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# Acceptability of the integral solar water heater by householders in the low income urban community

by

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# SYNOPSIS

A research and demonstration project on the use and performance of low cost integral solar water heaters in urban low-income dwellings was carried out in 1982/83. The project involved technical and socio-economic components. This report summarises the socio-economic study where the reaction of respondents to the use of the integral solar water was obtained, together with data on energy costs and hot water usage.

# SAMEVATTING

'n Navorsings- en demonstrasieprojek oor die gebruik en werkverrigting van laekoste integrale sonwaterverwarmers in stedelike lae-inkomste wonings is in 1982/83 uitgevoer. Tegniese en sosio-ekonomiese komponente het deel van die projek gevorm. Hierdie verslag som die sosio-ekonomiese studie op waar die reaksie van die deelnemers op die gebruik van die integrale sonwaterverwarmer verkry is, saam met inligting oor energiekoste en warmwatergebruik.

## INTRODUCTION

The pipe type integral solar water heater concept was expressly developed by the National Building Research Institute (NBRI) for use by families in the low income bracket[1], although it is being extensively used as a pre-heater to an electric geyser in middle-income houses. In order to test the performance and acceptability of this system as a basic household amenity among urban low income families one hundred commercially designed integral solar water heaters were donated for research purposes by two commercial concerns.[2]

The research project was divided into a technical and a socio-economic study, the latter part of which is summarised in this paper[3]. The technical study involves monitoring the performance of the different water heating systems by the NBRI for a year and will be completed early in 1984.

## THE INTEGRAL SOLAR WATER HEATER IN OPERATION

The integral solar water heater is a relatively low cost unit which combines the functions of absorbing solar radiation and storing hot water with ease of installation and low maintenance. It is resistant to freezing and lime scaling, and has both high performance and durability when manufactured from suitable materials.[1] As shown by the typical temperature/time profile of the integral unit in Figure I, there is normally a rapid increase in water temperature in the morning. Maximum temperature is reached at about 15h00 followed by a slow decline after 16h00 under conditions in which no water is drawn from the unit.

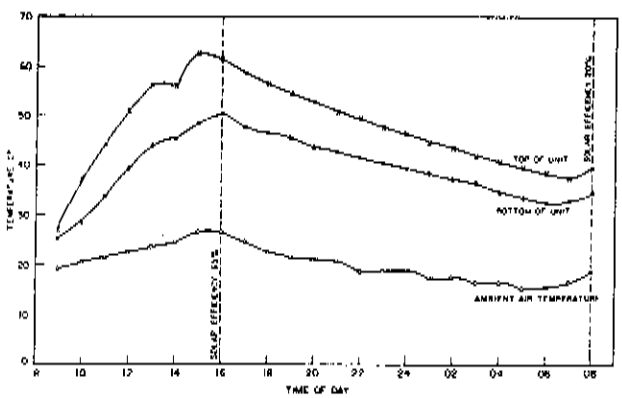


**FIGURE 1:** TEMPERATURE/TIME PROFILE FOR AN INTEGRAL SOLAR WATER HEATER ON A TYPICAL AUTUMN DAY IN PRETORIA

## USER REACTION STUDY

The objective of the socio-economic portion of the study[3] was to establish the degree of satisfaction shown by users of integral solar water heaters under two sets of conditions.

(i) Where it was the sole source of hot water from a fixed installation.

(ii) Where it was used as an ancillary preheating device in conjunction with an electric geyser.

The study also set out to obtain behavioural data on the following topics:

a) hot water consumption patterns;
b) the cost of energy;
c) the ability of families to make the best use of integral solar water heaters;
d) perceptions of their cost effectiveness;
e) their aesthetic acceptability or otherwise;
f) individual evaluations of the usefulness of solar water heaters.

The socio-economic study was funded by the National Programme for Energy Research of the CSIR and carried out by a firm of techno-economic consultants, who reported periodically to a steering committee. The study involved research among a pre-selected sample of low income households, which consisted of a 'test' group which participated in the technical part of the project and whose electricity and hot water meters were read and reactions on the availability of hot water obtained every month, and a 'control' group of an approximately equal number of households which had no previous knowledge of the project. Interviews were conducted in the townships of Mamelodi (near Pretoria), Daveyton (near Springs) and Klipspruit (near Johannesburg), (see Figure 2) in February 1983 by trained interviewers (generally teachers) using a structured 18 page questionnaire. Details of the hot water systems in the houses and sample sizes are given in Table 1.

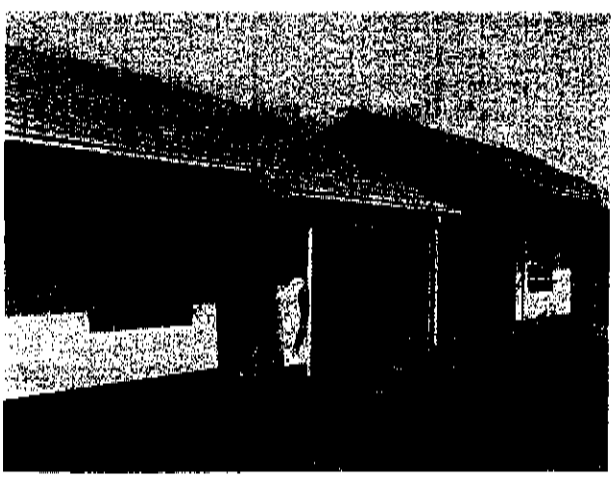

**FIGURE 2:** INTEGRAL SOLAR WATER HEATERS INSTALLED AT KLIPSPRUIT

Mr L Heyl – Private techno economic consultant

**TABLE 1:** SOURCE OF DATA FOR STUDY
(number of households)

| Hot water system installed in household | Mamelodi | Daveyton | Klipspruit | Total |
|---|---|---|---|---|
| Integral solar water heater | 15 | 15 | 0 | 30 |
| Integral solar water heater combined with electric geyser | 13 | 13 | 26 | 52 |
| Electric geyser used on its own | 49[2] | 0 | 74[3] | 123 |
| No fixed domestic hot water appliance[1] | 47[1] | 37[1] | 34[1] | 118[1] |
| Total | 124 | 65 | 134 | 323 |

1. Control group, i.e. respondents not involved in technical study.
2. 17 in control group.
3. 47 in control group.

## SUMMARY OF SOCIO-ECONOMIC DATA

It was found that 65 per cent of the interviewees were female and that the mean family income in the townships of Mamelodi, Daveyton and Klipspruit was R605, R405 and R745 per month respectively. The mean age of the respondents was approximately 40 years. In the case of Mamelodi, the income reflected is subject to a measure of bias in the sense that some of the houses in this township did not have an internal water-supply, a requirement which was essential for the technical part of the project and which was available to all houses in the other townships. All the houses involved in the study had an existing electricity supply.

The extent of home-ownership in the three townships was about 50 per cent, 20 per cent and 26 per cent respectively, whilst the mean occupancy was 2,9, 2,7 and 3,3 persons per house on weekdays, and 6,5, 5,2 and 5,6 during evenings and at weekends. Although these rates correspond to those noted in the technical study, there is a strong possibility that the actual occupation rate could have been as much as 30 per cent higher because of unauthorised lodging arrangements.

## SALES MARKET FOR SOLAR WATER HEATERS

The integral solar water heater is not only an energy saving device, it has the potential to become the sole source of water heating wherever an intermittent supply of hot water is acceptable to users. Under such circumstances it is estimated that hot water can be obtained at lower cost than from any other source[2], provided the cost of the installation is kept to a minimum.

The primary sales market for integral solar water heaters is thus seen to be in respect of dwellings without electricity, whilst houses with electricity are seen as a secondary market.

Based on published statistics and the application of logical assumptions it has been estimated that by the year 2000, about half the houses for Blacks in urban areas in Southern Africa (1,2 million) will be without electricity. In 1982 the number of houses without electricity in the urban areas administered by Administration Boards was 358 000, a figure likely to decrease to about 255 000 by the year 1990 as a result of electrification schemes now in progress.

## HOT WATER SYSTEMS

The sources used to obtain data on the hot water systems involved in this study are reflected in Table 1. The control group, which was not involved in the technical study, provided the following information.

- About 85 per cent of the control group houses at Mamelodi and Daveyton do not have a fixed water heater. Electric kettles and stoves, as well as wood stoves, are the appliances most often used to heat water.
- Only 27 per cent of the houses in Mamelodi have electric geysers, whereas none in Daveyton enjoyed this facility.
- In Klipspruit 54 per cent of all houses have an electric geyser. Those without this facility utilise electric kettles and stoves for heating water.

As will be indicated later the availability of a water heater has a distinct influence on the preferences expressed in respect of integral solar water heaters.

## HOT WATER CONSUMPTION

The hot water consumption was estimated by requesting information from respondents on the number of conkas (20 $\ell$ containers) of hot water at an approximate temperature of 40 to 45°C that were consumed by each household for specific purposes in summer and in winter. The data for the 'test' group was divided by the measured water consumption data obtained with the technical survey[3], and figures of 53 per cent, 85 per cent and 73 per cent were obtained for Mamelodi, Daveyton and Klipspruit respectively. On the basis of this comparison it becomes clear that the use of individual judgement to estimate hot water consumption is not sufficiently accurate

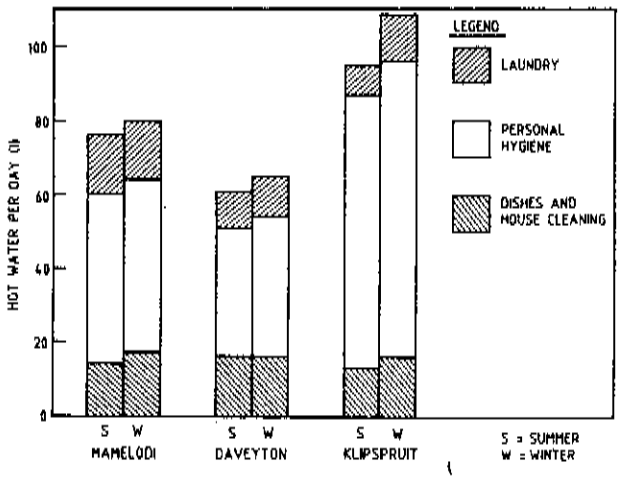


**FIGURE 3:** ESTIMATED DAILY CONSUMPTION OF HOT WATER

and that at most it can indicate trends in consumption. The temperature of the hot water as measured in the technical survey varied from 50 to 75°C.

Results from the total sample are indicated in Figure 3. The increased consumption in winter is probably underestimated because the respondents were asked to make their estimates in February. Consumption follows socio-economic ranking in the three areas. Laundry, dishwashing and kitchen hot water use is relatively small and forms a base load for all three groups. On the other hand between 60 and 74 per cent of the hot water used by all groups was for personal hygiene during both summer and winter.

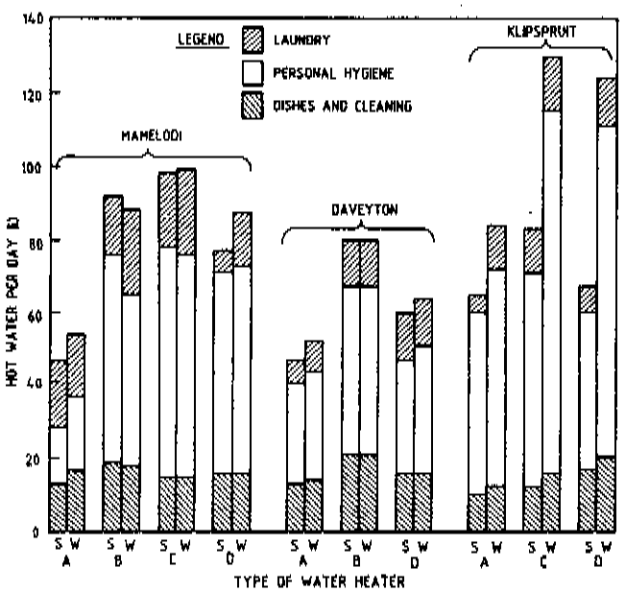


**FIGURE 4:** ESTIMATED DAILY CONSUMPTION OF HOT WATER AS A FUNCTION OF THE TYPE OF WATER HEATER

A = no fixed device, B = integral solar water heater, C = electric geyser, D = integral solar water heater and geyser
S = Summer, W = Winter

The availability of a water heater has a decided effect on the use made of hot water (Figure 4). The lowest consumption has been shown to occur in homes in which water must be heated by alternative means such as a stove or electric kettle. In Mamelodi and Daveyton there was not much difference in consumption between winter and summer or where different types of water heater were installed. The variable component in all cases was unquestionably the use made of hot water for personal hygiene. It seems that where an integral solar water heater is the only source of hot water (bar B in Figure 4) consumption is related to the capacity of the unit. An integral unit, with a storage capacity of 100 ℓ will generally produce between 100 and 200 ℓ of water at 40°C per day, depending on climatic conditions. This approximately matches the data reflected in Figure 4 when the difference between estimated and measured values is taken into account, where

$$\text{Mamelodi} = \frac{90}{0{,}58} = 170\ \ell \text{ per day}$$

$$\text{Daveyton} = \frac{80}{0{,}85} = 94\ \ell \text{ per day}$$

A sizeable proportion of the respondents said they were willing to use cold water in summer for laundering. A small proportion would also use it for personal hygiene but hardly any would use it in winter. See Table 2.

**TABLE 2:** HOUSEHOLDS WILLING TO USE COLD WATER (%)

| Location | Laundry | | Personal hygiene | |
|---|---|---|---|---|
| | Summer | Winter | Summer | Winter |
| Mamelodi | 63 | 30 | 36 | 0 |
| Daveyton | 20 | 0 | 3 | 0 |
| Klipspruit | 49 | 10 | 6 | 0 |

## MORNING HOT WATER USE

Previous studies[1,2] have indicated that depending on the climate and the consumption patterns, an integral solar water heater can provide hot water between 10h00 and 21h00. (See Figure 1). The unit alone cannot provide hot water early in the morning. The requirement for hot water before 10h00 is given in Table 3.

**TABLE 3:** PERCENTAGE OF RESPONDENTS MAKING USE OF HOT WATER BEFORE 10h00

| Location | Laundry | Personal hygiene | Dish-washing | House cleaning |
|---|---|---|---|---|
| Mamelodi | 20 | 90 | 30 | 20 |
| Daveyton | 30 | 100 | 20 | 40 |
| Klipspruit | 25 | 90 | 50 | 35 |

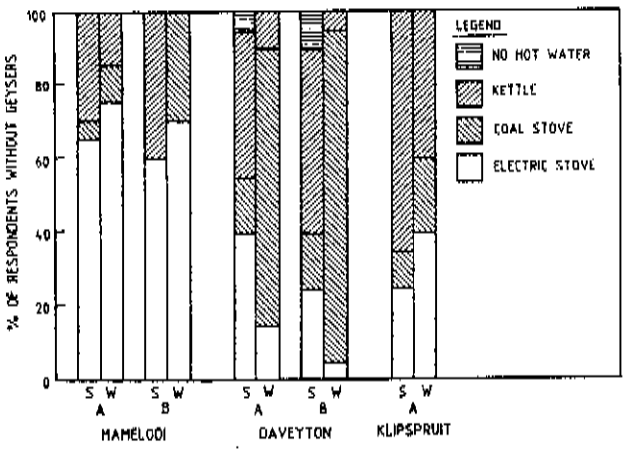


**FIGURE 5:** METHOD OF HEATING WATER FOR USE BEFORE 10h00, EXCLUDING HOUSEHOLDS WITH GEYSERS

A = no fixed water heater, B = integral unit only
S = Summer, W = Winter

The study showed that more hot water was used for personal hygiene in the early morning, than for other purposes. In virtually all the households without electric geysers, hot water for early morning use was produced by means of a stove or electric kettle.(See Figure 5). The use of coal stoves for this purpose predominated in Daveyton. Also noticeable was that coal stoves are used to a far greater extent for heating water in winter, ostensibly because they also provide space heating. It may therefore be concluded that almost all the respondents do not consider cold water an appropriate substitute for hot in the morning, and that alternative means of heating water are used at those times when the solar water heater is incapable of providing it. These comments should however, be treated with caution as the expressed attitudes and reactions of respondents do not always conform to their actual behaviour.

## EVENING HOT WATER USE

The study has shown that the use of hot water in the evening is generally for personal hygiene and dishwashing. This is reflected by the data given in Table 4.

**TABLE 4:** EVENING USE OF HOT WATER (17h00 TO 20h00) (percentage of respondents)

| Location | Laundry | Personal hygiene | Dish-washing | House cleaning |
|---|---|---|---|---|
| Mamelodi | 0 | 90 | 55 | 0 |
| Daveyton | 10 | 70 | 85 | 5 |
| Klipspruit | 10 | 90 | 70 | 25 |

Respondents were asked whether they would be willing to change their existing water use habits to make better use of the hot water from an integral unit which would generally be available between 10h00 to 20h00. Their answers, as indicated in Table 5, were inconsistent. Quite understandably those households without a water heater would be more than willing to change their habits if this meant that they would obtain something better. In the case of households with electric geysers there would be no need to change their habits because hot-water would in any case be available at all times. It would require an extensive study to establish to what extent respondents would change from doing what they currently do, to what they have suggested they would be willing to do.

**TABLE 5:** RESPONDENTS WHO INDICATED A READINESS TO CHANGE THEIR HOT WATER USAGE HABITS (%)

| Water heater installed in household | Mamelodi | Daveyton | Klipspruit |
|---|---|---|---|
| No water heater | 40 | 70 | 100 |
| Integral solar heater | 80 | 10 | None installed |
| Integral unit and geyser | 100 | 0 | 90 |
| Electric geyser only | 30 | None installed | 90 |

## COST OF ENERGY

It was possible to establish monthly expenditure patterns for the various forms of energy that are generally used. However, results should be interpreted with caution, since:

- most respondents do not keep detailed records;
- the survey was undertaken in February, as a consequence of which winter expenditure had to be recalled from memory;
- difficulty was experienced by most respondents in interpreting the method by which the cost of electricity was calculated and set out in municipal accounts.

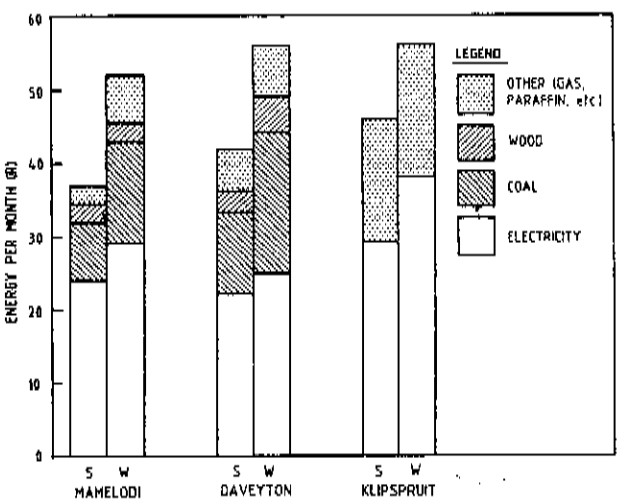


**FIGURE 6:** ESTIMATED MONTHLY EXPENDITURE ON ENERGY

S = Summer, W = Winter

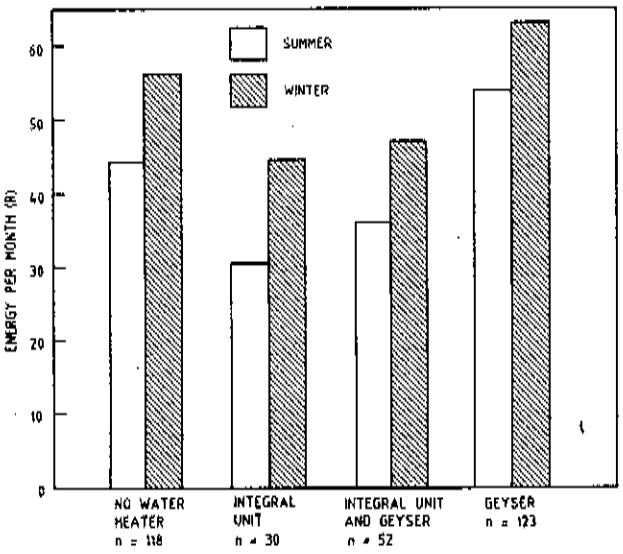


**FIGURE 7:** ESTIMATED MONTHLY ENERGY EXPENDITURE AS FUNCTION OF TYPE OF WATER HEATER

The data shown in Figure 6 indicate that the cost of electricity is a major item, that the consumption of coal increases in winter and that winter expenditure ranges from 25 to 45 per cent higher than summer expenditure. Energy accounts for 6 to 14 per cent of total expenditure.

The weighted mean monthly expenditure on energy for the three townships expressed as a function of the type of water heating used is given in Figure 7. As demonstrated also in Table 1, the results are not conclusive because the integral solar water heaters were used only by low income families whereas electric geysers were available in dwellings occupied by families of higher socio-economic status. Higher energy costs were also related to a higher consumption of hot water as indicated in Figure 3. Energy costs for the families with integral solar water heaters both with and without an electric geyser, were the lowest, whereas they were highest for the group which used electric geysers on their own. The fact that the difference between summer and winter energy expenditure is larger for the groups with integral water heaters (see Figure 7), indicates that this solar heater performs better during the summer. The energy expenditure for households with no fixed water heater is about 15 per cent lower than the group with electric geysers whereas their hot water consumption is about 40 per cent lower. It may be concluded from this that the use of appliances such as pots on stoves or kettles is both less efficient and more expensive.

## AWARENESS

The use of solar water heaters involves the application of an intermediate technology of which developing communities are not generally aware. Respondents in this study were therefore deliberately questioned to establish how aware they were of the existence and practicality of solar water heaters before their operation and use as a means of obtaining hot water at possibly less than normal cost, was explained. The results indicated that almost all the respondents living in dwellings not provided with solar water heaters did not know of their existence. Those that had solar water heaters (and were at the same time participating in the technical study) had a fairly good awareness of the technology applied with the exception of the respondents living in Daveyton (see Table 6).

**TABLE 6:** DEGREE OF AWARENESS OF THE AVAILABILITY AND OPERATION OF SOLAR WATER HEATERS (percentage of the respondent group)

| Location | Type of hot water system used by respondents | | | |
|---|---|---|---|---|
| | No water heater | Integral solar heater | Integral unit and geyser | Geyser |
| Mamelodi | 23 | 100 | 100 | 25 |
| Daveyton | 0 | 47 | 30 | None installed |
| Klipspruit | 15 | None installed | 62 | 42 |
| Weighted mean | 13 | 74 | 64 | 34 |

The generally low awareness shown in the above table confirms a need for information about solar water heating to be disseminated among communities not previously exposed to this technology. Although the monitoring staff were asked to inform users of the function and operation of the integral unit on their houses, this does not appear to have been successful in Daveyton, and it appeared to be only partly successful in Klipspruit. No correlation was found between the level of income of respondents and their awareness of the existence or principle of operation of solar water heaters. Moreover, the approximately 13 per cent of the respondents who had no water heater and who were aware of the existence of solar water heaters could not describe how they operated. This factor reinforced the need for solar water heaters to be more extensively publicised than heretofore.

## ATTITUDES TO SOLAR WATER HEATERS AS A DESIRABLE DOMESTIC ASSET

A generally positive attitude to integral solar water heating units was noted. Of the respondents who had no integral solar heating unit, 67 per cent indicated that they would like one. Of this group, 44 per cent were respondents who presently had

cost of electricity plus repayments of the capital cost over a period of 15 years, is also expected to be much lower. This statement holds only if solar water heaters are installed in large numbers as a single project and financed so as to achieve economies of scale in manufacture, marketing, installation and funding. In order not to confuse the respondents, issues such as maintenance cost, changes in the value of money and escalating electricity cost, were ignored.

Mainly because of lower cost factors, most of the respondents indicated that they would prefer an integral solar water heater to an electric geyser. This is indicated in Table 9.

**TABLE 9:** PREFERENCE FOR AN INTEGRAL SOLAR WATER HEATER RATHER THAN AN ELECTRIC GEYSER (percentage of respondents in each group)

| Location | Test group | Control group |
|---|---|---|
| Mamelodi | 80 | 70 |
| Daveyton | 60 | 90 |
| Klipspruit | 60 | 70 |
| Weighted average | 69 | 74 |

Although 60 per cent of the households in the test group had experienced the use of integral solar water heaters, their lower expressed preference indicates that their experience was not as positive as the scenario quoted to respondents. This reaction can be attributed to the fact that the 66 home-owners using the unit in combination with an electric geyser, are unable to visualise the cost savings clearly. When these reactions are analysed in terms of any existing hot water system available to a respondent, the highest preference rating for integral units was expressed by those households which had either no water heater or an integral unit only (see Table 10). The lowest rating came from those households with both an integral unit and a geyser. This rather strange reaction may be ascribed to the fact that the additional cost advantages gained from the integral unit are not manifest. No correlation could be determined between the preferences expressed in this instance and the income level of respondents.

**TABLE 10:** PREFERENCE FOR AN INTEGRAL SOLAR WATER HEATER RATHER THAN AN ELECTRIC GEYSER (percentage of respondents in each group)

| Existing water heater | Preference (% of respondents) |
|---|---|
| No water heater available | 85 |
| Integral solar heater | 95 |
| Integral unit and geyser | 25 |
| Geyser | 60 |

## QUESTIONS THAT MIGHT BE ASKED

At the end of each interview the respondents were given the opportunity to ask questions. Though most had no questions the reasons for those questions that were posed are listed in Table 11. It is of interest that a number of respondents living in Klipspruit, which may be regarded as enjoying a higher socio-economic status than Daveyton and Mamelodi, requested information on the cost of maintenance and expressed doubts about some of the information given to them. Operating problems were related to the intermittently low water pressure in Mamelodi and to the long period taken to install the units in Daveyton. Suspicion as to the motives of the study were fuelled by a fear that by installing solar water heaters the electrification of the area would be delayed.

**TABLE 11:** QUESTIONS POSED BY RESPONDENTS (percentage of respondent groups)

| Question | Townships | | | Weighted Mean |
|---|---|---|---|---|
| | Mamelodi | Daveyton | Klipspruit | |
| None at all | 74 | 54 | 43 | 57 |
| Maintenance costs | 2 | 0 | 25 | 11 |
| Suspicion of facts | 2 | 3 | 20 | 10 |
| Operating problems | 5 | 12 | 2 | 7 |
| Suspicion on motives | 5 | 14 | 1 | 5 |
| Marketing and purchasing information | 7 | 1 | 3 | 4 |
| Possibility of improving the system | 3 | 11 | 2 | 4 |

## CONCLUSION

As far as is known, this is the first major research and demonstration project carried out in South Africa on both the use of solar water heaters and human ability to adapt to them. The project is also unique not only in that it researched the use of low cost integral solar water heaters used without geysers but also in that a large social study was undertaken.

This study has proved that hot water is required in the morning for personal hygiene and that supplementary methods are readily used to heat water when the solar heater cannot satisfy demand. It could not be conclusively established that respondents would be willing to adapt their living habits to conform to the times when hot water was available from the solar heaters. The general reaction by respondents to the use of the

electric geysers in their homes. Respondents favoured with integral units indicated that no less than 82 per cent of their friends and relatives expressed a desire to have such units on their homes.

## ADVANTAGES AND DISADVANTAGES OF SOLAR WATER HEATERS

Respondents indicated that low operating costs (74% of respondents), safety factors (31%) and the reasonable availability of piped hot water (24%) were the main advantages of the system. The disadvantages identified related to the lack of hot water in the early morning (72%) and the reduced supply of hot water on cloudy days (53%), whereas 12 per cent claimed that there were really no disadvantages.

## PREFERENCES FOR A WATER HEATER AS A DOMESTIC FIXTURE AGAINST OTHER FACILITIES

Respondents were asked to rate their preference for a television set, a stove, a refrigerator, a washing machine, a hi-fi set, and a ceiling against that for a water heater (in this case not specifically a solar water heater). Detailed results of the preferences expressed are given in Appendix I and are summarised in the following Tables 7 and 8.

**TABLE 7:** MEAN PREFERENCE FOR FIXED WATER HEATER IN RELATION TO THE DOMESTIC APPLIANCES LISTED IN THE TEXT (percentage of respondents in each group)

| Location | Hot water system of respondent | | | |
|---|---|---|---|---|
| | No water heater | Integral solar heater | Integral unit and geyser | Geyser |
| Mamelodi | 20 | 15 | 16 | 37 |
| Daveyton | 71 | 29 | 46 | None installed |
| Klipspruit | 33 | None installed | 29 | 28 |
| Weighted mean | 40 | 22 | 30 | 32 |

Mamelodi and Klipspruit respondents generally preferred the other domestic appliances above a fixed water heater, whereas those in Daveyton without a water heater preferred a fixed water heater. When these responses are combined, the highest preference for a fixed water heater is where none exists and the lowest where an integral solar water heater is used.

**TABLE 8:** PERCENTAGE OF RESPONDENTS WHO PREFERRED SPECIFIC APPLIANCES TO A FIXED WATER HEATER

| Appliance | Percentage of respondents |
|---|---|
| Stove | 82 |
| Television set | 80 |
| Refrigerator | 71 |
| Washing machine | 70 |
| Hi-fi set | 68 |
| Ceiling | 36 |
| Mean | 68 |

From Table 8 it can be concluded that the highest preference is for a stove (82% rated it more important than a fixed water heater) and the lowest for a ceiling. The difference in preference of the five quoted domestic appliances is not high. The mean preference for a fixed water heater in relation to the other domestic appliances is therefore 32 per cent.

From the above data the following conclusions can be drawn:

Mamelodi: Respondents in this township expressed a preference for other domestic appliances, excluding a ceiling, above that of a water heater.

However, water pressure problems in this area, as well as an above average socio-economic level and hence ability to afford 'luxury' items, may have influenced their order of preferences.

Daveyton: Most households favoured with solar water heaters preferred other appliances, whereas households with no water heaters rated the water heater as more important than other appliances, except for stoves.

Klipspruit: Respondents generally rated domestic appliances as more important and desirable than a water heater.

The generally low preference for a ceiling is understandable as the benefit is not clear to the homeowner. Notwithstanding the fact that a ceiling has a significant effect both on comfort and in reducing the cost of heating energy, its benefits may not be recognised by families which have not experienced living in a house with a ceiling.

## FINAL EXPRESSION OF PREFERENCES

Respondents were asked to choose between an integral solar water heater and an electric geyser, after the functional characteristics and cost effectiveness of each had been explained, as shown in Appendix II. Although the standard of hot water supply of the integral solar water heater has been reflected to be lower than that of the geyser, the total monthly expenditure, consisting of the

**APPENDIX I:** PREFERENCE FOR DOMESTIC APPLIANCES, MEASURED AGAINST A FIXED WATER HEATER
(% preferring appliance listed)

| Appliance | Hot water system used by respondent | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No water heater | | | Integral unit | | Integral unit and geyser | | | Geyser | |
| | Mamelodi | Daveyton | Klipspruit | Mamelodi | Daveyton | Mamelodi | Daveyton | Klipspruit | Mamelodi | Klipspruit |
| Television set | 85 | 30 | 85 | 100 | 85 | 100 | 60 | 100 | 60 | 90 |
| Stove | 90 | 60 | 90 | 100 | 75 | 90 | 60 | 90 | 80 | 85 |
| Refrigerator | 90 | 20 | 85 | 90 | 60 | 100 | 30 | 80 | 70 | 85 |
| Washing machine | 70 | 40 | 40 | 100 | 85 | 85 | 80 | 75 | 45 | 75 |
| Hi-fi set | 70 | – | 50 | 100 | 60 | 100 | 85 | 60 | 70 | 60 |
| Ceiling | 75 | 5 | 50 | 20 | 60 | 30 | 10 | 20 | 55 | 35 |
| Mean | 80 | 29 | 67 | 85 | 71 | 84 | 54 | 71 | 63 | 72 |

**APPENDIX II:** CHARACTERISTICS OF WATER HEATING SYSTEMS FOR USE IN LOW INCOME URBAN HOUSEHOLDS

| Attribute | Integral solar water heater | Electric geyser |
|---|---|---|
| Availability of hot water | 10h00 to 20h00 on sunny days | At all times |
| Total monthly cost established from the following: | R6 - R8 | R15 - R17 |
| Mean daily hot water consumption | 150 ℓ[1] | 200 ℓ |
| Mean monthly use of electricity | — | 260 kWh[2] |
| Monthly cost of electricity (4c per unit) | — | R10,50 |
| Installed cost of water heater | R600[3] | R450 |
| Monthly repayment of installed cost over 15 years at an interest rate of 12% | R7 | R5 |

1. Estimated daily volume of hot water produced by 100 ℓ integral unit.
2. Heating of 200 ℓ of water from 20 to 50°C plus heat losses from 100 ℓ geyser according to SABS 151.
3. Marketed, installed and financed as one large contract.

solar water heater was unquestionably a positive one. Respondents without solar water heaters were fairly ignorant of their existence. When specific data on performance and operating cost of both integral solar water heaters and electric geysers were given, a preference for the solar water heater was expressed. As indicated in a previous paper[2], the life cycle cost of an integral solar water heater is expected to be lower than that of an electric geyser. This study has therefore indicated beyond doubt that the use of the integral solar water heater, as an only form of heating water, is a viable proposition provided that the higher initial cost can be reduced by economies of scale and by collective financing under reasonable terms and conditions.

The cost of energy forms a sizeable proportion of a family's income. The use of a solar water heater to reduce costs is therefore likely to be seen as a favourable proposition and investment.

Because the construction of dwellings en masse is likely to continue for the next two decades, a large primary market for solar water heaters will inevitably be created wherever electricity is not supplied. In any case dwellings wired for electricity will probably be fitted with solar water heaters whenever back-up water heaters or geysers are not installed.

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