Provision of long-term maintenance support for solar photovoltaic systems. Lessons from a Zimbabwean NGO


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ABSTRACT

Zimbabwe is in its third decade of solar photovoltaic dissemination. A total of 85 000 solar photovoltaic systems have been installed, mostly through private sector dissemination methods. Most of these systems are at homes (solar home systems). The provision of sustained maintenance support has proved to be one of the major problems facing owners of solar photovoltaic systems.

The objective of this paper is to explain the Facilitator approach used by the non–governmental organisations that participated in the Global Environment Facility /United Nations Development Programme /Government of Zimbabwe Photovoltaic Solar Project GEF Solar Project, which ran from 1993 to early 1999. The Facilitator approach has not yet been highlighted in accounts of the solar projects carried out in Zimbabwe. The perspective presented is that of one of the participating non–governmental organisations, the Biomass Users Network.

This paper first provides an overview of the major PV dissemination projects in Zimbabwe, highlighting their maintenance aspects. The other project to specifically tackled the issue of long–term maintenance of PV systems is the Japan International Cooperation Agency Study, which used the Energy Service Company approach. The two maintenance approaches are compared, and lessons for future dissemination of PV systems are highlighted.
Background and introduction

There are about 85,000 solar home systems in Zimbabwe (Energy Sector Management Assistance Program (ESMAP) 2000(5)). Over 70,000 of these systems were installed by private companies and through gradual build-up of system components by households. It is clear that the majority of solar home systems were installed outside any projects. The projects that have disseminated solar photovoltaic systems are summarised below. No projects have promoted amorphous silicon modules.

**GEF Solar Project**

The best-known solar PV project undertaken in Zimbabwe to date is the Global Environment Facility (GEF)/United Nations Development Programme (UNDP)/Government of Zimbabwe Photovoltaic Solar Project¹, which was implemented between 1993 and early 1999. The number of systems installed by the GEF Solar Project may vary depending on how the systems are counted. The GEF Solar Project was using the 45Wp equivalent system as the unit for counting installed systems. On this basis the number of equivalent systems was put at 12,000. (GEF Project Management Unit (PMU), 1998(6))

The range of solar module sizes available in the project was 25Wp to 83Wp, with most being in the range 40–60Wp (GEF PMU, 1998(6)). The three delivery modes used by the GEF Solar Project were:

- through the national electricity utility, the Zimbabwe Electricity Supply Authority (ZESA), which was allocated 500 equivalent systems;
- non-governmental organisations (NGOs), allocated a quota of 600 equivalent systems;
- private companies registered with the project, whose allocation was not fixed, but had to be at least 7,900 equivalent systems in order to meet the project installation objective.

None of the above delivery modes was confined to a specific geographical area, because there was no deliberate attempt at clustering of installations in the GEF Solar Project. The projects fund was handled by Agribank (then called the Agricultural Finance Corporation), a state-owned bank that usually provides loans to farmers.

By 1998, the number of private companies active in the solar photovoltaic industry was estimated at 73 (ESMAP 2000(5)), an increase of almost 50% over the 1977 figure. When the project formally ended in February 1999, most of the companies that had been formed collapsed (SEIAZ, 2001(12)) leaving many of their clients without maintenance backup. The major reason for the collapse of the solar companies was that their revenues were principally from the installation of systems (Ndlovu, 1998(10)), and in a few cases, fabrication of balance of system components.

Besides an obligation to provide warranty service for one year on their installations, and to visit each installation at least three times in the first two years following installation, solar companies were not obliged under the project to provide further

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¹ The GEF/UNDP/Government of Zimbabwe Photovoltaic Solar Project will be referred to as the GEF Solar Project in this paper.
maintenance services. Installing companies were paid fully by Agribank upon satisfactory completion of each installation. This provided a strong incentive for companies to install as many systems as possible to maximise earnings. Since clients owed nothing to the companies after installation, there was no incentive for customer care by the companies after sales were concluded (Afrane-Okese and Mapako 2003[4]).

NGOs ran separate loan schemes with their own eligibility criteria. They also used local ‘Facilitators’ in the areas where they installed solar home systems. Facilitators are trained locals who disseminated marketing information and provided maintenance for systems in their areas. The facilitators played an important role in providing maintenance to clients after the end of the project, and were able to extend their services to other solar home systems not linked to the GEF Solar project.

The Department of Energy (DoE) is considering a successor project to the GEF Solar Project, to be financed with the Z$50 million balance still in the revolving fund run by the Agribank (DoE 2002[4]). The successor project will focus on rehabilitation of faulty GEF Solar Project systems; details are still under discussion.

**JICA Study**
The Japan International Cooperation Agency (JICA) *Study on the promotion of photovoltaic rural electrification in the Republic of Zimbabwe*2 is a bilateral project between the governments of Japan and Zimbabwe, housed in the Department of Energy (DoE) in Zimbabwe (JICA. 1999[7]). The project began with a study phase that was intended to test the proposed approach, based on the *Energy Service Company* (ESCO) concept as an input into the Electrification Masterplan for Zimbabwe. In this concept, an energy service company installs and maintains the solar home systems for a service fee paid regularly by the client. Unlike the GEF Solar Project, maintenance is one of the key components of the project, and the end user is able to effectively demand service backup from the ESCO by being able to withhold service fee payments.

Following consultation with stakeholders, two clusters of 50 households each were selected at Sanyati and Turf, in Kadoma District, Mashonaland West province for the study. Turf and Sanyati are about 160km apart by road. Three local companies, Munyati Solar, Enercare, and Jotpav were hired by the JICA project team to install the systems. A total of 101 x 25Wp solar home systems were eventually installed, 51 in Turf and 50 in Sanyati. The project was subsequently forced by popular demand to offer an expansion option of 56Wp with three lights. By December 1998, 34 of the 101 x 25Wp systems had been expanded to 56watt modules. A year later, half of all the clients had opted for expanded systems (BUN, 2003[2]).

Ten rural clinics and two rural schools were also electrified with solar PV systems. Two clinics and one school are in Mhondoro–Ngezi district, three clinics and one school are around Sanyati in Kadoma district, and five clinics are in Gokwe South district.

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2 Referred to as the JICA Study Project in this paper. This project implemented the energy service company (ESCO) approach.
Following the installation of the systems, a local NGO, the Biomass Users Network (BUN) was contracted to act as the energy service company (ESCO) and maintain the solar home systems. This maintenance arrangement excluded the installations at schools and clinics, and any solar home systems not installed by the project.

The ESCO support to clients is expected to continue until around the middle of 2003. At that point, DoE will need to decide in consultation with clients on how to proceed. Some of the options available are to allow clients to take over their systems on payment of an agreed terminal lump sum to the ESCO, to continue with a modified maintenance arrangement still to be worked out, or to continue with the present arrangements, assuming all parties are still interested. Obviously the last option is only viable if most clients still wish to have an ESCO scheme.

**Chinese Donated Systems**

The Chinese government donated solar equipment to the Zimbabwe government in 1998. Kawanzaruwa village at Nzvimbo rural service centre in Mazowe district was selected to receive the solar equipment. Nzvimbo rural service centre is situated some 100 km northwest of Harare. Kawanzaruwa village is about 4 km from Nzvimbo rural service centre. It is a planned resettlement village. The total number of households in the village is about 200.

The budget for the project is not known, and DoE is still incurring some support costs in its efforts to address the maintenance needs of the beneficiaries. No criteria could be found for the selection of the target site for the donated equipment, nor for which specific households deserved the free solar home systems and televisions.

The Zimbabwe Electricity Supply Authority (ZESA) undertook the installation work with local technicians and Chinese experts. The equipment installed at each of the 110 selected household in 1998 included a 70Wp module and four lights.

**Community facility**

A communal water pump was also installed, and consisted of 21 x 51Wp polycrystalline solar modules, one submersible pump and one corrugated galvanised iron storage tank fitted with a tap and overflow. The pumped water was available to the community free of charge via the tap on the tank. The pump site was not fenced.

All the 21 water pump modules were stolen early in 1999. The stolen modules were replaced by the Ministry of Transport and Energy that same year. The water pumping system failed in mid 1999, soon after the stolen modules had been replaced. Repairs have still not been undertaken because the repair cost estimates were higher than DoE was prepared to pay.

No maintenance scheme was put in place for this project, and DoE has been attempting to arrange a fee–for–maintenance agreement with ZESA. This has not yet succeeded because households that received the free solar home systems are unhappy with the issue of fees coming up long after they were given free systems, with no mention of such a condition at the time. In the meantime DoE has trained five maintenance technicians who have been giving their services free, but have now requested remuneration. Funds for this remuneration are not available. The support
that DoE has provided to this project is unlikely to continue for long because there is no budget for the costs incurred.

Methodology
The data used in this paper is derived from the projects reports of the various solar PV dissemination projects that have been disseminated in Zimbabwe as well as recent surveys undertaken by the Biomass Users Network, the Japan International Cooperation Agency and the Department of Energy and by the author. The research focuses on the Facilitator approach that NGOs participating in the GEF Solar project used as a marketing and support strategy, and compares this to the similar ESCO approach used in the JICA study project. The issues that are compared are the ideal installation patterns, training, support for the field technicians, payment for services and replacement components, and financial viability. The steps taken by BUN to control repair costs are explained next. The paper ends with concluding lessons, focusing on the key features of the facilitator approach that may be useful for future projects.

The Energy Service Company and the Facilitator approaches
Figure 1 shows the relationships between the NGO and the community within which solar home systems are clustered. In most cases the relationships are similar in the ESCO and Facilitator approaches.

![Figure 1. Relationships between NGO or installing company, and the community where solar home system clusters are installed.](image)

**Ideal installation patterns**
The ESCO and Facilitator approaches are best applied in clustered village installations, in areas where there are significant income–generating activities. Income–generating activities are important to ensure that the clients are able to meet the financial obligations that are placed on them for the payment of regular maintenance fees, or battery replacement fund in the case of the Facilitator approach.
Clustering of installations is critical to the feasibility of both maintenance schemes, since the maximum number of solar home systems that a technician can effectively service partly depends on the distances that the technician has to cover to visit all the systems. Figure 2 shows the extent of clustering of solar home systems installed by BUN in the NGO delivery mode of the GEF Solar Project. Only the largest clusters in Mutoko and Chimanimani were provided with facilitators. In an ESCO scheme, a tightly clustered scheme is ideal because a technician can service more clients, and is supported by a larger number of service fee payments that improve the financial viability of the ESCO. ESCO technicians are not allowed to service non–ESCO systems. One major reason for this attitude on the part of the ESCO is avoidance of liability for non–ESCO systems, whose configuration and use are outside its control.

In the Facilitator approach, tight clustering of installations also means more business, with easily accessible clients, leading to shorter response times and lower charges due to reduced transport costs. The facilitator would also be occupied for more days each month.

![Figure 2. Percentage of solar home systems in clusters among BUN–installed systems](image)

The Facilitator approach easily allows the technician to cover any solar home systems and institutional installations in the village and within reasonable distance from the village. There is no reason why the Facilitator cannot offer support to accessible solar PV–electrified public facilities such as schools and clinics.

**Training**

For both approaches it is useful to introduce a suitable, standardised course at local tertiary training facilities so that technicians intending to take up this business can enrol and be trained and certified. It is important that trained technicians are certified, and known by the community, to avoid dishonest persons masquerading as technicians. The presence of a local trained technician improves the education of users through frequent contact with the technician. The Facilitator approach encourages greater user self–reliance, whereas the ESCO approach attempts to limit user access to components in order to minimise tampering and misuse. This is understandable since the ESCO has to minimise its exposure to avoidable faults that would drive up costs.
The holding of occasional user group meetings provides a venue for exchange of experiences, and for common problems to be aired and addressed. This is more common for the ESCO approach because project funds can facilitate such gatherings. A private company would find it difficult to convene such meetings, more so if the company is based far from the area. The facilitator can however take advantage of local meetings such as those organised by village health workers or agricultural extension workers to meet the community. The representation of solar home system owners at these meetings may not always be high however.

**Administration and backup support for technicians**
The ESCO approach provides the solar home system owners with a hired technician under a contract to service the needs of the systems installed under the ESCO scheme. The acquisition of spares, and sending/receiving of components needing repairs is facilitated by the ESCO through the technician. The technician is not faced with any competition in his/her duties. The ESCO relies on feedback from clients and random checks to monitor the performance of the technician.

The Facilitator approach provides the solar home system owners with a trained facilitator who earns his living from the charges made to clients for work done on their systems. In this case, competition is possible and desirable to allow clients to have a choice of technician, a situation that forces technicians to respond quickly, provide quality service, and charge competitive rates. The overheads to the installing company are lower in the Facilitator approach where the facilitator is freelance, with limited backup from the company. The company benefits from more reliable performance of the solar home systems, which is likely to result in increased purchases. A situation where many installed solar home systems are in disrepair is likely to inhibit potential clients from considering solar home systems.

**Payment for services and replacement components**
The ESCO clients pay a fixed regular fee in exchange for regular visits from the technician, and for replacement of the battery, charge regulator and module. The fees are set by the ESCO on the basis of the cost of these components and their expected service lives and anticipated fault rates. The major regular replacement cost is for the battery. If other components used have not been tested in the field before, higher fault rates could be experienced. Both the JICA Study Project and the Chinese donation projects in Zimbabwe had to replace batteries and charge controllers after initial installation due to technical shortcomings before the projects could proceed as planned.

Fees are collected by the technician for a commission, or banked direct by clients who have easy access to commercial banks. The collection of fees by technicians carries a risk of misappropriation of funds should the technician face unexpected hardship such as a funeral while holding cash. This has been experienced in the BUN ESCO project in Zimbabwe.

In the Facilitator approach the client does not need to pay regular fees; payment is only made when the facilitator has been summoned to attend to the systems. The charge depends on the nature of the service provided. To avoid overcharging, BUN in Zimbabwe negotiated a schedule of rates to be charged to clients in exchange for the support given to the facilitator. The Facilitator approach does not provide for the
replacement of any components except by the client. The facilitator can assist in the correct choice of components, and locating sources of components through the installing company or NGO. The need to replace batteries after three to four years means the clients need to save for this eventuality. There is so far no organised way in which clients have been assisted to save a battery fund, which must between US$50 and US$100 when battery replacement becomes due. It may be instructive to study how clients have coped with this problem elsewhere.

Financial viability
The ESCO approach has not yet been shown to be able to cover operational costs with the fees paid by clients anywhere (Niewenhout et al, 1999(11)). The JICA Study Project in Zimbabwe did not simulate a commercial operation since the equipment was provided and installed prior to the ESCO being contracted. The deteriorating economic climate, and the sharp fall in the value of the Zimbabwe dollar against the major foreign currencies has also compounded the problem since clients have no hope of paying service fees in step with the foreign currency equivalent of the initial monthly US$6.50 in 1997. This was then equivalent to Z$75, but would be nearer Z$9,500 at parallel market exchange rates in 2003. The parallel rate is quoted here because foreign currency is critically short and consequently not available through official channels.

The frequent droughts that form a normal part of the climate of Southern Africa disrupt the service fee payments of farmers. This can be dangerous for the ESCO because serious cash flow problems can arise when many clients are unable to pay fees. The most likely solution to this problem is for the ESCO to have other sources of income besides the service fee payments. It is normal for most businesses to diversify as a way to cope with a downturn in demand in any one of the sectors in which they operate, and ESCOs need to adopt the same strategy. Indeed, the companies that survived the end of the GEF Solar Project are those that had diversified business interests. The erratic service fee payment problem does not apply to the Facilitator approach.

Replacement of batteries and lights
The issue of replacement of batteries and lights is brought up because these are often imported components, and their availability may not be assured when time comes to replace them. Being a project, the ESCO may import proven, reliable components, particularly the modules, batteries and controllers. The batteries currently in use are deep cycle, with the charge controllers set up for this type of battery. In the Facilitator approach, clients purchasing their systems privately will procure what is available on the local market, which generally means automotive batteries. In these cases the charge controller is often omitted because of availability and cost constraints. The GEF Solar project initially allowed automotive batteries to be used.

When batteries come to the end of their lives after perhaps four years of use, the replacement is fraught with potential difficulties in the case of the deep cycle batteries, which are not available locally. The most feasible option is to replace these with automotive batteries. The danger here is that charge controllers, originally set for deep cycle sealed batteries, are unlikely to be reset to the new type of battery (shallow discharge, but requiring a higher float voltage when charging) to match the charge/discharge characteristics of the different new batteries. If this is not done, the
batteries will not be charged correctly, and will be deep discharged, reducing their service life. This problem affects the ESCO project more than the Facilitator systems because the latter project includes more automotive batteries.

The situation pertaining to lights and replacement tubes is similar. In Zimbabwe solar lights are fabricated locally using imported electronic components and fluorescent tubes. The repair and replacement of the lights requires continued availability of the imported components. The present shortage of foreign exchange has led to shortages, and high prices of tubes, lights and electronic components. A trend that has been observed is the introduction of 12-volt halogen and automotive bulbs to replace the more efficient solar lights.

**Measures taken to control the quality and cost of repairs.**

The unpredictability of repair costs is one of the more difficult problems facing clients whose lights have failed and are to be taken away by the facilitator or technician for repairs. Virtually all lights in use on solar home systems in Zimbabwe are locally manufactured. There are therefore many local electronic technicians who are familiar with these lights and have many years of experience with them. In 2000 BUN invited several light repair technicians to submit standard repair quotes on the basis of their experience of what components fail most often on the lights they have repaired. Following this, competitive estimates from reputable technicians were used as the basis for negotiating repair charges. The result was that repair bills were generally within a known range, and clients could be given fairly accurate indications of likely charges at the time their lights were collected by the facilitator for repairs. The charges have been revised through consultation between BUN and the repair technicians.

BUN also designed forms which the independent repair technicians filled in for every light they repaired, indicating what fault was diagnosed, and which component(s) were replaced. Although this does not completely eliminate unscrupulous behaviour by the repair technicians, it allows some checking of reported symptoms against the diagnosis. Transport costs are further reduced through an arrangement whereby the repair technician telephones the BUN office to check if any lights have been brought in for repair before coming to collect. Once repairs are completed, the technician delivers the lights to BUN, along with a form for each light. Because the lights are numbered, it is possible to check whether a particular light has been brought back soon after repair, an issue to be taken up with the responsible technician. The repair technician is paid after BUN verifies that the repaired lights are working normally after several hours of use. Payment is generally possible by the next working day following delivery of the repaired lights.

**Conclusion and recommendations**

The Facilitator approach shows a possible way forward for solar home systems disseminated along commercial lines. While the ESCO approach provides tighter contractual relationships between the ESCO, the technician and the community, it has not yet shown financial viability.

By allowing for full system ownership and providing for effective and potentially sustainable maintenance support, the Facilitator approach is a promising way to tackle the difficult problem of long term maintenance of solar home systems, and could be
considered in new, non ESCO solar home system projects. Once a facilitator is deployed, pre–existing solar home systems in the same area would have access to maintenance on the same conditions as systems installed after a facilitator is trained.

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