent	0
Rural Population	Mn	0.47*[34]
Total Population	Mn	0.77[35]
Grid Connected Electricity Access (Country level)	percent	100[36]
Grid Connected Electricity Access (Rural Level)	percent	100
Solar Irradiance	kWh/m2	4.99
Per capita consumption of Electricity	kwh	2671.6#[35]

Data for 2015
* As per World Bank – Rural Population is 61% of total population

Country Overview –

Bhutan is a mountainous country with settlements spread over numerous mountains and valleys with little or no access road. Due to such topographic conditions, providing electricity to remote rural households and institutions through grid extensions was not possible. Hence the Royal Government of Bhutan provided SHSs to identified households where grid based access would not be cost effective. Along with Maldives, it is the only SAARC nation with 100 percent electricity access which it achieved in 2014. Bhutan considers households with SHSs as electrified. It is also one of the only South Asian countries with an electricity surplus (which it exports to India). Majority of the installed generation capacity is Hydropower.

Administrative/Coordinating Bodies –

Since 2002, the Ministry of Economic Affairs (MoEA) has been acting as the principal RGoB administrator for the energy sector in Bhutan. There are three main bodies which function under its ambit, namely the Department of Energy (DoE), Bhutan Electricity Authority (BEA) and Bhutan Power Corporation Limited (BPCL). While the Department formulates energy policies and conducts planning and coordination, the Authority is the main regulatory agency of the energy sector and BPCL is in-charge of distribution and transmission of electricity.

[33] USAID, South Asian Power Sector : Investment Prospects, Challenges and Issues
[34] World Bank, Rural population (% of total population), 2016
[35] National Statistics Bureau, Statistical Yearbook of Bhutan, 2016
[36] World Bank, Access to Electricity, 2014

Rural electrification has been a focus point of RGoB which had started large scale rural electrification projects in the nation's sixth Five-Year Plan (FYP, 1988 to 1993). All subsequent FYPs have included rural electrification as one of their key elements. In the 2003 to 2005 period, the Japan International Cooperation Agency (JICA) sponsored a comprehensive Rural Electrification Master Plan (REMP) to identify and assess the households to be electrified in Bhutan. The study was carried out to assist RGoB in achieving its goal of providing electricity to all by 2020. The REMP identified 1,716 villages to be electrified. Of these, 1,267 villages (approximately 30,000 households) were identified to be electrified through the expansion of distribution lines, and 449 villages (about 4,000 households) through off-grid electricity, mainly through solar home systems (SHS)[37]. In 2008, the RGoB accelerated the nation's rural electrification programs and revised the goal of electricity for all to 2013. There was also a focus on providing grid connections to as many villages as possible. For this, BPC conducted a survey and identified additional households for on-grid connection who were designated for off-grid electrification in the 2005 REMP.

Since 2008, the DOE started installing SHS in off-grid villages through various programs financed by the RGOB and ADB. Subsequently in 2010, ADB launched the "Rural Renewable Energy Development Project" to provide technical assistance to the Ministry of Economic Affairs (MOEA) to assist the government to achieve its goal of providing electricity for all by 2013. The project had four components –

On-grid rural electrification sourced from hydropower

- **Off-grid rural electrification sourced from solar power (Solar Home System)**
- Pilot wind power generation plant connected to the power grid
- Pilot domestic biogas plants

The objective of the Off-Grid Rural Electrification Component was to provide electrification in rural households where extension of grid was not possible for techno-economic reasons. It comprised of two subcomponents –

1. Installation of SHS for 1,896 households in remote, isolated off-grid villages in ten dzongkhags
2. A sustainable SHS O&M program to ensure all installed SHS will be functional in the long run

The Department of Energy (Ministry of Economic Affairs) is the Executing Agency (EA), and Department of Energy's (DOE) Renewable Energy Division (RED) in MOEA is the Implementing Agency (IA). Financial assistance is being given by the Asian Development Bank (ADB) under the Rural Renewable Energy Development Project Grant.

Technical details –

The specifications for the SHSs to be installed were finalized taking into consideration the difficulty and cost of transporting, installing and maintaining SHS sets in remote households present in mountainous areas. Lighter weight and maintenance-free solar batteries, more efficient and longer life LED lights, and more reliable controllers were selected to reduce the transportation costs and needs for downstream repair and maintenance.

[37] ADB, Bhutan: Preparing the Rural Renewable Energy Development Project, 2011

The project design also accounts for weather conditions, Bhutanese solar insolation resources, cable losses, pane degradation factors, battery and charge controller efficiencies and aging of components over time.

Table 9: SHS system components and specifications - Bhutan

S. No.	Component	Specifications
1	Solar Panel	50 WP
2	Charge Controller	7 Amps
3	Luminaries	3 x 3 Watt WLED
4	Battery	50 AH@ c20, <32 kg
5	Night Lights	2 x 0.5 Watt LED
6	Mobile phone charge	Socket & cable
7	Wires	As available
8	Accessories	As available

Detailed analysis and specifications of individual components of the SHS have been provided under the Technical Analysis section of the project document[37].

Implementation and Delivery –

The main output of the Off-Grid Rural Electrification project was installation of 1,896 new Solar Home Systems and rehabilitation of 2,500 existing units throughout the country[37]. Along with this developing a sustainable O&M program was also a crucial element.

The new installations were spread over 10 dzongkhags across the country. The number of households targeted for each dzongkhag is shown below –

Table 10: Targeted Number of Households for SHS installation - Bhutan

S. No.	Name of dzongkhag	Targeted Number of Households
1	Chukha	563
2	Dagana	231
3	Gasa	188
4	Haa	170
5	Paro	44
6	Punakha	16
7	Samtse	177
8	Sarpang	177
9	Trongsa	70
10	Wangduephodrang	260

S. No.	Name of dzongkhag	Targeted Number of Households
	Total	1,896

The DoE as the implementing agency was responsible for procuring, installing, testing and monitoring the installed SHS sets. There are no external or private implementing agencies who are present in Bhutan. Turnkey Solar Home System packages were procured by DoE through International competitive bidding (ICB) procedures in accordance with ADB's Procurement Guideline. Bidding was not restricted to any pre-qualified list of bidders.

For Operation and Maintenance (O&M) of SHS sets, various approaches had been used in the past such as – use of District Technicians and Village Women Technicians. However they both had their own set of limitations and did not turn out to be very successful. Studies carried out by various agencies had suggested formation of new energy service companies or creating new energy service concessionaires. However the DoE after much deliberation decided to outsource the Operation & Maintenance services to Bhutan Power Corporation (BPC). The idea was to leverage on the existing resources and institutional strength of BPC, which was also in charge of the on-grid O&M services for households. BPC had established offices called Electricity Service Divisions (ESD) in all dzongkhags of Bhutan. Each ESD had several Customer Service Centers (CSC) in each dzongkhag to provide services to customers remote from the ESD office. Additionally, apart from the customer service staffs present in each CSC, BPC had also recruited and trained village technicians to provide service to on-grid customers in villages far from the CSCs.

In order to assist DoE in providing O&M services for SHS, BPC set up a project coordinator under its Distribution and Customer Service Department to coordinate and manage the SHS O&M services. The DOE and BPC also signed a MoU that stipulated their respective roles and responsibilities for the SHS O&M services. The key features included –

- BPC's contracted village technicians and customer service persons located at Customer Service Centers in rural areas would be directly responsible in maintaining and repairing SHS sets.
- BPC's existing maintenance crews at the CSCs will provide technical backup support to village technicians, with BPC' technicians at ESD offices as the last resort technical support to SHS O&M services.
- DOE would provide necessary training, tools and instruments as well as spare parts so village technicians can carry out SHS O&M services effectively.
- BPC's additional costs (including labor, training, transportation, spare parts, tools, and other incidental expenses) of providing SHS O&M services would be fully reimbursed by the DOE.

Ownership and Financing –

The households were provided with SHSs free of cost. Repairs and maintenance was also provided without any charge. However in order to enhance the feeling of ownership and avoid misusing the systems, the households were required to pay the equivalent of 10% of the cost of the spares in case of spare parts replacement.

ADB allocated a grant amount of $2.41 million for the off-grid solar rural electrification project. The grant proceeds were to be disbursed in accordance with ADB's Loan Disbursement Handbook (2007, as amended from time to time), and detailed arrangements agreed upon between the government and ADB. The grant funds under the Project were mainly for the supply of materials and construction of civil works, through ADB's disbursement procedures including direct payment, commitment, and reimbursement. The government was to bear the administration and overhead costs including staffing, taxes and duties, and part of the social and environmental mitigation costs.

It was also decided that ADB would finance the off-grid rural electrification's operations and maintenance works including spare parts and costs of village technicians contracted with BPC over the initial three years. After that, it would be the responsibility of the government to allocate adequate budgetary allocations to cover the costs required for overall off-grid rural electrification's O&M services. Also all taxes and duties were financed by the government

SHS Installation Status –

As per ADB's project data sheet for "Bhutan: Rural Renewable Energy Development Project", around 984 solar home systems have been installed and 1,132 sets of old solar home systems have been rehabilitated. The original target was to install 1,896 solar home systems in the targeted households[38]. As per ADB, the demand has been less than envisaged due to people's preference for grid connected electricity. 110 Village Electrical Entrepreneur and Electrical Technicians (VEEETs), including 18 women, have been working under supervision of Bhutan Power Corporation (BPC) for operations and maintenance of Solar Home Systems in both remote on-grid and off-grid areas.

[38] ADB, Bhutan: Preparing the Rural Renewable Energy Development Project - Project Data Sheet, 2017

2.3.4. India

Energy Profile – A brief country Energy Profile has been represented in the table below:

Table 11: Energy Profile - India

Parameters	Units	2016
Installed Capacity	MW	310005[39]
Solar Installation	MW	8513[39]
Solar Contribution	percent	2.7
Rural Population	Mn	887*[34]
Total Population	Mn	1324[40]
Grid Connected Electricity Access (Country level)	percent	93
Grid Connected Electricity Access (Rural Level)	percent	65
Solar Irradiance	kWh/m2	4 - 7[41]
Per capita consumption of Electricity	kwh	1075[39]

*As per World Bank – Rural Population is 67% of total population

Country Overview –

Among the SAARC countries India is the largest by size with a total area of around 3.28 million km2. It has a population of over 1.3 billion with more than two -third of the population living in rural areas. Although the overall electricity access has increased in India over the past 2 decades, there is a significant gap in access levels between rural and urban households. Nearly 35 percent of the 125 million Indian rural households have no electricity access and rely on kerosene as primary source of lighting. In terms of urban households around 7 percent are not connected to the grid.

The Indian government has set itself a target to provide electricity to all Indian households by 2019. It has also put a lot of emphasis on increasing the share of renewables, especially solar in the country's energy mix. This is aided by the fact that India has high Solar Irradiance levels ranging from 4-7 Kwh/m²/day and is also blessed with around 300 clear sunny days in the year. In order to leverage on the solar potential and meet its target of electricity for all, the government has been focusing on decentralized solar power systems to provide electricity to households and villages where it is not financially feasible to connect them to the grid. While progress is being made, there is still a huge need and potential for off grid energy market to cater to around 41 million households without electricity access.

Administrative/Coordinating Bodies -

[39] Central Electricity Authority, Executive Summay, December 2016
[40] Worldbank http://data.worldbank.org/country/india
[41] NREL database

In India, Rural electrification falls under the ambit of two ministries, the Ministry of Power (MoP) and the Ministry of New and Renewable Energy (MNRE). Over the years, the Government has initiated a number of programs and schemes to enhance rural electricity access and promote off-grid based systems in India. Majority of the schemes have only had mixed success.

Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) - In March 2005, the MoP launched its flagship scheme for rural electrification, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), to be implemented by Rural Electrification Company (REC). All other existing rural electrification programmes were brought under its ambit. The programme aimed to provide electricity access to all and improve rural electricity infrastructure by 2009. However it failed to fulfil its objectives for 2009, and also failed to provide electricity to individual households. RGGVY is now subsumed with Deen Dayal Upadhayay Gram Jyoti Yojana (DDUGJY).

Remote Village Electrification Programme (RVEP) - In parallel with DDUGJY, MNRE launched the Remote Village Electrification Programme (RVEP) for providing financial support for providing lighting/basic electricity using renewable energy sources. It targeted un-electrified remote census villages, un-electrified hamlets of electrified census villages where grid connectivity was either not feasible or not cost effective & not covered under DDUGJY for grid electrification.

During the 11th Five Year Plan, MNRE set a target for electrification of 7,000 villages and achieved the same in 5,229 villages. Progressively from 2007-08, the coverage under the RVEP declined over the years. No targets were fixed by MNRE for the programme for the 12th plan (2012-13 onwards). Most of the villages and hamlets electrified under RVEP were provided with basic lighting services for six to eight hours a day through solar based individual home lighting systems that included a 37 Watt-peak (Wp) module, two 11 W CFLs and a battery.

Projects under the programme are still being implemented in states by state-notified implementing agencies such as the state nodal agencies for renewable energy, power departments, or the forest departments. The programme however has been afflicted by several problems which have been covered later.

Decentralized Distributed Generation (DDG) scheme – While DDUGVY was responsible for village electrification majorly through grid extension, RVEP was mandated to provide village electrification through RE based off-grid solutions. However, sensing that both programs were far from reaching their targets, MoP launched the DDG scheme in 2009 under the flagship DDUGJY programme. The scheme was envisaged to provide electricity access to the un-electrified villages/habitations where grid connectivity is either not feasible or not cost effective. It aims to deploy suitable locally available technologies, either conventional or renewable such as biomass, biofuels, biogas, Mini hydro, solar etc.

As per the MoP, as on December, 2016, out of 4,604 DDG projects, 2,224 projects are based on standalone systems and balance are mini/micro grids[42]. *In January 2016, Standalone system (roof top) has been introduced under DDG. The standalone system consists of 200 Wp panel, battery, 5 LEDs, Fan, Mobile charger, 25 watt power socket etc. One standalone systems is given to each household (HH). As per the guidelines, standalone systems is provided in the villages/hamlets where the cost of electrification per HH through mini-grid is more*

[42] Standing Committee on Energy(2016-17) – MoP/MNRE - 'Energy Access in India-Review of current Status and Role of Renewable Energy', December 2016

than Rs.1 lakh or the no. of HHs in the villages is less than 15 or the HHs are scattered and the average distance of LT line per HH is more than 200 meters[42].

Off-grid solar application scheme – MNRE launched the Off-Grid Solar PV Programme under the Jawaharlal Nehru National Solar Mission which was launched in 2010. Under the programme, various off-grid/grid-connected and decentralized photo voltaic systems/applications up to a maximum capacity of 500 kWp per site are supported under the programme[42]. This includes solar based mini-grids, solar home lighting systems, solar lanterns, solar water pumps, solar streetlights etc.

The Scheme is implemented through multiple implementing agencies. These agencies enable significant reduction in transaction cost and time, since individuals and small groups of clients are in a position to access the provisions of the scheme. The following categories of implementing agencies are involved in the implementation of the Scheme:

i) State Renewable Energy Development Agencies (State Nodal Agencies)

ii) Financial Institutions/Financial Integrators (e.g. NABARD and Regional Rural Banks, Commercial Banks, IREDA and NHB)

iii) Channel Partners including RESCO

iv) Solar Energy Corporation of India

v) Other Large Govt. Departments/PSUs

Technical details –

India, being a vast country has a wide diversity of consumers. Hence there are a number of different configurations of SHS that are available. Additionally, there are 2 distinct delivery models. The SHSs are either sold through commercial model or through government programs (with subsidies) via government empaneled suppliers.

Commercial model – This is akin to market based sales. Various private enterprises sell SHS to end consumers without any sort of government support. They have the flexibility to customize the SHS configurations based on the individual needs of the end users. Most of these SHS enterprises offer a broad range of products between 10W and over 200W. Additionally each seller have their own after sales service and warranty offerings which is often dependent on the delivery model being followed by them. There are 'sell only' firms who provide no after sale support while there are firms who market themselves as 'servicing company' (e.g. SELCO) and provide after sales service, maintenance as well as warranty. There are also different types of after sales support that is provided such as: maintenance through service centers, replacement of entire products, on-site maintenance with the help of technicians, over the phone service, and linking customers directly with product manufacturers for further assistance. The warranty provided by firms usually range from 1 to 3 years. Outside of the warranty period, several firms also offer customers the option of signing annual maintenance contracts (AMCs) for an additional fixed charge.

Government Programs – These are implemented with the help of government support or subsidies. Over the years several policies and schemes have been introduced which have gone through several iterations. However this has positively resulted in the government gradually taking many steps in the right direction. There are 2 primary schemes for SHS currently - **Off Grid Solar Applications Scheme and Standalone System scheme** under Decentralized Distributed Generation (DDG). To ensure quality product and systems are deployed both the schemes have defined a number of technical specifications and related critical parameters such as:

1) Minimal technical requirement/ standards for each component,

2) Broad performance specifications for each component

3) Various models and configurations of SHS to be deployed

Both the schemes also have a list of empaneled manufacturers/suppliers through which SHS package or components have to be procured. This list is updated from time to time. The ministry has also chosen a list of accredited test centers through which manufacturers have to test their products or components and submit the reports. It is mandatory to follow all procedures in order to be eligible for the subsidy under each scheme. Additionally both the schemes have also defined certain warranty conditions which have to be provided by the manufacturers to the end users. The warranty for the Solar Home Lighting System is for a period of 5 years from the date of supply. An Operation, Instruction and Maintenance Manual, in English and the local language, is also mandated to be provided with the Solar Home Lighting System.

Implementation and Delivery –

There are multiple SHS enterprises operating in India ranging from large and established players to small enterprises who have deeper rural connect. As a result there are a number of different business models that have been adopted by these players. The business model adopted is dependent on where the enterprise is positioned in the SHS value chain which can be divided into four major parts – Manufacturers, Assemblers, Distributors and Retailers.

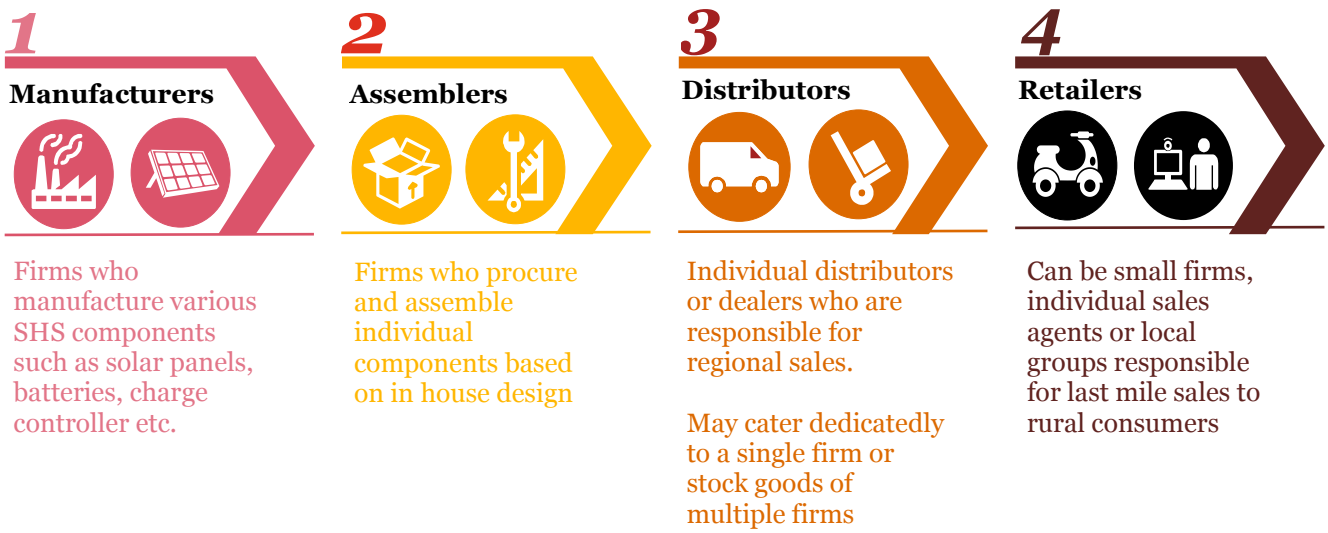


Figure 10: SHS Value Chain - India

Manufacturers – These are firms who have adequate production facility and expertise to manufacture individual components of a Solar Home System. Hence it usually comprises of large established players or subsidiaries of large companies and account for a bulk of the SHS sales. In order to participate in government tenders, they have to get themselves empaneled.

Assemblers – These are relatively smaller firms who possess product design capability. They procure components from manufacturers and assemble them based on in house designs. Often these firms are also responsible for the initial installation of the SHS.

Distributors – They have network of third party channels to cater to rural markets. Many manufacturing or assembling firms have their own proprietary distributor-dealer networks who dedicatedly cater to the firm's products. There are also dealers who stock products of multiple companies. They are generally regional players. Often these firms are also responsible for the after sales service.

Retailers – Small firms, NGOs or local groups that have deep rural reach through small outlets and provide last mile connectivity to rural households. They also consist of commissioned sales agents and local entrepreneurs and try to capitalize on greater trust that end users have on them.

Most SHS players in India do a combination of assembly and distribution. They buy components from manufacturers, assemble them based on in-house designs, and then distribute systems to channel partners who can sell them to the final customer.

The business model of the players is also dependent on the mode of delivery. As described earlier, SHS can either be sold via the commercial model or through government programs. Most of the medium and large players who have the expertise to get empaneled and the experience of navigating the large amounts of paperwork and

bureaucracy necessary for winning tenders and sell their products through both the delivery models. While the business model for the government program is very standardized, there are a number of different mechanisms that players employ to get their product to the end user during commercial sales.

Some of the commonly employed business models are described below -:

Table 12: Various business models for SHS distribution followed in India

Classification	Type	Description	Examples
Based on Distribution model	**In house channels**	Selling via network of proprietary franchises or trade channels. All personal are directly employed by the company. They are also responsible for installation and after sales service. Usually employed by large players.	Tata Solar, Orb Energy
	Village Level Entrepreneur (VLE)	Selling via Village Level Entrepreneurs who act as a touch point between the firm and the customer. The VLE chosen are typically well known individuals in the target community. They earn commission on every sale they make. Depending on the extent of investment required from the VLE, various types of models are used.	Greenlight Planet, Frontier Markets, Dharma Life, Sakhi Retail
	Multi-Channel	Selling via leveraging multiple existing retail channels such as – Use of Common Service centers (CSC) set up by government, Use of Post and telegraph department, use of cooking gas channel of HPCL or BPCL, use of general purpose consumer product distributors	d.light Design
Based on type of sale	**Only selling product**	Firms which only sell the product without taking direct responsibility of after sales service. For any maintenance or service post purchase, the customers have to take the product to authorized service centre which may be catering to multiple villages.	Government authorized retailers - "Akshay Urja" shops, Chinese firms
	Selling and providing service	Firms which take responsibility of after sales support and service. They have their own trained technicians who go to the customer's home for repair and maintenance.	SELCO, Onergy

Ownership and Financing –

Due to high upfront costs the initial adoption of Solar Home Systems in India relied heavily on traditional end user financing in the form of government supported subsidies. However, over time, innovations in technology have led to decline or small increase in prices of SHS while the propensity and ability to pay of the rural population in India has increased. This coupled with greater awareness have led various firms to come up with innovative finance models to successfully sell more of their products.

Government subsidies can be availed through two different schemes mentioned earlier - Decentralized Distributed Generation (DDG) scheme and Off-grid solar application scheme.

DDG Scheme – Under this scheme subsidy up to 60 percent of the system cost is available. For special category states, it amounts to 85 percent. An additional subsidy of 15 percent (5 percent for special category states) is applicable subject to timely completion of DDG projects. The balance amount can be arranged by the State Govt. / Implementing Agency through Loan/Equity. To help the States, and bring uniformity, detailed standard bidding document has been prepared and shared with the States.

Off-grid solar application scheme – This scheme is applicable only for individuals, Self Help Groups (SHGs), Joint Liability Groups (JLGs) and Non-Governmental Organizations (NGOs) who can avail subsidy under the scheme. 40 percent of the cost related to SHS is subsidized and the remaining 60 percent of the cost is eligible for a soft loan through a registered bank. The loan has to be repaid over a five-year period. During those five years, the supplier of the technology (who is authorized by the government) is required to provide after-sales support and maintenance service to the customer. The steps to apply for the subsidy are as follows –

1) The customer should open an account with a registered commercial or regional bank;
2) He should then select and approach a registered vendor of SHS and agree to purchase a product;
3) All documents have to be then submitted to the bank;
4) The bank will verify all documents and do a site survey to the home of the customer;
5) The bank will then submit the documentation to NABARD for release of the subsidy to the bank;
6) NABARD will then release the subsidy to bank;
7) Once the subsidy is released, the bank will approve the loan and the customer will receive the product from the vendor

MNRE, GoI, has advised stoppage of subsidy of solar schemes routed through NABARD with effect from 15 March 2017

The process of availing government subsidy is long and cumbersome. There have also been cases of significant delays in releasing of subsidy. This has prompted a number of SHS enterprises to not rely on government subsidy mechanism, but conduct business through direct sales or rely on developmental funds, disaster relief funds, corporate social responsibility (CSR) or grant funding.

Another aspect is with respect to providing financing to consumers for purchasing products. There are certain firms which do not provide any financing help while there are others (like Onergy, BOOND) who facilitate and offer a mix of financing options from micro-finance institutions (MFIs), self-help groups (SHGs), and regional rural banks (RRB). These financial institutions provide credit to the consumers with down payment of generally 20 percent while the repayment period usually ranges from 3 to 5 years. A tripartite agreement is signed between the financial institution, the supplying firm and the consumers. The supplier of the system is responsible for the maintenance and after sales support to be provided to the consumer.

Additionally, over the years firms have also come up with different business models with respect to financing. Some of these include –

Table 13: Various SHS financing models followed in India

Type	Description	Examples
Full Payment – Complete Ownership	No financing help provided by firm. Consumers have to purchase the SHS either through entire cash payment or a mixture of cash and debt which he may avail from any financial institution. Entire ownership of the system is passed to consumer automatically on payment.	Tata Solar, Orb Energy, Greenlight Planet
Rental model	The SHS is given on rent to the consumers who have to pay weekly or monthly fee to the company or VLE. Since the payments to be made are small no financing help is required. Ownership of the product stays with the company and is never passed to the consumer.	Sahjeevan
Pay-as-you-go	The company utilizes mobile payments and pre-paid metering technology. Post a small down payment for installation, the consumers have to buy energy services which they hope to consume by pre paying through mobiles. In some cases such as that of Simpa Networks, each of these payments made by the consumer acts as contribution towards eventual ownership of asset. They market it as 'pay to own' model	Simpanetworks, OMC Power

SHS Installation Status –

As per data available in the MNRE Strategic Plan 2011-17, there were only around 0.61 million Solar Home Lighting Systems installed in India as of December, 2010[43]. The plan had envisaged an ambitious target of covering 20 million rural households with solar lights by 2022. This included both coverage under the Remote Village Electrification Programme as well as through loans given by banks. However as per MNRE National Solar Mission Annual Report 2016-17, the total number of Solar Home Lighting systems installed in India is 1.39 million as of December 2016.

[43] Strategic Plan for New and Renewable Energy Sector for the period 2011-17, MNRE

2.3.5. Maldives

Energy Profile – A brief country Energy Profile has been represented in the table below:

Table 14: Energy Profile – Maldives

Parameter	Unit	2016
Installed Capacity	MW	330
Solar Installation	MW	4.08
Solar Contribution	percent	1.2
Rural Population	Mn	0.21*[34]
Total Population	Mn	0.48[44]
Grid Connected Electricity Access (Country level)	percent	100[45]
Grid Connected Electricity Access (Rural Level)	percent	100
Solar Irradiance	kWh/m2	5.2
Per capita consumption of Electricity	kwh	1147.9

* As per World Bank – Rural Population is 53% of total population

Country Overview –

The Maldives consists of over 1,190 islands, with a land area of approximately 224 sq.km. Only 188 of these islands are inhabited, with majority of the population being concentrated in few of the larger islands. Malé, the capital, is home to 39% of the country's total population, and only 19 other islands have populations exceeding 2,000 people. As per ADB, the Government of Maldives has been encouraging the population living in the outer atolls to relocate to the Greater Male' Region to mitigate the pressure on the public sector budget in order to promote more efficient public expenditure on economic and social services. The government is targeting about 70% of the total population to reside in the Greater Male' Region and has asked ADB to focus its assistance towards developing the region.

Energy Overview –

Maldives relies almost entirely on imported fossil fuel to meet its energy demands. In 2015, 506,334 metric ton of fuel was imported, with diesel contributing 77 percent of the import[46]. The major uses of fossil fuel are for transport and electricity generation. As per the Ministry of Environment and Energy of Maldives, electricity generation for the capital Male' and the islands in its vicinity (collectively called as greater Male' region) accounts for approximately 63% of the total electricity consumed in all inhabited islands in the country.

[44] Basic Statistics 2017, Asian Development Bank
[45] Energy Access Database, World Energy Outlook 2016
[46] Ministry of Environment and Energy, Maldives Energy policy & Strategy, 2016

Imports of fossil fuels currently cost the Maldives more than 20 percent of its GDP each year[47]. Hence reducing the economic, social and environmental implications of high fossil fuel dependence is a top priority of the Maldives Government. The government is working towards increasing the use of renewables as a means to achieve energy security. Hence increasing the share of Renewable energy in the National Energy mix is a key objective of the Maldives Energy Policy and Strategy document. Maldives is also a participating nation in the Scaling-Up Renewable Energy Program (SREP) through which it is able to tap into significant grant and concessional financing from World Bank and ADB to support its renewable energy development agenda.

The World Bank is supporting Maldives through the Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE) program which seeks to create project structures/design conducive for private sector participation. The program is concentrated in the Greater Male region and plans to install between 20-35 megawatts (MW) of solar photovoltaic based generation. ADB is supporting the government through Preparing Outer Islands for Sustainable Energy Development (POISED) program which plans to tap solar power and install solar-diesel hybrid grids on outer islands. It has a target of installing about 21 MW of capacity. Most of the renewable projects have been concentrating on solar, as among all other forms of renewable energy available to the Maldives, solar is the most promising with the country receiving a solar irradiation intensity of average 5.2 kWh/m2/day for most days of the year.

Maldives achieved universal access of electricity in 2008. All inhabited, commercial and tourist resort islands of Maldives have a 24-hour electricity service. Due to the dispersed nature of the islands, it does not have one single national grid. However, each island has its own electricity generation and distribution facility. Due to this none of the solar projects have concentrated on facilitating solar generation through standalone systems. Since all households present in the island are connected to the distribution grid present in that island, all solar projects have been looking to install either centralized solar PV plants or rooftop solar PV depending on space limitations. Even from an economic perspective, given a choice, it is always more cost effective to generate and distribute electricity from centralized production rather than localized production. **Hence in the case of Maldives, setting up solar home systems does not make business sense.**

[47] World Bank, Maldives Country Snapshot

2.3.6. Nepal

Energy Profile – A brief country Energy Profile has been represented in the table below:

Table 15: Energy Profile - Nepal

Parameters	Units	2016
Installed Capacity	MW	855.9[48]
Solar Installation	MW	18.4[49]
Solar Contribution	percent	2.4
Rural Population	Mn	23.4*[34]
Total Population	Mn	28.9[12]
Grid Connected Electricity Access (Country level)	percent	76[1]
Grid Connected Electricity Access (Rural Level)	percent	72[1]
Solar Irradiance	kWh/m2	3.6-6.2
Per capita consumption of Electricity	kwh	129.6[48]

*As per World Bank – Rural Population is 81% of total population

Country Overview –

Nepal has a total population of 28.9 million with rural population accounting for 23.4 million. Over 80% of the population of Nepal lives in rural areas that lack access to Nepal's national grid. Kerosene is the primary source of lighting for these off-grid households (almost 65-70%). Decentralized renewable energy solutions like solar PV etc. have numerous advantages for the local rural population of Nepal residing in areas where the national grid is not accessible.

Nepal receives ample solar radiation with average value or irradiance varying from 3.6–6.2 kWh/m2/day, and the sun shines for about 300 days a year. With national average sunshine hours of 6.8/day and solar insolation intensity of about 4.7 kWh/m2/day, there is huge potential for solar PV as well as solar thermal devices such as solar PV home system, solar PV pumping, solar water heaters, solar dryers, and solar cookers.

Administrative/Coordinating Bodies –

Majority of the SHS installed in Nepal are through the AEPC program.

The SHS market in Nepal is heavily dependent on the government's subsidy program. This program is overseen by the nodal organization for renewable energy promotion in the country, the Alternative Energy Promotion Centre (AEPC). It is estimated that SHS installations through the AEPC program constitute approximately 75-80% of the overall installations. More than 500,000 units of solar home systems are used throughout Nepal.

[48] CIA, The World Factbook : Nepal
[49] World Bank, Renewable Energy Capacity Needs Assessment – Nepal, September 2016

There has also been a sharp rise in the number of suppliers from 3 to 70 within the same timeframe (2001 – 2012)[50].

AEPC supports the solar off-grid lighting market through its SSP component. AEPC administers the Solar Energy Support Program (SSP) which is the nodal program for the promotion of off-grid lighting. The role of SSP entails setting the technical standards for SHS, qualifying the suppliers, approving the subsidies and monitoring the program implementation.

The Nepal Photovoltaic Quality Assurance (NEPQA) was developed and adopted by AEPC in December 2000 for dissemination of SHS and further revised in Nov 2002/ Sep 2005/ July 2009/ 2013 and 2015. NEPQA specifies the documents and technical requirements of the components used in PV applications. The AEPC produced a basic system sizing guideline for Small Solar Home System (SSHS) (10Wp) and SHS (20W and 50Wp). Based on NEPQA, the Renewable Energy Test Station (RETS) tests and certifies the quality of the PV systems and components used in PV applications – the Product Introduction Test (PIT) and Random Sampling Test (RST).

In addition to the subsidy programs, AEPC has adopted several measures to promote the market for quality solar off-grid lighting.

- ***Ensuring product quality:*** All companies which are supplying SHS through AEPC have to adhere to the Nepal Photovoltaic Quality Assurance (NEPQA) standards. The standards are specified for all the product components such as solar panel, battery, lamps, charge controllers, mounting structure for panels, cables, switches, sockets and protections. Standards are classified into 2 types: *mandatory & recommended.*
- Around 62 companies have been authenticated / certified by the AEPC to supply through the subsidy program. Almost 500 branches, offices, dealers and agents are affiliated to these companies. The companies which are interested to sell their products need to get certified through AEPC. This authentication is kind of a confirmation that the company's product meets the bare minimum mandatory standards tested by Renewable Energy Test Station (RETS), (testing center mandated by the government).
- ***Creation and training of skilled manpower:*** AEPC invests in giving training for the technicians who are involved in installations and after sales service. These trained people are absorbed by the private companies for any installation and servicing activity.
- ***Close program monitoring:*** AEPC makes sure that it conducts field visits to monitor and verify the SHS installations. Quality of installation, performance of SHS, consumer satisfaction, degree of consumer awareness, after sales service and user benefits from SHS are some of the criteria's against which the suppliers are evaluated.
- 10% of the subsidy amount is always retained to make sure that there is no issue with the after sales service. After the evaluation, companies are graded into different categories according to their performance. On the basis of these grades companies are even disqualified / penalized for non-compliance to quality issues.

[50] IFC, Lighting Asia: Solar Off-Grid Lighting, February 2012

- ***Marketing and promotion:*** The SSP is propagated on radio and TV. Various promotional booklets and materials on SHS, SSP and Tukis have been developed by APEC.

Technical details –

The Nepalese market for solar off-grid lighting is dominated by SHS. The market has a unique product that is known as "Solar Tuki" which is a Small SHS (SSHS).

Table 16: SHS configuration - Nepal

Solar Technology	Configuration
Small Solar Home Systems	10 – 20 Wp
Solar Home Systems	>20 Wp

Solar Tuki or a SSHS in Nepal is typically configured with a 3 Wp to 5 Wp solar panel, two LED lamps that use Nickel Metal Hydride rechargeable batteries. The lamp unit also has an outlet for connecting a FM/AM radio. Tukis are priced in the range of USD 50 to 70 and come with a one-year warranty[50].

20Wp SHS account for 80% of SHS sales. A 20Wp solar home system, which can light three 5 W tube lights, is the most dominant model sold in the market. This system is typically sold for USD 220 and is targeted at the low-income segment. In terms of technology aspects of product components, SHS in Nepal use LFL products sold in rural areas. SHS are typically offered with a warranty of five years on battery and ten years on the panel.

Implementation and Delivery –

One of the major implementing agencies in the country is Solar Electric Manufacturers Association Nepal (SEMAN). This body is a non-governmental, non-profit making, non-political professional business association. SEMAN is committed to fulfilling all the problems of the solar company as well as the entire solar sector through cordial interactions with the AEPC/NRREP. It also works as an umbrella organization to protect, develop and professional rise & duties of all the Solar PV Companies. It also promotes towards the development of pool of technical manpower of different levels through organizing seminars, exhibitions, workshop programs.

Apart from SEMAN other important bodies involved in the implementation of SHS are Empower Generation and Winrock International. *Empower Generation* is a small non-profit organization that consists of a network of 12 micro-enterprises run by 20 women entrepreneurs across 10 districts of Nepal. *Winrock International* with support of UNEP Climate Finance Innovation Facility (CFIF) is engaged to extend the reach of SHS in rural Nepal through credit financing.

The main objectives of the above mentioned programs has been to create necessary awareness amongst the local people about solar off- grid lighting, to spread information on UNDP/GEF Small grants program, to provide microfinance and to purchase solar tukis. These programs also intend to mobilize technical manpower at the local level.

Winrock International in support of UNEP Climate Finance Innovation Facility (CFIF) is engaged to extend the reach of SHS in rural Nepal through credit financing.

The Center for Renewable energy (CRE), Global Environment Fund (GEF), the United Nations Development program's (UNDP) Small Grants Program, Clean Energy Industry, Home Employment Lighting Program are some of the organizations that have promoted SHS in Nepal.

Ownership and Financing –

Up to 60% of the system cost is covered by subsidy based on wattage and location.

The higher the panel wattage, and the more remote the location of the household, the higher the subsidy provided. Subsidies range from USD 67 to 134 depending on the remoteness of the location of the households as defined by APEC, and the system wattage.

Subsidy structure of APEC[51]:

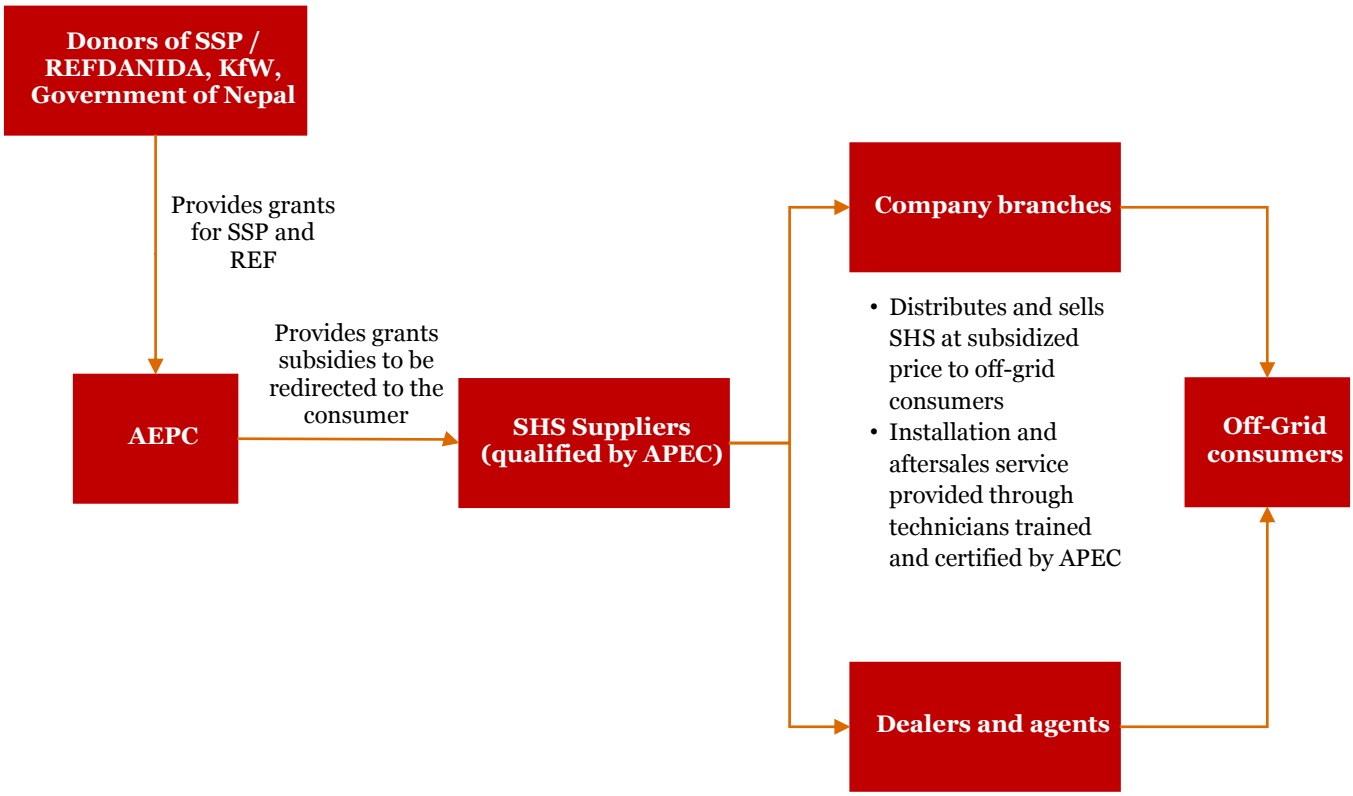


Figure 11: SHS subsidy structure - Nepal

DANIDA (Danish International Development Agency) is the funding agency of the Government of Denmark; KfW is the funding agency of the government of Germany

[51] AEPC Nepal, Renewable Energy Subsidy Policy & Subsidy Delivery Mechanism of Nepal

For a 20 Wp system priced at approximately USD 220, the subsidy is 30-60% of the price, depending on the remoteness of the location. The total subsidy amount disbursed by AEPC up to September 2010 was in the range of USD 20-25 million.

SHS sales are capped by the available subsidy funding. SHS sales depend heavily on the subsidy which is provided by the donors. In Figure 12, one can see that the sales dropped in 2006. This happened because the subsidies were withdrawn in that particular year since all the donor funds were exhausted.

Solar Tukis have been recently included in the subsidy program (since 2008). This subsidy support is limited to tukis model which have a minimum capacity of 5 Wp with amount of subsidy being uniform USD 27 across locations. The 5 Wp tukis are priced around USD 70 hence the subsidy is around 40% of the cost.

The GoN also provides a fiscal incentive to private solar companies by waiving VAT and import duties (1 percent) on components imported for manufacturing and assembling the SHSs locally, which reduces the price of the system by almost 30 percent (IFC study 2014, unpublished).

According to the ***Renewable Energy Subsidy Policy, 2073 BS*** the following subsidy is being given to the Solar PV Home systems.[52]

Table 17: SHS subsidy - Nepal

Subsidy category	***Category 'A' region***	***Category 'B' region***	***Category 'C' region***
10 - 20 Wp Small SHS (per HH per system)	***5,000***	***4,800***	***4,500***
50 or more than 50 Wp SHS (per HH per system)	***10,000***	***9,000***	***8,000***

(amounts are in Nepal Rs)

There is also a Special subsidy arrangement for earthquake affected areas.[52]

- Maximum subsidy amount of up to Rs. 8,000 per household but not exceeding 75% of the total costs for 20 Wp solar home systems, up to Rs. 10,000 per household but not exceeding 70% of the total costs for 21-40 Wp solar home systems will be provided.
- However, technology installment of 10 Wp solar home systems and metallic improved cook stoves will be done on a competitive low cost basis by private companies through reverse auction.

[52] GoN- Ministry of Population and Environment, Renewable Energy Subsidy Policy, 2073 BS

SHS Installations Status:

The adjacent figure shows the solar home systems installed by AEPC between 2001 and 2010. As per a recent report supported by The World Bank and conducted for The Alternative Energy Promotion Centre, as of July 2016, the total number of solar household systems installed in Nepal is *606,730* resulting in a total installed capacity of 14,624 kWp[49].

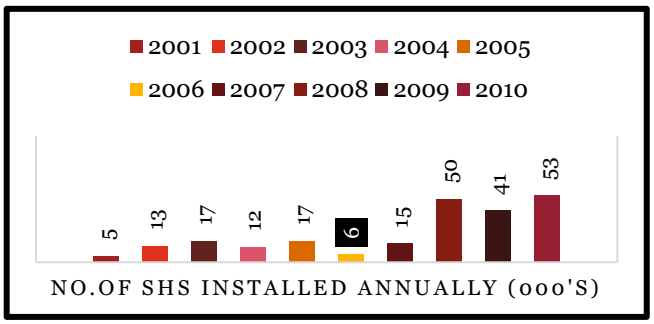


Figure 12: Annual SHS Installations through APEC

A total of *53,733* number of small solar household systems have been installed till July 2016, resulting in a total installed capacity of 537.3 kWp. Additionally, another 148,800 systems are in the final stage of installation[49].

2.3.7. Pakistan

Energy Profile – A brief country Energy Profile has been represented in the table below

Table 18: Energy Profile - Pakistan

Parameter	Unit	2016
Installed Capacity	MW	23,718[53]
Solar Installation	MW	100
Solar Contribution	percent	0%
Rural Population	Mn	120.6
Total Population	Mn	195.4[53]
Grid Connected Electricity Access (Country level)	percent	73[1]
Grid Connected Electricity Access (Rural Level)	percent	61[1]
Solar Irradiance	kWh/m2	5.3
Per capita consumption of Electricity	kwh	521.8[53]

Country Overview –

Pakistan is a federal parliamentary republic with four provinces. It is the 6th most populous country with a population of around 195 million which covers approximately 11 million households. Approximately 27% of the households are off-grid with 61% reside in rural areas. A World Bank survey which focused on the changing patterns of household expenditure on energy indicates that 30-45% of rural households in Pakistan use kerosene as a primary or secondary source of lighting. [54] The study also indicates that 80-90% of kerosene users in rural Pakistan are off-grid. As kerosene is not a major cooking fuel in Pakistan, it is safe to assume that this usage of kerosene is used to meet lighting needs. It has also been observed that candles are an important source of lighting due to the high cost of kerosene.

Pakistan covers an area of 796,096 sq. km lying in a sunny belt having a high level of insolation and adequate hours of sunshine. This energy source is distributed widely and available abundantly in the country. Pakistan receives solar insolation over more than 95% of its area.[55] The sunny days in Pakistan ranges from 185 to 290 in a year as evident from historical data.

The efforts of various administrative bodies and agencies in implementing solar household systems has received mixed response. In some areas like Tharparkar district the SHS implementation has been a success but in some other areas success has been minimal.

[53] GoP - Ministry of Finance, Pakistan Economic Survey, 2016-17
[54] World Bank, Changing Patterns of Household Expenditures on Energy - A case study for Indonesia and Pakistan, 2009
[55] Abdullah,Deyi Zhou,Tariq Shah,Khalil Jebran,Sajjad Ali,Asad Ali,Asad Ali, Acceptance and willingness to pay for solar home system: Survey evidence from northern area of Pakistan

Administrative/Coordinating Bodies -

The Government of Pakistan (GOP) formulated the Policy for Development of Renewable Energy in 2006 with an aim to promote and facilitate private investment in RE for power sector development in the country. The policy also set out the key regulatory agencies who would be responsible for RE development.[56]

Alternate Energy Development Board (AEDB), which was set up in 2003, is a government body which is dedicated to the promotion of renewable energy in Pakistan. It is the sole representing agency of the Federal Government with the main objective to facilitate, promote and encourage development of Renewable Energy in Pakistan and with a mission to introduce Alternative and Renewable Energies (AREs) at an accelerated rate. The administrative control of AEDB was transferred to Ministry of Water and Power in 2006.

Under Roshan Pakistan Program and Parliamentarian Schemes for Rural Electrification under AEDB, more than 8,000 villages are going to be electrified through renewable energy technologies. A big share out of which is expected to be done through solar home systems.[57]

The individual provincial governments support the development of renewable energy projects within their geographical jurisdiction either on their own or in collaboration with the AEDB. The provinces have also established their own dedicated provincial departments for promoting and encouraging private sector investment in RE sector. These provincial departments are responsible for harnessing RE resources, preparing RE policy, addressing issues/matters at provincial level, facilitating local and foreign investors, promotion and implementation of RE projects in their relevant province.[58]

Pakistan also has a dedicated institution, Pakistan Council of Renewable Energy Technologies (PCRET), which is responsible for coordinating R&D and promotional activities in different renewable energy technologies. The council has been actively working in the field of Photovoltaic, Solar thermal, Biogas, Wind and Micro-hydel technologies while also conducting renewable energy training workshops for the general public and offering testing and certification services. The council has its head office in Islamabad and regional offices in four provincial capitals. It also has close interaction and working relationship with NGOs, Provincial Agriculture & Social Welfares departments, Local Government & Rural development offices and other organizations working for the socio-economic development of the rural and semi urban areas of the country.[59]

The Pakistan Poverty Alleviation Fund (PPAF) is a fund dedicated to poverty alleviation and functions under the Ministry of Finance. The fund works with Partner Organizations (POs) and community institutions providing financing through both grants and loans. PPAF has established an independent Renewable Energy (RE) Unit, and is implementing a KfW supported Hydro and Renewable Energy Project which is involved in the development of indigenous renewable energy resources (small scale hydropower, solar, wind and biomass) to generate electricity locally to off grid communities. The RE Unit was also successful in designing four solar PV mini grid

[56] IFC, Solar Developers Guide
[57] AEDB, Solar Energy Applications viable in Pakistan
[58] SAARC, Assess RE Developments and policies in SAARC region
[59] Pakistan Council of Renewable Energy Technologies (PCRET) website

projects that have been completed in coastal areas of Sindh. Various Solar PV Projects have also been initiated in the Khyber Pukhunkhwa Province of Pakistan.[60]

Technical details –

With respect to technology, lead acid batteries are dominant in the market. Both CFL's and LED's are used for lamps. SHS components are entirely imported, but SHS are assembled in Pakistan. Almost all the equipment manufacturers depend on imports (product components) to assemble the products locally. The solar panels are mainly bought from Japan, China, Austria, UAE and Germany whereas the LED's are imported from China. As far as batteries are concerned they are bought from China and procured locally also. Some manufacturers have questioned the quality of the local made batteries and prefer to import the same from China.

As per an IFC report on Solar Off-Grid Lighting published in 2012, the 20Wp and 50Wp SHS have been the most commonly sold configurations in the rural areas. The recent global trend of declining solar component prices have led to reduction in SHS prices in the past 2 years. While there are no official figures present, a basic SHS in Pakistan is available in the range of USD 90 to USD 110[61]. The decline in prices have also increased the affordability of the systems leading to increasing usage of 80 Wp to 120 Wp SHS. **Implementation and Delivery –**

Although the country has the presence of Alternate Energy Development Board (AEDB), as of now there hasn't been any national level program by the government to promote the usage of Solar Household Systems. AEDB is the government body which is dedicated to the promotion of renewable energy in Pakistan.

AEDB had launched a project in 2005 to propagate and distribute SHS in rural locations. The agenda of this pilot project was to disperse these solar household systems free of charge and later collect fees for the after sales support. This after sales support would be provided through a trained representative of a particular village. This pilot engagement was deemed to be implemented in 68 villages[50].The pilot project envisaged to distribute approximately 15,000 SHSs. The project did not meet its above mentioned goals since only 3,000 SHSs were distributed. Some of the reasons cited for the failure of the engagement were:

- Lack of adequate funds
- Poor planning with respect to after sales service and subsequent fee collections. The systems were not maintained properly since there was no ownership by the users. It was assumed that the users would pay the after sales service charges but AEDB on account of its inexperience did not envisage that the users would default, and thus, faced many roadblocks in the fee collection process. AEDB performance in providing after sales support has also left a bad image of the governing body.
- The government has not given sufficient powers to AEDB. This is also a probable reason as to why the implementation of SHS failed.

[60] Pakistan Poverty Alleviation Fund (PPAF) Annual Report, 2016
[61] IFC – Lighting Asia, Pakistan Off-Grid Lighting Consumer Perceptions

Another project implemented by AEDB in 2008 experienced a lot of success. This project was implemented in the Tharparker district of Pakistan. The project scope was to install 3000 Solar Home Systems in Tahrparkar district villages of Chachro, Mithi, Diplo and Nagarparker. 3 levels of wattages were offered to the users, namely 120 Watts, 80 Watts and 40 Watts. Five people from each village were trained to do the regular maintenance and operations of the entire system. The suppliers/ installers of the SHS provided free maintenance service and guaranteed the satisfactory operation of the system for one year. Some of the high impacts of this successful project was:

- Providing solar energy to 3000 families would save 216 liters of kerosene and nearly 30000 candles every year.
- The installation of the system was free for the locals. They had to pay a small monthly fee (rupees 200) for system maintenance

Pakistan Solar Power and Solarwell (SHS implementing agencies) have also tried to use their existing distribution model in the agriculture sector to cater to this off-grid SHS market.

Apart from the above programs, IFC launched a Lighting Asia – Pakistan program in 2015, aimed at increasing access to clean affordable energy in households underserved by the electricity grid in Pakistan. The program works to remove market entry barriers, provide market intelligence, foster B2B linkages and raise consumer awareness on modern solar lighting products and systems.

- **Quality assurance:** IFC arranges product testing and quality verification for manufacturers who are interested in joining the Lighting Pakistan program. This quality assurance makes it easier for distributors and consumers to differentiate between poor-quality and high-quality products. The QA framework and test methods have been institutionalized through, and are now based on, IEC/TS 62257-9-5, Edition 2.0, a technical specification published by the International Electrotechnical Commission. Lighting Global maintains a set of minimum quality standards which off-grid lighting products must meet in order to access program services.

- **Market Intelligence:** Throughout the life of the program, IFC would offer market intelligence reports regarding solar devices. One such report, called Pakistan Off-Grid Lighting Consumer Perceptions Study 2015, involving 6,000 households has already been released. The study provides insights about local market size and segmentation, consumer awareness, attitudes towards off-grid lighting, and price points.

- **Business to Business Connections:** IFC makes direct connections between quality-verified manufacturers and local distributors, as well as microfinance institutions. The purpose of these direct connections is to lower market entry costs for manufacturers and assist distributors in developing a viable off-grid lighting sector. Currently, several such connections have been formalized.

- **Consumer Awareness:** Lighting Pakistan works to develop confidence in the benefits of off-grid solar products by showing consumers how to identify and buy quality-verified products. An extensive consumer awareness campaign to that end is being designed.

Ownership and Financing –

Small scale projects are underway to provide consumer financing for SHS. The GIZ along with Tameer Bank (now known as Telenor Bank) envisaged a pilot project to promote SHS. This promotion would be on the basis of micro – credit. This pilot project had a targeted installation of 20,000 SHS in the first 2 years. Tameer bank is believed to use its existing customer touchpoints for the implementation of this project.

The project will offer a range of different products ranging from 30 Wp to 90 Wp. For the 30 Wp product, the target customer group will be households. Some of the features that will be offered to the customer are[50]:

- 35% per annum would be the interest rate on the SHS loan
- Loan period will be 3 years

The operating model is very similar to the IDCOL program in Bangladesh (both financing and the supply of SHS have been undertaken by the same company).

SHS Installations Status -

Data is not available for the total number of SHS installed in Pakistan.

2.3.8. Sri Lanka

Energy Profile – A brief country Energy Profile has been represented in the table below

Table 19: Energy Profile - Sri Lanka

Parameter	Unit	2016
Installed Capacity	MW	3887[62]
Solar Installation	MW	1.2
Solar Contribution	percent	0.03
Rural Population	Mn	17.3*[34]
Total Population	Mn	21.1[12]
Grid Connected Electricity Access (Country level)	percent	99[1]
Grid Connected Electricity Access (Rural Level)	percent	98[1]
Solar Irradiance	kWh/m2	3.5-4.5*
Per capita consumption of Electricity	kwh	677.7[62]

* As per World Bank – Rural Population is 82% of total population

Country Overview –

Sri Lanka is situated in South Asia. It is an island in the Indian Ocean covering close to 65,410 sq km and with a total estimated population of 21.1 million. The population is primarily concentrated within a broad wet zone in the southwest, urban centers along the eastern coast, and on the Jaffna Peninsula in the north. Rural people dominate Sri Lanka's population with almost 82% people living in the rural areas. By 2015, almost 98% of the total rural population had access to electricity. Sri Lanka considers SHS also as a means of electrification.

Sri Lanka is blessed with an impressive solar energy resource as it is located near the equator. Two thirds of the country's lowland area receives a radiation of 4-5.5 kWh/m2 per day, whilst the remaining area in the central hills receives a lower radiation of 2-3.5 kWh/m2 per day, due to persistent cloud cover in those areas. Complete electrification target using the National Grid (NG) is a noble idea but economically not viable in a country like Sri Lanka with scattered households. Therefore, Solar Home Systems have been used to help the rural community in the country, not connected to the NG.

Administrative/Coordinating Bodies -

The Sri Lanka Sustainable Energy Authority (SLSEA) is the primary body responsible for the issuance of licenses for sustainable energy developments in Sri Lanka. In addition to being the key license provider, it is also in charge of promoting renewable energy and sustainable developments in the country.

[62] Public Utilities Commission of Sri Lanka, Generation Performance in Sri Lanka, 2016

The Sustainable Energy Authority has a *Renewable Energy Services "Off grid for Rural" Programme*. Objectives of the programme is to electrify households away from the national grid using off grid solar system and off-grid mini grid solutions by 2017. Solar Home Systems has been considered as a *viable technology under this scheme*.

SLSEA will assist Provincial Councils in consultation with related Divisional Secretariat offices to uplift the rural electrification schemes in their territories. Financial assistance will be provided from SLSEA.

According to a survey done by SEA in 2010 a total of ***106,000 solar home systems*** were lighting up the rural homes. They also felt during the survey that off-grid electrification seemed to be a matter of declining interest. Some of the other findings during the survey was:[63]

Table 20: Household survey conducted by SEA - Sri Lanka

	Households	Sources of Info
Total households without electricity	684,000	SEA survey end of 2010
Suitable households for *Viduli Athwela**		SEA survey end of 2010
Total households without access to electricity	270,000	SEA survey end of 2010
Households earmarked for RE projects	240,000	CEB indication
Households left for off – grid	30,000	SEA survey end of 2010
Households left for off – grid	37,814	CEB, 2010
Households left for off – grid (approx.)	***40,000***	

*Vidula Athwela is a programme which seeks to provide financial assistance to low-income families in order to obtain initial electricity connections from the national grid.

Technical details –

Solar Home Systems sold in Sri Lanka are usually in the range of ***30 W-60 W***. The solar companies registered under the World Bank projects were selling Solar Home systems to the off-grid customers. Providing after sales services was also a responsibility of the solar company.

Implementation and Delivery –

With a view to meet the electricity needs of the off-grid population, the World Bank and Global Environment Facility (GEF) have co-funded two sequential projects, the Energy Services Delivery Project (ESDP), and the Renewable Energy for Rural Economic Development Project (REREDP).

The Energy Services Delivery Project

The Energy Services Delivery Project (ESDP) was a five-year long, $55.3 million project. The Project financing included a US$24.2 million line of credit from the IDA, and a $5.9 million grant from the GEF. The project's stated objectives were to:

[63] Sri Lanka Sustainable Energy Authority, Solar Energy Development in Sri Lanka, 2011

- "Promote the provisions by the private sector, NGOs and cooperatives of grid-connected and off-grid energy services using environmentally sustainable renewable energy technologies;
- Strengthen the environment for Demand Side Management (DSM) implementation; and
- Improve public and private sector performance to deliver energy services through renewable energy and DSM."

This project ended in December 2002, and according to an independent evaluation of the project, "the Sri Lanka Energy Services Delivery (ESD) Project, a uniquely designed and implemented project, can serve as an excellent model for other rural electrification initiatives with renewable energy and energy efficiency components." Other World Bank publications also refer to the success of this model (Martinot et al, 2001; World Bank, 2002).

Working of the off – grid component of ESDP:

For SHS, the company collects a down-payment (equal to 20-25% of the cost of the SHS), and introduces the customer to the micro-credit agency. Once the micro-credit agency decides the customer is credit-worthy, it extends a loan to the customer (loan periods range from 1-5 years, and are charged at a reducing balance interest of 25% per year). The company installs the SHS at the customer's residence/workplace. The company then collects the system price (minus the GEF grant) from the micro-credit agency. The micro-credit agency is refinanced for this amount by the DFCC using the World Bank line of credit.

The company also collects the GEF grant directly from the DFCC Bank. The micro-credit agency repays the loan to the DFCC Bank at approx. 12 % interest over 10 years, the DFCC Bank repays the World Bank over 15 years.

The ESDP also supported training programs for technicians, provided grants and loans to the SHS and hydro companies, and funded a very effective awareness-creation program, carried out by the non-profit Sri Lanka Business Development Center.

The ESDP surpassed its goals, and has resulted in the installation of 18,619 off-grid Solar Home Systems (SHS)

Approximately one dozen solar companies now operate in rural Sri Lanka, assisted by 6 financing agencies which extend credit for solar PV and mini-hydro installations. There is also a well-functioning quality assurance system in place. This project has generated considerable awareness about renewable energy in the country, and is supported by the national and some local government agencies.

The Renewable Energy for Rural Economic Development Project

The success of the ESDP has encouraged the World Bank and GEF to design a follow-on project in Sri Lanka – the Renewable Energy for Rural Economic Development Project (REREDP). The REREDP is a $133.7M project, this includes an $8M GEF grant component. The REREDP is designed essentially as a ramp-up of the ESD project, with some additional components such as the inclusion of a new technology – biomass systems, and more active work with the Ceylon Electricity Board. The REREDP's ambitious goals over its five-year life include the installation of 85,000 household SHSs and 1,000 community, commercial and institutional solar PV systems.

The project aims to support private sector and community-based development models, and help develop initiatives for productive use of electricity to increase rural household incomes and improve the delivery of rural social services, such as health and education.

This project, lasting from 2003 till 2011, has provided SHSs to 110,575 rural households with a cumulative capacity of around 4.81 MWp. The south central province of Sabaragamuwa has the highest penetration of SHSs accounting for around 20% the total SHS installation in the country, followed by the northwestern province (18%) and the Uva province (16%) in the southeastern part of the country.[64]

It should be noted that there have been a number of renewable energy projects before the ESDP, however these have been mostly one-off, independent of each other, and largely government or NGO-funded and implemented. About 5,000 solar home systems were installed in Sri Lanka before the ESDP. There was some private sector activity in the solar home system industry, but sales volumes were very small (under 30 sales a month, in total), and prior to the ESDP intervention, the companies were struggling to survive. In 1991, the government of Sri Lanka funded the Pansiyagama SHS project, where 2,000 SHS were installed, paid for almost entirely by an Australian Aid grant. The country's largest grassroots development organization – Sarvodaya also implemented a SHS project funded by the Solar Electric Light Fund.

Ownership and Financing –

The country has one of the most successful solar PV home system programme, promoted through innovative financing schemes such as Energy Services Delivery (ESD) and Renewable Energy for Rural Economic Development (RERED) project, with private sector involvement. The ESD project provided the basis for a market based approach for introducing renewable energy development in the country. The ESD credit programme resulted in a dramatic increase in the development of off-grid renewable energy projects, prepared and implemented by the private sector and village communities. The project catalyzed the solar market by installing 20,953 solar home systems, with a total capacity of 985 kW, against a target of 15,000 systems.

After the successful implementation of the ESD project, the government, with the help of the World Bank and the Global Environment Facility (GEF), established the Renewable Energy Rural Economic Development (RERED) Project, which electrified more than 130,000 rural households through solar home systems and independent mini-grids and provided 1,000 off-grid electricity connections to small and medium enterprises and public institutions. This helped thousands of rural households to switch from poor-quality kerosene lamps to more efficient electric lighting.[65]

Studies have concluded that the largescale penetration of SHS in Sri Lanka have helped the rural communities to improve socio-economic conditions and reduce adverse environmental impacts. The success of the off-grid projects in Sri Lanka can be attributed to flexible project design responsive to the needs of implementing organizations, suppliers, and beneficiaries. The work has been further aided by improved access to capital, innovative and easy payment schemes introduced by micro-financing institutions, and output focused approach

[64] Oasys South Asia Research project, Solar Energy Programs for Rural Electrification: Experiences and Lessons from South Asia, 2013
[65] Debajit Palit, Decentralized Off-Grid energy solutions in the South Asian region

adopted by the private companies and nongovernmental organizations. The projects had effective after-sales maintenance networks in place, particularly for systems financed by the micro-finance institutions, which were trained in basic technical repair skills. Furthermore, strong outreach networks enabled the micro-finance institutions to reach the rural customers with the help of effective service delivery channels.

Consumer credit through the Microfinance Institutions

The most popular SHS financing model under Sri Lanka's Renewable Energy for Rural Economic Development Project (RERED) is consumer credit through the microfinance institutions that work closely with the solar companies. The project's centerpiece has been the market-based credit programme available to the participating credit institutions (PCI) — commercial banks, microfinance institutions, and leasing companies that meet the eligibility criteria. The solar companies, via their dealer networks, sell SHS and offer operation and maintenance services. The business model is structured through a memorandum of understanding between the microfinance institution and the solar company. The PCIs can refinance up to 80% of their loan amount and offer sub-loans to households, community-based organizations, and private developers, to finance SHS, village hydropower systems, and mini-hydropower projects, respectively.

SHS Installations Status -

According to a survey done by SEA in 2010 a total of ***1, 06,000 solar home systems*** were lighting up the rural homes.

Table 21: SHS Installation - Sri Lanka - 2010

	Technology promoted	Target	Achievement
ESD	SHSs	15,000 households	20,953 households
RERED	SHSs	160,000 households	106,116 households

3. Challenges with Respect to Growth of SHS

3.1. Classification of Challenges/barriers

There are significant challenges and shortcomings that make implementation of Solar Home Systems difficult. For a continuous sustainable development these shortcomings need to be analyzed and addressed accordingly. This section lists down the general challenges/roadblocks in the implementation of household solar and the subsequent sections identify and analyse the challenges prevalent in each SAARC member state.

The list of key challenges have been divided into 4 broad classifications.

- ***Institutional and Organizational Barriers***
- ***Technical and Implementation***
- ***Financial***
- ***Social and Market Based Factors***

Addressing these core issues will help in propagating the usage of household solar.

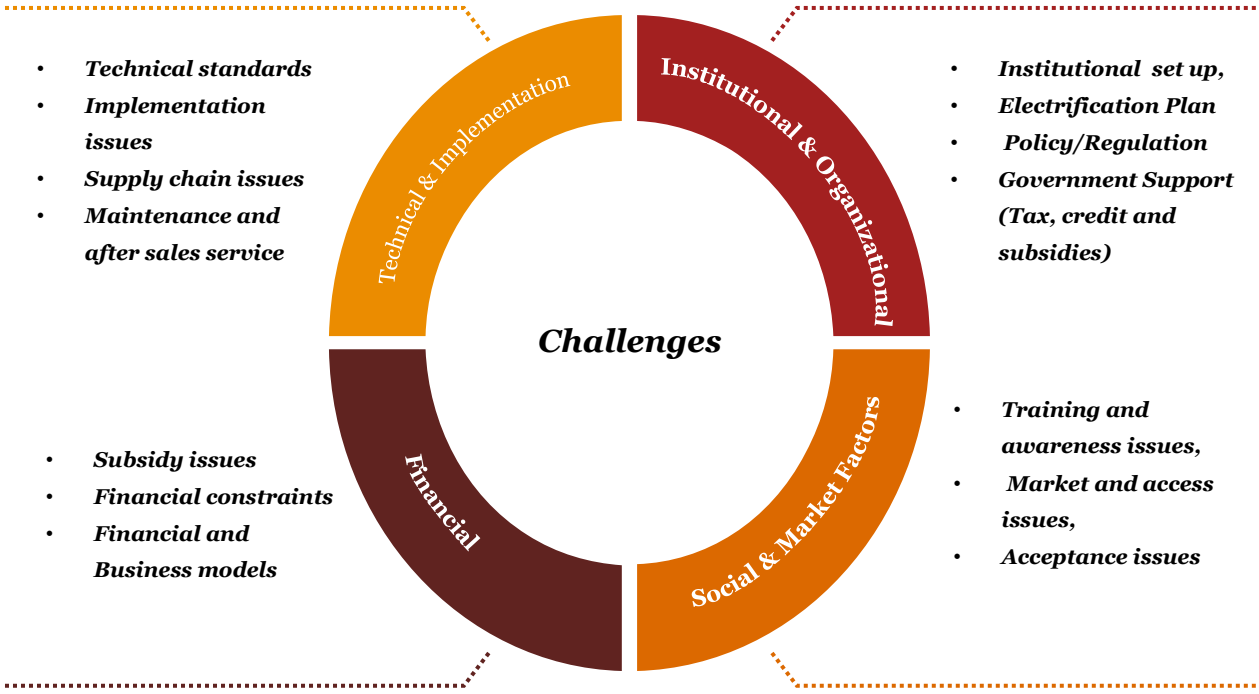


Figure 13: Broad classification of challenges faced in SHS implementation

3.2. Country Wise Challengers/Barriers

3.2.1. Afghanistan

Institutional and Organizational:

A low level of capacity at all levels of Government, private sector and non-governmental organizations for the promotion of renewable energy in Afghanistan has been observed.

As per the guidelines set in 2013, an excellent institutional framework has been laid out by the governing bodies for implementing SHS. However, hardly any progress has taken place on account of the poor institutional framework and infrastructure present at the sub-national level for rural energy promotion, which is a key barrier in implementing SHS.

Specific targets and actions regarding rural households' access to clean fuels are limited in RRES (Renewable and Renewable Energy Strategy). RRES outlines Afghanistan's rural renewable energy action plans until 2020 and development objectives until 2032.This is a long time frame of almost 12 years. Till this time the people would need electricity for their daily activities. This sets the platform for using SHS. With abundant sunshine and market potential SHS can prove to be a game changer for Afghanistan's energy woes.

Technical and Implementation:

Some of the barriers in particular are:

- In villages there is a lack of trained human personnel for O&M.
- At the district and provincial levels there is a shortage of personnel trained in providing technical support.
- At the central and provincial level there is lack of capacity in planning and project management.
- Private sector manufacturing SHS equipment need to increase the quality of its products and service reliability.
- Quality of equipment and services related to the solar home system installations is of poor standards. Many poor quality products have entered the market which are unbranded and which have no warranty.
- Concern of the quality of the SHS system acts as a major deterrent when people are making a choice for SHS. The residents have this fear that the system will break down and there money is wasted. Negative word of mouth about the frequent break down of these home systems is only aggravating the issue.
- Due to lack of awareness many residents don't know that they are entitled to after sales service.
- Poor baseline data availability. This acts as a major hindrance for kick starting a SHS program. Basic data such as income level, number of villages, number of families, family needs, individual needs etc. are not available.
- Threat to kidnapping and criminal activities also acts as a barrier in increasing the dissemination of SHS. There have been unforeseen incidents where equipment have been stolen or the technical staff responsible for installation has been kidnapped.
- Reports of custom clearance issues and delays have also been observed.

Financial:

The capital cost of SHS technology is high compared to conventional energy fuels and hence acts as a deterrent in implementing SHS. It has been found that cost perception is a major barrier to uptake SHS by consumers. The purchasing habits of these rural residents has been small, incremental purchases of their daily lighting needs such as kerosene, candles, and batteries, rather than larger upfront purchases required by current retailers of SHS. The country lacks long term consumer credit through a microfinance organization. These microfinance institutions have been reasonably successful in other SAARC nations by helping in reducing the initial payment that needs to be made by the consumer for the SHS.

Social and Market based factors:

Lack of consumer awareness on the benefits and opportunities of SHS is a barrier in increasing the usage of SHS.

3.2.2. Bangladesh

The SHS program in Bangladesh has largely been a success with about 4.1 million Solar Home Systems (SHSs) installed in off-grid rural areas of Bangladesh till October 2016. 18 million beneficiaries have been provided with solar electricity covering 12% of the total population of Bangladesh as part of this programme. Installations under the programme saw steady growth over the first ten years and peaked in 2013 with over 0.8 million SHS distributed in a single year. Even though Bangladesh continues to be one of the largest markets for SHS, there has been a gradual decline in annual growth since 2013.

Hence it is essential to identify any new challenges or barriers that might have unfolded as a result of the evolving power market in Bangladesh.

Institutional and Organizational:

The recent government in Bangladesh has set a target of providing 100 percent electrification by 2018. While there is still a lot of debate about whether this will be achieved by 2018 or 2021, it is highly important to coordinate the activities of off grid electrification programs (largely the SHS program) with the government's grid extension plans in order to prevent SHS to be installed in rural areas which are likely to receive connection from the grid in the near future. As per the rules of IDCOL's program, in case the electricity grid is extended to a location of a SHS within 6 months of installation, the value of that system is deducted from subsequent eligible disbursements to the POs. Therefore the POs carry the risk of the grid being extended to regions where they are active and would suffer from financial losses if the grid extends sooner than expected. Hence it is essential that the POs should be aware of the grid extension plans of the Government. The Rural Electrification Board (REB) is responsible for grid expansion in rural areas of the country and it has elaborated a Master Plan with details of the intended grid extensions. However the POs do not have access to that plan which makes it difficult for the POs to know where and when the grid will be expanded. Additionally, this lack of clarity and information asymmetry leads to reduced demand and adoption of SHS by potential end users. The un-electrified households while wanting to get access to electricity are left in a dilemma whether to purchase SHS or wait in the hope that soon they would also be provided with on-grid connection.

Technical and Implementation:

The aim of the IDCOL subsidized program was to help in early adoption of Solar Home Systems and build in house capabilities, post which the subsidies would reduce over time. The idea was to gradually transition to a commercially viable, demand-driven (and not subsidy-driven) market. As a part of building capability, IDCOL gradually encouraged the promotion of local manufacturing and assembly of SHS components. The resulting competition resulted in cost reductions of the systems, making it possible to continuously reduce the level of required subsidies. The cost reductions and increasing demand has prompted firms and entrepreneurs to start their own businesses for the dissemination of SHS outside of IDCOL's program. Since this parallel market is not under the ambit of IDCOL and hence not regulated, the SHS offered do not have to fulfill any regulatory requirements such as quality, maintenance, environmental, and health standards. This makes such products cheaper than the SHS which are disseminated by IDCOL. Over the last couple of years, on account of lack of regulations, the quality of the SHS offered in this parallel market has reduced drastically. Additionally falling global solar prices have also resulted in influx of low quality SHS products in the market. If this unregulated sale is allowed to continue, it can eventually lead to a negative effect on the rate of solar home system dissemination. Hence regulations must be put in place to protect consumers from substandard products and services.

Disposal of used lead batteries is also a continuous challenge for IDCOL. Under IDCOL's SHS program the manufacturers are required to provide five years of warranty for batteries used in systems with a capacity of 30 Wp and above and three years for smaller ones. It is the responsibility of the POs to collect expired-warranty batteries from the users and return them for recycling. A significant fraction of used batteries were initially being dismantled and refined under uncontrolled conditions in the informal recycling sector. However IDCOL introduced incentives under which the POs receive US$5 for collection of each expired-warranty battery and the recyclers receive an equal amount for eco-friendly recycling of each battery. While these steps have resulted in increasing the share of batteries recycled through formal sector, it continues to be a challenge for IDCOL. Additionally, with the informal SHS market also starting to come up ensuring safe recycling of batteries becomes even more important.

Financial:

The financial model in Bangladesh was designed such that customers paid a monthly installment for the financing received from IDCOL. It was the responsibility of the POs to collect payments from the households in a timely manner. While they did face issues with respect to collection efficiency, measures taken by IDCOL ensured that collection efficiency reached above 90 percent. However as the scale of the SHS program grows, with more and more number of households under the ambit, it is important for IDCOL to look at new financial models or collection mechanisms like pay-as-you-go and mobile banking, which are more scalable and more efficient than collecting dues from the field. This becomes even more essential for the Partnership Organizations as they look to rationalize their expenses in the backdrop of declining financial help in the form of subsidies.

Social and Market based factors:

While effective capacity building, technical assistance, and information sharing has been provided by IDCOL in the past, it needs to continue to make sure that all stakeholders are kept abreast of evolving market dynamics.

IDCOL should strive and ensure to provide adequate services to the changing demands of the customers. It should look to educate technicians as well as existing customers that provision of upgrading to bigger and efficient systems is available and what are the benefits of such a move. As more and more grid electrification takes place, IDCOL should educate and encourage customers to adopt or continue using SHS during times of unstable supply from the grid. Similarly it also needs to emphasize the benefits of purchasing systems under IDCOL program and the criticality of using better quality and certified systems instead of the cheaper sub-standard systems that are flooding the market.

3.2.3. Bhutan

Technical and Implementation:

Similar to other countries, disposal of used lead batteries is a major challenge for the government. Majority of the end users are unaware of the harmful effects of not disposing used batteries. Additionally, considering the remote locations at which households are located they neither have adequate knowledge nor the resources to discard and safely dispose the batteries. It is also essential on the government's part to make sure that the batteries are recycled through a formal set up rather than through the informal sector.

Financial

The current installations of SHS systems have been financed through the ADB grant which enabled the government to provide the systems to the households without any charge. Expenses related to the O&M services are being financed by the government through budgetary allocations. However it is essential that the government also make adequate budgetary provisions for any future expenditure that might come up, such as replacement of existing systems, providing subsidy to users who may want to upgrade their system size, or even for providing subsidy to grid connected users who may want to purchase the systems. The government should aim to become self-sustainable to finance future investments rather than only depend on grants.

Social and Market factors:

People who have been using SHS for few years have themselves gone through a lot of changes. It has been observed that with higher income, change in lifestyle and possible increase in family size there is an increase in there requirement of energy. However there is a lack of awareness among the people that the present systems itself can be upgraded to higher wattage without incurring much additional cost. Similarly, even technicians have to be made aware and trained for such requirements. Since the households in Bhutan are located in remote locations, the interaction between technicians and users do not happen on a regular basis. Thus it is a challenge for the government to facilitate a periodic and effective communication channel.

The use of electricity for income-generating activities has been very limited. Currently most of the households in Bhutan have been using SHS only for lighting purpose and are not aware of ways in which they can leverage the system and use it for energy related income generating activities. Apart from increasing awareness about this the government also will have to make investments in improving supplementary infrastructure such as access roads. Creating and managing additional demand for electricity through increased consumption but using energy-

efficient devices can also ensure long-term sustainability of the project benefits. It would also encourage consumers to diversify electricity use from consumption to production purposes.

3.2.4. India

Institutional and Organizational:

India has established formal institutions in charge of energy and electrification in the country. Over the years a number of off grid electrification programs and schemes have been initiated to enhance rural electricity access. Majority have only had mixed success. Currently implementation of solar home lighting system is a part of both, the Decentralized Distributed Generation (DDG) scheme as well as Off-grid solar application scheme under the Jawaharlal Nehru National Solar Mission. The DDG scheme is governed by Ministry of power (MoP) while the Off-grid solar scheme is governed by Ministry of new and renewable Energy (MNRE). Both the schemes have different set of guidelines, technical standards and financial incentive mechanisms with no clear demarcation of applicability between the two. Existence of two parallel programs with different guidelines often leads to greater complexity and confusion for the end stakeholders. It also reduces the accountability of the organizations in charge of implementing the programmes. There is no necessity in having two separate government led programs that compete with each other. There should be an integrated policy framework which allows both the programs to co-exist by complementing each other. Ideally one of the two programs should deal with off grid solar equipment such as individual solar home systems, solar lanterns, and solar pumps while the other can concentrate on renewable energy based distributed generation with micro/mini grids.

Another issue that could be affecting wider penetration of SHS is lack of local or regional participation from state governments. In India, especially for the government led off-grid programs of which SHS is a part, there seems to be low participation of state governments in the decision making process. While there are a number of private SHS implementing agencies in India who have strategically positioned themselves and have concentrated on specific regions, often customizing their offerings, no such initiatives have been taken for the government programs. The states have also not been given any specific targets with respect to installation of SHS or other off-grid measures.

Lack of, or inadequate long term electrification planning is another issue that has adversely affected the adaption and impact of SHS. There have been cases where grid connected electrification has been provided to villages in which Solar Home Systems had been deployed only in the recent past. This constrains the long term sustainability of SHS systems as it not only reduces the usage of installed SHS sets, but also inhibits future purchase of SHS sets by households who prolong their decision in the hope that they would eventually be provided by grid connected electricity.

In the choice between on-grid and off-grid electricity almost all households show a preference for on-grid electricity. This is understandable, but it is leading to a catch-22 situation for the rural households. The current government which came to power in 2014 has set a target of achieving universal electrification by 2019. However, one of the interesting caveats in the government's electrification program, is that a village to be considered electrified even if only 10 percent of the households in the village are connected to the grid. This is leading to a situation where un electrified households in a village where some sort of grid electricity has been provided are

not forthcoming in installing any off grid electricity solutions in the hope that soon they would also be provided with on-grid connection. However, it is uncertain to predict how soon on-grid electrification will be extended to all households in the village. Even those households who have and are being provided on-grid electricity often complain of unreliable electricity supply of just 4 to 5 hours in a day.

Subsidized kerosene is another factor that is having a negative effect on adoption of Solar Home Systems. India has one of the highest subsidy levels for kerosene in the world. The government began subsidizing kerosene to enable poorer households to purchase essential cooking fuel. However over the years kerosene has largely been used as a lighting fuel across the country although it is highly inefficient, polluting and damaging to both health and the environment. While the subsidy was meant to act as cooking fuel and was targeted at below the poverty line (BPL)—families, it has been very difficult to get people to forego these subsidies once they have risen above the poverty line. Since it has been available to the rural population at such subsidized rates it has tended to price out viable decentralized renewable energy alternatives, like Solar Home Systems which offer a better cost-performance option (from lifecycle cost perspective) with health, safety and environmental benefits. Though there have been recommendations that the kerosene subsidies be reduced or phased out, they have never been implemented as kerosene subsidy is a highly political subject since majority of consumers are rural and low-income households, who form a critical voter base for any political party.

Technical and Implementation:

As with other countries quality and maintenance are of vital importance for adoption of SHS systems in India. Although the performance of the SHS systems is affected not only by technical functionality but also improper usage, dissatisfaction over performance inhibits other potential adopters from purchasing or adopting SHS systems in the future. The technical aspects related to SHS can be analyzed under two parameters – quality of the individual components and system integration and performance.

In India, as mentioned earlier in the report, SHS systems are sold via both, the commercial model as well as through government based schemes. Since the government schemes have gone through several iterations over the years, constructive steps have been taken based on stakeholder feedback and experience. The government has defined technical standards and performance specifications for all individual components. It has also empaneled a list of pre-qualified suppliers and has set up accredited test centers where manufacturers can get the individual components verified and tested. Since subsidy under the government scheme can only be availed if all procedures are followed, quality of components being used is not a major issue for SHS installations done under this scheme. However, under the commercial model in which a large number of private implementing agencies are in operation in various regions, dissatisfaction of households on account of performance issues have been widely reported. The major reason has been the use of low quality components since currently there are no guidelines that require commercial installations to adhere to any quality standards or certifications, unlike in the case of government schemes. Additionally with cost being a major decision factor, there have been attempts to increase the affordability by developing cheaper sub-standard products leading to an infiltration of low quality products in the market, especially in over the counter shops selling SHS components and packages. Since these are priced at rates much cheaper and attractive, people have been purchasing such products, only to see it perform

poorly or even stop functioning over a period of time. This leads to major loss of trust among the rural population resulting in market spoilage.

Even in some cases where good quality components have been used, issues have arisen once they have been integrated and installed as a system and put into operation. These have been on account of misevaluations or inaccurate assumptions made upfront leading to unsuited system sizes or because important safety principles have been ignored and design calculations have been based on rule of thumb. Most of these problems have occurred since the personal entrusted with final installations lack adequate training and expertise. The outcome may vary from a minor decrease in usability to a severe drop of service life. Such issues are more prevalent in cases where the selling firm or the small implementing agencies who usually lack technical and human resources are only concerned with selling or installing the system, while not taking responsibility of the maintenance or after sales service. Such firms usually want to implement one design or size solution in all contexts and also often overstate the benefits or use of Solar Home Systems while not educating the consumers of proper dos and don'ts leading to improper usage of the systems. While these issues and similar instances are prevalent in other countries also, the magnitude and adverse impact is much more in India, given its size and the population that is affected.

Inadequate, poor, or no after sales service has also been a barrier in particular villages or regions which has prevented large scale adoption of SHS. The presence of good after sales service is essential considering the relatively large amount paid by the end users in purchasing SHS systems and the uncertainty that they have regarding proper functioning of the system. There are multiple reasons for the same. In certain areas which are very remotely located, the players face both manpower as well as logistical challenge to provide efficient and prompt after sales service. In terms of distribution model, there are multiple players with different after sales service models. While some take responsibility of after sales support and service and have their own trained technicians who go to the customer's home for repair and maintenance, there are firms who only sell SHS systems without providing any dedicated maintenance or after sales service. Understandably the cost to consumer for such offerings is less which leads them to often purchase such products. Since these are commercial players there are currently no regulations that apply to them. Hence in such cases, if the SHS malfunctions, usually the user has to carry the equipment to the nearest authorized service center that may be catering to multiple villages. There have also been issues faced in cases where the private players have been selling products via channels like VLE or WE on account of inadequate or lack of technical expertise in handling complex issues.

With respect to warranties, while the government under its scheme has defined component level warranties which is applicable to all products selling under the scheme, it is not mandatory for private players to provide any warranty. Like in the case of after sales service, such products are obviously available at cheaper rates which prompts the users who are not adequately informed of the risks to purchase such products. Some firms also provide system wide warranty or free maintenance service for a period of 3 years, post which the users have to purchase an Annual Maintenance Contract (AMC) for an annual or monthly fee. However these have not received a favorable response from the end users.

As with other countries, disposal of used lead batteries is also a major issue in India. The challenge is even bigger in India considering the large size of the country and the existence of a number of agencies who sell SHS via the

commercial model. While lack of awareness among the end users is an issue, dealing and coordinating with a large number of last mile distributors present in India is also a major challenge. Additionally it is also essential on the government's part to monitor and make sure that the batteries which are recycled are done through a formal set up rather than through the informal sector where dismantling and recycling is done under uncontrolled conditions. The end users who are unaware of the harmful effects generally end up selling the disposed batteries to the informal sector who are able to offer higher proceeds since the cost of recycling through informal sector is cheaper.

Financial –

In India, with the existence of multiple small and large private players present, a number of consumer financing options have been tried. Most companies have either tried to facilitate purchases through helping the consumers avail government subsidy or by looking to develop relationships with banks and microfinance institutions. However both options have faced challenges and have had mixed success.

While the Indian Government provides subsidy to the consumer through banks for purchasing SHS, the Implementation Agencies assist the consumer in availing the subsidy. However, the agencies have often complained that availing the subsidies is a long, complex and cumbersome process involving a lot of paperwork, administrative processes and checks. Off late implementing agencies have also complained of significant delays in releasing of subsidies by NABARD. The subsidy scheme through NABARD was stopped in May, 2017 by MNRE. Post that no guidance or indication has been given whether a different subsidy scheme is under planning or not. Lack of information or indicative announcements makes it difficult for end users as well as implementing agencies to plan their future investments. Both the parties are unsure whether to go ahead with sales or to wait for a new subsidy scheme to be announced.

Implementing agencies have also tried to tie up with micro financial institutions for providing credit. However this has met with mixed success due to low penetration of MFIs and hence their reluctance to lend to consumers in those areas where they don't currently have presence. MFIs have also been resistant since they find it tough to gauge the credit risk of end users and have reported instances of not receiving regular instalment payments. Such issues have also resulted on account of consumers being unsatisfied with the performance of the SHS, either due to inferior quality of the system or improper usage by the consumer himself or due to over promises made at the time of selling the SHS.

Similar issues have also been faced by implementing agencies who have tried to facilitate financing on their own. Irregular payments received from end users pose significant working capital issues for such agencies as in these schemes even the initial down payment to be paid by end users are kept low considering the low financial ability of the consumers being served.

In a large country like India there is still a large segment of the population that does not have access to the formal banking sector and hence raising finance to facilitate purchases for consumers staying in such areas is a major challenge. Innovative financial model like Pay-as-you-go have been tried by few players in specific regions but are yet to be fully successful considering constraints related to technology awareness, usage and complexity.

Social and Market based factors:

Similar to other countries, raising awareness and providing adequate knowledge to both adopters and non-adopters has been a major challenge. In a number of cases, the lack of knowledge by adopters has resulted in improper usage, constant tampering, and inability to maintain the systems. This creates a negative perception and prevents potential customers from making a decision to adopt the systems. The scaling-up of Solar Home Systems is also constrained by incompetent technical manpower and lack of formal training institutes.

Along with raising awareness, it is also essential to effectively market the product in a planned and organized manner in order to make the end users more comfortable and give them more confidence that can result in increasing their willingness to pay. However in India there has been multiple instances where the system has been sold to the end users by making unrealistic promises.

3.2.5. Nepal

Institutional and Organizational:

Due to lack of coordination between various government bodies grid connection is being provided to villages in which SHS systems were sold in the recent past. Since there is no definitive rural electrification plan, it becomes difficult to identify villages for providing Solar Home Systems. This situation has been observed in the Kabhre region where Solar Home Systems have been installed in places where the national grid is going to be extended. Duplication of effort and wastage of the resources can be minimized by demarcating areas for SHS installation.[66]

Technical and Implementation:

The sites in which SHS are implemented are extremely remote in nature. To add to this difficult terrain, poor infrastructure results in poor access roads and further difficulties in providing maintenance and after sales service as well as training.

With increasing adoption of solar PV systems, there is also a need to establish environmentally responsible recycling of lead-acid batteries at the end of their life. Currently there is no definite mechanism for collection of disposed batteries.

Absence of effective monitoring and providing post installation services also have been identified as a barrier in people opting for SHS.

Social and Market:

The SSP Phase 1 target for SHS was 40,000. While the target period for this installation was 1999-2004 it was achieved by 2002 itself. The target for 2010 – 11 was increased from 50,000 to 65,000 SHS, however, it still fell short of demand[50]. The SHS targets are generally achieved before time. This results in the market getting capped. Because of this situation, AEPC has stopped giving subsidies since it has exhausted most of its funds.

[66] S.Shrestha and K.Bajracharya , A case study of Solar Photovoltaic Technology in Nepal

This is a bad situation for the companies since the customers wait for the next subsidy announcement. The supplier in turn ends up exhausting its own funds. Also the supplier is found guessing since it might face financial loss if the sales depend on the subsidy provided by AEPC.

Nepal has poor planning for marketing and increasing general solar lighting awareness and education, as well as convincing potential customers that solar SHS are superior to traditional lighting sources (kerosene).Many potential consumers are not aware of the benefits of SHS. Even amongst people who are aware of the benefits, they have a misconception that SHSs are costly. Awareness campaigns are therefore necessary to convince customers that not only are they buying better and safer lighting that will improve their quality of life, they are also making significant savings.

3.2.6. Pakistan

Institutional and Organizational:

In Pakistan, AEDB is the central institution in charge of promoting and encouraging renewable energy as well as village electrification. As a central body AEDB is responsible for planning and policy making while the energy departments of the individual provinces are responsible for the execution and implementation. Considering the large size of Pakistan, such a de-centralized implementation set up is adequate to cater to diverse areas across the country. However, even though AEDB has set a target to provide renewable energy to around 8,000 rural villages (majority through SHS), no substantial progress has been made. While the lack of coordination between the provinces as well as between AEDB and the provincial energy departments is certainly a major implementation barrier, the low regional participation from provinces is also on account of unfamiliarity with technological know-how. As a facilitator, AEDB should provide institutional support to improve administrative capacities of the relevant provincial agencies, both in terms of sectoral knowledge and sufficiency of human resources.

Accountability and hierarchy between the central and provincial agencies should also be clearly defined so that timelines and processes can be standardized. Currently there is no precedence of monitoring implementation progress as no national or regional level programs or targets have been set for SHS implementation. While the number of private companies engaged in SHS implementation has been gradually rising, they have not received much support from the government. Along with starting a national level program the government should also look at providing an enabling environment for the private players. Additionally, like in other countries, inadequate long term electrification planning as well as lack of inter departmental coordination between agencies responsible for village electrification and those responsible for off-grid implementation has also adversely affected the adaption and impact of SHS.

There are also an increasing number of private companies in Pakistan who are getting involved in providing off-grid electrification through SHS installations. Along with starting a national level program the government should also look at providing an enabling environment for the private players. Currently the private players do not receive much assistance from the government.

Technical and Implementation:

One of the major concerns in the minds of the customers pertains to the frequent break down of the SHS products and the subsequent lack of after sales service. Due to lack of knowledge many people buy faulty products which speaks volumes about the poor quality of the SHS products. In 2013 IFC estimates that close to 120,000 solar products were imported into Pakistan, majority of which were unbranded, no – warranty SHS. Only 11% of the products were quality verified products.

Table 22: SHS Price Differential - Pakistan

	Overall average	Highest Price	Lowest Price
Basic SHS	11,561	17,838	9,701

In one of the surveys done by IFC close to 95% of the people who bought solar household products bought it from a nearby city. This is an indication that last-mile distribution system is yet to be set up in Pakistan. It has been observed that the retail price of the same SHS having the same technical specifications varies a lot across the country .While in cities the SHSs cost less, their cost is relatively on the higher side in the remote locations. Hence last mile connectivity will ensure that people will have more options with respect to cost and quality. This barrier has also been captured by an IFC report which states that there exits significant regional variations in the amount off-grid households pay for the lighting technologies, often due to the remoteness of the province.

While such issues have persisted from a long time, lack of data management practices, both at central or provincial level has prevented agencies from taking more informed decisions. There is no record of past SHS systems that have been installed, what are the issues that have been faced, in which regions it has been a success or a failure and on what account. Agencies have often been inexperienced, ill-equipped, or poorly staffed for carrying out such field level exercises. However efficient data gathering and analysis is not only extremely important for tracking performance and impact but also to take informed decisions and provide customized offerings such that the program implementation can have a larger impact.

Financial:

Access to funding seems to be an issue. It seems that while the government has received grants and aids for poverty alleviation, no part of it has been directed towards providing electricity access to the rural population.

Even the private players present face difficulties in raising finance. This not only prevents them from widening their reach but leaves them with little option of structuring financing schemes that could be beneficial for the end user. While the microfinance industry is growing in Pakistan, lending to private companies for renewable energy initiatives has not picked up. Often MFIs consider the customers and the technology too high risk to provide lending. MFIs also lack the capacity to follow up on private player to monitor whether they are meeting the terms of the agreement with the customer and ensuring after sales maintenance and servicing. It is important for the government to look at ways in which it can encourage commercial partnerships between MFIs and private SHS vendors. The Ministry of Finance has established Pakistan Microfinancing Institute for the purpose of

microfinancing SHS. However its impact on facilitating funding to private players or end consumers remains to be seen.

A few private players like Roshan Energy have explored innovative business models like Pay-as-you-go and have tied up with Telenor and Tameer bank to provide SHS solutions via rental as well as Lease model. These initiatives have met with some success and hence more private players should also look at adopting these innovative business models. Few private and public sector corporate organizations have also undertaken SHS implementation programs on a smaller scale, often targeting a particular village or community as part of CSR initiative. However not much records of the same has been maintained or documented.

Social and Market based factors:

Lack of information is considered to be one of the biggest challenge in implementation of SHS. Information and awareness about the functioning of the solar home system, how economical it is and the different user experiences are some of the data points that a prospective customer will look for. Other vital data points that a future customer will like to have knowledge on are technical assistance in case of breakdown, environmental impact, brand image of the solar system provider etc. Apart from all these factors the customer has very low trust on the agency which is providing the solar household system. Media also can have a big role to play in the dissemination of SHS. They can help spread awareness and increase knowledge related to SHS development.

The other challenge is the deficiency of trained solar work force for which there is need for national plan for creation of solar workforce in Pakistan. Government does not have any Certification system for Solar Certified Technicians.

3.2.7. Sri Lanka

Technical and Implementation:

The SHS selling companies have failed to give adequate technical support (follow up and knowledge sharing etc.) at the community level. Apart from this the SHS firms have not been able to replace components on time where there is a damage which is in the warranty period. For this failure some of the SHS companies have cited unavailability of components in the rural area.

Financial factors:

The project strategy of involving MFIs in the SHS sector has improved sales significantly. However, this has resulted in a need for improved collection of loan installments by MFIs. MFIs have a door-to-door collection mechanism where an MFI credit officer visits each household on an agreed day every month. Weaknesses inherent in this mechanism include high travel costs, and risks of credit officers mishandling collected cash, customers not being present or not having adequate funds on the date of visit. Increasing numbers and a gradual geographical spread of the customer base, combined with rising fuel prices, are making it difficult for many MFIs to sustain this collection mechanism.

Social and Market based factors:

ESD and RERED have contributed to the development of the RE sector in Sri Lanka for well over a decade. Recently however, issues have surfaced that may affect the long-term sustainability of certain market segments

of the RE sector, particularly off-grid solutions. The electrification rate in Sri Lanka grew from 42 percent to 83 percent between 1996 and 2009.The Government of Sri Lanka has ambitious plans of achieving close to 100% electrification. This also means that only the remotest, most isolated pockets of the country will remain without access. Anticipating grid electricity, many un-electrified villages are losing interest in off-grid schemes and SHSs. The project experience shows that when grid electricity reaches a village using a SHS, village members tend to switch to the grid.

4. SHS Developments in World

This section covers few relevant case studies across the world where SHS has been successfully installed. Some of the steps taken that were critical and had a positive impact in overcoming existing barriers have also been highlighted. The SHS program implementation has been a major success in Bangladesh. Hence it is essential to look at the critical factors that led to the success of the program and the important lessons that can be learnt. These have also been covered. Pay-as-you-go has emerged as an innovative financial model that is being employed by companies across the world to increase the affordability of solar home systems for the end users. Hence key features of the model, and its advantages for the end users have been mentioned.

Case 1: Installation of Solar Home Systems in Off Grid Areas of Tharparkar District in Pakistan

Background

At this point of time the rural electrification in the country was at a nascent stage in terms of progress. Out of an estimated 125,000 villages in the country only about 90,000 villages were connected to the national grid. Of the remaining 35,000 villages close to 7,876 villages suffer from being in extreme remote and scattered locations. The Government of Pakistan plans to exploit renewable energy to ensure that people living in the remote locations get minimum basic energy services and clean drinking water.

One of the most successful rural electrification projects in Pakistan has been the RE Electrification of 3,000 homes in the Tharparkar district of the Sindh province. The Alternative Energy Development Board (AEDB) has taken the initiative of Village Electrification in far flung area like Tharparkar though alternative energy resources. Tharparkar is a district in Pakistan with a rough terrain and poor infrastructure. Population residing this part of Pakistan is mostly poor and uneducated. Literacy rate in the area would be close to 10% only.

Project details

Scope of the project was

- To install 3000 solar home systems in 3 villages of Chachro, Mithi, Diplo and Nagarparker.
- To offer 3 levels of power to the users, namely 120 Watts, 80 Watts and 40 Watts.
- To train five people from each village to do the regular maintenance and operations of the entire system.

Each Solar Home System consisted of the following:
A PV panel mounted on a pole adjacent to the house,

• Charge controller,

• Lead acid batteries,

• Compact florescent lamps (CFL), one in each room, kitchen and court yard;

• Switches and Sockets for mobile charging/ Radio

The suppliers of these SHS ensured free after sales maintenance services and satisfactory operation for 1 year.

Implementation

Tharparkar district being an extremely remote area had its own set of problems. Owing to the literacy rate of the people and the area being under developed, AEDB faced a lot of problems with respect to the social acceptance of this implementation. This was a unique project because the SHS implementation had the power to directly change the lifestyle of the people and the people initially were a little skeptical of how their life would change post this project.

With all these challenges the project was eventually completed and the benefits of the project were realized by the local population once the system became operational. The highlight of this project was that the majority of the beneficiaries were women and children.

Impact / Outcome of the Project

- Energy was provided to close to 3000 families. This would save around 216 liters of kerosene and nearly 30000 candles on an annual basis.
- The local people did not pay any money for the installation (it was free). However they had to pay a monthly fee of Rs 200/- for the system maintenance.
- Daily maintenance, like cleaning of the solar panels and checking battery water levels, was done by the household personnel.
- Access to electricity acts as a motivation and allows people to improve their homes and their society. This access also helps in improving the quality of life, increases income generation opportunities.

Electricity also eliminates the health hazards caused by using kerosene and candles. People in these undeveloped villages often live in small huts with no ventilation. Smoke from kerosene and candles cause problems like bronchitis and use of solar powered electricity eliminates this danger.

Success Factors: Creating Awareness among potential customers of SHS, ensuring set of trained technicians in each village and free after sales maintenance services and satisfactory operation for 1 year.

Case 2: Decentralized Electricity for Universal Access in Bolivia

Background

Bolivia in 2004 had one third of its population living in rural areas. Poverty rate in these areas was around 82%. Almost half of the rural population had no access to electricity. Majority of schools and health centers in rural areas were not electrified at this point in time. Infrastructure was a necessity but also costly. In 2003 the World Bank approved a $20 million credit as the first phase of a ten-year Adaptable Program Loan package for Decentralized Infrastructure for Rural Transformation (IDTR), a major component of which focused on rural electrification. This project developed an innovative model for Off-grid rural electrification through public-private partnerships: medium-term service contracts (MSCs) for electricity provision through Solar Home

Systems (SHSs) for dispersed rural population, in which the service provider was responsible for the operation and maintenance of the SHSs during its initial years.

In 2006, the Government of Bolivia (GoB) launched a strategy for universal access to electricity, which recognized the need to mobilize both public and private sector financing and expertise. The GoB was interested in exploring MSCs as the lead mechanism for the off-grid window of its Universal Access Fund.

Project details

The Global Partnership on Output – Based Aid (GPOBA) project was approved in 2007. This project worked under the framework and ambit of the Government's universal access strategy and totaled $5.2 million of grants to support the provision of electricity. The grant recipient was the Ministry of Services and Public Works, with implementation by the Project Coordination Unit of the IDTR. The project's aim was to increase access to renewable electricity for households, micro-enterprises, schools, and clinics in remote, rural areas of Bolivia through output based service contracts and subsidies to private sector providers for the sale, installation, and after-sales service of at least 7,000 SHSs.

Implementation

The project was structured to adapt to new organizational conditions, allow more time for its completion, take account of lower-than-estimated subsidy costs for SHSs, and reduce the aftersales service period. The subsidy was originally set at $650 per SHS unit (61 percent of project costs for a typical 50Wp system for households, and 69 percent of a typical school system). Users would pay: (i) upfront fee of $50; (ii) repayment of remaining system costs, either in cash or through micro-credit of approximately $335; and (iii) replacement of battery of about $65 if the battery failed before the project ended. User payments were verified regularly on a random sample basis, with penalties for providers who overcharged. The user was responsible for replacement of batteries and spare parts for the rest of the system's estimated 20-year operation. User contribution was estimated based on a demand survey, assessing willingness-to-pay and the IDTR experience. However, it was expected that subsidies could be reduced through the competitive bidding process.

Impact / Outcome of the Project

- After initial delays associated with political changes and institutional challenges, the project closed very strongly in 2013, exceeding its original targets.
- A successful bidding process succeeded in achieving a lower subsidy level per unit, making possible the installation of a larger number of SHS than planned.
- Installation of 7,700 SHSs for dispersed, low income, rural households, schools, clinics, and micro- and small enterprises (including 126 systems for public buildings not initially included in the program)
- Consolidation of output based service contracts between the government and private sector service providers as a mechanism for electrification of poor, dispersed households under the new universal access policy. The project involved eleven contracts – 8 for SHS, 2 for Pico – PV systems and one for public schools, with 2 service providers who are now well established in rural areas and in a position to continue providing their service.

- As of 2015, the percentage of Bolivia's rural population with access to electricity has risen to 72.5 percent.

Success Factors: A well designed bidding process which reduced the subsidy requirements and flexible project design enhanced the results of the rural electrification project.

Case 3: Women Entrepreneurs Light the Way for Solar products in India

Background

In India, 400 million people do not use grid electricity as their main source of lighting[67].This has an adverse effect on women in particular. Apart from the time taken to complete the daily household chores lack of electricity also reduces the opportunities to earn income. Women are also more exposed to health risks from kerosene oil and other fuel-based lighting sources.

Despite its vast potential, the market for modern off-grid solar products in India is severely underdeveloped, with IFC assessments estimating a 5 percent to 7 percent penetration rate. Two key barriers to market development are ***building demand among last-mile customers*** and ***ensuring delivery to them.***

The population in rural areas is least likely to have access to safe forms of lighting, yet it also presents sales challenges for two reasons: First, last-mile customers typically have ***low incomes***, and because of their ***remote locations***, it costs more for the private sector to serve them reliably. Second, these customers tend to have ***limited access to information*** and networks, decreasing their participation in energy markets. In India, the early entry of low-quality solar lighting also meant that potential customers were wary of spending money on likely faulty products. Lighting Asia/India knew that persuading customers to adopt solar lighting would require creative approaches.

Project Details

Lighting Asia/India, part of IFC's Lighting Global program, accelerates access to clean and affordable energy in rural India by promoting modern off-grid lighting products, home systems, and mini-grid connections. The program works with the private sector to address barriers to growth by providing market intelligence, fostering business-to-business connections, strengthening last-mile access, and raising consumer awareness of quality-assured lighting products in the states of Uttar Pradesh, Bihar, and Rajasthan.

Implementation

Lighting Asia/India overcame the challenges associated with last-mile sales and built the market for off-grid solar lighting by focusing on women as distributors and customers. Frontier Markets, a clean-energy-products company, to develop a network of Solar Sahelis. The network is made up of a group of self-employed women recruited from self-help groups. These women-run alliances provide access to funds and technical assistance to

[67] IFC – Lighting Asia, Kerosene for Home Lighting: A Key Indicator to Prioritize Districts for Clean Energy Initiatives in India, December 2015

help women in local villages improve their lives and start their own businesses[68]. Based on initial results, Frontier Markets plans to expand the *Solar Sahelis* network from 250 women to 20,000 between 2016 and 2020.

Solar Sahelis promoted awareness of the benefits of high-quality solar lights through the *Suryoday,* or "Sunrise," campaign. The campaign highlighted the economic savings and health benefits of solar lighting. It also improved customers' ability to identify high-quality solar products, ensuring that substandard goods did not discourage the adoption of more reliable products. The awareness campaign particularly targeted women, reaching 56,000 of them across three states through self-help group meetings.

Impact / Outcome of the Project

At the end of the 18 months' partnership between IFC and Frontier Markets, the Solar Sahelis network accounted for 30 percent of all sales. To date, Frontier Markets has sold 12,000 solar home-lighting systems—bringing the benefits of clean, safe, and affordable light to the homes of approximately 630,000 people (this includes 115,000 solar lamps also). This was possible because the network helped overcome the cost and awareness challenges associated with last-mile distribution. Specifically, gender-smart solutions helped to build distribution networks, increase customer trust and market access, and enhance public awareness and recognition.

Last mile distribution: Buying solar home system is a longer-term, one-off financial investment, making it impractical to maintain a full-time, dedicated sales staff in remote communities. By working through independently employed women, Lighting Asia/India and Frontier Markets gained a flexible network that was also deeply tied to local communities. At the same time, *Solar Sahelis* earned an average of $35 per month for part-time work, a substantial addition to what was typically a low or nonexistent income.

Customer Trust: While high-quality solar household systems delivers cost savings in comparison to fuel-based lighting over time, in the short term, it can be a substantial investment for rural customers. Having a network of *Solar Sahelis* embedded in local communities and available to answer post-sales inquiries built the trust needed to purchase off-grid solar lighting.

Market access: Studies across markets show that women are key decision makers in energy purchases, influencing what type of lighting products to buy and how much is spent on them[69]. Working with a network of female entrepreneurs facilitated sales in a market segment that male agents might not have been able to access.

Public Awareness: Coordinated campaigns and an active network of entrepreneurs produced results: Consumer knowledge of the availability and benefits of high-quality solar lighting jumped from 25 percent to 60 percent among consumers in the target area.

Public Recognition: Frontier Markets recently won the 2016 Ashden Award for Clean Energy for Women and Girls.

Success Factors: A well designed Success Factors: Dedicated sales staff ensured last mile distribution, Post sales activities helped to build trust and Consumer knowledge on the products increased

[68] World Bank, In Rural India, It Takes a Village—and Women's Self-help Groups — to Improve Livelihoods, September 2015
[69] IFC, Expanding Women's Role in Africa's Modern Off-Grid Lighting Market, 2011

Case 4: Lighting Cambodia – The Solar Way

Background

Cambodia is a tropical South East Asian country located in the lower Mekong region. The country with a population of approximately 14 million, finds itself classified as LDC (Least Developed Country). A priority goal of the Royal Government of Cambodia is its commitment to reduce poverty throughout the kingdom. The underlying strategy to accomplish this objective is the development of sustainable and affordable energy supplies for all its constituents.

Between 50% and 75% of Cambodia's rural areas get access to electricity by ***batteries***. The communities buy the batteries and get them recharged by a local entrepreneur in the village. Each battery charging station uses old diesel generation sets and on average charge 50–80 batteries a day, with an average charging time of 5–7 hours. The pollution generated by the generation sets is high and battery disposal is erratic. Each of such battery charging stations cater to 2–3 villages.

Project details

The government is implementing REF (Rural Electrification Fund) project which is part of RE&T (Rural Electrification and Transmission) project, funded by the World Bank. Created by the Royal Decree of Cambodia, the REF is not located within any ministry. The project got funding from World Bank ($8.4M), GEF grant ($5.6M) and $146K from the government for incremental operating cost. On the other side REF would have to pay for the technical assistance, grants to sub projects (new connection etc.), and operations. As per the REF Grant program the grant for at least 40W of SHS will be $100.This rate is per SHS only. The grant rates can be revised annually if approved by the REF board and the World Bank.[70]

Implementation

Under the project, REF has been providing grant assistance of USD 100 per SHS to selected solar companies for the installation of 12,000 SHSs (with a minimum installed module capacity of 40 Wp) in rural areas of the country. The purpose of providing the grant assistance was to encourage these companies to reduce their per unit capital cost of SHS so that the price of SHS becomes affordable to rural households and to facilitate an access to electricity where the electricity network has not yet reached. However, as only 1,300 SHSs out of the targeted 12,000 systems were put up, the SHS programme has recently been revised. The REF will now purchase the SHSs in bulk and undertake the installation of SHSs at the rural households through approved suppliers. The beneficiary households will make down payment of 20% of the cost of the SHS and the balance repaid in instalments within a time period of up to five years. REF will pay a service charge to local service companies for maintenance of the SHS and collection of the instalment payment. The intended objective of the REF grant is to reduce the capital investment cost leading to a lower retail cost of power in the rural areas. After this revision 1,600 SHS contracts were executed against a target of 1,650 SHSs.

[70] Rural Electrification Fund : Cambodia, Providing grants & promoting rural electrification and renewable energy technology, February 2008

Impact / Outcome of the Project

Initially only 1,300 SHSs were installed against a target of 12,000 SHSs. After a revision from REF against a new target of 1,650 SHSs, 1,600 SHSs were installed. This grant was able to bring light into the lives of many people by displacing kerosene lamps and paraffin candles with solar home systems.

Success Factors: The grant from REF ensured affordability and hence more rural consumers opted for SHS.

Case 5: Promoting SHS in Sri Lanka

Background

In 1996, the electrification rate in Sri Lanka stood at 42 percent. By then, several off-grid community-based village hydro projects (VHPs) had been implemented by nongovernmental organizations (NGOs) and donors with grant funding, and a number of SHSs were also installed by private companies, demonstrating the technical viability of these technologies. In spite this early development, SHSs were not considered a credible means of providing energy access for rural areas.

Financing SHSs proved a particular challenge, since commercial and development banks lacked the necessary infrastructure in rural areas to appraise small loans; and the SHS industry operated in a highly decentralized manner, with many vendors and a lack of standards. Market development was further constrained by the lack of technical and service standards.

It was against this backdrop that the Government of Sri Lanka (GoSL) launched the Energy Services Delivery Project (ESD) in 1997.

Project details

Energy Services Delivery Project (ESD), 1997-2002

ESD focused on promoting installation of household SHSs throughout Sri Lanka. It was funded by the credit line from International Development Association of the World Bank (IDA) and a grant from the Global Environment Facility (GEF).

ESD aimed to provide electrification to rural households that lacked access to the national grid. Women and children were expected to benefit the most: improved lighting would allow women additional time to undertake income-generating activities, while children would be able to study in the evenings, watch television and listen to the radio. Project preparation included extensive consultation with public and private sector stakeholders. ESD was implemented nationwide between 1997 and 2002.

Renewable Energy for Rural Economic Development Project (RERED), 2002-2011

Following the success of ESD, the GoSL launched the follow-on Renewable Energy for Rural Economic Development Project (RERED) in 2002. RERED promotes the same technologies as ESD, and is funded by the IDA, the GEF and the GoSL.

RERED was initially set to conclude in 2008. However, after project targets were met, the GoSL successfully negotiated with the World Bank to extend the IDA credit facility, carried forward the balance of the GEF grant, and provided counterpart funding to extend the project (with revised targets) until 31 December 2011.

Implementation

The project used a multi-stakeholder partnership approach.

The Ministry of Finance and Planning oversees the project. The Project Management Department of the DFCC Bank functions as the project Administrative Unit (AU) and reports to the Ministry. Specifically, the AU is responsible for administration of project credit, grants, subsidy and implementation of project support activities.

The project offers credit facilities through the IDA credit component for individual investments in grid-connected MHPs, SHSs and community-based VHPs (referred to as 'subprojects'). The credit is disbursed to investors through participating credit institutions (PCIs). Credit funds are disbursed to the PCIs by the Central Bank of Sri Lanka (CBSL), rather than flowing through the AU.

The GEF grant is used for project support and technical assistance activities, rather than direct funding of subprojects. Similarly to the IDA credit, the grant is directly disbursed by the CBSL to the respective beneficiaries. ESD did not receive funding from the GoSL. When RERED was introduced, the GoSL began contributing 20 percent of the cost for most of the project support activities, including project promotion, capacity building, Project Preparation Grants and consultancy assignments. It also contributes to the SHS subsidy scheme and provides attractive tariffs for RE IPPs.

Detailed Institutional set-up:

Table 23: Institutional set up for SHS - Sri Lanka

Funding Agencies	GoSL , IDA , GEF
Implementation and Administration	MOF&P , AU , CBSL
Financial Intermediaries	PCI/MFI
Beneficiaries	SHS Vendors , Consultants , SHS HH's , ECS's , RE IPP's

SHSs are provided and installed by SHS vendors. Vendors occasionally demonstrate and promote their products in off-grid areas; potential customers may also visit a branch office or a franchisee of a vendor. If interest is shown, the vendor's technician visits the customer's household and evaluates their electricity needs. If the customer requires a credit facility, the technician also performs a preliminary credit assessment and directs the customer to a microfinance institution (MFI). The MFI conducts a detailed credit evaluation and provides the loan. In the case of credit sales, the vendor collects a (typical) 15 percent down payment from the customer and installs the SHS. The MFI thereafter collects the installments from the customer as agreed (monthly or seasonally). SHS loan

tenures typically extend three years with 36 equal monthly installments. Since January 2006, the GoSL has provided a nation-wide subsidy to SHS buyers in the form of upfront discounts on SHS selling prices. The vendors claim this subsidy from the GoSL through the AU. In addition, the GEF provides a co-finance grant of USD

40 for installed capacities between 10 Wp and 20 Wp.

Impact / Outcome of the project:

Overcoming *the financial barriers was one of the most important outcome of these projects*.

Financing SHSs posed a challenge for large commercial banks in Sri Lanka, as network and operational overheads did not allow for appraisal of such small loans. Consequently, during the project's initial stages, financial appraisal of potential customers, provision of credit facilities and collection of loan installments were undertaken by SHS vendors. To provide consumers with credit, vendors obtained working capital loans from PCIs. However, it soon became clear that credit evaluation and collection were difficult, since the vendors' competence lay in sales and marketing; moreover, their borrowing capacity was limited. Consequently, the project started working with MFIs which had a rural outreach to provide credit facilities for SHS buyers. Initially, MFIs were ineligible for re-finance under the project's credit programme, and obtained working capital loans from PCIs. Eventually the eligibility criteria were revised to enable a host of financial institutions (including MFIs, finance companies, leasing companies and merchant banks) to become PCIs.

MFI involvement has had an immense impact on SHS sales in the country. Once MFIs – in particular, the Sarvodaya Economic Enterprise Development Services (SEEDS) – joined the project, SHS sales boomed, with 10,742 systems sold in 2001 alone. SEEDS went on to finance about 44 percent of all SHSs sold under ESD and about 63 percent of credit sales under RERED.

The project helped SEEDS establish a Solar Division, allowing it to move systematically into the business of financing SHSs. Initial technical assistance to SEEDS included preparation of a corporate plan for the Solar Division; development of a financial information system, a human resource development system and a management information system (MIS); a review of SEEDS' solar credit operation; and training of credit officers in SHS technology.

The SHS industry in Sri Lanka operates in a disjointed manner, with each vendor operating on their own. Identifying the potential benefits of having these vendors work together, the project helped form the umbrella Solar Industries Association (SIA) and provided the necessary seed capital to set it up. In addition, the project assisted in the purchase of SHS demonstration units and audio-visual equipment for road shows and field demonstrations, and sponsored market surveys to identify industry potential. The project also funded the design and printing of brochures, posters, banners, and radio and television commercials promoting SHSs.

With SIA and SEEDS support, the project provided training in SHS installation and O&M to over 500 technicians, including credit officers from MFIs. It is envisaged that these people will provide informal training to other SHS technicians during their careers with MFIs and vendors.

Success factors: Involving the MFI's in SHS financing, assuring consumer confidence by informing the customer, maintenance and service contracts and money back guarantee

Some of the other initiatives / projects worthy of mention:

Adoption of Solar home Lighting Systems in Karnataka*:* Karnataka, a state in India, has been one of the most successful markets for Solar Lighting Systems. The Karnataka model of Solar lighting systems without subsidies could provide insights for structuring policy support in other parts of the country and in other developing nations.

- Within India, Karnataka and Uttar Pradesh have developed an ecosystem for the sale of SHS systems. Rural banks offer flexibility for the repayment within the loan products they offer. The banks also create a feedback loop that improves the quality of the products and after sales services.
- In addition to providing credit, the SHS market is critically dependent on the role that the banks play in ensuring good service and maintenance .Banks also play a key role in acting as intermediaries between consumers and solar firms in rural areas.

Government programs should be carefully designed to match the incentives of the firms, banks and consumers if the success of the "Karnataka model" are to be repeated and amplified.

Kenya: "The ToughStuff" Story

ToughStuff International Solar PV has been involved in mitigation, adaptation and poverty reduction objectives. One of the countries where ToughStuff has been extremely successful is Kenya where it has been piloting a "*rent – to – buy*" scheme and a "*layaway*" scheme.

Key Factors:

- The key to ToughStuff's commercial success lies in an understanding of the needs of the market it targets. ToughStuff created an affordable and robust solar kit which is able to provide the poor with the basic services they need.
- Kenya suffered from the influx of low-quality and cheaply constructed hardware of solar home system products. ToughStuff was instrumental in developing a product quality assurance programme in an attempt to curtail the negative impacts of inferior solar lighting products. The ToughStuff Room Lamp Kit and Desk Lamp Kit recently passed the standards set by Lighting Africa.
- The firm utilizes established product distribution and wholesale channels in order to supply products to outlets such as mobile phone shops, supermarkets and electrical hardware shops. However, this strategy is also combined with a micro-enterprise programme called Business in a Box (BIAB). The BIAB programme aims to generate employment and 'stimulate entrepreneurship in local communities'; it also helps diffuse ToughStuff products in more remote off-grid communities who lack access to conventional retail outlets.
- Solar Village Entrepreneurs (SVE) are selected by staff and receive training related to the established ToughStuff business model. This process involves product and sales training, and access to networks

and marketing support is given. The firm also works with donor organizations and microfinance institutions in order to provide SVEs with access to credit, to start an enterprise

The company is also undertaking pilot studies in Kenya which include a 'rent-to-buy' and a 'layaway' scheme. The 'layaway' enables customers to incrementally build up savings through a 'mobile-phone based money transfer system'; once enough savings have accrued the customer is sent a message to collect the phone.

Distributed Renewable Energy & Microfinance: A Potent Combination - Nicaragua: Renewable Energy for Rural Zones Program (PERZA)

In Nicaragua 89% of the rural population were without electricity access in 2003. As the economy of the country depends to a large extent on agriculture, rural electrification is significant for economic and social development. While in the past the Nicaraguan electrification strategy was based on grid electricity the government started more and more also to consider off-grid solutions for rural areas. In this context the PERZA program was implemented to provide sustainable electricity service to selected areas and strengthen the government's institutional capacity to implement its national rural electrification strategy. The program was used to pilot some new sustainable delivery mechanisms and a variety of decentralized energy systems that are based in renewable energy technologies. International financial support and technical assistance came from the International Development Association (IDA) and the Global Environmental Facility (GEF).

PERZA concluded at year-end 2011, but its success is clearly evident: 6,863 rural Nicaraguan households gained access to electricity via solar photovoltaic (PV) home energy systems. PERZA also was successful in stimulating sustainable local entrepreneurial and business activity. More than 3,000 rural residents participated in PERZA program workshops and meetings. Forty-three business plans were developed, and 10 microfinance institutions now offer loans for rural electrification, according to Worldwatch's report.

PERZA is an excellent example of a national level attempt at integrating electrification with bottom – up small business development.

Case: Key features and factors that led to the success of the Solar Home System program in Bangladesh

The SHS program in Bangladesh was envisaged in 2003 to provide cost-effective electricity to the rural population and contribute to the improvement of living conditions and decrease in poverty. It was to be implemented by Infrastructure Development Company Limited (IDCOL) which was set up by the Bangladesh government. IDCOL created a centralized framework in which it not only administered the funding from donors and multilateral development banks to various energy access enterprises (Partnership Organizations) but also served in standardizing policy, technical standards and other relevant issues.

The programme has installed about 4.1 million Solar Home Systems (SHSs) in off-grid rural areas of Bangladesh till October 2016. 18 million beneficiaries have been provided with solar electricity covering 12% of the total population of Bangladesh as part of this programme. IDCOL initially received credit and grant support from the World Bank and GEF to launch the scheme. Later, GIZ, KfW, ADB, IDB, Global Partnership of Output-Based Aid,

JICA, USAID and DFID provided additional financial support for expansion of the programme. At present, 56 partner organizations (POs) are implementing the programme in the field level. IDCOL provides grants and soft loans as well as necessary technical assistance to the POs. POs are responsible for selecting customers, extending loans, installing the systems, and providing after sale service. IDCOL's total investment under the programme is US$696 million (BDT 52,240 million) out of which US$600 million has been obtained from loans and the rest as grants. IDCOL has a target to finance six million SHS by 2021, with an estimated generation capacity of 220 MW of electricity.

Details about the program have already been mentioned above in the report.

The key factors that contributed to the success of the program and the lessons learnt are -

- ***Providing technical and financial services through common interface***– Under the program, both, the installation and maintenance of the SHS systems and the extension of loans and collection of payments are done by the same channel - the local Partnership Organizations (POs). Offering technical and financial services via the same interface ensures that customers are not left alone after system installation, and the regular debt collection activity leads to a continued relationship between the PO and the customers.

- ***Overcoming the financial affordability barrier*** – In order to reduce the impact of the large upfront investment required to purchase SHS systems, IDCOL sourced grants from various development partners to partly subsidize the capital cost of SHS at the end user level. It also developed a financing and payment scheme for households who could not afford cash purchase. The structure was designed in a manner so that households end up paying almost the same amount as monthly installment that they would otherwise incur to run kerosene lamps. Hence it made sure that the payments to be made for SHS fitted the target customers' energy budgets. The POs were able to provide loans with longer repayment period of up to three years on account of the refinancing facility that was provided to them by IDCOL.

- ***Instilling a sense of ownership*** – Under the program the customers become the owners of the SHS after making full installment payments or the required one-time payment. This feeling of ownership encourages customers towards proper usage of the system. This has helped to ensure proper maintenance and upkeep of the SHS systems. Other approaches such as renting/leasing of SHS were tried but proved to be ineffective, as the customers were not dedicated to the upkeep of the SHS. The POs also provide free training to customers so they can carry out routine maintenance and repairs. The idea of becoming owner after full installment payments has also facilitated the POs in receiving regular payments from the customers.

- ***Quality Assurance framework that ensures sustained quality control and after sales service*** – In order to protect the interests of the end users and shift performance risk to the POs and suppliers, IDCOL devised a Quality Assurance framework that combined testing of SHS components and financing for approved packages with field inspections of selected installed systems and strong and enforceable warranty requirements. Under the framework, the components of SHS must be tested and approved before they can be used in an IDCOL financed SHS. The components must be configured into

a package that meets IDCOL system design requirements and must be sold with a warranty that meets IDCOL's requirements. Compliance of SHSs with IDCOL specifications is then assured through extensive monitoring, technical audits, field inspections, and the enforcement of financial penalties. The use of component testing and restriction of financing to approve SHS packages helps ensure that systems sold meet a basic set of component quality and system design requirements. Strong and enforceable warranty requirements ensures manufacturers must deliver high quality products in order to avoid the cost of servicing a significant number of warranty returns. Field inspections of sample installed systems are carried out so that SHS vendors know that at least some of their installed systems will be inspected to evaluate compliance with IDCOL requirements.

Shifting of most of the project risks to the POs and suppliers, increases the sustainability of the project and also mitigates some of the governance and corruption risk. When a SHS does not perform properly, households can stop paying their installments until the problem is resolved. The POs are bound to solve the problems identified by IDCOL inspectors or lodged by customers within 7 working days. Frequent complains and violations can also result in a possible termination and blacklisting. This robust Quality Assurance framework is one of the critical factors for the success of the program.

- ***Leverage PO's existing rural network*** - Developing an efficient supply chain network was crucial for the successful dissemination. The program leveraged the existing network and credibility of NGO/MFI operators present in rural Bangladesh by including them as POs. The existing institutional set-up of the NGO/micro finance institutions enabled them to reach remote customers in a cost-effective and efficient manner while the credibility that they enjoyed with the rural population helped in increasing the readiness of the households to try SHS. Due to their involvement in micro-credit operations, NGOs were also efficient in credit extension and collection mechanism.

- ***Effective capacity building initiatives*** – While the POs had network and credibility they were not technically proficient with SHS technology which was an essential element since most of the target customers were located in the remote rural areas, who had little knowledge and a lot of suspicion about the new product. This was addressed through effective capacity building and technical assistance that was provided by IDCOL through extensive trainings to the staff of the POs on various factors such as SHS configuration, positioning of SHS, installation procedure and guidelines, maintenance and troubleshooting of SHS, guidelines for monitoring and inspection of SHS, market development, micro-credit methods for marketing, and maintenance of battery used in SHS. 75 percent of the training costs were sponsored by IDCOL with the rest 25 percent shared by the POs. As part of capacity building, adequate logistical support was also provided to the POs in the form of tool boxes, motorcycles, demonstration kits, hydrometers, and battery chargers to render better services to the customers.

Case: Pay-as-you-go (PAYG) Business Model

In the past few years, in order to offset the relatively large upfront costs required for purchasing Solar Home Systems, a number of companies have started to develop and market products via a service model, known as

"pay-as-you-go". While there are a variety of technologies, payment rules, financing and ownership structures that are possible under the model, what they all have in common is allowing the end user to pay for SHS systems in affordable instalments and incorporating a technology enabled mechanism that enables the firm to disable the system if a payment is overdue.

A typical PAYG model offering works as follows –

- The firm offers a solar home system package for which the customer makes an initial down payment equivalent to around 10 percent of the total cost of the system.
- A payment amount is decided, which the customer has to pay regularly to avail the services of the system. The amount decided is usually calculated so that it is competitive with the daily expenditure on stop gap technologies or alternatives used such as kerosene
- The payments are usually made using mobile money or alternative ways such as scratch cards, direct cash payments or using mobile phone credit. The SHS is usually enabled to operate by instructions received via a built-in GSM chip or after the customer enters a code sent by SMS.
- Customers are either charged on per kWh consumed basis or can be charged per unit of time. Depending on the business model, the customer either makes scheduled payments or can top- up their account on need basis at any time.
- When the account is empty or in arrears, the SHS will stop functioning until a payment is made. The customer may either own the solar kit once a certain sum has been paid in (rent-to-own model) or make continuous service payments (perpetual lease or service model).

The PAYG model has been in successful operation in sub-Saharan Africa from the past 3 to 4 years, especially in the countries of Tanzania, Kenya, and Uganda etc. A number of international as well as local players are present there providing options of varied business models. Some of the bigger players include Mobisol, Azuri, M-Kopa etc. Simpa Networks also provides a PAYG model in India in collaboration with SELCO.

Benefits to the consumer –

- Helps in reducing the initial upfront cost and making it more affordable to the rural customers
- PAYG shifts the risk related to uncertainty of technology or that the manufacturer will not honor the warranty from the customer to the distributor. As the customer understands that the distributor or PAYG operator has a financial interest in the correct functioning of the system, it helps in assuring the customer regarding the technology and giving them more confidence.
- The better customer relationship as well as the usage data history also ensures that the PAYG operator is well placed to offer tailored and affordable upgrades to the customer in the long run.

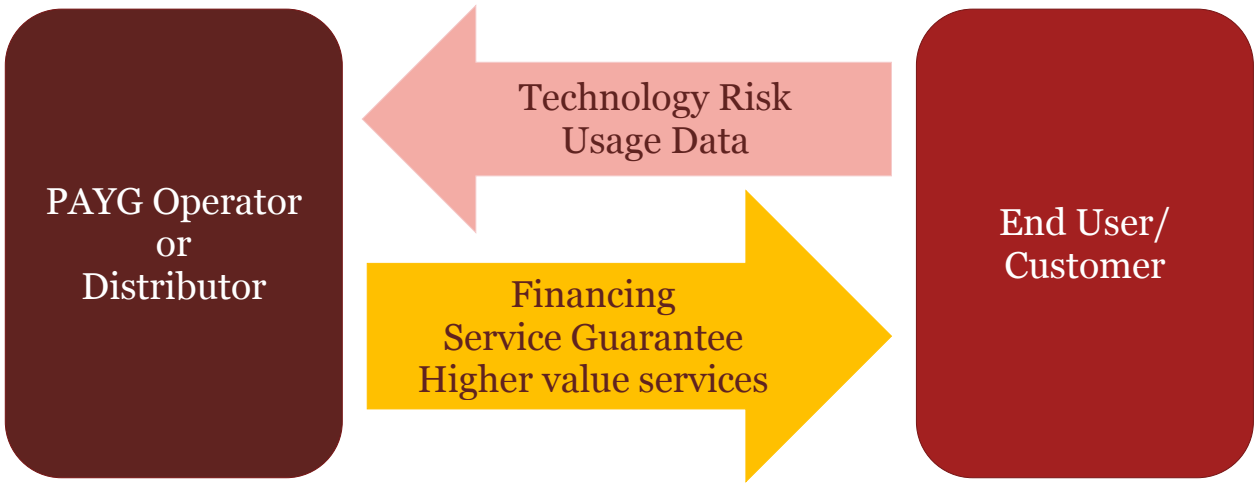


Figure 14: Benefits of Pay-as-you-go (PAYG) model for the end user

Prevalence of the lease-to-own model vs perpetual lease or rental model–

PAYG operators can either offer their customers a lease-to-own or energy-as-a-service model. In the lease-to-own model, customer payments go towards paying off the system and customers eventually becomes the owner of the solar home system. They can also complete their payments ahead of the collection schedule. In the energy-as-a-service model, customers pay for access to a reliable service (similar to a utility) and there is no incentive for customers to complete their payments in advance. They also never become the owners of the system. Overall, the lease-to-own model has been more prevalent than perpetual lease or rental model, as customer's value asset ownership for long term engagements.

However, the two models can be used complementary when approaching new customers. In Cambodia, Kamworks customers used perpetual lease as a low-risk, low- commitment way to test their home solar system before deciding to buy it. Of the customers who signed up for lease, 48% transitioned to rent-to-own or repaid their systems fully on a 24-month loan term.

Partnering with mobile operators to leverage their distribution network and fast track deployments –

PAYG operators are also tying up with Mobile Network Operators (MNOs) as partners and enablers for distribution of Solar Home Systems. The assets of MNOs includes sales network, logistics support, warehousing, after sales support and marketing. The far-reaching distribution and sales networks of MNOs, combined with their recognizable and trusted brands, gives PAYG operators the opportunity to leverage these assets to reach underserved customers.

Lumos & MTN Nigeria marketing and distribution partnership – In Nigeria, Lumos, maker of PAYG off-grid Solar Home Systems tied up with MTN, Nigeria's largest Mobile Network to distribute Solar Home Systems in the country. The partnership will allow MTN to support distribution, sales and after-sales service for the product. It also provides Lumos access to MTN's nationwide logistics, warehousing, inventory management, retail stores

and call centre services, which helps in keeping the cost of service to a minimum. MTN's understanding of the local market was instrumental to better address and communicate with customers while their existing customer base of 60 million subscribers offers a head start and fast access to the Nigerian Market.

Fenix International & MTN Uganda co-branding - Co-branding and marketing of the Fenix Solar Home Systems with MTN proved critical in establishing customer trust and creating pull in unproven market conditions. Before Fenix launched its product "ReadyPay Solar" in 2014, solar was often viewed suspiciously in Uganda due to sub-par quality products and unethical practices by other vendors. In addition to partnering with MTN Uganda for marketing and distribution, co-branding the ReadyPay systems with both MTN and Fenix's logos and matching the plastic casing with MTN's brand colour were instrumental to create early growth.

5. Recommendations towards Improvement

The implementation of SHS systems indicate similar experience and challenges in majority of the SAARC member states. As mentioned earlier the key challenges have been divided into 4 broad classifications - :

- ***Institutional and Organizational***
- ***Technical and Implementation***
- ***Financial***
- ***Social and Market Based Factors***

The country wise analysis of the above issues reveals that most of the problems are interrelated and cannot be solved independently from each other. The impact of various shortcomings do vary from country to country. Hence while solutions for certain issues are common and applicable for all member states, some solutions need to be tailored specifically for the individual member state. This section tries to provide recommendations and probable steps for overcoming the above barriers.

Institutional and Organization:

Government Bodies, Programs and Policies –

The government has the most important role to play in ensuring successful implementation of Solar Home Systems. Apart from the governing bodies, specific programs which have focus on rural electrification and subsequently on SHS are considered to be essential for success of any SHS program. Having a separate dedicated program for off – grid rural electrification using renewable sources ensures focused approach and planned targets. While all SAARC nations have government bodies and programs which are dedicated to off-grid or rural electrification it is also important that the governing bodies set holistic and overarching policy goals that provide a broad vision to all implementing agencies while also setting priorities, targets (in terms of SHS implementation) and accountability. Some countries that have committed programs for SHS such as Bangladesh, Bhutan and Nepal have seen success in increasing the usage and acceptance of SHS.

Centralized Vs De-centralized implementation –

For larger countries like India (3.287 million sq. km), Pakistan (7, 96,095 sq. km) and Afghanistan (652,864 sq. km), where there is wide diversity in terms of rural population, it is better to have more involvement of the local and regional bodies. Since these countries cover a larger area, it is difficult for a central authority to implement and monitor programs. In case of rural electrification projects, local state bodies and municipalities are in the best position to tell the technical needs of the people. The local population trust these state bodies and hence are more open about their needs while in conversation with them.

Additionally since the above 3 countries are divided into states or provinces it will be easier for the state governments to set individual targets and look after the complete implementation, execution and monitoring of the program while the central government can be responsible for planning and investment.

Despite the advantages of decentralization it may be problematic if local institutions in a decentralized administration lack the expertise, know-how and management capacity to administer the services. Additionally, efficient coordination between the central and local bodies is also extremely crucial for the success of such de-centralized implementation arrangement.

For relatively smaller countries like Bangladesh, Nepal, Bhutan and Sri Lanka, a centralised approach makes more sense. In this case, the central government will be responsible for the execution as well as monitoring, while planning should be done by involving the local bodies.

Electrification plan –

In most member states there have been multiple instances of villages getting grid electrified within a year of being provided with Solar Home Systems. Such issues occur because of the tendency for mainly top-down grid extension centralized planning. Instead efforts should be made to have an integrated national plan that takes into consideration national grid, mini grids as well as standalone systems. Policymakers should mix centralized top-down grid extension with decentralized demand-driven bottom-up strategies (mini-grids and standalone solutions). The territories to be electrified or are a prospect to be electrified should be clearly identified.

While this is an ideal scenario, creating such an extensive plan that has to be periodically updated is a massive task, especially for larger nations like India, Pakistan and Afghanistan. However, saving the interests of the rural households affected due to overlapping of on-grid and off-grid electrification is also important as in such a case the Solar Home System installed becomes a stranded asset for them. The government on its part should frame a policy such that if any household gets electrified within 3 years of receiving the SHS, provision should be there for the household to sell the SHS back to the implementing agency for a pre decided depreciated fee. Such a scenario will be easier to implement in countries where a secondary market for SHS may exist.

Kerosene subsidy –

Kerosene, candles and battery powered torches are the three most widely used lighting devices across most of the SAARC nations. Kerosene is used primarily for food purposes but many residents across SAARC nations use it for lighting purposes. The largest spending on the off-grid products comes from kerosene with households spending a considerable amount of their monthly disposable income.

While kerosene subsidies is provided in India and Bangladesh, the amount of kerosene subsidy provided in India is substantial. The Indian government has taken steps to gradually reduce the subsidy given to kerosene however it is still heavily subsidized. In Bangladesh, the subsidy on kerosene is not seen as an impediment on the usage of SHS. In most of the other SAARC nations there is no subsidy on kerosene, however the usage of kerosene for lighting purposes in these nations does serve as a barrier for SHS.

Policies in India must promote a transition from kerosene to Solar Home Systems. The size of kerosene subsidies should be gradually decreased through continued year-on-year reductions of allocations to states. Incentivizing the mechanism through cash incentives to states who uptake voluntary reductions has worked well in the past.

Policymakers in India can also look at introducing a solar voucher. Households could choose between a standard kerosene subsidy and a voucher that they can use to purchase solar products from a competitive market. Under this model, the voucher would allow households to replace traditional kerosene lighting with off-grid solar power.

Alternatively, even a direct cash transfer would reduce the bias against off-grid solar products. If households would receive their kerosene subsidy in cash, perhaps through India's Aadhaar system, households would not be forced to buy kerosene to benefit from the policy. Some households might continue buying kerosene, others would invest in solar lighting, and yet others would find completely different uses for their money. Unlike the solar voucher, this policy would not directly expand demand for off-grid solar technologies, but it would still remove the artificial advantage that kerosene has, thanks to generous subsidies.

Technical & Implementation:

Quality standards (Individual components manufacture, system integration, after sales service) –

All SAARC members have designated bodies which are responsible for specifying the technical requirements and quality standards of the individual components.

In India and Bangladesh, the government has a list of authorized and prequalified suppliers who can supply SHS systems. These SHSs adhere to the minimum quality standards set for them and a diligent checking and testing process is in place to ensure that these components meet those standards. But this provision has not been made mandatory for the commercial model where in the private / commercial players sell SHSs and its spare parts. This results in many cheap products entering the market through over the counter sales or private installations. The private suppliers in this case are not liable to provide after sales service and maintenance activities. They are also not bound to give any warranty on their products. This leads to low quality products and poor customer feedback once they break down.

In Pakistan, although the government has set quality certifications and performance standards (IES 61215, IES 61730, IEC 62124 and IEC 61724) for SHS components, it is not mandatory for private players to adhere to those standards. Hence sub-standard quality products are present in the market. In 2013, IFC estimated that close to 120,000 solar products were imported into Pakistan, majority of which were unbranded and offered no warranty. Only 11% of the products were quality verified products.

To counter these issues, there should be a quality framework which ensures that all SHS products sold, either through government schemes or through private players, should meet the quality specifications and performance standards set by the government. To implement this, the government should set up authorized test centers in the country and mandate that products of all companies should be independently tested and verified for quality at these test centers. Additionally, the government can also devise a quality mark (eg: like the ISI mark in India which is a certification mark for industrial products) for product specification of SHS that would indicate that the product is safe to use and is meeting the minimum requirements. All players should be mandated that their

products should have the quality mark. This will allow distributors and consumers to easily differentiate between poor-quality and high-quality products.

Along with standards, monitoring and adherence is also critical. Any supplier who does not adhere to the set quality standards should be penalized and even blacklisted for repeat offence. Surprise visits should be made to vendors and store owners to make sure that are not stocking or selling non-certified or low quality products.

The Lighting Global programme of IFC is already present in India, Bangladesh, and Pakistan and now in Afghanistan. This programme operates an independent, non-commercial global quality assurance framework for modern off-grid energy and lighting products. The Lighting global quality framework includes testing and verification of quality and performance of **off-grid solar products**. The framework seeks to strike an appropriate balance between quality and affordability, and seeks to rigorously evaluate product quality without interfering with the ability of manufacturers to innovate. This is done by an approach that focuses primarily on product durability and on confirming truth-in-advertising (*i.e.* making sure that manufacturer's advertised performance claims are accurate). Governments can also look at collaborating with the Lighting Global programme.

To tackle the growth of poorer quality products, market players will have to develop a more informed customer base over time and back this up by providing a positive brand experience. This will involve placing special emphasis on consistent and timely after sales service. Robust after-sales service mechanisms are important to attract distribution partners such as microfinance institutions, who are often reluctant to serve as distribution partners if they are left carrying the product risk associated with the sale. Assurance on quality through warranties (either repair or replacement) will also help generate the demand required to quicken the move of the solar lighting category from "push" products to wholesale and retail based "pull" products.

Battery recycling –

Disposal of used lead batteries is a major issue in all the SAARC member states. This challenge is bigger and more prevalent in countries like India, Pakistan and Afghanistan which are large in size and have a number of existing agencies who sell SHS via the commercial model. While lack of awareness among the end users is an issue, dealing and coordinating with a large number of last mile distributors present in India is also a major challenge. Additionally it is also essential on the government's part to monitor and make sure that the batteries which are recycled are done through a formal set up rather than through the informal sector where dismantling and recycling is done under uncontrolled conditions. The end users who are unaware of the harmful effects generally end up selling the disposed batteries to the informal sector who are able to offer higher proceeds since the cost of recycling through informal sector is cheaper.

With the above background, it is imperative that better processes are required to ensure safe disposal of lead batteries. Additionally, with the informal SHS market also starting to come up ensuring safe recycling of batteries becomes even more important.

Distribution Channel –

Pakistan and Afghanistan suffer from poor distribution channels and last mile distribution of solar household system products. One of the biggest constraints holding back the growth of the SHS market at the bottom of the pyramid has been the absence of proven last mile distribution strategies which simultaneously generates and meets demand. Last mile distribution requires peer-to-peer social marketing. Distributors must cover vast, sparsely populated areas with weak transport and communication infrastructure, and reach customers who tend to be suspicious of 'outsiders' and new technologies. Poor transport and communication infrastructure are the main reasons for poor distribution channels. A unique distribution model can overcome barriers like trust in solar technology and product availability. The distribution model is most appropriate at an early stage, when the trust, demand and market penetration are low, and it is vital to reach out to early adopters.

A community level distribution model builds trust and demand through a sequencing of routes to market, appropriate for different stages of market growth:

Promotions: In virgin markets, where demand is low to non-existent, local authorities help in bringing groups of volunteers together and train them to promote SHS to the local population. Once the local authorities have secured orders, the implementing agency deliver SHS for them to take back to their communities. Research has shown that it is only once trust has been built through this approach that local vendors and distributors are willing to stock and promote products.

Follow up sales: As demand begins to build and people see SHS working in their communities, local authorities directly act as mediators to sell the products in their community after taking SHS from the implementing agency, delivering them on public transport for them to sell on in their communities.

Dealer / Sales Agent Networks: Once enough demand and momentum has been created by sales to early adopters, one can plan to develop an ecosystem of dealers or sales agents to sell to the broader community. This can be the next step in the development of this model.

The above model has been replicated in Africa where in the implementing agencies have worked with the schools and head teachers to promote and distribute SHS. The model facilitates the creation of massive demand with a small team, at low cost, in a difficult environment.

Another model that will be of good use is the Franchisee Model. This model involves offering franchising packages to micro-entrepreneurs. In rural areas, such micro-entrepreneurs must travel around a large, sparsely populated area in order to generate adequate SHS sales. Demand for SHS and trust in the seller are critical factors which determine whether micro-entrepreneurs are able to generate sufficient income.

In contrast, in the above model head teachers are incentivized with free lights for their schools and homes, but are not reliant on SHS sales for their income. Head teachers offer a more appropriate route to market in the early stages of market growth, helping to generate the demand needed for franchise models to become viable in rural areas.

India, Bangladesh, Sri Lanka have satisfactory distribution channels to supply and promote SHS. However, all these countries can take a leaf out of the above model, as deemed necessary.

SHS can also be sold through retail outlets which may be directly owned by the government or by private entrepreneurs. Such outlets usually sell SHS over the counter while also providing repair and maintenance services. Since the entire cost of the SHS has to be paid upfront by the end user, affordability remains an issue. This often leads to low quality SHS being sold by the retailers which look attractive to the consumers but have a small shelf life. Such products also do not offer any maintenance or guarantee. Hence for the success of this model, it is necessary that only products from pre-approved vendors are sold over the counter. While it is easy to monitor this for government shops, the private entrepreneurs need to be incentivized by the government to follow such norms.

Such a model has been operational in India as a part of 'Akshay Urja' program and has met with mixed success. While a network of solar product distribution centers were set up around the country, many retailers struggled to connect their products to large markets of consumers on account of: high upfront costs remain burdensome for the consumers, maintenance problems aren't addressed, and competition with an expanding electric grid. [71]

Capacity building –

SHS projects have been implemented in a number of countries, but capacity building activities have tended to be concentrated in only a few of the areas where it is needed: the success of many projects is often hampered by a lack of capacity in the other, related areas. Raising awareness in only one or two areas will help increase the dissemination of the technology, but raising awareness and skills more widely will, in general, contribute to the rapid and sustainable implementation of SHS and assist in creating a sustainable market.

Almost all the SAARC countries have a long way to go in terms of building a workforce which will propagate the use of SHS.

The following skills, knowledge and expertise should be taken into consideration while enhancing the capacity building engagement.

- Understanding of the role of energy across various sectors, particularly health, education and water provision.
- Understanding of the value of electricity services to rural populations, its role in communities, and for income generating activities.
- Ability to carry out a survey of the current energy use of different facilities, businesses and households not connected to the grid and to determine the amount they currently spend on energy.
- Life cycle cost analysis of SHS compared with other renewable energy technologies.
- Understanding the different models for the deployment of SHSs in rural areas.
- Information on any SHS programmes carried out in the country and knowledge of the local capacity in SHS – from PSHS suppliers, rural enterprises, financing organizations and NGOs. Access to lessons learned from case studies of SHS programmes particularly locally, but also abroad.
- Socio-economic and environmental impact assessments of SHS and other competing technologies.
- Comprehensive knowledge of the costs associated with SHS and the various forms of financing available.

[71] Jennifer Richmond and Kartikeya Singh, 'Are India's Government-subsidized Solar Shops Thriving or Barely Surviving'

- Capacity to undertake promotional and educational activities to promote PV technology to the community. This could include development of information leaflets and/or booklets, local workshops and demonstrations.
- Knowledge of SHS technology and associated components, how to design a system and its installation and maintenance requirements. Awareness of the life expectancy of the SHS system components and the need for safe disposal and recycling.
- Understanding of the importance of the quality of SHS system components, installation and after sales service.

Apart from the above skills and knowledge it is also important that institutional support is provided to improve the administrative capacities of the relevant agencies, both in terms of sufficiency of human resources and setting professional HR standards policies and practices

Financing:

Program funding through subsidies/grants in the form of output based aid –

The relatively high initial investment costs and the irregular income of rural families is certainly an impediment in adoption of SHSs. Hence most programs in developing countries have either received grants from multilateral or development agencies or the respective governments have provided financial assistance. Majority of this assistance, including grants have been dispersed in the form of subsidies. Past experience has shown that providing subsidies directly to the end consumer is not a sustainable practice. It has more impact when the subsidy is addressed towards institution and capacity building measures.

Among the SAARC member states, grants in the form of subsidies from development agencies have been provided exclusively for Solar Home Systems in Bangladesh, Bhutan and Nepal and have been routed via the government. All the three countries have had good success in their SHS implementation.

In India, while subsidies from development agencies have been received by private players for regional implementation of SHS, majority of the subsidy has been directed by the government itself towards the consumers in the form of capital subsidy. While the subsidy has been temporarily stopped in May, 2017, concerns had been raised with regards to the long and complex process of subsidy application as well as time taken in receiving the subsidies. If the government decides to restart the subsidy scheme it should make sure that the process is more seamless, involves less paperwork and that proper accountability and timelines are set for faster disbursement of subsidy.

Pakistan and Afghanistan, both, have high potential for SHS installations considering the large number of rural households who do not have electricity access and still rely on fossil fuels for basic lighting. In both the countries while small scale and regional installation of SHS has taken place, no large scale national level program has been implemented. However, Pakistan does have few private players who provide SHS sets. In both the countries, the government needs to play a larger role and direct the grant funding it receives from multilateral institutions and bilateral donors for spurring the off-grid growth in the country. The emphasis should be to set up an off-grid electrification fund and structure a grant-subsidy mechanism in the form of Output Based Aid (like in

Bangladesh) that would link the payment of subsidies to the delivery of specific services, or outputs. Under OBA schemes, service delivery is contracted out to a third party, public or private, who is responsible for pre-financing the project and is reimbursed once services have been delivered and independently verified. The idea of the government should be to stress on "smart subsidies" that are transparent, rule bound and time limited while also focusing on creating an enabling environment through institutional capacity building and product development. Forming a dedicated fund will help in having a strategic dedicated focus. The fund should also aim to support feasibility studies for new business models, technology implementation, and providing access to finance for entrepreneurs and local businesses. It should also look at forming partnerships with commercial banks or microfinance institutions, to whom it can provide concessional loans based on certain quality criteria's or targets being met.

Develop or Leverage MFI's –

Microfinance Institutions (MFIs) play an important role in providing a supply of credit to the rural masses who do not have access to formal banking institutions. A well-established microfinance industry is a useful tool for SHS as it not only helps in lowering the initial investment barrier but also contributes through its wide network and rural penetration and the high trust levels that it enjoys with the rural population. It also allows an emphasis on usage of high quality products as reliability is the most important condition to ensure that an end-user will be willing and able to pay for instalments. The design of the microfinance plan is often done according to the existing energy expenses (on kerosene, candles etc.) in order to ensure that the users will be able to regularly pay the instalments.

Within the SAARC member states dissemination of SHS using microfinance institutions has been taking place in Bangladesh, Sri Lanka and India. While in Bangladesh, the MFIs worked under the ambit of the government program, in Sri Lanka and India, they tied up with private companies or implementing agencies. Under the Bangladesh microfinance model (known as one handed dealer credit model), the MFI is the provider of finance as well as in charge of installation of SHS as well as training, maintenance and after sales. Under the model followed in India and Sri Lanka (known as two handed business model), there is a long term partnership between the MFIs and a private energy service provider or implementing agency. While the MFI provides the finance the service provider is in charge of installation, training, maintenance and after sales.

In India and Sri Lanka, some MFIs have faced issues of irregularity in instalment payments. Also there have been instances where MFIs have complained about high administrative costs on account of physical door to door collection of instalments. On their part, both the MFIs and the energy service provider or implementing agency can ensure that quality standards of SHS sets are maintained, proper maintenance and after sales services are provided and adequate knowledge and information transfer regarding proper usage of the system is provided. Difficulties and cost related to credit assessment of end users can be minimized by bundling SHS systems with existing microcredit products such as agriculture loans and livestock etc. In order to ensure that unexpected expenses related to administrative costs do not come up, it is important that the financial scheme should be based on cost coverage principles irrespective of what people usually spend for traditional energy sources. It should take into account all costs including administrative costs such as collection of instalments. If the user's capability to pay does not allow cost coverage, it should be carefully evaluated whether the target group is the right one to

absorb a SHS dissemination programme, otherwise the selection of the target group should be reviewed and if necessary changed.

In Pakistan, while the microfinance industry is growing, lending for renewable energy initiatives has not picked up. It is important for the government to look at ways in which it can encourage commercial partnerships between MFIs and private SHS vendors. It can ensure that risks related to reliability of the SHS systems is mitigated by ensuring quality and technical standards are followed. It has to create an enabling environment by investing in training of on ground sales staff and creating awareness among the consumers. Even the bigger commercial banks will have to play a role in terms of increasing their outreach and providing access of capital. The banking regulator can help in developing a market of solar financing for rural population by setting performance targets for banks to increase lending for solar initiatives or by making it a part of priority sector lending.

Use of Innovative financing Models –

The use of innovative finance models such as pay-as-you-go (PAYG) has been a success in a number of African countries. While few private players in the SAARC member states have adopted this model, it has not yet been tried by majority of the players. PAYG is a completely customer centric model that combines solar and mobile technology. Both, the product and the payment arrangements are affordable, simple to use, reliable and convenient. Customers pay off the monthly instalments using their mobile phones and after one to three years, they fully own the systems. Various business models can be designed to respond to the needs of rural households and their ability to pay. Flexible credit facilities can be tailored depending on what customers' affordability and their income patterns. The mobile platform is able to link customers, equipment, support and payment such that it benefits both the customer and the provider. Most systems have the ability to remotely turn off the equipment if monthly payments are not made and to switch them back on again once payments resume. The various advantages of PAYG model to the consumer and the prevalent business models being used worldwide have been mentioned earlier in the report.

There has been a dramatic shift towards PAYG in recent years. A Bloomberg analysis found that "pay-as-you-go companies attracted twice as much investment as cash-sales companies in half the time."[72]

For models such as PAYG to be widely adopted in SAARC member states the respective governments' will have to take a number of measures to enhance the parallel development of mobile payments and financing systems. Apart from looking to strengthen the mobile infrastructure and facilitate mobile payment platforms, the government will have to make sure that transaction costs for mobile payments are kept low or exempted.

Government incentives – (import duty / taxes)

Governments should also look at developing a supportive tax and customs framework with consideration given to import and tax exemptions for import of solar technologies to be used in off-grid applications. The policy can be applicable during the initial phases in countries which do not have in house solar manufacturing capability. The exemptions will help in keeping the cost of SHS systems low.

Social & Market factors:

[72] Bloomberg New Energy Finance, Off-Grid Solar Lighting Market Trends, October 2015

Awareness and Promotion:

Low product knowledge and lack of trust stand out as the most important barriers to successful dissemination of SHS.

Low product knowledge: New products or services are not well known – and this represents a significant risk to consumers with little available income. The health issues around traditional energy sources like using open fires may be unclear. Thus, behavior change (e.g. to increase usage of a cleaner energy product) requires prolonged interventions.

- Above-the-line marketing through TV and radio advertisements typically makes little difference to actual sales, certainly in the early phases of growth.
- Direct engagement by field staff at the village level is needed to educate the consumer on the value of the product. Supplementing this with below-the-line marketing, such as product demonstrations, door-to-door selling and wall paintings, leads to higher sales conversion rates.
- High marketing costs and resource-intensive sales processes are difficult to absorb into a sustainable business model.
- Safer, cleaner and brighter energy must be seen as aspirational
- Focus on the right purchasing drivers. Economic benefit, i.e. cost savings or income-generating opportunities, will be valued far higher than health benefits. The field staff should work through the payback calculations with potential buyers and educate them about the benefits.
- Target the decision-maker. Early campaigns appealing to women in India typically failed, as husbands were not convinced. We have found this to be reversed in East Africa, where women are in sole charge of household expenses. However later the solar saheli model of promoting SHS was successful in India.

Lack of Trust: Low-income consumers are rightly skeptical about unknown brands promising them the world. They need hard proof that claims around cost savings, reliable performance, durability and customer care are true – and this takes time to build.

- Partnering with well-regarded and trusted brands can help early-stage enterprises build credibility and reduce risk perception
- Word-of-mouth is critical to sales in low-income communities where people rely heavily on the practical experience of friends, neighbors and particularly village elders to make important decisions. Early customers will be higher earners, who are more likely to carry weight in the community.
- Extensive after-sales support is needed to allow enterprises to help customers to use the product correctly, and to respond to those with bad experiences by issuing replacements or developing improved products. Warranties and guarantees are similarly crucial to customer loyalty.
- Independent standards or quality assurance will be increasingly important to build trust in new products as the markets develop.
- Female sales agent and entrepreneurs are far better than their male counterparts in selling SHS and its components. Customers find that women are better able to explain these products and are more likely to believe that they are safer and easier to use. This has been observed by Envirofit (a social enterprise

established in 2003 to develop technology that will reduce pollution and enhance energy efficiency in developing countries) and Dharma Life (a social enterprise that has recruited many village entrepreneurs to sell products like solar lamps etc. that improve quality of life).

6. Benefits and Outcomes

The benefits accruing from Solar Home Systems range from reducing poverty and improving the standard of living to mitigating macroeconomic instability.

- ***Enhancing Income Generation*:** SHS facilitates and opens up a variety of income generating activities. When compared to kerosene lighting, Solar Home Systems provide better quality lighting for small home-grown shops and businesses, enabling them to extend their business hours and thus their income. This boosts the livelihood of poor families depending on those shops and helps push them towards a better standard of living. A World Bank study stated that the benefit from enhanced income is close to 1500 taka monthly in Bangladesh.[73]

- ***Achieving Gender Parity*:** Energy also has a significant impact on gender equality. In some developing countries, the burden of collecting firewood or buying kerosene falls mostly on women. The provision of SHSs can help save this valuable time and allow women to use it more productively. According to UNDP 2013, in India a typical woman spends 40 hours collecting fuel per month during 15 separate trips, many walking more than six kilometers round trip.[74] The time saved for women coupled with access to electricity, opens the opportunity for new entrepreneurial initiatives to be taken up by the women which further enhances their status in the society.

- ***Increasing Communication and Awareness:*** Access to electricity enables rural population to connect to the rest of the world through the medium of radio, television or, at a more advanced stage, the internet. This provides access to entertainment facilities, but more importantly, keeps the people in villages in sync with the events across the country, and the world. Having enhanced media penetration eases the implementation of awareness programs or new public policies or schemes and thus helps the rural population to take a more active and informed decisions about the issues like health problems, customer complaints, government processes and policies etc. At an advanced stage, electricity access will complement the advent of internet penetration to open up a gamut of new possibilities.

- ***Improving Rural Health*:** Energy access can also prevent the incidence of diseases. According to the World Health Organization (WHO), approximately 1.6 million deaths (mostly women and children) occur annually caused by household cooking fires and the inhalation of indoor smoke.[75] Studies suggest that usage of fuels like coal or kerosene are significantly associated with increased chances of low birth weight and neonatal mortality.[76]

[73] World Bank, The Benefits of Solar Home Systems An Analysis from Bangladesh, 2013
[74] UNDP, 2013
[75] WHO, 2014
[76] Demelash H, Motbainor A, Nigatu D, Gashaw K, Melese A, Risk factors for low birth weight in Bale zone hospitals, South-East Ethiopia : a case–control study. BMC Pregnancy and Childbirth, 2015

The problem is only elevated by the fact that, according to the World Banks's Global Tracking Framework (2017), the twenty high-impact countries in Asia and Africa (including four of the SAARC members) account for three quarters of those who use such fuels for household cooking and heating.

Secondly, with access to media, people would be better aware about any spreading epidemic diseases and thus enable them to take the right action at the right time.

- ***Improving Rural Education***: SHS would improve rural education in multiple ways. Firstly, SHS increases electricity penetration which has a direct impact on rural education. Studies have observed a strong correlation (above 66%) with electricity consumption per capita and higher scores on the education index (a proxy for the mean years of schooling a student receives—across 120 countries)[77]. Secondly providing continuous access gives students the option of extending their study hours which was earlier not possible with kerosene lighting. A World Bank report states that SHS adoption has increased the evening study hours of both boys and girls in Bangladesh[73]. Thirdly, with access to media, students have an additional source of information which increases their general knowledge and enables them to question / challenge their existing understanding.

- ***Ensuring Safety***: SHS ensures 24x7 access to lighting and thus helps people to be aware of their surroundings. According to a news article in "The Guardian", 80% of the leopard attacks, in places with no access to electricity, happen when people go out to answer nature's call after dark.[78] This was just an example. Increased access to lighting in the vicinity of the house leads to, not just reduction in animal attacks, but also a decrease in the possibility of thefts.

- ***Reducing Oil Dependency***: Reducing dependence on non-renewable resources is not only environmentally friendly but also economical and sustainable. Dependence on fossil fuels makes countries more vulnerable to oil price shocks and can lead to macroeconomic instability. According to the World Bank report, average household saves 2 liters of kerosene per month by adopting SHS and thus helps in tackling this issue.

[77] UNDESA, Electricity and education: The benefits, barriers, and recommendations for achieving the electrification of primary and secondary schools, 2014
[78] The Guardian, The leopards of Mumbai: life and death among the city's 'living ghosts', November 2014

7. Conclusion

The high solar potential of all SAARC member states gives them an opportunity to provide cost-effective electricity access to the rural population through Solar Home Systems. All member states have received varied amount of success in SHS implementation in their respective countries. While Bangladesh acts as a role model in the dissemination of SHS, India and Nepal have received mixed response. Pakistan and Afghanistan on the other hand have witnessed low penetration of SHS and hence in terms of market potential would rank highest amongst its SAARC peers. Potential of SHS in Maldives is low considering that all inhabited islands have their own generation and distribution facility with all households within the island connected to the island grid.

High	*Medium*	*Low*
Bangladesh, Sri Lanka, Bhutan, Nepal	India	Pakistan , Afghanistan

** SHS is not an optimal solution in Maldives*

Figure 15: SHS penetration in SAARC member states

In order to increase the adoption of SHS in the region, it is important to address three primary barriers: Affordability, Awareness and Availability. SHS can be made *Affordable* for the rural population by availing output based grants and subsidies or/and by leveraging the distribution network and traditional financial schemes through MFIs or/and using innovative consumer centric financial models like pay-as-you-go (PAYG). It is important to ensure the *Availability* of good quality SHS systems through setting up a robust quality assurance framework involving technical standards, stringent monitoring, adequate after sales service and effective capacity building. A*wareness* of the end users about the benefits and proper usage of SHS can be increased by adequate promotion and dissemination of information through innovative channels of communication.

The below table summarizes the primary barriers and their impact prevalent in individual countries, and subsequent recommendations to overcome these barriers. It should be noted that most of the barriers are interrelated and hence cannot be solved independently from each other.

Table 24: Summary of major barriers and recommendations

Issue	*Impact*			*Comments*	*Recommendations*
	High	*Medium*	*Low*		
Overlapping of grid and off-grid	Nepal	India	Bangladesh , Bhutan , Sri Lanka	Barrier not faced in Pakistan & Afghanistan due to low SHS implementation	• Integrated planning required between off-grid & on-grid. • Alternatively, develop policy to buyback SHS if the concerned area is electrified within *3* years.
Institutional weakness		Pakistan & Afghanistan	Bangladesh , Nepal , Bhutan , Sri Lanka , India		• Large countries like India, Pakistan & Afghanistan should have active involvement of central as

					well as local authorities (de-centralization)
Conventional fuel subsidies	India	Pakistan	Bangladesh , Pakistan , Nepal , Sri Lanka		• Encourage direct cash transfer or reallocate subsidies via solar vouchers
Quality issues	Pakistan , Afghanistan	India	Bangladesh , Bhutan , Nepal & Sri Lanka		• Technical standards for all components • Authorized testing centres • Mandatory after sales service and warranties for government and all commercial players. • Non – adherence will invite strict penalty.
Capacity building	Pakistan , Afghanistan	India	Sri Lanka , Nepal , Bhutan , Bangladesh		• Set up dedicated training centres
Last mile Distribution	Pakistan , Afghanistan	India	Bhutan , Bangladesh ,		• Community level distribution channel should be present which promotes , follow up sales activities and monitors dealer / agent networks
Battery Recycling	India , Sri Lanka , Pakistan , Afghanistan , Bhutan , Nepal	Bangladesh			• Better processes should be in place to ensure safe recycling of batteries
Program funding through grants / subsidies	Pakistan , Afghanistan	India	Bangladesh , Sri Lanka , Bhutan , Nepal		• Structure grant subsidy mechanism in the form of output based aid. • Stress on smart subsidies that are transparent rule bound and time limited
MFI Set up	Afghanistan	Pakistan	Sri Lanka , Bangladesh , India	Bhutan & Nepal – SHS implemented without MFI	• Government should look to create an enabling environment and encourage commercial partnerships between MFIs and private SHS vendors
Use of Innovative financial model like PayG		India , Pakistan	Bangladesh , Bhutan	In Bangladesh, Bhutan & Nepal funding has been through grants and aids.	• Players should offer consumer centric and customizable models using mobile payments

				• Government should look to facilitate and enhance mobile payment platforms
Awareness of SHS	Afghanistan	Nepal , India , Pakistan	Sri Lanka , Bangladesh	• Increase product knowledge and trust among customers • Look at innovative approaches to widen channels for promotion and implementation

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