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DEMONSTRATION OF PV MICRO-UTILITY SYSTEM FOR RURAL ELECTRIFICATION

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Abstract—Many rural market places in Bangladesh rely on inefficient and expensive fossil fuel based lighting. Photovoltaic (PV) based electricity is an interesting option to provide quality light and better service in these situations. A PV based micro-utility system was initiated in a rural market in Bangladesh in October 1999. Twenty one shop owners were provided electricity for 5 h a day on fee-for-service basis, and paid a tariff daily. A local operator cum technician was trained to take care of the system and in charge of repair, maintenance and tariff collection. Feedback from the users of the system indicates that PV based electricity has been providing very satisfactory service to the consumers. The success of this type of PV dissemination model has been due to the users' willingness to pay a daily tariff, clear agreements with the Bazaar Management Committee and users, and operator training. The model proved to be successful and two more rural markets showed interest in this approach of rural electrification. This is likely to succeed in other countries with similar socio-economic conditions.

1. INTRODUCTION

Currently, about 2 billion people rely on traditional energy sources (WB, 1996), while 1.7 billion people do not have access to electricity (WEC, 2000). With an estimated world average growth rate of 2.8%, electricity demand is expected to double between 1997 and 2020. During this period, the electricity demand in developing countries is projected to be 4.6% annually (G8, 2001). At present the supply of grid electricity meets primarily the demand of urban and the industrial sectors in the developing countries, whereas, most population live in the villages. Even those rural population with access to electricity do not receive quality service.

Bangladesh has a population of about 131 million. Its per capita commercial energy consumption of about 77 kg oil equivalent (kgoe) in 1997 was very low as compared to the world average of about 1474 kgoe (ADB, 2000). Biomass fuels, accounted for 73% of total energy consumption. The share of the major fuels were: wood — 65%, agriculture residues — 22.1% and animal dung — 7.8% (World Bank, 1998). Indigenous natural gas is the major energy source in the country, and is mainly used for the production of electricity and fertilizer. The other commercial energy sources are crude oil (which is imported) and hydro-electricity. The installed electricity generating capacity of Bangladesh in 1999 was 3.3 GW, of which around 93% was from thermal, mainly natural-gas-fired. Only around 18% of the population were connected to the electricity grid, and, of the 21 million households in the country, only about 2.8 million were under the electricity network (EIA, 1999). Rural Electrification Board (REB) is responsible to build grid network and supply electricity to the rural areas of Bangladesh. Bangladesh's Power System Master Plan (PSMP) projects a doubling of electricity generating capacity by 2010. It is estimated that a total investment of USD 4.4 billion will be required for capacity addition through 2005 (Shakti, 2000). But, due to the high cost of extension, about Tk. 30 000/km, i.e. USD 507/km (REB, 1999), a large number of rural establishments have not been connected to the grid as they do not meet the load demand criteria. The huge investment required to satisfy the electricity demand means that homes, business centers and other establishments in many villages and isolated areas may not be

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connected to the grid in the near future by conventional electricity generation and distribution methods.

To supply electricity with quality light, reliable service and long term sustainability, photovoltaic (PV) technology is an important emerging option. PV systems not only would provide reliable, clean and environment friendly energy, it could also create employment opportunities in the vicinity of its operation. Despite these appealing features, PV systems do not yet have broad market acceptance due to barriers to its large-scale implementation. The main obstacle is its high initial cost. Lack of demonstration of the technology, awareness and adequate after-sales service are the other barriers in the promotion of PV-based electricity. Martinot *et al*. (2001) and Nieuwenhout *et al*. (2000) have listed various options to promote PV-based electricity generation and use. Barua *et al*. (2001) have demonstrated how a credit system could be effective in a developing economy. Another success in promoting PV systems on credit is Sri Lankan SEEDs model, where a sales rate of 400 systems per month has been achieved under a suitable financing approach (Lipp, 2001). Over 50% of the rural populations are thought to be potential users of renewable energy if there is no upfront cost and the only charge is a monthly fee for an energy service, if this monthly fee tends to equal to the amount that the customer is currently paying for fuel. This model appears to be most attractive to outside investors, and is being duplicated in several countries (APEC, 1998). With cost reduction, appropriate financing arrangements and mode of operation suited to local conditions, PV systems could, in the future, play a significant role in rural electrification.

There has been some efforts to reduce the overall system cost by developing accessories appropriate to the local countries (e.g. charge controller, inverter for lamp, DC–DC converter, etc.) through adaptive research in recent years (RETs in Asia, 2000). To promote adaptive research and dissemination of mature/nearly mature renewable energy systems in selected Asian countries, a regional research and dissemination programme was sponsored by the Swedish International Development Co-operation Agency (Sida) and coordinated by the Asian Institute of Technology (AIT). In Bangladesh, the PV programme involved adaptive research, demonstration, dissemination and training by two organizations — Grameen Shakti (GS) and Center for Mass Education in Science (CMES).

This paper presents details of the activities conducted in implementing a PV micro-utility system by CMES in Bangladesh. The concept of micro-utility systems and its applicability in rural areas, the site/users selection criteria for demonstration and installation, the tariff structure, operation and maintenance procedure of the system are described. An analysis of the technical and financial viability of the proposed model has been made using RETScreen software (RETScreen, 2000). Finally, an evaluation of the demonstration systems and the dissemination effort are presented.

2. MICRO-UTILITY PV SYSTEMS FOR RURAL ELECTRIFICATION

Rural energy markets with no access to grid-based electricity and aspiration for better quality light, need to switch either to diesel generator service or any renewable energy-based systems. Cabraal *et al*. (2000) observed that PV systems are an effective complement to grid-based power, which is often too costly for sparsely settled and remote areas. For such rural conditions, fuel-independent, modular solar home systems could offer the most economical means to provide lighting and power for small appliances.

PV systems ranked high in all respects such as reliability of power, quality of light, low operation and maintenance cost, etc., if the cost of per kWh energy is not calculated. Liebenthal *et al*. (1994) note that solar PV and diesel systems should not be compared on the basis of the cost per kWh of electricity produced under these two systems because such a comparison fails to account for the major operational differences between solar PV and diesel systems.

PV micro-utility system in a broad sense is similar to the Energy Service Company (ESCO) model where the users pay for service received. The basic difference is that in an ESCO model the system is installed in the premise of the user, whereas, in micro-utility system, the system comprising a number of modules is installed at a common place and the users are connected to it. Other features remain almost the same. A number of such models have turned to be successful worldwide. Cabraal *et al*. (1996) note that such a model permits the monthly cost to the consumer be reduced by spreading the cost of the solar home system over a period comparable to its physical life. The smaller monthly payment makes the system more affordable. One of the successful programmes of this model was by SOLUZ Inc., in the Dominican Republic which started its operation in early 1994, supplied electricity to 100 consumers within months. Up to November 2000, it served 3700 consumers of which 2000 were fee-for-service. Based on the success in the Dominican Republic, a similar project was initiated in Honduras in 1998 and up to November 2000 the programme served 1300 consumers of which 700 were on a fee-for-service basis. The company also targets to reach 10 000 consumers as fee-for-service by 2004 in these two countries (Hansen, 2000).

Martinot *et al*. (2001) studied 12 energy service projects funded by the World Bank group since 1992 and noted that the fee-for-service model has been a successful approach of electricity supply in rural areas of developing countries, in Benin, Togo, Cape Verde, Sri Lanka, etc. where rural people cannot afford to purchase the system.

An ESCO model in the eastern Province of Zambia has been successful in creating interest and awareness around PV technology, and in the concept of making people pay for service rather than ownership of certain pieces of equipment. The project has been successful in creating business opportunities in the solar energy areas, and in training people for the various tasks involved: technical, business, management, etc. (SEI, 2001).

Building institutional frameworks for the management of the system, especially in the case of micro-utility where the system is not installed in the premise of the user is important for the success of the micro-utility. Early experiences show that involvement of the local community can yield better results to avoid problems like non-payments, allocation of site for installation, theft of equipment, mishandling, etc. Wilknison (2001) notes that community participation is now widely accepted as a pre-requisite to ensure equity and sustainability of local infrastructure investments, such as water supply or rural electrification. The community participation appears to be the one common factor in all sustainable PV projects analyzed by NRECA (Smith, 1998). NRECA had no major financial failures with solar home system projects when the community was involved. Community involvement cannot be superficial. For example, the community must take responsibility for payments of the solar home systems.

However, dissemination of such a model requires demonstration to build up awareness to the potential users and the policy makers. Rural people learn more about a technology by practical demonstration than by listening to radio or reading in a newspaper. In a study made in Lesotho in 1993, 26% of the Lesotho population had heard of PV. In 1999 this had increased to 58%, mostly through seeing a system in the neighborhood or at a friends place (74%) and for the rest through the radio (15%) (Nieuwenhout *et al*., 2000).

3. PROMOTION OF PV MICRO-UTILITY MODEL IN BANGLADESH

About 81% of the total population of Bangladesh live in rural areas. The rural markets are considered as growth centers and big bazaars called ‘Hat’ are held twice a week. Farmers from long distances come to the Hat with their products to sell to merchants, who usually come from cities or major towns. The trading continues till evening. A Hat without electricity does not attract merchants and the farmers may have to sell their products at a comparatively low price. This results in wastage of huge unsold products yielding great loss to the farmers.

Kerosene lamps called ‘Cuppi’ and ‘Harricane’ are the major appliances to meet the lighting needs of these shops. Some shops use the more expensive mantle lamps called ‘Hazzak’ to obtain brighter light. Diesel generators supply electricity in some rural markets. This involves an initial cost of about Tk. 50 000 (~USD 845) for a 5 kVA capacity, but requires high operating cost and frequent maintenance. Though the quality of service is usually poor it provides better quality light. Voltage fluctuation also shortens the life of the appliances connected to it. Table 1 summarizes the options available to the shopkeepers in the rural markets, their corresponding monthly cost and the quality of light.

The rural market’s electricity needs for lighting and the pattern of payment suited to the shop owners showed that most shops needed one or

Table 1. Options available for lighting in the rural markets

Options	Fuel	Monthly expenditure	Quality of light	Remarks
Cuppi	Kerosene	Tk. 40 (~US¢ 67)	Very very poor	High risk of fire
Harricane	Kerosene	Tk. 150 (~US$ 2.53)	Very poor	Some risk of fire
Hazzak	Kerosene	Tk. 260 (~US$ 4.39)	Poor	Some risk of fire
Engine generator	Diesel	Tk. 150 (~US$ 2.53)	Good	Poor service

USD 1 ~ Tk. 59.17, October 2001.

two lamps for an operating period of 4–5 h daily. A smaller PV system with one or two lamps are comparatively more expensive and are not affordable to the shop owners. However, some shop owners currently pay Tk. 4–5 (~US¢ 8) daily for diesel-based electricity. Most of these supply a lamp or two to every shop in a village market, and thus creating a low-investment enterprise. This led CMES to promote the PV-based micro-utility system and demonstrate its applicability for rural electrification.

In a PV micro-utility system, a number of solar modules are mounted at one location, preferably in the middle of the load distribution, and the controllers and batteries accompanying the system are placed in a room close to the solar array. The client shops are then connected to the system by keeping the cable as short as possible. Each lamp is equipped with an individual switch placed within the user's reach while a main switch, which controls all loads, is placed in the control room. The main switch is turned on in the evening and turned off at the end of the operating hours as agreed with the users. A local person (operator) is trained on the operation of the systems, who is also capable of doing minor troubleshooting while the major ones are taken care of by CMES personnel. The operator is also responsible for collecting the daily tariff from the users. The tariff is set by mutual discussion with the users and the bazaar committee; it is the same as that charged by the diesel generator service. The operator maintains a bank account under direct supervision of CMES. The revenue collected is used to pay the technician's monthly salary, meet the repair and maintenance cost as per requirement and the rest is deposited in the fund aiming to recover the cost of installation. The initial deposit from the client is maintained as security against the assets (lamp, ballast, cable, etc.). As per the agreement, CMES has the right to forfeit the deposit in case of damage to its assets by the user.

The first PV micro-utility system was initiated in October 1999 in the Manikganj bazaar of the Dinajpur district, about 400 km from Dhaka (Fig. 1). First, a meeting was arranged with the shop owners, local leaders and potential users of the PV system. The operation, benefits and maintenance procedure was explained to them. A daily tariff of Tk. 5 (~US¢ 8) and a refundable deposit of Tk. 200 (~USD 3.38) for each connection was agreed upon. A contract was then signed with the Bazaar Management Committee (BMC) by CMES. The micro-utility service was designed to provide power to the appliances (lamp and ballast) to the shops, and supply 5 h of electricity every night. The bazaar was connected with the PV micro-utility system on December 12, 1999. Seven solar modules of 50 Wp each divided into two groups, were installed in two suitable locations of the bazaar. The batteries and the controllers accompanying each group were placed in two

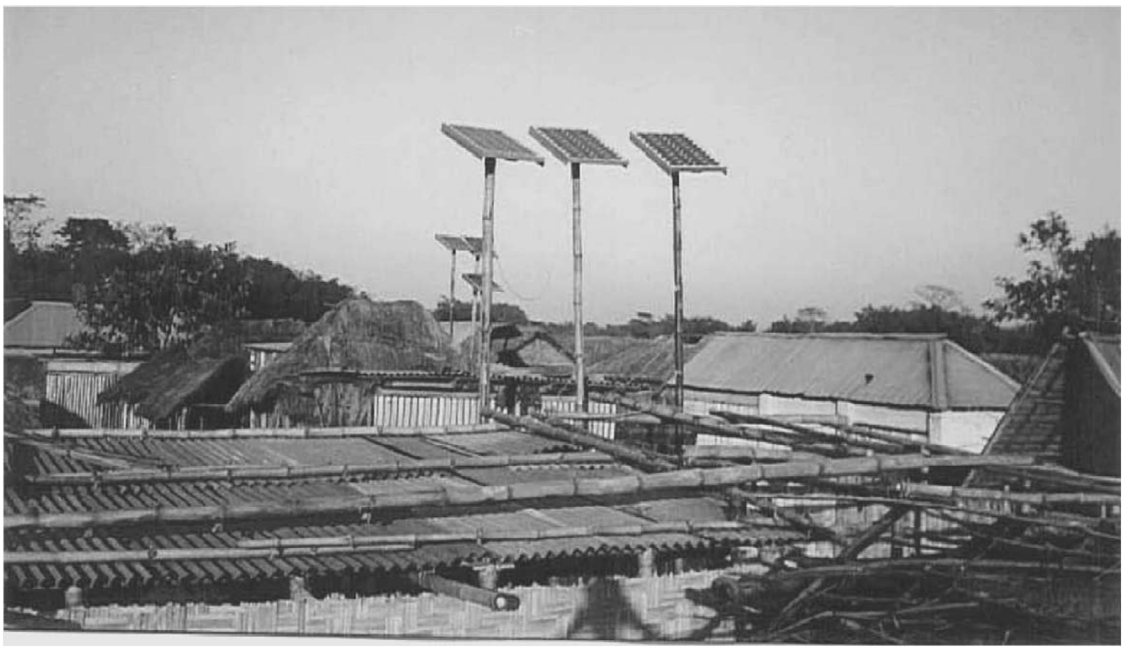

Fig. 1. PV panels in Manikgonj bazaar, Bangladesh.

Table 2. Specifications of the installed micro utility system

Component	Model	Origin/manufacturer	Technical specifications	Quantity (numbers)		
				Manikganj bazaar	Alok Dihi bazaar	Chinibashdanga bazaar
PV module	SR-50	Siemens (Germany)	Watt: 50 Wp	7	6	5
Battery	6BC 160T/3	Rahimafrooz (Bangladesh)	Type: Lead-acid Capacity: 100 Ah@10 h Nominal voltage: 12 V	7	6	5
Charge controller	Type-A (CMES)	CMES (Bangladesh)	Rating: 10 A Over charge protection: 14.5 V Over discharge protection: 11.5 V Trickle charging mode available	7	4	3
Ballast		CMES (Bangladesh)	Watt: 7 W Frequency: 50 kHz	24	24	20
Fluorescent Lamp	FL-7	Toshiba (Japan)	Watt: 7 W Current consumption: 0.6 A Voltage range: 11.2–14.4 V Illumination: 700 Lumens	24	24	20

suitable rooms close to the respective solar arrays. Table 2 gives the specification of the micro-utility system installed at the Manikganj bazaar. The clients of the system were a grocery shop, restaurant, barbershop, pharmacy, village doctor's chamber, tea stall, etc. (Fig. 2)

The PV based micro-utility systems were connected to:

- eighteen shops each provided with one 7 watt lamp
- three shops each provided with two 7 watt lamps and
- one black/white TV in the communal room of the Bazaar Management Committee (Fig. 3).

4. ANALYSIS

The micro-utility based PV system appears to be a suitable model for implementation in rural areas where there is a market for such lighting needs. The success of the PV micro-utility system is due to the following factors:

- survey to asses the shop owners who were willing to pay a daily tariff of Tk. 5 (US¢ 8) to get better quality light,
- explaining the PV based system's capabilities, benefits and comparison with the other available options to the potential users, and its constraints so that the users could shorten their operating hours in the extreme bad weather,
- agreement with the Bazaar Management Committee (BMC) which includes the terms and conditions of service, maintenance procedure, payment and financial details of the users and security deposit, and
- training of the technician to take care of the system.

Since the beginning of the operation, the repair and maintenance works carried out for the different micro-utility systems were the replacement of the blackened lamps, problems of connection with the charge controllers, replenishing distilled water of batteries, etc. The repair and maintenance cost of the system over a total monitoring period of 22 months is about Tk. 2500 (~USD 43) while the salary of the technicians amounted to Tk. 17 600 (~USD 307).

Due to the continuous power supply to operate light for 5 h every evening, the working hours of the shops effectively increased. This has increased the income of the shopkeepers. The lights are bright and steady, and the illumination from all the shops extended to the road where even the hawkers can do their business. The micro-utility is appreciated by the shopkeepers. Their smoky open kerosene lamps were inadequate and expensive, and the mantle lamps (Hazzak) gave inferior lighting as compared to the present fluorescent lamp. PV-powered television is an added attraction. Four shopkeepers wanted to operate a cassette player/radio in their shops, and were willing to pay more. Requests for electricity connections from five other shopkeepers were also received.

4.1. User feedback

A monitoring and evaluation programme was carried out. Record sheets including information of system status, user's feedback, repairing and maintenance tasks, etc. were developed. The monitoring visits were made monthly while the

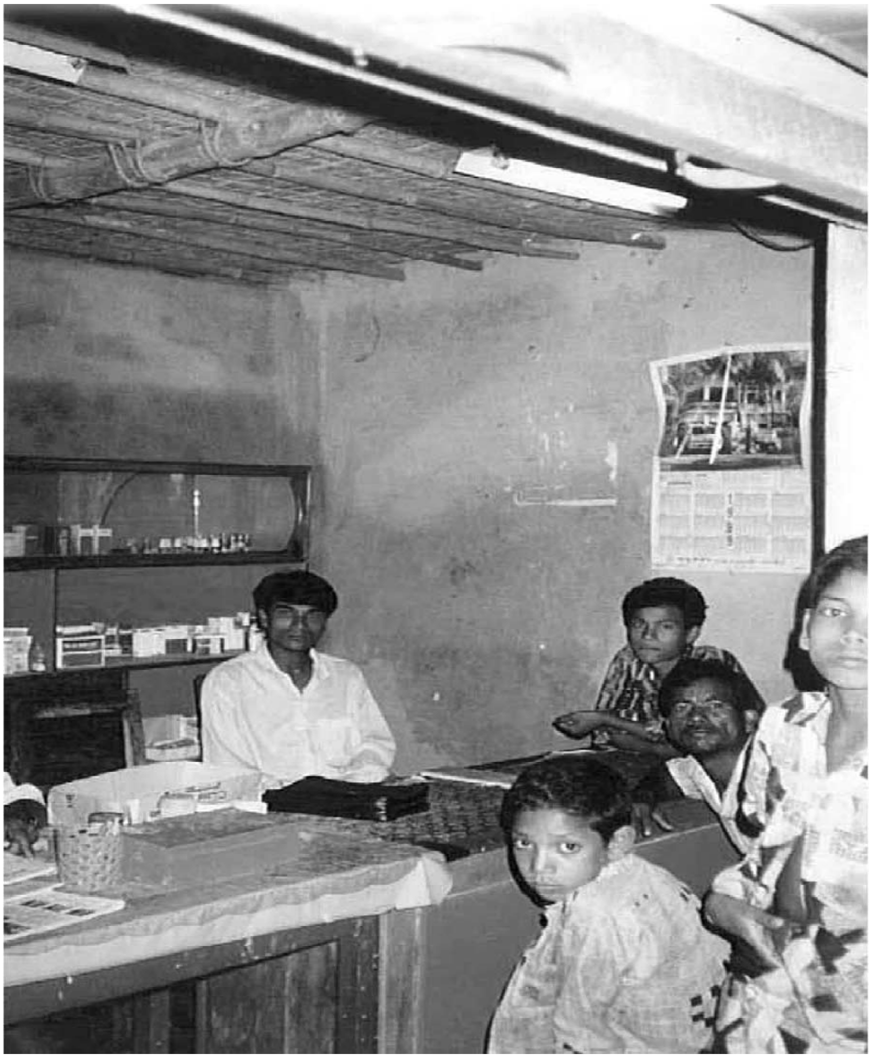

Fig. 2. A medicine shop served by the PV micro-utility at Manikgonj bazaar.

evaluation visits were done once every three months. During these visits, CMES personnel recorded different technical parameters related to the system, repair and maintenance works and their costs done during the period from the technician and user's comment. These data show that the users are highly satisfied in terms of amount of light and quality of service. The pharmacy owner reported that the market had become livelier and had created an environment for the people to stay longer in the market resulting in an increase in sales. The tea-stall owner noted that his income had significantly increased since other stalls did not have bright light. The grocery shop owner observed that more customers were visiting his shop. The restaurant owner reported that his working hours had increased and more customers visited his restaurant.

Table 3 shows a comparison of PV-based lighting with other options, based on interviews with the users. It shows that the quality of light, reliability and comfort are better with PV micro-utility systems than other lighting options; this also requires least maintenance. PV systems are also free from the hazard of smoke. The monthly expenditure for PV systems is comparable with or less than other common options, e.g. hurricane, mantle lamp and generator based service.

4.2. Analysis of technical and financial viability (using RETScreen software)

An analysis regarding the technical and financial viability of the installed micro-utility in Manikganj bazaar, as a model for rural market electrification, by using RETScreen software has been done. This software, developed by the Ministry of Natural Resources, Canada can be used to evaluate the energy production, life cycle

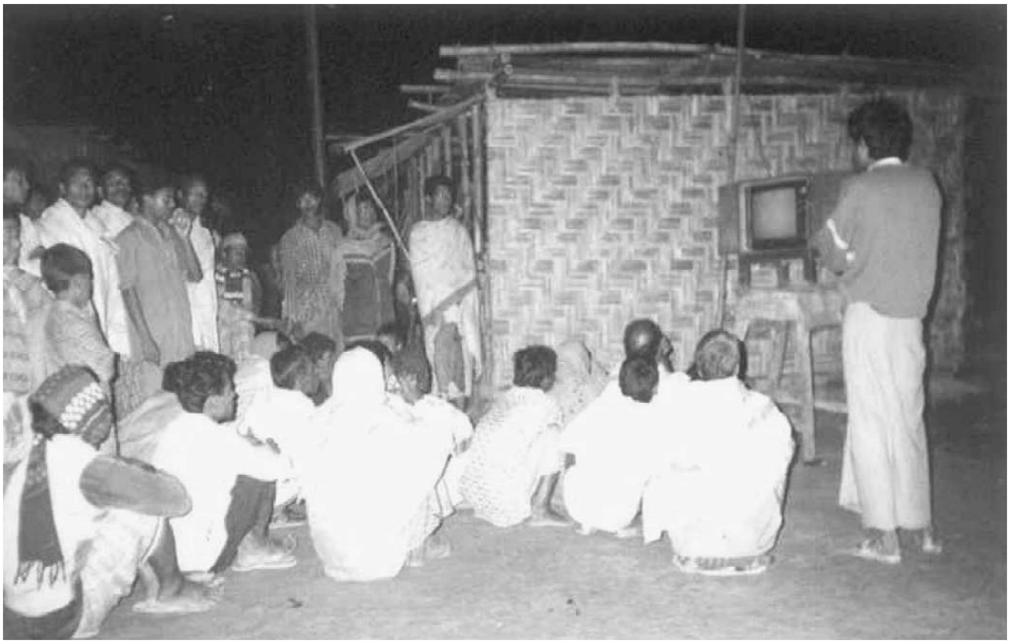

Fig. 3. Television for the bazaar community powered by PV micro-utility.

costs and greenhouse gas emissions reduction for PV-based electricity generation.

Table 4 gives the inputs used for evaluation. Details regarding the site, system (capacity, battery and load), costs and revenue have been provided. The cost of the PV module is 58% of the total cost whereas the balance of system costs, transportation and installation form the rest. The project life is estimated as 25 years, while the batteries and the lamps are expected to be replaced every five and three years, respectively. The fund for installation has been assumed to be a soft loan with 2.5% interest.

The results of analysis are given in Table 5. Based on the radiation data and load demand, the suggested PV array size by the RETScreen software is 420 Wp which is 70 Wp higher than the installed capacity. The annual electricity demand

Table 3. Comparison of options available for rural electrification in Bangladesh

Category	Cuppi (uncovered wick lamp)	Harricane (wick lamp with glass enclosure)	Hazzak (mantle lamp)	Diesel engine generator	PV micro utility
Amount of light	Insufficient	Insufficient	Insufficient	Sufficient	Sufficient
Quality of service	Very bad	Bad	Bad	Bad	Very good
Maintenance required	High	Very high	Very high	Very high	Very low
Switch on convenience	Difficult	Difficult	Difficult	Easy	Simple
Initial investment to user	Tk. 20 (~US¢ 33)	Tk. 150 (US$ 2.39)	Tk. 400 (US$ 6.7)	Tk. 100 (US$ 1.69)	None
Monthly expense	Tk. 40 (~US¢ 67)	Tk. 150 (~US$ 2.53)	Tk. 260 (~US$ 4.39)	Tk. 150 (~US$ 2.53)	Tk. 150 (~US$ 2.53)
Smoke emitted	Yes	Yes	Yes	No	No
Heat produced	Yes	Yes	Yes	No	No
Reliable service	No	No	No	No	Yes
Comfort	Very low	Low	Low	Medium	High

USD 1 ~ Tk. 59.17, October 2001.

Table 4. Description of inputs used for RETScreen for the system installed in the Manikganj bazaar

Site/location	Project site	Manikganj bazaar, Dinajpur, Bangladesh
	Solar radiation data	Shillong (since data at Dinajpur, Bangladesh is not available, Shillong was considered as the nearest available station
System description	Application type	Off-grid (PV/battery)
	Nominal system voltage	12 V DC
	Days of autonomy	3 days
	Tilt angle	25° (true south facing)
Battery	Charge acceptance efficiency	85%
	Maximum depth-of-discharge (DOD)	60%
	Nominal battery capacity	700 A h @ 10 h
PV module	Type	Single crystalline silicon cell
	Model	Siemens SR50-Z(1)
	Nominal PV array	350 Wp
Load description	Load-1	24 nos. 7 W fluorescent lamp
	Load-2	1 no. 15 W B/W TV
	Operating period	5 h per day
	% of night time use	100%
Cost — Hardware	PV module	Tk. 300 per Wp
	Battery	Tk. 5000 per kW h
	Other electrical equipment	Tk. 70 per Wp
Transportation	To the site	Tk. 4000
Total cost	Initial cost	Tk. 175 701
Annual cost	Maintenance	Tk. 1500
	Salary of the technician	Tk. 9600
Periodical cost	Battery replacement @ 5 years	Tk. 42 000
	Lamp replacement @ 3 years	Tk. 10 000
Revenue	From users (25 nos. lamps)	Tk. 5 per lamp per day
	Annual revenue increment	5%
Project period	Based on expected life of PV module	25 years
Finance details	Interest rate	2.5% (considering soft loan)
	Period of repayment	5 years
	Inflation	5%
	Discount rate of the hardware	10%

estimated by the software is 349 kWh whereas the installed system will be able to meet 332 kWh. This deficit would affect only during the bad weather and particularly in the months of June and July when the system will meet 86% of total energy demand. However, this problem can be minimized by shortening the operating period by 1 h in this period. The cost options available in RETScreen related to logistic, engineering, training and unforeseen were not considered in the analysis. The simple payback period is found to be about 4.9 years. However, assuming costs for

Table 5. Summarized results obtained from RETScreen

Technical issues	PV module capacity	Suggested	420 Wp
		Installed	350 Wp
	Annual energy demand	Demand	349 kW h
	and supply	Supply	332 kW h
Financial Issues	Total project cost	Tk. 175 701	
Annual revenue	@ Tk. 5 per lamp per day	Tk. 46 965	
Annual payment	Loan repayment (for 5 years)	Tk. 37 819	
	Operation and maintenance	Tk. 11 100	
Summary	Simple payback period	4.9 years	
	Net present value	Tk. 219 241	

Revenue from TV has not been considered.

these increases the total project cost by about 10% and the simple payback period to be about 5.4 years.

4.3. Prospects for rural electrification by PV

This first demonstration of PV micro-utility system as a model of rural market electrification earned wide acceptance due to its quality of light, ease of payment and adequate service. Many visitors came to see the system and discussed its benefits to the users. There was an interest from Alok Dihi and Chinibashdanga bazaars, located within 5 km from the Manikganj bazaar; in the last quarter of 1999, two micro-utility systems were installed in these bazaars with 21 and 18 connections, respectively. The specifications of these systems are given in Table 2. The total number of fluorescent lamps installed in Alok Dihi and Chinibashdanga bazaars were 24 and 20 respectively. The vendors in these two bazaars were a grocery shop, restaurant, barber shop, pharmacy, village doctor's chamber, tea stall, and other shops. However, due to the arrival of grid-based electricity, the system in Alok Dihi bazaar was withdrawn after ten months of operation.

Table 6 shows the cost of electricity paid by domestic users in many countries. The variation in electricity charges is quite large and it is clear that users in many Asian developing countries are paying a high price to obtain good lighting service. This has also been noted by Cabraal *et al.* (1996). In most of these cases, high initial cost along with the other barriers noted earlier seem to inhibit the use of renewable energy based electricity generation systems. The experience of micro-utility in Bangladesh suggests that this model could be replicated in other developing countries.

5. CONCLUSION

Electrification of rural communities in developing countries deserves special attention because of its influence on rural economic growth. Providing electricity to meet the lighting needs of the rural market places can bring several positive impacts including improvement in quality of life and increase in income and employment opportunities. Presently available options provide poor quality light; these are also hazardous to health and expensive in terms of operation and maintenance. Supplying electricity using PV micro-utility systems has been demonstrated to be successful and suited to local conditions where the target group is unable to pay high initial cost.

The other attraction of the approach to the users is that they are free from the responsibility of maintaining the system. However, involvement of the local community in management avoids the risk of damage of the whole system. The users are assured of a dependable service by making available the operator/technician within the local community. Analysis shows that this model is not only technically viable but also it is financially

Table 6. Cost of domestic electricity in different countries (up to 50 kWh per month)

Range of domestic electricity tariff (US¢/kW h)	Country: Asia	Country: Others
2 to 4	China[a], Thailand[b]	
4 to 6	Lao PDR[c], India[d], Vietnam[e], Bangladesh[j]	USA[f]
6 to 10	Nepal[g], Taiwan[f], Singapore[f]	Brazil[g], Dominican Republic[g]
10 to 15		Jamaica[g], Panama[g], UK[f], France[f], Germany[f], Spain[a], Belgium[a], Italy[a]
15 to 20		Barbados[g], Austria[a], Denmark[a]
20 to 30	Japan[f]	
30 to 50	Myanmar[h]	
70–90	Cambodia[i]	

[a] http://cea.nic.in/idg/idg_annaxure3.1.htm
[b] http://www.nepo.go.th/power/pwc-tariff-E.html
[c] http://www.caa.org.au/campaigns/adb/fact_sheets/nt2.html
[d] http://www.gseb.com/WEBGEB2K/word/TARIFF%5CLFD-I.htm
[e] http://www.worldbank.org.vn/rep13/fu302.htm
[f] http://www.electricity.org.uk/uk_inds/pricesla.html
[g] http://www.jamaicatradepoint.com/idg/electricity.asp
[h] http://www.myanmar.com/gov/trade/int.htm
[i] Final report on RE strategy and Programme for the Cambodia Rural Electrification and transmission Project, Khemer Consulting Engineering Corporation Ltd., World Bank contract no. 7110176, March 2001.
[j] http://shakti.hypermart.net/articles/power/tariff.htm

sustainable if a soft loan (for example with 5% interest) can be availed. A simple payback period of less than five years may be reasonable enough to attract investors.

Demonstration of the PV micro-utility system has been successful to create interest among the rural people and demand from other locations was received. This approach could be equally applicable to other developing countries with similar rural conditions.

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