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Rural people pay for solar: experiences from the Zambia PV-ESCO project

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Abstract

In the eastern province of Zambia, three companies for solar energy services have been operating for more than two years, with 400 clients paying for the use of solar photovoltaic (PV) installations. Clients do not become owners of the systems. Instead, the company continues to charge a fee for keeping the systems in operation. In this way, the useful lifetime of the solar systems is increased, and clients have local access to skilled service and spare parts. The fees for solar services cover the full operational costs of the companies, including battery replacement and makes them independent of further support from government or donors. Results to date show that clients are happy with their systems, which are of a standard solar home (SHS) size of 50 Wp, with four lights and a socket for radio or other light DC appliance. This is in spite of paying a higher price than what was previously spent on candles and kerosene for lighting. The most important benefit cited among the clients is that children now have the possibility to do their homework in the evening. The second most highly valued feature is entertainment, such as radio and video. Solar systems contribute to increased income earning opportunities especially in the service sector. The poorest rural people cannot afford to pay for a solar system in their house, but benefit from systems in the shops.

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1. Introduction

The Zambia photovoltaic-energy service company (PV-ESCO) project was initiated by the Ministry of Energy Lusaka in 1996, developed in cooperation with a team of researchers from the Stockholm Environment Institute, and funded by Sida from 1998.

The objective was to investigate novel approaches to supply rural people with solar PV electricity in an affordable and sustainable way, while using a minimum of subsidies.

The project is now in its sixth year, and has yielded important experiences on how to provide electricity from solar photovoltaics in a fee-for-service delivery mode. The pilot phase is ending this year, and plans are afoot to expand the approach into a national programme for electrification in rural areas without prospect for grid connection in the near future.

Numerous projects aimed to provide solar power in Africa have been implemented over the last decade. Early projects were more of technology demonstrations, aiming to show that the technology could work in the African environment and with little concern for cost or replication. In recent years, more effort has been made to provide sustainable structures for continued supply of solar power, and support to market formation. This has been in the form of incentives for solar (reduced tax and duties), subsidies to consumers, concession monopolies, etc.

In several of the projects supported by large multilateral donors, it appears that the large sums involved coupled to the demand for quick disbursement and swift dissemination of systems has been contra-productive, even in spite of attempts to foster markets. In Zimbabwe, for example, a large number of systems were installed as part of a GEF project, with an explicit aim to help develop a solar market. After project funding ended, most of the companies formed did not survive [1].

In an attempt to summarize the lessons learnt and the need for further experiences, a GEF group concluded that substantial implementation experience is still needed before the success of the service approach can be judged [2,3]. Projects must explicitly recognize and account for the high transactions costs associated with marketing, service and payment collection in rural areas. Institutional arrangements for project implementation can greatly influence the project sustainability. For example, in Ghana, the electricity utility was to act as a fee-for-service provider, a most natural role for a utility, but subsequently the Ministry of Mines and Energy moved in with a parallel organization. This, among other things, caused the project to stagnate and not much headway was made [4].

Rural electrification policies and planning have a major influence on project outcome and sustainability, and must be explicitly addressed in project design and implementation.

Establishing reasonable equipment standards and certification procedures for solar home system components that ensure quality service while maintaining affordability is not difficult, and few technical problems have been encountered with systems.

In South Africa, large concessions have been given to companies or consortiums, with a numeric target for installations. While concessions clearly infringe on the market, this has been deemed acceptable in view of the very large subsidies offered by the South African government. A drawback of this is obviously that the customer is the government rather than the people provided with power in rural areas. Another drawback is that the concession forces people into a "solar trap", excluding them from grid connection for a long time to come, and this has resulted in popular protests.

Further, the modalities to get the concessions to work have apparently been very complicated, and have caused long delays in implementation. Experiences to date are mixed, with the Shell-Eskom consortium experiencing serious problems in terms of profitability and also in theft of systems [5]. The Noun-RAPS concession is still optimistic and calculate that they will reach break-even at 15,000 systems installed. The Noun-RAPS group have developed an advanced computerized management system for accounts, supply and service, which they hope will help secure operations for a long time to come [6].

2. Fee-for-service delivery of solar electricity

2.1. Energy service companies

The ESCO concept is to allow clients to pay for the use of solar electricity, rather than to sell the equipment to the end users. This delivery model is nowadays commonly referred to as "fee-for-service" or "utility model". The approach allows clients to enjoy the benefits of electricity without actually owning the system, rather than forcing them to become experts on solar PV technicalities. The concept was explored by Herbert Wade in Kiribati, and showed that sustainability of solar systems increased dramatically when they were serviced by trained personnel. He found that marketing of solar PV equipment was largely mis-directed, as people were not interested in PV technology as such, but rather in what they could do with the power [7].

Three companies were selected in three towns of eastern Zambia: Nyimba, Chipata and Lundazi. One is a farmer's cooperative, one is a company dealing in farm products and implements, and one was devoted to waste management. It was emphasized that the companies supported should be based in the rural region targeted, since one of the main problems for rural clients is the dearth of access to service and maintenance locally. Without this explicit conditions, urban-based companies tend to pluck the grapes as long as there is fresh subsidy to be harvested, then to disappear after the project. Such tendencies have been noted both in Zimbabwe [1,8] and other places [9].

The companies were provided with solar home systems of a standard design (50 Wp panel, four light fixtures), purchased through a competitive international tender, which included the initial installation at the premises of the companies' clients. The first company acquired 100 systems, and the two following 150 each. The first

PV systems were installed in late 1999, and all systems were in operation by late 2001.

At the present time, the ESCOs have all been in full operation for more than one year, the first for three years, and some experiences are starting to emerge.

3. Lessons learned

3.1. People are willing to pay

At the beginning it was unclear whether and how much people would be willing to pay for solar energy services. A survey was carried out early on in the project, in order to determine the cost for present energy sources [10]. This informed about the prospective client's ability to pay, and guided the determination of the service fee. Based on this assessment, and on the estimated operation costs as per the business plan for the first ESCO, the service fee in late 1999 was determined at ZMK 20,000 (US $ 7). Due to the high inflation in the country, the service fee has since had to be adjusted, and is currently ZMK 35,000 (still US $ 7). Increasing the fee is a rather painful process for the ESCO, since clients complain of increased costs. However, so far none has opted out. A comparison with the actual inflation rate in the country shows that the service fee has barely kept on par with inflation (Fig. 1).

A survey of consumer satisfaction after some years of operation of the ESCOs showed that people are actually paying more for solar electricity than they were previously paying for kerosene, candles and batteries [11]. This is in spite of the fact that they do not get more hours of light, however, the light is of a higher quality. This willingness to pay has also been observed by others [12]. At the present level of the service fee, each ESCO has a waitlist of several hundred prospective clients.

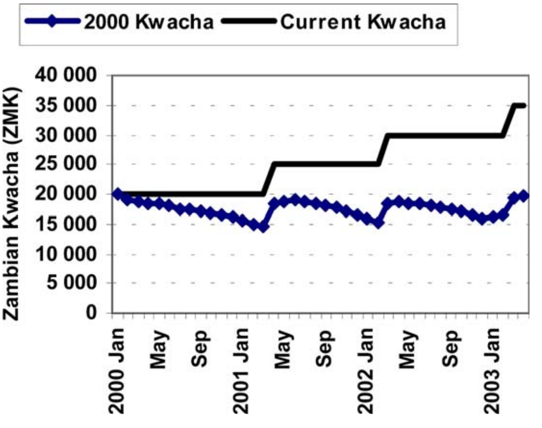

Fig. 1. Inflation effects: service fee development at one of the ESCOs 2000–2003.

Several assessments have shown that rural clients will have to pay the equivalent to US $ 3–12 per month in fee-for-service schemes, in order to cover the operation costs of the companies [13,14]. At the lower end there would be no capital payment, but even at the higher end the subsidy would be in the order of 50% of the capital.

The payment morale among clients is reasonably high, and although there can be delays in monthly payments, all the clients eventually pay. One ESCO has taken a proactive approach to long-term defaulters or system mis-users, and for those not paying after several months, the system is removed and placed with another client.

The ESCO clients in Zambia are relatively more wealthy than the average, and there is a greater proportion of formally employed people than in the general population. The poorest people cannot afford an installation.

3.2. People enjoy light and entertainment

The quality of light was quoted by the clients as one of the major advantages with solar power, especially that it provided children with the opportunity to study after dark. The second most important aspect quoted by clients is the opportunity to play music and watch video (there is no television coverage in the area). In this way they feel more connected to the modern world, which is greatly appreciated [11]. While PV was not frequently used for productive purposes in the households, it definitely served to boost business in shops, bars, restaurants and motels in the otherwise dark rural surroundings.

3.3. Risk of theft is not large

In some of the larger PV programmes, for instance, the GEF programme in Zimbabwe, theft and vandalization have become a serious problem [1]. In South Africa theft has also taken a serious toll [13] and ingenious technical designs have been applied to prevent it, however, with little success. Around 10% of the 6000 systems installed by the Shell-Eskom concession in South Africa so far have been stolen [5].

In the Zambia PV-ESCO project so far, there have been three thefts of panels, one of which was subsequently retrieved. This translates into an aggregated risk of theft of 0.2–0.3% or one theft in 500 panel years.

This is largely attributed to the fact that all the systems are installed in the premises of the clients, and that there is a close social control over them. Clients are also required to sign an agreement where they take responsibility for the equipment, and might be liable to very severe costs if a system is lost. From the experience we feel that it is unjustified to believe that fee-for-service programmes would be more liable to theft than cash-purchase programmes, as stipulated by IEA [15], although it is early to draw definite conclusions.

It is also an illustration that the arbitrary insurance rates of 3% p.a. that were offered for insuring the systems were clearly showing ignorance and lack of interest from the local insurance market to contribute to PV development in Zambia.

3.4. Battery lifetime and servicing

In the early stages of operation there was substantial ignorance from the side of the technicians in how to best ascertain continued operation of the batteries. During this time several of the batteries took a heavy beating, and had to be replaced already before one year of operation had passed. This was largely because the systems were over-used, and although the users in time learnt that they could not press the batteries beyond certain limits, some of the batteries were not fully recharged ever, and went out of commission.

The service fee was calculated on the basis of a battery lifetime of three years. Evidence is now gathering that the batteries may last longer than this on average, once a good maintenance record has been set (Fig. 2).

However, in one of the ESCOs half of the batteries have decayed in less than one year. The supplier (Siemens Zambia) blames the users and ESCO technicians for poor maintenance, in spite of not having provided specifications for the batteries. Suspicions are that the batteries were below the requested specifications.

3.5. Drawbacks of the procurement process

Although sometimes believed to be more efficient, and resulting in lower supply costs, the competitive tender process applied for the pilot project had some definite drawbacks.

Primarily, the extended time used for the procedure had negative effects. As ESCOs were formed they were asked to obtain quotations of interest from prospective clients, which they did quite quickly. However, when delivery was delayed, the clients started to lose faith in the process, and some even withdrew their applications. The ESCOs also suffered from this delay, because technicians employed (and trained) for PV servicing opted to find other employment after a few months wait.

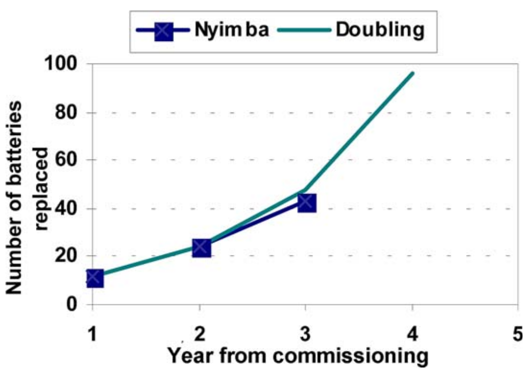

Fig. 2. Battery decay at Nyimba Energy Service Company and a doubling of battery decay starting at 12 the first year.

Another aspect of the competitive process was that a direct relationship between suppliers and ESCOs was not formed. This may turn out to be a serious drawback in a development scenario, when ESCOs will start to purchase systems and appliances on their own. The competition necessary for a true market formation has not been favoured. The suppliers delivered their equipment and used their personnel or hired contractors (other than ESCOs) to make the installations. Although ESCO technicians were allowed to observe the installations, contractors sometimes treated these rudely, and refused to take advice, in spite of being less well trained in solar installations than the ESCO technicians.

Furthermore, some of the conditions linked to the tender process made it impossible for some local suppliers to participate. This was mainly due to the very large guarantees required, and the extended credit periods necessary. As discussed elsewhere, a local company without international support is left to the local financial market for supply of credit instruments, a market that is severely deficient, and demanding very high premiums for its services. The result was that only companies with a substantial financial muscle, or in close connection to international companies were able to bid for the contracts offered.

It may be that the market formation would have been better served by small and dedicated companies growing and benefiting, than from large companies without interest or experience in the industry prospering from this niche as well.

In spite of international competitive bidding, solar home prices were about twice as high as those obtained for larger orders elsewhere in Africa. In the first tender (1999), equipment cost US $ 917, in the second (2001, Siemens prepayment system) US $ 1188, and in the third (2001), technically identical with the first, US $ 899. Hence, price reduction for two years was US $ 18 per 50 Wp standard solar home (SHS), including battery, four lamps and installation material.

3.6. Poor performance by international suppliers

A specific problem of the tender process was in the limited possibility to ascertain quality of the products actually offered. A case in point was for the second ESCO to be formed, where it was decided that a prepayment model was to be tested. The winner of that contract, Siemens Zambia Ltd, a subsidiary to Siemens AG (now Shell-Siemens), offered what was claimed to be a proven model for prepayment system. Once delivered, it turned out that this was the first occasion where the prepayment device was being actually field tested. In real practice, it turned out to work so poorly that more than half of the systems could not be recharged, but had to be disconnected and put on a post-payment mode. The service organization had been built on prepayment conditions, and suffered heavily from this.

Added to this, the poor batteries supplied have caused this ESCO to contemplate going out of business. This is an illustration that large international companies are not always fit to best provide for the needs of small customers.

3.7. Quality control

In the pilot project, great emphasis was placed on quality control, mainly in order to reduce the risk that substandard technical design would cause the project to fail. This resulted in a very high standard on all levels, which probably to some extent caused the systems to be more costly than could have been the case with slightly simpler solutions. The quality of installations was inspected by the energy regulator in Zambia, the Energy Regulation Board (ERB). Staff of the ERB participated in some of the training activities in order to gain knowledge on solar PV, which was previously lacking. Subsequently, all installations have been inspected by the ERB. In general, the installations were of good quality from the beginning. Complaints in some cases were for poor placing of panels (shadowing) and sloppy workmanship in fixing panels and making holes in walls. These were subsequently rectified, reinspected and approved. The role of ERB in this respect has certainly contributed to improved standards among the contractors, although not yet so much among the ESCOs, who took little part in the initial installations. In a growing PV market, it is difficult to see that ERB could be able to inspect each individual installation, and quality control will have to be designed in a different way.

It could be noted that in spite of high specifications for battery performance, none of the finally selected suppliers provided batteries according to specification, and some did not provide any specifications at all with the batteries finally delivered.

3.8. No financial market

In the initial project design, the idea was to provide rural entrepreneurs with training and a credit to purchase solar systems. After assessing the situation in the financial market, this idea had to be abandoned. This was for three reasons:

1. The current lending policy of banks in Zambia is one of prohibitive rates. Typical interest rates are 50–60% p.a. At an inflation rate of 20%, it is obvious that very few investments would yield a profit to offset this, maybe with the exception of buying government bonds.
2. Most banks do not have a service network in rural areas, let alone one with personnel skilled and allowed to make credit judgements. As the project started there were three banks present in eastern province, but today there is only one. One went bankrupt (Lima Bank) and the other (Barclay's) decided to reduce its rural network. Only the parastatal Zambia National Commercial Bank (ZANACO) remains, but is under threat of liquidation.
3. There was no interest from the financial institutions to take any part in the risk of the undertaking, not even to learn about the project and its prospects. The only service they could offer was to manage funds on the behalf of a lender, and to act on clear and definite instructions.

One part of the issue is that banks appreciate the risks and transaction costs in rural areas to be very high. This is obviously true when there is no local presence, and no way to actually manage the loans offered. This has also been observed by other students of the area [16,17].

3.9. Critical size of an energy service company

One of the crucial aspects of ESCO establishment is that the company must be able to make a sufficient profit as a part of its operation. With information starting to emerge on the actual operating costs of an ESCO, it appears that the minimum size needed for profitable operation, including paying for the initial capital is when the company has 150–200 clients on a fee-for-service programme.

The initial capital required for an ESCO with 150 clients is around US $ 150,000 at current PV prices in Zambia. This is a *huge amount of money* for a small rural company.

Experiences show that the company must plan carefully for each step in its establishment. Company administration must be kept at a minimum—there is no point in paying high salaries for executives before there is any turnover, or employing more technicians than actually needed.

It is also important to consider the geographical area of coverage. This has to be aligned with the means of transportation available. If the company does not have a motorized vehicle, or possibility to rent one, the area should be no larger than what is possible to reach on foot or bicycle. Extending beyond that will mean a hike in the costs, usually with limited increase in income, because peripheral clients are by nature scarce. If there is need to expand the transportation infrastructure, it is wise to go gradually, maybe first investing in a motorbike rather than a truck or lorry.

4. Ways forward

4.1. Ownership and capital pay-back

The Zambia experience is still a pilot project, with many of the conditions of the real world missing. As such, all the hardware was a donation, with no demand for payment, and, consequently no ownership of equipment by the ESCOs. These have, so far, only been performing in a lent costume. The present situation is that the Government of the Republic of Zambia (GRZ) is the owner of the equipment, and with the Department of Energy exercising the obligations of the owner. This is not a satisfactory long-term solution for the equipment in the project, let alone for the development and growth of PV use in rural areas. ESCO representatives have also stated that there is need for them to own the equipment as soon as possible. From the business perspective, it is not feasible to insist on increases in the service fee to cover inflation, when people know that the equipment is the property of the government.

After long discussions in the project team, the current idea about the way forward is that the ESCOs should be made to pay for the PV systems in their custody. The repayment period shall be 20 years, and the repayment will be based on the initial purchase price, with inflation added and a small premium for administration of this mechanism. The ESCOs of the pilot project will additionally be given a grace time of two years, translating into a 10% subsidy on the capital cost immediately. In this mechanism, the ESCOs will become the owners of the systems once they sign the agreement for repayment, but they will immediately have to pledge the PV systems as collateral for paying. This is done through a system of "ownership certificates" which are issued for each individual SHS.

The long repayment period is in order to keep the payment level down. The reason that this could be acceptable is that the mechanism is actually an example of rural infrastructure building, although the infrastructure becomes private and operated by a local entrepreneur. The argument goes to the situation where middle and upper class urban dwellers are subsidised with the national grid, which has been erected on even more favourable terms (e.g. 40 years repayment, and complete write-off after half the term if payment morale has been good). The lenient interest rate (1% above inflation) is argued in similar terms. However, there is some emphasis that the capital should actually be repaid, and not given away by inflation. This is also a learning experience for the ESCOs, who will have to increase their fees on par with inflation, in order to avoid its complete erosion (see Fig. 1). The reason to select the national inflation rate, rather than, for instance, the exchange rate to US $ or EUR is that the national inflation rate to a greater extent reflects the effects of national conditions. Although, admittedly, rural people have little influence on the national conditions, they have no influence whatsoever on the exchange rate changes to foreign currencies.

At the proposed conditions for capital pay-back and transfer of ownership to the companies, the subsidy level is actually rather small (10% in the form of a two year grace period). In our view, it could easily be argued that the levels should be higher, especially since urban grid connected customers are heavily subsidized. But with scarce resources, Zambia cannot afford to offer any sizable subsidies at the present time.

4.2. Towards a national programme for solar PV

In order for solar PV to be able to contribute to improving the living conditions in rural areas of Zambia on a wider scale, obviously much more than a pilot project is needed. From the experience of the pilot project, it is clear that there is need for an infrastructure that can take on various tasks associated with PV development in rural areas. This is a rather common observation in many projects where pilot implementation appears to be on the threshold to larger developments [18].

The lack of a functional and dedicated financial market is one of the major constraint, as noted above. There is also a lack of a long-term stable proprietor in the sector. There are several tasks that a proprietor for solar development needs to take on in a scheme dedicated to fee-for-service delivery of solar electricity:

- Administrate capital provided by government and donors.
- Serve as a link between capital and end users (ESCOs).
- Be the intermediate owner of assets while ESCOs are paying their credits.
- Oversee the operation of ESCOs, and take action when some companies do not perform.
- Select new ESCOs coming on the market.

In the traditional electricity sector, these are all tasks of a national utility, although these are now increasingly under siege from international development institutions. Its role is to own, manage and develop the grid connection in the country. Although the utility could possibly play a role in solar development, in Zambia, as in many other African countries, the electricity utility has shown little interest in solar development. A possible exception is Eskom of South Africa, but the silence on PV development there in recent years throws some doubt about viability of those initiatives.

While some of the tasks could theoretically be taken up by the private sector, the actual situation with the banks precludes this solution. These are also not tasks for a government department, which does not have the mandate, skills and resources for the tasks at hand.

The option to go forward is to create a new institution for the purpose, a solar utility, or Solar Fund. This institution should take on the responsibilities for the development of the sector, while interfacing with other government initiatives. It should be an institution with influence both from government, because government and donor funds will be handled, and from the private (non-government) sector, including rural stakeholders, existing solar energy service suppliers, etc.

With such an institution in place, Zambia could create a programme for rural solar PV electrification that would relatively quickly be able to provide solar energy services in remote areas. An estimated US $ 16 million per year over 10 years would feasibly provide solar services to 20,000 rural households per year, totalling 200,000 households in 10 years.

5. Conclusions

A pilot project in Zambia shows that solar services can be provided by local rural companies at rates that are affordable by rural people. The service companies make a profit if they do not need to pay for the solar systems. A number of lessons have been learned:

- People are willing to pay more for solar energy than what they used to pay for kerosene and dry cells previously.
- Proximity to clients is a key element for success in providing energy services. Service technicians should be able to reach the clients on foot or bicycle. It is also important in order to obtain payment and keep defaulting at a minimum.
- Theft is not a big problem under these circumstances.

- Large international companies are no guarantee for quality performance.
- Inflation erodes incomes, and service fees need to be adjusted at least annually.
- Procurement through international competitive tender reduces possibilities for local market development, and excludes small local companies.
- Providing credit through formal financial institutions in rural areas in a country like Zambia is virtually impossible, due to disinterest, lack of local presence and abominable interest rates by the banks.

In order to expand the diffusion of solar services in rural areas, it is necessary to design an institutional framework which is not there at present. Neither the existing electric utility nor the financial sector or government has the capacity or the interest to go into large scale dissemination of solar services.

The major achievement of the project so far is to show that local companies providing solar energy can sustain their operation through the fees paid by their clients. This ensures the sustainability of the operation even after the project is completed.

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