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Financing Mechanisms of Solar Home Systems for Rural Electrification in Developing Countries

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Abstract - Photovoltaic (PV) based solar home systems (SHS) are often the least expensive electrification option in sparsely populated areas with low electric loads. This makes the SHS appropriate for rural electrification in the developing countries. However, the acquisition of a SHS requires high initial investment and moderate operating and maintenance cost. The lack of financial services for users of SHS is often regarded as the main barrier for their commercial dissemination. Several financing approaches have been practiced in different countries and reflected both positive and negative impacts. This paper reviews various financing mechanisms used worldwide for dissemination of SHS and discusses the potential of commercialization of SHS in remote rural areas in presence of a financial service. The success of a mechanism depends on various factors ranging from selection of the right mechanism for right location to implementation strategy of the selected mechanism. Donated or highly subsidized projects are found not to sustain for long term. Cash sale approach has lower market penetration record. Hire purchase and fee-for-service approaches are found to have higher success records than the others. However, financial schemes should be designed in such a way that financing institutions and financial intermediaries can recover their operational costs.

Keywords: Solar Home Systems, Rural Electrification, Financing Mechanism

1. INTRODUCTION

Electricity is the mainstay that gears the development activities leading to improvement in quality of life. Access to electricity can bring many positive impacts including poverty alleviation and improved child education. However, rural areas of the developing countries lack proper infrastructure. The households as well as other establishments are sparsely settled that makes the extension of grid network to connect those areas are not economically viable. An estimate in Bangladesh shows that the cost of extension of an existing grid in 2000 was of the order of USD 553/km [1].

Rural electrification using Solar Photovoltaic (PV) has been emerging as a viable option for the developing countries. PV systems not only would provide reliable, clean and environment friendly energy but 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 certain barriers. These include awareness about the technology, capacity building and financing. Since, PV based Solar Home System (SHS) is targeted for the rural people who do not have sufficient means to guarantee for the payment, financing agencies are not interested in this business. In addition, financing program of SHS needs careful design and target oriented planning. There have been a number of schemes already implemented in different countries which resulted both negative and positive experiences. This paper reviews the financing mechanisms for solar home systems implemented in different countries and discusses the advantages and/or disadvantages associated with the mechanisms. It also summarizes the lessons learned to recommend important issues related to a successful program.

2. POTENTIAL OF SHS FOR RURAL ELECTRIFICATION

The rural areas of developing countries have poor access to electricity. This is mainly due to the following reasons:

- High cost of expansion of grid network due to the sparsely settled pattern of establishments
- Low energy demand by the households and other establishments

The lighting need of the households is met by kerosene lamps. Some of the houses also use lead acid battery to operate Black and White television which they recharge from a distant market place. There are also diesel generator based electricity supplies in some of the areas. However, poor reliability of the service together with noise and pollution, the service is loosing popularity. In addition, from the operator point of view, it is not an attractive business as it involves high operation and maintenance cost.

On the other hand, solar home system is an environment friendly technology and involves low operation and maintenance cost. A well designed SHS very much reliable. Several studies have concluded that rural people prefer PV lighting in absence of grid electricity. These features have significantly increased the use of SHS in the developing countries during the last decade and expected to grow more. Furthermore, it has been widely accepted that SHS is a cost effective mode of electricity supply in the rural areas of developing countries.

3. NEED FOR FINANCING

In spite of the potential for larger growth of PV technology for rural electrification, there are a number of barriers, which hinder the widespread use of PV systems in developing countries. These include high initial cost, lack of awareness of the technology among the potential consumers, improper management, lack of service, improper selection of customers, and lack of knowledge in system performance. Among these the high cost of SHS is considered to be the most crucial barrier.

The initial capital cost of a solar home system is very high in proportion to its total life-cycle costs (typically more than 75 percent). For many low and middle income rural households, the purchase price of a solar home system represents almost one year's income [2]. The target groups for basic rural electrification by means of Solar Home Systems are rural households living in remote villages far from the grid and unattractive for grid extension by the national or regional electric utilities. An important precondition of PV-electrification of interested rural customers is the need to mobilize enough money for the acquisition of the system. The current price of a standard SHS lies in the range between USD 500 to 600. The common income group of rural areas in developing countries have serious economic constraints and unable to pay this cost in cash. The local banks or financial institutes are generally not interested to finance solar home systems. Although, there seems to be no qualitative difference between the acquisition of a SHS and any other consumer good which can be financed e.g. through a hire purchase or any other form of consumer credit scheme, the banks

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see it as high risk investment without a collateral.

On the other hand, since income generation from PV systems is rather insignificant, users have to finance a SHS from their current income. This refers not only to the initial investment for a SHS but also to the operational cost over the lifetime of the system. Without having access to an affordable credit scheme or other forms of financing mechanisms like hire purchase, leasing, etc. the interested rural customer will hardly be in the position to acquire a SHS.

In an off-grid rural electrification program in Sir Lanka, SELCO solar Lanka Limited (SSL) experiences that around 50 % of rural households can afford a solar home system (SHS). Of these, about 10 % can afford to pay cash, 90 % need credit. The other 50% might be reached through partial grant, donor, or subsidy programs [3].

A World Bank study found that the average monthly expenditure in rural households of developing countries for kerosene lamp and lead acid battery alone ranges between $2.30 for low income families, to $17.60 for upper income families [4]. These expenditures are similar to the monthly cost of a SHS if some kind of financing is provided.

4. REVIEW OF AVAILABLE FINANCING MECHANISMS

a. Donations

The term donation here refers to the case that the sponsor provides the hardware for free, or almost free. Users are generally less involved in this type of project and feel less responsibility to the system they use. In addition, most donated projects provide the hardware only, often resulting in neglect of maintenance and service requirements. However, the advantages of such projects are low or zero initial cost for the users, the potential for cost reduction through economies of scale, and rapid deployment.

Experiences show that these types of projects often do not sustain. In a government funded program in Tunisia, the hardware was given free and the consumers were asked to pay an operating cost of USD 5.20 per month, still the users refused to pay. This was not caused by an inability to pay, since sometime later, the users could afford USD 208 to get the grid connection.

The phase I of Zacapa project in Guatemala is another example. An international NGO installed 124 systems with full subsidy. The users were supposed to do the maintenance and replacement of components, when needed. A detailed training on the importance and need for the maintenance for different components as well as techniques to minor troubleshooting were also given. But, in a survey made after 5 years it was found that 45% of the systems were not working mainly due to minor problems or need for replacements [5].

b. Cash Sales to Consumers

The main advantage of cash sales is its easy financing, low transaction cost and flexibility in customers' choice. However, it targets only the higher income group. The general rural people cannot afford the high cost of a solar home system. In addition, there are major drawbacks in this approach, such as:

- The user has a tendency to buy an undersized system to save money. This results in short life of battery,
- The replacement is often done with cheap and non-compatible components which severely undermines the system's performance,
- The installation is not properly done as the users do not prefer to hire a professional installer, and
- Maintenance can be a serious issue even with warranty on the components when the seller is in city and the buyer is in countryside.

Studies show that about 21% of the systems in Kenya purchased in cash were not operational. The Solar Energy Company (SEC) of Kiribati installed 270 systems in 1984. The PV systems were sold at commercial price in cash but the maintenance service was given at a very nominal charge as SEC obtained grant from USAID for the maintenance. A survey in 1992 showed that about 90% of the systems were marginally operational. The reasons were that the users purchased undersized system, the systems were not installed as per the manual, and the replacements were not done with standard components [5].

c. Energy Service Company (ESCO)

An energy-service-company (ESCO) model means that the ESCO owns the system, charges a monthly fee to the household, and is responsible for the service. Electric utilities, cooperatives, non-governmental organizations, and private companies can operate as ESCOs which buy solar PV systems in bulk, install solar home systems, retain ownership, and bill for services. ESCO models allow for the most affordable payment schemes, and can thus reach a larger customer base than other credit delivery schemes. A local or regional electric utility or a distribution company can serve as an ESCO. The ESCO can obtain economies of scale in procurement and in the delivery of support services, make product standardization and quality assurance easier, and facilitate battery recycling. While the ESCO model is an attractive concept, its long-term viability requires business management skills and technical capabilities that may be limited in rural areas. The ESCO model also carries greater commercial risk due to the longer cost-recovery period. Under ESCO delivery models, financing for ESCOs comes from either government or multilateral sources, but may be channeled through commercial financiers. This model have been practiced in many countries in the world e.g. in Argentina, Benin, Togo, the Dominican Republic and Cape Verde [4]. The overall feedback from the projects that have used the ESCO model is positive. However, difficulty of this model lies with the fact that as the user is not the owner, he would not take good care of the system. Also there would be tendency to operate more than the prescribed duration which at the end would damage the battery.

d. Leasing or Hire-Purchase Arrangements

In this approach, the consumer enters into an agreement with the supplier that the capital cost of the system will be paid in installments over a period. Generally, for such an arrangement, the user pays a down payment, which is determined based on the affordability of the target group. In addition, a service charge is levied by the supplier on the outstanding amount that the user will be paying in installments. In most of the credit schemes the supplier receives seed financing from external parties to establish revolving funds. Usually, local banks or financial institutions are reluctant to provide loans for such investments which they generally perceive as 'non-bankable investment'.

There have been a large numbers of successful programs based on this approach. Sudimara in Indonesia sold about 7,000 systems in 2.5 years over a 4-years credit period [6]. This high uptake was possible because of the credit facility. In Bangladesh, Grameen Shakti (GS), a sister concern of Grameen Bank, has built a good example of credit sales. In 1996, GS started with 50% down payment and six months credit period. The penetration was low and GS noted that the rural people cannot afford this high down payment. Therefore, GS reduced the down payment to 25% and extended the credit period to 2 years. This increased the sales but did not reach to a rate required for acceptable business. In 1999, GS further reduced the down payment to 15% and extended the crediting period to 3 years. This made a breakthrough in sales and as of June 2005, GS sold about 42,000 systems. The recovery rate of credit is close to 90%. GS used the micro financing experience of Grameen Bank

to provide financing and collection of installments for the users of solar home systems. It operates through local branch offices where pre-trained qualified field workers are responsible for marketing, technical support and collection of payments [7].

In Sri Lanka, the SELCO Solar Lanka Limited (SSL) sells solar home systems both in cash and credit. Sarvodaya Economic Enterprise Development Services (SEEDS), a micro-financing agency, provides financing to the customers. An agreement is signed among the SSL, the consumer and SEEDS prior to system installation. The approximate price of a typical 4-light system is USD 400-450. There is a World Bank grant available of USD 100, so customers pay approximately USD 300-350. If they access the financing, they pay 10 % as down-payment, and the remaining amount, plus interest, divided equally between the number of months of their loan period (one, two, three or five years). Commonly, they pay USD 10 -15 a month. Ownership is passed to the customer on payment of the down payment but the system itself is used as collateral. Prior to the WB programme and SEEDS involvement, SSL used own fund for financing. This proved extremely difficult, and affected SSL's cash flow badly since SSL did not have either the infrastructure or the know-how to function as a credit agency. This problem was solved with the involvement of SEEDS [3].

SSL has sister companies in India and Vietnam, both of which have their own unique sales, marketing and consumer financing approaches. SELCO, India closely works with the national financing institutes that are ready to provide loans to the customers of solar home systems. It has been successful in installing 38,000 systems in less than ten years and won 'the Ashden Awards for Sustainable Energy' for its achievements in India [8].

Solar system sale in credit (as well as in cash) is also being practiced in Zimbabwe since 1998 with the support from Japanese government to assess the ability to pay by rural households. Financing is provided by the credit stores located in most of the towns. The user pays 25% down payment and the remaining is paid in 6-24 monthly installments. The special feature of this mechanism is that the public service holders can purchase without a down payment as their payments are paid directly to the store by the government Salary Service Bureau. Ownership is transferred to the customer on completion of payment. It has been noted that about 70% of the systems are sold through credit, and only 30% on a cash basis [3].

e. Fee-for-service

Soluz Honduras, a subsidiary of Soluz, Inc., sells solar home system in Honduras through fee-for-service. Under this scheme, the company maintains the ownership of the PV system. However, the battery is the property of the customer. Soluz provides the rental of the system at an affordable monthly fee, ranging from USD 10 to 20 per month, prices equivalent to that paid for kerosene, dry cell batteries, and the re-charging of car batteries for TV usage. Although, Soluz Honduras sells systems in other modes e.g. cash and credit, fee-for-service offer is now the most common choice by the customers. Soluz Honduras has supplied over 1,600 PV systems with about 1,100 of these on a fee-for-service basis. In some areas, up to 50 % of the population has been reached through fee-for-service [3].

SunLight Power Maroc, S.A. (SPM) in Morocco sells solar home systems with different financing schemes. However, it has noted that 80% of the customers prefer fee-for-service. The ownership of the system in a fee-for-service case remains with the SPM and the user pays a monthly tariff depending on the size of the system but ranges between USD 9 to 24. The user enters into an agreement with SPM about the payment and allows the SPM staffs to maintain and inspection of the system. Before installation, the customer pays two monthly installments, one part is used as warranty, and the other part is an advance payment for the first month's service. For late payments, a penalty is charged calculated on the amount due. The customer can cancel the contract with one month's notice, in such a case; the customer will be charged a removal fee of 25 USD. The warranty payment will be used to cover the service costs of the last month. The SPM officers regularly visit the local market places know as 'souks' to interact with the potential customers as well as to collect the fees from the existing customers. This greatly reduces the operation cost of the program. SPM has sold more than 2,000 solar home systems since its inception in 1998 and most of the systems are working well. To overcome the initial capital investment problem, SPM is using private capital and has applied for money under ONE's (state owned electric utility) electrification programme. Micro-credit organizations are also to be involved in the future [3].

PV based micro utility system in rural Bangladesh is also a kind of fee-for-service model. The approach was pioneered by Center for Mass Education in Science (CMES). These systems are usually installed in market places by PV companies. The interested shops are given connections as per their demand and pay a monthly tariff. The system remains the property of the installing company and the service and maintenance is done by a local technician who is trained prior to the appointment [9]. The technician also collects the tariff from the users. The approach has been widely accepted by the rural people and the number of such installed systems has increased from nine in 2000 to more than 450 in 2005. The users pay a monthly tariff of USD 2.5 per month per light. A security deposit of USD 3 is also taken from each user before connection; CMES reserves the right to forfeit this deposit incase of violation of agreement. CMES involves a management committee comprising of local people from the market who are responsible for preventing any theft or damage of the system [10].

5. DISCUSSION

It is well understood that financing is essential for rural households that would like to acquire a solar home system. A financing mechanism suitable to the target group needs to be designed for a successful program. However, there are various issues associated with different financing mechanisms which need to be taken into consideration prior to implementation of a mechanism. Some important features of different mechanisms are discussed below:

Market penetration: Fee-for-service has the highest market penetration rate as the users do not have to pay a high initial payment. The cash sales model has the lowest penetration rate. Hire purchase model lies in between fee-for-service and cash sales.

Technical performance: It is likely that fee-for-service would suffer from some poor technical performance as the users would not carry out proper maintenance of the systems. Moreover, there would always be a tendency to overuse the system which would damage the battery. Hire purchase models would have less risk of poor performance as the installer would regularly check the system during payment collection. Also the user understands that he would be the owner of the system once the payment is complete. On the other hand, although systems sold in cash are completely the user's asset, there are concerns about the poor performances. This is due to the fact that at the time of purchase users try to save money by selecting an undersized system than the requirement.

Collection of payment: There are substantial risks involved in credit recovery for hire purchase model. Poor performance of the system is on of the major reasons of payment default and the user usually takes the advantage of the issue that the supplier would have difficulty in taking back the systems sold under this scheme. Therefore, the supplier needs to ensure that the system works properly. However, selection of right customer also

reduces the risk of non-payment.

The following lessons can result in better recovery of installments:

- It should be judged whether the buyer has the ability to payback the installments as well he as willing to pay the installments. It is noted that the credit problem could be broken down into two components- the end-user's ability to repay and the willingness to pay. For a successful credit recovery both the issues need to be given priority during customer selection [11]. The ability to pay can be judged by the monthly expenditure on energy.
- When a user pays off all the money, a kind of incentive could be given to encourage him/her payment.
- Adequate awareness program needs to be done to make the user understand the benefits of being owner of the system.
- The field workers who are responsible for collection of installments can be rewarded upon successfully collection of all the installments. This can also boost up the credit recovery.

The non-payment problem for fee-for-service and/or ESCO model is usually low. This is because the supplier owns the system and able to take the system back whenever necessary.

It is generally accepted that the structure of the financing mechanism is location specific and depends on the institutional, legal, socio-economic, and cultural conditions. These include amount of down payment, crediting period, target group selection, maintenance policy, service charge rate and payment collection procedure. However, there are certain issues that are found to be common and should be taken into consideration. They are:

- The implementing company should have a presence in the vicinity of its operation, preferably by setting up branch offices consisting of qualified workers and technicians. This is not only to ensure that the users get quick and proper maintenance of the system but also to ensure timely collection of payments.
- Generally, credit term should not exceed the life of the battery. This ensures that the user would take good care of the battery.
- For credit scheme, the customers should be carefully selected so that they have the ability and willingness to pay the installments.
- For fee-for-service, the battery should be made the users property. The user should replace the battery when needed. This helps to ensure that the user uses the system properly. Otherwise, there would be a tendency to overuse the system and destroy the battery.
- Good quality products are essential. Frequent failure of system due to use of low quality components severely undermines system's performance and creates payment defaults.
- There should be clear maintenance contract. This is to prevent the user desiring free maintenance service throughout the system life.
- Users trainings on system operation and minor troubleshooting are must. This not only avoids frequent maintenance call for the supplier but also increases the user's confidence about the system as they know what they are using.
- Government should cooperate with the solar program implementing agencies in terms of extending or committing extension of grid network in the areas of PV operation. An unplanned electrification in a PV program area could result severe non-payments problems.

6. CONCLUSION

Review of the financing mechanisms practiced worldwide shows that donations/full subsidy and cash sales models are not desirable for a sustainable PV program for rural electrification. While donated systems suffer from early failure due to user's negligence, cash sales model has very low market penetration and can reach only to the higher income group. Fee-for-service is the most preferred choice from the consumer point of view. This is mainly because the users do not have to own the system and there is no need for high initial cost. This features of the model help to disseminate the SHS very quickly. The non-payment problem for this approach is usually low. However, this mechanism involves huge capital investment and can only be implemented with the support from financial agencies.

On the other hand, implementers/suppliers would prefer the hire purchase model due to its relatively low capital investment requirement. Another important factor is that the systems are sold to the users. However, there are risks associated with the credit recovery with this approach. The supplier has to have a strong network with qualified staffs and branch offices in the areas of operation. Incentives for early payment or on full payment and penalty for late payment could substantially reduce non-payment risks.

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