IMPROVING THE AVAILABILITY OF PV-SYSTEMS AT SOUTH AFRICAN SCHOOLS AND CLINICS

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ABSTRACT: Since 1994 three independent programmes on PV electrification of rural schools and clinics were executed in South Africa. In total 2340 schools and 200 clinics were provided with solar PV systems. No publicly available evaluation of these programmes exists and the general impression was that these programmes were not without problems. This article describes a study in which a representative sample of the installed systems was visited and evaluated on technical performance aspects.
From the study it can be concluded that the technical performance of the installed systems is not optimal, mainly caused by theft of panels and batteries, and due to technical problems. The focus of the programmes has been too much on the quantity of systems delivered instead of the quality of the systems. To increase sustainability, more emphasis needs to be placed on the provision of electricity to the schools and clinics covering the lifespan of the system.

Keywords: Developing Countries - 1: Stand-alone PV Systems - 2: South Africa - 3

1. INTRODUCTION

The first democratic government in South Africa initiated large programmes to improve the quality of life in the rural and less developed areas in South Africa. One of the political targets set was electrification of all schools and clinics in the country by the year 2000. Three independent programs contributed towards reaching this goal, namely:

- the **RDP schools programme**. As part of the Reconstruction and Development Programme (RDP), the national utility ESKOM managed a program to electrify 1340 rural schools with PV between 1996 and 1998,
- the **EU 1000 schools programme**. In 1998, an EU-funded programme to electrify another 1000 schools was initiated. The installation of these solar systems was finished this year,
- the **IDT clinics programme**. The Independent Development Trust (IDT) managed the electrification programme for clinics: in 1996/7 (phase 1) and 2000 (phase 2) in which 200 rural clinics were provided with solar electricity

Although the target to have all rural schools and clinics electrified by the year 2000 was not met, substantial numbers of systems were installed. Different sources gave the impression that the performance of the installed systems was not as good as one might expect, but no formal evaluation of these three programs was available.

This article describes research carried out between September 2000 and May 2001 to evaluate the installed solar PV systems at these rural schools and clinics in South Africa. Information was gathered through the study of available reports on the projects, interviews of involved experts and a field survey in which a representative sample of 160 schools and clinics was visited in the Northern Province and the Eastern Cape province. Out of the 160 site visits, the information gathered at 149 of these is used in the data analysis.

2. RURAL SCHOOLS AND CLINCS

In 1995, approximately 25,900 rural schools and a number of rural clinics were identified for electrification. Of these, 16,400 rural schools and 2000 clinics were identified for non-grid electrification. In 1995, ESKOM estimated that approximately 75% of the schools and 47% of the clinics in South Africa would still be unelectrified by the end of 1999. (Bedford 1996)

Information on schools is very limited in South Africa. Until 1996, no accurate national database was available on the number, location and individual situation of the schools in South Africa. In 1996 the 'School register of needs survey' was done by the Department of Education to make a start with the monitoring of the situation.

IDT had estimated in 1995 that there were about 900 unelectrified major clinics in South Africa and 161 visiting points, while about 250 new rural clinics would require electrification. (Thom 1995). See table 1 for more detailed information on electrification of clinics.

3. SURVEY DESIGN

The research described focused on the two provinces of South Africa with the majority of the rural schools and

province	schools					clinics				
	number	with grid electricity[1]	without grid electricity[2]		with PV system[3]	total	urban	rural	unelectrified	
									major clinics	visit points
Eastern Cape	5916	1082	4799	81.6 %	1170	450	249	201	317	40
Northern Province	4174	873	3270	78.9 %	170	400	48	352	282	10
Kwazulu-Natal	5234	1944	3267	62.7 %		348	271	77	77	31
Gauteng	2229	1929	286	12.9 %		430	428	2	0	0
Free State	2898	1200	1663	58.1 %		240	177	63	5	7
Mpumalanga	1900	957	931	49.3 %		220	95	125	100	7
North West	2413	1004	1382	57.9 %		290	127	163	125	8
Northern Cape	530	412	111	21.2 %		120	94	26	5	20
Western Cape	1772	1553	202	11.5 %		450	428	22	0	25
TOTAL	27066	10954	15911	59.2 %		2948	1917	1031	901	161

Table 1: Electrification status of schools and clinics. Information on schools as of February 16th 1998 (please note, these figures are from before the start of the EU program on schools) (Source: Department of Education). The information on clinics is provided by IDT, 1995.

1 Includes only schools that are wired and supplied with grid electricity.

2 Includes schools that are wired but not supplied with grid electricity, that are not wired and/or have no electricity, that have generators and a category called 'other energy supply'', including solar energy.

3 Only for EC and NP numbers were available but in the other provinces, non or very few systems are installed

clinics: the Northern Province and the Eastern Cape province. The population of schools and clinics is stratified according to the program that provided the PV system, whether RDP, EU or IDT. A representative sample was taken from each project by simple random sampling.

All the schools and clinics in the sample were visited and physically inspected. Headmasters and nurses present at the location were interviewed to learn more about the systems.

4. SURVEY RESULTS

4.1 Performance

The best method of evaluating the effects and results of the electrification programmes is by looking into the availability of the systems. In this research, availability was defined as the whether the PV systems were functioning properly.

Out of the 48 visited RDP systems, installed in the period 1996-1998, not one was totally functioning. The main reason (in 81% of the cases) was theft or vandalism of one or more of the parts (panels, batteries, inverter, regulator). Two systems had technical problems with the inverter, which caused AC loads not to be used.

The EU-systems visited performed better. Of the visited systems, 44 (57%) were working, 16 (21%) were partly working, and 19 (22%) not working at all. Of the systems that were not working at all, 31% were not functioning because of theft or vandalism.

The field survey revealed that theft and vandalism play a major role in the failure of rural electrification of schools. An associated problem, encouraged by theft of systems in the neighbourhood, is de-installation of the solar system by the headmaster to prevent theft. The de-installed systems are not re-installed, which makes the systems useless.

As the systems were installed only recently (1998-2001), the long term success of the EU programme could not be evaluated, but might be similar to that of the RDP program unless other actions were taken. The European Union has started an evaluation of their program (partly in conjunction with the research described in this article), which may provide additional insights.

The performance of the systems at clinics, where the first systems were installed in 1996, was better. With one exception, no theft or vandalism was reported. The only technical problem that occurred was worn out batteries. This resulted in a lack of electricity during cloudy periods. However, due to the installed priority switch, the fridge, being the most important appliance, never had a shortage of electricity. Further reduction of the performance of the batteries might change this situation. A program to replace the batteries needs to be set up to enlarge the lifetime of the system. After an operation period of four years, the inspected systems at the clinics had no technical failures, aside from the batteries not working properly.

4.2 Security

Both EU and RDP systems were installed in the schoolyard, with the panels on an array that was easy reached from the ground. This made the panels an easy target for criminal activities.

In the cases were panels were found stolen, they were removed without the proper equipment, most probably damaging the panels beyond repair. At the moment the new

systems of the EU schools are provided with burglar proof bars. These bars make it a lot harder to steal the panels without heavy equipment.

Of the RDP-schools, 27% had a night guard and of the EU-schools 60% had a night guard. The schools are responsible for appointing night-guards themselves, and had to allocate money from their budget for security staff salaries. However, in most cases the night-guards were on leave during the summer-recess.

Fencing is the responsibility of the schools themselves as well, which often resulted in good attempts but bad fencing. For fences to be effective ideally they should be 2 metres high, with barbed wire, and have gates with proper locks.

Clinics were mostly provided with a night guard as well as a proper fence. Another factor that might influence a lower incidence of theft at clinics is the fact that responsible people are present at clinics 24 hours a day, every day whereas at schools, the teaching staff leaves during the evening hours and during school holidays.

The nature of the panel thefts and reactions of several headmasters suggest that local people might be involved in the removal of the panels. In some villages people have been arrested for stealing panels. Panels are often removed in such a way that they will not be usable anymore, and in some cases were found vandalised in the bushes near the system installations.

4.3 Need and use of the system

It is clear that the use of the systems depends on the presence of electrical appliances. Although promised to the schools, televisions, VCRs and overhead projectors generally had not been delivered by the time the field research was carried out. This makes the benefit of the systems limited. The systems were mainly used for lighting the school during exam periods, for students to study at night and to charge mobile phones of the teachers, students and other community members. At several schools, the charging of cellular phones was a source of income. In some schools, adult education and community meetings were also held in the school.

On the other hand if one takes into account the condition of some of the classrooms, the attitude of some headmasters and the way systems were vandalised, it is questionable whether the promised equipment will last long in such an environment without additional guidance. Especially televisions and VCRs require some knowledge to install and use. From the experience in the field, the impression is that knowledge how to program a VCR is not always present in schools. If the required technical and social back up is not present, provision of televisions and VCRs will not make the difference that is hoped.

Remarkably, several schools had the lights switched on in cold periods during winter, for heating purposes. As the installed lights in a classroom have a total heat-production of approximately 12-Watts only, this is a clear evidence of improper use of the system.

At clinics the need for electricity is indispensable as it serves several purposes. At clinics the electricity is used for cold storage of vaccinations and medicines, as well as lighting in cases of emergencies at night. Besides the clinic itself, the compound has floodlights as safety protection for the nurses. Also nurse-houses are electrified which give the nurses the possibility to listen to the radio, sit together or read at night.

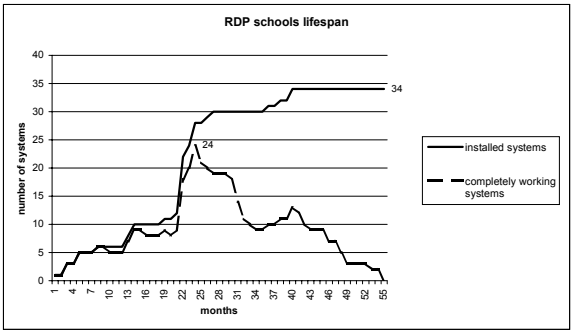

Figure 1: Number of total installed systems and number of completely working systems over time for the RDP schools program.

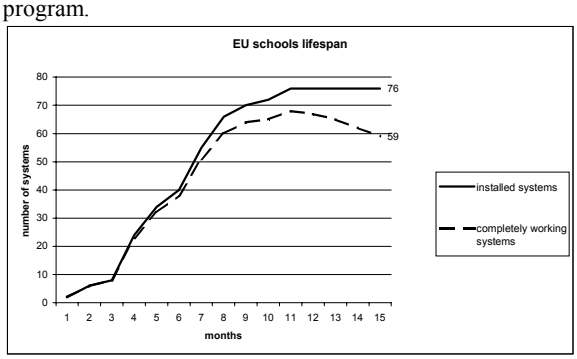

Figure 2: Number of total installed systems and number of completely working systems over time for the EU schools program.

4.4 User satisfaction and involvement

Real satisfaction of the user about the system was not easy to ascertain. The headmasters say that they are better off with the system than without. Also they indicate that they need a system that can produce more power, without giving examples of how to consume the additional power. At schools where the promised equipment was not installed yet, the use and satisfaction is limited. This sometimes influences the involvement and the motivation to maintain the system. Failing systems are often neglected, or not properly looked after, which can then provoke theft and vandalism.

Comparing the attitude of the users towards grid electricity and the solar systems, most users prefer a grid connection. The main reason given is that grid provides more power. Also the vulnerability of the PV-systems to breakdowns, theft and vandalism plays an important role. On the other hand, users of grid connections that were visited sometimes have a different view, as they indicate that solar panels provide free electricity, equipment is provided for free, and during windy periods solar systems are more reliable than grid.

The behaviour of the headmasters, in particular their level of involvement, has quite some influence on the success of the system, but it is very hard to quantify. In some cases, the headmaster was able to stimulate the community to look after the system and to prevent theft and vandalism. The systems were used to develop the whole community, but in some cases even an involved headmaster could not prevent damage to the system.

Although the condition of the PV systems at clinics was generally better than at schools, nurses are far more critical to the system's performance than teachers. This can be explained by the high dependency on electricity for the proper functioning of the clinic and the personal benefit of higher security and personal use at the nurses' houses.

4.5 Training, product support and maintenance

The average user of the PV systems has limited technical background and therefore a lack of knowledge of the system. The training and the reference manual that were provided, give the user information on how to maintain the panels and the batteries and what to expect from the system. Also the use of the system is briefly described. No other educational methods, like videos, were used. At most schools the physics or mathematics teacher is made responsible for the maintenance of the system. What to expect of the system is mostly known, as 87% of the persons interviewed knew that the system was not powerful enough to use with heaters or to boil water with an electric kettle.

The maintenance of the systems has to be organised very well. Systems that are broken down for some time, are more likely to be vandalised and subject of theft than systems in good working condition. At this point in time no maintenance system is in place for the RDP-systems. Although at the commissioning of the system a service phone-number was given to the headmaster, many of them could not recall this number. However, even in cases were defaults were reported to the correct phone number, the follow-up is not clearly defined as no organisation feels responsible for the maintenance, nor had any funds available for this purpose.

Maintenance of the EU-systems was better organised, as the installer is responsible for the maintenance during the first year. The installer has to check the system twice during the first year. Also field workers are appointed to detect/report problems and inform communities. Unfortunately, the technical knowledge of those field-workers is limited and they are not qualified to make repairs to the system, only to report the problems to the technical responsible person.

Maintenance of the IDT systems is organised through the hospitals. Clinics have to report problems to the hospital, where action will be taken. Distilled water and lights are supplied through the same infrastructure that is in place to supply vaccines and other medical equipment to the clinics.

5. LESSONS TO BE LEARNED

The field survey revealed that the performance of the EU systems at schools is better than the performance of the RDP systems. The main problems were theft and vandalism. The IDT clinics' systems, in general, performed better. Main problem with these systems is the need for replacement of the batteries. Theft and vandalism seem to be a less problematic at the clinics.

In general it can be concluded that the main emphasis of the two schools programs, and to a lesser extent the IDT clinic program as well, has been on the quantity of the installed systems. Instead of focusing on the number of installed systems, the emphasis needs to be on how many schools/clinics have been provided with trouble-free electricity for the lifetime of the PV system. The establishment of a maintenance program needs to be an integral component of such an improved approach.

Other lessons that can be learned from the presented inventory are that more attention is needed for the user need assessment and involvement of the users. Furthermore several technical improvements seem to enhance the availability of the systems, such as installation of panels on the roof of buildings (as in the IDT program) instead of on a pole next to the buildings (as at the schools) and adding burglar bars.

Overall the study confirmed the general feeling that the availability of the installed systems would be very low and this study is the first of its kind to quantify the performance. However, the authors wish to see the research as a way of learning lessons for improvement, as many schools and clinics in rural South Africa still awaiting electrification can benefit from these lessons.

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