

**Solar Photovoltaic in Rural Electrification:
Market Assessment Survey in Bangladesh**
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1. BACKGROUND AND CONTEXT:

Of the 12.7 million rural households in rural Bangladesh, only about 2 million (approximately 15%) currently enjoy electrification from the national power grid. The task of providing electricity to the remaining 10 million rural households is a large one. The task is made more challenging by constraints such as the lack of an extensive transmission network throughout the country, the limited generating capacity to serve additional rural markets, and the scarcity of capital for investments in generation, transmission, and distribution. Economic extension of rural electrification is further constrained by the generally small loads and greater dispersion of rural customers, making it difficult to justify the costs of distribution networks. Three individual government owned enterprises, Rural Electrification Board (REB), Bangladesh Power Development Board (BPDB), and Dhaka Electric Supply Authority (DESA) are presently engaged in providing electricity service to the rural population. More than 70% of the rural connections are served through Palli Biddut Samities (PBS)s operating under the regulatory guidance of the REB. Currently there are 54 PBSs in commercial operation, which are user owned co-operatives, offering electrification services to households, small commercial enterprises, rural industries and irrigation needs in diverse parts of the country.

Bangladesh has joined its Asian neighbors as well as other countries throughout the world in considering a broader array of options for providing the benefits of electrification to rural populations. Alternative options to the conventional grid based electrification, such as low cost isolated grid systems, solar, wind and micro hydro are under consideration for serving remote villages and other clusters of customers. Another strong contender, particularly for disbursed consumers and clusters with combined loads too small to justify grid systems is the use of solar photovoltaic (PV) panels for electrification of individual homes or buildings. These are commonly called solar home systems (SHS). Thus, grid supported conventional methods of power generation may be complemented by utilizing SHS for providing electrification services to these sparsely distributed unelectrified rural households. Such systems can offer basic electricity services of lighting and operation of small appliances such as TV, radio, or fans. The convenience, safety and high quality service provided by SHSs make them generally more desirable than traditional rural energy usages such as kerosene and externally charged automotive batteries. However, a typical SHS is not economically viable for household appliances consuming large quantities of electricity, that is generally available from the grid.

Information on solar home systems is not yet widespread in rural Bangladesh. However, in a recent effort of REB, 700 households within an island of 29 square km, have already been electrified by SHSs in an ongoing pilot program with support from the French government. Narsingdi PBS is in charge of operation and maintenance of this project. Suitability of SHSs for rural electrification in the

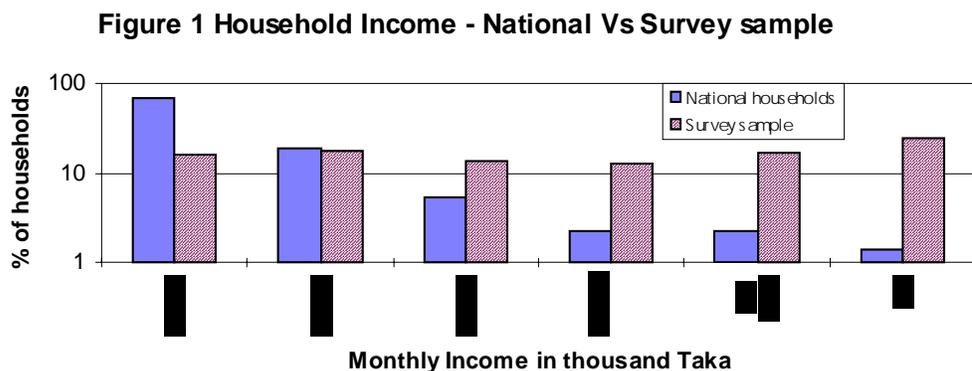
socio-economic context of this region has already been demonstrated in this project. Survey ¹ of 166 users show that 52.4 percent of the total users are either satisfied or very satisfied with the use of SHSs. The remaining 47.6 percent of the users are not particularly satisfied or totally dissatisfied with the services. More than 30% percent of the users of battery systems with external charging using a central PV station have expressed their dissatisfaction, which originates from transport of batteries, and insufficient daily charging for desired usage. This pilot project provides a platform for benchmarking the solar PV service requirements in rural Bangladesh through the existing rural electrification service delivery mode of the PBSs.

2. SURVEY OBJECTIVE AND METHODOLOGY:

The survey performed is an initial investigation² towards determining the potential market for SHSs in Bangladesh in view of the growing demand for rural electrification. The survey was limited to 701 samples covering three Thanas (administrative areas) within PBS territories, and one Thana outside the operating area of any PBS. Objective of the survey was to determine the potential for SHSs to serve rural households of Bangladesh which may not be accessible to grid electrification in the near future. The survey focussed on obtaining following information relevant to this determination:

- a. Current energy usage and expenditure for lighting and battery charging
- b. Desired service level for electrification
- c. Attitude of the households towards solar PV electrification
- d. Preferred mode of service delivery

The survey focussed on middle to high income households. The relationship of the survey categories in relation to the national income distribution of unelectrified rural households are shown in Fig 1. As seen in the figure the survey population is nearly uniformly distributed at above 10% for



¹ Survey of Solar PV Applications in Rural Electrification: Narshingdi Solar PV Project, World Bank Survey by PSL, June 1998

² Market Assessment Survey of Solar PV Application in Bangladesh, World Bank Survey by PSL, July 1998

all income groups above 2000 Taka per month. Small commercial enterprises, who could also be part of a potential market for solar PV were also included in the survey. The information gathered on the above characteristics from the survey was combined with that from the Household Expenditure Survey (HES)³ to characterize the households that are likely to adopt SHSs and to predict the potential market for each administrative division in the country. Additionally, this information will be useful in selecting PBSs that will be targeted for the initial marketing of SHSs.

Three different payment schemes for solar home systems was offered in the survey:

(A) Cash purchase through a single payment

(B) Cash purchase through payment in monthly installments

© Monthly payment with a down payment for electrification services to Energy Service Company (ESCO)⁴

Customer's monthly payments to the ESCO cover amortized capital costs, installation, operation, maintenance, component replacement costs, and other service fees. This monthly fee is dependent upon the financial assumptions used, including the on-lending terms of long term loans typically obtainable for rural electrification in Bangladesh. Description of SHS's capacity, and service levels as used for the survey are indicated in Table 1a.

Table 1a. Estimated SHS Capacity, Costs, and Service Levels

| | Module Capacity | Battery Capacity | Service Level for Solar PV |
|--------------------------------|-------------------|------------------|---|
| Small Solar Home System (SHSS) | 35 W _p | 70 Ah | 35Wp system operating 3 lights of 10W each |
| Large Solar Home System (SHSL) | 75 W _p | 100 Ah | 75Wp system operating 5 lights of 10W each OR operating 3 lights of 10W with 1 B/W Television |

³ HES:Household Expenditure Survey 1995-96 , Bangladesh Bureau of Statistics, Govt.of Bangladesh

⁴ (ESCO):Energy Service Company Best Practices in Solar PV Applications, 1996, ASTAE, World Bank Report

Three different payment options for Solar PV electrification used in the survey are given in Table 1b.

Table 1b Payment Options for Solar PV Electrification Service

Scheme A. Cash Purchase of SHS:

| | |
|---------------|-------------|
| SHS- Small | 22,600 Taka |
| SHS- Large | 40,700 Taka |
| Solar Lantern | 2,500 Taka |

Scheme B. Purchase of SHS with Credit:

| System Type | Option I | | Option II | |
|-------------|----------|-----------------|-----------|-----------------|
| | Deposit | Monthly Payment | Deposit | Monthly Payment |
| SHS- Small | 10,000 | 325 | 4,000 | 500 |
| SHS- Large | 10,000 | 850 | 4,000 | 1,000 |

Scheme C. Payment for Service with SHS Only:

| System Type | | Option I | Option II | Less than Offered |
|-------------------------|--------------|-------------|-------------|------------------------------------|
| | Connection | Monthly fee | Monthly fee | Values suitable to the respondent. |
| SHS- Small | 1,000 | 200 | 160 | |
| SHS- Large | 4,000 | 350 | 300 | |
| Battery Charging | 700 | 150 | 110 | |

1\$ = 46.5 Taka

3. RESULTS

3.1 The Potential Solar Home System Market in Bangladesh

The survey indicates that a significant market for SHSs exist in Bangladesh. The report provides market estimates based on administrative districts and household income categories. According to the data obtained from HES, rural households typically do not have sufficient income for direct cash purchase of a solar home system. However, use of credit or other forms of extended payment can expand the potential market significantly. The lowest monthly costs are obtained when the SHSs are owned by an ESCO and the customer only pays for the service from the system.

Ability to pay for solar home systems has been estimated by two different methods, which yield market predictions as follows:

- In most developing countries, households typically spend no more than 5% of their income on lighting and use of small appliances. By this measure, about 4.8 million rural Bangladeshi households could pay for a solar home system as shown in the “*Potential SHS Market*” of Tables 2 and 3. This accounts for nearly 45% of all *unelectrified rural* households.
- A more conservative market estimate “*Existing SHS market*” was obtained through the survey conducted for this study, based upon the current expenditure level of the households. Ability to pay for the services is measured by the current expenditure for lighting and battery charging, most of which is to be replaced by a SHS. This market, which is approximately 470,000 households, is shown on Tables 2 and 3 according to division and income category differentiation respectively. Figure 2 shows the relative distribution of the projected existing market within the administrative divisions.

Table 2. Projection of Solar PV Market in Bangladesh by Administrative District

| Division | Rural Households in Bangladesh | Total unelectrified Households | Potential SHS Market (Liberal Market) | | Existing SHS Market (Conservative Market) | |
|--------------|--------------------------------|--------------------------------|---------------------------------------|----------------|---|----------------|
| | | | SHSS (1) | SHSL (2) | SHSS (3) | SHSL (4) |
| Barisal | 888,240 | 778,072 | 361,803 | 52,131 | 29,469 | 10,768 |
| Chittagong | 2,416,469 | 1,848,455 | 1,059,165 | 177,452 | 92,134 | 31,708 |
| Dhaka | 3,802,678 | 3,274,445 | 1,293,406 | 121,154 | 99,045 | 34,942 |
| Khulna | 1,348,908 | 1,096,733 | 470,498 | 44,966 | 35,268 | 12,512 |
| Rajshahi | 3,436,323 | 3,018,767 | 821,105 | 81,507 | 64,208 | 25,300 |
| Sylhet | 861,797 | 717,057 | 261,009 | 63,101 | 24,926 | 8,081 |
| Total | 12,754,415 | 10,733,529 | 4,266,986 | 540,311 | 345,050 | 123,311 |

Table 3. Projection of Solar PV Market in Bangladesh by Income Group

| Division | Rural Households in Bangladesh | Total unelectrified Households | Potential SHS Market (Liberal Market) | | Existing SHS Market (Conservative Market) | |
|--------------|--------------------------------|--------------------------------|---------------------------------------|----------------|---|----------------|
| | | | SHSS (1) | SHSL (2) | SHSS (3) | SHSL (4) |
| below 2000 | 6,606,787 | 5,926,232 | | | | |
| 2000-3999 | 3,992,132 | 3,364,026 | 3,364,026 | | 217,034 | 108,517 |
| 4000-5999 | 1,237,178 | 902,960 | 902,960 | | 50,633 | - |
| 6000-7999 | 408,141 | 251,133 | | 251,133 | 27,563 | 3,063 |
| 8000-9999 | 178,562 | 105,513 | | 105,513 | 9,848 | - |
| 10000-14999 | 204,071 | 114,225 | | 114,225 | 20,561 | 3,427 |
| 15000-19999 | 38,263 | 30,915 | | 30,915 | 7,134 | 2,378 |
| 20000 & More | 89,281 | 38,525 | | 38,525 | 12,277 | 5,927 |
| Total | 12,754,415 | 10,733,529 | 4,266,986 | 540,311 | 345,050 | 123,311 |

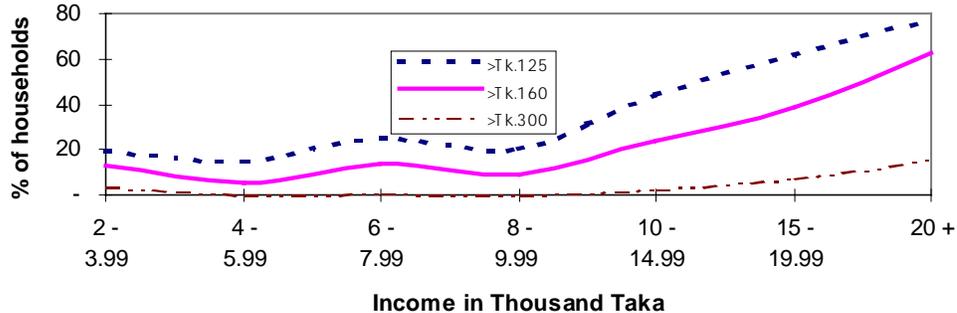
- 1) monthly income Tk.2,000-5,999
- 2) monthly income above Tk.6,000
- 3) currently spending Tk.160-300 for kerosene and battery charging
- 4) currently spending more than Tk.300 for kerosene and battery charging

3.2 Current Energy Usage Pattern:

The survey results show that 98% of the households use kerosene lanterns or “hurricane” lanterns for children's studying, and 69% use them for an average of 5 hours per night. More than 90% of the respondents feel the most valuable impact of solar PV electrification will be in providing better lighting for studying. Usage of batteries for watching television is also widespread among the high income rural households. These households will benefit from SHSs by having an improved quality of environment and removal of inconvenience caused by transportation of the batteries to the charging stations.

In the survey households, current spending for lighting and battery charging indicate that 39.34%, 18.67%, 4.17% of the respondents spend above 125, 160 and 300 Taka per month respectively. Percentage of households spending more than 160 or 300 Taka per month, increases monotonically with income above 8000 Taka, as shown in Figure 3.

Figure 3. Current Expenditure on Kerosene for Lighting and Battery Charging

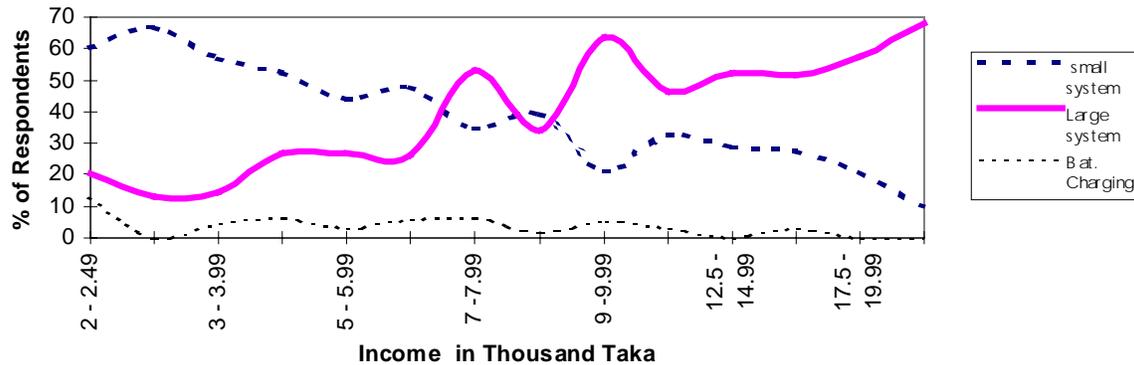


3.3 Willingness to Pay for Type of SHS

The survey covered 606 households and 95 commercial enterprises in three different districts (Natore, Gopalganj and Kishoregonj). 80.5% of the surveyed holdings have shown an interest in obtaining any

SHSs. In general, the higher income groups show willingness to pay for the large solar home system (SHSL) while lower income groups are willing to pay for small solar home system (SHSS) as shown

Figure 4. Income Vs. Willingness to Pay for Solar PV



in Figure 4. The survey did not reveal wide regional variations in the preference for SHS. One striking exception, however, was the survey in the riverain island of Kishoregonj district. Here, 100% of the respondents expressed willingness to obtain service from SHSs through monthly billing. The agricultural and fishing industry in this area has created a somewhat higher level of wealth than in the average Bangladeshi village. However, the annual floods all but preclude extension of grid service. The high willingness and ability to pay for electricity services, and the lack of a competitive alternative combine to create an excellent market for SHSs. Similar areas throughout the country may offer the best near-term market for solar home systems.

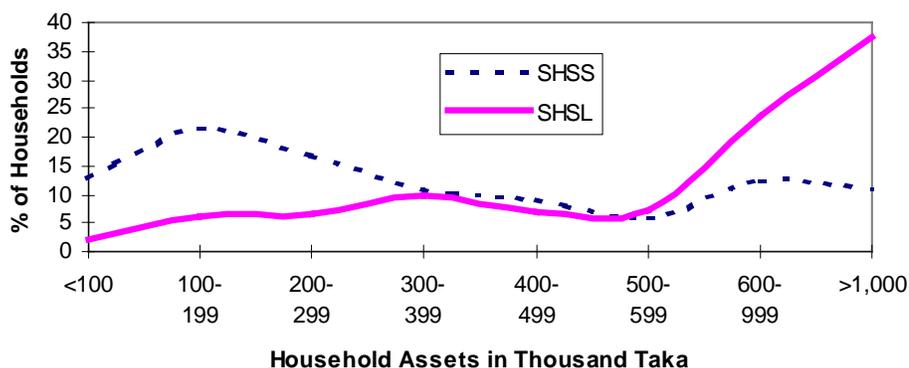
Willingness expressed in the survey towards battery usage with central PV battery charging is low. Only 3.3% of the survey respondents are interested in receiving their electrification services through a solar PV battery charging station, although 15% of the households surveyed are currently watching television through battery charging. This signifies the difficulties people face with remote charging.

In addition to monthly income, interest in SHS is found to be a strong function of the assets owned by the households. Figure 5 shows direct correlation between willingness of the respondents to pay for SHS and their household assets. Considering the results obtained on willingness to pay for electrification, and the variation of income and asset among the potential users, it is recommended that the SHS be sized according to the desire of the users, ie options for service levels such as SHSS and SHSL should be made available.

3.4 Preferred Mode of Payment

The surveyed households and commercial units showed a strong preference for obtaining SHSs based on monthly payment as opposed to direct purchase either outright or on a credit payment plan. Nearly 68% of the respondents showed preference for service with monthly billing (similar to ESCO method) at rates shown in Table 1, while 12% opted to pay in cash or credit. In an ESCO system the PV installation remains the property of the ESCO, and the lighting services inclusive of replacement of major components are provided for a monthly fee. Service for wiring and procurement of

Figure 5. Household Asset vs. Willingness to Pay for SHS



consumable items like the lamps are typically purchased by the user directly.

3.5 Preferred Mode of Service Delivery:

With respect to choice of service providers, 61% prefer to receive service from the existing PBSs in the area operating as an ESCO. The next preferred service delivery organization (18% of respondents) is local co-operatives.

If the ESCO service is to be provided by a private dealer or enterprise using financing arrangements available commercially (including charges for dealer financing), a higher rate of monthly payments beyond the purchasing capacity of the households would be required. Purchase of SHSs through cash or credit is *not a preferred mechanism* of electrification to nearly 88% of the households.

3.6 Preference Within the Buffer Zone:

The zone within a range of 1 km from an existing distribution line is identified as the "buffer" zone. The households within this zone are close enough to distribution networks but are unable to obtain a service due to the high cost or delayed request of securing a connection. The survey shows that a favorable interest exists for SHSs in such buffer zones. 67% of the 274 respondents in the buffer zone expressed willing to obtain SHSs as shown in Table 4. Nearly 30% of these households are currently spending more than 160 Taka per month on lighting and battery charging for watching television. On the other hand, 85% of the 374 households outside the buffer zone have shown interest in SHSs. 44% of these respondents are currently spending more than 160 Taka per month, and more than 32% is using batteries for watching television.

**Table 4 Willingness And Ability to Pay for SHS:
Households in Buffer vs. Non-buffer Zone**

| Type of Zone | Willingness to Pay Households Willing to Pay for SHS | Ability to Pay | | | Using TV |
|-----------------------|---|------------------------------------|----------|----------|----------|
| | | Current Monthly Spending More than | | | |
| | | 125 Taka | 160 Taka | 300 Taka | |
| Buffer Zone (274) | 67% | 48% | 29.5% | 6% | 26% |
| Non Buffer Zone (332) | 85% | 75% | 44% | 8% | 32% |

3.7 Preference of Commercial Enterprises:

Owners of shops in rural markets have significant interest in using small solar systems (SHSS) for lighting, in order to facilitate their business operations. Outside the buffer zone, 90% of the commercial respondents are willing to obtain SHSS while only 8% are willing to pay for the large solar system. Within buffer zones, 60% of the commercial respondents are willing to obtain SHSS while 13% are willing to pay for SHSL. 10% of the commercial respondents within the buffer zone are currently spending more than 300 Taka per month on lighting, which is equivalent to the monthly payment of the SHSL. However, the SHSS is the optimum size for the rural shops of Bangladesh. It is interesting to note that 20% of the owners of commercial enterprises outside the buffer zone, are using batteries for watching television in their homes.

3.8 Socio Economic Background of the Survey Respondents:

This survey has focused on the middle and higher income groups of the rural population in the selected areas. This was done to ensure that the survey adequately characterized these income groups, which will comprise the near-term market for SHS⁵. In comparison to the national average monthly income of 3,658 Taka per month², the survey households earn 13,062. The main occupation of 65% of the survey population is agriculture and 45% of the total respondents are owners of large farms. Preference for SHSL have been expressed by 55% and 45% of the owners of large and medium size

⁵ The survey scope, limited by budget constraints to 700 households, would not have adequately characterized these groups if a completely random household sample had been used because the absolute number of each of these income groups is relatively small.

farms respectively. The SHSS is preferred by 50% of the small and marginal size farm owners . The roof material of 96% of the households is tin or tile, reflecting semi permanent structures. It is noteworthy that 58% of the surveyed households have a single earner in the family, 44% of whom showed preference for the SHSS. 50% of the households with more than two earning members are willing to pay for the SHSL. National average for the number of family members per household is 5.26, while the average number of earners is 1.48 according to the HES².

4. CONCLUSIONS:

- The present study on market assessment provides information on the rural consumers and their requirements in the context of solar electrification. A market size of approximately 0.5 million households is envisioned for solar electrification, which has the potential of extending to 4 million in the future. National and regional plan for implementation of large scale program for SHS in rural electrification should now be developed using predetermined criteria for qualification of solar PV programs. This plan should be consulted in association with the conventional master plan in place with REB for expansion of rural electrification, considering 61% of the respondents have opted for service from the existing PBSs.
- The survey shows that solar battery charging stations are not a suitable option for electrification in Bangladesh and should therefore be avoided in future implementation of solar PV programs.
- Appropriate measures should be taken for local certification and quality control of hardware. Use of trained distributors and maintenance contractors are recommended for sustainability of the systems.
- Large scale demonstration of SHS in different geographic regions should be initiated to create awareness for SHS.
- Considering the results obtained on willingness to pay for different levels of service, and the variation of income and assets of the potential users, it is recommended that the SHS be sized according to the desire of the users, ie, options for service levels should be made available.
- Quality of service must be ensured from the beginning of any future SHS program through standardized systems and effective implementation of regulatory rules.