

From SHS to grid electricity in low-income rural households

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Abstract

The Maphetheni area is a unique area. First of all, it was the first rural area with Photovoltaic (PV) experience in KwaZulu-Natal. In 1996 a project was started by Solar Engineering Services to install Solar Home Systems (SHSs) in 50 households in this area. Secondly, Maphetheni is now one of the few areas with both SHSs and grid accessibility.

This survey investigated the experiences of households with access to both SHS and grid electricity. Specific objectives included comparing the usage of grid electricity and SHSs; to compare the daily lives of the households when using the SHS and using grid electricity; and to find out if a SHS is seen as an inferior energy source.

All six households that qualified were interviewed, two households with grid electricity and a functioning SHS and 4 households with grid access but a non-functioning SHS. The survey was conducted through structured interviews of approximately one hour, with some space for unstructured discussion to express feelings about the usage of the different kinds of energy sources. There was a warm welcome in most of the families and they loved to talk about the subject.

Results indicated that SHSs were not seen as inferior energy sources in the rural area of Maphetheni. Half of the households preferred SHS to grid electricity, and all households were very content about the working of the SHS, while there were some complaints about the functioning of the grid. All those families who did not have a working SHS at the moment wanted it fixed. The households themselves did not have the feeling that much changed after they accessed the grid, but the equipment used with electricity increased, as did the number of lights in use. Refrigeration, cooking and bulk water heating changed slightly because most families already had a refrigerator before they

accessed the grid (a move from gas to electricity), and cooking and water heating were still mostly done with paraffin. Kettles were now used for making tea.

Keywords: Solar Home (PV) systems, grid electricity, Maphetheni, domestic electrical equipment

1. Introduction

The total world population is more than 6 120 million people, with more than 1 600 million people without access to electricity (ABB 2003). This is about one quarter of the world's population. In South Africa in 2001, there was a total population of 44 560 743 as can be seen in Table 1 (NER 2001). Of these people, 33.9 percent did not have access to electricity; this is 1.3 times greater than the world average. For the rural areas, the figures are worse; 50.9 percent of the households were not electrified. In KwaZulu-Natal, the percentage of households in rural areas without access to electricity in 2001 was even higher: 64.4 percent (NER 2001). That is 2.5 times higher than the world average! Something needs to be done about this.

About 77 percent of the country's primary energy needs are provided by coal (Eskom 2004). South Africa relies heavily on coal to meet its energy needs because it is well endowed with coal resources. At the same time, South Africa recognizes that the use of fossil fuels, like coal, causes emissions of greenhouse gases, such as carbon dioxide, and this has led to increasing concerns worldwide about global climate change (DME 2003). Although South Africa is also well endowed with renewable energy resources as sustainable alternatives to fossil fuels, these have remained largely untapped.

There are many reasons to choose renewable

Table 1: Electricity supply statistics for South Africa (NER 2001)

Type of area	Population	Households	Households not electrified	% not electrified
Rural	20 832 416	4 267 548	2 172 318	50.9
Urban	23 728 327	6 503 427	1 480 242	22.8
Total	44 560 743	10 770 975	3 652 560	33.9

energy. An obvious one is that renewable energy is inexhaustible, while fossil fuels will run out eventually. Sun, wind, water will always be available and are clean energy resources. For many people in rural areas of South Africa, a connection to the electrification grid is a dream. However, it is expensive for both the user and the supplier. Population density is low and homesteads are far apart from each other making installation expensive. In addition, people in these areas often cannot afford pay for the grid connection, use very little electricity monthly (<50kWh in an Eastern Cape study (Prasad and Ranninger 2003)) and the government will not spend the money to extend the grid to these rural areas.

As a result the South African government (DME 2003) has started a Non-Grid Rural Energy Programme to provide rural energy services. The government recognizes the electrification of households as one of its core objectives and it sees a potential role for solar home systems (SHS) and other renewable energy technologies in providing electrification to remote rural communities.

This off-grid renewable energy market has not been fully utilised, only about 50 000 to 80 000 SHS have been installed in the past in South Africa (Martens *et al* 2001). These are all fee for service systems, where a fixed sum per month is paid for the service and for maintenance. The Non-Grid Rural Energy Programme that the Department of Minerals and Energy (DME) started will extend the number of SHS installations with another 350 000 within the next 5 years. This will be divided over 7 concessionaires each responsible for 50 000 households (Karotti and Banks 2000). Two examples will be given here that show that this is not only an improvement for the livelihoods in the rural areas but also good for South African market development and economics, and that it will also strengthen international partnerships.

- One concessionaire is taken by a joint agreement between Eskom, the national power supplier of South Africa, and Shell International Renewables (EIA 2002). A solar panel, charge-controlled battery and a metering unit can be installed in homes, without owners having to pay the large upfront costs often associated with such systems. Customers purchase a magnetic card that activates the solar home for the period that is paid for.

- Nuon RAPS Utility (Pty) Ltd. or NuRa responded to the government announcement to address rural electrification needs in South Africa through the issuance of concession areas to private companies. Rural Area Power Solutions (Pty) Ltd (RAPS) established a partnership with the Dutch utility NUON to effect the capitalization and implementation of an energy services utility in South Africa. The RAPS-NUON Joint Venture was subsequently selected by the government to receive one of seven off-grid concession agreements, that for the northern KwaZulu-Natal area (RAPS Undated).

Maphephetheni, a private electrification initiative, was chosen as the study area because of several reasons; it was one of the earliest communities with PV experience in the country and now also has some areas with electrical grid connections. It is rare for one household to have experience of both electricity sources. Therefore, this study was undertaken to reflect the experiences of such households. In a survey done in 1998 in Maphephetheni, only 17.8 percent of the interviewees responded positively to the question if they wanted a SHS, while 84.5 percent preferred grid electricity. They wanted grid for cooking (38% in comparison with SHS 4.2%), lighting (28.2%, SHS 10%), refrigeration (31.6%, SHS 30.1%), ironing (26.6%, SHS 3.1%), TV (27.4%, SHS 5.8%) and Radio (25%, SHS 5.3) (Green and Erskine 1998). Most pre-SHS surveys showed that SHSs were often seen as a second-class energy source because people would be unable to run stoves, fridges or irons with the SHS, and the power was limited (Green and Wilson 2000; Martens *et al* 2001).

2. The study area

The community of Maphephetheni is situated in the Valley of a Thousand Hills in KwaZulu Natal, some 80 km west of Durban. Maphephetheni is bordered by the Mqeku River to the West, and the Inanda Dam to the South, while the mountainous Pisweni and Matata plateau are on the Northern and Eastern section of the village. The area is divided into upper and lower Maphephetheni, with the last being on the southern side of the escarpment near the dam.

The Maphephetheni community is still administered by a traditional leader, Chief Gwala and a

local councillor on eThekweni Metro council. The population of this area is about 16 000 people spread over 2 000 homesteads (Green *et al* 1999); an average of 8 persons per household. A household has on average 4 buildings where multiple generations of the family live together. The average total regular monthly income per household varies widely, but in 2003 it averaged R642 (Ndokweni and Green 2003). In that year, 65.5 percent reported receiving no salaried income at all. Agriculture, small-scale informal activities and a few commercial enterprises are the main economic activities in the area.

Solar home systems (SHS)

Photovoltaic (PV) or solar modules are made up of solar cells that are connected in series and transforms sunlight into Direct Current (DC), which can be stored in a 12V battery. A typical solar module comprises of 36 cells connected in series to produce an operating voltage of 12V. A simple 50Wp SHS provides enough electricity to power 3 lights for 5 hours each, a radio, a cell phone charger and a black and white TV set. When the system includes a battery bank for energy storage and a charge controller that regulates the power flow into and out of the battery bank, it is called a Solar Home System (SHS). Battery banks are typically sized in order to provide energy during days of no or limited sunshine (cloudy/rainy days). The batteries will charge very slowly during long periods of cloud or mist.

South Africa has one of the highest solar irradiation levels in the world, with an average in KwaZulu Natal of 5.5 peak sun hours per day (Wiersma *et al* 1999). Expressed in technical terms, the average daily solar radiation in South Africa varies between 4.5 and 6.5 kWh/m² (16 and 23 MJ/m²) (DME 2003), compared to about 3.6 kWh/m² for parts of the United States and about 2.5 kWh/m² for Europe and the United Kingdom.

A pilot project with SHS started in Maphephetheni in 1996. Solar Engineering Services initiated the project with funds from Solar Electric Light Fund (SELF) of the USA and the South African Department of Minerals and Energy. The objective of the pilot project was to manage the installation of approximately 50 SHSs, and in the process develop a replicable formula for installing SHSs in South Africa (Cawood and Simelane 2002).

Six local community members (3 men and 3 women) were trained as installers, and 2 women were trained as sales staff. The KwaZulu Finance and Investment Corporation (KFC) provided loans over a three-year term, at commercial interest rates. The SHSs cost between R2 500 and R3 000 and repayments varied from R57/m to R82/m due to Rand and interest rate fluctuations. Thirteen systems had been removed due to poor payment

records, and currently approximately 21 systems were still on the books of the KFC. These should be paid within the next 12 to 18 months. Maintenance was originally completed on an ongoing basis by the SHS installers, but these installers have either left the area to work in Durban or have passed on.

These systems were all ownership systems; once the SHS was paid off, it belonged to the household and they had to pay for maintenance and repairs. As seen in this research, there was no household knowledge on how to repair and maintain the SHS, and where there was knowledge, there were no spare parts or no cash money to pay for parts. Solar Engineering Services had recently started a new project during the time that this survey was completed. From June 2004 until December 2004, the families were to pay R18 monthly for maintenance and repair. After this period, this new contract would be evaluated.

Grid

The people of Maphephetheni were informed about the possibility of a connection to the grid through a community meeting. After the meeting there was opportunity for signing up for this grid extension, and when signed, households had to pay about R250 for this installation. After this was completed, the families that signed did not hear anything about the grid connection for many years (up to eight according to some of the households interviewed). One day men just showed up with poles and wires and started to extend the grid to the households that had signed up for it.

3. The households

The survey included all six households in Maphephetheni that had both grid and SHS experience. This meant that they had had a functioning SHS in the past or their SHS was still working and they had access to the grid. Three of these households were located in Mkhukhwini area (western region) within Maphephetheni, and all were in the lowlands. The average household size was 10 people (the people that were living on the premises during week days), with one exception of only 5 people (Table 2). The households included two or three generations, and included orphans and cousins. Of these 10 people, an average six of them were children still going to school or too young for school. Four households had people working away from home; these people came and lived at home during the weekends or a weekend once a month and brought money with them.

These were both women and men. The average income of the surveyed households could not be determined because not all the interviewees knew the income of the different people within that household. However, in an energy audit conducted in 1998, those with a higher regular income were

Table 2: Family composition of SHS/grid households in Maphephetheni

House -hold	No. of people	M(males) / F(females)	Children at school or younger	Working away from home	Working locally – with income	SHS working
A	10	10F	7	3M	1F	No, still working but no token
B	9	9F	6	1M	-	No, battery problem
C	12	4M and 8F	5	-	2M	No, still working but not reinstalled
D	5	3M and 2F	3	1F	-	Yes
E	13	5M and 8F	10	-	2M	Yes
F	10	3M and 7F	6	2F	2M	No, battery problem

the households who purchased the SHS (Green and Erskine 1998). The price of the SHS at that time was about R3 000 (Green *et al* 1999).

All the households interviewed received their SHSs between 1996 (when the project started and 1999). Two households accessed the grid in 1998, while the others were around 2001 to 2003. There were two households (households D and E) with a working SHS's and a grid connection. In household C, the SHS was still working but not currently installed; they took it down when they were building a new house and they did not know how to put it up again themselves. Households B and F had a problem with the battery, their SHSs were not working. Household A had a working SHS but no token. Nobody could apparently provide a new token. This was a reflection of the lack of an official maintenance programme, an essential part of any rural electrification programme. The local installer passed away some time ago.

4. Objectives and methodology

The *main objective* of this study was the comparison of the usage and perceptions of solar home systems (SHS) and grid electricity of households in Maphephetheni that have or had access to both.

The *specific objectives* of the study included the following:

1. To compare the equipment connected to both systems;
2. To compare the satisfaction level of households for both systems;
3. To compare the changes of lifestyle when accessing the grid; and
4. To identify whether households see SHSs as an inferior energy source.

Methodology

All the households with a grid connection and a (simultaneous) functioning SHS were identified in conjunction with Solar Engineering Services who installed the SHSs. These families were surveyed using structured interviews of approximately one hour duration, with some time for unstructured discussion to express feelings about the usage of the

different kinds of energy sources. There was a warm welcome in most of the families and they loved to talk about the subject. The interviewees were all female and, most of the time, were female heads of households with help from one of their daughters.

5. Changes in lifestyle

Everyone answered 'nothing' to the direct question, "What has changed since you were connected to the grid?" Is this true or will we find something different when we ask more specific questions about their daily lives?

Equipment connected

While using only the SHSs, all households had a black and white TV, radio and lights connected to the SHS system. Only the number of lights was different per household: this could be two or three. All households continued to use their SHSs for lights after they were connected to the grid. The TV and radio were now connected to the grid and most families (4) bought a colour TV after they accessed the grid.

Other new equipment purchased since they accessed the grid was a kettle (4 households), a cell phone charger (4 households), an iron (2 households) and a video recorder (1 household). This reflected a substantial number of purchases for six households.

Before, with the PV panel, all households had only one or two buildings with lights inside. Since the households were connected to the grid, there were two households that mentioned one building without lights, but in both cases these were shacks. All the other buildings within the household had lights inside, and most of the time there were one or even two lights outside on the property that were functioning from the grid. Differences in the quality of light were not mentioned, but then the improvement from candlelight to any electrical light is far greater than between the types of fittings.

Refrigeration

A remarkable finding was the changes regarding refrigerators. Five households previously possessed

a refrigerator working on gas and then connected the fridge to electricity instead of gas. This reduced the need to purchase gas and provided the same service. Only one family had bought a fridge in the period since accessing the grid.

Cooking

While all the households interviewed had electricity, none of them used this as the main source for cooking. For one family (A) biogas was the main source, with paraffin as secondary source and electricity came in third place. One other family cooked on gas, while the remaining four families still cooked on paraffin and sometimes fuel wood. Three of these four families mentioned owning an electric stove, but they all said they hardly used it because it would use too much energy and it would be expensive.

Water heating

All families used paraffin or fuel wood to heat water in the past; household A with a biogas digester now used the biogas to heat the water. All the other households still used paraffin to heat their water, three of these five families used an electric kettle to heat the water for tea and one household used the kettle to warm bath water for the father.

Personal vision

All the female heads of households reported that nothing changed as regards doing homework; the children had light in the evening when they had (only) the SHS and the time they spent on homework did not change with the grid connection. The same thing was said about entertaining friends or other social activities. For all these things, light was the most important source and it did not matter which source provided this.

6. Financial impacts

One of the great advantages reported of the SHS was that the generation of electricity was free; one buys the system and one is set for free electricity. All the surveyed households had the SHS before they accessed grid electricity, and they were now used to the free electricity. This resulted in five households complaining about the monthly costs of their grid usage. Only household F did not complain about the costs. Even the households A and B for whom it is easy to pay for the grid usage (see Table 3), complained about the monthly amount (they all have pre-pay systems). However, costs indicated that all households used more electricity than the SHSs could supply.

Head of household A told us that the wide variation in monthly costs was because of the children. When nobody was watching, they sneakily used the electricity for cooking and baking. They have had discussions about this but the children keep on

doing this and it is difficult to control.

Another household (F) stated that especially the iron and the kettle took a lot of energy and they tried to save a bit by reducing their usage of them. The problem was that these instruments may be relatively cheap to purchase, but they use a lot of energy compared to more expensive purchases like a TV, so that in the long-term, these appliances were much more expensive than they seemed. Grid electricity seemed to make people more aware of energy efficiency requirements.

Head of household E reported that they only obtained the grid connection for their children. She did not like TV or radio; she does not use the grid at all. One of the reasons for this was that every time they used the grid electricity too much, her husband yelled at her and the children. He got angry with them because it would increase the costs. This family mentioned their high grid costs, which could be explained by the fact that they also had the most equipment connected to the grid.

7. Satisfaction level

As mentioned before, urbanites and decision makers often see SHS as an inferior energy source. What do households that have experience with both grid and SHS say about this subject? We asked all the families and the results are shown in Table 4.

Three families preferred the SHS, two families were indifferent about the two systems and one family preferred grid electricity. It is good to link this information with Table 1. Is the system they prefer linked to the fact that their SHS is still working or not? No, Table 4 shows that there is no connection between these aspects. Two of the families that preferred SHSs, had a non-working SHS at that moment (but not 'broken'), while the remaining one's SHS worked. The two families that were indifferent about the SHS and grid electricity had one working SHS and one non-functional SHS, so there was no connection between a working SHS and preferring the SHS.

The main reason why people preferred the SHS above the grid electricity seemed to be financial. All three families that preferred SHSs mentioned money as the main reason; the electricity from the SHS was now free while the costs of the grid usage could, unnoticed, increase to high amounts. There seemed to be no link between ease of grid payments and preferences. People who said they struggled with paying for the grid did not all prefer the SHS, and of the people who did not struggle to pay, not all preferred the grid. There was a mixed response, so it is not really only a matter of finance.

Another reason to prefer the SHS was that the grid did not always function well. When it rained or when there was bad weather, sometimes the grid failed to work. There were even power cuts without any reason, which could take up to a week to be

Table 3: Monthly costs for the grid connection according to the female heads of households

Family	Costs per month (R)	Easy to pay for the grid usage?
A	50-100	Yes
B	50	Yes
C	110-120	No, it is very difficult and sometimes they have to go back to candles (that is why they want SHS back)
D	30-50	No, but then they have the SHS working
E	140	They struggle, but have the SHS as backup
F	50-100	Yes

Table 4: Which do you prefer, SHS or grid electricity?

Family	Preference	Reason (some quotes)	SHS working	Easy to pay for grid usage?
A	SHS	'You can't trust the grid, it often falls out, and especially when it rains, there is no electricity while the SHS is always working..'	No, still working but recently no token available	Yes
B	Indifferent	'Both have their own advantages and problems, I do not think one is better than the other one.'	No, battery problem	Yes
C	SHS	This family struggles with paying the grid costs, they even have to go back to candles sometimes, they really like the SHS because it always works well and it means free electricity.	No, still working but not reinstalled	No
D	Indifferent	'I just love both'	Yes	No,
E	SHS	Because of the money, SHS is free and is always working and grid costs get high without noticing. Besides that she just does not like the grid, her husband will yell at her and the children if they use it too much.	Yes	No
F	Grid	It never gives problems and now they're able to watch TV the whole day.	No, battery problem	Yes

restored. However, the results in Table 4 reflect the poor levels of maintenance of the SHSs. This reinforced the opinion that there was little difference between the systems; that maintenance was not a major issue when assessing satisfaction. The maintenance of the SHSs may have seemed more within their control; they knew who to report to.

Another reason for preferring the SHS was family arguments. As mentioned before in family E, the husband got angry if the women and children used the grid electricity too much. Family A also mentioned some discussions between the elders and the children about the (ab)usage of the grid. Using pre-pay systems does not seem to help limit grid electricity usage.

Family F preferred the grid because they had some problems with the functioning of the SHS (especially during rain). They also loved the fact that they were able to watch TV for the whole day now.

All families with a non-functioning SHS wanted their systems back, even family F who preferred the grid, wanted their SHS functioning again. They

might prefer the grid but the system was theirs and free electricity is always welcome.

8. Conclusions

For these low-income households who felt that they could not afford to cook using grid electricity, there were few major or obvious differences reported through using a SHS and accessing the grid. However, one should bear the smallness of the sample in mind.

The head of the households themselves did not have the feeling that anything changed for them once they installed a grid connection although certainly some things did change. After they accessed the grid, they had lights in almost every building instead of only in one building. There were more security lights outside on the property. Additional equipment on the grid included battery chargers, colour TVs, irons and kettles. There was even one household with a video recorder.

Although in earlier surveys people mentioned they wanted to use grid especially for cooking, very little changed regarding bulk water heating and

cooking. Most families still used the same sources of energy for cooking as before, mostly paraffin. They only used the grid connection sporadically for these purposes. The main change was from refrigerators running on gas to electricity, which reduced the variety of energy sources. In addition, there was neither more homework done nor more social activities enjoyed since the grid connection.

SHS was definitely not seen as an inferior electricity source in Maphephetheni. The households were very satisfied with their SHSs and reported that they worked well on the whole. On the other hand, there were grid power cuts fairly often that took time to restore. People appreciated their solar home systems and wished they could have more to put the colour TV and other equipment on. Nobody mentioned here that they wanted electricity for cooking. Half of the families included in the survey preferred the SHS to grid electricity, and two families were indifferent about it, they just liked both. Only one family preferred the grid electricity.

One thing that could be improved about the SHS was the maintenance and repair. There was no technical knowledge within the households, and if they reported a failure it could take up to 5 years (Family C) before 'they' came to check or fix it.

Of course, all these SHSs had been purchased over time. The findings may well not be the same when compared to a fee-for-service PV system rather than an owned system.

References

- ABB (Asea Brown Boveri Ltd). 2003. Access to Electricity: Bring the benefits of electricity to people who still have no access to electricity. URL: www.abb.com (Accessed May 2004).
- Cawood, W. And Simelane, R. 2004. Solar Engineering Services. Solar Engineering Services homepage. URL: www.solarengineering.co.za (Accessed June 2004).
- DME (Department of Minerals and Energy). 2003. *White Paper on Renewable Energy*. Pretoria: Department of Minerals and Energy.
- EIA (Energy Information Administration). 2002. South Africa: Environmental Issues, Official Energy Statistics from the U.S. Government. URL www.eia.doe.gov/cabs/safrenv.html (Accessed June 2004).
- Eskom. 2004. Eskom homepage. URL: www.eskom.co.za (Accessed June 2004).
- Green, J M, Wilson, M, & Cawood W. 1999. Maphephethe rural electrification (Photovoltaic) Programme: The constraints on the adoption of Solar Home Systems. *Development Southern Africa*, 18 (1): 19-30.
- Green, J M & Erskine, S H. 1998. An Energy Audit of Maphephethe: assessing present energy usage patterns as a precursor to the introduction and expansion of alternate energy sources. University of Natal, Pietermaritzburg.

- Green, J M & Wilson, M. 2000. The impact of domestic solar energy on development and quality of life in Maphephete, rural South Africa. *Proceedings of the Domestic Use of Energy Conference, Cape Town*, pp. 153-158.
- Karotti, R. and Banks, D. 2000. PV power and profit - Electrifying rural South Africa. *Renewable Energy World*, 3(1): 50-59.
- Martens J W, De Lange T J, Cloin J, Szewczuk S, Morris R & Zak J. 2001. Accelerating the Market Penetration of Renewable Energy Technologies in South Africa. Energieonderzoek Centrum Nederland (ECN).
- Ndokweni, M F & Green, J M. 2003. Maphephetheni household survey report. Community Resources, University of Natal, Pietermaritzburg.
- NER (National Electricity Regulator). 2001. Electricity supply statistics for South Africa 2001. URL: www.ner.org.za/stats/statistics_kwazulu.htm, (Accessed May 2004).
- Prasad, G & Ranninger, H. 2003. The social impact of the basic electricity support tariff (BEST). *Proceedings of the Domestic Use of Energy Conference, Cape Town*. pp17-22.
- RAPS (Rural Area Power Solutions). Undated. RAPS Utilities. URL: <http://www.raps.co.za> (Accessed August 2004).
- Wiersma, S, Kempenaar, L, Singh, D & Witherden, M. 1999. Renewable energy development and training centre, Solar / LPGas hybrid system at Myeka high school, Durban Institute of Technology. URL: <http://mzone.mweb.co.za/residents/inl0347/myeka310.htm> (Accessed June 2004).

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