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RENDEV

D16 Financial model design

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The RENDEV project

The RENDEV project aims to explore ways to link microfinance and access to renewable energy, bringing a positive contribution in rural development and poverty alleviation in Bangladesh and Indonesia by increasing access to solar energy, the development of micro enterprise, and the provision of microfinance mechanisms tailored for low income people's needs.

The project started in January 2007 and will last until December 2009. RENDEV is financed by the European Commission under its Intelligent Energy line.

The main objectives of the RENDEV project are:

- To promote development of income generating activities with renewable energy supply;
- To identify measures justifying involvement of Small and Medium Sized Enterprises in the solar energy sector;
- To build synergies between the microfinance sector, the renewable energy sector and the micro enterprises in Bangladesh and Indonesia;
- To better inform stakeholders providing pro-poor sustainable renewable energy services;
- To bring a positive impact on the quality of life in rural districts.

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The RENDEV final international conference took place in Dhaka, from 7th to 9th December 2009. On Monday the 7th, a workshop was organized to discuss the recommendations of both D16 with the main stakeholders of the two countries. Concerning the Bangladeshi representatives, here is the validated action plan that was discussed during the workshop. The objective is to expand/improve the REREDP to reach poorer populations. 45
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Executive Summary

Solar PV has reached a large part of the rural population of Bangladesh within the past 10 years with the introduction of national SHS program being implemented in the country. On the average 12,000 SHS are currently being installed per month in the rural sector through 15 partner organizations of IDCOL, which has streamlined the marketing, financial and technical models[1][2][3] developed in period of 1998 to 2001. The widespread presence of NGOs typically engaged in various rural programs, where micro-credit is disbursed in particular, is an advantage for this rapid dissemination of SHS. Micro-financing of SHS to rural households has therefore been successful under the program being funded with IDA funds of the World Bank, KfW, GTZ and others.

This study reveals that the unmet demand of electrification among the lower income poor households can be satisfied with a few targeted solar electrified appliances. The mainstream products currently being marketed cater to the middle and higher income population. Considering the high upfront cost, the SHSs are still beyond the affordability of most of the rural people of Bangladesh. Very few households can purchase them with cash. Selective provision of low cost solar electrification options will become popular to this income group who are willing to spend about 300 Taka per month for lighting by substituting their current cost for kerosene wick lamps and lanterns. Local production of such amenities can be a possible solution to be reached. Current growth of solar hardware suppliers in the country indicates that the market potential is high. More NGOs can be encouraged to participate in dissemination of solar appliances among the nearly 100 million un-electrified populations. It is also expected that some of the future systems will be scaled down to cater to lower income households as well.

Under these circumstances, possibility of payment on installments under the Government's RERED project implemented by IDCOL has proved to be a very strong instrument in making SHS attractive to the rural people. Since 2002, the GOB has supported the national solar program of IDCOL, which has produced the most successful off-grid electrification scheme in the country. Due to the high level of investment needed, mostly higher income households can purchase the typical models of SHS with cash or credit.

Although a very attractive micro-financing scheme is operational, considering the high upfront cost and overall cost, the SHSs are still beyond the affordability of majority of the low income rural households of Bangladesh. It is hence expected that some of the future systems will be scaled down to smaller sized SHS (e.g 10Wp to 20Wp) to cater to lower income households. Nationwide sales of small solar home system (SSHS) are currently underway, and the extension to the rural poor will be possible through the proposed recommendations involving the NGOs engaged in the locations.

[1] *Market Assessment Survey of Solar PV Application in Bangladesh,* by Prokaushali Sangsad Limited for The World Bank, 1998.

[2] *Feasibility Study for a Solar Home Project within the Context of Alternative Options for Rural Electrification,* by Prokaushali Sangsad Limited for The World Bank, 2000.

[3] *Bangladesh Rural Electrification – Solar Home Program Preparation* by Prokaushali Sangsad Limited for The World Bank, 2001.

The proposed scenarios are practical alternatives for extending solar electrification to the rural poor who are beyond the reach of existing SHS operations in the field. ***Financing portable solar lanterns*** are viewed as one of the most promising approach for the rural poor. This type of lighting for the lowest socio-economic group can only be disseminated through the local NGOs, and GOB's national solar program (via IDCOL) may finance them parallel to the solar home systems.

The study recommends four scenarios to be adopted for serving the rural poor of Bangladesh with solar power:

- Scenario 1. Solar PV for household lighting of rural poor adapting IDCOL financial model

  - LED and CFL based Small Solar home systems SSHS with solar panel of 10 to 20 Wp for the rural people from middle class to lower middle class family.

- Scenario 2. Portable solar PV solution for the poorest with micro-financing.

  - Portable Solar Lanterns with LED and CFL
  - Solar PV based Battery Charging stations in remote rural villages to charge batteries to run LED lanterns, lamps, mobile chargers etc.

- Scenario 3. Adaptable systems for commercial application of solar PV targeted toward the poor.

  - Mini grid system for rural markets
  - Micro-Utilities in rural markets
  - Solar PV water pumping system
  - Micro enterprise electrification

- Scenario 4. Socially motivated applications that are highly subsidized for the public.

  - School Electrification
  - Solar PV for Street Lighting
  - Health Clinic and Hospital Electrification

In summary, the proposed scenarios offer some measures that can contribute to objectives of RENDEV project in compliance to the National Energy Policy of Bangladesh (1996). In particular, this includes:

- *Environmentally sound and sustainable energy for continued economic growth, especially for the lower and middle income rural population.*
- *Energy needs of different socioeconomic groups, in particular to meet the need of the poor.*

List of Abbreviations

CBO	Community-Based Organization
CDM	Clean Development Mechanism, for carbon credit acquiring (United Nations)
Commission	European Commission
CEWDC	Coastal Electrification & Women's Development Cooperative
GoB	Government of Bangladesh
IDCOL	Infrastructure Development Company Limited
IPP	Independent Power Producer
LED	Light Emitting Diode
MCP	Microcredit programs
MFI	Microfinance institution
MRA	Microcredit Regulatory Authority
NGO	Non-Governmental Organization
PBS	Palli Biddut Samity (rural cooperative for electrification)
PGCB	Power Grid Company of Bangladesh Ltd
PSL	Prokaushali Sangsad Limited
PV	Photovoltaic
PO	Partner Organization
REN	Renewable Energy
REREDP	Rural Electrification and Renewable Energy Development Project
REB	Rural Electrification Board
RES	Renewable Energy Sources
RFM	Rural Financial Market
RMG	Ready-Made Garments
SHS	Solar Home System
SSHS	Small Solar Home Systems
WB	The World Bank

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1 Introduction

The focus for RENDEV

The RENDEV project aims to complement and strengthen the existing dynamics by focusing on those aspects which are not covered by the current design of the REREDP project, without interfering with the development of the solar market. In particular RENDEV will focus on:

- **How to reach poorer people**; currently SHS are used mostly by the middle and high income families, whereas the poor are still unable to afford it. Different solutions are thinkable, e.g. in the short term the initial investment can be decreased through the use of smaller SHS system and/or a higher grant. In addition, sale of solar system has to be linked with income generating activities. The experiences of the pilot project which is currently being funded by GTZ consisting of 24,500 small SHS might offer interesting ideas on this front;

- **Target Small and Medium sized Enterprises**; aiming to link electrification through PV more closely to income generation. Potential areas of focus include agriculture and food processing, and a range of services at local markets. The focus of the RENDEV activities should be to identify innovative and promising initiatives related to the above mentioned areas and next to support, strengthen and wherever possible multiply these initiatives.

Previous studies done under the RENDEV project have already allowed reviewing the strengths and weaknesses of Indonesian and Bangladeshi solar energy experiences, identifying the needs and markets for REN technologies, and assessing the potential role of microfinance institutions in both countries.

Building on the findings of these studies, this report seeks to provide recommendations on financial schemes that could effectively promote solar energy access in Indonesia, on the role of microfinance within these schemes, and on the different steps that should be taken to design and implement an adequate national solar energy program on the basis of the recommended financial models.

2 Context

Main ideas:

Electrification situation

Shortage of power supply, at times very acute and unreliable, has constrained economic growth. The lost output is, according to some estimates, as high as one percent of the GDP. This is critical because the foregone economic growth could have taken Bangladesh beyond the threshold of 6-7% of GDP growth rate that many policymakers think could make a significant and sustained dent on poverty. Around 80 to 90 million Bangladeshis still do not have access to electricity. 85% of them live in rural areas.

Renewable energy, and in particular solar energy, has a high potential in Bangladesh, and could be a solution to the electrification of rural, remote areas, especially for lighting and information.

Microfinance situation

Bangladesh is, in many ways, the most developed microfinance market in the South Asian region. Both India and Bangladesh count 16 of the 20 largest Microfinance Institutions (MFIs) of South Asian region.

Previous studies undertaken through the RENDEV project assessed current energy needs and the state of microfinance development in Bangladesh (*D3 – Overview of policies, Bangladesh; D8 – Needs assessment analysis and market feasibility for solar energy applications, Bangladesh; D14 – Identification of Microfinance Institutions, Bangladesh*). A brief summary of their findings is provided here as a reminder of the context of electrification and microfinance in the country.

2.1 Electrification situation

Electrification needs in Bangladesh

The total installed capacity for electricity production as of October 2009 was about 5,719 MW including Independent Power Producer (IPP) in utility service. The plants are predominantly thermal, and natural gas fired (natural gas is an indigenous fuel). Since power sector reforms in 1998, IPP have been investing capital to build, own and operate power stations. Total capacity under private ownership for utility service is 1,542 MW including small IPP and rental (28% of total). The largest power station so far built is the Meghnaghat Power station with a capacity of 450 MW in one block. Estimated capability is about 4,300 MW, out of this, daily availability is only about 3,700 MW.

The **electrification rate** of the country is now **42%,** but the **rural areas** are not as developed as the urban areas seeing that their electrification rate is only **23 %** (against 79% or urban areas). The break-up of electricity consumption is shown on the diagram below[4]:

[4] Data from http://banglapedia.net/HT/E_0055.HTM

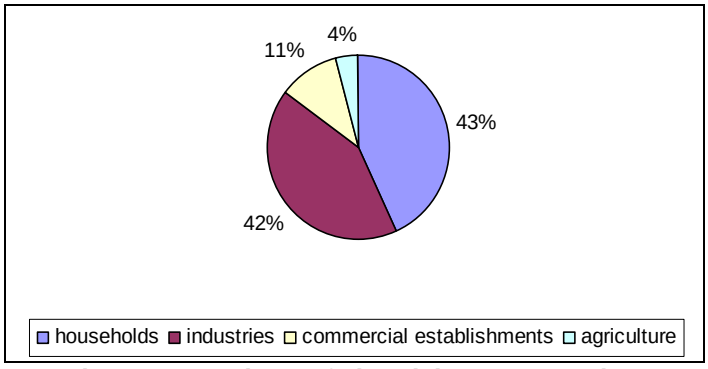

Figure 1: Break-up of electricity consumption

Bangladesh has a large unsatisfied demand for commercial energy with most of the supply limited to urban areas. The country's economy operates at low levels of commercial energy consumption, which is a crucial bottleneck to economic development. The country has nevertheless had an **economic growth higher than 5%** for a few years, which led to an **increase of the electricity demand of 10% per year** (around 500 MW per year).

But against current demand of about 5,000 MW estimated, an average of about 1,000 MW has fallen short in capability out of 5,700 MW installed capacity due to old age. Additionally, about 1,300 MW has fallen short in availability out of 4,400 MW of capability due to lack of maintenance and shortage of gas supply. The graph below illustrate the unsatisfied demand: it shows the evolution of generation capability and the electrical demand (around 170 kWh per inhabitant and per year) between 1995 and 2007.

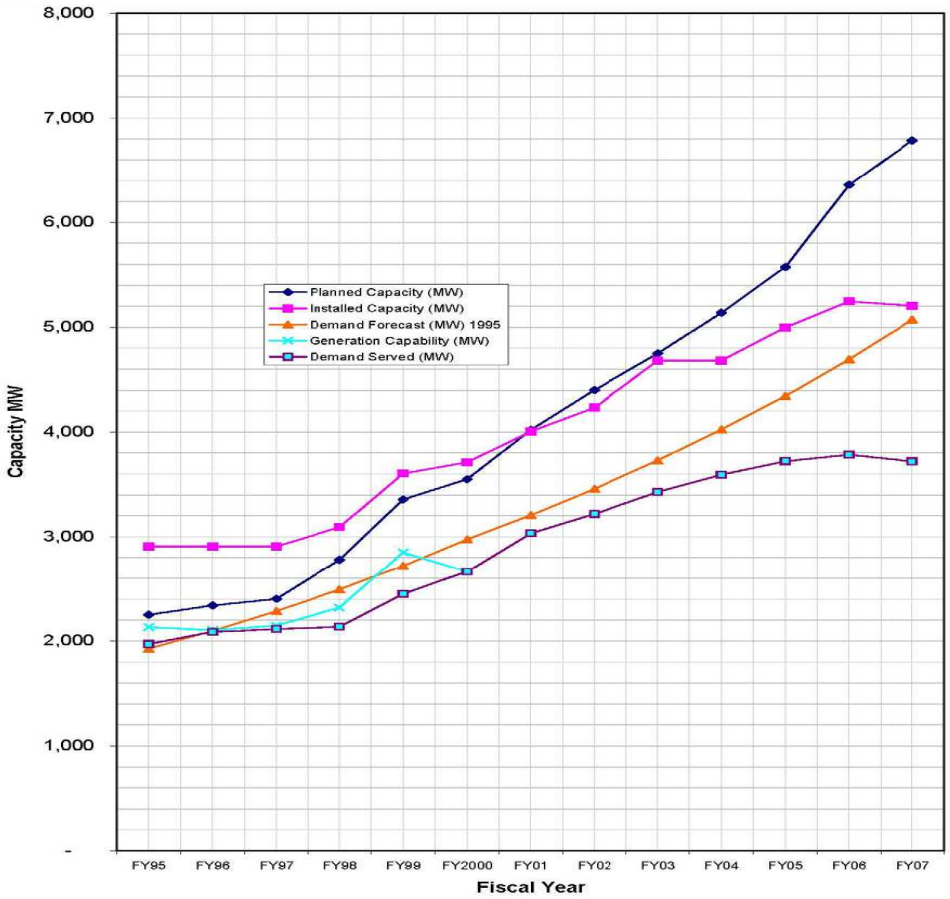

Figure 2: Installed Capacity, Generation Capability, Demand Forecast, Demand Surveyed and Planned Capacity

Under these circumstances, the Government of Bangladesh (GoB) launched the REREDP to provide remote rural populations with electricity through grid extension and Solar Home Systems (SHS). But a large population is still not served by the NGOs under the national solar electrification program, and is beyond any grid electrification plan. The energy needs of this population (households, farmers, fishermen, micro entrepreneurs) are still unsatisfied.

Grid expansion and limits

Grid expansion

The picture below is a scheme of the national electrical grid of the Bangladesh provided by the Power Grid Company of Bangladesh Ltd (PGCB)[5]

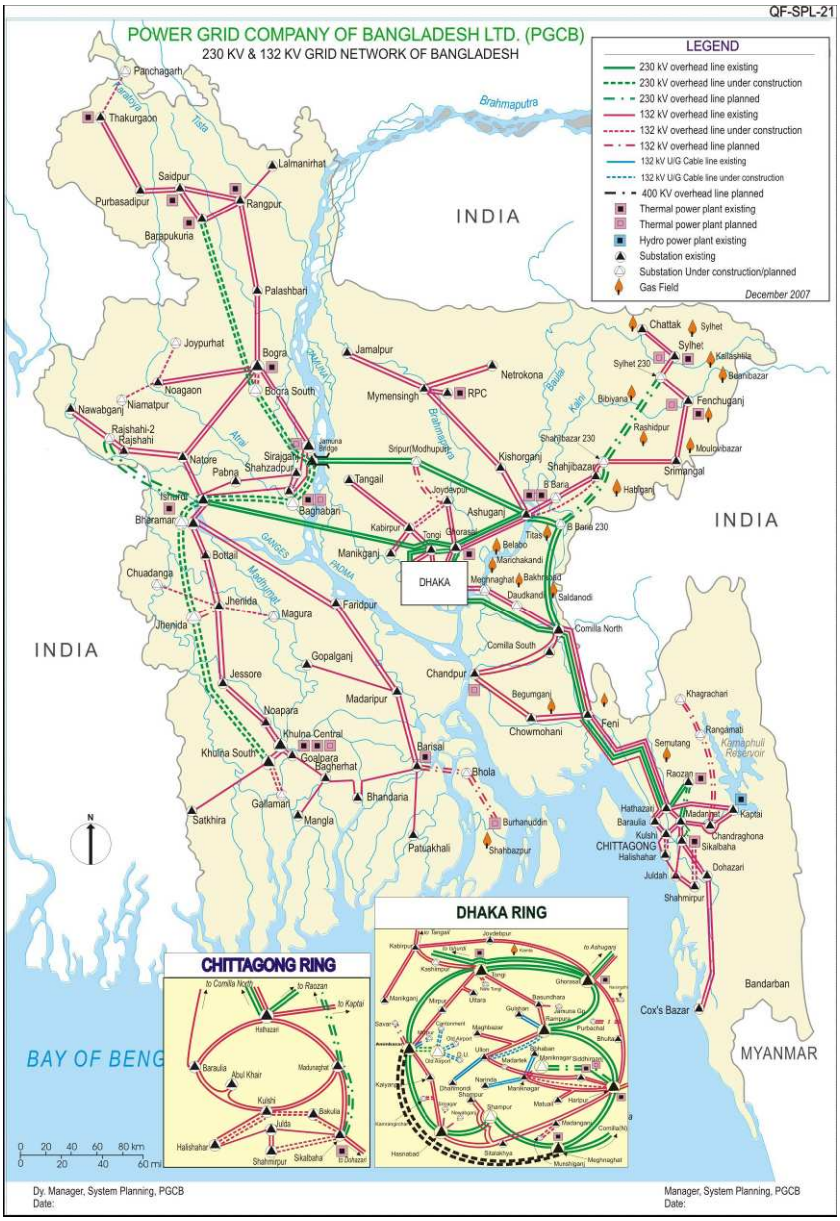

Figure 3: Bangladeshi electrical grid

[5] Data from http://www.pgcb.org.bd , December 2007

We can see that the grid spreads on a relatively great part of the country, but still leaves many regions out of it. Problems in the power system in Bangladesh include shortfall of generation, load-shedding and low voltage, largely due to excess pressure on the supply network, dilapidated transformers and transmission lines or management failures in distribution systems. Of course, the quality of the grid kept on improving for the last years but there are still some dysfunctions. The following chart shows the expansion of the grid (132 and 230 kV transmission lines) since 1980[6]:

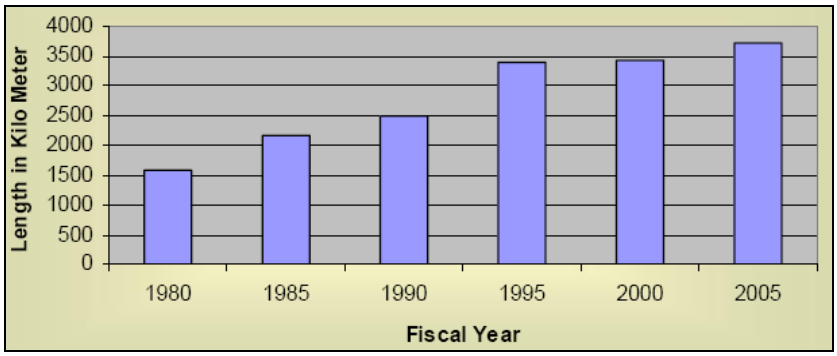

Figure 4: Grid expansion

Grid limits

There has been **generation shortfall** towards power demand of the country for the last 7 years. So, nationwide power supply system is facing inevitable **load shedding**. No consumer groups are spared except the agricultural consumers. Even in the midnight, load shedding becomes necessary almost everyday. This consequently causes great distress to the industry. For example, it was observed that the feeders supplying power to Ready-Made Garments (RMG) factories are switched off 3 to 5 times a day during the production time of the factories. In each power cut, the load shedding time is almost fixed to one hour. During this period, stand-by generators are run and almost all the RMG factories are now equipped with their own captive power plant. But small factories without such standby generators face production loss. Moreover, the cost of electricity produced by diesel oil has been estimated to be Tk.11 to 15 per kWh which is 3 to 4 times higher than that supplied by utilities.

We can say, generally speaking, that the reliability of the grid is rather poor but we also have to take into account that about 30 to 40 % of the power plants will have to be replaced in short-term because of their dilapidation. **Interconnections** with the countries of the South Asian Association for Regional Co-Operation (SAARC) that encompasses 8 countries (Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka, Afghanistan and Bangladesh) are planned. This will enable to decrease load shedding, to improve reliability, efficiency and cost-effectiveness of the electric service but it doesn't necessarily mean that it will impact the electrification of the rural areas.

Renewable energy potential

Renewable energy contributes about 40 % of the energy consumption in the country, mainly through biomass, e.g. agricultural residues contribute almost half the national total, with cow dung, bagasse and fuel wood making up the rest.

[6] http://www.sari-energy.org/PageFiles/What_We_Do/activities/GEMTP/Bangladesh_Presentation.pdf (« Global Energy Market Trading » USAid, Feb. 2008)

Developing renewable energy access can address the electrification problem of rural and isolated areas. **The potential for some types of renewable energy** (solar and biomass), **is very significant, while others (wind,** hydro, geothermal, ocean) are not yet feasible. The potential for solar energy, in particular, is major: the yearly **average solar irradiation in the country is 4.5 kWh/m².day.**

But current utilization of the potential for renewable energy is minimal, apart from the 230 MW of hydropower being produced at the Kaptai Hydropower Plant, the approximately 385,000 SHS that have been installed as part of the REREDP conducted by IDCOL, and the extensive use of biomass for cooking and processing of rice and other agricultural products.

The deployment of those available fossil and renewable energy sources in a balanced mix could enable Bangladesh to relatively easily **step up** from its current **growing economy by 6-7% to 8-9% per year**. Moreover renewable energy is best placed to provide access to energy **in remote and rural areas**. The continued and improved development of energy services for the poor can play a triggering role in tackling poverty by increasing economic activity in both agricultural and industrial areas, thus creating income generation opportunities and livelihood improvement.

As the potential is there, it is rather a matter of putting in place the right framework conditions at policy and regulatory level in order to step up the level of deployment of renewable energy in general, and solar energy in particular.

2.2 Microfinance situation[7]

Financial system in Bangladesh

The financial system of Bangladesh consists of Bangladesh Bank (BB) as the central bank, 4 State Owned Commercial Banks (SCB), 5 government owned specialized banks, 30 domestic private banks, 9 foreign banks and 29 non-bank financial institutions. Moreover, the Microcredit Regulatory Authority (MRA) has given license to **335 Micro-credit Organizations**. The financial system also embraces insurance companies, stock exchanges and co-operative banks.

Micro Finance System

Microfinance Institutions

Bangladesh is, in many ways, the **most developed microfinance market in the South Asian region.** India and Bangladesh together account for 16 of the 20 largest Microfinance Institutions (MFIs) of South Asian region.

The MFIs constitute a rapidly growing segment of the Rural Financial Market (RFM) in Bangladesh. Microcredit programs (MCP) in Bangladesh are implemented by various formal financial institutions (nationalized commercial banks and specialized banks), specialized government organizations and Non-Government Organizations (NGOs). The growth in the MF sector, in terms of the number of MFIs as well as total membership, was phenomenal during the 1990s and continues till today. Over the period of June 2003 to June 2006 the growth rate was over 70% in terms of horizontal expansion of microcredit borrowers.

[7] http://www.bangladesh-bank.org/

Microcredit programs of NGOs (known as NGO-Microfinance Institutions or NGO-MFIs) and Grameen Bank play dominant role in this financial market. NGO-MFIs serve more than 61% and Grameen Bank alone serves 24% of the total borrowers. Among NGO-MFIs more than 80% of the outstanding loans are disbursed by the top 20 NGOs and three of them are very large and have coverage all over the country. Service charge on credit varies from **10% to 20%** at flat method of collection. Average interest offered by NGO-MFIs on **savings** to the members is **5%.** About **90% of the clients of this sector are female**. Loan recovery rate is generally very high compared to the banking sector. Average loan size of NGO-MFIs was found to be around **Taka 4,000.**

Microcredit Regulatory Authority

MFIs in Bangladesh were left unregulated for a long time since their inception. The issue of a regulatory framework has come to the forefront because NGO-MFIs, the major provider of this service, are providing financial services to the poor outside the formal banking system. The government, with the close cooperation of the Bangladesh Bank, undertook efforts to establish a regulatory framework which culminated in the enactment of the Microcredit Regulatory Authority Act, 2006. The main responsibilities of the **Microcredit Regulatory Authority (MRA)** include issuance and cancellation of the license for microcredit, overseeing, supervising and facilitating the entire activities of MFIs. According to the Act, no MFI can carry out microcredit activities without obtaining licence from MRA.

4,236 NGO-MFIs have applied to MRA for licence by February 26, 2007. It was decided by the Authority that among these organizations, only those who can fulfil minimum criteria (**have equal to or more than 1000 borrowers, or equal to or more than Tk 4,000,000 loan outstanding**) will be considered for licence. Rest of the organizations that applied to the Authority had till June 2009 to reach the above mentioned minimum criteria. If they were unable to meet those criteria within specified time, they will have to close their microcredit operation. Applications from 705 institutions have been considered for license. After evaluating their application and real operations at field level, they are being finally considered as eligible to get license. Up to 11 November 2009the authority has issued 335 licences to different NGO-MFIs and licensing procedure of other selected NGO-MFIs are under process.

MRA is also working to prepare detailed rules and policies to monitor and supervise licensed NGO-MFIs that will cover governance issues, financial transparency, mode of operations and other related issues to ensure transparency and accountability in operation.

3 Identifying relevant financial schemes for promoting access to solar energy technologies

Main ideas:

There is a broad range of potential use of solar PV application in Bangladesh. Although many of these options are being explored in a small or pilot scale, most of these opportunities are already in operation in various extents that may be socially motivated application, demonstration projects, subsidized programs or commercial operation. The most successful application of solar PV in Bangladesh is the national solar program under execution by IDCOL, which is on-going since 2003. Depending upon the scope of use, direct benefit to the poor can vary significantly. The most attractive use of solar PV for the poor is in the opportunity of increased income generation, followed by individual household use.

This section provides recommendations for gaining most benefit from solar PV application for the poor on the basis of past experience with the pilot projects, household expenditure pattern, convenience of use, advantages and limitation of the technology and most importantly the delivery scheme of the financial model. In summary, there are four scenarios to be considered:

Previous studies undertaken through the RENDEV project assessed past and present renewable energy policies and programs in Bangladesh (*D3 – Overview of policies, Bangladesh; D7 – State of the art of solar energy applications in Bangladesh*). These studies identified the overall achievements and weaknesses of the financial models that have been implemented so far to promote access to solar energy technologies. A brief overview of the main findings is provided here.

3.1 Solar energy program in Bangladesh: achievements and weaknesses of the REREDP[8]

The Rural Electrification and Renewable Energy Development Project (REREDP) aims to provide rural and remote households with solar energy systems. It is the largest scale, and actually the most successful solar energy project being developed in Bangladesh thus far.

General presentation

The national solar program of Bangladesh, REREDP (Rural Electrification and Renewable Energy Development Project) has been launched in 2003, based on the wide experience of national NGOs and microfinance institutions (MFIs) in offering microcredit to rural populations. The financial model developed within the national program is based on two main ideas:

- Access to solar energy can be broadened using microfinance,
- Some level of subsidies is necessary to encourage and enable rural households to adopt solar technologies.

As part of the program, the Government of Bangladesh (GoB) provided loan fund from IDA to a Government owned non-bank financial institution IDCOL (Infrastructure Development

[8] http://www.reein.org

Company Limited) to execute the national solar program, implemented by its Partner Organizations (POs):

IDCOL provides soft loans and grants to partner organizations (POs: NGOs, microfinance institutions and others) so that they can in turn offer microcredits for SHS at a lower cost.

IDCOL offers soft loans of 10-year maturity, with a 2-year grace period, at 6% to 8% per annum interest to its POs. The loan amount (refinancing) is limited to 80% of the loan given to the households or USD 230 per system, whichever is lower. Usually, IDCOL does not require any collateral or security for the loan, except for a lien created on the project accounts. Unless and until there is an event of default, POs are authorized to operate the project accounts on their own.

In addition to refinancing, IDCOL also offers a subsidy grant for each installed system. As its principal objective is the commercialization of SHS, IDCOL has adopted a policy of reducing grant with the progress of the project, as detailed in Table 1. The grant is used both for reducing the capital price of the SHS and for institutional development of the partner organization.

Item	Amount of Grant Available per SHS/household		
	Total	Buy-down grant	Institutional Development Grant
The World Bank funds (GEF grant)			
First 20,000 systems	$ 90	$ 70	$ 20
Next 20,000 systems	$ 70	$ 55	$ 15
Next 30,000 systems	$ 50	$ 40	$ 10
GTZ funds			
33,660 systems	€ 38	€ 30	€ 8
KfW funds			
First 30,000 systems	€ 38	€ 30	€ 8
Next 35,000 systems	€ 36	€ 30	€ 6
Next 35,000 systems	€ 34	€ 30	€ 4

Table 1: Phased reduction of IDCOL grants

There is strict policy control on the refinancing loan fund given to the NGOs, but there are no specific regulations for usage of the grant fund by the POs. Policy allows the PO to use the subsidy fund as a marketing tool for capital price reduction of the SHS. Therefore there is a competition among the participating NGOs in a particular area to satisfy the needs of the potential consumer with product and price.

IDCOL has established a list of criteria for selection of POs. Any NGO or MFI meeting these criteria can become a member of the program. Today, 18 POs are involved in the program. They range from massive organization like Grameen Shakti and BRAC (more than 4 million microfinance members) to smaller NGOs. 7 more POs have been selected in November 2009 who will start to work immediately.

Actors and responsibilities

Responsibilities of actors

Role of partner organisations (MFIs, NGOs):

- ***Implementation***: The program is being implemented through the partner organisations (POs). The role of the POs is to select the project areas and potential customers, sign up contract with customers and install the systems, extend loanin

kind in the form of the SHS, and recover the loan in monthly instalments within loan period..

- ***Promotion***: The promotion is ensured directly by the POs themselves. Part of the grant they receive is dedicated to institutional development and can be used for SHS promotion

- ***Maintenance***: The POs are responsible for maintenance of the systems during the 3 years of loan duration after which additional warranty may be purchased by the customer.

Role of IDCOL:

- ***Funding:*** IDCOL provides grants and soft refinancing loans to POs.
- ***Technical quality control:*** IDCOL sets up technical specification for solar equipment and control that quality standards are respected. IDCOL inspectors carryout round the year monitoring of technical aspects of SHS program of the POs.
- ***Promotional support:*** IDCOL has developed and distributed publicity materials to raise awareness and popularize the use of SHS in different parts of the country. Posters, leaflets, T-shirts, and billboards have been distributed and more will be provided to the POs for wider publicity of solar energy. TV and radio spots have also been developed and aired.
- ***Training:*** IDCOL also conducts and supports training programme to build awareness among the staff of the POs' and the consumers. Training is provided to the staff of the POs on SHS configuration, positioning of SHS, installation procedure and guidelines with measurements, 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. 80% of the total expense is borne by IDCOL and the rest is shared by the POs. Since SHS is entirely new to the households, consumer trainings are conducted regularly to educate them. They are trained on how to use the SHS and fix petty problems without waiting for the technician.
- ***Monitoring of POs' performance:*** IDCOL controls the financial and overall performance of partner organisations. It has a comprehensive database where information about all the individual SHS is preserved and disbursement of funds by IDCOL to POs is linked to proper verification of the systems and their documentation.

Role of the donors:

Donors support the program by providing:

- ***Subsidy to***: (i) decrease the selling price, (ii) support the promotion action of POs and IDCOL, and (iii) support the training of POs staff and clients. The subsidy has never represented more than 25 % of the price of a SHS.
- ***Soft loans***, at a 5 % interest rate, to IDCOL for refinancing POs/MFIs.Finally donors are providing soft loans to the MFIs for their operations through a transparent, efficient, monitoring and financing body: IDCOL.

Relationship between the actors

Transparent operational schemes are followed by IDCOL ensuring a complete participatory role of the NGOs and MFIs through scheduled operational meeting and discussions.
A very effective monitoring process and support system has been adopted by IDCOL, including multiple functions:

- Monthly meeting of the operation committee, with mandatory participation of the POs, for discussing important ongoing issues.

- Reporting on achievements of all POs in installation of SHS on a monthly basis.
- Sharing of information on the status of refinancing and grants applications.
- Maintenance of records on loan recovery and collection rate by the POs.
- Resolving issues related to the suppliers availability and limitations.
- Technical design approval for qualifying in the national solar program.
- Providing support for marketing and promotion of SHS to potential consumers.
- Offer support for technical training of technicians and consumers of the POs.

Rules and conditions

In the original plan of operation, SHS could not be on a site where a grid is available. But this requirement has recently been waived in areas where grid service is poorly served;

- It must be the first SHS for the household in question
- A standard loan agreement with the end user has to be signed, including the service fee to be charged over the repayment period (1-3 years, depending on the policy of the PO)
- The end user agrees to pay a monthly fee, which has to be collected by someone from the PO's local office.

Financial product offered by POs to end-users

Partner organisations (POs) extend loan to households for the purchase of SHS. Different POs extend credit on different terms and conditions. The loan tenor varies from 1 to 5 years, and interest rate varies from 8% to 15% per annum on declining balance method and 10% to 15% per annum on equal principal payment method. In all the instances, the repayment frequency is monthly. Households are required to pay a minimum 20% of the system cost as down payment.

Financial scheme

Under the program, the process to be followed by partners is the following:

1) Clients make the required down payment.
2) POs enter into a sale/lease agreement (provisions of which are approved by IDCOL), install the system (mostly on credit) and make electronic disbursement request to IDCOL for refinance and grants, as applicable.
3) After in-house checking, IDCOL conducts physical verification of the SHS installed.
4) IDCOL releases grants and refinance amount only if the inspection result is satisfactory. The refinance amount does not exceed US$230 equivalent in Taka per system.
5) IDCOL makes the disbursement within 21 days from the receipt of disbursement request.

This mechanism implies that POs need to mobilize other sources of funding to purchase and install SHS before IDCOL releases the funding.

The comprehensive financial model of IDCOL's program is presented hereafter:

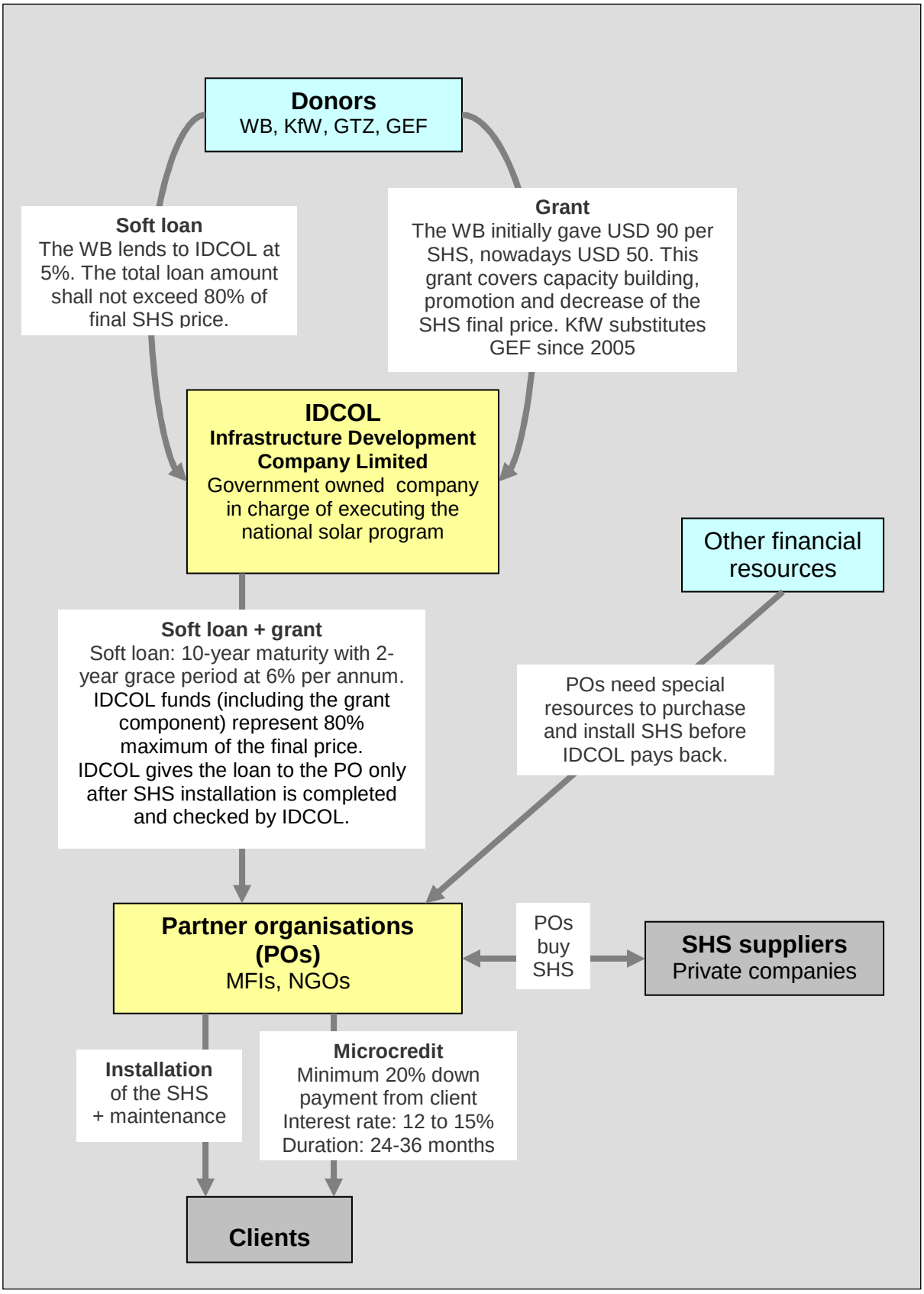

Figure 5 : IDCOL financial model

Who and where ?

The majority of the clients are the higher and middle income households. Some lower income households commit to buying a SHS when they have some prospects of increase in their income in the near future. **The poorest households remain unable to afford the down payment or the monthly payments**. The maintenance of the system is mostly done by women.

Although there is a demand in urban areas for solar backup systems because of unreliable service from the national grid, the program focuses on rural and remote areas. which are unlikely to be electrified through grid extensions in the foreseeable future. The customers of SHS are relatively universally spread over Bangladesh although some of the poorest areas in hilly areas in the southeast are probably less covered.

The table below lists the number of SHS installed by division:

Division	Number of SHSs Installed
Barisal	47,333
Chittagong	69,965
Dhaka	73,798
Khulna	54,875
Rajshahi	48,123
Sylhet	39,997
Total	**334,091**

Table 2: Installation of SHS by division (July 2009)[9]

Achievements

REREDP was successful beyond expectation; the initial target was to finance 50,000 SHSs over a period of five-and-half years (January 2003 - June 2008). This target was already achieved in September 2005, almost 3 years ahead of schedule and at US $2.0 million below the initially estimated project cost. Therefore, the target was revised to finance a total of 200,000 SHSs by the year 2009 with additional support from the World Bank, GTZ and KFW.

Here again, the objectives have been largely attained: at the end of September 2009, **384,887 SHSs** have been installed. The ongoing projects include funding from Asian Development Bank (US$33 million) and World Bank (US$ 92 Million) along with other donor funds for institutional and buy down grants.

[9] http://www.reein.org/solar/idcol/index.htm

The following table shows the achievements of each PO as part of the REREDP:

Participating Organization	Number of SHSs Installed upto September 2009
Grameen Shakti	244,948
BRAC Foundation	51,326
RSF	39,879
Srizony Bangladesh	10,559
UBOMUS	7,713
BRIDGE	5,885
COAST Trust	3,305
Integrated Development Foundation	3,917
Centre for Mass Education and Science	3,052
Shubashati	2,630
Hilful Fuzul Samaj Kallyan Sangstha	6,511
TMSS	1,992
PDBF	2,104
PMUK	678
Others	388
Total	**384,887**

Ref: IDCOL

Table 3: Installation status of the REREDP

A very important performance monitoring criteria of the MFIs is the efficiency of monthly instalment collection. On the average the **POs of IDCOL achieved more than 97% overall collection efficiency**, which is monitored to minimize the financial risk of IDCOL.

This scheme has been successful since IDCOL has a regulatory role for quality control and financial risk minimization. The hardware used in the national program are certified by IDCOL. The dedicated bank accounts of the MFIs for IDCOL funded Solar Home project are subject to scrutiny by IDCOL itself. These two important criteria are essential parts of supervision and monitoring scheme for sustainability of the MFIs activities.

Behind the Scene of Successful SHS Program in Bangladesh

Success of successful SHS program can be attributed to a combination of well-developed institutional, financial and technical models. In case of the IDCOL program in Bangladesh, this can be summarized as follows:

(a) Monthly meeting are held by IDCOL's operations committee, that has mandatory participation of the MFIs (Partner Organizations) for discussing the important ongoing issues.
(b) All the POs are required to report their achievements of installation of SHS on a monthly basis. This includes system size, number of installations, locations, and system price.
(c) Sharing of information on the status of refinancing and grants applications. This is essential for monitoring the performance of an MFI and its relative position with respect of to other POs.
(d) Refinancing POs for 80% of the approved installations. This generates the revolving fund for the PO for extension of the program with an added 20% investment by the MFI.
(e) Subsidy fund as a grant fund to the MFI is useful for reducing the first cost of SHS for the consumer, and institutional development of the POs engaged in expansion of their operations in new areas. Declining scheme of subsidy amount is justified by the fact that benefits of SHS are well-known to the rural consumers after six years of operation, and hence market is reaching a more commercial status.
(f) Maintenance of records on loan recovery and collection rate by the POs. Like all financial institutions, IDCOL reduces its financial risk through strong monitoring and oversight of accounts of the POs.
(g) Resolving issues related to the suppliers availability and limitations are important to IDCOL and the POs.
(h) Technical design approval for qualifying in the national solar program. A Technical Standards Committee (TSC) supports IDCOL in selection and approval of hardware used in SHS in order to preserve the standard of the overall program.
(i) Providing support for marketing and promotion of SHS to potential consumers. IDCOL provides subsidized items for promotion of SHS, which include T shirts with solar application graphics, etc.
(j) IDCOL offers support for technical training of technicians and consumers of the POs. Hence any PO in need of trained personnel can request IDCOL for 80% of the cost for training the MFIs. The trainer organization is selected and contracted by IDCOL for quality control.

Generally speaking, the program's success is due to several factors:

- Low coverage of rural electrification network and large number of scattered households with low energy demand that can be met with small solar home systems;
- The successful organisational setup using a capable and flexible coordinating organisation like IDCOL, at the same time delegating all operational work to POs and system suppliers and installers;
- The ownership of the system by the client is pointed out by several stakeholders to be an essential success factor, as this stimulates the household to appreciate the value and take better care in operating and maintaining the system;
- Availability of locally operating NGOs in most of the unelectrified areas with ability to undertake technical implementation and recovery of price of the SHS given as loan to consumers in kind.

- The close follow-up of repayments, operation and maintenance by skilled people through the local offices of the POs. The vicinity of skilled people (with offices on average every 20 kilometres) is essential to allow a smooth collection of fees, and to rapidly react to system failures (for example battery charging problems, charge controller breakdown);

Limits

There seem to be no technical barriers. **The only barrier IDCOL reports is possibly a financial one, in the sense that price of solar home systems is still quite high for most people , and secondly that due to high success additional donor funding is required.**

Despite the obvious success some issues can be identified:

- *The poorest:* In terms of poverty reduction strategies, **the poorest households remain unable to link in to the program.** In principle several solutions are possible, e.g. decrease the size of the system, or increase the investment subsidy for the poorest clients. Systems could be given for free to some households or cross subsidies could be used, where a higher price is paid by rich households which subsidises the cost of the system for poor households. In order for the possible solutions to be successful in the longer term, they must aim at increasing the income of the household. Electrification to improve the living conditions undoubtedly has advantages in the sense of health and education, but is not economically sustainable in the longer term for the poor.
- *Limitation of power:* **SHS are not sufficient for productive uses.**
- *Aid dependency:* stakeholders pointed out that the provision of small scale energy systems is often hardly a profitable business for small and medium sized MFIs, as they lack the scale and necessary resources. The current growth of the solar system markets is possible thanks to financial support from international aid agencies, and because it is usually developed as a side activity within a larger company where it can, when necessary, rely on more profitable core businesses;
- *Training:* Although the continuous training programmes at different levels (POs through system suppliers and IDCOL, new and existing clients through POs supported by IDCOL) seem to play an essential role in the program's success. Some stakeholders pointed out that the current training efforts are not sufficient for the present and there will be a much higher need for training in the future because of rapid project expansion.
- Even under the challenging objective of 1,000,000 SHS for 2015, only 5% of those without access to electricity will be covered.

3.2 Recommendations[10]

In the light of the above findings on current Bangladeshi program, RENDEV recommends four different scenarios for serving the un-met energy demand of the poor:

- Scenario 1. Solar PV for household lighting of rural poor adapting IDCOL financial model

  - LED and CFL based Small Solar home systems SSHS with solar panel of 10 to 20 Wp for the rural people from middle class to lower middle class family.

- Scenario 2. Portable solar PV solution for the poorest with micro-financing.

  - Portable Solar Lanterns with LED and CFL
  - Solar PV based Battery Charging stations in remote rural villages to charge batteries to run LED lanterns, lamps, mobile chargers etc.

- Scenario 3. Adaptable systems for commercial application of solar PV targeted toward the poor.

  - Mini grid system for rural markets
  - Micro-Utilities in rural markets
  - Solar PV water pumping system
  - Micro enterprise electrification

- Scenario 4. Socially motivated applications that are highly subsidized for the public.

  - School Electrification
  - Solar PV for Street Lighting
  - Health Clinic and Hospital Electrification

  Other applications include urban and rural application of solar PV in various use where off-grid power is necessary.

[10] Data from studies conducted by PSL in Bangladesh, see also http://www.psldhaka.net/

Scenario 1. Solar PV for household lighting of rural poor adapting IDCOL financial model to reach the poorest population.

With the onset of the national solar program under IDCOL, the potential of solar home systems has been well established in Bangladesh. During the initial years the program has extended its subsidy portfolio for systems larger than 30 Wp. Prior coverage was limited to systems of 30 Wp and above using hardware qualified and enlisted by IDCOL. These systems cost in the range of Taka 23,000 to Taka 43,000 including installation in the households. The target population being served by the systems typically included middle and higher income groups of the population.

In order to extend the benefits of solar electrification to the poorer sector of the rural population, dissemination and promotion of Small Solar Home Systems (SSHS), ie smaller than 30 Wp is essential. The IDCOL program for SSHS has begun since 2007 following the success of the national SHS program. Up to September 2009, a total of 17,898 small SHS has been installed under IDCOL SHS project, with a target of 24,500 before the end of the year. Most of the system users are from households mid level and lower income group or owners of small shops. There is no physical or geographical boundary for dissemination; hence partner organizations of IDCOL are selling the systems all over the country at a competitive price. There are some price variation of SSHS, which range from Taka 11500 toTk.13500.
Currently the sizes of the small solar home systems range from 10 to 30 Wp. Small systems are required to have low energy consuming appliances, and preferably LED lamps with high luminosity at low energy consumption. However the POs of IDCOL are not yet disseminating 10 Wp systems due to the unavailability of LED lamps of good quality. It can be expected that with the availability of reliable LED lamps the smallest SHSs can make a breakthrough in the coverage of poorer segment of the population.

Scenario 2: Low Cost Portable Solar Lighting

Original effort toward use of portable lanterns started under the Rural Electrification Board's solar program of 1995-2000 under Narshingdi PBS. The outcome of this pilot project had shown a strong resistance among the target group for using solar lanterns, on a pay for service basis. Total awareness and popularity of solar as a viable alternative to grid services was not established at that initial time. However, since then some organizations have disseminated solar lamps and lanterns under independent pilot projects.

3.2.1.1 Experience of PSL and CEWDC (UBOMUS) with Portable Solar Lamps

In order to provide an affordable lighting solution for the un-served people residing in remote areas of Bangladesh, PSL is association with the women's cooperative, CEWDC, implemented a small solar charged LED table lamp and portable solar lanterns with LEDs. The dissemination program took place in Rangabali, Char Biswas, Char Montaz islands in the southern coastal region of Bangladesh. Need assessment was carried out through discussions with local people, businessmen, entrepreneurs, and some school authorities to make them aware of the potential benefits of improved lighting. Demonstration of the lamps took place in rural markets at night time in several locations, where the impact was found to be attractive. People asked about the operational details, cost, lifetime and availability of the lamps. The research team envisioned that the school children would be the major beneficiaries from using the LED table lamps by replacing their kerosene lanterns, whereas LED solar lantern would be used by all the members of the household.

Marketing and Consumer Selection:

Introduction of new appliances to the public is guided by the marketing plan adopted by the promoters. It was decided that all the 11 unit offices of women's co-operative (CEWDC) under the solar electrification program of the adjacent islands would be used for dissemination of LED table lamps and lanterns. PSL provided technical assistance to all the unit offices and experience from one location were used in marketing in another area as appropriate.
There were three different marketing options under consideration.

1. Through the local schools.
2. Sales by the women members of the cooperative.
3. Using the ongoing micro-financing network of SHS program.

Option 1: As mentioned earlier, the portable LED table lamps were expected to have most benefit for the students. The local schools were used (1) as a guiding mechanism for reaching the children, (2) keeping the product use in the proximity of service delivery, (3) keeping cost of marketing within limits, since infrastructure in the islands is extremely poor. It was expected that since the selected schools are from the neighbouring villages, they can be monitored and managed within the limitation of the project. Discussions with the stakeholders reinforced the assumption that potential beneficiaries could be school children, whereas general application for households can be additional use of solar lighting systems and appliances. Hence it was decided that portable solar lamps in the configuration of table lamps will be made available to households that are unable to afford the standard Solar Home System (SHS), and it was planned that the lamps are to be used by school children for studying at home. In order to meet the charging requirements multiple solar battery charging stations would be suitable locations and they will bring the small batteries for charging.

Option 2: It was anticipated that the members of the women's cooperative would interact with the households having school going children and motivate them toward buying the solar charged lamps. In addition, the women members could sell the lamps to households within the villages.

In both Options 1 an 2 it was assumed that the 7 AH batteries used for the lamps would be centrally charged by the women members. It was expected that women members could operate a solar charging station with solar modules if sufficient number of batteries would be sold within her proximity. This would generate sufficient income and create a business of solar battery charging for the women members of the cooperative. In addition, the 1.6 kW existing solar battery charging station of CEWDC, located in Char Montaz, would be available for battery charging at nominal rates.

Limitations: There were several limitations to Options 1 and 2 which affected initial progress of the project, which include:

1. Light emitted from the LED lamps reduced with discharge of the batteries.
2. Households did not bring the batteries for charging on a regular basis. This damaged the batteries and hence performance of the lamps deteriorated further.
3. With poor performance using discharged batteries, households lost interest in using the portable lamps.
4. Women members of CEWDC were not enthusiastic about going long distances to promote the lamps.
5. After initial exposure to the lamps, many households switched to purchasing SHS for the NGOs, which had better service for the value.

Option 3: In view of the above mentioned limitations, the project made change in product design, product sourcing and marketing. Manufacturing of LED table lamps and portable LED lamps were not continued further. Individually powered solar lanterns were searched and procured from the international market. Additionally, the existing sales and micro-financing network of CEWDC for SHS was used for the purpose of marketing solar lanterns.
Marketing and motivational work to reach the target group was done by the staff of the unit offices of CEWDC, and the area of operation extended well beyond the initial boundaries of the project. There was growing interest among people in general. However, since the sales was accompanied with the marketing and sales of SHS, the households being approached in the villages were from the higher income group.

Our selection process verified the fact that affluent families are already using SHS, or planning to use them, when available. Therefore they did not find solar charged LED lanterns with its limited capacity as adequate service for replacing one kerosene lantern or a wick lamp. They were more interested in a SHS of permanent nature than the potential benefits of solar lanterns. Therefore, the target group for marketing solar lantern had to be changed and lower income households were approached separately through the unit offices. Simultaneously the option for longer term micro-financing the solar lanterns were taken into consideration, which brought addition possibility to increasing sales among the poorer households.
Finally the loan period for the lanterns was also extended from 6 months to 12 months to make it more affordable for the poorer households. Growing interest among the potential consumers was seen following these steps undertaken by the project.

Table Lamps of original design:
Portable LED lamp were designed to provide maximum service (hours) with minimum charging requirements. According to the initial design the batteries would be charged through the solar charging facility operated by women's cooperative. The portable table lamp made of 8 LED lights was used with 7AH batteries. The project had initially promoted the table lamp system for two reasons. Firstly, this ensures application of lighting in children's education. Secondly, the 7 AH battery is expected to give a portable lamp with more reliable performance with extended period of use per charging.

The table lamps are portable in the sense that 7 AH battery can be attached to light the lamps through a connector, and the system can be moved from one location to another, as compared to a wired household system. Procurement of components for about 50 lighting systems was carried out to finalise the design, test the actual performance, and assess the demand for the product. The members of the Women's Cooperative were then trained in assembly of the lamps by soldering LED lights using a modified printed circuit board (PCB). Only a total of 20 lamps had been micro-financed by the women's cooperative initially. These units costing about 1000 Taka ($14), including annual charging was to be purchased by the users on a micro-credit over one year period. The lamps were designed to be used by the school children for approximately 4 hours each evening, and batteries would be brought to the solar battery charging station at the end of 7 days. Fee of 120 Taka ($1.7) per month would cover the cost of charging at a central solar charging station of the cooperative.

Figure 6:Portable LED Table Lamp

In spite of its versatility, due to the lack of overall illumination (lumens) from these lamps for household usage, the users showed dissatisfaction with 8 or 12 LEDs in the table lamp. The plastic casing has also been occasionally damaged by the user. Additionally, the 7AH battery as a reliable (trade marked) unit had only 6 months warranty. However, the potential users want a minimum warranty of 1 year, which was beyond the scope of the project, and hence production of portable LED lamps was not continued further.

Portable solar lanterns:

On the basis of feedback from the field, the LED table lamps were no longer continued, instead solar lanterns of 32 LEDs were procured for better lighting rechargeable batteries. These lamps were then imported for dissemination, with a total cost of $50 for the user. Micro-financing over a period of one year was affordable to households that are unable to afford solar home systems. These lanterns are independent packaged units comprising:

1. A solar module of 3 W with 10 year expected lifetime.
2. LED lanterns with 32 LEDs with one year manufacturer's warranty.
3. 4 Rechargeable Dry cell batteries with 6 months warranty.
4. Necessary cable for battery charging.

Physical structure of the solar lanterns were more sturdy and hence more portable compared to the original design of table lamps. Households found these lamps more useful for variety of application replacing their portable kerosene lantern. Moreover, this option eliminated the need for external charging of the batteries on a regular basis, and dry cell batteries are available on a retail basis. Households find solar lanterns more useful for variety of application replacing their portable kerosene lantern. Moreover, this option eliminates the need for external charging of the batteries on a regular basis, and dry cell batteries are available on a retail basis.

Figure 7: Portable Solar LED Lantern

3.2.1.2 Financial model and lessons learnt from Solar Lantern project

With an investment of only $50 over one year, each household has the scope of using solar lanterns to meet the demand for modern lighting. Knowing that a full SHS costs minimum of $315 after financing, these buyers are unable to afford the full SHS system.

In the initial scheme the down payment was 42% of the selling price with service charge of 7%, having a monthly instalment of $5 for 6 months as shown in Table 3. Field experience showed that many people were interested in purchasing the solar lantern, but could not afford the rates, and they desired financing for 12 months. Financing of solar lanterns were done through 12 monthly instalments of $3, with a service charge of 5.70%. This proved to be the key breakthrough for sales of the project. Sales of these solar lanterns increased rapidly and hence it was concluded that such models are economically viable solution for low income households with appropriate financing schemes.

Financing Model of Solar Lantern with Initial model having 6 months loan (in USD)

Purchases price	Sales Profit	Cash sale	Down Pay	Loan to HH	Service Charge	Outstanding to HH	Monthly Installment for 6 months
45	5	50	21	28	2	30	**5**

Financing Model of Solar Lantern with extended period of 12 months loan (in USD)

Purchases price	Sales Profit	Cash sale	Down Pay	Loan to HH	Service Charge	Outstanding to HH	Monthly Installment for 12 months
45	5	50	14	35	2	37	**3**

Table 4: Financing scheme of Solar Lanterns for the households

Lessons Learnt: Survey of Solar Lantern Users by PSL

A survey of the users of portable solar lanterns was done for monitoring and impact assessment of the pilot project of PSL. Some very important lessons were learnt from this survey. When asked about the most important contribution of the solar lantern, the current users responded that the most important use of solar lantern is in education of their children. It was also mentioned that sometime household members use the lantern for other household lighting purpose. Commercial users include some small shops use solar lantern for business lighting during the evening. Once the shops are closed the owners use the lantern for better mobility with lighting, and after reaching home they use lantern for household lighting purpose. Such versatile use of solar lantern has been observed in the field.

The respondents said that hassle free bright lighting is the most attractive part of solar lantern to house hold. The lanterns have no risk of fire and offer no health hazard to the children around. Villagers also mentioned about environment friendly aspect of solar lighting.

According to the survey the worst problem of solar lantern is brightness of LEDs when used in close proximity. It appears that the LED is too bright to open eyes when children are reading at the table with the solar lantern. Owners are also aware of the potential problem of sourcing battery replacement in the lanterns.

It was found that solar lanterns can adequately meet the basic need of lighting for commercial application. User satisfaction is evident since some respondents use multiple lanterns, where the same owner uses individual units for different shops. All the users of solar lantern are eager to buy Solar Home Systems in the future.

Finally, users of solar lantern in Patuakhali district were found to belong to a cluster of villages. This proves that demonstration is the main factor of marketing, which ensures confidence of the potential users of a new technology.

Scenario 3. Adaptable systems for commercial application of solar PV targeted toward the poor.

- Micro-grid grid system for rural markets
- Micro-Utilities in rural markets
- Solar PV water pumping system
- Micro enterprise (grocery shops, tailoring shops, clinics, restaurants, sawmills, rice mills, cellular phone services, barber shops) Electrification

3.2.1.3 Solar micro-grid grid system for rural markets

Mini and micro grid power are generally used to serve a concentrated load centre in a remote site not served by the national grid service. The service from these low-voltage networks are within a cluster of villages of small market served from a single source of power. In case of solar powered micro-grid the generation capacity can range from 10kW to 100kW, typically with the potential of serving evening loads in the rural markets or clustered households. Cost of power supply is an important criteria in selection of the type of generator. Although Diesel generators are perceived as the lowest first cost option, solar power supply is an attractive option when life cycle cost is considered along with the environmental costs associated with other alternatives. The guiding principles of a micro-grid system would include, (a) safety, (b) adequate power supply, (c) expandability, (d) high system efficiency. These issues are important in the rural areas, where resources are limited.

3.2.1.4 Micro-grid in the coastal island of Bangladesh

During the first quarter of 2008 a survey was performed by PSL to collect information on current power demand in Sandwip island, which is located in the south-eastern part of the country with an area of 700 square kilometers. This island is a habitat to a population of 300,000 who are detached from Chittagong mainland by a channel of about 75 kilometers. Because of its position and inaccessibility there is no possibility of grid electrification service to this area in the distant future. However the island is habitat to a dynamic population with several active private and public services that provide support to the general public. It is

noteworthy that there are several educational institutions including primary schools, high schools and colleges, health service centres and hospitals, major markets, several computer service centres etc.
Private service providers currently supply electricity to the shops in the markets of Sandip island. Currently electricity providers use Diesel generators of 10kW to 25kW for service of about 4-5 hours a day. Existing power lines used by the private suppliers are not suitable for reliable power supply since they were not implemented considering high efficiency and low line loss. With the high cost of Diesel transport, power production for these service providers is around 50 Taka per kWh ($0.71/kWh). Table 3 gives the estimated tariff of current users of Diesel based power in the area on the basis of daily rates and service hours. Depending upon the type of appliance being used, daily rates being converted to tariff range from 45 Taka/kWh to 75 Tk/kwh. Such high rates are acceptable by the shop owners due to the high demand for electricity. However, due to such high tariff, there is limited scope of direct benefit from solar micro-grid to the poorer sector of the population.

Existing Load and Tariff of local grid electricty at Sandip Bazar (Run by Diesel generator)

Appliance/Load Type	W	Hrs/day	kWh/day	Tariff (Taka/day)	Unit Price Taka/KWh	Monthly Rate (Taka)
CFL Lamp	24	5.5	0.132	10.00	75.76	300
Ceiling Fan	60	5.5	0.33	20.00	60.61	600
Florescent Tube	40	5.5	0.22	10.00	45.45	300
Television	40	5.5	0.22	10.00	45.45	300
Average Tariff (Taka/kWh)					**56.82**	
Monthly Payment (Taka)						**1500**

Table 5: Tariff Estimation of Diesel Micro-grid Service

On the other hand, a Government owned and operated Diesel mini grid service also operates in the island that occasionally operates for 1-2 hours a day with significant losses. Although used sparingly, the selling price of power is about 3 Taka per kWh ($0.42/kWh), whereas production cost is around 35 Taka per kWh ($0.50/kWh). The government owned mini power grid is more than 30 years old, and maintenance is overdue.
In addition to the service providers, several Diesel based captive power generation is found in markets, clinics other cases. It is interesting to note that various uses of electricity has taken place in Sandwip in spite of the lack of reliable power supply, and computers are operated in several locations using the limited supply of Diesel based electricity.

Planning of 100 kW solar PV micro grid:
Economic development of the rural sector is closely tied with the availability of productive and efficient power supply. Preliminary survey in Sanwip island suggests that the current consumers of Diesel electrification service are eager to modernize with alternative energy, and solar PV grid is an option. A possible alternative under consideration is a micro-grid of 100 kW solar, which can only be suitably installed with nearly 50% subsidy to reach the current power cost of Diesel. Therefore, from economic consideration this type of grid is suitable if sufficient commercial use is guaranteed to ensure cost recovery for the investors. The business owners are typically highest income group of the population earning beyond USD 200 per month, and eager to pay Taka 1500 (USD 2.5) in order to sustain their businesses. Furthermore, a major drawback of solar electrification of rural markets is that the power demand increases in the evening and hence battery backup service is essential for secured power supply, which also increases the life cycle cost of the system.

3.2.1.5 On-Going Solar Micro-Grid Operation

There are a handful of on-going solar micro-grid services for rural markets, most of which are not designed on economic consideration. One example is a demonstration of solar PV technology where UNDP through its Sustainable Environment Management Program (SEMP) has electrified a Growth Center, which is a business center and rural market place. Main objective of the project was to install a demonstration project of a centralized solar photovoltaic system for electrification of a rural market in the off-grid area and to assess its technical and economic viability in the context of rural Bangladesh. The location had been selected because of its remoteness, where nearby power grid is about seven kilometers distance. The system has the capacity of 1.8 KWp which provides electricity to 45 shops, 3 food processing and small industries and one community center. This project has increased commercial activities of the market by four hours after the dusk. The responsibility of operation and maintenance of the micro-grid remain with the market management committee.

Although the shop owners are mostly from higher income groups, this project has created positive socio-economic impact and great enthusiasm among the local villagers, farmers, merchants and as well as tourists. It is claimed that the lease value of this Growth Center has increased by 65% and farmer's income has increased by about 45% from increase in business. Furthermore security in the market area has improved remarkably. Different cultural activities and adult education normally takes places in the community center. People also benefit from watching National TV and radio programs and it has improved their social awareness significantly, followed by higher demand for solar home systems in the nearby villages. This project was completed in the year 2000 with a high cost for a demonstration project, hence economic viability can not be justified. Since its inception, application of solar power electrification has reached higher levels of usage in the rural areas of the country and unit cost has reduced significantly. Although higher business volume for the farmers is a tangible benefit, direct benefit of this type of application is limited to the shop-owners, who typically represent the higher income group.

Another notable application is a 10kW solar micro-grid under operation is in the Chittagong hill tract area, which has recently been implemented by Bangladesh Power Development Board (BPDB).

3.2.1.6 Micro-Utilities in Rural Markets

A large number of SHS ranging from 50Wp to 100 Wp has been sold by Grameen Shakti to their customers for creating micro-utilities in the rural market. In this case 3 to 4 small shop owners who are neighbors in a rural market, jointly use one SHS, as they are connected to a common SHS. Each shop uses a single lamp and collectively the monthly installment cost is paid by the shop owners, whereas one person remain legal owner of the system. This scheme of micro-utility is affordable to the shop owners since the true cost of the system is borne by more than one person, where the users pay fixed sum for the service they take from the system. Micro enterprises like grocery shops, tailoring shops, clinics, restaurants, sawmills, rice mills, cellular phone services, barber shops etc are known to have extended business hours using solar electrification.

Such provisions of micro-utility are suitable for adjacent shops in rural markets due to their proximity. The maximum distance between the load and the charge controller is limited to about 30 feet based upon the cable provided and the safe allowable voltage drop in the line.

This distance could be varied for a better designed micro-utility if the cable size is improved. This further implies more investment by the user for the cable itself to prevent undue damage of the appliances used.

3.2.1.7 Solar PV water pumping system

Highest impact on the poor through solar power utilization can be achieved through direct use in income generating activities associated with agricultural use, and predominantly through investment in solar pumping for irrigation. In many parts of Bangladesh, agricultural water is limited, and farmers are able to grow a single crop during the year. With the help of Diesel operated water pumps and grid electrification service they are able to produce twice a year. However, in remote locations, increasing cost of fossil fuel places enormous economic pressure on the farmers of Bangladesh who depend upon Diesel for water pumping. With their limited revenue from sales they are facing the challenge of sustaining their livelihood while covering all costs related to crop production. With the decline of cost of solar modules, a large part of the demand for water for irrigation can be potentially met with solar water pumping.

3.2.1.8 Empowerment of Women

In the small scale of investment, experience has shown that community based activities can also make financial impact on the individual members. The women's cooperative CEWDC have been successful in collecting sufficient revenue from assembly of solar appliances, to regenerate the revolving fund for business continuation. Small gadgets and appliances assembled by the members of CEWDC have reasonable market and create additional source of income for the women. A very important outcome of the lantern promotion project was empowerment of rural women in assembling other electronic appliances with attractive market value as shown in Table 5. Knowledge transfer to the rural women is therefore used for other income generating activities leading to higher household income.

Appliance type	Number sold	Revenue Earned in US$	No. of beneficiaries
Dim light	3000	$8142	22000
DC-DC converter	170	$364	
Mobile charger	600	$2142	

Table 6: Number of small appliances manufactured and sold by CEWDC

The large network of Grameen Technology Centres (GTC) is based upon the concept of women's cooperative in Char Montaz. GTCs engage a large number of women in technical capacity and entrepreneurship among rural women is encouraged.

Scenario 4. Socially motivated applications that are highly subsidized for the public.

3.2.1.9 School Electrification

Schools and colleges in villages of the remote islands without grid electrification are facing the challenges of the new era where computers, audio-visuals, and mass communication play an important role in the education process. Like other neighboring countries Bangladesh is trying to bring computer education within the reach of its fresh minds. Accordingly all public high schools (covering grade 6 to 10) are now encouraged to use computer hardware with computer instructor to be funded by the government. Lack of grid electrification poses a problem for those schools in the un-electrified areas, since they are unable to meet the power requirements for such services.
PSL in association with the NGO Rural Energy and Development Initiatives (REDI) has extended the boundaries of renewable energy. Rural schools in southern islands of the country are now being connected with solar powered lighting and computers systems with internet communication.

3.2.1.10 Solar PV Street Lighting

Bangladesh has a well developed rural roads and communication system that has been established over the past decades. However, security for mobility using street lighting is typically limited by the access to grid power service. This is more scarce for the remote locations of the country, where off-grid solutions are more appropriate for the public. Solar powered street lights with limited hours of operation can become adequate solution for the rural villages. This can create a safe environment for performing essential tasks after dusk in the rural markets and other communication.

3.2.1.11 Health Clinic and Hospital Electrification

An essential part of public health system of Bangladesh is availability of reliable health services in the proximity of the people. In the rural villages such services are limited by lack of power, shortage of properly trained staff, and quality medical supplies. Power supply in grid supported locations are able to solve some of these problems. However, solar powered electrification can become instrumental to remote un-electrified villages where people are known to spend significant amount resources to reach the nearest towns for a reliable medical service. The poorer population, women and children in particular, suffer the most since they are unable to make trips to the nearest towns due to their limited financial resources.
Basic solar lighting in the health clinics can bring much benefit to the services offered in the health clinics and hospitals during the evening hours. Solar powered vaccine refrigeration for immunization is an important application for the health clinics and hospitals. Such facilities are also known to retain better qualified medical personnel and hence offer improved medical services to the public.

How the recommended financial models answer the challenges faced by past Bangladeshi government programs

There has been several efforts by the GOB to extend the benefits of rural electrification to the un-served poor of the country. With the onset of REB an approach was taken to bring access to grid electrification to the remote rural areas of the country. After 30 years of operation, the program has been able to serve a limited population with grid service option. There has been very limited effort toward using alternative off-grid solutions of solar PV application.

The initial project of the GOB took place in 1995 using 16 kW solar PV for Narshingdi PBS, in the riverine island of Karimpur within 50 miles of Dhaka. The project demonstrated solar electrification for households, solar battery charging station and a limited number of portable solar lanterns. PBSs are devoid of basic knowledge and authority for solar PV implementation under the REB's regulatory role. Therefore many problems arose in project operation, and the project was not suitable for the location, which is too close to the urban centre across the river. This led to a negative experience of solar electrification within REB. Most recently, there has been 12000 SHS installed by REB under the REREDP program, with limited interest among the typically grid based PBS management.

Since 2002, the GOB has supported the national solar program of IDCOL, which has produced the most successful off-grid electrification scheme in the country. Due to the high level of investment needed, mostly higher income households can purchase the typical models of SHS with cash or credit. Under these circumstances, possibility of payment on instalments under the Government's RERED project implemented by IDCOL has proved to be a very effective.
Although a very attractive micro-financing scheme is operational, considering the high upfront cost and overall cost, the SHSs are still beyond the affordability of majority of the low income rural households of Bangladesh. It is hence expected that some of the future systems will be scaled down to smaller sized SHS (e.g 10Wp to 20Wp) to cater to lower income households. Nationwide sales of small solar home system (SSHS) is currently underway, and its extension to the rural poor will be possible through the proposed recommendations involving the NGOs engaged in the locations.

The proposed scenarios are practical alternatives for extending solar electrification to the rural poor who are beyond the reach of existing SHS operations in the field. Financing portable solar lanterns are viewed as one of the most promising approach for the rural poor. This type of lighting for the lowest socio-economic group can only be disseminated through the local NGOs, and GOB's national solar program (via IDCOL) may finance them parallel to the solar home systems.

In summary, the proposed scenarios offer some measures that can contribute to objectives of the National Energy Policy of Bangladesh 1996. In particular, this includes:

- *Environmentally sound and sustainable energy for continued economic growth, especially for the lower and middle income rural population.*

- *Energy needs of different socioeconomic groups and sectoral areas, in particular to meet the various needs of the poor.*

4 Designing the subsidy policy

Designing a subsidy policy is closely related to the willingness and ability to pay of the target population and the necessary cost expenditure for a product. In case of solar PV applications, there are several parameters that are important, this include (a) willingness of the target population for pay for solar appliances, (b) current expenditure incurred by the potential user, (c) actual cost to be paid for transition to solar application from traditional solutions, (d) most preferred use of solar appliances, (e) availability of suitable NGOs to operate a financial model for efficient cost recovery.

This section summarizes the existing scenario in the remote rural areas of Bangladesh where solar PV could make positive impact on the lives of the rural people.

4.1 Willingness to pay of the target populations

The status of solar energy application in Bangladesh has vastly changed in the past decade and remarkable progress in application of solar energy for rural household electrification has been observed. Fifteen NGOs, as partners the executive agency Infrastructure Development Company Limited (IDCOL), are implementing the national solar program in the field level under its regulatory oversight. Since the ongoing national program for solar electrification has reached these remote locations with sales of about 385,000 of SHS, people are aware of the benefits and limitations of solar electrification as an alternative to grid power.

Target populations: rural households in remote areas

A survey has been conducted by PSL under the RENDEV project in order to obtain a representative evaluation of the market for solar application for households and others. This survey focuses on the population un-served by the NGOs under the national solar electrification program, and beyond any grid electrification plan. Comprehensive data of this type was collected by PLS through market assessment survey and feasibility study for the World Bank in the period of 1998-2000, when the price of Kerosene fuel was about 14 Taka per litre. The current price of kerosene being 40 Taka per litre, PSL considered the scenario to be changed, which demanded collection of new primary data. Information collected by PSL is based upon the socio-economic condition of the survey population and meets the objective of study that is to identify the need and possible market for solar equipment for the low income poor.

The study locations are beyond any grid service plan of the Rural Electrification Board. Results documented here should meet the needs assessments for a wider photovoltaic (PV) systems dissemination for similar remote locations of Bangladesh. PSL performed the current analysis based upon field survey executed in January 2009 in the remote island on the southern coastal area of the country, and in March 2009 in a remote inland location. The surveys were held in randomly selected (1) offshore island and (2) remote inland locations. A total of 100 people were interviewed in the off-shore island location and 228 people were interviewed in remote inland location by technicians who are engaged in SHS business and hence adequately able to address the financial and technical issues.

Typical island locations are separated from the mainland by rivers, and hence require about 4 to 6 hours of transport by motor boat. There is no possibility of grid electrification service to these areas as per plan of the REB. Therefore the population residing in these locations

have adopted solar home systems as a long term solution for household electrification offered by the NGOs. On the other hand, population from the remote inland locations expect grid electrification service in the long run and hence see solar as an immediate solution for household lighting.

Primary focus of the survey was the population from the lower income group residing on remote villages of Bangladesh without any access to grid electricity. The respondents included small business men, farmers, fishermen, housewives and others. Majority of the respondents (53%) from the island location, and 48% from remote inland location respectively, are from the lower income group earning between 3000 to 5000 Taka per month. The people being surveyed were poor households, who do not have any provision of cash savings. Access to micro-financing is therefore an important alternative for this population to enjoy solar appliances for household application or small businesses. In majority of cases rural households do not have a uniform monthly income over the year, and earning is strongly dependent upon the agricultural cycle for harvesting. Regular monthly payment of instalments for solar appliances is therefore linked to availability of funds from other seasonal activities.

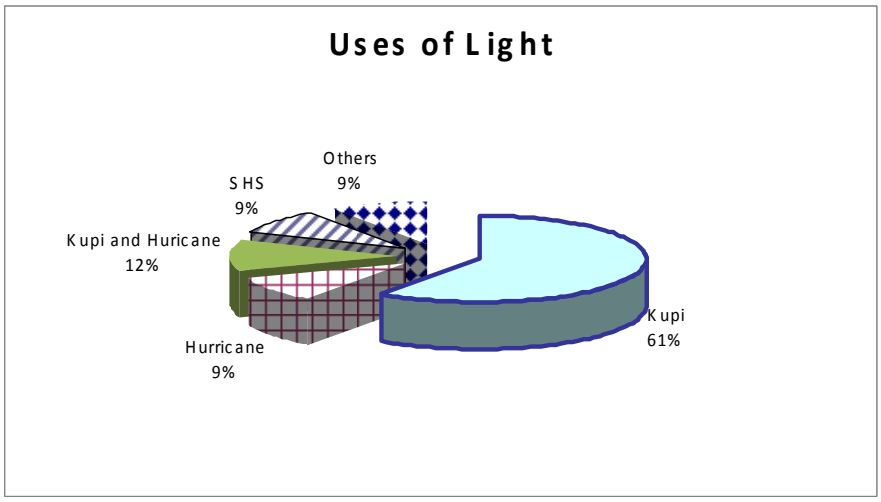

Figure 8: Various lighting Appliances Being Used in Island Location[11]

As shown in Figure 8 and Figure 9, a significant 61% of the island population and 41% of the inland population use kupi, which is a wick lamp, for lighting their household. These are the cheapest lighting appliance available in the rural market, which are environmentally very polluting, and it consumes high level of kerosene fuel while producing limited amount of light. Low income households usually invest about 100 Taka on multiple kupis for lighting, which are sometimes replaced by kerosene hurricane (lantern) if the family can afford. 12% of the households were found to use Kupi and hurricane simultaneously.

[11] Data from field survey executed in January 2009 by PSL in the remote island on the southern coastal area of the country

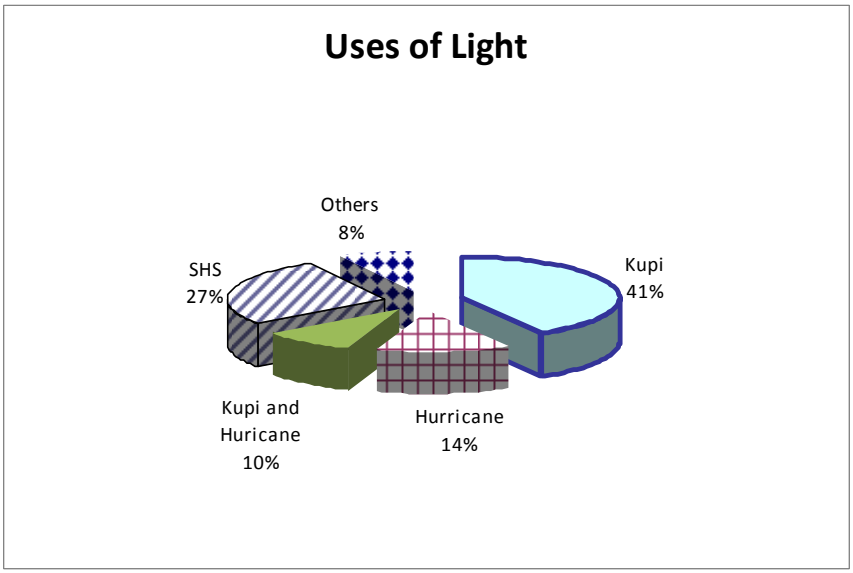

Figure 9: Various lighting Appliances in Remote Inland Location[12]

According to Figure 9, 27% of the respondents use SHS for household lighting within the inland survey location. This is less for the island respondents shown in Figure 8, where only 9% are currently using SHS. There are several factors that influence this observation, which include availability of NGO services, income distribution of the population and general livelihood pattern and access to jobs. Poorer farmers and fishermen in the islands are often found to migrate to nearby locations seasonally to make income, and often are landless. Small businesses owners are however found to be stationed nearby to their homestead and hence qualify for micro-financing a SHS from the NGOs.

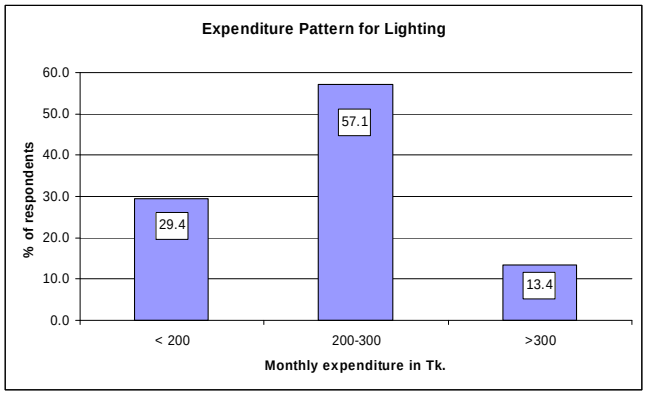

Figure 10: Monthly Expenditure for Lighting in Island Locations

As shown in Figure 10, about 57% of the respondents spend 200-300 Taka for lighting. Although it may appear reasonable, this is nearly 10% of their monthly household expenditure shown in Figure 2a. As shown in Figure 11, the expenditure pattern is quite evenly distributed among the households from remote inland location.

[12] Data from field survey executed in March 2009 by PSL in a remote inland location

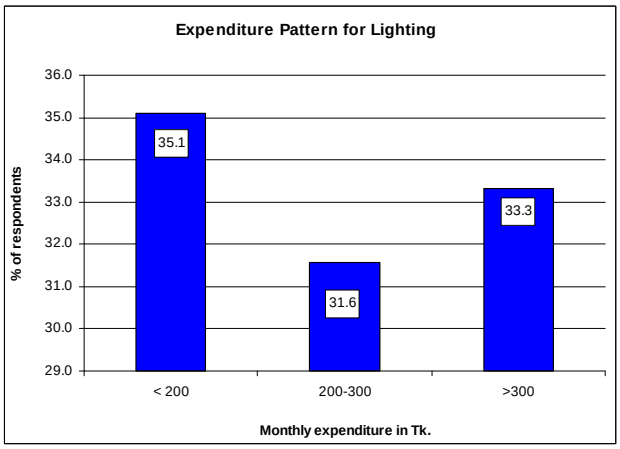

Figure 11: Monthly Expenditure for Lighting in Remote Inland Locations

Households using SHS are most likely spending above 300 Taka per month in monthly installments for solar, whereas, poorer households using kupi are spending below 200 Taka per month for lighting.

Limited Willingness to Pay for Solar Lighting

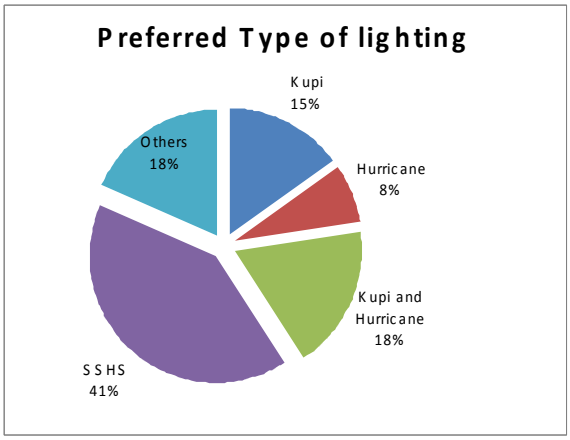

Figure 12: Preferred Type of Lighting in Island Locations

The advantage of solar lighting is known to the population in the islands. According to Figure 12, most people (41%) would like to have Small Solar Home Systems (SSHS) for lighting at night. A SSHS essentially provides 3 lamps for lighting with limited use of radio or cassette player. The poor population do not show a need for larger size solar home systems, which are currently being adopted by the wealthier households.

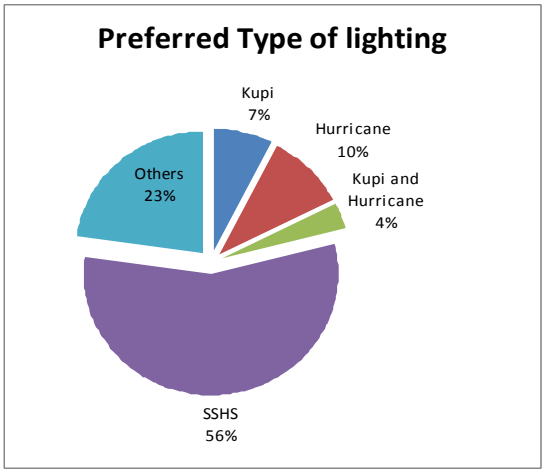

Figure 13: Preferred Lighting in Remote Inland Locations

Figure 13 shows the preference for lighting appliances of respondents from remote inland locations. As mentioned earlier many households in remote inland locations perceive solar electrification as a temporary substitute to grid electrification. A significant 56% of the respondents have shown preference to SSHS. However, study has revealed that even with access to grid electrification, less than 50% of the households actually take connections at the initial stage. Economic reason is a main cause for the poorer households, but lack of interest in long time commitment with the service provider is another reason for not adopting grid service. Solar electrification serves as a pre-electrification option, which enables people to get customized with modern lighting and appliances. Wick lantern and kupi, which has a unit cost between 50 and 100 Taka is preferred lighting device for a total of 21% of the respondents.

Given the many possibilities of using solar PV for un-electrified rural areas, the respondents were asked to comment on their opinion on the most valuable application of solar power. Figure 14 shows the preference of the respondents from the island locations.

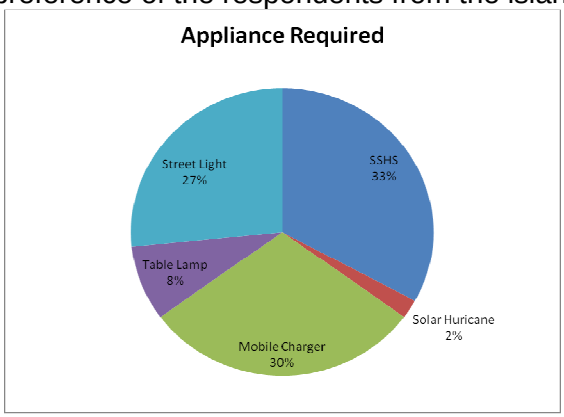

Figure 14: Preferred uses of Solar Electrification in Island Location

Within island locations highest preference (33%) for use of solar PV was found to be for small solar home systems. Similarly with the overwhelming use of mobile phone for wireless communication, 30% of respondents have showed high level of interest in using solar PV for charging mobile phones. This is justified since in the absence of land phones, mobile phone is a major business for rural Bangladesh. In addition to satisfying the individual need for solar PV application, the respondents have shown interest in community level application through street lighting. Since grid services are not available in the survey areas, there is a great

demand for street lighting in public areas, which is highlighted by 27% of the survey respondents.

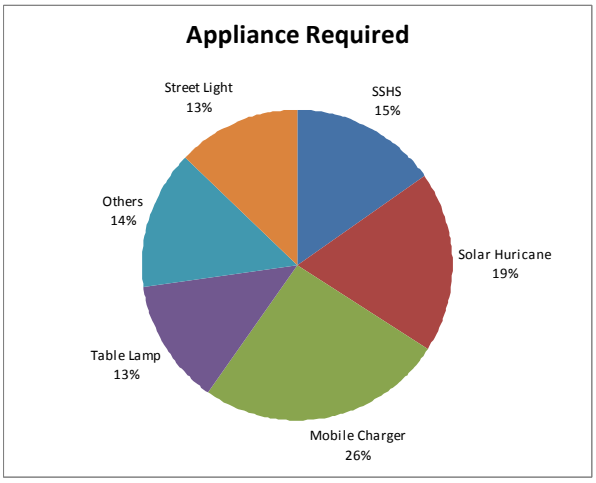

Figure 15: Preferred uses of Solar Electrification in Remote Inland Locations

As shown in Figure 15, in the absence of grid electrification in remote inland locations, people are most interested in using solar PV for mobile charging. This is a very attractive market for the solar home system providers. As a marketing strategy the NGOS currently sell mobile chargers along with SHS. Households find solar lanterns more useful for variety of application replacing their portable kerosene lantern since this eliminates the need for external charging of the batteries on a regular basis. Solar lantern were found to be a preferred appliance for 19% of the respondents, which was followed by SHS, solar table lamps and then street lights. Inland locations are typically more accessible like small towns and hence there is less priority for solar street light compared to the islands where mobility is an important issue.

Differential Willingness to Pay

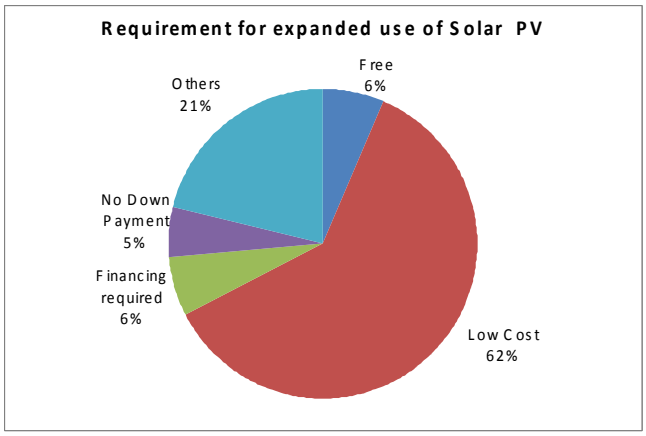

Figure 16: Requirement for expanded use of Solar PV in Island Locations

Given the exposure of people to solar electrification in the off-shore islands, they are able to comment on the most desired feature needed for expansion of solar PV. According to Figure 16, lower cost of PV for lighting is the most important criteria for most people (61%). This is typical response for first cost barrier removal of solar appliances. Only about 6% have shown the need of financing as an important need, although the national solar program is based upon the fact that NGOs are micro-financing SHS in the remote locations. It should however be noted that the low income households are not the typical consumer for the ongoing SHS

program, where larger systems are being offered with a monthly instalment ranging from 400 to 800 Taka per month depending upon the size of the system and payment options. Lower income household are unable to afford these systems. It is important to note that according to Figure 16, 5% of the respondents have suggested that the down payment (which is typically 15% of the system cost) is a barrier to adopting SHS.

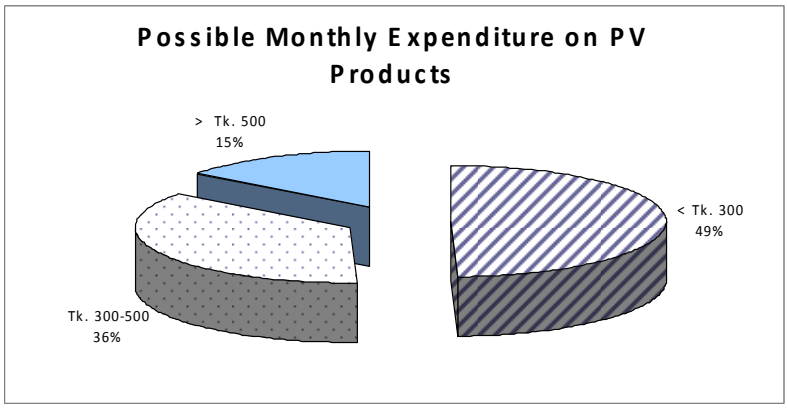

Figure 17: Willingness to Pay for Solar PV Electrification in Island Locations

According to Figure 17 and Figure 18, nearly 50% of the people are not willing to pay more than 300 taka per month for lighting given their income and expenditure patterns. This reveals the fact that *low income people are essentially willing to replace their current cost of kerosene for solar lighting without incurring any additional costs.*

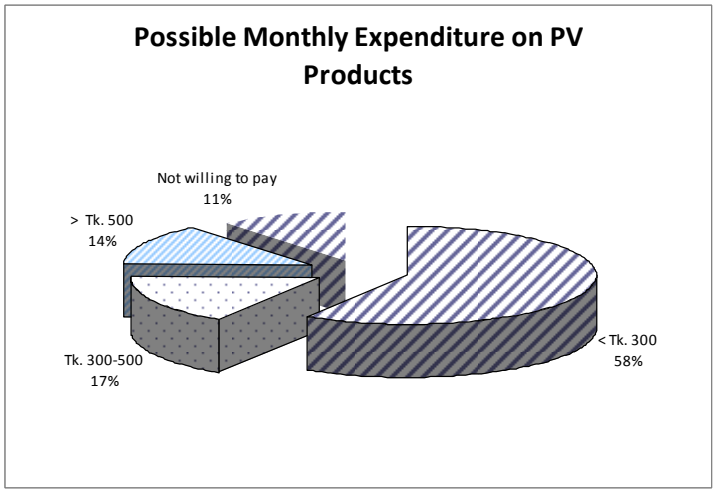

Figure 18: Willingness to Pay for Solar PV Electrification in Remote Inland Location

4.2 Subsidy Policy

The role of subsidy in Implementation of solar products is to make it an attractive alternative in contrast to conventional ones. Whereas environmental benefits and sustainability is the primary reason behind promotion of all renewable energy products, relatively higher unit costs is a major barrier to its adoption.

Scenario 1. Subsidy for Small Solar Home Systems

Subsidy model used in the IDCOL project is of declining nature that reduces with increase in the total volume of SHS financed by IDCOL. As per original design[13] of the subsidy scheme in national solar project, the grant has two components (a) reduce initial capital cost of the system, (b) institutional development of the POs of IDCOL.
Although the original design proposed two subsidy values as a function of larger and smaller SHS, the absolute value of the subsidy adopted by IDCOL (see Table 1) is independent of the size of the systems being sold by the NGOs. Since financial investment for SSHS is smaller than for the larger systems, the NGOs feel encouraged to disseminate these in return of obtaining the same subsidy grant fund. **Ideally, the potential owners of the SSHS would benefit more from the relatively higher subsidy and feel motivated to buy a SSHS if the targeted subsidy would be transferred to them by the NGOs**. There is no such binding in the current regulations of IDCOL, hence the amount of subsidy grant delivered to the end user is up to the discretion of the NGO. **This is a scope of improvement of the current subsidy policy of the IDCOL financial scheme.**

Scenario 2. Subsidy for Portable Solar LED lanterns

Experience shows that the versatile portable solar lanterns, costing about $50 each, are the most useful lighting product for the low income population. It is evident that the target population can only use these appliances if a suitable financing scheme is in place. **The two important features that have direct impact on adoption of solar lantern are: (a) lower down-payment, and (b) longer financing period which results in lower monthly installment**. Transaction cost associated with dissemination of such smaller solar products can however be relatively higher for the NGOs when compared to the sales of SHS. With the same rate of service charge (about 8%), a larger number of solar lanterns need to be sold by the PO to cover the basic overhead cost. **A targeted subsidy for the NGOs based on the number of solar lanterns disseminated can be an effective subsidy scheme.**

Scenario 3. Subsidy for Adaptable solar PV systems for commercial Application

Economic development of rural poor through application of solar PV solution will need focused subsidy for technology adoption. Like most renewable energy technologies solar PV is based on certain hardware and technical know how that is not commonplace in the energy market. **In order to promote solar micro-grids and micro-utilities in rural markets, a**

[13] *Bangladesh Rural Electrification – Solar Home Program Preparation* by Prokaushali Sangsad Limited for The World Bank, 2001.

national subsidy scheme has to be in place which is similar to what the GOB offers for imported Diesel fuel. Import duty on solar modules has been removed by the government, and tax incentives for using solar PV technology are already under discussion. Rapid use of solar PV for commercial purposes will require targeted subsidy that generate enough interest among the business community of Bangladesh.

Scenario 4. Subsidy in Socially Motivated Applications for the Public

Social and environmental costs associated with fossil fuel usage can be reduced with the use of renewable energy resources, especially with the use of solar PV where suitable. The public health, education and transport system can become directly involved in this venture. GOB has made provision of using solar power for all development programs. In order to make its application more effective, a clear policy scheme should be in place. **Subsidy in public programs geared to the poor are to be adjusted to incorporate solar powered electrification and services for all remote area facilities like rural schools, health centers, cyclone shelters, and others.**

5 Conclusion and next steps

The RENDEV final international conference took place in Dhaka, from 7th to 9th December 2009. On Monday the 7th, a workshop was organized to discuss the recommendations of both D16 with the main stakeholders of the two countries. Concerning the Bangladeshi representatives, here is the validated action plan that was discussed during the workshop. The objective is to expand/improve the REREDP to reach poorer populations.

- Formation of the Sustainable Energy Development Authority (SEDA) for the Renewable Energies policy implementation. This institutional support will make the program more efficient.
- Creation of a special fund for the unserved population.
- Increase the use of Small SHS (SSHS) to reach poorer people. To do so, it will be necessary to arrange for **higher subsidy** for SSHS, to ensure **high quality of products** by implementing a **quality testing institute** in the private sector.
- Generally speaking, to keep on expanding the government program, it will be necessary to train new personnel to meet the increased demand and to provide liquidity support for operators of Solar program.

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