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Educational benefits from solar technology—Access to solar electric services and changes in children's study routines, experiences from eastern province Zambia

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Abstract

Solar technology is diffused in many parts of the world with the ambition to improve the situation in rural areas. One claimed benefit of solar power at household level is improved situation for studies. The aim of this article is to analyse the impacts that access to solar electric services can have on education in a rural setting. The results presented concern the use of solar home systems related to children's possibilities to study at night and their exposure to TVs and radios are based on two surveys. Children are reported to spend more time studying after getting solar services than prior. They do not complain to the same extent about the light as the children living in houses without solar electric light. TV and radio cassette players are found in many households. Most households served have at least one household member with a formal income, a typical occupation is teacher. A number of schools also have access to solar services through the ESCO-project. The possibility to arrange evening classes is appreciated. Targeting schools serves as a possibility to improve the educational services offered in the rural setting, benefiting all students and not only those that can afford solar at home.

Keywords: Education; Solar photovoltaic technology; Southern Africa

1. Introduction

It is no secret that among the most attractive services from a solar home system is the possibility to listen to music and look at TV and video. Studies on the type of appliances found in households with solar home systems show that TVs are common (Jacobson, 2004; Morante and Zilles, 2001; Nieuwenhout et al., 2001; Nieuwenhout et al., 1999; Ranniger, 2004; Reinders et al., 1999), and the time spent using these appliances depends on the power supply but can reach up to 5 h a day (Nieuwenhout et al., 1999). Solar systems purchased by users on commercial basis in Kenya are more often meant for use together with a TV set, than for getting solar lighting (Hankins, 2004; van der Plas and Hankins, 1998).

Most solar home systems found in rural areas of Africa are part of a development intervention and watching karate movies or soap operas are not results brought forward in project justifications. In solar PV projects the justification for the technology introduction is rather that it brings the users a number of benefits, such as creating income-generating activities, delivers improved health services, and availability of a modern and strong light source that can extend working hours and give possibilities for studies. These benefits are associated with general strategic development goals. At the same time these benefits are often based on a conjecture of the potentials of the technology and secondary information in development literature.

The aim of this article is to analyse the impacts that access to solar electric services can have on education in a rural setting. The analysis is based on a case study on the Zambian PV (ESCO) (Energy Service Company) project. In this article, I argue that even though there is no evidence of actual improvements of school children's marks as a consequence of access to solar services, children are able to spend more time studying compared to their neighbours without these services. The children (and adults) will also be more exposed to news and events taking place outside the rural community through radio and TV broadcasts. In

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a few cases schools have accessed solar services through the project. These schools can offer improved reading and studying conditions to students from all types of households, challenging the fact that solar technology only reaches the better off segments in the society.

1.1. Studies on impacts on education through electrification

There are relatively few studies focusing only the impacts on education from introduction of solar technology. Education is often brought forth as a potential benefit from the improved light, but often there are little empirical evidence or experiences underlying these claims. In short these texts normally argue that the access to electricity will impose a positive impact on education and the argumentation will stop at that (cf. Andersson et al., 1999; Foley, 1992, 2000; Willkins, 2002). Nieuwenhout et al. (2001) argue that there is "a lack of documentary information on actual experience of households with solar home systems" and that most documents concern the first 1–2 years, even though much relevant information can only be obtained after a longer period.

A study made by a team at the Netherlands Energy Research Foundation (ECN) simply states that "the effects [on education] are unclear" (Nieuwenhout et al., 1999). In their study references are made to reports indicating both increased time spent on reading and writing (Nepal) and decreased time spent on studies (Tunisia). The latter was argued to be a consequence of access to television. In the reports they refer, television appears to improve the general knowledge of the situation in the country, and foreign language skills.

Another group of studies are focusing on individual solar projects. A typical example is a study made of a government programme in Bangladesh implemented from 1996 to 1998. The respondents did not rank the effects of children's studies very high on the benefits returned from the solar system, while the possibility to "sew at night" was considered most important (Eusuf, 2000).

In two reports from EDRC (Energy and Development Research Centre) (James, et al., 1999; Wamukonya and Davis, 1999) the impacts from rural electrification in Namibia is discussed. While on a household level people experience the light as an important improvement of the lives, making it possible to spend more time studying, the teachers do not consider the improved light as directly linked to improved school results. It will make a difference, they argue, but other factors are playing roles as well. The possibility to attract teachers to remote schools is noted in the reports, but they claim it is difficult to verify as the possibility for teachers to choose their post is limited.

A third group of studies, which is by far the largest, are looking at socio-economic impacts from rural electrification realised through conventional grid extensions. In these studies impacts on education are sometimes found as one part. Zomers (2001) presents a number of studies on the effects of electrification on education and children's study routines. In short the studies he presents are supporting the notion that the increased exposition of radio and television can improve the knowledge of the language used in these broadcasts. At the same time the time spent watching TV can reduce the time for studies. He also notes the problem to quantify these types of effects.

Barnes et al. (2002) studied the socio-economic effects from rural electrification in the Philippines. Even though they saw that children in households with electricity stayed in school for an average of two more years, these were average figures and no conclusions were drawn from this. They conclude on the issue of education that "While important, education is not the largest benefit resulting from electrification. Lighting and time savings are greater and entertainment benefits are about the same." The study had an economic approach and was part of the ESMAP (Energy Sector Management Assistance Programme) "Electricity Benefit Assessment project" that aimed at developing methods to quantify the economic benefits from rural electrification. The study was able to present a monetary net value for the benefits per household received from electrifying a Philippine village. The methodology was subsequently used in World Bank rural electrification projects in Bangladesh and Vietnam (Wang, 2004). The study demonstrates linkages between better energy services and improved education and livelihoods (Wang, 2004).

ESMAP argues that provision of modern energy, such as electricity, is an input to development in rural areas. According to ESMAP (2002), provision of modern energy services will enable people to study and read at night. It is also argued that it is becoming more accepted that modern energy is a key to achieve the Millennium Development Goals. A recent report from UN-Energy (2005) is linking each of the millennium development goals to energy services, and how electrification can play an important role in meeting these. Issues such as attracting teachers, the role TV can play in diffusing public health information and improved health services by access to good light are presented.

1.2. The Zambia PV-ESCO project

The Zambia PV-ESCO project was launched in 1999 as a pilot project aiming at investigating the potentials of solar home technology for electrifying rural and remote areas. The solar systems are run and maintained through three local ESCOs found in the towns of Chipata (152 systems), Lundazi (152 systems) and Nyimba (102 systems) in the Eastern Province of Zambia. All systems have similar technical specifications; one 50 Wp solar module, one 100 Ah deep cycle battery, one regulator, four lamps and a double socket for connecting 12 V DC appliances. Chipata and Lundazi town areas are connected to the national grid and clients are normally found in villages and areas around the towns. Nyimba have just very recently received a grid extension (Chambwa, 2005), but at the time of the surveys most clients were found in the town. In

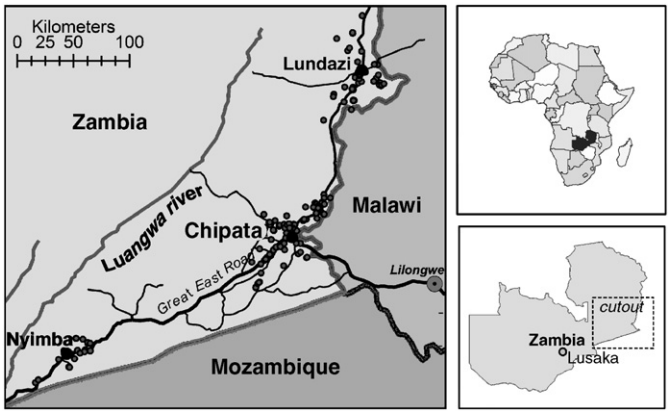

Fig. 1. Eastern Zambia, The three ESCOs operates solar systems around the towns Nyimba, Chipata and Lundazi. Dots represent the geographic location of solar home systems.

Fig. 1 each client to the three different ESCOs are plotted on a map of the region.

The clients to these ESCOs are mainly households and the improved light was brought forward by the clients as the most appreciated service coming from the solar system (Gustavsson, 2004; Gustavsson and Ellegård, 2004). The possibility to spend more hours studying is one aspect of the changed condition, but increased access to radio and television was also noted. In addition, the ESCOs also have a number of schools as clients. These schools offer night classes and extra teaching for graduating students.

2. Methods

The results presented here are based on two surveys carried out in 2001 and 2002. The surveys covered all clients to the ESCOs in Chipata, Lundazi, and Nyimba, totalling 406 systems, and also included the closest neighbour to each household. In 2001 the installations had not yet been made in Lundazi and Chipata and in these two locations potential clients were picked from the list of already accepted customers. These households were subsequently found in the group of clients in the survey carried out the year after. In this article, only those households that reported that there were children attending school living in the household are found. The number of questionnaires are thus for households with solar at home $N = 269$, neighbours to household with solar $N = 114$ and potential clients $N = 49$. In those cases other selections from the surveys are used, the number of cases (N) is given in the text.

The neighbour was selected by picking the closest house along the road the fieldworker reached the client. Households found in this group should not be seen as a typical household living in the area but rather included to illustrate experiences with access to electric appliances, types of light and their children's experiences with studying at dark hours when no solar services is found.

One section in the questionnaire was specifically devoted to how children used the solar electric services and the impacts that the household members experienced in terms of changes in study routines. Neighbours were asked similar questions including what type of light source was used. Sets of questions were associated with issues related to the different household members' access to the energy services received from the solar home system. Standard questions relating to energy use, expenses and access to energy services and electric appliances were also part of the surveys. Neighbours were asked about expectations and views on the potentials of the technology.

There were some minor changes to the questionnaires used in 2002 compared to the one in 2001. Most changes were a result from the experiences made from the survey carried out the previous year. A number of open-ended questions were made into closed questions. A set of attitude questions, inspired from the study of Barnes et al. (2002) were introduced. The majority of the questions were kept intact.

During the period from 2001 to 2005 interviews have been carried out with clients, headmasters and teachers. These interviews are also forming an empirical material used in the study. It is indicated in the text, where interviews have been used.

This study was carried out as part of an individual research project at the Human Ecology Section, Göteborg University. It has been implemented and funded independently from the Zambia PV-ESCO project.

3. Results

Off all clients to the three ESCOs ($N = 406$), 84% were households and the second largest group was shops (7%). In 4% of the cases a household was found at the back of the shop. The remaining 5% consisted of schools, guesthouses, and health and medical centres. The number of systems operated by the ESCOs has been kept steady, but each year roughly 5–10% of the systems are shifted from one location to another. Reasons are for example clients moving or getting another post, changing living conditions or long periods of default payments.

The ESCO is charging a monthly fee for the service rendered from the solar home system. This fee has changed from ZMK 25,000 in 2001 (USD 8.7, ZMK 49,500 indexed to January 2005) to between ZMK 35,000 (USD 9.5) and 50,000 (USD 10.5) in January 2005.[1] People are well aware that prices do increase. Almost everyone agreed on the statement that things get more expensive, while they argued that they had difficulties in understanding why this is the

[1]The monthly fee paid is higher than what typically would have been paid to the national electric utility Zesco (cf. Gustavsson, 2004). But grid will most probably not be extended to the areas where the ESCO clients are found within the next 10 years. In an interview with Chief Ndake outside Nyimba, he argued that solar is a good option in rural areas where no hydro [grid] is found but for the town's strong power is needed. This interview was made prior to the decision to extend the grid to Nyimba. Similar arguments related to access to grid electricity in areas outside the towns were expressed in interviews with clients and neighbours.

case. The 12-month inflation rates have been in the range of 17–25% during the last 4 years (CSO, 2005).

The ESCOs all claim that they consider the client's possibility to pay the service fee as an important factor in deciding new customers. The study of non-grid electrification concessions in South Africa presented in Ranniger (2004) found that solar home users was the most likely group to have a regular employment, and was also the group having the highest income compared to un-electrified and grid connected households. To be eligible for a solar home system the households had to prove that they had regular incomes. This was also noted in Nieuwenhout et al. (1999).

When schools are clients the monthly fees are paid through the Parent Teacher Association (PTA), which means payments are controlled locally. ESCOs experiences with payments from central administrations have been that these can be erratic. Another issue is that adjusting the fee levels, which is supposed to happen on a yearly basis, can become a complicated and long process.

3.1. The typical household with children attending school

87% of the 310 households that had a contract with one of the ESCOs at the time of the surveys also had children attending school. The corresponding figure for neighbours was 83%. The typical households with solar services and children in school consisted of 7 people (median), one man, two women and three children (in various ages), all median values. A median number of 3 children are going to school. These figures were similar for both clients and neighbours, with the difference that there were a median of two men in the household for neighbours.

The houses equipped with a solar system typically have concrete or burned brick walls (85%), with an asbestos or iron sheet roof (90%). The building materials found among the clients and neighbours in the sample is more durable compared to the mud hut with thatched roof that is the most common house in the Eastern Province (CSO, 2004a). There were a median number of 5 rooms and the household had lived there for a median of 4 years. In almost 70% of the cases the household is not the owner of the house. Their neighbours are living under similar conditions, but have in median numbers lived 3 years in their houses.

Neighbours spent ZMK 33,800 (USD 7.7, January 2002) on energy services, including cooking energy, while the households with solar services spent ZMK 51,900 (USD 11.8, January 2002). No increase of the costs for energy services was found compared to what households with solar services spent prior to getting the systems (Gustavsson, 2004).

Almost 90% of the household clients with children at school have at least one member with a formal income. For the neighbours the corresponding figure was 85%. Typical occupations are teachers, policemen, civil servants, and health workers. One of the reasons for the similarity between the two groups is that teachers, policemen and other civil servants are posted in an area. Along with the post comes an opportunity for living quarters. These houses are often found in clusters with people working in the same place thus the neighbours are similar to the clients. While Farming activities is the main occupation in these areas (CSO, 2004b), there are few, if any, subsistence farmers found in the client group. Farming activities are, however, taking place in almost every household, despite having one formal income. The farming activities represent an important input to the household's livelihoods.

A simple index was used to measure the wealth of the household. Information was collected on the household's possession of certain items (book other than bible, sofa, motorcycle, and bicycle) and aspects of living (glass in the windows, extra room where nobody sleeps) that were not related to energy services or electricity. The neighbours show a wealth index average value 3.4 and the households with solar an average value of 4.0. These results suggest that solar households are often at least somewhat better off than their unelectrified neighbours.

3.2. Use of light from the solar home system

The results from the surveys show that children spent more time studying after they had received solar electric services than they did before. Almost 82% of the client households reported that the children studied at night, while for the neighbours with school going children the same figure was 53%. Prior to having solar electric light, studies were made during the day or in the light of candles, or oil wick lamps. Candles and oil wick lamps are too faint to be suited for reading and writing for long periods of time. These light sources typically emit a flux in the range 10 Lumen (Louineau, et al., 1994; van der Plas and Graaff, 1988), which can be compared to an 8 W solar fluorescent light emitting about 250 Lumen (Narvarte and Lorenzo, 2001; Nieuwenhout, et al., 1998). The solar fluorescent lamp will improve the quality of the light drastically. A typical placement of a light point is a central position in the room and fastened to the roof, which is about 2.5 m high. Light switches and cables are clipped to the wall.

Some sort of light source is used in both households with and without solar services for a median of 3.0 h per day. At the time of the survey 96% of the households with solar used the floursecent type of lamps as the main source for light. The missing 4% of households had either broken lamps, a system that was either not fully installed or had missing or broken parts. Most of the solar equipped household reported that they still used some candles and paraffin. Of those neighbours reporting that their children were able to study at night, 85% were doing this in the light of candles or oil wick lamps. In a number of cases, households with solar services were found where children from neighbouring households without solar came over at night to study. Sharing of a good light source have been noted in other studies, for example Åkesson and Nhate (2002).

About half (51%) of the neighbour households reported that their children complained about the light in connection to studies. The complaints were typically smearing eyes, lack of supply of candles or fuel for the oil lamp, and faint light. In 12% of the households with solar, the children had raised complaints of the light. The reasons were mainly broken lamps or lamp fittings, and in a few cases blackouts. The main reason for blackouts is the high load put on the systems in combination with low state of charge of the battery, rather than periods of low sun irradiation (Gustavsson, 2006).

Almost 75% of the respondents said that the children had changed their study routines compared to prior to having access to solar services. In the open-ended question, concerning the way they had changed their routines, the most common answer (69%) was that the children now spent more time studying in the evenings. A high percentage of the respondents (71%) said that their children had improved their marks in school. Improvements in school marks have been discussed in other studies. James et al. (1999) experiences from Namibia showed differences in the views on the impacts from electrification between the households and those working in the schools. While direct linkages were expressed by the households, these linkages were less obvious to the teachers. Barnes et al. (2002) also agree that there are other factors influencing formal education, such as school fees, but argues that the time spent reading in households with electricity is longer and more effective compared to those without.

In 30% of the households with solar electric services and 17% in the neighbour households the women are not involved in any types of studies. The children are reported to be the only ones performing studies in 43% of the cases in solar households, and 55% in neighbour houses. These results can be compared to a more gendered chore such as washing dishes. Women and children are fully responsible for this in 95% and 93% of the households, respectively.

Almost 25% of the households with solar services consist of at least one person working as a teacher and these responded that with the access to electricity from a solar system came the possibility to prepare the following days work and do reading in the evening. In a number of cases, teachers also mentioned that they had considered, and in some cases also started giving private lessons during the evenings. The extra teaching gives the teacher a possibility to earn some extra money, but also offers students in these areas a service that is not commonly found. The high proportion of teachers taking advantage of solar services has been noted in other countries. In Kenya about 30% of all household solar systems purchased on a commercial basis will be found in households occupied by at least one teacher (Jacobson, 2004; van der Plas and Hankins, 1998).

3.3. Appliances and access to these

TV and radio have the potential to make the outside world more tangible for the children and other household members. Many of the national broadcasts from radio and TV are for example in English, which makes the children more exposed to the language. At the same time, drama and various Hollywood action movies are among the most popular types of films. National broadcasts are also ranked high by the clients. One reason for that is of course that many do not have a VCR that would enable a wider range of films.

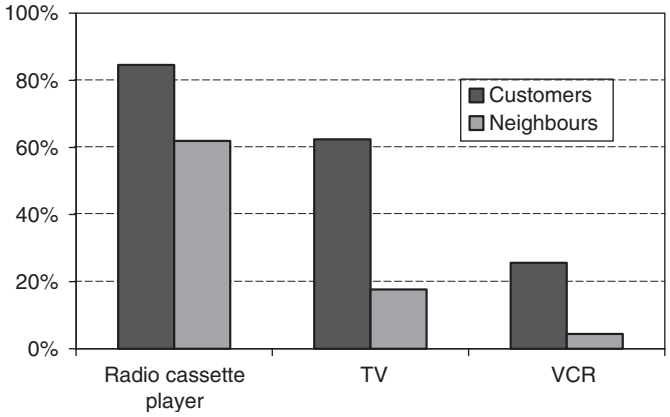

Fig. 2. Percentages of client and neighbour households with radio cassette player, TV and/or VCR at their homes.

Radio cassette players, television sets and VCR's are typical larger appliances that can be run on a solar home system and is found in solar client household to various degrees (Fig. 2).[2]

More than 90% of the customers have access to at least one of these more power consuming appliances, compared to 76% of the neighbours. Radio cassette players are quite common also among the neighbours as these can be operated with dry cell batteries, while only few TV sets are found. Car battery-operated TV sets were only found in a very few places.

In order to operate a TV set there is need of a more powerful source of energy than dry cell batteries. A 12 V DC black and white TV is suitable for the solar system and these are found among many (62%) of the households with solar power. There were a few cases where 220 V TVs were found at neighbours. In some cases these were operated with a small local grid (Gustavsson and Ellegård, 2004), but the most common reason was that the items had been brought along as the household moved from an area with grid extension. More than 60% of the households had lived in an area with grid electricity prior to moving to their present house.

In many of the client households that have not yet got a TV the acquisition of this appliance was considered for the near future. In interviews with ESCO managers and technicians they claim that for most of their clients it is

[2]At the time of the two surveys there was no mobile phone coverage in the areas. As was noted by for example Jacobson (2005) and Cox et al. (2002) mobile phone charging can be an important energy service from a solar system.

only a matter of time before a TV is found in the households. Most of the households found in the typical solar client group will be able to save money to afford buying a TV. The difference that could be seen between the access to TV between potential households and households that had solar services also supports this statement.

Access to television as a prime reason to sign a contract for solar services was only expressed in a few cases. More common were what could be labelled general improvements in the living standards and included herein the possibility to improve light conditions in the household was seen as a big incentive. More than 50% of the respondents said that the children were those that benefited most from the solar energy services and one of the reasons is the improved condition for studies. In about 30% of the cases the man in the households was reported to benefit most.

Listening to radio is a relatively gender neutral activity. In 73% of the households with solar electric services men, women and children were equally involved in listening to the radio, compared to 66% in neighbouring households.

3.4. Improved infrastructure in the rural setting

A number of schools are clients to the ESCOs and systems here are used mainly for light, but also for playing educational audio tapes and music during evening dances (normally kept weekly). Typical installations in schools have been one to three lights in classrooms and at least one lamp in an office. The same systems as found in households, are also found in the school. The light has enabled schools, which previously were dependant on sunlight or candles, to start evening classes and to offer students a possibility to take extra classes or do homework in the evening. The evening classes are usually meant for students preparing their examinations. The headmasters and school administrators who were interviewed did not bring up the issue of connecting appliances such as computers or photocopiers to the systems. The main reason is probably that they are well aware of their limited resources in terms of purchasing and operating this equipment.

The schools equipped with solar systems that offer night classes have experienced cases where students attending other schools have come to participate in the extra teaching. The headmasters in especially secondary schools believed that the school had gained an improved reputation in the area, hence attracting students. Some of the schools have besides offering night classes opened their classroom to community meetings at night.

In many of the interviews with headmasters, issues of improved possibilities to attract teachers to rural schools realised by the solar technology was expressed. They argued that a school that could offer solar services in the houses found on the school premises would become more attractive for the teachers. Most of the teachers have experiences from living in urban areas and with grid electricity. Teachers are, however, posted to a certain school and the possibility to choose is normally limited.

In most Sub Saharan Africa countries access to electricity in rural areas is less than 10% (Gustavsson and Ellegård, 2004). In Zambia for example the rural electrification rate is in the range of 2% (DOE, 2000). Access to electricity was regarded as important by almost every respondent in terms of both the possibility for children to study and the status of the rural area. The argument that electric light was important for children's studies was emphasised as 'very important' by more than 1/3 of the respondents in the households that had solar energy. In the interviews carried out with clients and other people, solar technology is claimed to bring a notion of modernity to the rural setting. One client, for example, said that now when he has solar electric services at home "it is almost like living in the town". At the same time the respondents consider that they do not have access to the same health, school and other societal services as those living in towns.

4. Discussion

4.1. Households

The access to solar electric services is experienced by the users to improve their children's possibility to study. Children have prolonged the time they spend studying in the evenings. The improved light also makes reading and writing less physically constraining compared to doing the same activity in the light of a candle. In addition to these changes, the children will become more exposed to radio and TV broadcasts than prior to having electric services. Most households with solar energy have a radio cassette player and many also have a TV. The improved light is the most appreciated improvement, but the possibility to watch TV and listen to radio and music is mentioned.

The services available in the solar systems are limited. The panels found in the area are 50 Wp, which was a fairly standard size for development assisted solar projects in the end of the 90's. Many systems bought over the counter have a smaller effect of the panels, resulting in a reduced total investment but the charging capacity will be reduced correspondingly. In Kenya where many systems are based on modules with a rated effect less than 50 Wp, competing interests on how the available energy should be used in the household is found. Watching TV was for example found prioritised before children's studies in a number of cases (Jacobson, 2004). In the Zambian study presented here, the main reason for complaints related to lighting in connection to studies were on broken lamps or lamp fitting. In some cases black-outs was also given as a reason for complaints. The systems used in the Zambian PV-ESCO project are designed to facilitate the a daily use of a TV and lamps for a couple of hours (cf. Gustavsson, 2006). A household is not a homogenous group with equal control over resources, which is displayed in the Kenyan case

reported by Jacobson. In a few years the number of appliances operated in the households will possibly have increased and the available energy will be more limited. Managing the limited supply of power will then be more problematic and if competing interests exists these will be more apparent.

The empirical data in the user survey show a slightly higher wealth index for those households with solar at home. We also know that the neighbours targeted in the user survey are better off than the average community in the rural setting. One of the challenges here concerns the inequity in the society in terms of access to energy services. People consider the rural setting to be disadvantaged compared to urban areas in terms of social services. Solar represents a potential solution for electrifying and supplying basic energy services to rural and remote areas. The impact that the solar services have on a household level can be described as a general improvement of living standards.

4.2. Schools with solar

In the efforts to electrify rural areas targeting societal institutions, such as schools, creates opportunities for larger parts of the rural community to take advantage from the benefits. Solar electric services can enable schools to start evening classes and open the schools for students to prepare homework.

All the schools that were studied have taken an active role in getting this technology. The headmasters have had to contact the ESCO and arrange for routines to pay for the service fee. This can be compared to a supply oriented diffusion approach, where solar equipment is located on schools as a part of a more centralised programme. The challenge is to arrange support structures that secure a long operating life of the technical systems. It is all too often that the hardware is supplied without considering the requirements of maintenance, know-how required for the operation and support if the system breaks.

Even though the numbers of schools electrified through the Zambia PV-ESCO project are few, the systems installed are still working after up to 3 years in the field. The organisational set-up with an ESCO keeping a vested interest in having the technical systems in working condition, have proved successful in this respect.

5. Conclusion

The results presented in the article cannot say anything about actual improvements in children's school marks, as school results were not collected and the survey data can only indicate but not stand as evidence in such claim.[3] The results presented show that more time is spent reading and studying is less straining for the eyes as a consequence of the improved light. Several studies have indicated the same changes when households get access to solar electric services. In the Zambia PV-ESCO case the benefits for the children was brought forward in the surveys much stronger than in other similar studies. One reason could be that many of the parents are teachers, and thus securing good education for the children is considered more important than would be the case if they had another occupation.

Even though the possibility to attract good teachers is unclear there are other benefits related to the services offered by the schools in rural areas, which stems from the access to solar services. The possibility to offer night classes and a place to do homework in the evening is bringing improvements to the rural students. One of the problems often experienced in supply oriented programmes is to keep the solar systems operational. The ESCO approach has been successful in this respect. Two factors seem to have been central in the success. Firstly, an outside body with a vested interest in keeping the system operational, i.e. the ESCO, is maintaining the system and securing the operation. Any problems concerning faulty batteries or daily maintenance are handled by their trained personnel. Secondly, payments for this service are handled on a local level. Linking the ESCO with central bureaucracy would make schools less attractive as customers to the ESCO and thus a different customer would be chosen.

Solar technology can bring improvements in the possibility to receive formal education in rural areas. On a household level this is mainly delivered through the improved light that emits from solar lamps, but exposure to radio and TV broadcasts can have positive effects on making the outside world more real. The real challenge lies in sharing these positive features to households that have less income. The possibility to target schools seems to bring community benefits and also to include students from households from all income segments.

[3]A second part of this study on educational benefits from solar technology is presently (March 2006) being implemented. This second study is a quantitative analysis of the changes in students' results in school, where access to solar at home or not is a factor.

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