"Solar Home System(SHS) impact in Bangladesh"

An Independent Study

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Of

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By

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DECLARATION

I hereby declare that this report is based on the results established by us. Materials of work found by other researchers are mentioned in the reference. This study, neither in whole nor in part, has been previously submitted for any degree.

Signature of Supervisor

Signature of Authors

Acknowledgement:

I would like to thank my parents for supporting me. Without their encouragement I might not able to do this. My hurtful thank to supervisor Dr. AKM Abdul Malek Azad for his intellectual guidance. Each time he guided me so well that I am pleased to have a chance of working under his supervision.

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Abstract:

Access to electricity is one of the major factors that impinge on socio-economic maturity of a country. At present Bangladesh is distressing from an acute electricity problem. Around 65% of people having lack access of electricity and majority of them are living in village. The generated power was incapable to assemble the demand, leading to a load shedding up to maximum 1500MW. In this situation SHS technology can be a smart effort to solve this problem by harnessing energy the country's free-flowing renewable such as sun shine. In the last 15 years SHS installation is increased tremendously. So it is the high time to measure what are the impacts of SHS in our country. This result will lead us to solve our energy problem more effectively.

Contents:

Chapter1

Introduction:

Background of Solar Home System (SHS)

Bangladesh is one of the most densely populated countries with 79% of the population living in rural areas [1]. Again the electricity coverage is only 42% at per capita electricity consumption is about 140 kWh which is one of the lowest in the world. So we can say, though we are most densely populated country but maximum of our people do not have the advantages of electricity. With the time the graph of electricity demand is stirring upward. For a developing country like Bangladesh it is economically very much thorny to electrify residences through the extension of the distribution grids. So here renewable energy can be an effective

solution. The core energy sources of Bangladesh are biomass and natural gas. Over 80% of people depend on conventional energy sources such as firewood, cow dung and agricultural residues for their energy needs [1] [2]. Excessive use of firewood's threatens the remaining forest cover, which is only 10% of the total land area [2].So solar energy is most environments saving project for us. Sunlight combines with two types of energy: light and heat. Both may be utilized directly or indirectly by converting them into electricity. Again only heat can be used in other heating purposes also. As being a tropical country which receives sunlight throughout the year, there are lots of possibilities to be benefited by properly using this energy. Not just that, there are also ideas that the solar electricity may actually be supplied through the normal grid [4].

According to the recent data Bangladesh economy is growing up and poverty rate is falling. If we figure out numerical data that indicates, economy has grown at around 6% or more and poverty has fallen substantially from 45% in 2005 to around 30 by 2010 [3] [4]. The general lack of access to electricity imposes limits on the prospects of growth and increased welfare. This lack of electricity is also opposing our process of digitalize the nation. To increase such condition and generation of electricity we can realize the importance of solar home system (SHS). Actually solar home system is designed to meet the demand t of electricity to single household. SHS always consist of one or more photovoltaic (PV) modules, a battery, a charge regulator, a load consisting of lights and one or more sockets of radio, television or other applications. In fact, solar electrification

program is already yielding a positive impact on the rural economy. Apart from connecting rural Bangladesh with the rest of the world through television, it has created more than a thousand skilled and unskilled jobs. More than 750,000 and rural shops have already been connected to Solar Home Systems [3]. Every month, 30,000 systems are being installed**.** The report is going to discuss briefly about the overall present condition of SHS in Bangladesh. We know that environmental issue is the burning topic in case of using any kind of renewable energy. So the environmental aspect of the SHS is also included here. Here is also a chapter related to the carbon emission in terms of battery using and unique recycling process to keep our future clean [5].

Let's focus on the purpose of doing research on SHS evaluation. As discussed before, the necessity of solar home system is increasing day by day. Adding to the benefits are zero CO_2 and greenhouse gas emissions, and significantly improved health and safety conditions as compared to traditional fossil fuel alternatives [6]. Using the solar home systems is also yielding substantial social benefits. Besides enabling small business owners to stay open longer, thereby significantly increasing their incomes, the artificial light they bring enables students to study in the evening with better quality light. It also lifts some of the burden of running a household carried by Bangladeshi women. On top of all this, installation of the solar home energy systems is quick, safe and relatively simple. Just 42% of Bangladesh's 142-million people have access to the national electricity grid. As I told before, this is not enough for our proper

development [4]. Finding for effective alternative SHS is like blessing for us. Again solar home energy systems can be installed in a day. So it is less expensive and time consuming too. Only utilizing the proper use of it can make our rural life developed like urban areas. In summary, research and development on this field can enlighten our future work. By updating the information with time is very much essential for making a clear path in the future. So evaluating the overall present condition of SHS in Bangladesh we can ensure the future development of this prospective field. That's why research interest in SHS is increasing tremendously [7].

In this study, research work is divided into two parts. In the first part, there is paper based work and tried to realize the proper glance of SHS in Bangladesh. Many experts' works in this field has also been studied and tried to realize the future opportunity as well as their plan. Paper based work has subdivided into some categories. At first research has done on the overall view and present situation of SHS. After that a brief study has maintained on IDCOL and the main Partner organizations. It is tried to realize their extension of work and the advantages that they are providing our rural people. Then this research focused on the technical study. In that part paper discussed about the components, the loads and how efficiently they can work. There is also a deeply study on testing of the component battery issue which is related to the carbon emission.

In the second part, there is a survey based work. A survey was managed in the rural area and some sample questions was asked to them related to SHS. Again a survey document on Partners organization is attached later in this report.

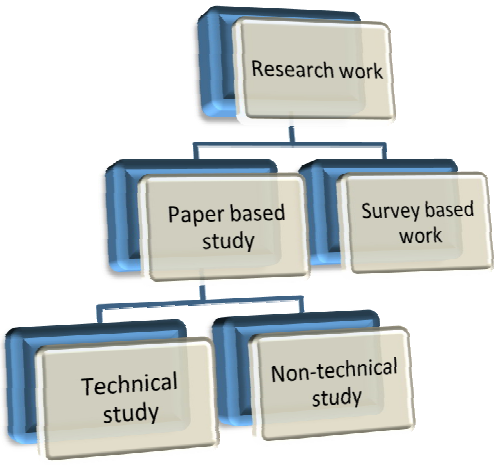


Figure1: Research study pattern (author).

In the chapter two, the potential of the solar home system is discussed briefly. To make a proper impact evaluation of SHS, potential analysis is very much important. Bangladesh is situated in such a region that solar energy is very much available. For this reason solar home system can be justified as proper alternative to the power generation option. This chapter also provides the solar radiation data which can be used to compare the potential over other country.

A brief discussion about the Partner Organization (PO) is available in chapter three. PO's have the authority of distributing and installing SHS in Bangladesh. Knowing the PO's activity is very

important to have a proper SHS picture in our country. In Bangladesh there are lots POs but only some of them are doing very well. Their activities are also very much effective to enlarge SHS popularity in all over the country. From last 15 years they have installed about 12,00,000 SHS till this year. So, this is a phenomenal increment and this job is done by the POs. Top POs are: Grameen Shakti, BRAC Solar, RSF, Srizony etc. This chapter is discussed briefly about those top POs and their activities.

Chapter four is all about the SHS component testing. It seems that SHS installation is increasing tremendously (Increment of Last 15 years data will show later in this report). It is very much possible that the number poor SHS panel will increase with the increase of installation. So it is very important to focus on the standard SHS testing for Bangladesh. Chapter four will discuss briefly about the procedure of standard testing for all the components. The protection system is also discussed in this chapter.

Chapter five will discuss the survey data which includes household survey and PO survey. This survey data is very important part of this report. As this report is going to evaluate the impact of SHS in Bangladesh this survey result will give an image of actual people thinking. In this chapter there are a lot of figure which will explain the proper scenario. This chapter will show satisfaction factor of the SHS and daily life changing circumstances of household by SHS. In the PO survey segment, there are lots of direct question answer is provided which were asked in terms of surveying.

Chapter six is about the cost comparison study between SHS and diesel generator. This is a unique research segment in this report. As we know govt. of Bangladesh is giving the subsidy for the diesel for its power generation impact. But we know that diesel based generator is so much costly and it is also a threat for environment. Again sometimes it is very hard to get diesel in the rural areas. So a better alternative is very much needed which is available and cost effective. This chapter it will prove that SHS is the better alternative over diesel generator. Detail calculation is also found in this chapter.

Chapter seven is the conclusion part. In this part an effort is made to summarize the impact and future possibilities. There are some suggestion is provided after analyzing the whole report which can be very much effective for the future research work.

Chapter2

Solar Home System Potential In Bangladesh

Bangladesh is situated between20.30-20.38 degrees north latitude and 88.04-92.44 degrees east which is an ideal area for solar energy. Utilization of solar energy potential is very important for the impact analysis of SHS in our country. Daily average solar radiation varies between 4-6.5 KWh per square meter [8]. We can get maximum amount of radiation on March-April and minimum from December –January. According to recent studies, yearly average insolation availability in Dhaka is 1.73MWh per square

meter on a horizontal surface and 1.86MWh per square meter on a tilted surface. Again the annual amount of radiation is varies from 1840-1575 KWh/m^2 which is 50-100% more than the Europe. Taking an average solar radiation of 1900 KWh per square meter, total annual solar radiation in Bangladesh is equivalent to 1010*1018 J. Present total yearly consumption of energy is about 700* 1018 J. It shows that even if 0.07% of the incident radiation can be utilized, total requirement of our energy can be met [8]. At present energy utilization in Bangladesh is about 0.15 Watt/sq. meter land area, whereas the availability is above 208 Watt/sq. This shows the enormity of the potentiality of SHS in Bangladesh by using this huge solar energy [9]. What fraction of it can be used for our use will depend on the availability of the technologies suited to local conditions [10].

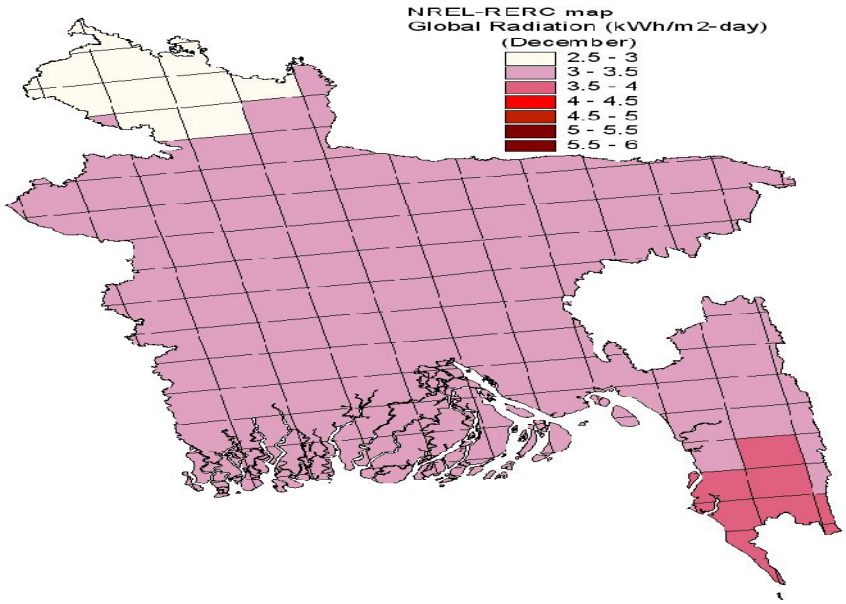


Fig2: Solar Radiation Map in Bangladesh. [11]

Table1: Here is the monthly average hourly GHI* (Wh/m^2) data, 2003-2005, Bangladesh [9]

Hours/months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5:30			1	5	17	19	11	7	3			
6:30	3	8	29	66	106	93	86	66	58	46	31	11
7:30	57	93	148	198	252	200	198	180	165	169	157	97
8:30	175	254	318	354	406	321	355	288	303	324	331	237
9:30	300	424	489	521	561	416	438	433	435	473	490	382
10:30	411	573	629	666	681	494	503	514	485	487	580	479
11:30	494	672	712	751	727	532	548	537	485	520	614	498
12:30	518	701	722	764	711	593	570	535	486	488	573	489
13:30	483	646	657	693	641	500	503	482	441	406	510	426
14:30	379	528	541	553	577	451	463	453	385	323	377	309
15:30	236	353	377	402	419	329	372	356	281	208	204	183
16:30	94	175	204	237	257	215	244	231	164	76	57	54
17:30	10	37	55	72	93	93	107	89	45	6	1	2
18:30			2	4	11	17	18	8	1			
Daily average (kWh/m^2-day)	3.16	4.46	4.88	5.28	5.46	4.22	4.42	4.18	3.74	3.53	3.92	3.17

*Global Horizontal Irradiance

(Source: SWERA Project, RERC, University of Dhaka, Bangladesh)

Chapter3

Top Partner Organization (PO) In Bangladesh

3.1. Grameen Shakti:

3.1.1THE COMPANY AND SHS:

Grameen Shakti (Shakti meaning "energy" in Bengali) was created in 1996 as a not-for-profit company under the Grameen Bank. The goal of Grameen Shakti is to promote and supply renewable energy technology at an affordable rate to rural households of Bangladesh

[12]. Thus, their work not only focuses on the technical and capacity-building sides of renewable energy promotion. Founding Director of Grameen Shakti was Dipal Barua. After having served as Managing Director of Grameen Shakti and Deputy Managing Director of Grameen Bank for many years, Dipal Barua left Grameen Shakti and set up the Bright Green Energy Foundation in 2010. The new CEO of Grameen Shakti (as of 2011) is Abser Kamal [13].

Rural electrification through solar PV technology is becoming more popular day by day in Bangladesh. GS's solar program mainly targets those areas, which have no access to conventional electricity and little chance of getting connected to the grid within 5 to 10 years. It is one of its most successful programs. Currently, GS is one of the largest and fastest growing rural based renewable energy companies in the world. GS is also promoting Small Solar Home System to reach low income rural households [14].

3.1.2 INSTALLION OF SHS:

Established in 1996 to provide green energy solutions to rural areas with no electricity, GS has so far installed over 5lakh PV (photovoltaic) SHSs, benefiting over 30 lakh people. Grameen Shakti promotes renewable energy technologies - especially solar home systems, which typically consist of a small 30-100 Wp photovoltaic panel connected to a battery for storage. In 2007

Grameen Shakti had installed more than 110,000 solar home systems, with a capacity of about 5MW peak. Now they installed more than 5lakh with the capacity over 20MW peak. The installation rate is growing exponentially, with plan to reach 1 million installations in 2015 [15].

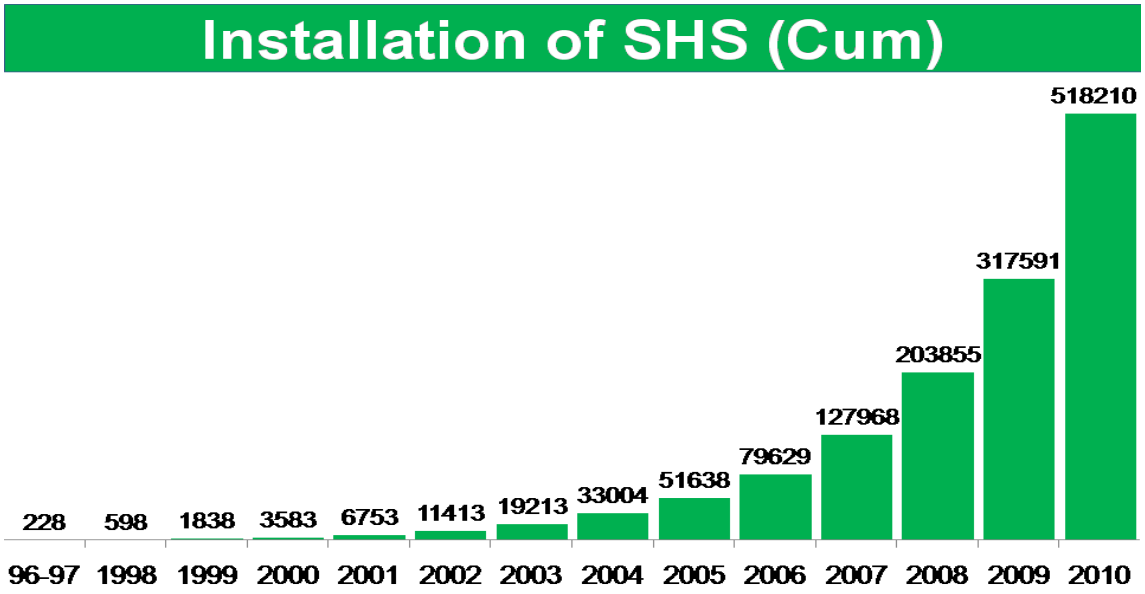


Fig.1: SHS installation growth up to 2010 [12].

3.1.3 FINANCING SHS:

Grameen Shakti has developed four different credit schemes to make the solar home systems affordable. Customers pay different proportions of down-payment and monthly installment according to their circumstances, supported by low-interest loans that Grameen Shakti receives from the Dutch Stichting Gilles Foundation and

from the World Bank through the Bangladesh Ministry of Finance's Infrastructure Development Company Limited (IDCOL). Four different schemes are [10]:

- ✓ The user has to pay 15% of the total price as down payment. The remaining 85% of the total cost is to be repaid within 36 months with 6% (flat rate) service charges.
- ✓ The customer has to pay 25% of the total price as down payment. The remaining 75% of the cost is to be repaid within 24 months with 4% (flat rate) service charge.
- ✓ Micro-utility: The customer has to pay 10% of the total price as down payment. The remaining 90% of the loan amount is to be repaid by 42 checques. There is no service charge.
- ✓ 4% discount is allowed on printed price in case of cash purchase [10].

3.1.4 INVOLVING THE LOCAL COMMUNITY:

Grameen Shakti has always sought to involve the local community in the planning, implementation and maintenance of solar home systems and has started a network of technology centers. The technology centers are managed mainly by women engineers, who train women as solar technicians. The women are equipped with tools to service and repair the systems in their areas, and to manufacture solar home system accessories [10].

3.1.5PROMOTIONS:

Grameen Shakti follow very much disciplined process to promote SHS in the rural areas.

- ✓ Demonstrations, door to door visits.
- ✓ Meeting with village leaders, distributing brochures.
- ✓ Science fairs at the local level
- ✓ Buyback system.
- ✓ Workshops for policy makers at national level [10].

3.2. BRAC Solar:

3.2.1 THE COMPANY AND SHS:

BRAC is one of the largest NGO in the world & it is working for environmental issues for long time. BRAC Green Enterprises is a combination of three enterprises, which work under an umbrella to provide green solutions for the corporate urban market: BRAC Solar Enterprise works for power solutions, BRAC Nursery for landscaping and plant rental, and BRAC Recycled Paper for office stationeries. Together, this group of green enterprises is engaged in the production of environment-friendly products, and are consequently aiding in the social uprising of green initiatives in both rural and urban communities [16].

BRAC Solar Enterprise started its journey towards rural electrification through solar home systems in 1998, in collaboration with the Infrastructure Development Company Ltd. An integrated and multipurpose program, its projects spread across the country in a wide variety of settings including households, BRAC and other NGO offices, training centers, schools, health clinics, cyclone shelters, a weather monitoring station, a government rest house and income generating centers such as carpentry, tailoring shops, cloth dyeing and printing shops, leather workshops, restaurants and grocery shops. The project operated with an aim to change the overall socio-economic status of rural people of the project areas by creating new jobs, increasing the education hours and helping the poor to carry out income generating activities [16].

3.2.2 INSTALLATION OF SHS:

With support from WB/GEF/GTZ/Kfw BRAC installed capacity 1.38 Mw (September, 2007) Standalone Solar Home System to provide electricity in rural off-grid areas and served 56,444(March 31, 2010) beneficiaries. In the year 2004, BRAC Foundation installed 4,840 Solar Home Systems. It has received refinancing from IDCOL amounting to Tk 49,149,122 and a grant of Tk 21,246,717. In 2007 BRAC foundation installed 2500 SHS thus far under REREDP. Again in May 2008 BRAC foundation installed 36,631 solar SHS with the support from WB/GEF/GTZ/Kfw. According to the IDCOL report 2009(July) BRAC foundation

installed 48,974 SHS. At present BRAC foundation has installed 72,470 Solar Home System all over Bangladesh under IDCOL. So the number of installing SHS by BRAC is increasing day by day [16] [5].

3.2.3 OFFICIAL MANAGEMENT:

According to the RENDEV final report 2008 BRAC has 5 people working on its solar activities in Dhaka, and 400 outside in the field. The key people are the Project Officers (POs) who are in charge of sales, installation, recovery, and maintenance for the clients and systems in their area. POs generally hold an engineering degree. The facilities of BRAC Foundation, consisting of 260 unit offices, 59 districts office and 30 technical centers throughout the country, are used to manage and follow up the clients of the solar loans and the solar systems. BRAC has one warehouse for spare parts in each district office [5].

3.2.4 FINANCIAL MODEL OF BRAC:

Monthly payments	
Down payment	*15% of Total Cost*
Loan length	*1 to 3 years*
Interest cost	*12.5 %*

Table2: Payment types.

Source: IT Power the costs for a typical system are about 21500 TK (40W), 26500 TK (50W), 37,200 TK (75W). The most popular package is a 50 WP system with a two year loan.

A 40 WP system can operate 2 light bulbs for 4 hours, 50 WP 3 lamps, 65 Wp 4 lamps and a 75 Wp system 5 lamps. The operation of a black and white TV is equal to the use of two light bulbs. Customers are generally not required to pay a guarantee. In the case of repetitive non-payment the solar system ultimately can be taken away from the client. This is highly exceptional, as the collection rate is about 98%, which is in line with the collection rates for BRAC loans for other products [5].

3.2.5 TRAINING:

POs are trained on sales, loans and installation. Initial training is 3 days long. IDCOL and RahimaFrooz organize focus on technical training while BRAC focuses on human skills.

BRAC also organizes training in villages. POs train the client on how to operate and maintain the solar system. POs are also trained in using tools to estimate the potential client's willingness to pay. In terms of promotion BRAC operates a direct approach. IDCOL also

gave subsidy for promotional material (T-Shirts, Posters and Meetings) [5].

3.2.6 NEW PROJECT:

BRAC is currently working on a pilot program with GTZ, consisting of 425 SHS aimed at the poorest households. In June 2007 200 of the 425 SHS had been installed. Depending on the results an upscale will be considered. They also asked IDCOL for funding to expand the SHS to mini grid systems, which suggest a big potential for the rural poor, especially in terms of income generation. Another initiative is looking at solar lanterns from 3 to 5 Wp (produced by Tata BP) [16].

3.3.Rural Services Foundation (RSF):

3.3.1 THE COMPANY AND SHS:

Installation of SHS is one of the main activities of RSF, a social development initiative of Rahimafrooz. From its inception RSF has install 2, 01,300 SHS by February, 2012 through its 468 Unit Offices under IDCOL, GTZ and RSF own financing program [17].

3.3.2 NEW PROJECT:

i. Small Solar Home System Pilot Program:

At present IDCOL is financing for 30 Wp and above size through RARE Program. RSF has initiated the project with the financial support of GTZ. The project is speculated as pilot project to find out the sustainability. After successful implementation of the project, now it is incorporated into the IDCOL regular program. To facilitate the lower income group RSF has designed the small SHS (16Wp & 21Wp) with low power LED lighting device. Initially 200 small SHS under the pilot project and finally 700 SHS have been installed [17].

ii. Mini SHS to Reach the Pro-poor*:*

Successful implementation of small SHS has inspired to take pilot initiative for finding the technical and economical scope and impact of mini SHS. With the financial support of GTZ, RSF is implementing the program at field level. Under the framework of the project, RSF is installing 500 small solar home systems for the very low income group. The system is based on 7.5 Wp PV module with a 7.5 Ah rechargeable maintenance free battery and few small lighting devices. Main targeted users of the system are small grocery shop, small home business as well as small home in rural areas where there is no electricity. So far 500 have been installed under this project [17].

3.3.3 TACHNICAL SIDE:

RSF has designed SHS for use in Bangladesh that can supply from three to six fluorescent tube lamps (FTL), using PV modules rated

from 40 to 75 Wp. The systems are sized to provide light for four hours a day with twelve hours reserve battery capacity (autonomy), so that the supply is maintained during several days of limited sunshine. If two lights are switched off, then a television can be used for four hours per day instead [18].

RSF imports PV modules from Tata BP Solar (a joint venture between the Tata Group and BP Solar) in India, but are involved with the design and manufacture of all other system components. Rahimafrooz manufactures the lead-acid batteries for their own installations, and supplies them to several commercial customers. The batteries are rated at storage capacities from 55 Ah to 130 Ah. They differ in detailed construction from standard lead-acid car batteries, because a PV battery must withstand daily deep discharge cycles which would rapidly reduce the lifetime and storage capacity of a car battery. For this reason, Rahimafrooz batteries have tubular plates, which enable significant removal and replacement of lead during the discharge and recharge process, and allow regular discharge up to 80% of their capacity. They also have a large reservoir of electrolyte, to reduce the frequency of topping-up. Other benefits are much higher charging efficiency (again, a feature which is not very important in car batteries) and a low rate of self-discharge. RSF has also developed charge controllers and FTL according to its own specifications [18].

3.3.4 FINANCIAL MODEL OF RSF:

Most of the systems sold by Rahimafrooz have been purchased by 14 other POs which are partners in the REREDP. POs receive both subsidy and concessional loans from IDCOL, which enables them to purchase the systems from Rahimafrooz (RSF). Initially the subsidy was about £55(1£=130 taka approximately) per system but this has been gradually reduced to £28 per system and is due to end in 2008.This subsidy enable PO's to offer credit to the rural families so that they can buy costing about half of their income. They can pay 400 to 800 taka per month and it will run for 3 to four years [18].

3.3.5 TRAINING AND SUPPORT:

Rahimafrooz batteries are designed to last for a minimum of eight to ten years with proper care and maintenance, and carry a five-year warranty. Rahimafrooz repairs batteries on behalf of the POs free of charge in most cases. So far, more than 3,300 batteries have been repaired even though they were not under warranty. Rahimafrooz buys batteries back for recycling at the end of their service life, paying the users Tk 300 to Tk 500 (£2.30 to £4), depending on their condition. The charge controllers and FTL have an expected lifetime of five years and carry a three-year warranty. Rahimafrooz provided 2% emergency stock of charge controllers and FTL free of charge to the POs until January 2006, so that replacements could be provided rapidly if problems arise [18].

This service is very valuable to users, many of whom live in remote locations and might have to wait without a working system for up to two months if individual components had to be returned to Dhaka

for repair. Now the emergency stock is only 1% because the designs of RSF have proved very reliable in use. The PV modules carry a 25 year warranty, to produce at least 80% of their rated power. RSF has used its substantial technical expertise to support the POs with whom it works [18].

One way is by providing training on the basic maintenance and safety of SHS. RSF takes a solar demonstration kit around villages along with the POs, to show people the benefits of owning an SHS. RSF also carries out servicing and repairs on behalf of the POs [18].

Chapter4

Solar Home System Components and Their Testing Procedure
(PV module and Battery testing)

4.1: PV Modules:

Pv is the most important component of the SHS. There is some of the characterization which should be needed for our testing:

Irradiance:

- Global irradiance on the plane of incidence, G > 600 W.m-2
- Diffuse fraction of global horizontal irradiance, D(0)/G(0)< 0.2in a clear day.

Wind Speed: should be higher than 1 m.s-1 which is equivalent to a gentle breeze.

PV modules (sensors and tested):

- Co-planar position, without obstacles hindering thermal dissipation.
- Orientation should be towards the equator.
- Tilt is an angle leading to incident angles direct solar irradiance below 40º. [For example: solar zenith angle at noon or, generally speaking, tilt angle equal to $|\varphi|$(local latitude) in autumn-winter, and equal to $\max\{|\varphi|-20º, 0\}$ in spring-summer.]
- Should be cleaned before with soap and clean cloth.
- Modules should expose outdoor before testing to make assures that modules are at thermal equilibrium.

(V, I) Measurements:

- Should be performed within 1 hour from solar noon.
- Total duration for the three (V, I) points and their corresponding operation conditions must be less than 5 minutes. In this way, no major variations of operation conditions can be achieved. (For this same reason, no measurements should be done in days with strong wind or passing clouds)[19].

After having the PV module in the hand, there are some visual inspections which should be done. By having visual inspections outer damage and others things can be identified. Table I lists the different aspects to be inspected, as well as defects leading to a PV module rejection.

DEFECT	REJECTION CRITERION
1.Broken or cracked cells	Breaking or spreading of a crack, causing a piece of more than 10% of a cell area to be separated.
2. Cells out of line	Cells touching each other.
3. Front surface of cells	Very noticeable metal stains.
4. Inclusions in lamination	Coverage of more than 1% of a cell area.
5. Bubbles in the encapsulant	If they allow a path between the cells and the frame or edge of the module.
6. Front glass	Broken.
7. Connecting tape	Torn apart
8. Labels	Indelible labels missing
9. Tedlar	Damaged or holed

10. Connection box	Broken or worked loose

Table3. Defects leading to PV module rejection (detection by visual inspection) [19]

4.1.1 PROCEDURES OF TESTING:

1. OPERATION CONDITIONS MEASUREMENTS:

- Irradiance measurement
- Cell temperature measurement

STEPS:

Irradiance measurement:

The method is based on the linear relation between I_{SC} and G, from which the following expression results:

$$G\ (W\ m^{-2}) = 1000 * (I_{sc} / I^{*}_{sc})$$

Where subscript “S” added denotes as the sensor-module.
This expression involves a slight overestimation, since no second-order effects (TC influence) are considered. Nevertheless, the use of the proposed expression in procedure 3 has the effect of cancelling such error.
According with figure 1 and eq. (above), the voltage measurement in the calibrated shunt (precision resistor) allows calculate the irradiance value [7].

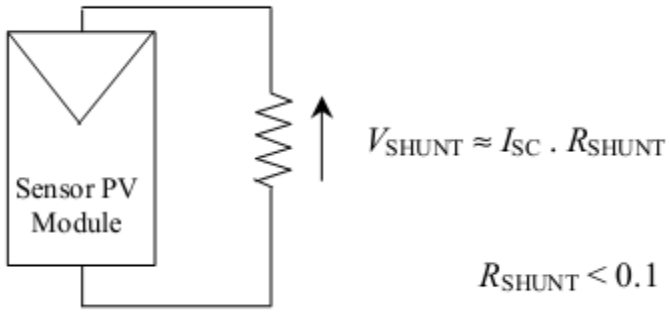


Figure4. Irradiance measurement method [19].

Cell temperature measurement:

The method is based on the linear relationship between VOC and TC, without considering second-order effects (G influence). It leads to:

$$T_{c} = \{1 / (N_{s,s} * \beta_T)\} * (V_{oc,s} - V^{*}_{oc,s}) + 25°C$$

β_T=2.3 mV/°C and NS,S is the number of series-connected solar cells in the sensor-module.
This expression involves a slight overestimation (rapidly decreasing with increasing G). Nevertheless, as it is the case with irradiance measurements, the use of the proposed expression in procedure 4 has the effect of cancelling such errors. Figure 2 shows the assembly required for the use of the proposed method [19].

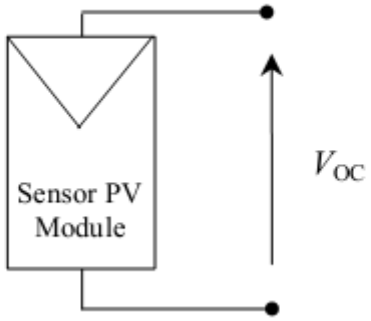


Figure 5. Cell temperature measurements method [19]

2. ELECTRICAL PARAMETERS TEST AND EXTRAPOLATION AT STC:

- Characterization of the short-circuit current parameter.
- Characterization of the open-circuit voltage parameter.
- Characterization of the Maximum Power.
- Fill Factor determination:

STEPS:

Characterization of the short-circuit current parameter:

Measure one day I_{SC} values of the module under test by irradiance measurement procedure. Single values must be individually extrapolated to STC using the following expression:

$$I^*_{sc} = 1000 * (I_{sc} / G\ (W\ m^{-2}))$$

Measurements periodicity should be at least 1 hour. The desired parameter I_{SC*} is the average value of the individual extrapolations [19].

Characterization of the open-circuit voltage parameter:

Measure during one day VOC values of the module under test, together with TC estimates from the cell temperature measurement. Single values must be individually extrapolated to STC by means of the following expression:

$$V^*_{oc} = V_{oc} - (N_s / N_{s,s}) * (V_{oc,s} - V^*_{oc,s})$$

Measurements periodicity should be at least 1 hour. The desired parameter V^*_{OC} is the average value of the individual extrapolations [19].

Characterization of the Maximum Power:

It is based on the measurement of three single points of the module I-V curve, which are to be used for the determination of the maximum power at STC, PM*, once the fill factor, FF*, has been calculated [19]:

$$P_M^* = (I^*_{sc})\ (V^*_{oc})\ (FF^*)$$

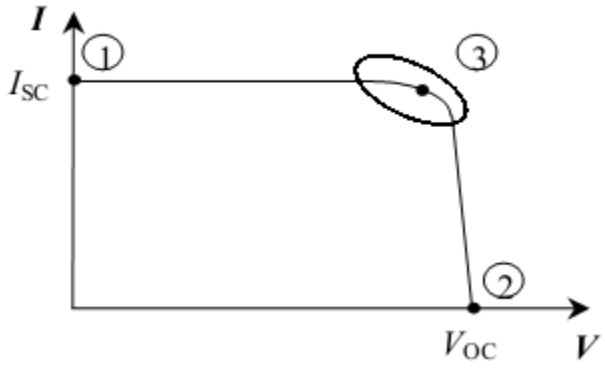


Figure6. Graphical representation of the three (V,I) points to be measured [19].

Fill Factor determination:

For the practical determination of FF in a PV module, the following equations are proposed:

$$FF = FF_o \cdot (1 - r_s)$$

Where FFo is the ideal fill factor (no resistive effects):

$$FF_o = \{v_{oc} - \ln (v_{oc} + 0.72) / (v_{oc} + 1)\}$$

V_{oc} is the normalized open-circuit voltage of each solar cell (average):

$$V_{oc} = V_{OC} / N_S \cdot V_t$$

Where V_t is the thermal voltage.

r_s is the normalized series resistance of each solar cell (average):

$$r_s = R_s(I_{sc}/V_{oc})$$

These parameters enable to calculate directly the maximum power point (V_M, I_M):

$$V_m = Voc\ \{1-(b/Voc).\ \ln a - r_s.(1-a^{-b})\}$$

$$I_m = I_{sc}(1-a^{-b})$$

Being a and b two intermediate parameters:

$$a = v_{oc}+1-2v_{oc}\ r_s \qquad\qquad b = a/(1+a)$$

All these equations can be used for any operation conditions, given the following compliance: voc > 15 and rs < 0.4. This covers real operation for most Si solar cells. Accuracy in the calculation of the maximum power using above equations is better than 1%.

The series resistance, assumed independent of operation conditions, can be calculated using above equation and three (V,I) points [19]:

$$R_s = R_s^* = [N_s.V_t(25°C)\ \ln(1-I^*/I^*_{sc}) + V^*_{oc} - V^*]/I^*$$

Current measurements are extrapolated as the short-circuit current:

$$I^* = I^* + (I^*_{sc} - I_{sc})$$

Voltage measurements are extrapolated as the open-circuit voltage:

$$V^* = V^* + (V^*_{oc} - V_{oc})$$

4.1.2 Instrumentation:

Figure bellow shows schematically the equipment and assembly recommended.

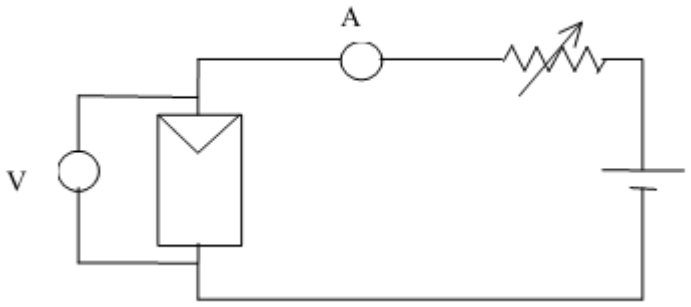


Figure7. Instrumentation and assembly recommended

Instrumentation comprises the following elements:

- Voltmeter, for the PV module voltage measurements.
- Ammeter for the module current measurements or, alternatively, a combination of shunt + voltmeter.
- Battery, for fixing a certain operation voltage at the PV module. If it is a conventional (36 series-connected) module, a 12-Volts battery will be used. For other types of modules (e.g., low-voltage, based on 12 series-connected assemblies), combination of 2-Volts battery vases can be used (or even the battery can be disregarded).
- Potentiometer (variable resistor), for a more precise adjustment of the module operation voltage. It should be noted that this adjustment, because of inherent limitations of the potentiometer, cannot be as fine as would be desired. This component must be able to stand the maximum power of the PV module under test.
- Irradiance sensor-module: calibrated module in I_{SC*} parameter.
- Cell temperature sensor-module: calibrated module in V_{OC*} parameter [19].

4.2: Battery:

Batteries have been identified as the most costly component during the SHS lifetime. Commonly, lead-acid batteries are used. Battery lifetime depends strongly on battery type, correct sizing of the SHS, local climate and proper operational management for example, charge regulation algorithms and maintenance procedures [5]. The most important feature of battery operation in SHS is cycling. During the daily cycle, the battery is charged over the day and discharge over the night-time load. Superimposed onto the daily cycle is the seasonal cycle, which is associated with periods of reduced radiation ability. This together with other operating parameter (ambient temperature, current voltage etc.), affects the battery life and maintenance requirements [6]. In order to maximize the lifetime of the lead-acid batteries, the following operation conditions must be avoided:

- High voltage during charging(to prevent corrosion and loss of water)
- Low voltage during discharging. (corrosion)
- Deep discharge(sulphation, growth of dentrites)
- Extended periods without full charging(sulphation)
- High battery temperature (all aging process are accelerated)
- Stratification of the electrolyte(sulphation)
- Very low charge current(sulphation)[20]

A simple scheme of the battery is observed in figure 1.

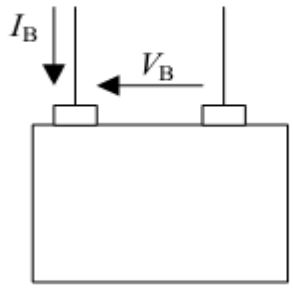


Figure 1: Scheme of the battery [19]

Now coming back to the Universal Standard for Solar Home System, its battery deals with tubular and automotive batteries referred to as SLI. The latter are in three categories:

- Classical
- Modified
- Low maintenance[20]

“Classical SLI’’ batteries use lead grids alloyed with antimony and require periodic topping up with water.[20] Again certain condition must be met in order to categorized as “modified SLI” , as follows :

- The thickness of each plate must exceed 2mm.
- The amount of electrode must exceed 1.15 per 100 Ah of 20-hour nominal capacity and per cell.
- The separator must be made of microporous polyethylene.
- The density of electrolyte must not exceed 1.25 g/cl. [20]

Above requirements should be checked directly in terms of battery testing. Again if the battery is delivered dry-charged it should be filled with electrolyte of a density lower than 1.25g/cl.

“Low –maintenance” SLI batteries are sometimes marketed as a maintenance free batteries, often grid containing calcium alloys. The calcium increases the voltage at which gassing begins but reduces the cohesion of the active material to the grids. Hence, it cut down the loss of water but also reduces the cycle life. Such batteries are particularly vulnerable to damage to damage from deep discharge. In addition they are also liable to be damaged by high temperature variations. So, it is recommended not to use in the hot countries. [20]

The 20-hour nominal battery capacity in amp-hours (measured at 20 W and up to a voltage of 1.8 V/cell) should not exceed CR times the PV generator short-circuit current in amps (measured at Standard Test Conditions) [20]. CR values are proposed for each type of battery in the table below:

Battery type	CR
Tubular	15-20
SLI (automotive):	
- Classical	30-40
- Modified	35-40
- Low-Maintenance	30-40

The maximum depth of discharge, PD_{MAX}, (referred to as the 20-hour nominal battery capacity) should not exceed the values proposed in the table below:

Battery type	PD_{MAX}
Tubular	70-80
SLI:	
- Classical	30-50
- Modified	40-60
- Low-maintenance	20-30

The useful capacity of the battery C_u ($C_{u=}$ C_{b*} PD_{MAX}) should allow for a three to five-day period of autonomy [6].

The cycle life of the battery (i.e., before its residual life drops below 80% of the nominal capacity) at 25 degree C must exceed NOC cycles when discharged down to a depth of discharge of 50%. A NOC value is given for each type of battery in the table below [20].

Battery type	NOC
Tubular	600
SLI:	
- Classical	200
- Modified	200
- Low-maintenance	300

4.2.1 PROCEDURES OF TESTING:

1. INITIAL CAPACITY:

This starts just after filling the battery with correct electrolyte density. It determines the initial state of formation of the plate.

STEPS:

Now when the battery is filled, discharge the battery down to 10.8V at an I_{20} rate, or close. This discharging is done through a load with the adequate ohmic resistance (this load can be a lamp) to take the desired current from the battery. Measure the supplied Ah (norm CB5). The pass criteria establish a minimum capacity of 95% of the nominal capacity. Batteries with low initial capacity need a strong charge before the installation, which should be clearly indicated in the technical information by the manufacturer [19].

INSTRUMENTATION: Current source, lamp, calibrated shunt resister, multimeter.

2. STABILISED CAPACITY AND CYCLING:

The objective of this test is, first, to obtain the real stabilized storage capacity of the battery after some charge and discharge cycles, which can be compared with manufacturer data.
Second, from this test can also be determined the voltage evolution of the battery with its state of charge, a crucial point for the regulation functions of the charge controller [19].

STEPS:

After the first discharge, the battery is charged completely by a current source at 14.4V for more than 24 hours until the input

current remains constant, in order to assure an absolute formation of the plates [7].

Now, constant I20 rate, or close, discharge and charge cycles are performed until the battery capacity reaches a stabilized value, while voltage VB and current IB values are measured. The measuring time steps should be 60 seconds if an automatic data acquisition system is utilized, but 10 or 15 minutes if manually data measuring is done. The battery capacity and voltage evolution with state of charge can be obtained from this test (norms CB3, CB5 and RB2) [19]. The capacity corrections to discharge rate observe the following expression:

$$Cn = C_{10} \frac{1{,}67(1+0{,}005\Delta T)}{1+0{,}67(\frac{I_N}{I_{10}})^{0{,}9}}$$

Another parameter can be determined from this test. Divide C20 between I_{GSC} to obtain the CR factor, which relates the PV Generator current with the battery size. CR should be within a range depending on the battery type, in order to assure the correct charging current.

3. VOLTAGE REGULATION THRESHOLDS :

With charge and discharge curves from section 7.2.2, the regulation set points and warnings, that the associated charge controller should have, can be determined (norms RR5, CR2, CB4, RR1 and RR3) [19].

INSTRUMENTATION: Current source, lamp, calibrated shunt resister, multimeter.

4. GASSING (BATTERY GASSING CURRENT) :

The objective of this test is to determine the battery gassing current as a function of Voltage (V) and temperature (T). It gives information

about its performance in the high voltage range and also about its water losses. Both issues have a great influence on battery maintenance tasks and on its cycle life [19].

STEPS:

Assure the fully charge of the battery by applying 14.4V during more than 24 hours with a current source. Measure the input current IB and temperature for the floating voltages given in the data forms, all between 13.2V and 15.5V where gassing is produced. Take data after at least 10 minutes for each voltage point, in order to measure correct stabilized values (figure bellow). The pass criteria establish a gassing current, normalized to a battery capacity of 100Ah, lower than 50mA, at 2.23V/cell and 20°C [19]. The gassing phenomenon is accepted to follow the Tafel expression:

$$I_{ga}\ (mA\ /\ 100\ A.h) = I_{go}.\ \exp\ [C_U.\ (V_{vaso} - 2.23) + C_T\ .(T - 20)]$$

Where parameters are I_{go}, C_U y C_T obtained by adjusting the experimental results.

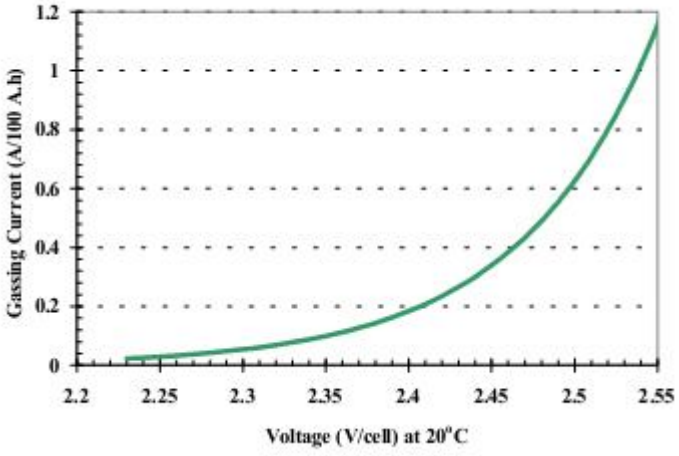


Figure8: Gassing current Vs battery cell.

INSTRUMENTATION: Current source, multimeter.

The following information and specifications must be available from the battery manufacturer, supplier or recognized test Laboratory:

- Make, type, nominal voltage and nominal capacity.
- Capacity at 10-hour discharge rate (at specified temperatures).
- Electrode type and type of electrolyte.
- Specific gravity ranges for the electrolyte (for flooded batteries).
- Graphical information on charge and discharge characteristics, at different current rates and specified temperatures.
- Graphical information on cycle life versus depth of discharge (at specified temperatures)
- Information on any particular regulation requirements for optimal cycling in a PV environment[20].

In general, the data must be sufficient to establish the suitable method of battery regulation and suitable set points.

Additionally, the tenderer shall submit information in respect of:

- Battery safety requirements.
- Battery maintenance requirements.
- Battery replacement requirements [20].

4.2.2 BATTERY PROTECTION:

Batteries shall be protected from the weather and installed in boxes or suitable enclosures which fulfill the following requirements:

- Access to the terminals and electrolyte shall be restricted to authorized and responsible persons only. Batteries shall be protected from access by children. However, the batteries shall be accessible for inspection by authorized persons.
- The terminals shall be protected from accidental short-

circuiting from a tool being dropped across the terminals, for example.

- There shall be sufficient ventilation for hydrogen to escape. Hydrogen shall not be routed to any location where there is a danger of sparks or flames.
- There shall be at least 20 mm free space between the batteries and the walls and top of the battery box.
- The battery box or enclosure shall be made of suitable, durable and acid-resistant materials.
- A permanent notice shall be fixed to a battery box or suitably placed at a battery enclosure as a warning of the hazard from a release of gases, the danger of explosion, and that smoking or flames should be prohibited[20].

Chapter5

House Hold And PO's Survey Result: Impact Analysis

5.1 House Hold Report:

5.1.1 Background:

We have conducted our survey on different household having SHS in their home. Different types of questions regarding SHS were asked to them. Based on this survey we have figured out the summery of the impact of SHS in Bangladesh.

5.1.2 Methodology:

Several researches have been done to evaluate the solar home system condition in Bangladesh. But the main focus of our research is to identify the proper social improvement of our country though

SHS. That's way our questionnaires were patterned differently so that it can reflect the impact of SHS. We conduct our survey on the Gazipur (Kapasia) area which is near to the Dhaka city and our data base survey will definitely define the condition of the socio-economic scenario of those areas as a symbol of rural area of our country. We have made our interview with the household owner and some small grocery owner. We have also made a huge study on the previous research work, which helped us to make an effective summery on our research work. Our next section will discuss briefly about our research work and the effective results.

5.1.3 Household Survey:

We have conducted our survey on the 25 household and other 5 grocery shop. All the households are dominated the male member of the family. The income of those families was not so high. We found that there are more than 50 percent families whom are incoming lower than 7 thousands money per month and only a few household having more than 10 thousands taka per month.

Income range(per month)	Percentage of household
5-7 thousand	48%
3-5 thousand	32%
7-10 thousand	12%
Above 10 thousand	8%

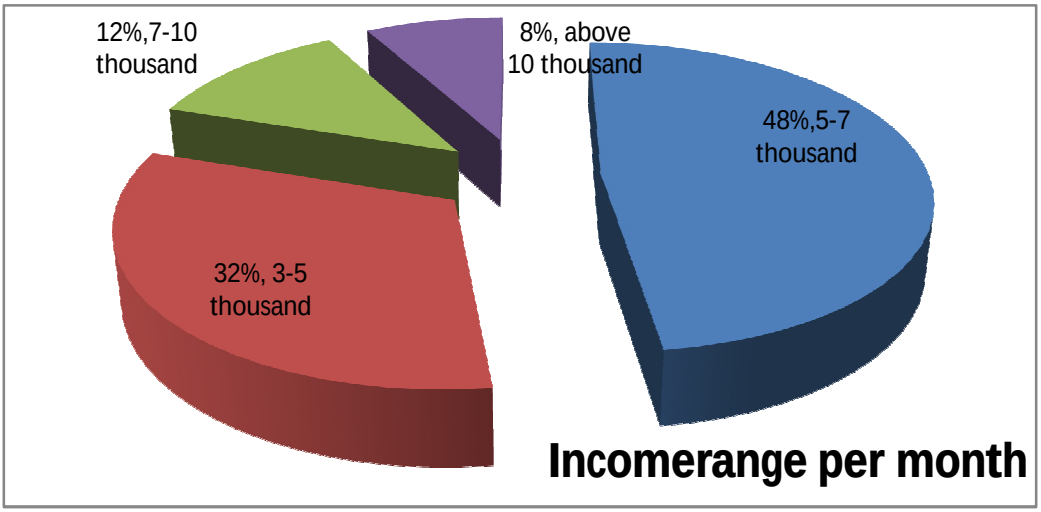


Fig9: range of income per month.

This chart says that 48% of the households are low income family. So this is very hard to them to pay the total amount installation money. Here comes the feasibility of the monthly installment with low interest. More people go for the monthly installment rather than bearing total installment cost. From our data we can say that about 80% household install SHS by monthly installment scheme. Usually different types of panel are offered by the Pos. But the most popular is 50Wp solar panel. 50 Wp solar home systems were most common in the study area which can run three lamps and one black and white TV system. Larger capacity systems (75Wp) were used by comparatively larger family (higher income group) it was also a popular size [15]. But still larger groups of people are using 50 Wp panel because of their cheaper prize and lower installation program. Here is the top two PO's 50 Wp scheme:

PO Name	System in Watt	Load Provided	Price
Grameen Shakti	50 Wp	4 Nos. 7 watt lamp and 1 No 17'' B/W TV point	26,800 taka
BRAC Solar	50 Wp	Four lamps of 8 watt & one Black and White TV	22,500 taka

Table4: 50 Wp system with load and price.

From the table we can the price of 50Wp solar panel price of top two PO's. Now there is our one of the researcher data of most using SHS system.

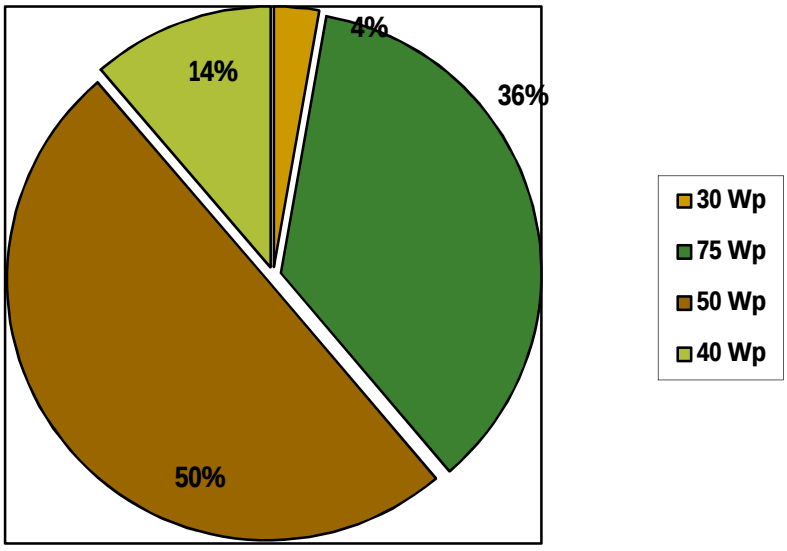


Fig10: Most used SHS system (15).

From the survey report that we get from the rural areas we summarize a report in which it can be realized that what amount of load they are actually used. The result indicates that there are some common loads which are used in the household. They are like light, mobile charger, fan, radio, TV (B/W), Refrigerator etc. But from the survey it seems that about most of the family use light and mobile charger. Not all the families are usually go for the fan and radio but lots of families are now having fans. Near about 50% families are having at least B/W TV in their home. Refrigerator is not so popular yet. But the number of families who are using refrigerator is also increasing with the increase of their family condition. From the government report it can be find that the poverty graph is decaying from the last 15 years. An increasing data of electronic materials since last 10 years is also included here.

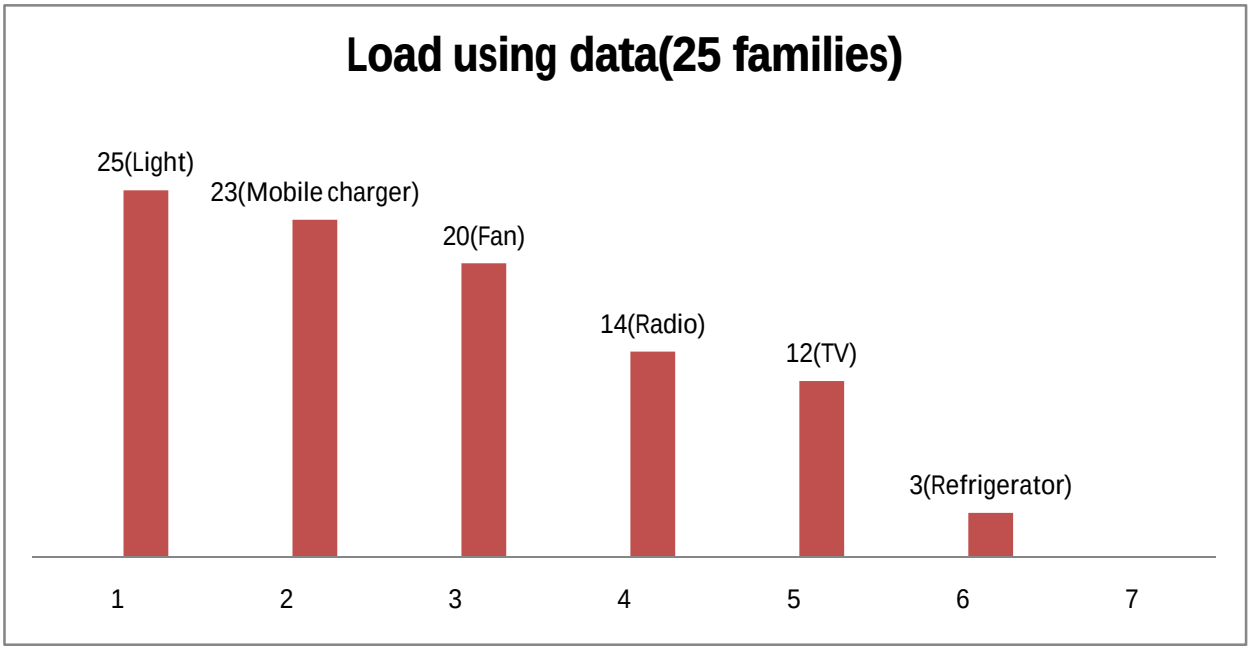


Fig11. Load using data.

Table5: Here is the data of increased number of electronic materials in our rural area in last 10 years

House Hold No.	2002- 2005						2006-2012					
	Light	Fan	Mobile charger	Radio	TV		Light	Fan	Mobile Charger	Radio	TV	
1.	Yes	No	No	No	No		Yes	Yes	Yes	No	No	
2.	yes	No	No	No	No		Yes	Yes	No	No	No	
3.	No	No	No	No	No		Yes	Yes	Yes	No	No	
4.	Yes	No	No	No	No		Yes	Yes	Yes	No	No	
5.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	Yes	
6.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	Yes	
7.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	Yes	
8.	No	No	No	No	No		Yes	No	No	No	No	
9.	No	No	No	No	No		Yes	No	Yes	No	No	
10.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	Yes	
11.	Yes	No	No	No	No		Yes	Yes	Yes	Yes	Yes	
12.	Yes	No	No	No	No		Yes	Yes	Yes	Yes	Yes	
13.	Yes	Yes	No	No	No		Yes	Yes	Yes	No	No	

14.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	Yes
15.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	No
16.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	Yes
17.	Yes	Yes	Yes	Yes	No		Yes	Yes	Yes	Yes	Yes
18.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	No
19.	Yes	No	No	No	No		Yes	Yes	No	No	No
20.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	Yes
21.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	Yes
22.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	No
23.	No	No	No	No	No		Yes	No	Yes	No	No
24.	No	No	No	No	No		Yes	No	Yes	No	No
25	Yes	No	No	No	No		Yes	Yes	Yes	No	Yes

All those data includes the rural electric load using situation of our country. Actually in the rural area all those loads are not used constantly. There are some particular time of using all those loads and all those are using at a time. We have also focused on time of using loads. After conducting the survey we make a summary of time table of using load.

Table6: The Period of Daily Energy Consumption for Lighting and Entertainment

Consumption	**Morning**	**Afternoon**	**Evening**	**Night**
Lighting	-	-	6pm-7pm	7pm-10pm
TV			3:30pm-7pm	7pm-9pm
Radio	7am-8am			

Table7: Daily Typical Energy Requirement for Lighting and Entertainment [15]

Appliance	**Power (W)**	**Duration (Hour)**	**Energy (Wh)**
Lamp 1 (reading And bed room)	6	5	30
Lamp 2 (bed room)	6	4	24
Lamp 3 (bed room)	6	2	12
Radio	10	1	10
TV(Black and white)	20	4	80

From Table we can see that the average daily electricity requirement for one house hold is 156 Wh.

Having realization of total background of the electric system in the rural area, now it's time to have a proper comprehension on the regular problems of the households. Though the poverty line our country is decaying day by day but still we are below poverty line and per capita income our country is very low. People living in the rural area still have to survive for their food and cloths. Those are the real scenario of our country people. So without any doubt it can be dogged that financial problem is the foremost problem in our country. But still electricity problem also take the crucial place in rural areas people life. For this reason problem identifying survey took a vital place in our report.

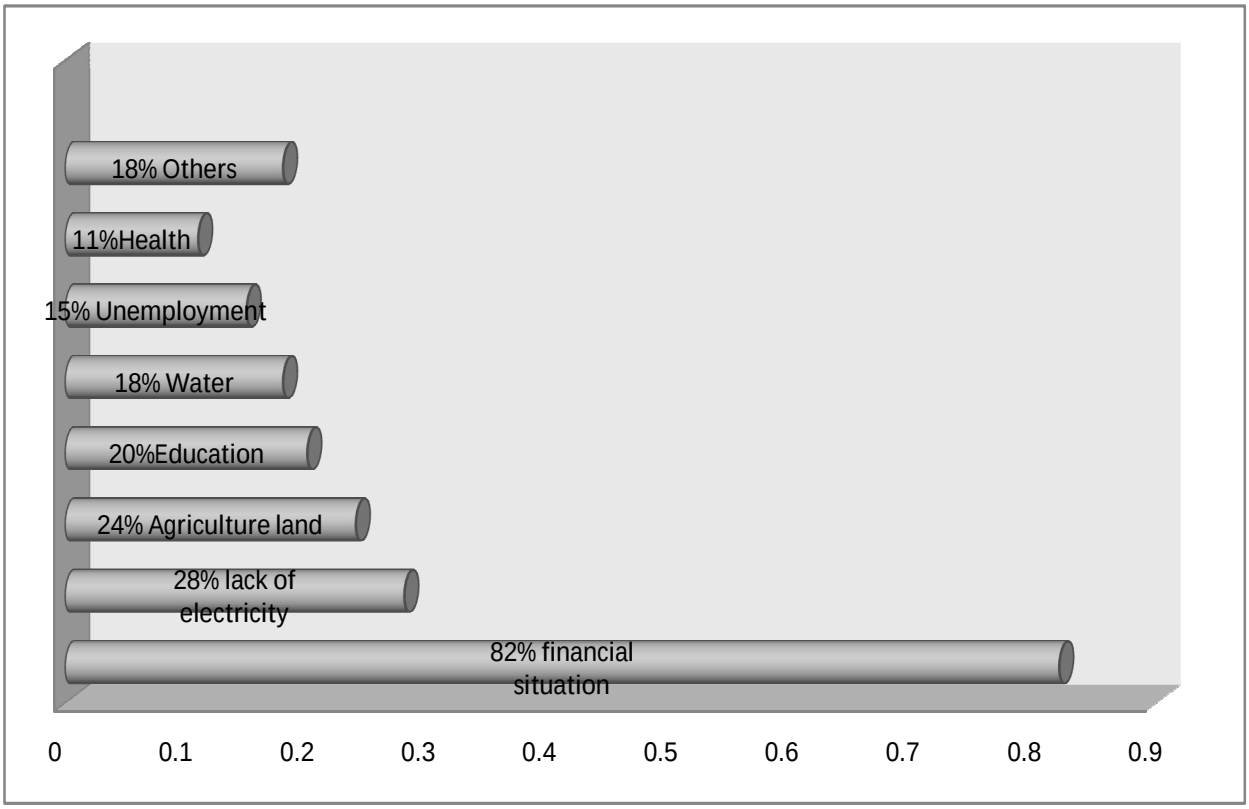


Fig12: Main problems of the households [16].

We can see the actual phenomena of our rural areas by analyzing this fig. So Solar Home System (SHS) can play an obvious roll where there no grid electricity is connected. SHS can provide electricity with a low cost and without distorting the environment. We conduct a survey that how SHS can contribute an impact in the rural regular life.

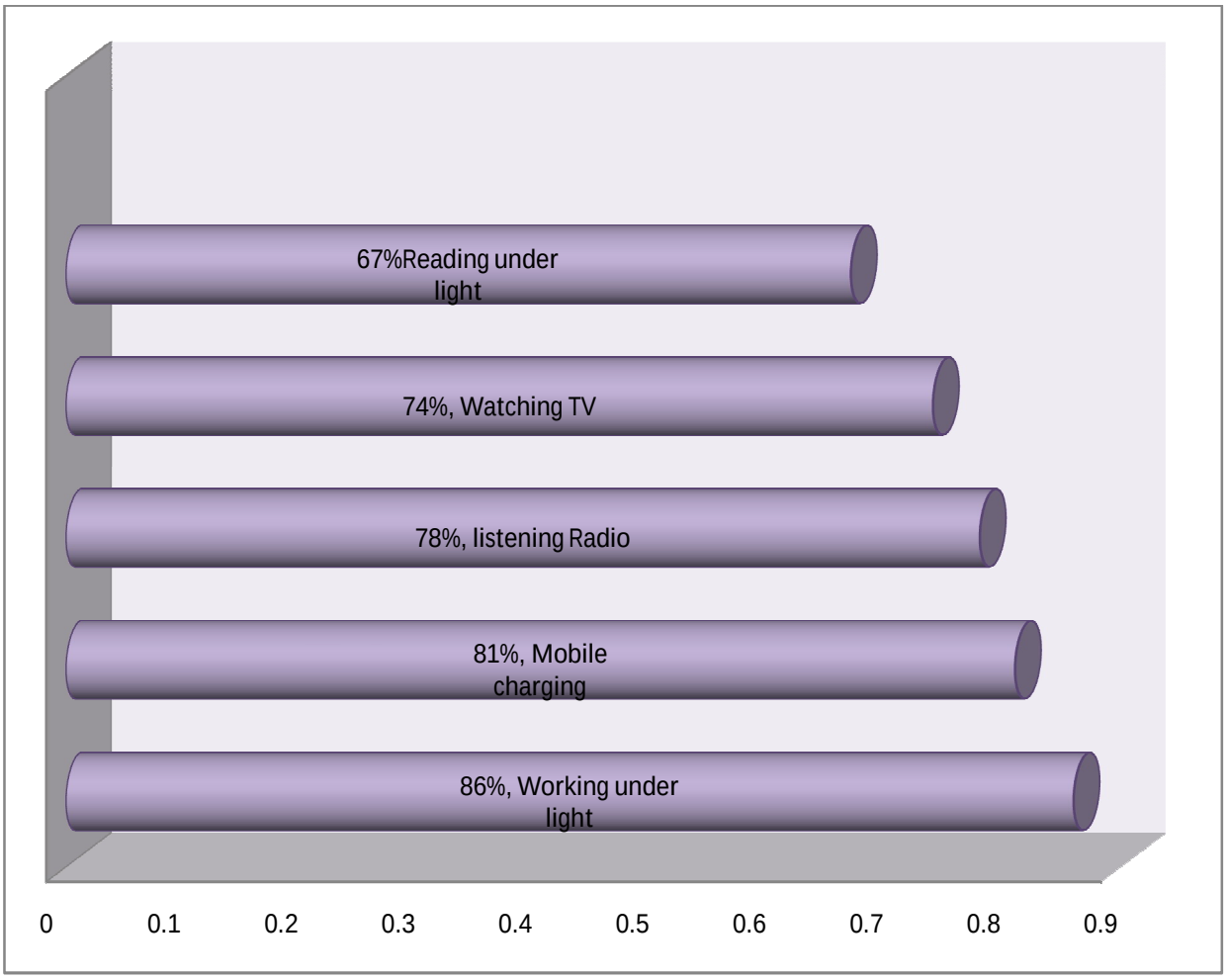
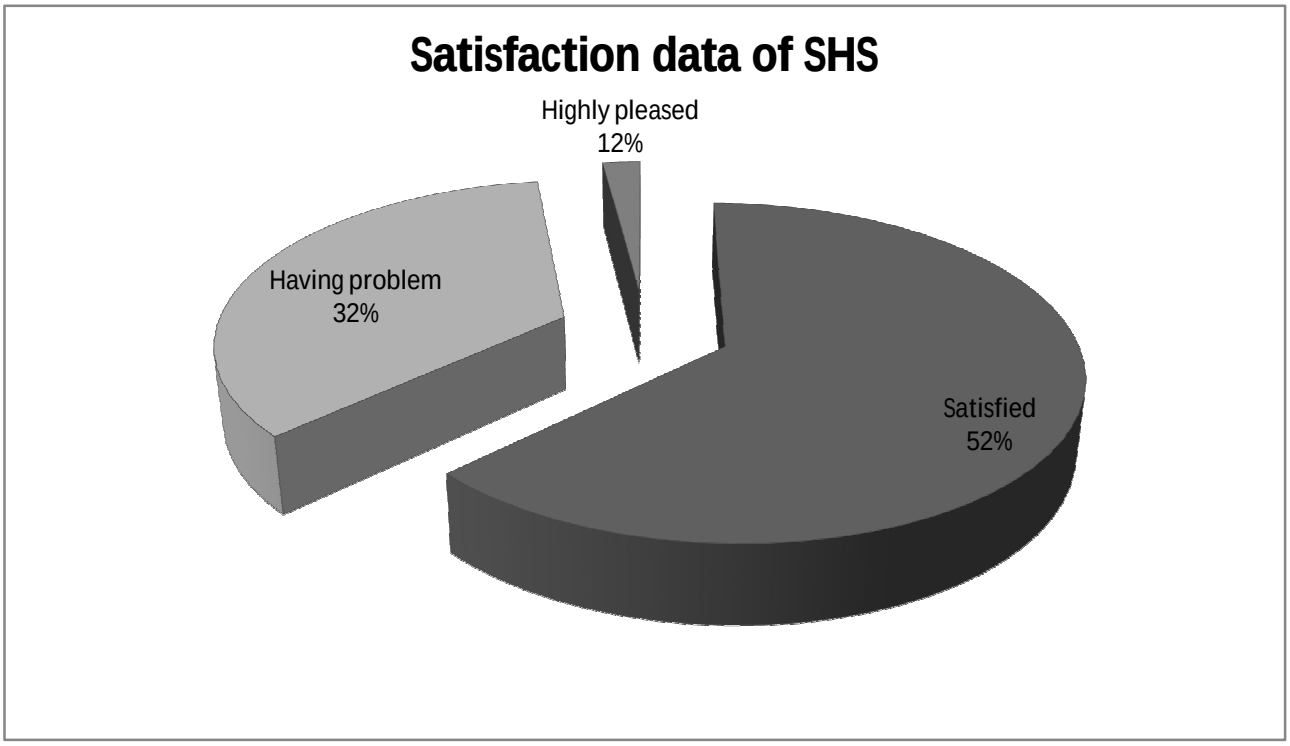


Fig13: Electricity consuming activity through household [21].

Here we can see that some of the regular activities with the help of SHS. So it is demonstrated that SHS has our rural life more active and easier than before, when there was no electric

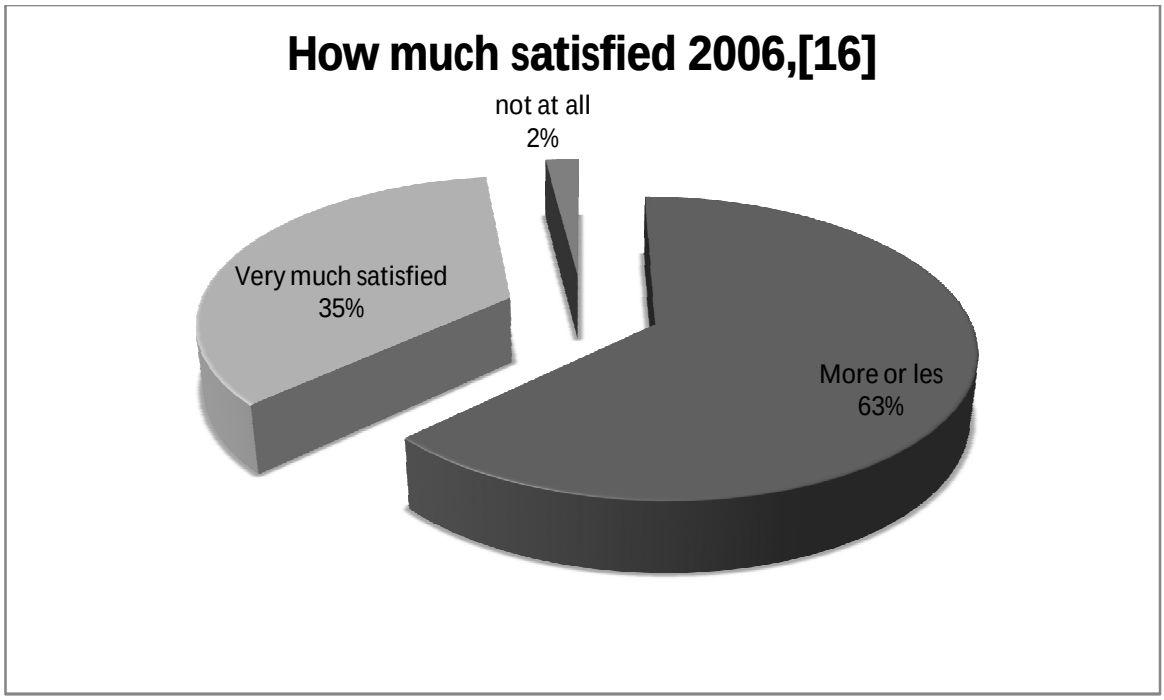
Gradually SHS is having priority to the rural people. But still because of high installation price many people are not that much interested to have SHS in their home. Again some people are not enough satisfied with the service of the SHS organization. But overall result declares the maximum numbers of satisfaction with SHS service who are using this. For utilizing better impact we have also conduct a survey to those household who are not using the SHS along with 25 household.

Fig14. Comparison of satisfaction data.



If we compare this report with the Michael Blunck report 2006 [21] we may have a clear concept that how SHS is gradually becoming a

popular name to our rural people. Let's have an overview of Blunck's satisfaction data 2006.



Here we can see positive improvement of SHS within 6 years. So, we can say that people are benefiting much more from the SHS. Only that's way we can see an improvement of 35 %(2006) to 52% in our survey. Now our target is to find the reason why people are getting more interested with SHS. So our next conducted data is based on the reasons behind the public popularity towards SHS. In

the survey we have asked people about the socio-economic impact of the SHS. Our motive was to identify the changes that SHS brought to them. Lots of points were in survey that brings changes in household regular life. People get better entertainment facilities with the help of SHS. That entertainment brings change in rural people life. Rather than doing gossiping ideally people prefer to see many TV shows and gaining some knowledge. It also helps people to keep steps with the modern world and knowing the present world events. Having light facilities in the home children can have more time to study. Farmer can work more time in the field. Better lighting facilities have also changed the routine of the household girls. Now they do not depend only the sunlight top do their household chores. In the daily communication is not a big deal to the rural areas people. With the help of mobile and better lighting facilities they can move easily anywhere needed. Actually they feel more secured life of their own. These all are the positive impact of the SHS in the rural life. Actually in summery we can say that the standard of our rural areas people has increased with the help of SHS.

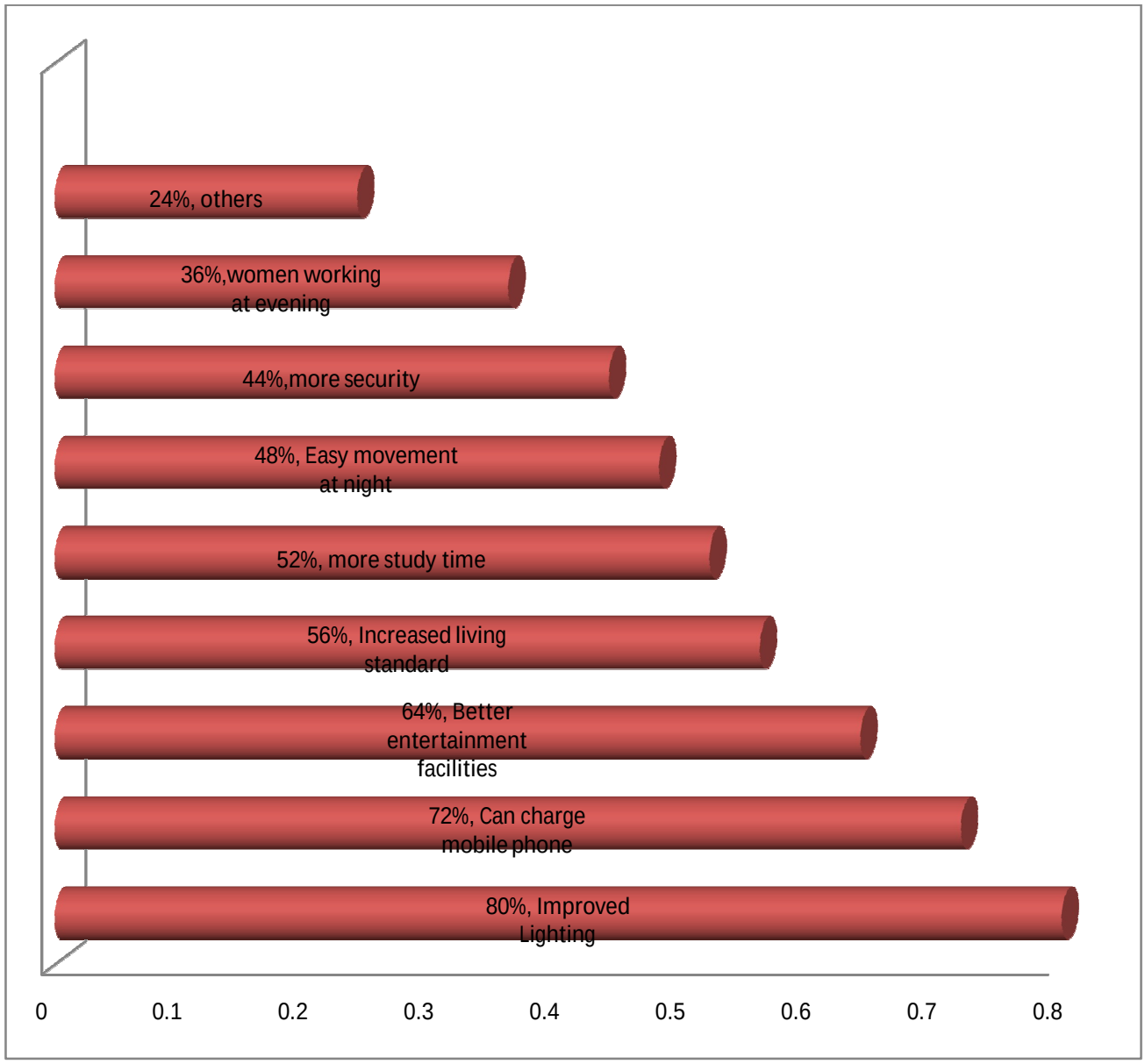


Figure15: Daily life changing by SHS.

From the figure we can have a clear idea that everyone in the family having benefits through SHS. But our motive was to find the most benefited member by using SHS. The result of our survey defines that the most benefited members are women. Actually they are having lots of activities by using SHS. They are having entertainment at night by watching TV rather than ideal setting. By

this they are also learning something and advancing with the world. Some of them are educating themselves by watching TV and hearing radio. Children are also very much benefiting as their activities increases. They are having chance to grow up like town people. Most of all security of the women and children has increased by having SHS.

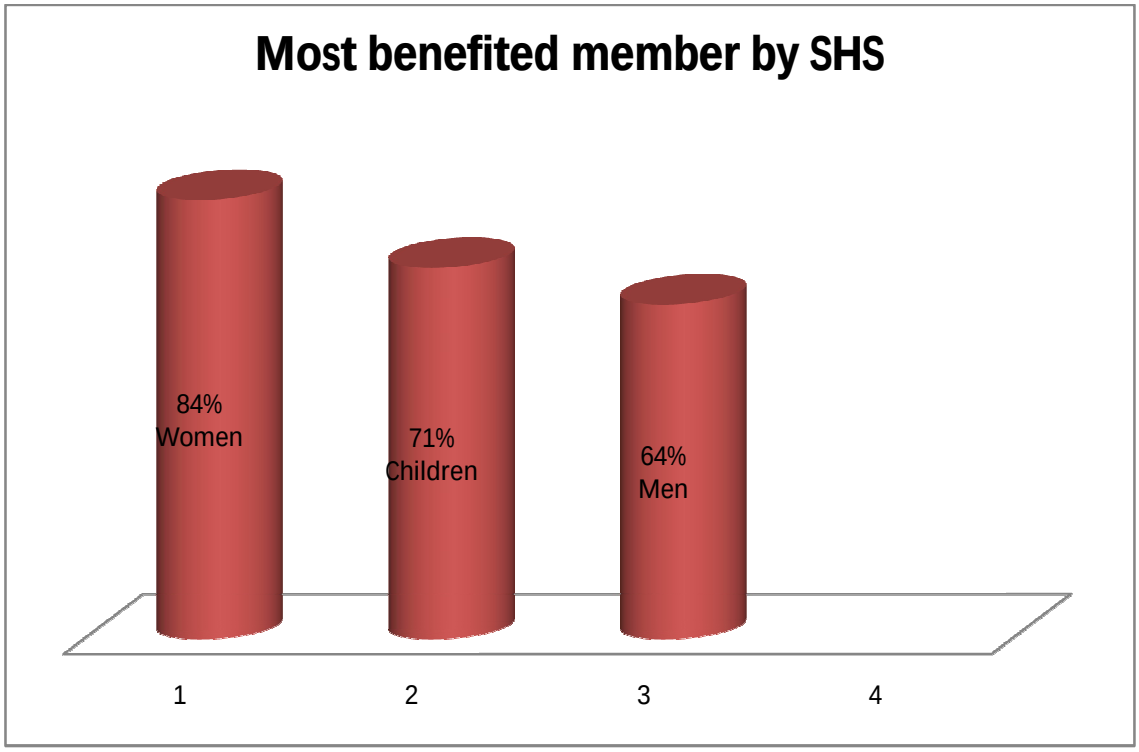


Fig16: Most benefited member.

In our survey we also asked the battery and charge regulator matter to the household. Because this two components contain short time warranty period. So, people need to change these things after certain amount of time. Each PO's have their own program to teach people what to do with those damage components. We

surveyed 25 families to make it clear that what they do with those damage components. Maximum of them returned the NGO after using but not all. Some of them throw it out which might be very much harmful for the environment [16].

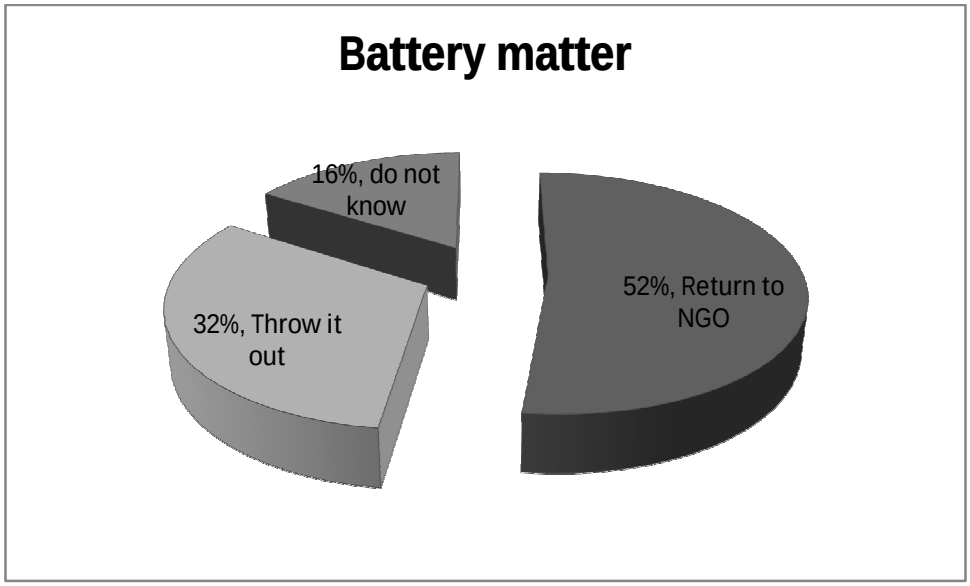


Fig17. Damaging battery issue.

From the above data we surveyed it is clear that SHS is having a clear cut impact in the rural social life. We hope that is impact will bring more positive results furthermore in our country and reduce the pressure on national grid.

5.2 PO's Survey:

We have managed a survey in the Grameen Shakti and asked them a lot of questions related to the SHS. The answers they have provided is very much important for my research work. Based those answers a comparison study between SHS and diesel generator is provided in the next section. Here are the questions and their answers:

1. How many Solar Home Systems (SHS) Unit has been installed and how to identify them?

Answer: About 7 lakes (ongrid+offgride, 2011, GS). Anyone can identify by asking the owner or having a look on the rooftop, where u can see solar panel.

2. What percentage of remote area are getting benefits from your SHS installation?

Answer: We have all already installed 59.45% of total installation & benefiting over 30 lakes of people.

3. What kind of SHS package are you offering?

Answer: 10 packages,

4. Which package is mostly used by the user and why?

Answer: 50 Watt with 80 amp hour (around 20 to 50 percent sell) & 20 Watt with 30 amp battery (around 34% sell) .

5. How many solar hours are there in an average day where the SHS is installed?

Answer: Average sunlight hour in Bangladesh range from 10 to 7 for summer and winter respectively.

6. What should people do in terms of winter or rainy season when usually less solar hour in an average day?

Answer: Actually, at that period people have to depend on the national grid. Because our efficiency decreases when there are less solar hours. But they can also save power for using that period.

7. What are the ac & dc loads used by or given to a user?

Answer: Black & white TV, Color TV, light, fan, charging mobile, again some schemes can provide power for operating computer.

8. How do you overcome the limitation of SHS components wiring?

Answer: they could not overcome.

9. What is the reason behind giving a 50watt or 30watt panel with a very high rating battery?

Answer: using 50 watt or 30 watt will provide more backup.

10. How many watts per hour is used by an average family in a typical day or approximately how many hours does a family uses the light and fan?

Answer: about 9 to 12 hours.

11. What complains mostly stated by a user of SHS?

Answer: Mostly stated complain is related to the costing. There are also some complain related to technical site.

12. What steps do you take to overcome those complains?

Answer: As we said before a lots of complain related to costing. So, we are trying to reduce our cost but still we have some limitations. Our technicians are always ready to meet any technical problems. But we think a lot of problems arise because of illiteracy of our people. Lots of people are unable to use properly. It causes less efficiency. But we have some programs to let those people know how SHS can use properly.

13. What are the most technical difficulties that you face while installing SHS in an area?

Answer: most technical difficulties are: condition of the rooftop.

14. What are the technical faults that come out of the SHS packages during the warranty period?

Answer: technical faults are: inverter problems, charge controller problems, permanent battery damages problem due to discharging less rated value.

15. The appliance that runs with a SHS package is mostly run with AC or DC current? If it runs with AC current then what kind of inverter you are giving? Is it made by local market or outside?

Answer: dc, local made square wave inverter.

16. What kind of charge controller given with the SHS package? Is it MPPT or not? Is it made by the local market or outside? How it's performing?

Answer: not MPPT, yes it is ,made by the local market. Good.

17. What kind of converter you are using for the dc package of solar home system? Is it made by the local market or outside? How it's performing?

Answer: they use only local made converter, & those are performing good.

18. We know many of remote area's people are not even accomplished with the Solar Home Systems. So, what types of marketing procedure are you going to take to spread it all over the country?

Answer: Grameen Shakti follow very much disciplined process to promote SHS in the rural areas.

- ✓ Demonstrations, door to door visits.
- ✓ Meeting with village leaders, distributing brochures.
- ✓ Science fairs at the local level
- ✓ Buyback system.
- ✓ Workshops for policy makers at national level.

19. Do you provide service centre for your customers? Do you think it may be an effective process to gain loyalty?

Answer: We have 786 unit offices in all over 64 districts & those are very much important to provide proper services to the customers.

20. Do you think Solar Home Systems can be a signature part to spread primary education and health care opportunity in remote areas? What's your plan to develop this opportunity?

Answer: Yes, SHS can be a signature part to spread primary educations. Actually, still we are providing SHS in many

primary schools on rural areas. Now we are promoting to spread it all over the country.

21. Do you have field level monitoring and verification department? How does it work?

Answer: Yes, our unit offices do the field level monitoring & verification. They also detect the field level problems of SHS & their solutions.

22. How come your SHS project creates employment locally?

Answer: Grameen Shakti has always sought to involve the local community in the planning, implementation and maintenance of solar home systems and has started a network of technology centers. The technology centers are managed mainly by women engineers, who train women as solar technicians. The women are equipped with tools to service and repair the systems in their areas, and to manufacture solar home system accessories.

23. What is your current promotion rate per month?

Answer: Average rate of 4000 SHS per month.

24. The rise of world market prices of SHS components has caused higher prices for system & the customers are irritated by price changes. In this case what should you do keep prices in the customers ability?

Answer: we can improve our technical side & make components of our own to keep prizes in the limit.

25. Solar energy technologies still remain a costly alternative to the use of readily available fossil fuel technologies. So, what is your technological future plan to reduce this cost & make this cheaper alternative to the people?

Answer: It still remains costly because of the components prize, so the main solution is to make them in our local market.

26. Microcredit concept has both positive & negative effect. Do you think it can be a revolutionary move in SHS? Or, it can ruin the interest of customer to get familiar with SHS?

Answer: We think it has a positive impact. Actually, our rural areas people are not capable of giving all the money together. So, microcredit is a easy solution for them.

27. What irradiance parameter is usually used to measure solar insolation? (DNI – Direct Normal Incidence, DIF – Diffuse Horizontal Irradiance, etc.)

Answer: they not yet think about that.

28. What instrument is used to measure the solar insolation at the site of PV installation?

Answer: not applicable.

29. During the summer time the solar panel should be tilt 15+ degree with the latitude an during winter it is 15- degree with the latitude? Does user follow this convention? If they

doesn't then will a one day training of this things be helpful or not?

Answer: they do not have the one day training procedure.

30. Is it feasible to install single axis or dual axis tracking systems (manual) for the PV modules?

Answer: not applicable.

31. What is the percentage increase in total cost of the SHS if a tracking system (manual) is included?

Answer: not applicable.

32. What is the efficiency of the inverter used in the SHS?

Answer: 50 percent.

33. PV modules are usually 14 to 18% efficient in converting sunlight to electricity. So after including inverter and charge controller inefficiencies, what is the net efficiency of the SHS?

Answer: 13 percent.

34. Do you have research unit for improvement of overall efficiency of the system and ancillaries? What kind of work they are doing now?

Answer: Research unit is very much efficient for our further work. Actually they are accelerating our work by their new ideas. Still we are working for our costing adjustment.

35. What methods can be employed to hybridise/combine the SHS with other power production methods so that electricity can be supplied round the clock after sunset?

Answer: introducing on grid SHS enable them to supply round the clock.

36. If, for example, a 200W SHS is going to be installed, which is the better option: two 100Wp PV modules or four 50Wp PV modules? What is the justification behind the better choice?

Answer: two 100 W. because they don't have micro inverter technology.

37. Is it possible to connect the SHS to the electricity grid so that excess power produced by the panels can be sold for a feed in tariff by the consumer? If they can be connected, then what are the extra components required and by how much will they increase the total cost of the SHS?

Answer: they don't have. Inverter is required dual switching mechanism, it is expensive.

38. How the PV systems are to be utilized in order to achieve sustainable development in rural households?

Answer: as we know most of our rural areas people are illiterate. So, we have to gain their attention and make them realize the system. Our promotion part may keep a vital rule in that case.

39. Have you investigated the other viable renewable energy sources in the areas and ascertained their feasibility in a smaller scale?

Answer: those are more costly than SHS.

40. Many battery types can pose serious problems when disposed as municipal waste; their toxic constituent can be released into the environment causing damaging health effect.

So what are your possible steps to reduce this kind of environmental damage?

Answer: we can make a effective group to collect them & recycle them to use again part to part.

41. Reduction of toxicity of battery may be solution of that damage. Again it is mainly issue to be dealt with by battery manufacturers. Are you concern to the reduction of toxicity issue?

Answer: yes, now we are concerning more to recycle our battery parts. Now it is an environmental issue.

42. Extend the life time of battery may be a solution of it. What kind of battery may be used to extend life time?

Answer: solar deep cycle battery, but expensive.

43. Now the advance world is thinking about the battery recycling. What do you think about it?

Answer: as we said before, yes we are now thinking our battery recycling process.

44. In this process batteries need to be collected. Who do you manage to collect those batteries from the rural areas?

Answer: we are thinking about the new department of recycling battery. We are thinking of having sub offices in every district that can manage to gather damaged battery.

45. Now we can see the growing amount of SHS demand. By this assumption we can calculate the huge amount of using batteries in the future. It will be a hazard for environment if still not taking any plan to reduce that. My question is, are

you really thinking ahead for that? As though it is totally scientific matter, how you going to aware rural people in which maximum number of them are illiterate?

Answer: we have to increase our field level training. If our field level staffs are properly taught then they can trainee rural illiterate people in their own way. Than the things will go in a chain way and the rural people can get those things gradually.

[Survey data sheet for both HH and PO is provided in the appendix.]

Chapter6

Cost Comparison Study between SHS and Diesel Generator

6.1Background:

Access to electricity is one of the major factors that impinge on socio-economic maturity of a country. At present Bangladesh is distressing from an acute electricity problem. Around 65% of people having lack access of electricity and majority of them are living in village. Among them about 44% are living below poverty line. So, energy supply in Bangladesh poses great challenges

[22].In 2010, the per capital electricity production in Bangladesh was 236KWh. At this time the maximum production was 4,606 MW, disseminated to 2.07 million consuming units (households, business etc.). The generated power was incapable to assemble the demand, leading to a load shedding up to maximum 1500MW. In contrast to this, the demand estimated in the year was 6454 MW, compare to a generation aptitude of 5271 MW. This data comprises only the grid covered areas, without considering the localities in our country which do not receive grid electricity [2]. Actually this statistics indicate that the demand in the grid connected areas alone far away from the production capacity, not to state off grid locality, where the greatest population lives. In this situation Renewable energy technology can be a smart effort to solve this problem by harnessing energy the country's free-flowing renewable such as sun shine, biomass, wind, tidal current, waterfalls or river currents, sea waves.

For the remote places and the remote island, the panorama of supplying grid electricity is near about impossible within foreseeable future. In absence of grid electricity, using of diesel

generator to supply electricity is often proposed as an alternative. Actually using generators is not an effective solution. Using diesel generators has its own set of problems. Generators themselves are quite expensive. So producing electricity by generator is very costly. Even if some household can afford to buy and run this, lack of fuel supply often limit the use of generator [3]. Biomass might be a good alternative source of energy. But it is becoming more expensive and scarce due to high demand. Electricity supply is often erratic due to inadequate power generation capacities [4]. Under these circumstances, Solar Home System (SHS) can be an appropriate alternative to provide electricity. Providentially, Bangladesh is endowed with copious supply of solar energy due to its geographical location. Annual amount of radiation varies from 1840 to 1575 kwh/m^2 which is 50-100% higher than Europe [8].

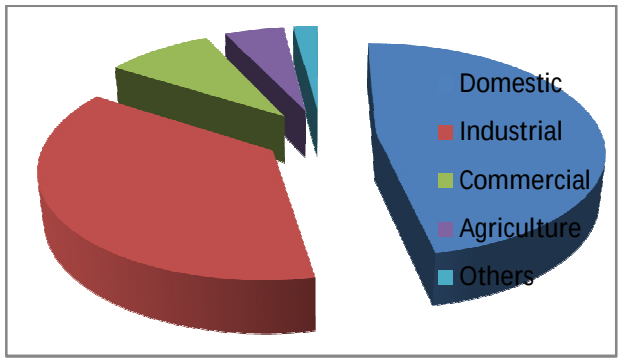


Fig18. Energy used in Bangladesh.

6.2 DIESEL GENERATOR COST: 20 YEARS CASE ASSUMTION:

Configuration of the model Diesel generator:

Fuel tank capacity: 15 L

Fuel option: Diesel

Weight: 170Kg

Fuel consumption: 1.25-1.5 lit/hr

Output (minimum): 4000 Watt

Maximum (maximum): 45000 Watt

Rated: Around 4000 watt

Operating time: 6 hours continuing

Voltage: 220V

Speed: 3000 rpm

Frequency: 50 Hz

Price: 90,000 Taka

1st 5 years:

Year(No)	Diesel cost (Taka)	Calculation (Taka)	
1	52 (Present)	(1.5×4×365×52)= 1,13880	
2	55.5	(1.5×4×365×55.5)= 1,21545	
3	59	(1.5×4×365×59)= 1,29210	
4	62.5	(1.5×4×365×62.5)= 1,36875	
5	66	(1.5×4×365×66)= 1,44540	
		Total	6,46050 + 90000 = 7,36050

2nd 5 years:

Year(No)	Diesel cost (Taka)	Calculation (Taka)
1	69.5	(1.5×4×365×69.5)= 1,52205
2	73	(1.5×4×365×73)=

		1,59870	
3	76.5	(1.5×4×365×76.5)= 1,67535	
4	80	(1.5×4×365×80)= 1,75200	
5	83.5	(1.5×4×365×83.5)= 1,82865	
		Total	837675 + 90000 = 9,27,675

3rd 5 years:

Year(No)	Diesel cost (Taka)	Calculation (Taka)
1	87	(1.5×4×365×87)= 190530
2	90.5	(1.5×4×365×90.5)= 198195
3	94	(1.5×4×365×94)= 205860
4	97.5	(1.5×4×365×97.5)= 213525
5	101	(1.5×4×365×101)=

		221190	
		Total	10,29300 + 90000 = 11,19300

4th 5 years:

Year(No)	Diesel cost (Taka)	Calculation (Taka)	
1	104.5	(1.5×4×365×104.5)= 2,28855	
2	108	(1.5×4×365×108)= 2,36520	
3	111.5	(1.5×4×365×111.5)= 2,44185	
4	115	(1.5×4×365×115)= 2,51850	
5	118.5	(1.5×4×365×118.5)= 2,59515	
		Total	12,20925 + 90000 = 13,10925

Total running cost: 7, 36050+9, 27,675+11, 19300+13, 10925 =

40, 93,950 Taka

Now,

Maintenance cost:

1 room: 2000 taka/ month (house rent is a subject to increase in next 20 years. So we take the average one)

Calculation for 20 years: (2000×12×20) = 4, 80,000 taka

Again two people for maintenance = 2×4000 = 8000 per month

Calculation for 20 years: (8000×12×20) = 1, 92, 0000 taka

Total: 4, 80,000 taka+ 1, 92, 0000 taka= 24, 00000 Taka

Total Amount for Diesel Generator: 40, 93,950 Taka +24, 00000 Taka = 64, 93, 950 Taka.

6.3 SHS COST: 20 YEARS CASE ASSUMTION:

Configuration of Our SHS Components :

Solar module: 50 Wp

Battery : 80 Ah

Charge controller: 5or 10 Amps

For 80 house hold we need 80, 50 Wp SHS.

Each 50 Wp SHS (including Battery, Charge controller, 4,6watt lamp, switch, switch board, installation and other accessories) costs 26,800 taka (GS).

Total installation cost for 20 years: (26,800*80) = 21, 44,000 Taka

Running cost:

Solar module is warranty for 20 years. So we do need to change it.

Battery warranty is 5 years. In the first installation battery cost is included. So the cost of changing the battery in 20 years is:

80+80+80=240

240*10000= 24, 00000 taka (10,000 for each battery)

Now, charge regulator is warranty for 3 years.

In first installation Charge regulator cost is included. So the cost of changing the charge regulator in 20 years is:

Approximately 6 charge regulator for each family.

80*6= 480-80(1st installation) =400

400* 1000=4, 00000 taka

Total cost in 20 years =21, 44,000 Taka+24, 00000 taka+4, 00000 taka

= 49, 44000 Taka.

Now, for comparing with the Diesel generator if we deduced the amount for providing light, switch, switch board, installation cost (included in 1st installation) which is not included in diesel generator, the amount will:

(49, 44000-81,600) Taka= 48, 62,400 Taka [(4*80) + (10*10) + (200*2) +200= 1020 per household]

SO, Diesel Generator will cost (64, 93, 950 Taka-48, 62,400 Taka) = 16, 31,550 Taka more in compare with SHS!!!

Here it is justified that SHS is the better alternative over Diesel generator.

Chapter7

Conclusion: Future Focus and Suggestions

In our above discussion we have tried to make an overall field assessment of the technical aspects of the SHS packages offered by different Pos. From the data of the different packages of SHS Pos, we make a comparison about their efficiency, cost, sizing & some other point of view. Talking about the cost which is still very much high from the affordable range of the local area people we can realize the proper view of SHS. In the short word we can say the growing rate of SHS is around the middle class family & the poorest are still unable to afford it. Again Pos are also trying to reduce their cost but the reality is they have also some limitations & they also have to run their market policy [23]. One thing we can suggest to

Pos to increase their research & development sector for having more new ideas. Some strategies could include:

- Offer small system, so that initial investment amount is reduced.
- Cross subsidies may make SHS more accessible to the poor people.
- Installing SHS in school, college, market may increase working hour.
- At present there are limited number of supplier & lack of experience in the solar technology market, resulting the high price of SHS. Again the components are not always available or difficult to source. So it is necessary to increase technology market. Pos all together can make that possible.

Nowadays with the increasing number of SHS installation health issue is adding new dimension. Battery recycling process is compulsory project for each organization to ensure the health and environmental issue. Moreover, at the top end of the organization tree, approved specification, guidelines & technology should be updated frequently to run with modern energy world. Again in the bottom of the organization tree the need to increase their technical training to ensure the proper maintenance service [2]. However there are complains that recently installed SHS performance is

certainly worsened from the initial installations. So, thinking the future perspective of the SHS organization should concern about their quality [6]. But still the growing rate of SHS is very impressive & that credit goes to partner organization. So, we can hope that by increasing their service they will put a real impact on the national power generation.

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House Hold (HH) Survey Questionnaires

Interview date: | | | | | | | | |

Day Mont Year

District: _____ | | Upazila: _____ | |

Union: _____ | | Village: _____ | |

Mohalla/Para: _____ Important Landmark near the Household: _____

Household No: | | | |

Name of the Respondent: _____ Respondent's Relationship with Household Head[§] | |

Name of HH Head_____ Father's Name of the HH Head: _____

Household Head's Mobile Phone No: 0 1 | | | | | | | | | |

Name of Interviewer and code_____ | |

Name of Field Supervisor and code_____ | |

§ Note: Use the relationship code from A03: Relationship with HH Head

Demographic characteristics of the members of the household

A01	A02	A03	A04	A05	A06	A07	A08
For all members							For members age 12 and older
PID	Name of the Household Members (including respondent)	Relationship with HH Head	Sex (Male=1, Female=2)	Age (Years)	Marital Status	Year(s) of Schooling Completed	Current employment status (If engaged in more than one activity, list the one that gives the highest compensation)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Codes for Section A

A03: Relationship with HH Head		A05: Marital status	A07: Schooling years completed
Self ……..…..1 Husband/ Wife… 2 Son/ Daughter… 3 Brother/ Sister… 4 Father/ Mother... 5 Father-in-law/ Mother-in-law ….6	Daughter-in-law/ Son-in-law ….7 Brother-in-law/ Sister-in-law ….8 Grandson/Granddaughter…….9 Niece/ Nephew. ……10 Other relative……..…...11 Other non-relative……....11	Unmarried ……..1 Married ……..2 Widow/widower …...3 Separated ……..4 Divorced ……..5	No schooling/In grade 1……0 Completed grade 1/In grade 2 ……1 Completed grade 2/In grade 3 ……2 Completed grade 3/In grade 4 ……3 Completed grade 4/In grade 5 ……4 Completed grade 5/In grade 6 ……5 Completed grade 6/In grade 7 ……6
A08: Current employment status			

Wage employment in farm sector ……1 Wage employment in non-farm sector ……2 Salaried employment … ……3 Self-employment in farm sector (agriculture, livestock, poultry, fishery, orchard/forestry, etc.) ……..4 Self-employment in non-farm sector (owner of industry, manufacturing, processing, retain stores, trading, etc,) ……..…5 Transport owner/business ……6 Fisherman ……7 Skilled trades (carpentry, masonry, weavers, etc.) ……8 Various repair work ……..……...9 Contractor ……..10 Hawker ……11 Barber ……..12 Tailor ……...13 Self-employed professional/specialist (doctor, nurse, spiritual healing, lawyer, tutor, religious imam/priest, etc.) ……14 Other self-employment (specify)_____..15 Domestic help ……16 Pensioner……17 Interest/rent/remittance earner ……...18 Housewife ……19 Student ……...20 Incapacitated ……21 Unemployed ……22	Completed grade 7/In grade 8 ……7 Completed grade 8/In grade 9 ……8 Completed grade 9/In grade 10 ……...9 Completed grade 10 (SSC)/In grade 11 ……...10 In grade 12 ……11 Completed grade 12 (HSC)/In BS 1st year. ……..12 In BS 2nd year……...13 Completed 2-year BS/ In 3rd year of a 3 or 4-year BS ……...14 Completed 3-year BS/ In 4th year of a 4-year BS program (Engineering/MBBS)/ In MS 1st year after completion of 3-year BS ……15 Completed 4-year BS (Engineering/MBBS)/ In MS 1st year after completion of 4-year BS/ In MS 2nd year after completion of 3-year BS ……16 In MS 2nd year after completion of 4-year BS/ Completed MS program after completion of 3-year BS ……17 In grade 1 of BRAC or NGO school ……30 Completed grade 1 of BRAC or NGO school/ In grade 2 of BRAC or NGO school ……31 Completed grade 2 of BRAC or NGO school/ In grade 3 of BRAC or NGO school

	……32 Completed grade 3 of BRAC or NGO school/ In grade 4 of BRAC or NGO school ……33 Completed grade 4 of BRAC or NGO school/ In grade 5 of BRAC or NGO school ……34 Completed grade 5 of BRAC or NGO school ……35 Vocational Diploma/Madrasa/Pre-primary/pre-kindergarten ……36

Employment hours (For Members of 12 and older who actually worked during last 12 months)
From Section A, enter PIDs for members who have 1 to 15 in Column 8. Enter Occupation Code from the Employment Status Code of Section A. Repeat PIDs if a member is engaged in more than one activity.

B01	B02	B03	B04	B05	B06	B07	B06	B07	B08	B09
PID	Occupation (Code)	During last 12 months					During last month (Bengali Month)			
		Number of months worked (months)	Average number of days worked per month (days)	Average number of hours worked per day (hours)	How much received for this work (including in- kind payment (Tk.)	Type of compensation received	Number of days worked (days)	Average number of hours worked per day (hours)	How much received for this work (including in- kind payment (Tk.)	Type of compensation received

C. Educational achievement and study behaviors (For Members of 5-18)
From Section A, copy PIDs and Names for members who are between 5 and 25

C01	C02	C03	C04	C05	C06	C07	C08	C09
PID	NAME	Is [Name] currently attending school? Yes= 1 No=2 (→C07)	Is [NAME]'s school electrified? Yes= 1 No=2	How many hours per day does [NAME] study at home after school during daylight hours? (hours/day)	How many hours per day does [NAME] study at home after sunset? (hours/day)	If [NAME] works in family-owned farm or non-farm activities, how many hours per day [NAME] works in such activities? (hours/day)	If [NAME] works for payment outside the family, how many hours per day [NAME] works in such activities? (hours/day)	How much does [NAME] earn from such activities? (Tk./day)

D. Health (for all members of the household during last 12 months)

D01	D02	D03	D04	D05	D06	D07	D08	D09
PID	Did [Name] suffer or is [Name] suffering from any major illness? Yes = 1, No =2	Type of illness experienced	Days lost due to illness (paid work, school, domestic work)	Whether taken medical support Yes=1, No=2	If yes, cost of medical support (Tk.)	If no, why did not you take medical support?	How did you finance the cost?	Did you get any information about [Name's] disease from the TV or radio? Yes=1, No=2

D03:Type of illness					D08: Source of Finace from	
Cough/ Cold ……..1 Headache ……..2 Breathing Problem…3 Common Fever…….4 Acidity ……5 Vomiting ……6 Worm ……7 Dysentery.…… 8	Diarrhea ……..……..9 Urinary infection ……10 Dental problem……..11 Ear/ Eye Problem…..12 Throat Pain……13 Belly Pain ……...14 Skin Problem……....15 Any other (specify)…16	Chronic Fever …..…17 Injuries/ Disability ….18 Asthma ……..19 Jaundice ……20 Malaria ……...21 Typhoid ……..22 Chronic Dysentery....23	Chronic Diarrhea….24 Cholera ……25 Chicken Pox …….26 Measles ……27 Mumps ……..28 Tetanus ……29 Gastric Ulcer …….30 Diabetes ……31	Blood Pressure ……..32 Chest Pain ……..33 Heart Attack ……..34 Rheumatic/ Arthiritis……35 Epilepsy ……3 6 Pre-Pregnancy Problem….37 Post-Pregnancy Problem…38 Any other (specify) ……..39	Regular income..... 1 HH Savings …..2 Selling HH Appliances…3 Selling HH Livestock ….4 Selling HH Trees…….5 Selling Tangible Property.---------6 Mortgage of land…….7	Borrowing from Friends/ Relatives……..8 Borrowing from Mahajans……..9 Donations……10 Other (specify)……11

D07:Reason for not taking medical support		
The problem was not serious……..1 Medical expenses are abnormally high ……2 Need to go far to get treatment……...3 Scared of being diagnosed with critical illness ……..4	Nobody in the family bothered about my treatment…...5 Nobody wanted to go with me ……6 Hassle of going outside the house ……..7 Do not know where to go ……8	Do not have money for the treatment……..9 Other (specify) ……10

E. Housing, Water and Sanitation

E01. How many rooms are there in the dwelling house not including the kitchen and cow shed?_____	E02 What is the material used fo floor? E03 What is the material used fo wall?	E05. How much is the Total value dwelling house? _____Tk.

E06. Does your house have a latrine? Sanitary latrine with septic tank …….1 Ring slab (water sealed)……2 Ring slab (water not sealed) …….3 Ordinary pucca ……4 Kancha (without septic tank)…….5 Bush/open space ……6 Other (specify) _____ ……..7 E07. **For codes (1–5)** Is it shared with other household(s es =	E08. What is principle source of drinking water for the household? Tube well (arsenic contaminated) ……1 Tube well (no arsenic contamination)…….2 Tube well (arsenic contamination not checked) ……..…..3 Artisan well…….. ……..……..4 Pond/river/canal ……5 Supply water (piped water) …….. 6 Deep tube well/shallow tube well ……7 Ring well ……..8 Others (specify) ……9 E09. **For codes (1–5)** Is it shared with other household(s es = 1. No

E02, E03 and E04: Materials for floor, wall and roof
Mud …… 1
Bamboo……2
Thatched/Straw ……3
Jute stick …… 4
Timber……5
CI sheet ……6
Brick/Cement ……7
Tally ……8
Nothing (remain open) ……9
Other (specify) _____ ……..10

Household assets

F1. Land and other real estate assets

F2. Agricultural and non-agricultural equipment

F101	F102	F103	F104
ID	Description	Size (decimals)	Current value (Tk.)
1	Homestead land		
2	Agricultural land		
3	Non-agricultural land		
4	Other land		
5	Buildings/structures/godowns/warehouse/shops used for own income generation activities		
6	Buildings/structures rented out for residential purpose		
7	Buildings/structures rented out for commercial purpose		
8	Other buildings/structures not mentioned yet (specify)		

F201	F202	F203	F204
ID	Description	Total value (Tk.)	Ownership share (percent)
1	Irrigation pump		
2	Power tiller		
3	Tractor		
4	Plough/Yoke		
5	Hand tube well		
6	Rice/flour mill		
7	Sugar cane crusher		
8	Oil milling machine		
9	Pesticide sprayer		
10	Handloom/power loom		
11	Fishing net/gear		
12	Other agricultural and non-agricultural equipments (specify)		

F3. Transport equipment

F301	F302	F303	F304
ID	Description	Total value (Tk.)	Ownership share (percent)

F4. Industrial and business asset

F401	F402	F403	F404
ID	Description	Total value (Tk.)	Ownership share (percent)

1	Bullock/buffalo/horse/push cart		
2	Boat/motorized boat		
3	Rickshaw/van		
4	Bicycle		
5	Motorcycle		
6	Baby taxi/auto-rickshaw/CNG		
7	Nasimon/karimon/bhotbhoti		
8	Car/jeep/microbus		
9	Bus/minibus/truck		
10	Other transports (specify)		

1	Products and raw materials		
2	Furniture		
3	Appliances		
4	Utensils		
5	Others (specify)		

F5. Household goods and furniture

F501	F502	F503	F501	F502	F503
ID	Description	Total value (Tk.)	ID	Description	Total value (Tk.)
1	Bed frame		10	Refrigerator	
2	Table/chair		11	Mobile phone sets (of all HH members)	
3	Cloth hanger		12	Fans	
4	Almirah/showcase		13	Sewing machine	
5	Dressing table/dresser		14	Cooking pots and pans	
6	Sofa set		15	Plates, bowls, etc.	
7	Radio/2-in-1		16	Other utensils	
8	TV		17	Watches, clocks	
9	DVD/VCD player/VCR/VCP		18	Other home goods	

F6. Livestock, fish, and trees

F601	F602	F603
ID	Description	Total value (Tk.)
1	Cows/buffalos	
2	Calves	
3	Goats/sheep	
4	Chicken/duck/pigeon/Quail	
5	Other animals	
6	Fish (in own ponds)	
7	Timber trees	
8	Fruit trees	
9	Bamboo grove	
10	Kitchen or flower garden	

11	Other trees	

F7. Financial asset

F701	F702	F703
ID	Description	Total value (Tk.)
1	Savings in commercial banks	
2	Savings in microcredit organization	
3	Savings in deposit pension scheme	
4	Savings in bonds/insurance scheme/wage earners' scheme/post office	
5	Shares/stocks (current value)	
6	Savings in informal organizations/cooperatives	
7	Money invested in other ways	
8	Savings or loans to other individuals	
9	Cash in hand	
10	Ornaments/jewelry	
11	Other savings	

F6. Debts

F801	F802	F803
ID	Description	Total value (Tk.)
1	Debt with commercial banks	
2	Debt in microcredit loans	
3	Debt with informal lenders/mahajans	
4	Debt with friends/relatives	
5	Goods purchased on credit	
6	Assets mortgaged	
7	Other debts	

G. Household income during last 12 months

G01	G02	G03
ID	Description	Value (Tk.)
Income from farm activities		

1	Receipt from all crop productions including by-products during last 12 months (own cultivation and share-cropping) *	
2	Cost incurred for crop production including tillage, irrigation, seeds, fertilizer, pesticides, hired labor, land rent, transport, storage, insurance, interest on agricultural loan, etc. during last 12 months	
3	Receipt from the sale of livestock and poultry during last 12 months	
4	Receipt from the sale of animal products including meat, milk, butter/ghee, leather, eggs during last 12 months	
5	Value consumed from own livestock, poultry and other animal products during last 12 months	
6	Cost incurred in livestock and poultry rearing, fodder, vaccination, and processing during last 12 months	
7	Value of fish sold during last 12 months	
8	Value of consumed fish caught from own or other sources during last 12 months	
9	Cost of fish rearing and other costs related to fish production during last 12 months	
10	Value of own tree sold during last 12 months	
11	Value of timber or fire wood used from own tree during last 12 months	
12	Value of fruits, vegetables, plants sold from own trees during last 12 months	

*By-products are paddy husk, bran, hay, etc.

Household income during last 12 months (continued)

G01	G02	G03
ID	Description	Value (Tk.)
Income from farm activities (continued)		
13	Value of fruits, vegetables, plants consumed from own trees during last 12 months	
14	Cost of production of fruits, vegetable, and plants sold during last 12 months	
Income from non-farm activities		
15	Value of sold products and services own non-farm enterprises during last 12 months	
16	Cost incurred in non-farm enterprises including raw materials, processing, hired labor, land rent, transport, storage, insurance, interest on enterprise loan, etc. during last 12 months	
17	Rental income from land, agricultural, non-agricultural and transport equipments during last 12 months	
18	Maintenance and repair cost of land, building, and equipments during last 12 months	
19	Rental income from land or building structures during last 12 months	
20	Income from various skill-based and specialized services†	
21	Income from various transfer and safety net programs during last 12 months	
22	Income savings, investment, prize bond, pension during last 12 months	

† Examples of these providers include driver of various transports (rickshaw, van, CNG, etc.), barber, tailor, physician, nurse, spiritual healer, lawyer, electrician, mason, carpenter, mechanic, etc.

G. Household income during last 12 months (continued)

G01	G02	G03
ID	Description	Value (Tk.)
Miscellaneous income from transfers, savings, investments and remittances		
23	Income from zakat/fitra/charity, etc. during last 12 months	
24	Income from remittance during last 12 months	
25	Income from freely collected resources during last 12 months (fuel wood, vegetables, fish, etc.)	
26	Income from recharging mobile phone sets during last 30 days	
27	Other miscellaneous income not reported so far during last 12 months.	

H. Household expenditure during last 12 months

H1. Expenditures on food items (Last one week)

H01	H02	H03	H04	H01	H02	H03	H04
ID	List of food items	Amount consumed	Total value (Tk.)	ID	List of food items	Amount consumed	Total value (Tk.)
	Coarse rice (gram)			13.	Fruits		
	Fine rice (gram)			14.	Tea/biscuits		
	Ata/flour (gram)			15.	Spices		
	Puffed rice (gram)			16.	Oil and butter (liter)		
	Lentils (gram)			17.	Milk (liter)		
	Beef (gram)			18.	Milk products (gram)		
	Mutton (gram)			19.	Baby food (gram)		
	Chicken (gram)			20.	Treacle (gram)		
	Duck meat (gram)			21.	Sugar (gram)		

	Egg (no.)			22.	Betel nuts and leaf		
	Fish (gram)			23.	Cigarette		
	Vegetables (gram)			24.	Other (specify)_____		

H2. Nonfood expenditures

H05	H06	H07
ID	Description	Value (Tk.)
Monthly nonfood expenditure		
28	Value of fuel and energy consumed (both purchased and collected) during last 30 days.*	
29	Expenditure on cosmetics, toiletries and cleaning products during last 30 days†	
30	Expenditure on transport during last 30 days (rickshaw, bus, van fare, petrol/diesel for cars, etc.)	
31	Expenditure on non-energy utilities (water, sewerage, telephone, mobile phone bills) during last 30 days	
32	Salary and wage paid during last 30 days	
33	House rent during last 30 days	
Yearly nonfood expenditure		
34	Expenditure on clothing and clothing products during last 12 months	
35	Expenditure on shoes and other footwear during last 12 months (purchase and repair)	
36	Expenditure on household textile products during last 12 months*	
37	Expenditure on household furniture and goods during last 12 months	
38	Expenditure on medical treatment, medicines, hospitalizations, etc. during last 12 months (purchase and repair)	
39	Expenditure on home maintenance, repair, improvement, real estate tax, etc. during last 12 months	

*Kerosene, candles, electricity, gas, coal, fuel wood, etc.
†Cream, lotion, powder, perfume, soap, shampoo, shaving and grooming products, etc.

Household expenditure during last 12 months (continued)

H05	H06	H07
ID	Description	Value (Tk.)
Yearly nonfood expenditure (continued)		
40	Expenditure on jewelry and other valuables during last 12 months	
41	Education expenses during last 12 months (tuition, books, supplies, etc.)	

42	Expenditure on social and religious ceremonies during last 12 months	
43	Expenditure on recreation and leisure during last 12 months	
44	Expenditure on insurance, taxes, interests, fines, fees, etc. during last 12 months.	
45	Other nonfood expenditure during last 12 months.	

*Bed sheet, bed cover, quilt, table cover, curtain, pillow cover, cushion cover, etc.

I. Food security situation in the household during the year ☐ **Food Security Code:** Always deficit = 1, Sometimes deficit = 2, Neither surplus not deficit = 3, Surplus = 4 [Questions J and K are if food security code is 1 or 2, else proceed to question L]

J. If always deficit or sometimes deficit, how many months did the members of the household get sufficient food? ☐☐ months

K. In which months it is difficult to provide adequate food to the members of the household (Put √ mark in the box against the month) **[More than one answer is possible]**

Sl.	Month	Put √ mark	Sl.	Month	Put √ mark	Sl.	Month	Put √ mark
1.	Boishakh		5.	Bhadra		9.	Pousha	
2.	Jaishtha		6.	Ashwin		10.	Magha	
3.	Asharh		7.	Kartick		11.	Falguna	
4.	Shravana		8.	Agrahayana		12.	Chaitra	

L. Ownership of property/asset by the female members [preferably to be answered by the female member(s) of the household]

M01	M02	M03	M04	M05	M06	M07
Ld	Type of property/asset	Value (Tk.)	Value (Tk.)	Value (Tk.)	Value (Tk.)	Value (Tk.)
	PID					
	Milching cow					
	Bull/bullock/cow					
	Calf					
	Buck/castrated goat/female goat					
	Doe					
	Ram/Ewe					
	Lamb					
	Chicken					
	Ducks/drakes					

	Others					

M. Participation of female members in decision making in the family [preferably to be answered by the female member(s) of the household]

N01	N02	N03	N04	N05	N06	N07
ID	Type of decision	Response	Response	Response	Response	Response
	PID					
	Freedom of Mobility					
	Visiting parental home					
	Going for shopping in the market place					
	Visiting friends and relatives					
	Going outside the village					
	Other mobility not included above					
	Household Decision Making					
	Education of children					
	Children's healthcare					
	Own healthcare					
	Matrimony of sons/daughters/other dependents					
	Solving family problems					
	Other autonomy not included above					
	Economic Decision Making					
	Purchase of personal items such as clothes, jewelry, etc.					
	Purchase of expensive properties such as land, etc.					
	Purchase of Children's clothes					
	Purchase of food items					
	Children's educational expenses					
	Other economic decisions not mentioned above					
	Personal Autonomy					
	Voting in the elections					

	Standing in (local) elections					
	Family Planning					
	Participation in social events					
	Other personal autonomy not mentioned above					

Response Code: Female member herself = 1, Husband/father = 2, Jointly with husband/father = 3, Jointly with others = 4, Other = 5, Not Applicable = 6

N. Women's empowerment (for women who are married and between 15 and 49) (contd.)

N08	N09	N10	N11	N12	N13	
PID	Is [name] engaged in any IGA? Yes =1, No = 2	What is the type of IGA activity undertaken? (Description)	IGA Code	Where is the IGA activity undertaken? Inside home …1; Outside home …2	Do you think women and men should have equal opportunities in the context of the following issues Yes …1; No …2	
					Food consumption	
					Education	
					Health and medication	
					Clothing	
					Performing domestic chores	
					Performing IGAs	
					Others (specify)	

Code for N11 (IGA code)		
1- Oil Milling 2- Paddy Husking, Rice/Flour Milling 3- Bakery/Sweetmeat 4- Saw mill	12- Shoe making/repair 13- Blacksmithy 14- Goldsmithy 15- Carpentry 16- Welding	23- Transport business (cart, rickshaw, bus, truck, taxi, boat, etc.) 24- Electric/electronic repair, 25- Transport/automobile repair 26- Other Misc. Repair

5- Weaving 6- Pottery 7- Cane/Bamboo work 8- Furniture/Wood products making 9- Handloom 10- Leather Products 11- Other Handicrafts	17- Clothing making/Tailoring 18- Misc. Cottage Industries 19- Tobacco/bidi Making 20- Misc. Processing/ Manufacturing Activity 21- Bullock cart, push cart, etc. making 22- Other construction Work	27- Grocery/stationary shop 28- Vending (vegetable, fruits, fish monger, etc.) 29- Rice, Paddy, Wheat, Flour trading 30- Other misc. trading 31- Restaurant/tea stall, 32- Physician/village doctor/ayurved, etc. 33. Recharging mobile phone sets 34- Others (specify)

O. Average time use for household members

Please tell us how many hours were spent doing each of the following activities in the past 24 hours. Enter number of hours or fraction for less than one hour and "0" for no time on an activity. Total hours for all activities must add up to 24 hours or less

P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12
ID.	Activity Description /PID										
1	Wage labor in farm sector										
2	Wage labor in non-farm sector										
3	Salaried employment										
4	Self-employment farm activities										
5	Self-employment non-farm activities										
6	Food processing										
7	Cooking/preparing meal										
8	Serving meal (including carrying food to field)										
9	Taking meals										
10	Taking shower, bathing, taking care of personal										
11	Cleaning dishes, pots and pans										
12	Fuel collection										
13	Water collection										
14	Time at school										
15	Reading and studying										

16	Washing clothes and household cleaning										
17	Taking care of children (incl. bathing, feeding, dressing										
18	Watching television, listening to radio										
19	Socializing, visiting neighbors, friends, relatives,										
20	Shopping										
21	Attending community activities, meetings, etc.										
22	Praying and other religious activities										
23	Resting, taking daytime nap, etc.										
24	Nighttime sleep										
25	Others										

Note: Time for any activity that does not happen on a daily basis should be converted to a daily equivalent.

Q. Monthly energy use from biomass

Q01	Q02	Q03–Q04		Q05–Q06		Q07–Q08		Q09	Q10	Q11	Q12	Q13	Q14
ID.	Energy Type	Purchased		Produced		Collected		%used for cooking/ per boiling (%)	%used for other purpose (specify) (%)	Total time spent on collection by men (age>16) (hours/week)	Total time spent on collection by women (age>16) (hours/week)	Total time spent on collection by boys (age 5-16) (hours/week)	Total time spent on collection by girls (age 5-16) (hours/week)
		Qty (Kg)	cost (Tk.)	Qty (Kg.)	Eq. cost (Tk.)	Qty (Kg.)	Eq. cost (Tk.)						
1	Fire Wood												
2	Animal Dung/cake												
3	Tree leaves												
4	Straw/ crop residue/ husk												

5	Charcoal												
6	Others (specify)												

Note: Eq. price (equivalent price) is the price the households would have to pay if they had purchased the amount

P. Monthly energy use from non-biomass non-solar sources

R01	R02	R03	R03	R05	R06	R07	R08
ID.	Type of Energy	Quantity used per month	Cost incurred (Tk./month)	%used cooking/per boiling	%used for lighting	%used for appliance	%used for other purposes
1	Kerosene (Liter)						
2	Diesel (Liter)						
3	LPG cylinder (Kg)						
4	Piped natural gas						
5	Biogas						
6	Candle (Number)						
7	Dry cell (Numbers)						
8	Storage cell						
9	Electricity from grid						
10	Electricity from mini grid						
11	Others (specify)						

Note: For storage cell and biogas cost refers to that for inputs and maintenance.

Q. Electric and non-electric appliances/gadgets in the household

S01	S02	S03	S04	S05	S06	S07
ID.	Appliance	Wattage	Numbers owned	Energy source	Average daily total use (hours)	Average monthly use (days)
1	Light Bulb					
2	Light Bulb					
3	Light Bulb					
4	Light Bulb					

S01	S02	S03	S04	S05	S06	S07
ID.	Appliance	Wattage	Numbers owned	Energy source	Average daily total use (hours)	Average monthly use (days)
5	Tube (fluorescent)					
6	Tube (fluorescent)					
7	Tube (fluorescent)					
8	Tube (fluorescent)					
9	Tube (fluorescent)					
10	Tube (fluorescent)					
11	CFL					
12	Solar lamp					
13	Solar lamp					
14	Solar lamp					
15	Solar lamp					
16	Solar lamp					
17	Cassette player					
18	VCR/VCD/DVD					
19	Electric fan					
20	Television (black & white)					
21	Television (color)					
22	Microphone					
23	Mobile charger					
24	Others					
25	Electric cooker					
26	Electric iron					
27	Room heater					
28	Refrigerator					
29	Air conditioner					
30	Computer					
31	Charger light					
32	Remote/calculator/toys					

S01	S02	S03	S04	S05	S06	S07
ID.	Appliance	Wattage	Numbers owned	Energy source	Average daily total use (hours)	Average monthly use (days)
33	Kerosene lamp (wick)					
34	Kerosene lamp (Hurricane)					
35	Kerosene lamp (Hazak)					
36	Kerosene stove (traditional)					
37	Kerosene stove (improved)					
38	Biomass stove (traditional)					
39	Biomass stove (improved)					
40	Others (specify)					

Code for S05: Energy source		
Fuel wood ……1	Piped natural gas ……5	Electricity from grid ……..9
Other biomass ……..2	Biogas ……6	Electricity from mini grid …….10
Kerosene ……..3	Dry cell ……7	SHS ……11
LPG ……4	Storage cell ……8	

[Questions in module R are applicable to the SHS households only]

R. Use of SHS

R01. Customer ID:	T02. PO Name:	T03. PO ID:	T04. PO branch office location:
R05. Mode of purchase: ☐ Cash =1, Credit = 2	T06. Price of the system (Tk.):	T07: Down payment (Tk.):	T08. Interest rate (%):
R09. Installment payment (Tk.)	T10. Loan duration (years):	T11. Date of installation:	T12. Last date of installment payment:

R13. How did you purchase the SHS? ☐ PO approached …….1 I approached ……2

R14. Why did you purchase SHS from this PO? ☐

This PO approached me first ……..1 My neighbors/friends/relatives recommended this PO ……..2
Most HHs in the village have taken SHS from this PO ……..3 This is the only PO operating in the village ……..4
This PO has the best price/service ……..5 Other (specify) _____
……..6

R15. (If the date U12 has already passed) When did you pay the last installment? Month_____, Year_____

R16. Have you defaulted in the paying any installment? Yes …….1 No ……2

R17. Did you get proper instruction from the PO on the basic operation of the system? Yes …….1 No ……2

R18. What is the capacity of the solar panel? _____WP

R19. How many hours a day you use all appliances simultaneously?

R20. Breakdowns/problems of the solar panel

R20.1	R20.2	R20.3	R20.4	R20.5
Type of problems	Number of times since the system has been installed	Number of times you have to pay (partially or fully)	How much did you pay in total so far for each category (Tk.)	Total days affected because of the problem so far for each category (days)
Major problem requiring panel replacement				
Problem requiring major repair work				
Problem requiring minor repair work				

R21. Breakdowns/problems of the battery

R21.1	R21.2	R21.3	R21.4	R21.5
Type of problems	Number of times since the system has been installed	Number of times you have to pay (partially or fully)	How much did you pay in total so far for each category (Tk.)	Total days affected because of the problem so far for each category (days)
Major problem requiring battery replacement				
Problem requiring major repair work				
Problem requiring minor repair work				

R22. Breakdowns/problems of the charge controller

R22.1	R22.2	R22.3	R22.4	R22.5
Type of problems	Number of times since	Number of times	How much did you	Total days affected because of the problem so far

	the system has been installed	you have to pay (partially or fully)	pay in total so far for each category (Tk.)	for each category (days)
Major problem requiring controller replacement				
Problem requiring major repair work				
Problem requiring minor repair work				

R23.1. How many times a year do you replace fluorescent luminaries (lights)? _____

R23.2. How much does a light cost on an average (Tk.)? _____

R24. How far is the location of PO technician (km)? Within village …….1, Outside village but within upazila ….2, Outside upazila …..3

R25. How satisfied are you with the performance of PO technician in fixing problems?

Unsatisfied …….1, Somewhat satisfied ….2, Very satisfied …..3

R26. Did you or any member of your household receive any training on repair works or parts replacement by the PO?

Yes …….1, No ….2

R27. If so, who received the training?

PID_____

R28. If so, does the member repair or replace parts of other SHS households in the village for charge?

Yes …….1, No ….2

R29. If so, how much does the member earn on an average in a month by doing such work (Tk.)? _____

R30. Does your household do any income generating activity using the SHS (excluding mobile set recharging)?

Yes …….1, No ….2

R31. If so, please specify _____

R32. If so, how much does the household earn on an average in a month by doing such work (Tk.)? _____

R33. In case of any increase in the price of SHS – would you still have purchased the system?

	For a 5% increase	For a 10% increase	For a 25% increase
I would still have purchased it	☐	☐	☐
I would not have purchased it	☐	☐	☐
I am not sure	☐	☐	☐

R34. Attitudes and perceptions of SHS users

The following statements concern SHS use and other issues. Please provide your response in terms of

[1] Strongly Agree; [2] Agree; [3] Indifferent/ Neutral; [4] Disagree; [5] Strongly Disagree

R34.01	Having electricity is important for my children's education	_____
R34.02	Because of good light, children have extended their studying time at nights	_____
R34.03	Because of good light, we are able to read in the evening	_____
R34.04	Reading is easy/comfortable with electric light compared to that with candles, kerosene lamps/lanterns	_____
R34.05	Because of electricity we are connected to the world information, news, etc.	_____
R34.06	Electricity has made the inside of our household smoke-free	_____

R34.07	Electricity from SHS is environment friendly	_____
R34.08	Electricity is benefiting our community through improved economic and enterprise development	_____
R34.09	Expense related to SHS purchase is very high and a financial burden to our family	_____

[Questions in module S are applicable to the non-SHS households in the treated village only]

S. Only non-SHS households from the treated villages

S.01	What are the reasons for not purchasing SHS? Price/down payment is too expensive ……..1 Installments are too expensive ……..2 No perceived benefits from SHS……..3 Other (specify)_____ ……..4
S.02	If you would be interested to get connected to the power supply, what would be possible reasons? Children's education……1 Better lighting ……2 Entertainment ……..3 Improved income generating opportunities ……4 Information and news ……5 Cheaper than other sources ……6 Security at night ……,7 Others (specify) ……8
S.03	If you opt to purchase, what is the maximum you would be willing to pay as …. Down payment (Tk.)_____ Installment (Tk./month)_____

[Questions T are applicable to the non-SHS households in the non-treated village only]

T. Only households from the untreated villages

T.01	Would you be interested in purchasing SHS if it is available in your village? Yes ……1, No ……2 ☐
T.02	If no, what would be the possible reason? ☐ Price/down payment is too expensive ……..1 Installments are too expensive ……..2 No perceived benefits from SHS……3 Other (specify)_____ ……..4
T.03	If yes, what would be possible reasons? Children's education……1 Better lighting ……2 Entertainment ……..3 Improved income generating opportunities ……4 … Information and news ……5 Cheaper than other sources ……6 Security at night ……,7 Others (specify) ……8
T.04	If you opt to purchase, what is the maximum you would be willing to pay as …. Down payment (Tk.)_____ Installment (Tk./month)_____

I thereby declaring that all the information I have provided are right and I have taken permission from household head.

Signature of the Interviewer: _____

Signature of the Household head: _____

Signature of the Supervisor: _____