The impact of solar electric services on lifestyles – experiences from Zambia

M Gustavsson
Researcher, Human Ecology Section, Gothenburg University

Abstract
In 1998 the government of Zambia launched a solar dissemination project, aimed at supporting the creation of three energy service companies. The project was funded by SIDA of Sweden. Today these companies operate 400 solar home systems. They have received loans from the government for the solar systems, which are put in the houses of their clients. A survey was carried out covering all 400 clients. In addition, neighbours of the clients were targeted. Results from the survey show that the integration of a solar home system will have an impact on the user's livelihood. Light will be stronger and become more abundant. But hours of light are not differing between clients and neighbours. It is kept for about 3.4 hours and 3.2 hours respectively. The improved light opens possibilities to read and extend working hours. Children are reported to be the main beneficiaries of solar power. Radio cassette recorders, followed by television sets are the most common appliances found. Appliances are used for 2-3 hours per day. Clients describe that they feel that their lives have become more urban and modern. One third have experienced problems with their system. In the majority of the client households (87%), there are one or more members with a conventional salary. A service fee is paid monthly, and this fee is normally found 'reasonable'. In most cases, clients want to own the systems instead of keeping a service contract. Clients spend about ZMK51 900 (US$11.8) per month on energy services compared to neighbours spending about ZMK33 800 (US$ 7.7). The distribution between expenses on electric services, and for cooking fuel is similar for neighbours and clients, one third on cooking fuel and two thirds on electric services. The results from this case study indicate that solar power has a positive impact but has not been accessible for the low-income groups in the setting.

Keywords: Zambia, solar home systems, solar electric services, energy service companies, appliances, pre-payment

Introduction

During the 1990s solar technology was taken up in rural electrification programmes in many African countries (Mulugetta et al 2000; Abavana 2000; Acker & Kammen 1996; Martinot 2001; Duke eta al 2002; DME 1998; Diarra & Akuffo 2002). The neo-liberal development paradigm had grown strong (Blaikie et al 1997; Barnett 1995), and solar photovoltaic (PV) solutions were well suited to fit within this frame. PV technology could be diffused using innovative diffusion strategies such as energy service companies (ESCOs), which could operate on commercial terms locally (Cabraal et al 1996). In addition, the reduction of hardware costs during the 1970s and '80s had made PV systems 'affordable' to consider in development programmes (cf Green 2000). There are, however, few, if any, countries where diffusion of solar PV technology on a larger scale has started spontaneously.

Diffusion of technology can be divided into two parts, the introduction of the technology and the integration of the technology into the user's livelihood system (Gustavsson 2000), with livelihood here understood as means of securing a living (cf Chambers & Conway 1992). The introduction of the technology concerns how the technology is introduced and made available to the users, including subsidies and structures for dissemination. This is usually well elaborated in the project documents on the implementation process. The second part concerns the technology and how it is integrated into the user's livelihood system. The technology will have an impact on the user's livelihoods in different ways, both in terms of opening up new possibilities also in terms of adding new demands. While the introduction may be planned, the integration of the technology lies beyond the control of the project manager and extension workers. Training and knowledge transfer might help for successful integration, but consideration of methods of knowledge transfer needs to be applied.

The Zambian ESCO Project[1]

In 1998 the government of Zambia launched a solar dissemination programme, aimed at supporting the creation of three ESCOs in the Eastern Province. The programme was a pilot project and experiences would be accumulated that could be considered in the national energy policy on rural electrification (Ellegård & Nordström 2001). The programme was funded by SIDA (Sweden).

At present three ESCOs have been formed, and a total of 400 solar home systems (SHSs) that have been installed. The Nyimba ESCO (NESCO) has 100 systems and has been operating since May 2000, the Lundazi ESCO (LESCO) has 150 SHSs, which were installed between September and December 2001. In the Chipata ESCO (CHESCO), the Zambia PV-ESCO project wanted to test the application of pre-payment systems, and 150 pre-pay equipped systems were installed between August and December 2001 (see Figure 1).

The initial plans were to give the ESCOs credits and they would purchase and make the installations themselves. This was, however, not possible for formal reasons, and the installations and supply of equipment became part of a public procurement process. The transfer of ownership has not yet been made, and the ownership is presently with the Department of Energy (DOE). The three ESCOs are supposed to become owners of the equipment and the credits taken will, once the transfer of ownership has been settled, be repaid.

The system specifications are similar for all three sites. There is a polycrystalline panel (50-55 Wp, mounted on the roof normally but in some cases pole mounted), a regulator (12A), four fluorescent lights (7-11W), one DC socket, a lockable battery box and wiring in conduit pipes. The Zambia PV-ESCO project has arranged training courses for technicians and managers. Business training has also taken place.

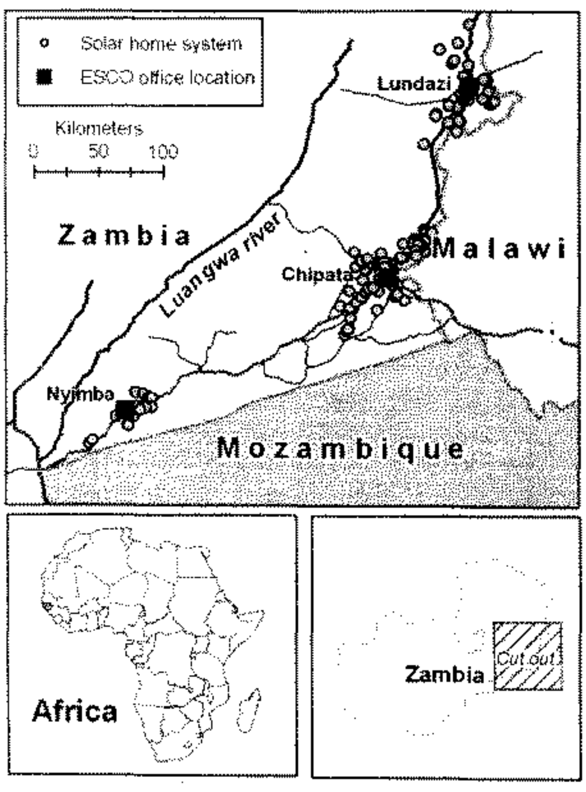

Figure 1: Location of ESCO and SHS installations

The study

Two surveys have been carried out as part of a research project at Gothenburg University on diffusion of technologies in development projects. The first survey was done in 2001 (Gustavsson & Ellegård 2002) and the second in 2002. The two surveys have covered all the 400 installations. The closest neighbour was also targeted to act as comparison. In 2001 a sample of potential customers was also targeted in Lundazi and Chipata. This sample was taken from the applications that had been made to the ESCOs to have a SHS, and it is expected that these households are found in the survey carried out one year later.

The questionnaire consisted of a large number of questions that concerned the use of solar services, and the changes that they had experienced since starting to use the service. A number of more general questions concerning energy use and living conditions were also included (Gustavsson 2002). Local enumerators were trained to perform the questionnaires. A total of 640 questionnaires were completed.

In the presentation of the surveys, money values in Zambian kwacha (ZMK) have been adjusted with the exchange rate of US dollars in order to make comparisons possible. Note that fee levels have been adjusted since the surveys were carried out. Locations of solar home systems in Figure 1 were taken with GPS at the time of the survey and later

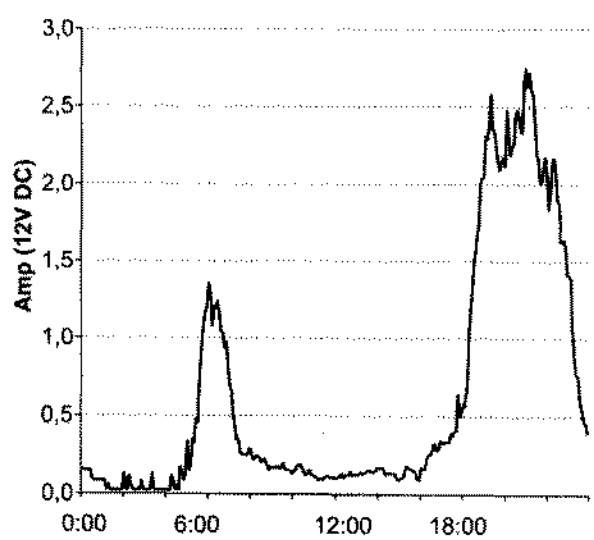

Figure 2: Load curve (mean 21 days)

plotted in GIS software. The load curve in Figure 2 was logged using data logger.

The impact on the user's livelihood systems

The SHS can bring benefits to the user, but it will also put up some new demands such as the monthly service fee. In terms of benefits, these will stem from the improved lighting conditions, and from the access to 12V DC electricity.

The systems are mainly used in the morning and in the evenings (Figure 2). A typical load curve for a household with TV, radio cassette player, lamps and a small radio is displayed in Figure 2. The household consists of five people, with two adults and three children. There is a peak power output in the morning, but it is during the night that most power is redrawn from the system. The power usage is 15 Ah per day during the period.

Clients to the ESCOs generally belong to a higher middle class in the rural setting, their neighbours show some characteristics of having a bit less incomes but are still relatively well off. The typical house where the SHS is installed is a concrete or burnt brick house with a steel sheet roof and five rooms (median value). The household had typically lived in the house for four years (median). Neighbours had the same characteristics of the house, but had lived there for three years (median). One of the reasons why the neighbour and client group are so similar in the survey results can be traced to the camp-type of living that clients lives in. If, for example, the client is a teacher, it is quite possible that the neighbour is also a teacher, or at least works at the school.

The relatively short period of time people have lived in their houses has its explanation in the same reason. Many systems are installed in teachers' homes in school camps, in Zambian national service camps, police camps and civil servants homes. These groups are stationed and can be transferred to new locations. Only about 50% of the clients live in a house that they own themselves.

Light

There was only a minor difference between customers and neighbours in terms of light hours per day in the house. Customers had light for 3.4 hours (median value) and the neighbours for 3.2 hours (median value). These figures, however, represent the time it was light in the house, and not the number of light sources or the quality/strength of the light.

The systems that are installed at the client's houses come with four fluorescent lamps. These lamps will give a stronger light than what you get from traditional light sources such as oil wick lamps and candles. While these latter light sources emit light in the range of 1-16 Lumen, a solar fluorescent lamp produces 340-560 Lumen (Louineau et al 1994), which is strong enough, if you are not too far from the light source, to read by for longer hours.

New daily routines are reported by 87% of the customers. Most of these new routines are a result of the improved light. Doing domestic work at night, reading and writing and extended working hours is reported by 64%, and 27% say that they are now enjoying listening to radio and watch TV.

Compared to their neighbours, children in client households' study more at night. While the children could only study in about half of the neighbour households, children studied at night in more than three quarter of the client households. Neighbours' children use oil wick lamps and candles, 60% of these households reported that the children complained about the light in both quantity and quality. Children in client households, studied in the light of fluorescent lamps and there were complains in 10% of the cases. Reasons for these complains were basically that a lamp was broken, or that power had been cut due to over-use of systems.

Commercial customers report that their sales have improved as a consequence of the light and the possibility to playing music for longer hours. As the light is bright, shop owners report that their shops have become meeting points where people meet to talk in the evenings.

PV systems have also been installed in schools, and the headmasters are very optimistic on the development. One problem, however, is that the lamps are suited for domestic use, and as classrooms are much larger, the light becomes faint.

One indication of the importance that people give to the improved lighting conditions is that almost half of the customer households say that the children are the ones that benefit the most from having solar electric services. In one third of the households, the man is said to benefit the most and in 20% the woman is said to benefit the most.

Appliances

Among the households that can afford to have a SHS, it is very common to have electric appliances. Among the clients, 96% report having electric appliances, compared to 75% of the neighbours. In the sample of potential customers in the 2001 survey, all households had at least one electric appliance in their house.

Lamps are found in all of the customer's houses, as it is part of the installation, but electric lamps are very rare among neighbours. Secondly, the most common appliance is a radio cassette player found in 80% of the client's houses and almost 70% of the neighbours. TV sets are found in almost 60% of the customer households and in 17% of the neighbours' houses. Small radios and torches are common appliances both in customer and neighbour households.

Inverters are not commonly found among the households. The ESCOs have been acting against the use of inverters, as appliances not meant for SHS can easily cause over-usage, and damage to the systems. It seems that the clients have not purchased inverters to their systems, but rather gone for 12 V DC appliances. In more than 80% of the cases, the TVs at clients' houses were 12V DC type, while this was only the case in half of the cases for neighbours. This indicates that people have purchased their television sets to suit the system, which also can be seen, as there is a 35% increase in TV ownership between the potential customer sample in 2001 and that in 2002. One of the reasons that the households haven a TV, even though they do not have any power, is that a relatively large group of both customers (62%) and neighbours (58%) have experience from living in areas with electric grids, and they bring their appliances with them as they move or transfer.

Households with a television report that ZNBC News is among the most popular programmes to watch. Hollywood action and Nigerian drama are popular as well, but a video is needed to watch these. Videocassettes are readily available on the market, and these are also borrowed from friends.

About one third of the households report that they have experienced problems with their systems. The most common problem is blackouts caused by regulator switching-off. During the cold and rainy seasons (November-June) cloud cover can become thick and direct sunlight is not present for many days, thus charging of the systems will be limited. Such periods can easily drain the battery and as a result the regulator will automatically cut power.

It seems that users have learned to use the system according to sunlight. Days with little sun, they will limit the use to lamps and radios. It also seems that users are balancing their use. If, for example, they watch TV and videos for two hours, they will limit the use of lamps and radio cassette players. The formation of what could be labelled local knowledge on how to use the solar system in their local context has been formed.

The ESCOs are local companies and the customers are happy with their performance. Customers claim that if problems arise, the ESCOs are normally quick to respond. The issue that customers and neighbours comment on is the limited number of solar systems. Many of the neighbours would also like to have the solar service, but there are no systems available. The Zambia PV-ESCO project had a limited number of systems to allocate for each ESCO and the ESCOs themselves have not been able to purchase or acquire additional systems. The main problem for them is to arrange with credits.

More or less every customer household argues that solar is good. Comments like 'our house has become more modern' or 'it is like living in the town' are quite common. At the same time, 70% of the customers would prefer to have grid. One of the reasons is that solar is limited in terms of capacity. People would like to use electricity for cooking, freezers and fans.

Paying for the service

Customers will pay a monthly fee for the service that they receive. The fee is payment for the electric service, and not a rent. In most cases, the customers are aware that they are paying for the service, and not for renting the system. Today, the monthly service fee is between ZMK30 000–45 000 (US$6.4 –9.6) depending on the ESCO. Commercial customers pay the same fees as households. The amount of money that the household spent on energy services differed between customers and neighbours (see Table 1).

Neighbours spend less money on energy services than customers. Cooking fuel is biomass-based, either charcoal or fuelwood. Fuelwood is either collected or purchased from local vendors. In terms of light, neighbours use candles and paraffin, while customers have solar. In Table 1, electric services are expenses on dry cells, but also in some cases, charging of car batteries. Customers usually purchased some dry cells, as well as buying some candles, but had reduced the need for these items drastically. Comparing the potential clients, with the clients, the total amount spent on energy services per month is almost the same, but as was discussed earlier, there is an improvement of the services received.

Almost 90% of the customer households have at least one household member with a formal income, compared to about 80% of the neighbours. Usually the households are involved in farming as well, both food and cash crops. While 85% of the customer households report that their income is stable over the season, the same figure for neighbours is 65%. The salaries that are paid from government sources are sometimes not paid on time, thus making payments of monthly service fees difficult. The ESCOs are aware of this, and try to be understanding.

Monthly default levels are in the range of 10-15%, but after the ESCOs have issued reminders, there are usually around 5% still left. If payments are not made for longer periods, the systems will be considered for removal.

In order to become a customer to one of the ESCOs, the customer needs to make an application and get accepted (as a customer). When accepted, an installation fee must be paid. The installation fee is in the range of ZMK250 000 (US$53), and will cover installation material and labour. Installations are made with conduit pipes, roof or pole mounted panels and lockable battery boxes.

Table 1: Expenses on energy services, ZMK (2002 money value, US$ within brackets)

	Cooking	*Light including solar*	*Electric services for appliances*	*Expenses on energy services total*
Neighbours	13 200 (3.0)	10 800 (2.5)	9 800 (2.2)	33 800 (7.7)
Clients	14 100 (3.2)	30 100 (6.8)	7 700 (1.8)	51 900 (11.8)
Potential clients	13 400 (3.0)	18 300 (4.2)	21 000 (4.8)	52 700 (12.0)

The tariff on the electricity that customers pay is high in terms of kWh. A typical household with lamps, a radio cassette player and a black and white TV will use about 10-15Ah per day (12V), which makes up to 3.5-5.5 kWh/month (Figure 2). With the present monthly fees, the price tag will end at more than $1/kWh. For comparison, the national electric utility in Zambia, ZESCO, has a fixed tariff for low residential consumers (2-15 A, unmetered), which is ZMK18 000 per month (US$3.8) (ZESCO 2003). A typical electrified small household with lamps, a radio cassette player and TV, will use about 50 kWh/month, and would pay only about ZMK20 000 per month (US$4.3).

A pre-payment function is part of the systems operated by CHESCO. The expectations on these systems were very high prior to installations. At the time of installation, all three ESCOs argued that pre-payment was a good solution for both them and their customers. Pre-payment would enable a more decentralised payment structure, as selling points could be localised outside the central town where the ESCO offices are found.

The prepayment system selected works with a token, which is recharged in a computer interface. Tokens are individual and must be taken to the computer for recharging. The computer is located in the ESCO office, which still makes this system centralised. Customers will have to go to town to recharge the tokens. Travelling is expensive in the area, and a round trip to town may reach up to ZMK20 000 (US$4.3), which is about half of a monthly service fee. As a result, CHESCO could not realise their plans of selling points closer to their customers.

These pre-payment systems have neither worked very well as tokens, when been re-charged, and have made regulators also cut power. The customer then needs to make one more trip to town to inform CHESCO about the problem. CHESCO will than go to the customer to reset the system. In terms of collection of service fees, both NESCO and LESCO are performing well to keep final default levels low, even without pre-payment. At present, CHESCO has started to by-pass the pre-payment as it causes more problems for them and their customers than it solves.

Inflation rates in Zambia are high and the service fee needs to be adjusted to this. 95% of both customers and neighbours are aware that there is a steady increase in prices, but at the same time 90% find this hard to understand. Since the ESCOs started to operate, they have increased the monthly fee in the range of 30-50% in kwacha terms. If adjusting for inflation, the fee level of ZMK45 000 per month (US$9.6) in July 2003 is only a 10% increase compared to the initial fee level of ZMK25 000 in January 2000.2 About 10-15% of the systems have been relocated to new customers. This has been because customers have terminated their contracts (it has been mostly small farmers that have opted to do this), or the system have been disconnected by the ESCO. The monthly fee is what is termed fee for service and almost 80% of the customers found the fees paid in 2001 and 2002 reasonable. At the same time almost every household wanted to purchase the system and own it themselves. Generally the amounts they were willing to pay for the systems were low, and only about 10% of the customers mentioned sums above ZMK2 000 000 (US$450).[3] As long as the ownership of the systems is not at the hands of the ESCOs they are not able to make it possible for customers to purchase their systems, but when ownership is transferred this option will be made possible.

Conclusion

The SHSs diffused through the Zambia PV-ESCO project have made an impact on the user's livelihood systems. The services enjoyed are enabling activities that were more difficult to do prior to having the service. Things like reading and writing at night are possible for a longer period of time. Children are those that benefit the most from the services, and one of the reasons for this is their improved possibility to study at night. In addition to this, the possibility of watching TV or a video, as well as listening to the radio or music is improved. Changes in the users daily life due to the integration of solar services is best described as improvements of their living standards. The customers have money to improve their standards of living and they are prepared to pay for it.

The Zambia PV-ESCO project has shown that

ESCOs can manage and operate solar PV systems in the rural setting and keep good customer relations. It has further shown that customers are willing to pay for the service. One of the challenges for both the ESCOs and the government programme is to work out mechanisms for expansion. Presently, there are many applicants for new customers, but the ESCOs do not have the credit capacity to expand their business.

Reaching the poorer segments of society is another challenge. Presently, the service fees are too high for these groups to afford and it may never be possible to reduce them enough to reach levels where it can be affordable, unless direct or indirect subsidies are involved. The ESCOs are commercial companies and aims at making a profit. The government could, however, consider different support actions in order to facilitate diffusion of the services as a part of rural development or rural electrification schemes.

Acknowledgements

The author acknowledges help from the Department of Energy, Government of Zambia, and the managers of CHESCO, LESCO and NESCO for permitting him to carry out the research. Financial support was received from Sida/SAREC, from the Paul and Marie Berghaus Donation Fund, a grant from the J Gustav Richerts Fund and from the Ångpanneföreningens Research Fund.

Notes

1. For more information on the ESCO project see Ellegård et al (2003).
2. Adjustments are made with the exchange rate of the US dollar.
3. The price per system of the winning bids in the procurement process was in the range of US$900–1 000. This included installation, transportation and some spares.

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Received 2 September 2003; revised 15 October 2003