SUPPORTING INNOVATION IN THE DELIVERY OF ENERGY SERVICES TO THE RURAL POOR:

OFF-GRID ELECTRIFICATION VIA CONCESSIONS IN RURAL SOUTH AFRICA

Solar electrification by the concession approach in rural Limpopo province

PHASE 1. BASELINE SURVEY

April 2005

ENERGY RESEARCH CENTRE

University of Cape Town

Executive summary

The Energy Research Centre (ERC) at the University of Cape Town has been involved in a research project to monitor, evaluate and support the off-grid electrification programme initiated by the Department of Minerals and Energy in 1999 in three provinces of South Africa. The energy service company (ESCO) approach, where a company installs and maintains solar home systems for fee-paying clients was selected. Private companies were granted exclusive concessions to operate as the energy service companies in the selected areas. A government subsidy was provided to reduce the connection and service fees payable by the users.

The three concession areas are in the northeast of KwaZulu Natal province, the northern part of Limpopo province, and the northern part of Eastern Cape province. ERC has been working in these concession areas since May 2001, principally through conducting surveys with the aim of understanding the social impacts and the installation and functioning of the solar home systems in order to inform relevant stakeholders.

This report is part of a series on the impact of the solar home systems. The first report[1] dealt with the first survey results from Eastern Cape Province. Following the above first set of reports, a second set of follow-up reports based on subsequent surveys in the three provinces will be prepared. The second set of reports will explore the trends over the last two to three years following installation of the solar home systems. A summary report will conclude the series and will compare the findings from the three provinces.

The *general background* to the evolution of government policy on providing universal access to electricity, and the integration of solar electrification is provided in the first report as well as a number of papers and articles.

The objectives of the household surveys.

The household surveys aimed to explore the impacts of solar home systems over time, ascertaining the nature and extent of any fuel switching associated with the solar home systems, impacts on rural livelihoods, and attitudes of households exposed to solar home systems

A total of 280 households were interviewed in the survey for this report. 121 of the households were solar home system-electrified, 45 were grid-electrified, and 114 were non-electrified. The grid-electrified and non-electrified households were used as control groups. All the households are in Duvhuledza, Tshamutilikwa, and Mbahe.

Characteristics of the households surveyed

Solar home system users were found to be the wealthiest; the mean monthly income for solar home system users was found to be R1543, compared to R1163 for grid users and R819 for non-electrified households. That solar home system users should have the highest mean monthly income is not surprising because to qualify for these systems they had to have regular income. The mean monthly per capita income showed a similar pattern, being highest for the solar home system-users. The household size of solar home system-users was found to be the largest, which was unexpected since wealthier households tend to be smaller. The reason for this may be the presence of more relatives at these wealthier households. The trend between the other sub-samples is more conventional, with the poorer non-electrified households having larger household sizes.

Installation of the solar home systems

Installation for solar home systems were found to have been quite prompt, with over 80% of respondents getting their systems installed in one month or less following application. Grid users had to wait longer, which may be the result of the more extensive infrastructural developments that have to go with grid extension. Solar home system-users were largely satisfied with installation of their systems.

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[1] ERC. 2004. Solar Electrification by the Concession Approach in the Rural Eastern Cape: Phase 1. Baseline Survey.

Customer satisfaction and ambivalence
By far the most liked feature of solar home systems was better light. Some ambivalence in attitudes can be expected since there are clear benefits and some frustrating limitations that come with solar home systems. The frustration is compounded by initial ignorance of the capabilities of PV based systems. The expectation that the grid will be coming and the overwhelming preference for grid electricity contribute to the ambivalence.

The inability of solar home system to meet thermal needs such as cooking is one of the technology's greatest shortcomings considering the importance of this service. Most solar home system owners seem to be unaware that grid-users face a similar dilemma in that the cost of grid electricity precluded some 80% of them from using electricity for cooking.

Problems with the solar home systems
About 40% of solar home system-users had had a problem with their systems. A similar percentage (37%) felt they were able to identify the problem and virtually all had reported the problems. The reports were generally made to the energy store, but a few respondents reported to the chief, the technician, and the fee collector. How reliably or promptly these reports reached the service provider is not clear. 16% of the problems were unresolved at the time of the survey, but it is not possible to say for how long the problems had been outstanding.

Solar home system-users pay much more than the other households in the other sub-samples and they were frustrated by this high cost. Their main suggestion for making payment easier was to reduce the service fee. Another major concern was the limitation in both what can be used with solar home system, the number of rooms that could be supplied with power, and the time limitation on power availability. The need to purchase other fuels adds to the cost of energy for solar home system households.

Cost, limited power and the cost of other necessary fuels
Solar home system users pay much more per month(R128) than the other sub-samples for their energy, a figure more than twice as much as grid-users (R59) who spend the least on energy among the three sub-samples. Solar home system-users are the only sub-sample with a mean monthly expenditure on energy that is above the overall mean of R93. The service level received by grid users is practically unlimited for household level needs.

Solar home system-users have to spend an additional R70 for other fuels on top of the R58 paid for the solar home system each month. 68% of them thought they should be paying no more than R30 per month for the service, which would be comparable to what grid users pay on average for their electricity.

The cost of fuels
Gas and fuelwood were found to be particularly expensive for the households who used them. Fuelwood was collected free by some 95% of households. Gas was more prevalent among solar home system-users because their incomes allowed them to use this expensive fuel. The mean monthly expenditures by solar home system-owners using the specified fuels were found to be about R21 on candles, R42 on paraffin, R129 on gas, R73 on fuelwood, R46 on dry cell batteries, and R11 on car batteries (charging).

Changes in fuel use after receiving solar home system or grid electricity
The major impact on fuel use was reduction in the use of lighting fuels, candles, and to a lesser extent paraffin. Because solar home systems cannot usually cover all rooms, candles and paraffin continue to be used for the other rooms and also when the solar home system cuts out. No impact had been made to the fuels supplying most household energy, i.e. those fuels meeting the thermal needs, mainly cooking, water heating, and space heating. Thus, the range of fuels used by solar home system-owners has not been altered. The need for supply of these fuels more conveniently still needs to be addressed.

Changes in people's lives

It has been stated that improved lighting was the major impact of solar home systems on households. This means that even without solar home system, lighting is possible, albeit at an inferior level. The other major impacts have been in information and entertainment through watching television and listening to the radio with greater convenience than would be the case with car batteries, or dry cell batteries. The overwhelming preference for grid electricity however indicates that solar home system-users are not yet content.

The satisfaction of grid-users, shown by their very limited desire to switch to any other fuel confirms grid electricity as the 'ultimate' source of energy for most households.

The reach of solar home system is generally limited to the more affluent rural households who can meet the service fee requirements. This is likely to remain the case into the foreseeable future as long as users must pay for the service.

Key questions and issues

The dissemination of information to potential solar home system users needs to be improved so that all the characteristics of the technology are well understood. The way in which information is packaged needs to be appropriate for the level of literacy of the intended consumer of the information.

The issue of ownership of solar home system needs to be addressed in the long term. Perhaps an arrangement whereby the ownership of the solar home system passes to the household, coupled with training of local freelance technicians with a system of certification may be useful.

That solar home systems fail to reach the poor households is a good case for an integrated approach with a focus on poverty reduction. This approach will entail collaboration across many development arms of government and other non-governmental stakeholders. The targeting of the subsidy to ensure access by the poor is a major challenge.

The approach of clustering of installation of solar home systems needs to be emphasized more as one way to reduce the cost of maintenance and thereby improve access and service to customers by the service providers.

The prospects of the grid reaching target areas for solar home system dissemination need to be frankly communicated to avoid a wait-and see attitude among users, and to avoid bitterness among those who accept solar home systems only to see the grid arrive soon afterwards. This can lead to a sense of having been cheated.

Policy recommendations

The dissemination of information needs to be refined so that information is packaged in a way that makes the information easily accessible to the target group. The level of literacy is not high so important documents like contracts and user manuals have to be suitably simplified. Contracts are legal documents and are necessarily complex, but there is no reason why short, plain language versions cannot be provided as well to enable the gist of the conditions to be understood. Examples of this approach are the South African Lotto pamphlets, or most online computer software licence agreements where the reader is given a simplified plain language version of the terms with the option of seeing the full details if he/she wishes.

The process of selecting areas where solar electrification is to be introduced needs to be reviewed. The question that needs to be answered is whether there will be grid electrification of all rural households; and if so over what period. Priority should be given to those areas with the remotest chance of being grid electrified, and this should be officially made clear to the recipients. Introducing solar home systems where users have been told that the grid is coming in a few years causes confusion and frustration for both service providers and users.

Consideration needs to be given to the setting up of fora for the exchange of experiences and ideas between service providers, and similarly for recipients of solar home systems and the technicians serving them. Exchange visits would be a useful way to facilitate exchange of experiences between communities.

If solar home systems are meant for the rural poor, the results so far show that they are reaching the wealthiest rural households. Are these households the best recipients for subsidies? Attempts to introduce cheaper systems by reducing their size are not likely to succeed since more frustration will result from the even lower service level. It has been established that the current service level of solar home systems is frustrating owners, yet they feel that the fees are too high. Higher capacity systems will cost more and become even more the preserve of the rural elite. Increasing capital subsidies may allow poorer households access, but will they be able to pay the costs of maintenance and repair? It may well be asked if solar home systems are what the poor need. Often there are many more pressing needs, and an integrated and bottom up approach to the planning of service delivery may address the problems more successfully.

There seems to be a case for the exploration of ownership schemes for solar home systems. This is because there is as yet no sure recipe for successful dissemination, and not enough information is available internationally to prescribe a winning approach.

The fact that there are many lessons and need for corrective steps points to the need for pilot schemes so that lessons are learnt before full scale implementation is attempted. This will contain costs and result in less frustration for both service providers and users.

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Acknowledgements

We acknowledge the advice and many discussions held with the DME and the NER in the course of this research.

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Our special thanks must be extended to Solarvision and their staff who devoted much of their time to answering our questions and keeping us informed of the Company's development. They provided invaluable assistance in locating a large sample of their customers and assisting us with the initial visits in 2002 and return visits made in 2004.

We also thank the Outlet staff for their help.

Our special thanks go to the team of interviewers who had to work exceptionally hard, to the community leaders who gave us much of their time and to all the households who so generously provided the answers to a large number of questions.

We must extend our thanks to the research team, especially to Nthabiseng Mohlakoana and Jocelyn Muller who prepared and assisted in not only the long field trips but assisted in the training of interviewers and the data capture. Margaret Matinga assisted in the initial stages of compiling the report.

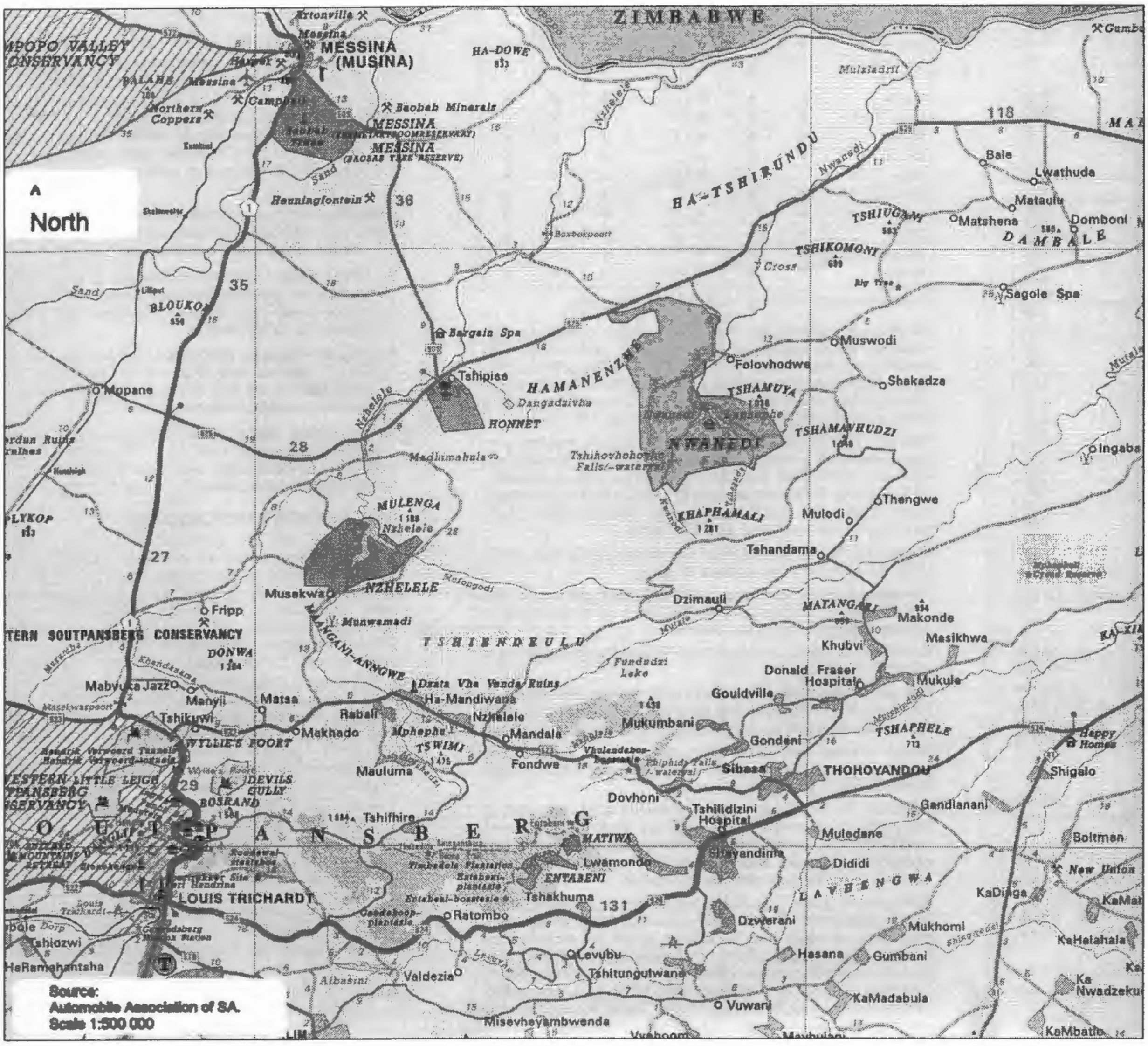
Our thanks go to all members of the research team that was led by Gisela Prasad and Bill Cowan. Gisela Prasad deserves particular mention for providing detailed comments for the improvement of the draft report. Hazel Ranninger did much to provide the template and valuable guidance on which this report is based.

The research would not have been possible without initial funding from the Shell Foundation and our gratitude goes to the Foundation for its initial support.

Last but perhaps most of all thanks must go to the local leadership and households in Limpopo province who make this type of research possible by willingly receiving the research teams and submitting to exhaustive interviews. We hope that our endeavours will contribute to the delivery of better services that more effectively meet their needs.

Maxwell Mapako was responsible for the data analysis and writing of this report.

Map of part of Limpopo province, showing survey areas



Scale 1:500 000

Source: Automobile Association of South Africa, 2003

The survey areas are around Thohoyandou. Some of the local place names mentioned in survey questionnaires and shown on the above map include Sibasa, Nwanedi, Tshamavhudzi and Folovhodwe.

1. Introduction

The Energy Research Centre (ERC) at the University of Cape Town has been involved in a research project to monitor, evaluate and support the off-grid electrification programme initiated by the Department of Minerals and Energy in 1999 in three provinces of South Africa. The energy service company (ESCO) approach, where a company installs and maintains solar home systems for fee-paying clients was selected. Private companies were granted exclusive concessions to operate as the energy service companies in the selected areas. A government subsidy was provided for to reduce the connection and service fees payable by the users.

The three concession areas are in the northeast of KwaZulu-Natal, the northern part of Limpopo province, and the northern part of Eastern Cape Province. ERC has been working in these concession areas since May 2001, principally through conducting surveys with the aim of understanding the social impacts and the installation and functioning of the solar home systems (SHSs) in order to inform relevant stakeholders.

This report is the second in a series of planned reports on the impact of the SHAs and is based on the July-August 2002 survey results of the 'First monitoring of Solarvision project in Limpopo Province'. The first report (ERC 2004) dealt with the first monitoring survey results from Eastern Cape Province.

The *general background* to the evolution of government policy on providing universal access to electricity, and the integration of solar electrification is provided in the first report as well as a number of papers and articles (a detailed account is given by Afrane Okese and Thom (2001)).

2. Socio-economic context of rural electrification in Limpopo province

The Limpopo Province is situated in the North-eastern part of South Africa. The province also borders Botswana to the west and north-west, Zimbabwe to the north, and Mozambique to the east and Gauteng province in the South. The province covers an area of 123 910 square km which is 10.2 % of national land area. The population of Limpopo province was 5 273 647 in 2001 (2001 Census).

Agriculture is the mainstay of the province's economy and the province also has a budding tourism industry due to its array of wild life and nature reserves.

Another significant economic resource is mining, with major mineral deposits including platinum group metals, iron ore, chromium, high and middle grading coking coal, diamonds, antimony, phosphate and copper as well as mineral reserves like gold, emeralds, scheelite, magnetite, vermiculite, silicon and mica among others.

2.1 Samples and sub-samples of SHS users, grid-users and households without electricity

The 280 households interviewed were selected from three communities, Duvhuledza, Mbahe and Tshamutilikwa, located roughly in the central part of the map. Table 2.1 presents the numbers of households interviewed in each community.

Table 2.1: Number of households interviewed in different communities in Limpopo province

Community	*Non grid solar*	*Grid electrified*	*Non electrified*	*Total*
Duvhuledza	32	0	23	55
Mbahe	21	22	45	88
Tshamutilikwa	68	23	46	137
Total	**121**	**45**	**114**	**280**

2.2 Income[2] levels of different sub-samples, sizes of households and per capita income

The overall mean income for all households was R1245 with a median value of R950, standard deviation R944. The difference between the mean and median suggests a skew in the income distribution. This is confirmed in Figure 2.1; the income pattern shows a pronounced negative skew, indicating that most households are towards the lower end of the income scale, with very few enjoying comparatively high incomes..

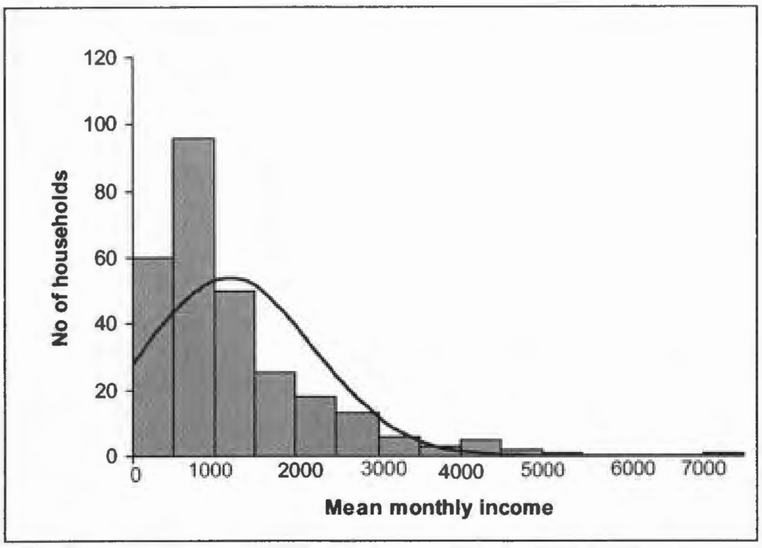


Figure 2.1: Mean monthly income of all households

Mean income according to sub-samples

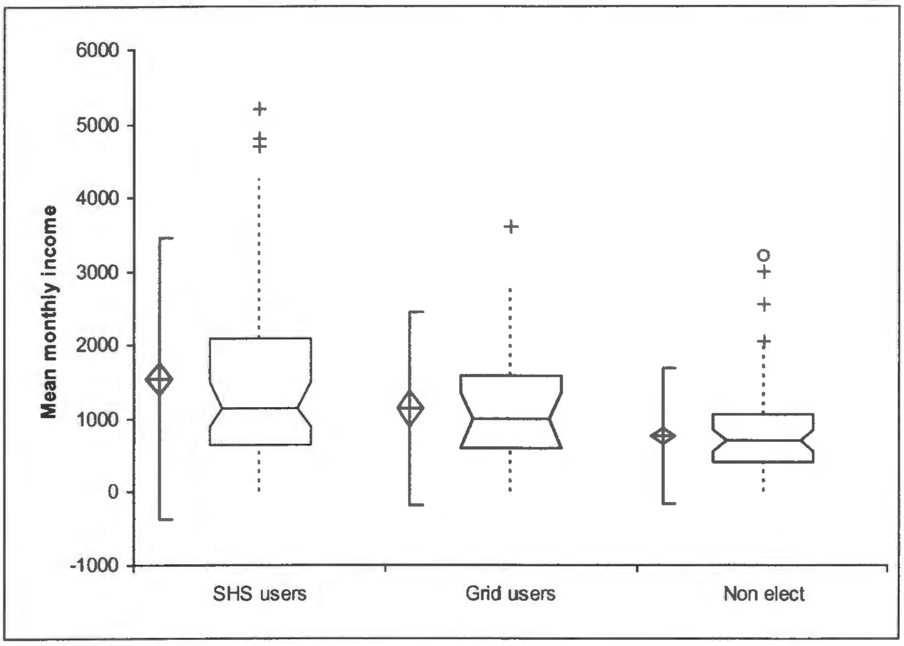
SHS-users have a mean income that is above the R1 245 mean for all households covered in the survey, and is almost double that of the non-electrified households.

Table 2.2: Mean income (rand) according to sub-samples

	Minimum	*Maximum*	*Mean*	*SD*
SHS users	150	5200	1543	1163
Grid users	60	3600	1134	799
Non electrified hholds	100	3200	819	823

The mean incomes can be more easily compared in Figure 2.2. The data is presented in box plots and both mean and median values can be seen as well as the incidence of outliers (extreme values). The more numerous outliers among the SHS-users pull the mean further from the median (most common value) more than in the other sub-samples. Far outliers (see note to Figure 2.2) have been excluded from the plots in this figure.

2 All income and expenditure figures in this report are in South African rands (ZAR) unless indicated otherwise.



Note: Explanation of box plot figures

The vertical lines with diamonds show the mean value across the centre of the diamond, with the confidence interval (95%) shown by the vertical spread of the diamond.

The boxes show the median value as the middle horizontal line, with the angled portion showing the confidence interval. Box height shows the inter–quartile range, IQR (upper, lower).

Outliers are plotted as ---- up to 1.5 IQR from the median, +++ from 1.5 to 3 IQRs from median, and oooo if further than 3 IQRs from the median (far outliers).

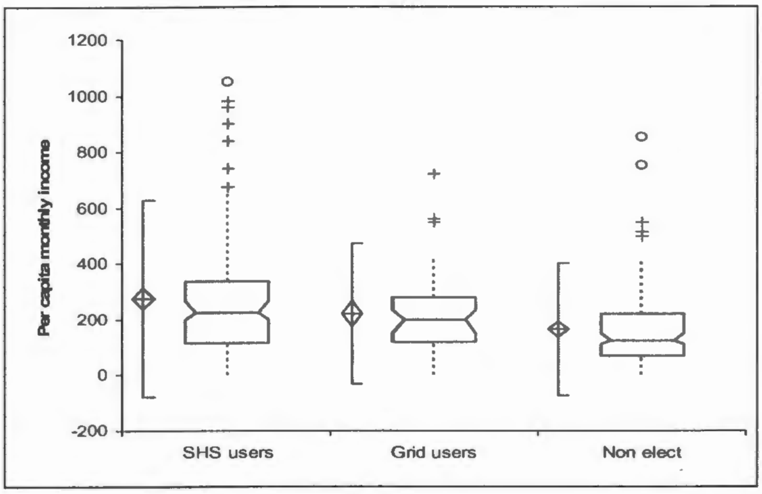
Figure 2.2: Comparison of mean income according to sub-samples

SHS owners enjoy the highest mean incomes, and the non-electrified households the lowest. This pattern can be largely explained by the selection criteria for households to qualify for SHSs, a regular income.

The sizes of the households in the three sub-samples are shown in Table 2.3. The SHS-users have the highest mean size, with the grid-connected households having the smallest family size. While the trend in household size between grid-users and non-electrified households tends to follow the conventional norm where poorer households tend to have larger family sizes, the apparent anomaly with respect to the SHS users needs to be explored further.

Table 2.3: Household size according to sub-sample

Sub-sample	*Minimum*	*Maximum*	*Mean*	*SD*
SHS users	1	10	6.157	2.56
Grid users	1	6	5.200	2.22
Non electrified households	1	4	5.702	2.59



Explanation of box plot figures.

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Figure 2.3: Comparison of per capita monthly income across sub-samples

The per capita monthly income follows a similar trend to that of total monthly income. That SHS-users still show the highest per capita income despite their mean family size being the highest underlines the margin by which they exceed the incomes of the other sub-samples. The grouped means of per capita income are compared in Figure 2.4.

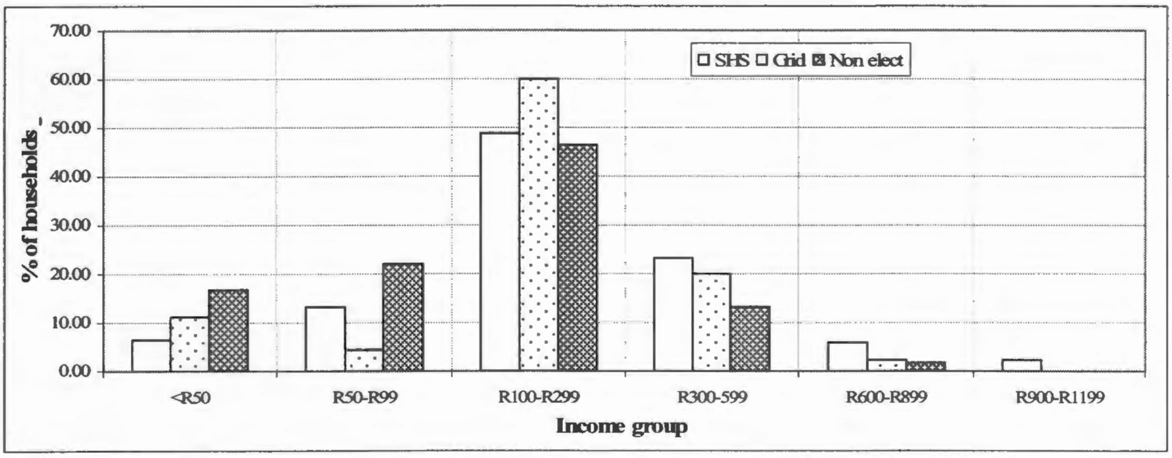


Figure 2.4: Grouped per capita monthly incomes of all three sub-samples

Though in all cases the most dominant income category is R100-299, income groups lower than this are dominated by the non-electrified households. SHS-users dominate all income categories above the dominant R100-299 one, and the trend whereby the incomes taper downwards from the SHS-users to the non-electrified households is clear in the upper income categories. The opposite trend is observed in the lowest (<R50) income category.

The mean per capita incomes given in Table 2.4 again illustrate the trend, with the non-electrified households having a mean income well below the other two sub-samples.

Table 2.4: Mean per capita income (Rands) according to sub-samples

	Minimum	*Maximum*	*Mean*	*Std Dev*
SHS users	19	1 050	276	215
Grid users	26	2 280	220	153
Non electrified households	19	850	164	144

2.3 Sources of Income

Because of the need for regular incomes to be able to pay monthly for SHSs, it is not surprising that the predominant sources of income among SHS households are salaried jobs, pensions and state grants. Table 2.5 summarises the sources of income by sub-sample.

Table 2.5: Sources of income according to sub-samples

Income sources	*SHS users N= 121*	*Grid users N= 45*	*Non-electrified households N= 114*
Regular earnings salary/wages	74%	56%	54%
Pensions and state grants	36%	44%	52%
Own business	8%	18%	3%
Piece jobs	7%	18%	24%
Informal selling	6%	9%	24%
Note: Percentages in this table do not add up to 100% because each household could indicate multiple sources of income			

Grid users and non-electrified households have lower but similar figures for income from salaries and wages, but differ in that the grid-users have the highest 'own business' figure. The survey did not explore the specific business activities in this case, but these could include electricity-dependent activities that are only possible for this sub-sample. Non-electrified households have the highest 'informal selling' figure, and depend considerably on this and piece jobs when compared to the other sub-samples.

Table 2.6: Highest education level of household head according to sub-samples

Highest education level of household head	*SHS users N=121*	*Grid Users N= 45*	*Non-electrified households N= 114*
No school	34%	42%	46%
Primary	9%	9%	21%
Secondary	23%	20%	19%
Matric	12%	13%	11%
Post-matric	19%	13%	3%

In all cases the proportion of household heads who did not go to school is higher than any other education-related category. There is also a clear trend from SHS-users to non-electrified households with the percentage of households heads who did not attend school rising from 34% to 46%. On the other hand, the trend for the most educated household heads goes in the opposite direction. This trend correlates well with that for income and formal employment, which is not surprising.

Table 2.7: Age categories of household head

Age categories	*SHS users N=121*	*Grid Users N= 45*	*Non-electrified households N= 114*
18-29	7%	9%	8%
30-44	41%	38%	33%
45-59	32%	31%	33%
60+	19%	20%	24%

The dominance of the young-to-middle-aged household heads (30-44 and 45-59 age groups) is quite similar between the SHS-users and grid-users, both showing a pronounced majority of younger households heads. The non-electrified households show a more even spread between the ages of 30 to over 60. Like the other sub-samples, the proportion of household heads is lowest for the under 30 age group. The observed differences in the sub-samples are not particularly marked and no explanation is immediately obvious.

2.4 Gender of household head

The SHS-users have the highest proportion of male-headed households, 83%, while the other two sub-samples have similar and much lower figures, 64% for the grid-users and 61% for the non-electrified households. On the basis of income, the SHS-users have been found to be the wealthiest. The pattern in household heads therefore suggests that male-headed households tend to be wealthier than female-headed households.

2.5 Type and size of homestead

Although both the grid-users and non-electrified households show a marked dominance of traditional homesteads, the non-electrified homesteads show greater dominance of traditional homesteads, over twice as many as any other type of homestead. In contrast, the SHS-users show dominance of mixed traditional and other buildings. There is a modest (13%) proportion of multiple-room brick houses among SHS-users and grid-users. This category is much lower among the non-electrified households as it is more expensive than traditional structures, which are likely to be the type of homestead that the owner can build at least cost with local materials.

Table 2.8: Type of homestead

Type of homestead	*SHS Users*	*Grid users*	*Non-electrified households*
Traditional homestead	42%	58%	67%
Single/brick house with multiple rooms	13%	13%	5%
Mixture of traditional huts and other buildings	45%	27%	27%
Brick house and shack	-	2%	1%

The mean number of rooms was highest among SHS-users at 4.63 compared to 3.74 and 3.60 for the grid-users and non-electrified households respectively. The SHS-users have an extra room on average when compared to the other two sub-samples.

2.6 Employment status of household heads

Table 2.9: Employment status of household head according to sub-samples

	SHS users	*Grid users*	*Non-electrified households*
Employed	58%	49%	40%
Unemployed	15%	9%	33%
Self-employed	8%	20%	2%
Housewife	19%	-	3%
Pensioner	-	29%	21%
Disability pension	-	-	2%

Having already noted the prevalence of formal employment among SHS-users, and own businesses among grid-users from looking at sources of income, the trends shown in employment status of household heads are to be expected. The high unemployment rate (more than double that of SHS-users and more than triple that of grid-users) among non-electrified household heads partly explains the comparatively low income levels found in this sub-sample. It has already been noted that SHS-users tend to have the youngest household heads, which partly explains the absence of pensioners for this sub-sample.

2.7 Migration: Household members living away from home

This section explores the issues around the movement of household members to other areas and their impacts on household income. It is readily apparent that roughly half of the households in each category have no members living elsewhere. There is striking similarity across sub-samples in this characteristic, which may have less to do with mode of electrification than with other local factors.

SHS-users have the highest percentage of absent household heads, which may be explained by the fact that this sub-sample has the highest percentage of formally employed household heads, who are predominantly male. Formal jobs are generally available in towns. SHS-users were found to have practically no contribution to household income from non-members, and they were also predominantly not supporting absent members. Grid-users, on the other hand, have only half the percentage of absent of household heads, which may be partly due to the sub-sample having by far the highest percentage of self-employed household heads who are most likely to work locally. The sub-sample has, by a wide margin, the highest incidence of incoming remittances from outside the household. The reason for this is not obvious. Like the SHS-users, there is virtually no reported financial support of absent household members.

Non-electrified households stand out in having the highest proportion of households supporting absent members, yet this is the lowest income sub-sample. They have virtually no incoming remittances, but have already been shown to have the widest range of income sources. The identities of the absent beneficiaries were not explored in the survey questionnaire.

Table 2.10: Absent household members and related issues

	SHS-users	*Grid-users*	*Non-electrified households*
Household head absent	33%	18%	25%
% of households with no members living elsewhere	51%	53%	54%
Someone else[3] contributing to households	2%	27%	4%
Supporting absent members (child, parent)	3%	4%	11%

[3] The survey did not explore the identity of the other persons contributing to the household

3. Main end uses of various fuel/energy sources

The ownership of electrical appliances by SHS-users and grid-users is discussed in Section 7.

3.1 Ownership and use of electrical appliances

The following three pairs of charts were produced from the data presented in Appendix I. Each pair of charts presents the *main* fuels currently used, and the fuels preferred for given end uses in each sub-sample. The charts are compiled from responses to two questions: What respondents *used as their main fuel* for each end use, and the *fuel they would prefer to switch to* in each case. The percentages refer to all households in a sub-sample, not just those using a given appliance/end use.

SHS households

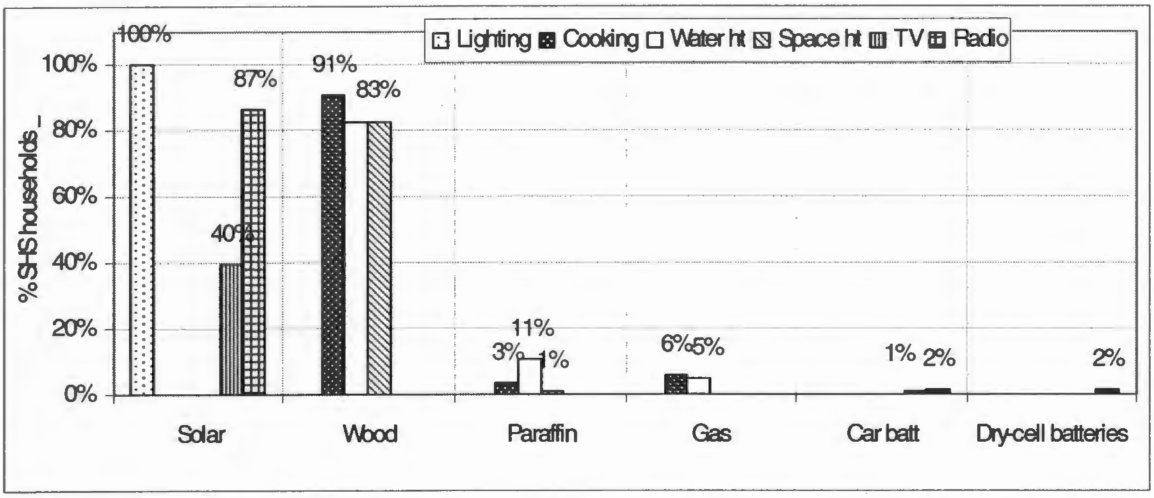


Figure 3.1: Main fuels currently used by SHS users for given end uses

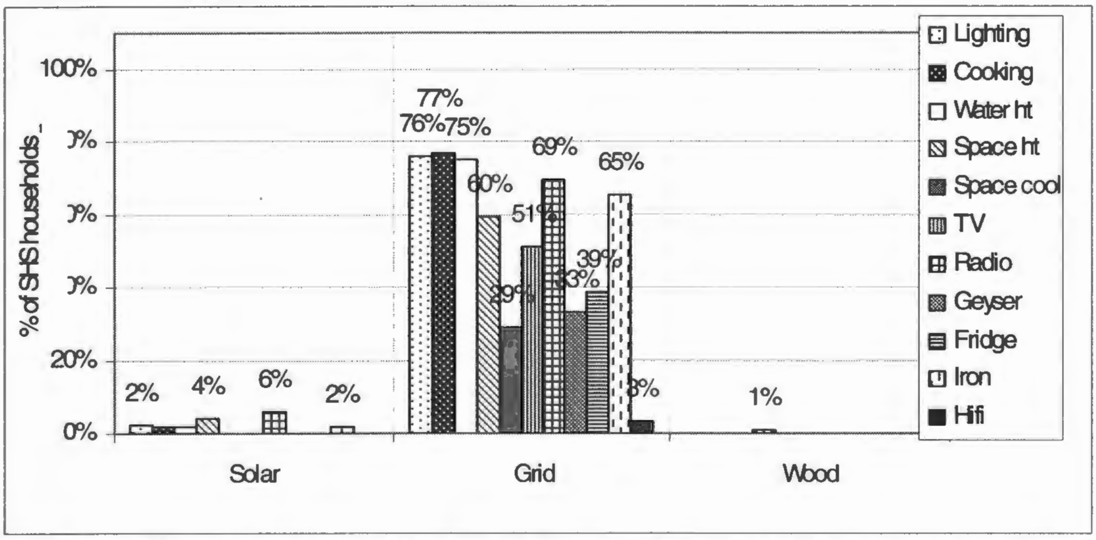


Figure 3.2: Main fuels to which SHS users would like to switch to for given end uses

Grid-electrified households

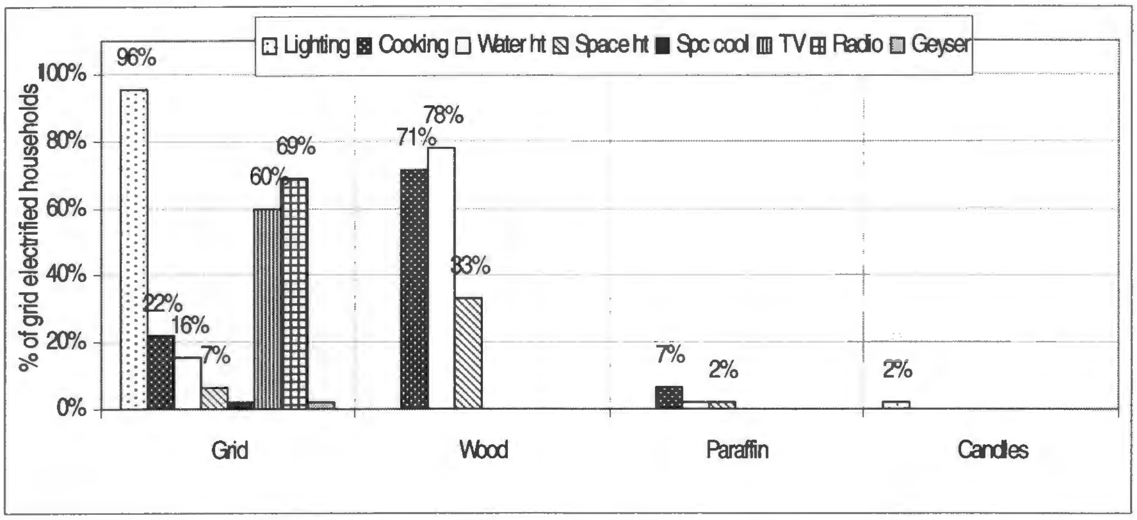


Figure 3.3: Main fuels currently used by grid users

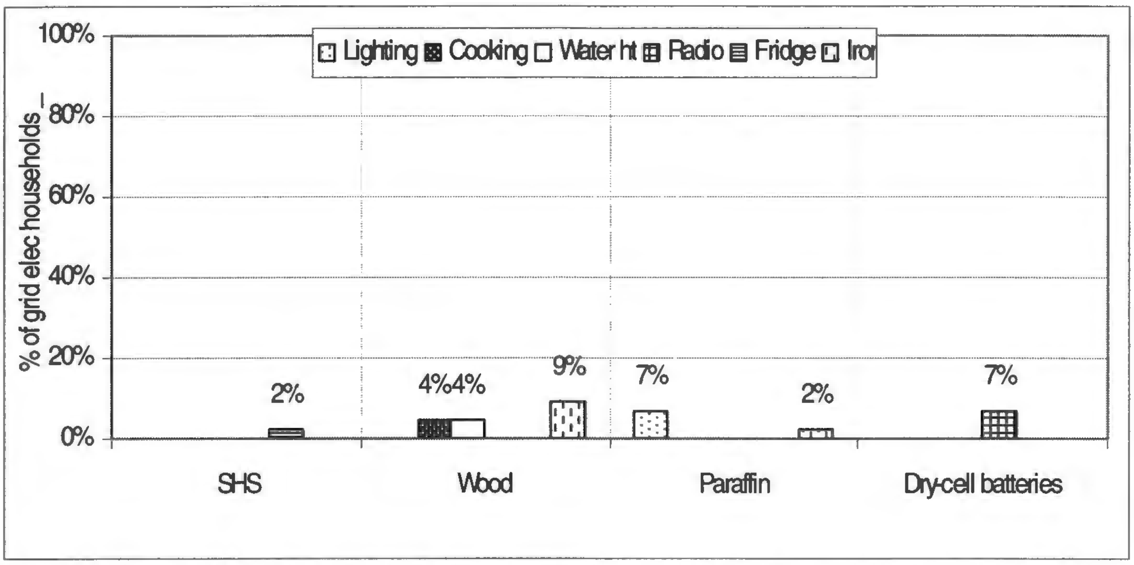


Figure 3.4: Main fuels to which grid-electrified households would like to switch to for given end uses

Non-electrified households

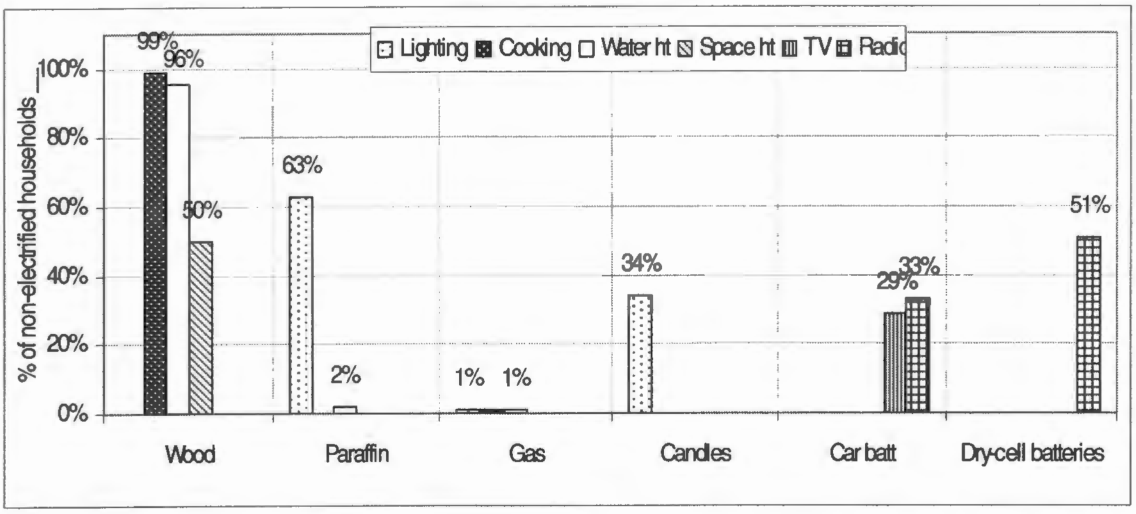


Figure 3.5: Main fuels currently used by non-electrified households

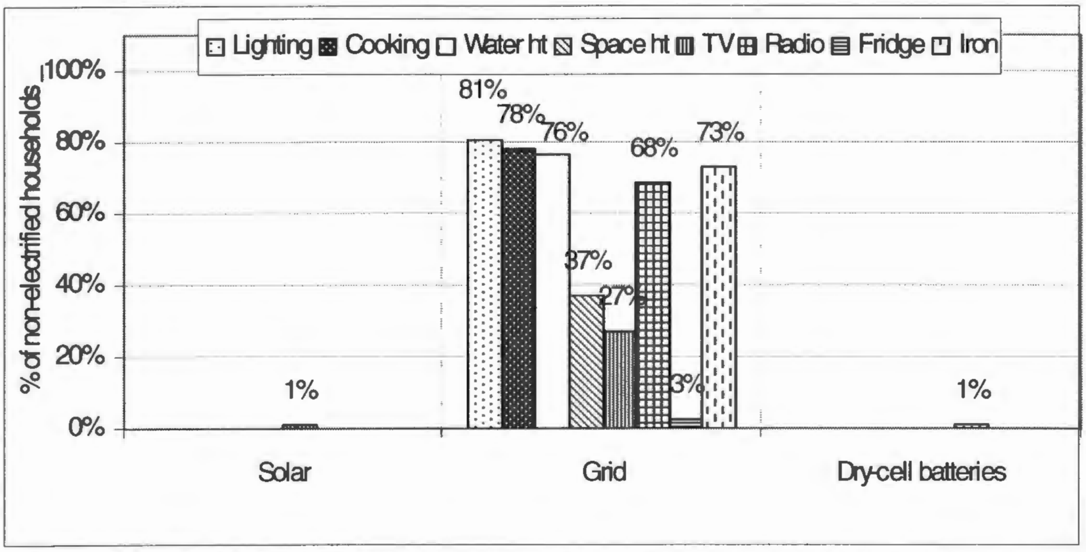


Figure 3.6: Main fuels to which non-electrified households would like to switch

3.1.1 Lighting: Main fuels presently used and fuels households would like to switch to

SHS-owners predominantly used their solar lights for lighting, but they were apparently not satisfied, because 76% preferred to switch to grid electricity, with only 2% preferring solar lighting. In contrast, 96% of grid-users used grid electricity for lighting, and none wanted to switch to solar. 7% wanted to switch to paraffin lighting; probably believing this would lessen their electricity bills.

Non-electrified households depended mainly on paraffin (63%) and candles (34%) for lighting, but, like the SHS owners, they seemed unhappy, with 81% preferring to switch to grid electricity and no other fuel.

3.1.2 Cooking: Main fuels presently used and fuels households would like to switch to

SHS owners almost all cooked with wood (91%), with very limited use of gas and paraffin (6% and 3% respectively). The majority preferred to switch to grid electricity for cooking (77%) while 2% wanted to cook with solar. This preference for cooking with solar indicates that these few households did not fully understand the limitations of solar electricity for high power applications, unless they were referring to solar thermal cookers. Wood was also the major cooking fuel for grid electrified households, accounting for 71% of the households. 22% cooked with grid electricity and 7% with paraffin. There was overall satisfaction with this fuel use pattern as evidenced by the small percentage of only 4% who wanted to switch cooking fuel to fuelwood.

Virtually all (99%) of non-electrified households cooked with wood; the remainder used gas. The percentage wanting to switch to cooking with grid electricity was similar to that for SHS-users, at 78%. No other fuel was preferred for cooking.

It is worth noting that while households without grid electricity strongly prefer it as a cooking fuel, grid-users mostly cook with wood. This is generally because grid electricity is too expensive to cook with. Households without grid electricity may not be aware of this constraint, hence their preference for electric cooking.

3.1.3 Water heating: Main fuels presently used and fuels households would like to switch to

The pattern among SHS-users for water heating fuels is quite similar to that for cooking fuels. Wood dominates other fuels by a wide margin: 83% compared to 11% and 5% for paraffin and gas respectively. Again most SHS-users prefer to switch to grid electricity (75%) with 2% expressing a preference for solar water heating.

Among grid-users, only 16% used electricity for water heating compared to 78% using wood and 2% using paraffin. There was also little desire to switch fuels among grid-users, with only 4% wanting to switch to wood.

The non-electrified households had the highest wood usage for water heating, 96% with 2% using paraffin and 1% using gas. The desire to use grid electricity was still very pronounced, with 76% wishing to switch to grid electricity.

3.1.4 Refrigeration: Main fuels presently used and fuels households would like to switch to

There were only a few (two to three respondents) responses under refrigeration, and no respondent reported using any fuel for refrigeration, just preference for electricity (3%) and solar (2%). It would not be useful to attach undue statistical significance to this relatively insignificant number of responses.

3.1.5 Media applications: Main fuels presently used and fuels households would like to switch to

SHS households predominantly rely on their solar systems to power televisions and radios, with insignificant use of car batteries (1%). The preferred fuel for powering TVs was found to be only grid electricity. For radios, again the main fuel by far was SHS, at 87%, with minimal use of car batteries and dry cell batteries (2% in each case). The preferred fuels for radios were grid electricity (69%) and SHS (6%).

The small preference (6%) for SHS for powering radios is probably because of the low power demand of radios which makes them more compatible than TVs with the limited power provided by SHSs.

Grid electrified households use only grid electricity for powering their televisions, and in most cases for powering their radios. Like the SHS households, batteries are also use to power radios by a minority of households (16%). No other fuel is preferred for powering TVs, but 7% prefer to power radios with dry cell batteries. Again, the low power demand of radios explains this observation. Grid-electrified households may use batteries for powering their radios where such radios are not designed for nor adapted to grid voltage.

Non-electrified households predominantly power televisions with car batteries and radios with dry cell batteries and car batteries. 29% used car batteries and 3% used a generator for TV power while 51% used dry cell batteries compared to 33% using car batteries to power radios. For TVs the preferred fuel was almost totally grid electricity (68%), with 1% preferring solar and 2% generator. The preferred fuel for radios was grid electricity (27%) with very little preference for solar (1%) and generator (2%).

3.2 General observations on use and preference for main fuels

The SHS- and grid-electrified households show a marked similarity in their use of firewood for thermal needs (chiefly cooking, water heating and space heating) while using electricity for low power applications (lighting, TV and radio). The other immediately striking similarity is between SHS- and non-electrified households in their overwhelming preference for grid electricity, this being virtually to the total exclusion of other fuels in the case of the non-electrified households.

The three *thermal uses* (cooking, water heating and space heating) are associated with a preference for grid electricity by the SHS-users and non-electrified households, in contrast to the use of wood by grid-electrified households for these end uses. The grid-electrified households are constrained from using thermal electric appliances due to the high consumption of these appliances which would lead to high electricity bills. Households without grid electricity are attracted by the virtually unconstrained power available with a grid connection and may not be aware of the cost constraints.

Multiple fuel dependence remains a fact of life among all the sub-samples for different reasons, though it is most pronounced among the non-electrified households, who are also the poorest in terms of income, compared to the SHS and grid-electrified households.

4. Application for and installation of non-grid and grid electricity

This section looks at selected aspects of the process of acquiring SHSs and grid electricity connections. Most of the questions are related to SHSs and' where appropriate' responses from grid-users are also examined. The experience with SHS and grid electricity was rather limited at the time of the survey because only 7% of SHS-user respondent had been using their systems for over 12 months; 45% of respondents had had their SHSs for one to six months, and 37% had had their SHSs for between six months and one year.

The situation among grid-users was not very different; with the majority (82%) having been connected to the grid one to twelve months prior to the survey; 33% had been connected one to three months prior to the survey, and only 10% had been connected to the grid for over two years.

4.1 Application for service

The majority, 58% of household had found out about SHSs at community meetings. The energy store seems to have played a distant second (15%) and friends and family 13%. No households reported having applied for more than one SHS – the reasons for this were not probed in the survey, but financial constraints may have been largely responsible for this situation.

4.2 Solar home system installation

Over half of all installations (53%) were carried out less than one month after application, and another 30% about one month after application. Thus, within a month of application, 83% of respondents had their SHSs in place. A few cases reported longer waiting times, these including two months (7%) and three months (3%). There may have been particular complications in these few cases.

Grid owners reported a totally different situation, with only 2% reporting connection within one month following application. 20% had been connected less than two years after applying. The majority, 76%, reported being connected two years after their applications, and a few (2%) waited longer than two years.

The level of satisfaction with the SHS connections was high, with 80% of households indicating they had no complaints. The significant complaints raised were about high costs (6%) and slow response (3%). Grid-users were also highly satisfied, with 86% having no complaints. There was also no dominant complaint, all the complaints being no more than 2% and including power cuts, slow response and high costs.

4.2.1 Knowledge of solar home system

Table 4.1: Levels of understanding of the SHS

Questions asked of households using SHS	*Yes*	*No*
Did the technician explain to you:		
How the SHS works (2% missing)	91%	7%
How to take care of the SHS	92%	7%
How to connect appliances	89%	9%
Do you know which appliances can be connected to the SHS?	89%	8%
Are you responsible for cleaning the module	18%	78%

Explanation of the SHS in general to owners seems to have been extensive, with around 90% of all respondents indicating that they had had explanations from technicians on how their SHS works, how to care for it and how to connect appliances to it. As a result most respondents were confident they knew what they could connect to their SHSs. 78% knew that they were not supposed to clean their modules, a service that is provided by the service provider. 18% seemed not to know this.

Table 4.2: Recollection of having obtained written information concerning the SHS

Did you receive written information about the SHS?	
Nothing	31%
Users manual	0.8%
Pamphlet	65%
Poster	3%

The majority of respondents (65%) indicated they had received pamphlets, with almost all the remainder (31%) claiming they received nothing. 3% claimed receiving posters and under 1% a user manual. It is possible here that the distinction between user manual and pamphlet was confused. It is not clear why as many as one-third of respondents claimed to have received no written information. Perhaps they were the most recent SHS-owners and had not yet got their written materials.

4.3 SHS Ownership

Table 4.3: Knowledge of ownership of the SHS

Who owns the SHS once installed?	
HH	2%
Solarvision	88%
Government	0.8%
Don't know	8%

The proportion of respondents who knew that the SHSs were owned by Solar Vvision was similar to that of respondents who had been given explanations by technicians. 88% knew the correct ownership of the SHSs while 8% did not know and 2% thought the household owned the SHS. There may be several explanations for the small degree of ignorance of the SHS ownership, including the possibility of the respondent not having been in the area at the time of installation.

4.4 Service contract

Table 4.4: Knowledge of the contract with the service provider

	Yes	*No*
Did you sign a contract with the service provider	98%	1%
Did someone explain the contract	69%	29%
Did you understand the terms of the contract	50%	45%

Virtually all respondents claimed to have signed a contract with the service provider, but 29% claimed not to have had an explanation of the contract, and only 50% indicated that they understood the terms of the contract. It will be seen later that this lack of detailed understanding of the contract did not seem to lead to unhappiness with the contract.

4.5 Service fees

Table 4.5: Amount per month SHS-users think they should pay for the fee for service token

Rand per month	*Number*	*%*
5	5	4
10	20	16
15	6	5
20	27	22
25	6	5
30	12	10
30-40	3	3
40-47	3	3
+47	28	23

Some 68% of respondents fell in the range of R10 to R30 in terms of how much they expected to pay per month for the fee for service for their SHSs. Very few suggested R5 per month, indicating that most respondents accepted that the SHSs cannot be provided free or at giveaway costs. Only 23% felt the service was worth more than R47 per month. (Some caution needs to be exercised in interpreting this result. SHS owners may have also considered what they can comfortably afford in making their responses, particularly if they felt that the results of the survey may have a bearing on the setting of future amounts for the service.)

5. Solar electricity, grid electricity use, households expectations and satisfaction

This section looks at a number of indicators that indicate expectations and satisfaction among SHS-users and grid-users. The fact that the questions dealt with in this section are from diverse parts of the questionnaire, and the quite limited exposure to electricity services at the time of the survey led to a certain amount of apparent ambivalence in the attitudes of respondents. The follow up survey of households in the same areas will probably reveal how attitudes have crystallised over time.

5.1 Customer 'satisfaction' measured as a dichotomy

A collection of responses to various questions on satisfaction are grouped in Table 5.1.

Table 5.1: Levels of satisfaction with different aspects of the SHS

Items measuring satisfaction	*Yes*	*No*
Have complaints about the installation	20%	80%
Satisfied with the location of the unit in the house	92%	8%
Satisfied with the contract	69%	27%
Satisfied with the location of lights	100%	0%
Satisfied with the services of the technician*	19%	11%
* The two responses presented in this case do not add up to 100% because the rest of the respondents were ambivalent and did not answer 'Yes' or 'No'		

The level of satisfaction with indicators where users had a direct input is, not surprisingly, highest. All respondents were satisfied with the location of their lights, and 92% were satisfied with the location of the SHS unit inside the house. The limited level of dissatisfaction in this case may be due to the respondent not being the one who specified where the SHS unit should be placed and therefore having a different opinion, or perhaps the unit could not be located exactly where they wanted for some technical or practical reason.

The level of satisfaction with the contract was good at 69%, which tallies with the percentage of SHS owners who reported having had an explanation of the contract. This also indicates that some respondents who did not understand the terms of the contract were nevertheless happy with it since the percentage of respondent who reported that they understood the terms of the contract was lower at 50%.

5.2 SHS electricity use

5.2.1 Willingness to pay more for a larger system

Table 5.2: Users' views of use of a larger system

*What would you use a larger system for?**	*%*
More inside lights	26
More outside lights	17
Watch videos	11
Watch TV	12
Colour TV	31
Buy more appliances	2
Sewing machine	1
* The selection of responses was provided	

The frustration with the power limitation of SHSs can be seen in the responses to the question of what respondents would do with a larger system. The largest group of respondents (almost 31%)

indicated that they would use their colour televisions. The use of these appliances with current SHSs is precluded due to power constraints. Also, colour TVs are not compatible with 12 volt dc supplies except for some small portables; inverters would have to be used in most, if not all cases.

The next largest group of respondents, just under 26%, wanted to increase the number of inside lights. This again is because there are generally some rooms that are not provided with solar lighting because of the capacity limitations of the SHSs. This situation forces SHS owners to depend on other fuels like paraffin and candles to light the rooms that their SHSs cannot cater for. Closely allied with the wish to have more inside lighting is the wish to have more outside lighting (usually security lighting) by about 17% of respondents. Roughly 12% would use the extra capacity to watch TV, and about 10% to run video cassette recorders (VCRs). Again VCRs are not generally 12v dc-compatible and would require inverters. About 2% would procure more appliances and less than one percent expected to use additional power to run a sewing machine. Clearly there is still considerable ignorance around appliance compatibility with SHSs.

5.3 Expectation concerning appliances

Table 5.3: First appliances SHS households expected to use with SHS

First appliance expected to be used	%
Stove	14
TV (black and white)	15
TV (colour)	12
Radio	44
Hi-Fi	5
Fridge	9
Light	1

Expectations for what *first appliance* they would be able to use with their SHSs shows the majority (44%) of respondents expected to use radios. Roughly similar numbers (in the range 12% to15%) expected to use a stove, run a black and white, or a colour TV. About 9% expected to use a fridge and only 1% expected to use lights as first priority. These priority expectations run contrary to what SHSs can provide, with the notable exception of the radio. The other first appliances listed, stove, colour TV and refrigerator are impractical with SHSs. These early expectations are likely to have been due to lack of information prior to the installation of the SHSs.

39% of SHS-users were satisfied with the appliances while 60% were dissatisfied. The explanations of the level of satisfaction given in response to another question are given below.

Table 5.4: Customers' explanation for satisfaction or dissatisfaction with the appliances that can be used with the SHS

Positive responses	%
Higher service level	12
All HH needs satisfied	13
Negative responses	
Power limitation	57
Power cuts	1
Can't power fridge	2
No color TV	3
Can't use all appliances	1
No color TV & fridge	1

It is hardly surprising that the most frequent negative response was 'power limitation', and in fact all the other negative responses can be seen as expressing the issue of limited power in different words. The positive responses were considerably fewer in comparison, with 13% of respondents indicating that their household needs had been met, and 12% indicating they had a 'higher service level', presumably comparing previous fuels like paraffin, candles, and batteries against SHSs.

5.4 Service level and problems with SHS

The fee-for-service approach is based on the continuous provision of maintenance service by a provider and payment of regular service fees by the client receiving the services. Ideally the resolution of faults should be prompt as long as service fees are being paid. The types of problems that have arisen, and the ability of the service provider and users to cope with these problems are the issues explored below.

Table 5.5 Incidence of problems with the SHS

Items relating to problems	*% of SHS-users responding 'Yes'*
Had problems	40
Able to identify problem(s)	37
Know what to do when there is a problem	56
Reported the problems with SHS	39
Have the problems been solved?	30
Are any of the problems still unsolved	16

40% of respondents reported having had a problem with their SHSs, and almost the same percentage felt they could identify the problem. The problems were reported in virtually all cases but 16% reported that the problems were not yet solved. It is not possible to say for how long resolution of the problems was outstanding without getting additional information

Where problems with SHS are reported

The majority of problems were reported to the energy store (28%) and technician (8%). One household each reported to the chief and the revenue collector. Unless this diversity of reporting points is agreed with the service provider and gets the fault report through timeously, delays in rectification of faults can be expected.

Table 5.6: Where problems with SHS are reported

Energy store	28%
Technician	8%
Revenue collector	1%
Chief	1%
No problem yet	62%

Table 5.7: Number of times have had a problem

Once	21%
Twice	7%
Three times	3%
More than three times	5%
No problem yet	61%

Most households (21%) who had experienced problems had only one instance, with much fewer reporting two or three problems. This low fault rate is to be expected given the relatively short time that respondents had had their SHSs at the time of the survey.

Table 5.8: Frequency with which problems were mentioned

Power cuts	2%
Little electricity	2%
Not working in bad weather	1%
Battery voltage low	23%

The problems most frequently reported seem to be related to power availability, thus, while low battery voltage is the predominant problem, the other problems are also related to this issue and can be seen as alternative ways of stating the same issue. This is not surprising because low battery voltage and the consequent cutting off of power are the visible symptoms of many other problems. For example if the solar module is dirty, the charge regulator malfunctions, or battery terminals are corroded and dirty, the result is normally little energy in the battery, leading to a low voltage situation within a short time. The above data is therefore symptomatic and may not reliably indicate what is wrong with the SHSs.

Table 5.9: Frequency of checks on the SHS

Once	20%
Twice already	6%
Three times already	2%
Five times already	2%
No visits or missing data	71%

The way the data on visits to check the SHS installations by Solarvision is presented does not provide a frequency, but rather how many times Solarvision had visited the SHSs before the survey. Whether this is frequent or infrequent depends on how old the system by the time of the survey.

5.5 Likes and dislikes about the SHS

Table 5.10:Likes and dislikes of the SHS

*What was most **liked***	*% of SHS-users*	*What was most **disliked***	*% of SHS-users*
Better light	59	Power limitation	44
Easy life	10	Power cuts easily	16
Cassette player and light	5	Weather effect	13
Radio	5	Nothing	3
Safe	4	Time limitation	1
Saves money	3	Paying when unused	1
TV and light	2.5	No colour TV	1
Everything	1	Cannot light all rooms	1
Nothing	1	N/a or missing	19
Extended study time	1		
Not applicable/missing	9		

By far the most liked characteristic of SHSs was the better light with nearly 60% of respondents citing this advantage. A distant second at 10% was 'easy life' followed by the ability to use small appliances like radio and TV at 5% and below. The dislikes were dominated by the problem of power limitation of SHSs, although this was expressed in numerous ways. Susceptibility to the weather was also a significant factor (the effect of cloudy weather is to reduce available power and limit the amount of energy stored in the battery).

6. Payment for electricity services

6.1 Frequency of purchase of tokens

All respondents reported paying their SHS fees monthly, though 16% indicated that there had been situations where they had been unable to pay their fees.

Table 6.1: When the token is bought

	SHS-users	*Grid-users*
Before new month starts	61%	4%
First day of month	9%	9%
First week of month	7%	4%
Pension day	6%	11%
When credit runs out	2%	62%
Mid-month	13%	0%
Altemate months	1%	0%
Not applicable/missing	0%	9%

Most grid-users reported purchasing their tokens when credit ran out (62%), or, to a much lesser extent, on pension day or the first day of the month. SHS-users predominantly paid before the start of the next month(61%), mid month, or early in each month. The difference in the timing of payment is due to the requirement for regular payment of the SHS service fee each month. It is reasonable for most grid-users to pay when their credit runs out, or when money becomes available (pension day). This suggests that some grid-users may sometimes run out of credit and go without power till the next pension day.

Table 6.2: Persons who pay for the token

	SHS-users	*Grid-users*
Husband	67%	80%
Wife	20%	13%
Son/daughter	13%	7%

Husbands were by far the most frequent token buyers, with wives and children scoring much lower frequencies. The role of husbands as being the breadwinners in most households explains this trend. The persons paying for tokens were reported to be mostly staying at home among both the SHS-users and grid-users

Table 6.3: Place where person buying the token lives

	SHS-users	*Grid-users*
At home*	80%	88%
Away from home	18%	22%
* The responses to this question gave place names, not an explicit indication of 'At home/Not at home'. Where the place name was local, the answer was taken to be 'At home'		

The percentage of households with token buyers staying away from home was found to be a little higher among SHS-users. It may be unwise to read too much into the difference considering the possible inaccuracy that may arise from the way the question was asked (see note to table). Most of the persons paying for the token were found to have a regular income. It has already been noted that it is husbands who pay for the token in most households.

Table 6.4: Does the person buying the token earn a regular income?

	SHS-users	*Grid-users*
Yes	84%	80%
No	16%	20%

The sentiment among SHS-users was overwhelmingly that fees should be cheaper in order to facilitate payment. This suggests that most felt that the service fees they were paying was higher than they thought they should be paying. The frequency of payment was not seen as an important factor in terms of making payment easier.

Table 6.5: Customer suggestions to make payment easier

	SHS-users
Token cheaper	95%
Pay weekly	1%
Pay every two months	2%
Pay nothing	2%

Question not asked in grid questionnaire

Only 8% of respondents stated that they expected to pay service fees for their SHSs as long as they had the SHSs. The overwhelming majority expected to pay until the grid was extended to them.

Table 6.6: Expected duration of payment for SHS

	SHS-users
As long as have SHS	8%
Until grid	75%
Until ownership of SHS	6%
This year only	4%
6 months only	4%
Don't know	1%
Other/missing	2%

This response suggests widespread expectancy that the grid is coming and that SHSs are only a stopgap measure. This is likely to result in growing frustration with the passing of time, with unknown results. Eight percent believed that payment of fees was a short-term arrangement to last six months to a year. It is not clear why some respondents were so misinformed, perhaps they were not present at the time of installation when explanations were given.

Table 6.7: If the outlet has been closed

	Grid-users
Never	82%
Sometimes	11%
Not applicable/missing	7%

For grid-users (SHS users were not asked), the outlet where they purchase tokens was reported to have been always open when 82% of respondents went to purchase tokens. Only 11% of respondents had sometimes found the outlet closed when they intended to purchase electricity tokens. The outlet has therefore not generally frustrated respondents when they needed tokens. This is important since most respondents had to travel a considerable distance to the token outlet as shown in Table 6.8 below.

Table 6.8: Distance to outlet where token is purchased

	Grid-users
Up to 6km	4%
6-8 km	4%
8-10 km	2%
Over 10 km	89%

Some 89% of grid-connected respondents reported travelling over 10km to the outlet where they purchased tokens, and only four percent reported travelling distances of 6km and less (again, SHS users were not questioned on this). Why the outlet is sometimes closed for 11% of respondents is not clear. It may be because the respondents were not fully aware of the operating hours of the outlet, or that the outlet is occasionally closed during business hours when it would usually be open.

7. Electrical appliances owned by SHS-users and grid-users

7.1 Ownership and use

Table 7.1: Ownership of electrical appliances: SHS and grid-users

	SHS-users	*Grid-users*
Radio	52%	51%
Radio cassette	50%	62%
Hi-fi	8%	22%
Colour TV	2%	25%
Black and white TV	36%	33%
Cell-phone charger	6%	20%
Fridge/freezer	10%	13%
Hotplate	8%	9%
Iron	10%	33%
Video	6%	7%

The ownership of low power appliances like radios and black and white televisions is not very different between SHS-users and grid-owners. A clear discrepancy is evident in the ownership of colour TVs and hi-fi systems. These consume more power and are more suited to run on grid electricity. Cause for concern however is the ownership of fridges, hotplates, video cassette recorders and colour TVs by some SHS-users. These appliances which are idle can be a further source of frustration and anxiety over the extension of the grid to these households.

Table 7.2: Ownership and use of TV: SHS-users compared with grid-users and non-electrified households.

	SHS-users	*Grid-users*	*Non-electr. households*
Have TV (black and white or colour)	39%	60%	33%
Watch daily	20%	20%	14%
Up to 4 hours daily	37%	51%	25%
Same in winter and summer	15%	Missing	Missing
% school children watching frequently	12%	18%	4%

Grid users have considerably more televisions than the other sub-samples. The percentage of respondents having televisions is almost double that for non-electrified households. Grid users also watch for longer, with 51% reporting that they watch for up to four hours daily, compared to 37% among SHS-users. The proportion of schoolchildren watching TV frequently is also highest among grid-users. These patterns are readily explained by the ability of grid electricity to cater for the loads imposed upon it. SHSs or car batteries will constrain users due to their lower power capabilities and limited energy storage capacity.

8. General use of fuels and energy sources

Multiple fuel use is a fact of life among all three sub-samples. The range of fuels used was shown to be widest among the non-electrified households. Among the primary fuels that were encountered are paraffin, candles, gas, fuelwood, dry cell and car batteries, petrol (for generators), and biomass fuels. Calculation of the quantities and costs of the various fuels involved the use of several variables such as quantities of fuels purchased per given time, the price paid for various quantities of the fuels, how long the fuels last, uses to which fuels are put, where the fuels are obtained, and the cost of return trips to procure fuels. It was not always possible to calculate quantities of fuels used because in some cases the units specified by respondents are not formally defined, for example 'bundles' of wood, whose size can vary widely. In other cases such as generator fuel, the number of questions asked was insufficient to allow calculation of quantities of fuels used.

The costs of the different fuels were calculated and the percentage of households income spent on energy was determined.

8.1 Costs and quantities

Table 8.1: Amount paid monthly for the electricity token (grid users)

Rands	*% of grid-users paying*
15-20	7
30-50	42
50-70	29
70+	22

While all SHS-users pay a service fee of R58 monthly, about half of grid-users pay no more than R50 monthly, and only 22% pay R70 and above. When the service level issues that have just been discussed are compared, clearly grid-users get a far higher service level for their money.

8.2 Costs and quantities of other fuels besides electricity

The mean monthly expenditure on selected fuels are shown in Figures 8.1 and 8.2, and the source table for the data used is given in Appendix II. It is important to bear in mind that the mean monthly expenditures given here are *for those households that use each fuel* and that the *number of these households varies for each fuel.* Figures 8.1 and 8.2 give two views of the mean monthly expenditure data. Figure 8.1 shows that the highest mean monthly expenditures are on fuelwood and gas. Only a *few households use gas* however. A clear trend is also apparent for fuelwood, with the mean monthly expenditure being highest for the non-electrified households. This is not surprising since some grid-users (22%) cook with electricity and also use it for meeting other thermal needs, and some SHS-users cook and meet other thermal needs with gas and paraffin in addition to wood.

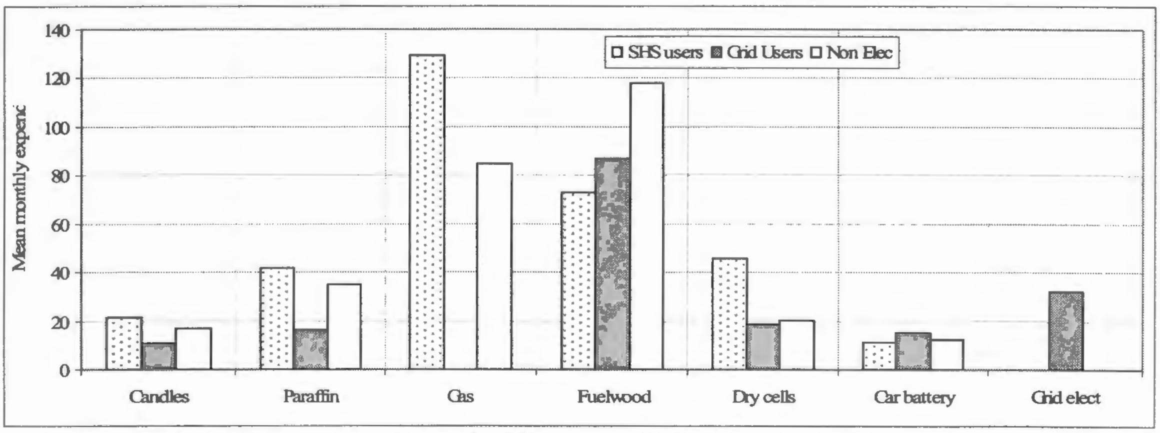


Figure 8.1: Mean monthly households expenditure on each fuel according to sub-samples, clustered by fuel; for those households that use the fuel in question

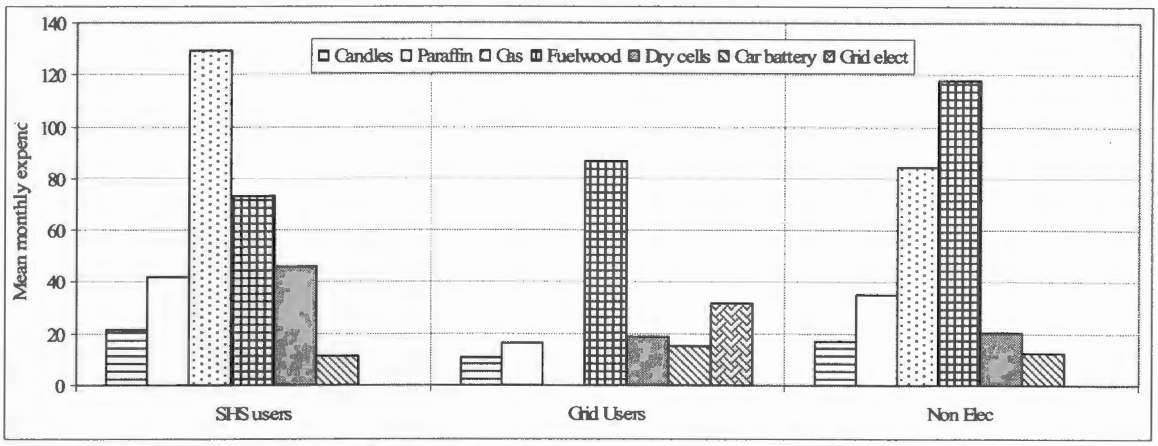


Figure 8.2: Mean monthly households expenditure on each fuel according to sub-samples, clustered by sub-sample

8.3 Sources of purchased fuels

Table 8.2: Where paraffin and gas are bought according to fuel type and sub-samples

	SHS-users	*Grid-users*	*Non-electrified households*
Paraffin			
In town	22%	0%	11%
Local shops	2%	20%	25%
Tuckshop/spaza	19%	11%	25%
Garage	14%	9%	18%
Gas			
Town	11%	Not used	2%
Local shops	8%	Not used	1%
Garage	4%	Not used	1%
Do not buy gas	78%	60%	97%

While the other sub-samples show a strong tendency to buy their fuels locally, the proportion of SHS-users going to town for paraffin and gas is considerably higher at 22% and 11% respectively. It may be that these households, which have the highest incomes, tend to do major shopping in town and may be purchasing their fuels at the same time. Unit prices for fuels are likely to be cheaper in town, more-so if purchased in larger quantities.

8.3.1 Distances and cost of return journeys to purchase fuels

The cost of going to procure fuels is an additional cost that was not included in the cost of fuels already discussed. Table 8.3 shows the mean cost of return journeys to purchase selected fuels and, in the case of paraffin, the distances to where the fuel is bought. SHS-users report the greatest mean distances to their paraffin sources (12km) while grid-owners report half this distance on average. Non-electrified households report 9km on average.

Table 8.3: Average distances travelled to purchase fuels and average cost of the return trip

	SHS-users		Grid-users		Non-electrified households	
% of households paying for fuel trips	53%		13%		61%	
Paraffin	Min	0.03	Min	1	Min	1
	Max	80	Max	16	Max	33
Distance (km)	Mean	12	Mean	6	Mean	9
	N	*68*	*N*	*24*	*N*	*92*
	Min	4	Min	8	Min	2
Cost of return trip (R)	Max	19	Max	12	Max	20
	Mean	11	Mean	10	Mean	10
	N	*47*	*N*	*4*	*N*	*51*
Gas	Min	4	Min		Min	10
Cost of return trip (R)	Max	120	Max		Max	11
	Mean	33	Mean		Mean	10
	N	*25*	*N*	*0*	*N*	*5*
Charging car batteries	Min	4	Min	5	Min	5
Cost of return trip (R)	Max	10	Max	10	Max	70
	Mean	7	Mean	8	Mean	10
	N	*6*	*N*	*2*	*N*	*42*
Total monthly cost of	Min	4	Min	5	Min	4
all return journeys (R)	Max	131	Max	12	Max	77
	Mean	**22**	**Mean**	**9**	**Mean**	**14**
	N	*64*	*N*	*6*	*N*	*69*

It is not surprising that the sub-sample with the least multi-fuel dependence, the grid-users, have the smallest percentage (13%) of households reporting that they spend money on trips to purchase fuels. In contrast over 50% of both SHS-users and non-electrified households report paying for trips to procure fuels. Non-electrified households have the highest percentage, 61%, against 53% for SHS-users.

The total monthly cost of return journeys to procure fuels is highest for SHS-users (R22) and lowest for grid-users (R6). The figure of non-electrified households is in between the other two at R14. The dominance of SHS-households may be due in part to their higher income level relative to the other sub-samples. It has already been suggested that SHS-users may do more shopping in town and purchase fuels at the same time, thus reflecting greater distances and higher expenses even though this expenditure may not be exclusively spent on fuel.

8.4 Estimated fuel replacement with solar or grid electricity

Table 8.4: Fuels used less since obtaining solar or grid electricity

Are there fuels used less?	*SHS-users*	*Grid-users*
Yes	94%	93%
No	6%	7%

A large proportion of both SHS-users and grid-users (over 90%) felt that electrification has resulted in them using less of other fuels. A small percentage (6-7%) in each case felt no difference had occurred. The reason for this minority view may have to do with reliability of the electricity supply, though this is less likely to be the case with grid-users. The major impact was on lighting fuels as shown in Table 8.5 below.

Table 8.5: Fuels used less since obtaining solar or grid electricity

Fuel	*% of respondents mentioning the fuel*	
	SHS-users	*Grid-users*
Candles	61%	49%
Paraffin	31%	40%
Wood	0%	2%
Dry cell batteries	1%	2%
Generator	1%	0%
n/a	6%	7%

Reduction in the use of candles was seen as the greatest impact on other fuels by 61% of SHSs users, with paraffin being the only other significant fuel said to have been affected by the acquisition of SHSs (31%). Since SHSs cannot cook or be used for other thermal applications, this impact is what might be expected.

Grid users stated that candles and paraffin were the fuels whose use had been reduced by their being connected to the grid. Wood is also mentioned, albeit by only 2% of grid connected respondents. Grid electricity can displace wood for cooking and other thermal applications, but is relatively expensive, which is why its impact on the use of wood is found to be limited. The fact that the majority of households using wood collect it free is a major factor here.

Table 8.6: Changes in expenditure on fuels since obtaining solar or grid electricity

Trend	*SHS-users*	*Grid-users*
Spending more money	22%	2%
Spending less money	52%	93%
Same	11%	2%
Missing or n/a	15%	2%

The question on the effect of electrification on expenditure on fuels produced a fairly unequivocal response (93%) from grid-users who indicated that they were spending less money than before electrification. SHS-users were less certain, with about half saying they were spending less money, 11% saying no change had occurred, and 22% saying they were spending more money. In view of the fact that the mean expenditure on grid electricity is a little over half of that on SHSs, the sentiment among SHS-users can be understood.

9. Household lighting in practice

The most important benefit of having SHSs was said by most respondents to be lighting, and the light was found brighter than candles and paraffin lamps. This section explores the views of respondents on this improved lighting compared to more traditional forms of lighting.

9.1 Coverage of household lighting (number of rooms, number of lights)

The configuration of SHSs in Limpopo province is typically three lights inside (one in each of three selected rooms) and one light outside. The mean number of rooms per homestead is 4.6 for SHS users, which is higher than the other sub-samples, both of which have less than four rooms per homestead. Clearly there would be a shortfall in the number of lights for SHS-owners in general since they have more rooms than lights. In fact only 24% of SHS owners had lights in all their rooms. About 54% had up to four rooms without lights. No household reported having applied for more than one SHS, and none were found to have more than one SHS installed. It is possible that the cost of two SHSs may have been an important factor in discouraging the acquisition of more than one SHS.

Among grid-users only six households (13%) had more than one room without electric lighting and 24% had one room without electric lighting..

9.2 When lights are switched on and off (differences between seasons)

The shorter day length in winter results in lights being switched on earlier than in summer. There is roughly a one and half hour difference in the sunrise and sunset times for Polokwane.[4] A table showing the winter (June) and summer (December) sunrise and sunset times for Polokwane is given in Appendix III. Three quarters of SHS-owners switched on their lights within 40 minutes to one hour after sunset. Given that the twilight is about half an hour, this pattern fits well with the onset of darkness.

In summer, by 19:00hrs, two thirds of household would have switched on their lights. By 19:30hrs, the percentage of households with lights switched on would have risen to 74%. Very few households (7%) switched their lights off before 21:00hrs. Most lights were put out between 21:00hrs and 22:00hrs. 39% of households switched off their lights at 21:00hrs, and by 22:00 hrs 74% of lights would be off.

In winter, 50% of lights were switched on at 18:00hrs, and in the next half hour the percentage of SHS-users with lights on would rise to 76%. Switch off was found to be earlier than in summer, with most lights being out between 20:00-21:00hrs. The largest switch-off peak was at 21:00hrs (34%) compared to 21% and 18% for 20:00hrs and 20:30hrs respectively. In winter, by 22:00hrs some 95% of lights would be off.

9.3 Attitudes towards electricity waste

There seemed to be greater awareness of the need to conserve electricity among SHS-owners compared to grid-owners. This is to be expected given the awareness of the SHS-owners of the limited energy at their disposal in the evening.

Almost all (97%) SHS owners switch off lights in empty rooms, the main reason being to save electricity (88%) and in a few cases (6%) because the battery would be low. While watching TV SHS-users mostly switched off lights (37% vs 24% who did not) primarily to save electricity (30%) – no other reason got more than 4% mention.

Grid-users behave quite differently, with only 56% switching off lights in empty rooms, and 31% giving the reason for this as *'saving electricity'* while another 22% had *'saving money'* as their

4 There are numerous sites available on the internet for calculating sunrise and sunset times for any location on earth if the co-ordinates and time zone are known. See for example *www.compsolv.com/los/sunset.html* or *mach.usno.navy.mil/cgi-bin/aa_pap (accessed July 2004).*

reason. When watching TV most grid users (56%) did not switch off their lights. Those who did (33%) had two main reasons; saving electricity (20%) and better view of the TV image (13%).

9.4 Lighting quality comparisons between different fuels

Grid-users unanimously felt that electric lights were brighter than candles and paraffin, but 9% felt that gas lights were equal or brighter and 51% felt that solar lights were equal to or brighter than grid electric lights. SHS-users were, like grid-users, unanimous that their SHS lights were brighter than candles and paraffin lamps (with one exception who felt that SHS lights were equal to candles). 26% felt that gas lights were equal to or brighter than SHS lights. When comparing grid lights to SHS lights, roughly equal percentages felt that the two were equally bright (34%) and that SHS lights were brighter (36%).

9.5 Activities for which SHS lights are used

Table 9.1: Activities using solar or grid lighting at the time of the survey

*Activities**	*SHS-users*	*Grid-users*
Socialise/rest	22%	40%
Watch TV/listen to radio	34%	13%
Read/write	13%	Not on list
Homework/study	28%	4%
Household chores	3%	31%
Craft work	0%	7%
Bath/prepare for work	0%	4%

*These activities were chosen from a pre-established list and multiple responses were possible. The first (most popular) activity is reported in this table.

The activities for which solar lighting was used are dominated by TV and radio, followed by homework and study. 'Socialise and rest' came third on the list, and 'read/write' was fourth. Among grid-users, the major difference is the greater emphasis on use for 'socialise/rest', and the far greater importance on use of grid lighting for household chores. The fact that grid lighting normally covers all rooms in a homestead means that all activities can be performed under grid lighting. In contrast, SHS lighting generally caters for selected rooms only and is necessarily reserved for priority but low power applications. This means some household chores must be carried out with other means of lighting.

9.6 Inside and outside lights

About 80% of grid-owners indicated switching times for outside lights compared to 98% for SHS-owners. The latter virtually all have outside lights because the configuration of their SHSs includes one outside light for a single system. 95% of SHS outside lights were on by 19:00hrs and 78% were off by 22:00hrs. Among grid-users 78% of outside lights were on by 19:00hrs, and 51% were off by 22:00hrs. This improved slightly to 56% by 22:30 hrs, suggesting that some households may leave their grid outside lights on all night. This is supported by the much larger percentage of grid-owners who felt that outside lights had an impact on security (76%) compared to a much lower 44% who felt the same way among SHS users.

10. Socio-economic impacts of SHS and grid electrification

This section looks at the energy use patterns of the three sub-samples, SHS-users, grid-users, and non-electrified households. The changing patterns of fuel use that have resulted from electrification are explored, as well as the expenditure on energy, which will be seen to be more onerous on the poorer households.

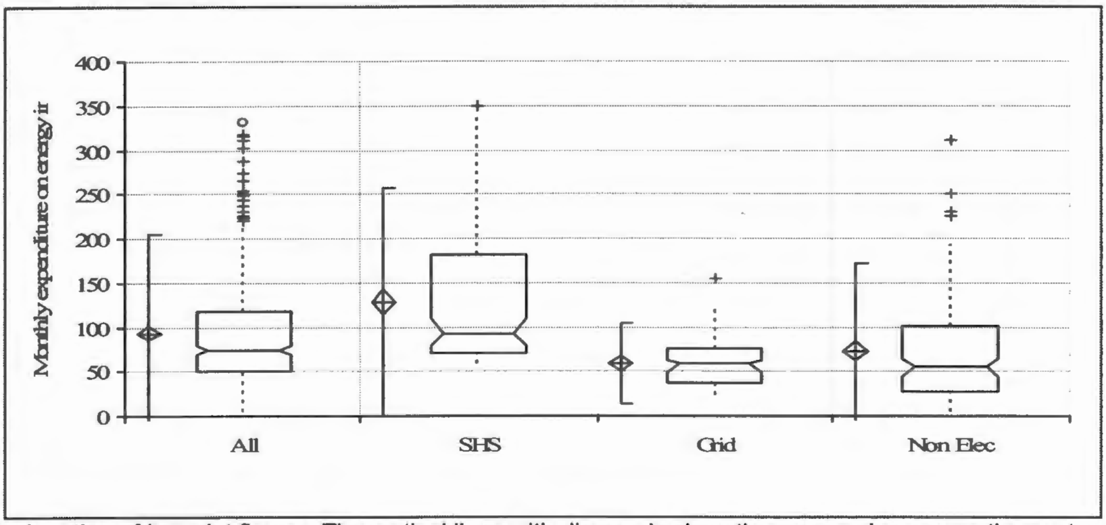
10.1 Energy expenditure of households

Total monthly expenditure on all fuels excluding electricity

SHS-users reported spending more than the other sub-samples on energy before the cost of electricity is added. Grid owners spent the least on energy before the cost of electricity is added. One explanation for this is that grid-users do not use as wide a mix of fuels as the other sub-samples, and that SHS-users have the highest incomes and can be expected to spend more. Non-electrified households, with their greater level of multi-fuel dependence spend almost twice as much as grid-users when the cost of grid electricity is not taken into account.

Table 10.1: Total monthly expenditure (R) on all fuels excluding electricity

Category	*Min*	*Max*	*Mean*	*Std deviation*
SHS-users	4.50	542.40	82.06	89.02
Grid-users	6.95	234.37	38.92	46.75
Non-electrified households	5.66	310.73	72.90	60.02



Explanation of box plot figures. The vertical lines with diamonds show the mean value across the centre of the diamond, with the confidence interval (95%) shown by the vertical spread of the diamond.

Figure 10.1:[5] Total monthly expenditure on energy by sub-sample

[5] For this box plot and the associated table following it, extreme outliers three or more IQRs (inter quartile ranges) from the median were ignored. The median value is the horizontal line across the box. The mean is the horizontal line across the diamond.

Table 10.2: Monthly expenditure (R) on all fuels including electricity

	n	*Mean*	*Median*	*SD*
All sub-samples	275	93.20	74.00	68.02
SHS-owners	120	128.02	92.17	78.04
Grid-owners	42	59.10	58.16	27.77
Non-electrified households	114	72.90	55.10	60.02

When the cost of electricity is included, the energy expenditure for SHS-users still remains the highest, and that for non-electrified households, unchanged, remains the second highest. The relative magnitudes of these expenditures can be easily compared in Figure 10.1 above. The figure also includes the overall mean for comparison, and it is apparent that SHS-users are the only sub-sample above the overall mean.

10.2 The proportion of household budget devoted to fuels and electricity

Average proportion of income spent on all fuels according to sub-samples

Table 10.3: Proportion of income spent on all fuels according to sub-samples

	n	*Mean*	*Median*	*Std dev*
All sub-samples	247	8.6%	7.0%	6.3%
SHS-owners	115	10.8%	8.3%	7.8%
Grid-owners	40	6.1%	4.7%	4.3%
Non-electrified households	95	7.6%	6.3%	5.6%

When all households are taken into account, the mean percentage of total income spent on energy is 8.6%. SHS-users top the list for percentage of income spent on energy, with a figure of 10.8% while grid-users spend the least, 6.1%. Thus, despite their higher incomes relative to the other sub-samples, the high energy expenditure of SHS-users means they still spend a larger proportion of their income on energy.

The fact that the poorest still spend a larger proportion of their income on energy is not altered however, as Figure 10.2 shows. It can be seen that households with incomes above R1 000 per month do not spend more than 20% of their income on energy (most are below 10%), those earning below this amount can spend far higher percentages on energy. Households earning above R3000 per month spend well below 10% of their income on energy.

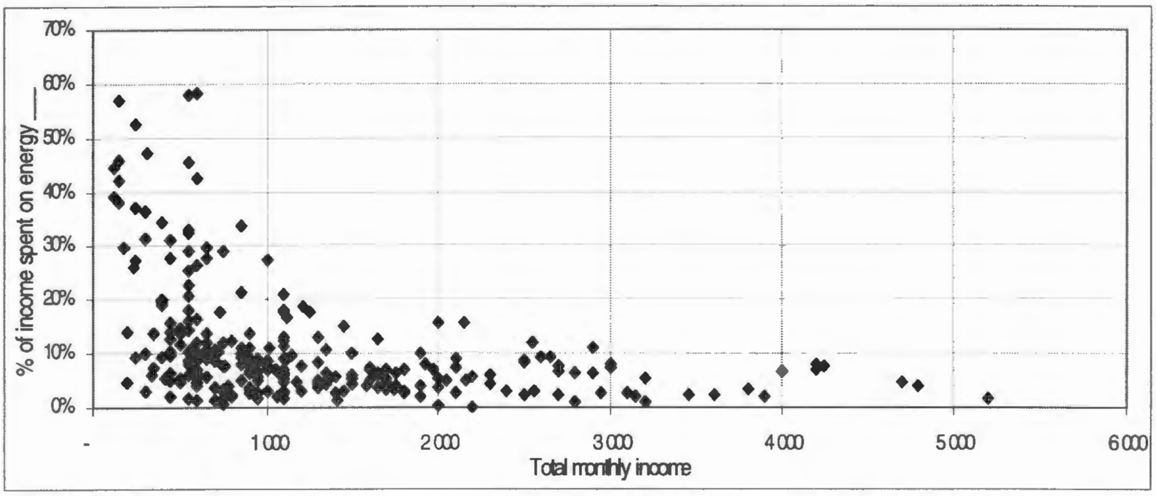
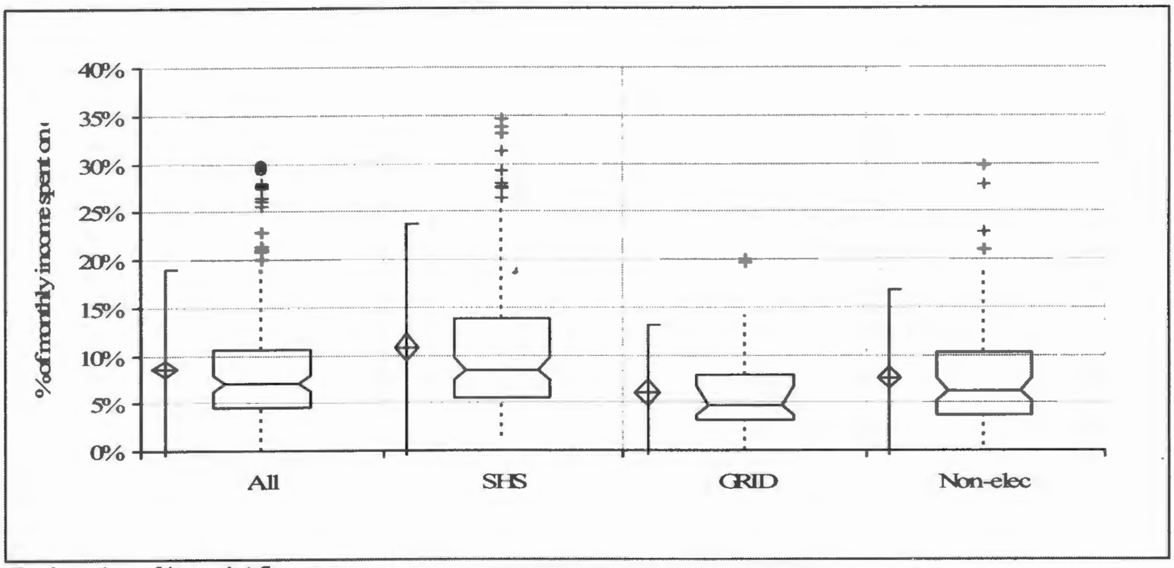


Table 10.2: Scatter plot of income vs expenditure for all households in all sub-samples

Figure 10.3 summarises the percentage of income spent on energy for all households, and for the three sub-samples. It can be seen that grid-users spend a smaller percentage of their income on energy and SHS-users spend the highest.



Explanation of box plot figures:

The vertical lines with diamonds show the mean value across the centre of the diamond, with the confidence interval (95%) shown by the vertical spread of the diamond.

The boxes show the median value as the middle horizontal line, with the angled portion showing the confidence interval. Box height shows the inter–quartile range, IQR (upper, lower).

Outliers are plotted as ---- up to 1.5 IQR from the median, +++ from 1.5 to 3 IQRs from median, and oooo if further than 3 IQRs from the median (far outliers).

Figure 10.3: Percentage of total monthly income spent on energy (all households and by sub-sample)

10.3 Information: Extent of use of radio and TV

Table 10.4: Household members who watch television most

	SHS-users	*Grid-users*	*Non-electrified households*
Adult men	4%	18%	1%
Adult women	4%	4%	0%
School-going children	12%	18%	4%
All	12%	18%	11%
Adult men & women	2%	0%	0%
Adult women and children	4%	0%	0%
Missing or n/a	62%	42%	69%

Schoolgoing children watch TV more than any other group except grid-users where adult men watch equally frequently. Perhaps men make a point of watching specific programmes like news and sport while wives are occupied with cooking, cleaning, washing up, and other household chores.

10.4 Entertainment

Duration per day of TV watching

Table 10.5: Duration per day of TV watching

	SHS-users	*Grid-users**	*Non-electrified households*
About 4 hours	6%	24%	2%
Up to 4 hours	37%	51%	26%
One hour	4%	0%	3%
*The minimum for grid-electrified households was 2 hours.			

Grid users were found to watch TV for at least 2 hours, and had the highest number of household members watching for four hours and more. The constraining effect of SHS is apparent, with only 6% reporting about four hours TV watching.

10.5 Education (extension of times of children's homework)

Persons in the household studying or doing homework

Table 10.6: Persons in the household studying or doing homework

	SHS-users	*Grid-users*	*Non-electrified households*
Yes	83%	71%	81%
No	17%	29%	19%

There were high percentages of persons studying in all sub-samples, particularly among the SHS-users and non-electrified households. The questions of how long they study and the extent to which SHS-users make use of solar lighting are explored in the following tables.

Table 10.7: Length of time they study

	SHS-users	*Grid-users*	*Non-electrified households*
Less than one hour	0%	2%	2%
One to two hours	29%	33%	49%
Missing or n/a	16%	29%	21%

The length of time students study does not seem to depend on the electrification sub-sample to which they belong. Those studying with grid lighting or solar lights do so under better light, but study is nevertheless possible with candles. The SHS-users also report studying with, and sometimes without using their solar lights.

Table 10.8: Use of solar light when studying

	SHS-users
Always	43%
Sometimes	41%
Never	0%
n/a	17%

There were no respondents who claimed never to use their solar lights when studying. 43% claimed they always used their solar lights, and 41% sometimes used their solar lights when studying. The reason for the sizeable proportion of respondents who use their solar lights sometimes for studying may be due to reliability of their SHSs, limited hours of operation of the SHSs, or because not all rooms are usually fitted with solar lights and the students cannot always have use of the rooms with solar lights.

10.6 Changes in lives

There is a general perception that electrification by both grid and SHS changed respondents' lives. This is very pronounced among grid-owners, with 96% indicating that their lives had been changed. For SHS-users the figure was 83%. The known limitations of SHS already expressed as the likes and dislikes of SHS-users provide part of the explanation for this difference.

Table 10.9: If SHS and grid electricity changes respondent's lives

	SHS-users	*Grid-users*
Yes	83%	96%
No	17%	2%
Missing	0%	2%

There are also differences between SHS-users and grid-users in what they saw as the most important changes resulting from electrification. Table 10.10 explores these differences further.

Table 10.10: Most important changes resulting from solar power and grid electricity

Change	*SHS-users*	*Grid-users*
Less work	2%	13%
Less candle use	7%	24%
Appliance daily use	11%	36%
Less wood collection	0%	9%
Safe/brighter lighting	27%	9%
Children are studying	6%	2%
Save money	8%	0%
Nothing	0%	4%
Missing	31%	6%

SHS-owners saw listening to the radio, buying less fuel, saving money, and bright lights as being the top four changes resulting from SHS electrification. Grid-owners, on the other hand, saw the daily use of appliances, reduced candle use, less work, and brighter lights/safety and reduced need to collect wood as their most important changes. The issue of reduced wood collection is interesting because some 22% of grid-users use electricity as their main cooking fuel, while the remainder use wood which is largely collected free and collection is seen as a minor problem. This situation limits the ability of grid electricity to reduce the use of wood as a cooking fuel, particularly while the wood is free. Some 9% of grid-users reported that they were no longer able to buy certain things because of the cost of grid electricity.

The proportion of SHS-users who are unable to buy certain items because of service fee payments is some three times higher that the corresponding proportion of grid-users

Table 10.11: Are there things the household cannot buy anymore since obtaining electricity

Things cannot buy	*SHS-users*	*Grid-users*
Yes	27%	9%
No	56%	89%
Missing	17%	2%

SHS-users have already been shown to be paying a larger proportion of their income towards energy costs, and that their monthly service fee of R58 is nearly double the mean grid cost of R31.90. The items that they are no longer able to buy are predominantly foods as shown in Table 10.12.

Table 10.12: Selected things households are unable to buy any more

Items impacted	*SHS-users*
Food	13%
Transport money	0%
School fees	0%
General household needs	1%

Grid owners do not feel constrained by their electricity payments to the extent of failing to buy things they were able to buy prior to electrification. They would also be more willing to recommend grid electricity to others as shown in Table 10.13. The percentage of SHS-users willing to recommend SHS to others is much lower than the corresponding figure for grid-users when these figures are compared to the proportion of respondents who felt that their lives had been changed

Table 10.13: Would advise others to get a SHS or grid electricity

	SHS-users	*Grid-users*
Yes	60%	96%
No	31%	2%
Missing or n/a	9%	2%

For grid-users the number who felt their lives had been changed by grid electrification is the same as the number who would recommend grid electricity to others. This further confirms the greater level of satisfaction among grid-users.

10.7 Contribution to job creation

It is perhaps expecting too much to look for a meaningful impact on unemployment from the implementation of a fee-for-service SHS project. By its nature the operation is quite centralised and after the installation phase, typically the only local people directly employed would be a few office staff and maintenance technicians. The Solarvision office employs seven persons excluding technicians, who are paid on the basis of number of SHSs attended to. Perhaps the major shortcoming has to do with the inability of SHSs to power productive activities such as grinding, welding, irrigation and food processing.

11. Conclusions and key issues

These conclusions pertain to the baseline survey. A second survey was undertaken in mid 2004 in the same area and will capture more recent developments including longer-term views and disconnections.

11.1 The objectives of the research

The household surveys aimed to explore the impacts of SHSs over time, ascertaining the nature and extent of any fuel switching associated with the SHSs, impacts on rural livelihoods, and attitudes of households exposed to systems.

11.2 Characteristics of the households surveyed

SHS users were found to be wealthier on average that the other two categories. The mean monthly income for SHS users was found to be R1543, compared to R1163 for grid users and R819 for non-electrified households. That SHS users should have the highest mean monthly income is not surprising because to qualify for these systems they had to have regular income. The mean monthly per capita income showed a similar pattern, being highest for the SHS-users.

The size of the SHS-users households was found to be the largest. The reason for this is not obvious but could be linked to the presence of relatives at these wealthier homes. The trend between the other sub-samples is more conventional, with the poorer non-electrified households having larger household sizes.

11.3 Installation of the SHSs

Community information dissemination seems to have been effective in informing most solar home system-owners about SHSs. Installations were also prompt, with 83% of installations being carried out one month or less after application. Grid connections were much slower, achieving a similar level of installation (76%) in two years.

The transfer of information to users was good, though distribution of written materials was rather limited, with about a third of survey respondents reporting that no written material was provided with their solar home systems.

Close to 90% of respondents knew that the SHSs did not belong to the households. All respondents except one had signed contracts with Solarvision, and about 70% had been given an explanation but half claimed not to understand the terms of the contract. Despite this limited understanding, 70% were satisfied with the contract provisions.

The expectations and satisfaction findings suggest general satisfaction with installation of solar home systems. 20% of respondents had a complaint and 27% were not satisfied with the contract. There was widespread desire for larger systems, particularly to power colour televisions and more lights. The issue of more lights arises because SHS-users generally have rooms that are not fitted with solar lights.

11.4 Customer satisfaction and ambivalence

By a wide margin, the most liked feature of SHSs was better light. Some ambivalence in attitudes can be expected since there are clear benefits that come with SHSs, but also some frustrating limitations. The expectation that the grid will be coming and the overwhelming preference for grid electricity contribute to the ambivalence.

Expectations for what would be used with the SHSs reveals some initial ignorance of the capabilities and limitations of solar home systems. Respondents expected to use incompatible appliances, for example stoves (14%), colour televisions (12%), and refrigerators (9%). Information may not have been effectively disseminated or packaged. The most cited source of dissatisfaction among owners of solar home systems was power limitation and issues around it, including power cuts, inability to use certain appliances. These complaints accounted for 65% of negative responses on satisfaction. In contrast positive responses were fewer and indicated better lighting (12%), and all needs satisfied (13%). 40% of respondents had experienced a problem with their SHSs, and 16% were unresolved at the time of the survey. Of course without knowing for how long these systems had been unattended, it is not possible to say whether this represents a maintenance problem; the survey was a snapshot of an ongoing project and it can be reasonably expected that some systems awaiting repairs would be encountered.

Most SHS owners seem to be unaware that grid-users face a similar dilemma in that the cost of grid electricity precluded some 80% of them from using electricity for cooking.

11.5 Problems with the SHSs

About 40% of SHS-users had experienced a problem with their systems. A similar percentage (37%) felt they were able to identify the problem and virtually all had reported the problems. The reports were generally made to the energy store, but a few respondents reported to the chief, the technician, and the fee collector. How reliably or promptly these reports reached the service provider is not clear. 16% of the problems were unresolved at the time of the survey, but it is not possible to say for how long the problems had been outstanding.

The most frequently mentioned problem was low battery voltage. This is generally a *symptom* that arises from many causes like loose connections, faulty charge controller, battery coming to the end of its useful life, misuse of the system, or prolonged cloudy weather. The problem as reported can therefore not directly assist in diagnosing what may be wrong with the systems.

SHS-users pay much more than the other sub-samples and they were frustrated by this high cost. Their main suggestion for making payment easier was to reduce the service fee. Another major concern was the limitation in both what can be used with SHS, the number of rooms that could be supplied with power, and the time limitation on power availability. The need to purchase other fuels adds to the cost of energy for SHS households.

11.6 Cost, limited power and the cost of other necessary fuels

SHS users pay much more per month than the other sub-samples for their energy (R128) – more than twice as much as grid-users (R59) who in fact pay the least among the three sub-samples. SHS-users are the only sub-sample with a mean monthly expenditure on energy that is above the overall mean of R93. The service level received by grid users is practically unlimited for household level needs.

SHS-users have to spend an additional R70 for other fuels on top of the R58 paid for the SHS each month. 68% of them thought they should be paying no more than R30 per month for the service, which seems fair and would be comparable to what grid users pay on average for their electricity.

Non-electrified households show the highest mean monthly expenditure on fuelwood while solar home system-users have the highest mean expenditure on gas. Grid-users do not use gas, and spend little on other fuels except for fuelwood. Grid electricity is their second major fuel expenditure item.

Because solar home system-users had on average 4.6 rooms per homestead, the three inside lights provided with the solar home systems were insufficient to light all rooms. Lighting times varied by roughly one hour between summer and winter. Lights were generally switched on 40 minutes to one hour after sunset, which is to be expected given that there is about half an hour of twilight after sunset. Switch-off time was not very different between grid-users and SHS-users, suggesting that bedtime was due more to habit than by electricity source characteristics.

The awareness of the need to conserve electricity was greater among solar home system-users, 97% of whom switched off lights in unoccupied rooms compared to 56% among grid-users. Switching off lights while watching television was common, largely to save electricity by SHS-users (20%) and to see the image better among grid-users (13%). The activities for which electric lighting was used differ in that grid-users cite 'socialise/rest' and household chores as their main uses far more than solar home system-users, and add 'crafts/work', and 'bath/prepare for work' which are not mentioned by solar home system-users The 'crafts/work' activities are interesting because they suggest a possible productive use. Solar home system-users indicated television/radio and homework/study as their main uses for electric lighting.

Far more grid-users (76%) felt that outside lights had enhanced security than SHS-users (44%), probably because the former could regularly leave their outside lights on all night; something solar home system-users could not do without risking automatic low voltage cut-offs.

Few grid-users (13%) spend money on trips to get fuel, and spend the least on such trips, only a mean of R6 per month. This is explained by the strong dependence on just two energy sources, grid electricity and firewood among grid-users, and the fact that most households using fuelwood collect it free. In sharp contrast, 61% of non-electrified households undertake paid trips to procure fuels, spending on average R14 per month on these trips. SHS-users reported a slightly lower incidence of undertaking paid trips to procure fuels, with 53% of households undertaking the trips and spending R22 per month on average. Possible reasons for the solar home system-users having the highest figure for monthly expenditure on fuel procurement trips include their use of gas which is transported in heavy cylinders to depots which are not always near, and their higher income status which may allow them to buy fuels in town.

11.7 The cost of fuels

The SHS service fee was seen as being too high. Only a quarter of respondents felt that the service was worth more than R47. The majority, 70%, suggested a range of R10-R30.

Gas and fuelwood were found to be particularly expensive for the households who used them. Fortunately fuelwood was collected free by some 95% of households. Gas was more prevalent among SHS-users because their incomes allowed them to use this expensive fuel. The mean monthly expenditures by SHS-owners using the specified fuels were found to be about R21 on candles, R42 on paraffin, R129 on gas, R73 on fuelwood, R46 on dry cell batteries, and R11 on car batteries (charging).

When the cost of electricity is excluded, the mean monthly expenditure of non-electrified households far exceeds that of grid-users and is close to that of solar home system-users. With the cost of electricity included, the mean monthly expenditure for all households is R93. SHS-users have the highest mean of R128 (median R92), non-electrified households the second highest at R73 (median R55), and grid-users the lowest at R59 (median R58). The median values for the non-electrified households and grid-users are quite similar. The mean values are so different due to the influence of outliers (extreme values).

The mean percentage of total income spent on energy per month is about 8.6% for all households. For SHS-users the percentage is 10.8%, 6.1% for grid-users and 7.6% for non-electrified households. SHS-users top the percentage of income spent on energy ranking even though their incomes are the highest. This underlines how much greater their energy expenditure is. A clear trend was also seen whereby the poorest households spend a greater proportion of their incomes on paying for energy. Virtually no households with incomes of at least R1000 spend more than 20% of their incomes on energy. Those with lower incomes than this may spend up to about half of reported incomes on energy while those with incomes above R3000 spend well below 10%.

11.8 Changes in fuel use after receiving SHS or grid electricity

The major impact on fuel use was reduction in the use of lighting fuels, candles, and to a lesser extent paraffin. Because SHSs cannot usually cover all rooms, candles and paraffin continue to be used for the other rooms and also when the SHS cuts out. No impact had been made to the fuels supplying most household energy, i.e. those fuels meeting the thermal needs, mainly cooking, water heating, and space heating. Thus, the *range* of fuels used by SHS-owners has not been altered, only the quantities. The need for supply of these fuels more conveniently still needs to be addressed.

Well over 90% of solar home system and grid-users reported that electricity had displaced candles and paraffin as lighting fuels. Little else was replaced as was already seen in the similarity between these two sub-samples in their fuels use patterns.

Most grid-users (93%) felt that having grid electricity was saving them money spent on fuels. Far fewer SHS-users (52%) felt the same way, and 22% felt they were using more money on fuels and energy sources since getting solar home systems. Only 2% of grid-users felt the same.

Non-electrified households show strongest multi-fuel dependence. The major similarities in fuel use and preference were:

- SHS and grid-users use wood for thermal end uses, and electricity for lighting and audiovisual applications;
- SHS and non-electrified households want grid electricity for virtually all end uses.

Grid-electrified households have least desire to switch. There are different reasons for the similarities between grid-users and SHS-users. SHS-users face a power constraint while grid-users face financial constraints and may also have other socio-cultural reasons for preferring to use firewood.

11.9 Changes in people's lives

It has been stated that improved lighting was the major impact of SHSs on households. This means that even without SHS, lighting is possible, albeit at an inferior level. The other major impacts have been in information and entertainment through watching TV and listening to the radio with greater convenience than would be the case with car batteries, or dry cell batteries. The overwhelming preference for grid electricity however indicates that SHS-users are not yet content. The satisfaction of grid-users, shown by their very limited desire to switch to any other fuel confirms grid electricity as the 'ultimate' source of energy for most households.

The reach of SHS is generally limited to the more affluent rural households who can meet the service fee requirements. This is likely to remain the case into the foreseeable future as long as users must pay for the service.

Respondents were positive that electrification had changed their lives, the change being better light for solar home system-users; better light and broader range of appliances for grid-users. Over a quarter of SHS-users reported that there were items they were no longer able to buy (mainly food) because of having to pay SHS service fees. Grid-users were much less affected, with only 10% reporting that electricity costs had constrained their ability to buy other items. Grid-users would readily advise other people to get grid connections, while only 60% of grid-users would do the same.

The SHS project did not have a significant impact on the employment situation in Limpopo province.

11.10 Key questions and issues

The dissemination of information to potential SHS users needs to be improved so that all the characteristics of the technology are well understood. The way in which information is packaged needs to be appropriate for the level of literacy of the intended consumer of the information.

The issue of ownership of SHS needs to be addressed in the long term. Perhaps a system whereby the ownership of the SHS passes to the household, coupled with training of local freelance technicians with a system of certification, may be useful.

That SHSs fail to reach the poor households is a good case for an integrated approach with a focus on poverty reduction. This approach will entail collaboration across many development arms of government and other non-governmental stakeholders.

The approach of tight clustering of installations of SHSs needs to be emphasized more to improve accessibility and service to customers by the service providers. This is one way to reduce the cost of maintenance because transport costs are lower and one technician can more easily service a larger number of clients.

The prospects of the grid reaching target areas for SHS dissemination need to be frankly communicated to avoid a wait-and see attitude among users, and to avoid bitterness among those who accept SHSs only to see the grid arrive soon afterwards. This can lead to a sense of having been misled.

12. Policy recommendations

The dissemination of information needs to be refined so that information is packaged in a way that makes the information easily accessible to the target group. The level of literacy is not high so important documents like contracts and user manuals have to be suitably simplified. Contracts are legal documents and are necessarily complex, but there is no reason why short, plain language versions cannot also be provided to enable the gist of the conditions to be understood. Examples of this approach are the South African Lotto pamphlet, or most online computer software licence agreements where the user is given a simplified version of the terms with the option of seeing the full and much more complex details if he/she wishes.

The process of selecting areas where solar electrification is to be introduced needs to be reviewed. The question that needs to be answered is whether there will be grid electrification of all rural households; and if so over what period. Priority should be given to those areas with the remotest chance of being grid electrified, and this should be officially made clear to the recipients. Introducing SHSs where users have been told that the grid is coming in a few years causes confusion and frustration for both service providers and users.

Consideration needs to be given to the setting up of forums for the exchange of experiences and ideas between service providers, and similarly for recipients of SHSs and the technicians serving them. Exchange visits would be a useful way to facilitate exchange of experiences between communities.

If SHSs are meant for the rural poor, the results so far show that they are reaching the wealthiest rural households. Are these households the best recipients for subsidies? Attempts to introduce cheaper systems by reducing their size are not likely to succeed since more frustration will result from the even lower service level. It has been established that the current service level of SHSs is frustrating owners, yet they feel that the fees are too high, yet service providers need to recover costs. Higher capacity systems will cost more and become even more the preserve of the rural elite. Increasing capital subsidies may allow poorer households access, but will they be able to pay the costs of maintenance and repair? It may well be asked if SHSs are what the poor need. Often there are many more basic and pressing needs for the poorer households. An integrated and bottom up approach to the planning of service delivery may address the problems more successfully.

There seems to be a case for the exploration of ownership schemes for SHSs. This is because there is as yet no sure recipe for successful dissemination, and not enough information is available internationally to prescribe a winning approach.

The fact that there are many lessons and need for corrective steps points to the need for pilot schemes so that lessons are learnt before full scale implementation is attempted. This will contain costs and result in less frustration for both service providers and users.

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APPENDICES

1. Sunrise and sunset times (with twilight) for Polokwane in Limpopo province

1-30 June 2002

Winter

	CTS	SR	SS	CTE
1	06:13	06:37	17:23	17:47
2	06:13	06:38	17:23	17:47
3	06:13	06:38	17:22	17:47
4	06:14	06:38	17:22	17:47
5	06:14	06:39	17:22	17:47
6	06:15	06:39	17:22	17:47
7	06:15	06:40	17:22	17:47
8	06:15	06:40	17:22	17:47
9	06:16	06:40	17:22	17:47
10	06:16	06:41	17:22	17:47
11	06:16	06:41	17:22	17:47
12	06:17	06:41	17:22	17:47
13	06:17	06:42	17:22	17:47
14	06:17	06:42	17:23	17:47
15	06:18	06:42	17:23	17:47
16	06:18	06:43	17:23	17:48
17	06:18	06:43	17:23	17:48
18	06:19	06:43	17:23	17:48
19	06:19	06:44	17:23	17:48
20	06:19	06:44	17:24	17:48
21	06:19	06:44	17:24	17:49
22	06:19	06:44	17:24	17:49
23	06:20	06:44	17:24	17:49
24	06:20	06:45	17:24	17:49
25	06:20	06:45	17:25	17:49
26	06:20	06:45	17:25	17:50
27	06:20	06:45	17:25	17:50
28	06:20	06:45	17:26	17:50
29	06:21	06:45	17:26	17:51
30	06:21	06:45	17:26	17:51

CTS is Civil Twilight Start, SR is Sunrise, SS is Sunset, CTE is Civil Twilight End

1-31 December 2002

Summer

	CTS	SR	SS	CTE
1	04:41	05:06	18:36	19:01
2	04:41	05:06	18:37	19:02
3	04:41	05:07	18:37	19:03
4	04:41	05:07	18:38	19:03
5	04:42	05:07	18:39	19:04
6	04:42	05:07	18:40	19:05
7	04:42	05:07	18:40	19:06
8	04:42	05:07	18:41	19:06
9	04:42	05:07	18:42	19:07
10	04:42	05:08	18:42	19:08
11	04:43	05:08	18:43	19:08
12	04:43	05:08	18:43	19:09
13	04:43	05:09	18:44	19:10
14	04:43	05:09	18:45	19:10
15	04:44	05:09	18:45	19:11
16	04:44	05:10	18:46	19:11
17	04:45	05:10	18:46	19:12
18	04:45	05:10	18:47	19:13
19	04:45	05:11	18:48	19:13
20	04:46	05:11	18:48	19:14
21	04:46	05:12	18:49	19:14
22	04:47	05:12	18:49	19:15
23	04:47	05:13	18:50	19:15
24	04:48	05:13	18:50	19:16
25	04:48	05:14	18:51	19:16
26	04:49	05:14	18:51	19:16
27	04:49	05:15	18:51	19:17
28	04:50	05:16	18:52	19:17
29	04:51	05:16	18:52	19:18
30	04:51	05:17	18:52	19:18
31	04:52	05:17	18:53	19:18

Values calculated at *http://www.compsolv.com/los/sunset.html* using the co-ordinates for Polokwane, namely latitude -23.87 degrees and longitude 29.44 degrees. These sunrise and sunset times are provided for comparison with the times at which households with electricity (grid and solar) reported switching their lights on and off in winter and summer. It is also possible to see the difference between summer and winter sunrise and sunset times and the duration of the twilight periods at dawn and dusk.

2. Selected energy data for Limpopo province from Statistics SA 2001 Census

Energy Source for Lighting	*Households*
Electricity	752691
Gas	2072
Paraffin	90420
Candles	325834
Solar	3169
Other	5778

Energy Source for Cooking	*Households*
Electricity	295512
Gas	19625
Paraffin	131633
Wood	702428
Coal	18651
Animal dung	5272
Solar	2981
Other	3864