SOLAR COOKING COMPENDIUM

Volume 2

Social Acceptance of Solar Stoves in South Africa

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Abstract

Based on the results of the thermal performance tests of ECSCR, verified through additional cooking tests at SESSA's renewable energy demonstration center, seven models of solar stoves were retained for the social acceptance test. A baseline study in five areas, representing a mix of fuel use patterns and representative of rural, semi-urban, and urban South Africa, involved households of different size and institutions. It generated valuable results for conducting the social acceptance test which comprised the selection of three test areas with 66 user families/households, 10 control households for each of the test areas, 14 user institutions, and monitoring personnel. In addition, cooking profiles were also compiled.

On 38% of all days the families used solar stoves at least once to prepare 35% of all cooked meals. They were satisfied with 93% of the results of all solar cooking attempts. Solar stoves along with wood were the most used cooking appliances followed by stoves fueled with gas, paraffin, and electricity. During the one-year placement period the households enjoyed 38% of fuel savings (with 33% of paraffin, 57% of gas, and 36% of wood). These results indicate acceptance of solar stoves by family test users. Institutions used solar stoves to a much lesser extent suggesting limited acceptance. In principle, solar stoves are a promising option to effectively respond to the challenge of household energy shortage.

Key words: Solar stoves, solar cooking, models of solar stoves, household use of solar stoves, institutional use of solar stoves, user acceptance, impact of solar stoves, energy saving

Foreword

The Solar Cooking Compendium (SCC) is about the viability of solar stoves as a solution to the scarcity of household energy. Viability is measured in commercial terms. It means manufacturing and marketing of solar stoves without subsidies. In the future, this will be the criterion for judging projects promoting solar cooking.

The SCC is based on the experience gained in implementing the Solar Cooker Field Test (SCFT) in South Africa from 1996 to 2003. It consisted of Phase 1 – Global market situation of solar stoves and social acceptance test (1996 - 1998) and Phase 2 – Estimate the market potential in South Africa, manufacture of solar stoves, and test marketing (1999 - 2003). The SCFT, a pilot program, was performed under a bilateral Technical Cooperation Agreement between the Governments of the Federal Republic of Germany and the Republic of South Africa (RSA). Executing agencies were the Department of Minerals and Energy (DME) and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ).

What were the reasons for implementing the pilot program in South Africa? The answer is as simple as the related challenge was difficult to meet: The will and commitment of both Governments to significantly contribute to solving the shortage of household energy, and more specifically the fuelwood problem, by coming up with a market oriented solution in South Africa; once and for all it had to be shown that solar stoves are not only a niche solution. Ideally such a solution is expected to be suitable in principle for replication in other countries where similar fuelwood problems prevail. Moreover, the SCFT is in line with the energy policy heralded in the White Paper on Renewable Energy (RE) compiled by the DME in 2002 to bring renewable energy into the mainstream energy economy of South Africa.
It also responds to improving the extent of basic energy needs satisfaction addressed by the Bundesministerium für Wirtschaftliche Zusammerarbeit und Entwicklung (BMZ). Finally, it contributes to achieving the goals of the Agenda 21.

Household energy shortage is an issue in many regions of the world with an estimated two billion people being affected. In the past two to three decades, fuelwood scarcity became a major constraint for people in rural and semi-urban regions, notably on the African continent. The problem involves social, economic, technical, health, and environmental aspects.

In turn, an array of solutions has been offered and discussed time and again by politicians and specialists alike. Some follow conventional patterns; others focus on new technologies, in particular tapping renewable energies. One option is solar cooking.

The magnitude and complexity of this global challenge call for an integrated, multi-disciplinary approach, addressing the associated issues from various angles and putting equal emphasis on all-important features. In doing so, the underlying basic rationale is clear: In countries with high solar irradiation of 500Watt per m^2 (this is 50% of the usual maximum irradiation) the use of solar stoves as an additional cooking option can contribute to alleviating energy shortages. The vision for the future is the availability of low cost solar stoves of high quality so that they will be affordable for everyone on the African continent.

In the past, measures to introduce solar stoves were often effected by enthusiasts favoring a technology driven approach. These activities did not result in the sustainable use of solar stoves because they neglected their social acceptance by the target group, notably low income people living in rural and semi-urban areas, and underestimated the mechanisms of the market. The successful marketing of solar stoves, covering the whole chain from the demand oriented design and production to their appropriate use in households, is a complex endeavor. It involves many players with various tasks and responsibilities.

The challenges, accomplishments, and lessons learnt in implementing the SCFT in South Africa have been channeled into the SCC. It provides a comprehensive account of this pilot program, starting from the project idea all the way to the final assessment of the achievements. Thus, the SCC illustrates

- Why have solar stoves been selected as a means to fight energy scarcity of households?
- What have been the key activities of the pilot program?
- How have they been planned, implemented, monitored, and evaluated?
- Which were the lessons learnt for shaping future programs or projects?

To keep it as a user-friendly manual-type document the SCC has been edited in five volumes:

Main Report	Challenges and achievements of the Solar Cooker Field Test in South Africa
Volume 1	Scarcity of household energy and the rationale of solar cooking
Volume 2	Social acceptance of solar stoves in South Africa
Volume 3	Making the case for commercializing solar cookers in South Africa. Justification for the development of a commercially viable renewable energy cooking technology industry.
Volume 4	The solar cooking toolkit. Conclusions from the South African Field Test for future solar cooking projects.

The concept, the various features of implementation, and the accomplishments of the pilot program have already been shared with policymakers and professionals in many fields throughout the last three years, e.g. at the international conferences in Varese, Italy (1999), Kimberley, South Africa (2000), and Adelaide, Australia (2001) as well as the International Workshop on Solar Cooking in Johannesburg, South Africa (2001) as well successfully participating in the World Summit on Sustainable Development (WSSD) during 2002. These events also generated valuable feedback for advancing the SCC. It was also presented to the German Ministry of Development Co-operation (BMZ) in November 2003 with the result that solar cooker programmes have been included in their standard set of development instruments and further proposals have been invited for projects of this nature.

The SCC compendium was updated at the end of 2003 to reflect the development of an expanded approach to the concept of commercialising solar cookers. The expanded approach entailed the broadening of the initial narrow focus on solar cookers, to that of a complete renewable cooking industry (including solar cookers, improved wood and coal stoves). The Energy Development Corporation (EDC), a division of CEF(pty)ltd. of South Africa expressed potential interest to become the champion of a renewable cooking industry provided that the potential commercial viability could be confirmed, calculated and quantified. After successfully demonstrating the "business case", for the development of a renewable energy cooking industry, the project has been incorporated into the structures of the EDC.

The Solar Cooker Field Test has received the attention and appreciation of South African and German politicians alike. They visited solar cooking demonstrations and tasted dishes cooked with the sun. The most prominent of them are:

- Ms Phumzile Mlambo-Ngcuka
  Minister of Minerals and Energy, South Africa
- Ms Susan Shabangu
  Deputy Minister of Minerals and Energy, South Africa
- Mr Johannes Rau
  President of the Federal Republic of Germany
- Ms Heidemarie Wieczorek-Zeul
  Federal Minister for Economic Cooperation and Development, Germany

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Abbreviations

BMBF	Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung
DEM	German Mark
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DME	Department of Minerals and Energy
ECSCR	European Committee for Solar Cooking Research
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
ISES	International Solar Energy Society
RSA	Republic of South Africa
SCC	Solar Cooking Compendium
SCFT	Solar Cooker Field Test
SESSA	Solar Energy Society of South Africa
USD	United States Dollar
WTP	Willingness To Pay
ZAR	South African Rand

Equivalent of 100 ZAR

	1997	1998	1999	2000	2001	2002	2003
DEM	37.65	32.14	30.02	30.63	25.72	10.10 Euro	11.72 Euro
USD	21.17	18.07	16.36	14.42	11.62	9.51	13.22

✍ Average annual figures published by the South African Reserve Bank

Overview

Situation before the social acceptance test

1 Prior to the social acceptance test, there were two basically different test methods available. Both of the methods focused exclusively on technical aspects of solar stoves. One focused on the determination of efficiency at ambient temperature and loss factor (figures of merit), the other on the establishment of solar stove characteristics like heat-up times, maximum temperatures, tracking frequencies, and similar data. Both had to be supplemented by additional criteria to put emphasis social and economic aspects as well.

2 The international test effected by the European Committee for Solar Cooking Research (ECSCR) in 1994 comprised 25 different solar stove models from 10 countries. Six key technical performance criteria like heat-up and cool-down times, tracking frequencies and several other features such as pot access and capacity or handling were applied. Out of this range of solar stoves 7 models were selected for the social acceptance test in South Africa.

3 However, prior to the final decision these technically suitable solar stoves were subject to a cooking test confronting them with a real-life user situation and the African climate. It showed that all selected solar stoves allowed the preparation of all test dishes including the baking of bread. Thus, all solar stove related prerequisites for the social acceptance test were fulfilled.

Baseline study to prepare the social acceptance test

4 The baseline study in the dry North-Western region of South Africa, i.e. the North West Province and the Northern Cape Province, scanned five potential test areas by interviewing 200 of a potential of 6,800 households and a series of institutions like old age homes, hospitals, clinics, schools, kindergartens, and small businesses. The five areas, Huhudi, Seoding, Pniel, Gong Gong, and Onseepkans, represented a mix of fuel use patterns and were representative of rural, semi-urban, and urban settlements.

5 Based on criteria like cooking profiles (weather conditions, fuel availability and prices, household size, availability of an appropriate sunny space, cooking techniques and timings) as well as socio-economic characteristics, three test areas were selected. Onseepkans, representative of small rural villages, where collected wood is the primary source of fuel. Pniel, though also a small rural village, is located 8 km from the nearest town; there is a fuel mix with wood and paraffin used in almost equal proportions. Huhudi, an urban township, has access to electricity, has a high reliance on paraffin for cooking and a comparatively low use of wood.

6 The two urban towns (Seoding and Huhudi) spent the most on commercial fuels while the rural towns relied more on fuelwood and reported problems due to dwindling supplies. Typical meals prepared in the areas were found to be suitable for solar cooking.

7 Schools were found to be the only suitable institutions. Selected schools served at least one meal per day and reported a desire to save on fuel expenses.

Design and execution of the social acceptance test

8 Solar stoves were tested by 66 families and 14 institutions in the three selected test areas during a one year placement period. 30 families without solar stoves acted as control households. Monitoring personnel, i.e. three persons for each test area, was selected and trained before being deployed in the field. Their task was to collect and process questionnaires completed by the user households, the control households, and the institutions and to compile additional data.

9 Six solar stove models were placed with families, three models each for large and small ones. Every family had one solar stove model for a period of two months before changing and using another one. Therefore, by the end of the placement period each family had tried every solar stove twice. Moreover, three large solar stove models were placed at institutions. For users and non-users, three different types of questionnaires were completed. In-depth interviews provided additional information. At the end of the placement period, a workshop was conducted in each test area to carry out a preference voting exercise. Finally waiting lists were established for the purchase of used stoves as a useful indicator of user preference.

10 The solar stoves during the social acceptance test exclusively used local cooking profiles taking into consideration such data as typical housing, monthly family income, number of persons in the household, type of dishes, cooking techniques, cooking times, meal times, existing cooking equipment, cooking area, number of cooking pots, fuels collected or bought, cost of fuel, weather conditions, annual daily insulation, and place for solar stove.

Results of the social acceptance tests at households

11 Intensive monitoring showed that families used the solar stoves at least once on 38% of all days, prepared 35% of all cooked meals on the solar stove, and were satisfied with the results of 93% of their solar cooking attempts.

12 Solar stoves, along with wood (open fires, wood-stoves and coal-stoves fueled with wood combined) were the most used cooking appliances followed by stoves fueled with gas, paraffin and electricity. These results indicate acceptance of solar stoves by family test users; “acceptance” of solar stoves being defined as “solar stoves are used as much or more than other cooking options in the household”.

13 The preference of family users for different solar stove models was assessed in three independent ways: By use frequencies of the six solar stoves, by the sales of the used test stoves and by user workshop voting results. There were use rate variations but not enormous ones. According to the first criteria, small families prefer the REM5 (over ULOG and Sunstove), large families the SK12 (over SCHWARZER1 and REM15). These priorities have been confirmed by the sales of the used test stoves while the workshop generated a slightly different ranking. Over all three test areas small families mostly used and bought the REM5 but voted for the ULOG as the best solar stove, while large families preferred the SK12 with the REM15 coming first in votes.

14 Solar stoves are used for cooking and baking. But they are add-on appliances - not appliances that replace others. Solar stoves, along with wood (open fires, wood stoves and coal stoves fueled with wood combined) were the most used cooking appliances among the test families. These were followed by stoves fueled with gas, paraffin, and electricity. Understandably, electricity use appears to be very low since only one out of three test areas is grid connected. In 7% of the cases non-solar stoves were used but the fuel type was not specified. On 2% of all days, no cooking took place.

15 During the solar stove placement period, the participating families enjoyed 38% of overall fuel savings (with 33% of paraffin, 57% of gas and 36% of wood). Considering the fact, that solar cookers are no “stand-alone” option and that many families use more than one fuel type for cooking, these fuel savings are considerable. In absolute terms, the 60 or so test user families have saved almost 60 tons of wood, more than 2 tons of gas, and over 2,000 liters of paraffin. In monetary terms, savings were the highest in Huhudi where fuel is mostly bought, and lowest in Onseepkans where collected wood is an important fuel source. Pniel took an intermediate position.

16 The solar stoves have been tested in complex social environments characterized by poverty, high levels of migration, low levels of production and lack of institutional support. Impacts on women at the household level include monetary savings, which have enabled them to allocate finances to their spheres of influence, as well as time savings, which provide the opportunity for them to spend more time strengthening their social networks. However, increased engagement in community politics was not identified. Fuel strategies to cope with poverty are not abandoned completely but adapted slightly. Preference among users of solar stoves varies from one household to another. If an elderly person or a child is responsible for cooking maneuverability of the solar stove is of importance. Safety is a key issue at all times, especially for women.

17 The macro-economic estimate complements the micro-economic assessment and sheds light on likely economic and social impacts once large-scale marketing of solar stoves will take place. Impacts include cumulative savings, reduced air pollution from wood use, and the avoided time used for wood collection. In addition, further effects might be employment generation to a certain extent, slight reduction in air pollution from coal combustion, paraffin poisoning cases, as well as fires and burns from paraffin. Moreover, small decreases will occur in the emission of green house gases such as carbon dioxide.

Results of the field test at institutions

18 Since solar stoves were poorly used by the eight initially selected institutions, the social acceptance test was eventually limited to those institutions with reasonable use and interest. Thus, only three of the original institutions remained and another six were added in June 1997. To permit further evaluation the test period was extended by six months.

19 Taking into consideration the original institutions where interest was observed together with the new institutions, solar stoves were used on over 50% of all occasions when visited by the monitors or supervisors. Overriding incentives for solar stove use were high motivation of the cooks, management incentives to reduce fuel expenditure and incentives for the cooks to use the solar stoves. The most important reasons for not using the solar stoves were lack of security for the solar stoves, lack of budget control by the cooks and control exerted by outside organizations.

20 Several interviews generated a series of interesting findings: Most institutions would likely buy a solar stove. Many prefer the SK 12. Pot size is an important criterion. Likely prices to be accepted range between ZAR 1,000 and ZAR 1,500. Where decisions are made at the institution, appliances are bought from the cheapest store. They are normally purchased with a 12 to 24-month guarantee. In general the solar stoves are expected to be delivered. The number of people catered for by hot meals varied between 25 and 170.

Long-term acceptance of solar stoves

21 Of the 66 solar stoves sold to families at the end of the social acceptance test 44 units were found more than three years later. Of the solar stoves that could not be located two units had been passed on to family members outside the test areas and two users were absent at the time of the visit. In some cases families moved away or because of a death in the family the solar stove was divided with other belongings among siblings in other areas. In general, the solar stoves were in good condition. Mostly minor repairs had been performed on 21 solar stoves. Six households were using their solar stoves during the visits.

22 The major messages from the ex-post purchase study were: Use rates decreased in winter when the elevation is lowest, limiting the available solar input power. The decrease rate is particularly strong for the two slower solar stove models, the ULOG and the Sunstove. The decrease rates in winter concerns mostly Pniel and Huhudi where practically all fuel is bought. In Onseepkans where most of the fuelwood is collected, the drop of the use rate in winter is less dramatic. High capacity solar stoves are used more than low capacity solar stoves. The use of solar stoves is dependent on a certain minimum per capita pot capacity, which should be in the order of 1 to 2 liters per capita.

23 To establish commercial viability of solar stoves, high quality products need to be available to potential customers. They have to be convinced of the benefits to purchase solar stoves. This requires a clear understanding of the usefulness of solar stoves to owners, in the short and long-term. One argument is that the cost of the solar stove will be amortized through energy savings over a period of time. A final survey in July 2000 revealed that 50% of the families were now using their solar stoves more than in 1997, 5% had a stable use rate, and 45% were using their solar stoves less by now. These figures suggest that long-term acceptance of the solar stoves is proven by the fact that more than half of the households increased the use rates three years after purchasing their solar stoves.

Lessons learnt

24 The key messages from the social acceptance test for solar stoves are:

- Solar energy is a promising option capable of being one of the leading energy sources for cooking
- The high use rate of solar stoves, at par with wood and above other fuels, indicates acceptance of solar cooking by families / households
- Each solar stove model has its own supporters. An obvious, universal, single choice does not emerge. However, clear user preference for certain solar stove models is evident and thus provides a sound basis for the selection of solar stoves to be promoted
- Considerable fuel and time saved by the use of solar stoves generate reasonable payback periods, except for the most expensive stoves. With price reductions on the horizon once solar stoves will be mass produced, payback periods will be reduced even further
- The willingness to buy test stoves suggests a viable market for solar stoves, confirmed by the independent ex-post market study

- While causing shift in cooking times and reorganization of household labor, the use of solar stoves does not disrupt social relationships

- Solar cooking generates positive macro-economic impacts

- The questionnaire method concerning family use has proven sound. For institutional use, direct observation was the adequate method

- All test stoves needed technical improvements and have undergone adaptations

- The adapted solar stoves will serve as a basis for local production

- The open approach of the social acceptance test where users can express their judgment of a technology in general, and preferences concerning different appliances in particular, has proven valid.

25 In terms of institutional solar stove use, it can be concluded that the original participating institutions did not maximize the use of the solar stoves available to them. Seven issues were identified which make up the management environment and which influence the potential use of solar stoves in institutions:

- Human resources

- Financial resources

- Communication channels and methods

- Attitudes to work

- Decision-making structures

- Wealth of the institution

- Institutional support networks

1 Situation before the social acceptance test

The goal of the SCFT in South Africa was to determine whether solar stoves meet user expectations, i.e. are accepted in principle, and whether they can be put on the market at affordable prices.

It was clear from the outset of the field test that several types of solar stoves would be compared and that the findings of independent comparative tests would play a role in the initial selection of the test stoves. Moreover, it was admitted that in the past test results gave only part of the picture. They were biased in favor of technical characteristics, a fact which hardly provided information on the user's preferences.

1.1 Basic field test methods

There are two basically different types of technical test methods:

- The method developed by Mullick and the one developed by Funk, both treat the solar stove as a solar collector, aiming at the determination of the two efficiency curve parameters: efficiency at ambient temperature and loss factor. The advantage of this procedure is that it can serve for the prediction of performance in different climatic conditions. However, these parameters (figures of merit) are difficult to understand and interpret for the majority of users.
- The method of the European Committee for Solar Cooking Research (ECSCR) for the determination of directly observable characteristics establishes heat-up times, maximum temperatures, tracking frequencies, and similar data. They "talk" directly to the user, but are not predictive. This method is best used for direct comparison of solar stoves under identical conditions.

Both test methods can be improved by addressing important unsolved problems in testing solar stoves:

- The "figures of merit" methods depend on the determination of efficiency (output power related to input power). This presupposes the definition of an aperture area (the reference surface the stove presents to the incoming radiation), a difficult exercise for boxes, particularly boxes with external reflectors. The effective aperture area of such boxes depends on the elevation of the sun. Either aperture and efficiency must be determined for different solar elevation angles, or a reference angle has to be defined.
- The "observable characteristics" method should define margins for irradiance, ambient temperature and elevation.

- Both methods should come to terms with wind, an important and frequently underestimated influence on solar stove efficiency as well as with load, number and quality of pots.
- The test methods should define and test quality and safety standards.

Probably, an ideal test method would feature elements of both methods, the “figures of merit” type and the “observable characteristics” type.

1.2 Thermal Performance Tests by ECSCR

Two international tests of solar stoves were performed by ECSCR at the Plataforma Solar de Almería (PSA) in Spain, (illustrated in **Figure 1**), funded by DLR (Deutsches Zentrum für Luft- und Raumfahrt) and BMBF (Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie). The first test in 1993 with 8 solar stove models was meant to be a “test of the test”. The results were not published. The second test in 1994 comprised 25 different models from 10 different countries (illustrated in **Figure 1**).

Six key performance parameters were measured:

- Heat-up-time of water from 40° to 80°C
- Heat-up-time of water from 40° to boiling
- Cool-down-time
- Amount of water which can be brought to boiling in one day
- Maximum temperature in oil
- Tracking frequency.

Other characteristics recorded were:

- Pot access
- Pot capacity
- Handling
- Safety

Figure 1
Testing of Solar Stoves in Spain

Source:

1.3 Cooking Tests at SESSA

Technical tests alone cannot predict the adaptation of a given solar stove model to a real-life user situation. It was felt that the adaptation of the test stoves to the South African climate and user situation had to be verified prior to the solar stoves being put into the hands of the users. Therefore, at the occasion of the first monitor training session at SESSA (Solar Energy Society of South Africa), a range of typical dishes was prepared using all solar stove models, e.g. the one shown in **Figure 2**.

The results showed that all selected solar stoves allowed the preparation of all tested dishes, including the baking of bread. However, there were important differences in the time needed and the quantities that could be prepared.

Figure 2
Cooking of dumplings in a solar stove model (Sunstove) during a monitoring training session

Source: SCFT

Figure 2 shows Yvette Hendriks, area monitor selected for Pniel preparing dumplings in the Sunstove at the SESSA renewable energy demonstration center, Pretoria, July 1996.

2 Baseline study to prepare the social acceptance test

To properly prepare the social acceptance test of solar stoves, a baseline study was conducted in an area with favorable climatic conditions, urgent household energy scarcity, and a not too remote location. The performance of the participating households and institutions was important for the design and implementation of the actual social acceptance test.

2.1 Purpose and method applied

The baseline study had a triple objective:

- to survey (data collection on the socio-economic background, cooking habits as well as energy use and expenditure) 200 randomly selected households out of a potential 6,800 in five pre-selected communities in the North West and Northern Cape Province of the RSA
- to assess institutions for the participation in the social acceptance test
- to identify and develop capacity in the communities to oversee and monitor the test and subsequent activities within the SCFT

The data collection at the households relied on a survey questionnaire consisting of twelve sections. It was intended that the questions should be answered by the person responsible for making decisions regarding cooking and purchasing fuels. In most cases, although not all, the mother of the household is responsible for these matters.

In four of the five areas a public meeting was held to explain the SCFT. At the same time the available solar stove (Sunstove) was demonstrated. In Huhudi where the size of the township prevented a public meeting, a meeting was held with the civic organization (local community representative organization). Background information on the study areas, primarily demographic and infrastructure information was gathered from local authorities, other research reports and knowledgeable community members.

The employment of local people in the capacity of field workers was considered important for two reasons:

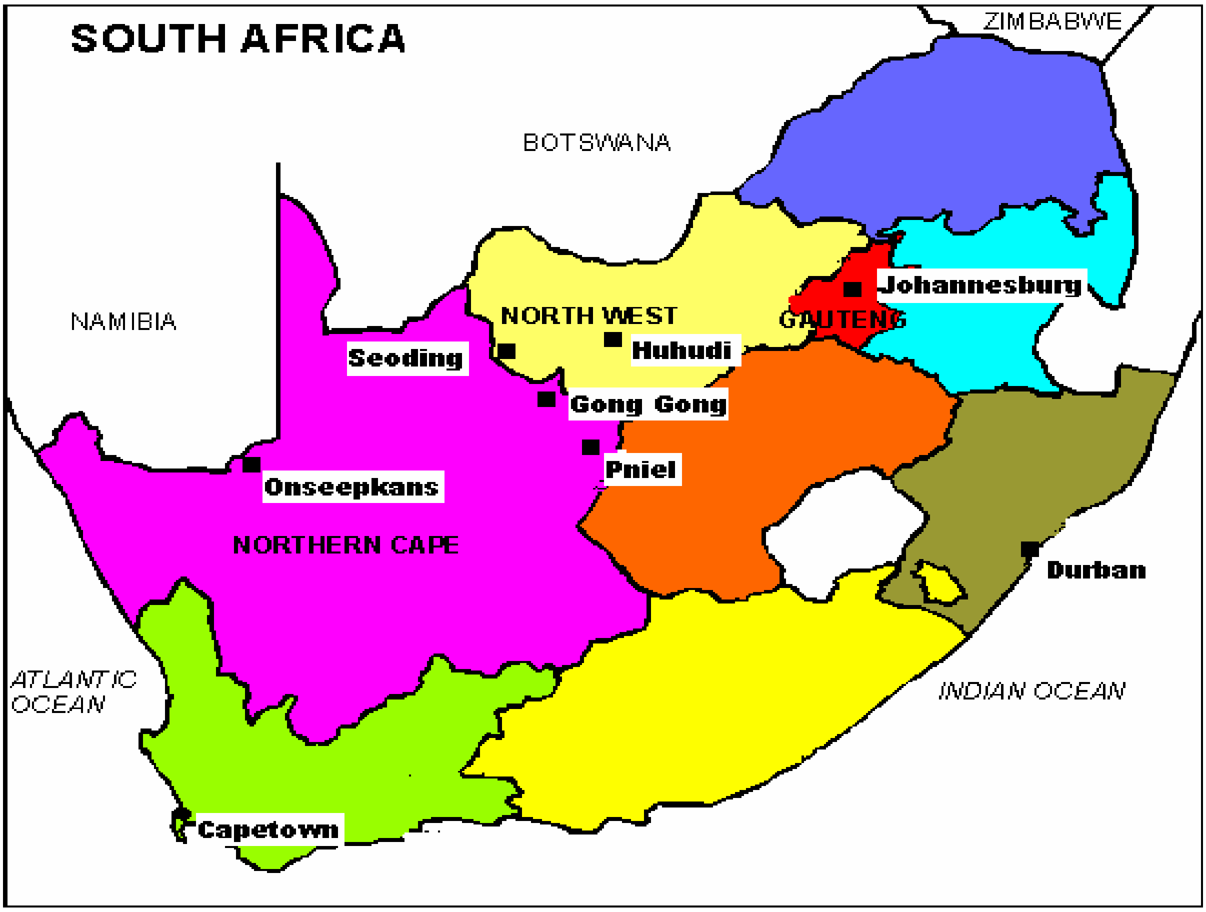
- to minimize fear and mistrust among the communities regarding the test activities
- to tap local knowledge, mainly about geographical and institutional matters

2.2 Selection of study areas

The five areas for the baseline study all fell into the north-western areas of South Africa. They were selected because solar radiation is amply available and because they are located in the drier portion of the country. The five areas also represented a mix of fuel use patterns with some areas relying on collected fuelwood while others had access to electricity. The five areas were considered to be representative of rural, semi-urban and urban areas (**Figure 3**):

- Huhudi, a township outside Vryburg in the North West Province
- Seoding, a township outside Kururman in the North West Province
- Pniel, a township between Kimberley and Barkly-West in the Northern Cape Province
- Gong Gong, a township between Kimberley and Barkly-West in the Northern Cape Province
- Onseepkans, a township 50 km north of Pofadder on the South African-Namibian border in the Northern Cape Province.

Figure 3
Location of study areas for the baseline study



Source: SCFT

The map illustrated in **Figure 3** shows the baseline study areas in relation to the country as well as their location in the sunny, drier North-Western region of South Africa.

2.3 Findings at households

The average family size was between 6 (Gong Gong and Huhudi) and 7.5 (Seoding) persons. Huhudi had the largest number of households earning less than R250 per month while Seoding had the most unemployed households. Onseepkans, along with Pniel, had the lowest number of unemployed households and a wider spread of income levels.

Figure 4
A typical household in the baseline study area of Pniel

Source: SCFT

A woman being interviewed in one of the baseline study areas (Pniel).

The fuels in daily use by the households in the various study areas suggested a heterogeneous panorama:

- In Onseepkans, Pniel and Gong Gong no coal or electricity was used on a daily basis. This was not surprising since they are all far away from any source of coal and none of the towns is electrified.
- Gong Gong relied heavily on wood (24 of the 40 samples) and equally on gas and paraffin for daily cooking needs.
- Onseepkans and Pniel relied most heavily on wood (34 and 40 households respectively) while relying to a lesser but about equal extent on gas and paraffin.
- There was only one electricity user in Seoding with paraffin being very important (31 of the 40 interviewed).
- While Huhudi is electrified, more people reported using paraffin than electricity while gas users equal electricity users (10 samples).
- There was only one report of wood in daily use in Huhudi and only 4 in Seoding.
- Only 5 households contacted in all 5 study areas used coal. This was not surprising given the distance of the study areas from the coal mines.

In terms of monthly fuel expenses, households in the two more urban towns (Seoding and Huhudi) spent the most on fuel while households in Onseepkans spent the least on fuel, relying more on collected fuelwood.

Most foods for the morning meal were maize-based in the form of soft porridge, often eaten with milk and sugar, followed by bread and fried foods. In the afternoon, meals were maize and protein-based, some families also ate other carbohydrates. Regarding food cooked for the evening meal

- 138 meals (24%) in the evening were protein-based, a surprise given the low income of the families surveyed,
- Carbohydrates and maize (20% and 17%) were the next most important food categories,
- Other significant food types were slow cooking vegetables and vegetables with a combined share of 21%. These food types are particularly suited to solar stoves.

Other interesting features were related to the cooking techniques applied for the morning, the afternoon, and the evening meal:

- In the morning, all families boiled part of their meal. 55 or 18% of the sample households fried something. The meals eaten in the morning are generally maize-based which together with tea and/or coffee require boiling. Baking bread and frying fat-cakes and dumplings may play a minor role in the morning meal.

- 34 families did not cook a midday meal. The majority of meals (61%) were boiled for the afternoon . Everywhere, frying (29%) was used to a lesser extent to prepare afternoon meals. Baking took place more in Pniel and Gong Gong than in the other areas, due to the remoteness of the villages.

- In the evening 172 households (56%) boiled their meals. Frying was next in importance (27%) followed by baking (13%).

All of the study areas visited experienced a problematic fuel supply. A shortage of money means that in the majority of cases the households are forced to depend on fuels that have an adverse effect on the local or immediate environment. Onseepkans, Pniel and Gong Gong were all heavily reliant on wood. In all areas there was a strong awareness of the ecological problems associated with wood use. When questioned about problems associated with the use of wood as a cooking fuel, the most frequent response concerned the dwindling supply. A strong awareness existed amongst fuel users that wood is not a sustainable fuel source. The perception was based on the householder's experience of collecting wood over the years and the increasing scarcity of the local wood supply. Declining supply was a feature of all five areas. The townships of Seoding and Huhudi were heavily reliant on paraffin. This fuel is used as a consequence of severe wood shortages in the area. Paraffin was regarded as a source of noxious fumes causing irritation and illness, especially with children.

2.4 Findings at institutions

Originally a strong emphasis on the institutional use of solar stoves was envisaged. It was assumed that institutions would accept solar stoves far easier than households. Therefore, a specific focus was on the location of well-suited institutions at which solar stoves could be placed. The range of institutions envisaged included old age homes, hospitals, clinics, and small businesses.

A number of institutions, such as schools, hospitals and clinics were visited by the research team with the view to make an assessment as to their suitability for participation in the institutional component of the social acceptance test. With most institutions being schools and five key criteria were used to determine their suitability: kitchen lay-out and equipment, type of fuel used, meals served (type of food and time), cooking techniques employed, and the decision making processes. **Figure 5** shows a pres-school in Pniel.

Figure 5
Pre-school, Pniel

Source: SCFT

The Tiger Kloof School outside Vryburg, due to its isolated location, was recommended to be monitored independently by a suitable person at the school. Meals were prepared in the large well-equipped kitchen for about 200 students and staff. Both lunch and dinner were suitable for solar cooking in terms of foodstuff and technique of preparation. Furthermore, the kitchen staff had already used a small box-type solar stove (Sunstove) and therefore had some knowledge of solar cooking. Tiger Kloof School is a Section 21 company (a non profit company) and governed by its Board of Directors and the Executive Body, which is made up of staff members. The Board of Directors sets policy, which is enacted by the Executive Body.

In Huhudi, three creches were visited after telephonic interviews had been conducted as a pre-screening process to determine if the institutions served cooked meals. Mmabana creche had adequate grounds and enthusiastic teachers and principal, given the shortage of money for cooking fuels. Because of its good exposure to the sun and its level of interest from the staff, the creche seemed to be the best of the three schools visited. The Moremogolo creche was a smaller school with limited exposure to the sun, but the staff members were all very enthusiastic about the project. Boichoko Early Learning Center had a staff motivated for the use of solar stoves but also a lack of sunny space. For this reason it was not included in the study.

In Onseepkans, three institutions were found to be suitable. The Saint Philomena Primary School had 284 students and 10 teachers. A feeding scheme was in place although the Department of Education was slow to approve funds, which resulted in the feeding scheme being non-operational. Cooked meals are only prepared twice a week on a wood stove for which the children bring wood to school to supply the fuel. Klein Begin Kleuterskool is a pre-primary school accommodating 46 children. Two meals were served per day and most cooking took place on a three-plate gas stove. St Anne's Primary offers pre-primary, sub A and B to 75 students. Two cooked meals were provided: porridge in the morning and a cooked lunch. The Department of Welfare funds the feeding scheme and it seemed to be more reliable than the funding to the other two schools in Onseepkans.

Pniel had only one possibility, namely the Klein Begin Pre-Primary. The only other school was unsuitable for the study since no meals were provided to the students. Klein Begin was extremely small and accommodated only 7 children. Two meals were served and prepared on a gas stove.

No suitable institutions were found in Gong-Gong. The only school named Waterval Primary burned down in 1982. There is a clinic in Gong Gong, which opens twice a month but it is a day clinic only and no food is prepared for patients.

In Seoding there was a creche, Mahobe A Mosho, one primary school, Lareng Primary School as well as Thsimologo Middle School. No schools were found to be suitable for inclusion in the project since no meals were served.

3 Design and execution of the social acceptance test

Based on the results of the baseline study, three test areas were selected: Onseepkans, Huhudi and Pniel. They represented rural, semi-urban and urban areas with concomitant fuel use patterns.

An array of questionnaires was designed to be completed on a daily, weekly, monthly and bi-monthly basis by the households using solar stoves, control households without solar stoves, area monitors, participating institutions and project supervisors.

3.1 Selection of test areas

At the beginning the three areas were analyzed by applying four criteria:

- Availability of households and institutions for participation
- Major fuel bought or collected
- Size and type of community
- Response of decision makers and field workers

The selection attempted to be representative of the full spread of differently sized settlements, using a variety of fuel types, either collected or bought fuel, a spread of income levels and the willingness to participate in the social acceptance test.

Onseepkans is representative of small villages with scattered settlements where collected fuel wood predominates. Pniel and Gong Gong were seen as representative of middle sized villages. The decisive factor for recommending Pniel was the evidence of the full spectrum of energy carriers used, with wood (bought) and paraffin in nearly equal proportions, a small institution (kindergarten) and suitable monitoring personnel. Seoding and Huhudi were seen to be representative of middle sized towns. The decision for recommending Huhudi was based on the fact that although they are electrified, the fuel for cooking and heating is predominantly paraffin. Seoding was rejected mainly due to plans to begin electrifying the township in July 1996. This was felt to have potential negative impact on the ability to study the use of the solar stoves, given the excitement and disruption electrification could create in people's cooking routines. Gong Gong was rejected due to the lack of any institution present in the village for the institutional component of the study. The Tiger Kloof school, just outside Vryburg was recommended to be used as an independent test institution to be monitored separately.

3.2 Selection of user households

A number of factors were taken into consideration when selecting the 20 households per area, such as willingness to participate in the study, availability throughout the study period, adequate space and sunshine availability. As a first step, all clearly unsuitable households were rejected. These were households that planned to move in the first year, refused to participate in the study or did not receive sufficient sun in their yards.

The remaining households were allocated a rating number, which aimed to quantify suitability for the social acceptance test. Given the intensity of the monitoring process as well as the average size of the settlements, a sample of 20 user households and a control group of 10 households were considered to be adequate to provide reliable data.

3.3 Selection of control households

10 households per area were selected as control groups, 30 all together. Criteria for the selection of control households were similar household profiles in terms of size and composition to test households, similar cooking habits and similar fuel use.
It was necessary to monitor the control households for energy use and expenditure to enable researchers to compare the impact of solar stoves on household energy with households without the stoves. A sample of 10 households per control group was regarded as adequate given the number of households (between 200 and 5 000) per area as well as the intensive data collection method employed.

3.4 Selection of user institutions

In the beginning, eight institutions in the baseline study areas were visited and their suitability for participation in the institutional component of the social acceptance test was assessed. Institutions were selected after analyzing information like:

- Willingness to participate in the study
- Cooking activities
- Available space to use a solar stove
- Cooking schedule
- Feeding scheme

A full cooking profile was completed for each institution:

- Tiger Kloof school outside Vryburg

Tiger Kloof school outside Vryburg was included as a separate institution, i.e. not linked to a specific test area, because the kitchen staff were already using Sunstoves and therefore, had some knowledge of solar cooking. Furthermore, the school management was very supportive and the conditions favorable to test another type of solar stove for the purpose of comparison. All meals for the 200 students were prepared in a large, well-equipped kitchen and both lunch and evening meals were regarded as suitable for solar cooking. **Figure 6** illustrates the delivery of solar stoves to Tiger Kloof School near Vryburg.

- Huhudi

Three creches were visited; Mmabana, Moremogolo and Boichoko. Mmabana and Moremogolo were recommended to be included in the study due to adequate space availability, enthusiasm for the project and shortage of money to buy cooking fuel. Boichoko was excluded because of limited space available in a sunny spot - one possibility was in the middle of the playground while the other was far away from the kitchen.

- Onseepkans

In Onseepkans three institutions were visited but only two were recommended for participation. Saint Philomena participated in the Department of Education feeding scheme through which two cooked meals are provided per week. Food is cooked on an old wood stove for which the children bring wood fuel from home.

St Anne's Primary school provided porridge in the morning, sandwiches and a cooked meal in the afternoon to 75 students. Funding for the feeding scheme comes from the Department of Welfare, which makes it more secure than the other two schools in the area. The school has a well-equipped kitchen.

- Pniel

Pniel had only one possibility - Klein Begin Pre-Primary School. However, no feeding scheme was in place at the school. Therefore, it was decided to investigate other possibilities in the vicinity of Pniel, such as Barkly-West Primary School and Hula Hoop Creche in Barkly-West.

Institutions selected in the first round did not make use of their solar stoves extensively. To obtain substantial data, it was decided to include more schools in the study but no stoves were removed from schools already in the field test. Schools included Pniel Primary School in Pniel, Catholic Mission School in Pofadder; and Emmanuel Creche, Kekane Creche, Saint Martin's, and Salvation Army Creche in Galeshewe near Kimberley.

Figure 6
Schwarzer 2 stoves being delivered to Tiger Kloof School, Vryburg

Source: SCFT

3.5 Selection and training of monitoring personnel

Suitable candidates to effect monitoring of the social acceptance test activities had to be:

- Resident in the test site and have credibility within the community,
- Fluent in both English and the predominant language of the test site,
- Capable of visiting all the selected households on a daily basis, if necessary,
- Committed to the project,
- Proactive, self-motivated and capable of working without supervision.

Due to the focus on gender balances and the nature of the test dealing with cooking and household energy issues, preference was given to women in the light of the nature and focus of the study. Field workers who assisted with the baseline study were considered to be well positioned for further involvement and encouraged to apply for the position. Three field workers per area were selected. One field worker also had to act as a technician should the need arise to fix solar stoves in the field.

The selected area monitors came to Pretoria for a training course. **Figure 7** shows selected area monitors being trained in assembling an SK 12 solar stove. The training course was conducted at the Silverton Renewable Energy Demonstration Center from 12 to 29 August 1996 and focused on two topics:

- Implementation of the round robin test

Each family had one type of solar stove for a period of two months before changing and using another one. Therefore, at the end of the placement period, each family had tried each solar stove twice. As the stoves' comparative acceptance to the users is important, such a "round robin" arrangement was useful in determining preference and household use patterns for each type of solar stove.

- Administration and management of the questionnaire system

This training focused on three broad topics, namely social research in general, detailed training in how to complete each questionnaire, how to assist families to complete questionnaires and how to report and manage the collected data, as well as operational details.

Figure 7
Area monitors receiving training on solar stove assembly

Source: SCFT

The monitoring program comprised three questionnaires:

- The first questionnaire type designed to be filled in weekly by the monitors, to determine solar stove use on the day of the visit
- The second questionnaire was placed with families and institutions for one week of every month to survey their daily cooking behavior
- The third questionnaire was filled in by the monitors once every two month, at the end of the round robin, as an assessment of the performance of the stove the household had been using.

In preparation for cooking with the various solar stoves, participants where asked to compile a list of area specific dishes and recipes and to prepare the meals in the solar stoves. Care was taken to prepare a wide variety of dishes, requiring various cooking methods such as baking, stewing, frying, simmering and boiling.

Technical and maintenance training started with the delivery of the bulk of the solar stoves at the demonstration center. The large stoves had to be assembled. The basic functioning of all models was explained to the trainees. Technical drawings and a basic tool kit were supplied to all technical assistants.

3.6 Cooking profiles, fuel consumption and questionnaires

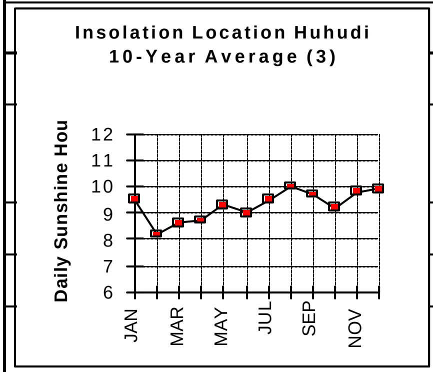
One of the most important issues of the social acceptance test was the requirement that solar stoves must be suited to local conditions such as

- weather conditions (to see to what extent the stove could be used)
- solar radiation (daily sunshine hours)
- fuel availability and prices (to assess motivation for the use)
- household size (households had to consist of between 4 and 15 members to be able to use the solar stoves in an optimal manner)
- economic information (to enable calculations of monetary savings and availability)
- availability of appropriate sunny space (to be able to use the solar stove)
- cooking techniques and schedule (had to be adaptable to solar cooking).

These data served to establish “cooking profiles” households/families and institutions, e.g. the one depicted in **Figure 8**.

Figure 8
Family cooking profile in Huhudi, January 1997

Location	HUHUDI, black township of the small town Vryburg (North-West Province); surroundings: agricultural productive land and savanna, no woods (1)
Typical Housing	some small brick houses, many corrugated iron huts or a combination, mostly all fenced in, occasionally vegtetable gardens (1)
Income	average income/month: 640.-R; most families have an income of less than 250.-R/month (2)
Household Members per Family	5 to 10 (2)
Dishes	porridge, fish, soup, soft porridge, potatoes, eggs, vegetables, bread, meat, oatmeal, "samp", rice, pulses, peanuts, cakes, dumplings, "steamed bread" , entrails with other innards, chakalaka salad, tea, coffee, milk, bones, spaghetti (1)
Cooking Techniques	boiling, frying, baking, simmering, steaming, roasting (1 and 2)
Preparation Techniques	cutting up, soaking (e.g.pulses; when using solar cookers very often omitted), stirring (e.g. porridge dishes need to be stirred vigorously) (1)
Start of Cooking	morning: between 6 and 9 o'clock; noon: between 10 and 13 o'clock; evening: between 12 and 20 o'clock (2)
End of Cooking	morning: between 6.30 and 10 o'clock; noon: between 11 and 14 o'clock; evening: between 17 and 21 o'clock (2)
Meal Times	morning: between 7 and 10 o'clock; noon: between 12 and 14 o'clock; evening (main meal): between 18 and 21 o'clock (2)
Existing Cooking Equipment	mainly kerosene cookers, some gas or electric cookers, occasionally wood stoves or three-stone fires; most families have more than one cooking facility, e.g. kerosene, gas and electric cooker (1 and 2)
Cooking Area	mainly inside, very rarely outside (1 and 2)
Number of Cooking Pots	typically 2 pots with ca. 5-8 l capacity (1)
Fuel (bought/collected)	mainly kerosene ("paraffin"); equal parts of gas and electricity (units are bought on a prepayment card system), some wood (collected or bought) (1 and 2)
Fuel Costs	5 l kerosene = 10.-Rd; 19 kg gas bottle= 68.23 Rd; small lorry load of wood = 40.-Rd (1)
Weather Conditions	sunny all year round, with less than 450 mm precipitation between November and March (mainly in February); August to October often strong wind with dust clouds (1and 2)
Suitable Place for Solar Cooker	near the kitchen, sometimes only room for small cooker, often fear of theft or damage of cooker (1)
Interest of Families to Acquire Solar Cooker (on a credit system)	yes (1)
Annual Daily Average Insolation	5700 Wh/m²/day (4)



Remarks:

* Some data (e.g. who decides about new acquisitions; is somebody prepared to track cookers regularly) are difficult to obtain on a regional basis and should be determined individually with questionnaires.

Sources:

(1) On-site inquiries (2) Questionnaire survey (3) Weather office South Africa, Armoedsvlakte station (4) W D Cowan (ed), "RAPS Design Manual", EDRC, University of Cape Town, 1992

Source: SCFT

In the study, fuel use was determined by measuring the consumption of different fuels every day for a week. This was done using the "kitchen performance test", which had to be undertaken at the beginning of the study (August 1996), before solar stoves were placed with families, then during the summer season (January 1997), and again in the winter (July 1997). The initial sample size was 21 solar stove users (7 in each area), plus a control group of 21 non-users. For the analysis of the data, only households with at least one complete set of three measurements were included. In this way, 29 complete user data sets could be used for evaluation, plus three sets for the control group. The drop off in sample size was also due to the movement of families out of the study area.

For users, non-users, and institutions, three different types of questionnaires had to be completed. In addition, the supervisors during their monthly visits also filled in questionnaires that recorded stove use during the visit and their general impressions or comments on a given family or institution. This was designed as part of quality control program.

In preparation for cooking with the various solar stoves, participants were asked to compile a list of area specific dishes and recipes and to prepare the meals in the solar stoves. Care was taken to prepare a wide variety of dishes, requiring various cooking methods such as baking, stewing, frying, simmering, and boiling.

Technical and maintenance training started with the delivery of the bulk of the solar stoves at the demonstration center, illustrated in **Figure 9**. The large stoves had to be assembled. The basic functioning of all models was explained to the trainees. Technical drawings and a basic tool kit were supplied to all technical assistants.

Figure 9
Delivery of solar stoves destined for the field test at demonstration center

Source: SCFT

4 Results of the social acceptance test at households

Box 1
Field test village experience

Welcome to my home and my people. As you can see my village is one again, with the inclusion of the solar stoves into our lives. It has altered the way we run our daily lives.

The elimination of wood collecting has meant that our women folk have been able to use the time in pursuit of a favored hobby or home industry and home life. Which I may add, has had numerous benefits not only to the landscape and deforestation, but it has begun to bond our families together, as our families can now spend more time together as a unit. This in itself has benefited our children as far as education is concerned as well as the pursuit of hobbies and crafts. The crafts can be traded and strengthen ancient culture and customs.

Source:SCFT

4.1 Use rate

Solar stove use was calculated according to region, stove type, seasonal use, use trends over time and use at different mealtimes. The solar stoves, which were used by small households were the Sunstove, REM 5 and ULOG, while larger households used the REM15, SK 12 and Scwarzer 1 stove. Each analysis provides a different perspective in developing an understanding of end user acceptance.

Averaged over all study areas and stove types, the evaluation showed that

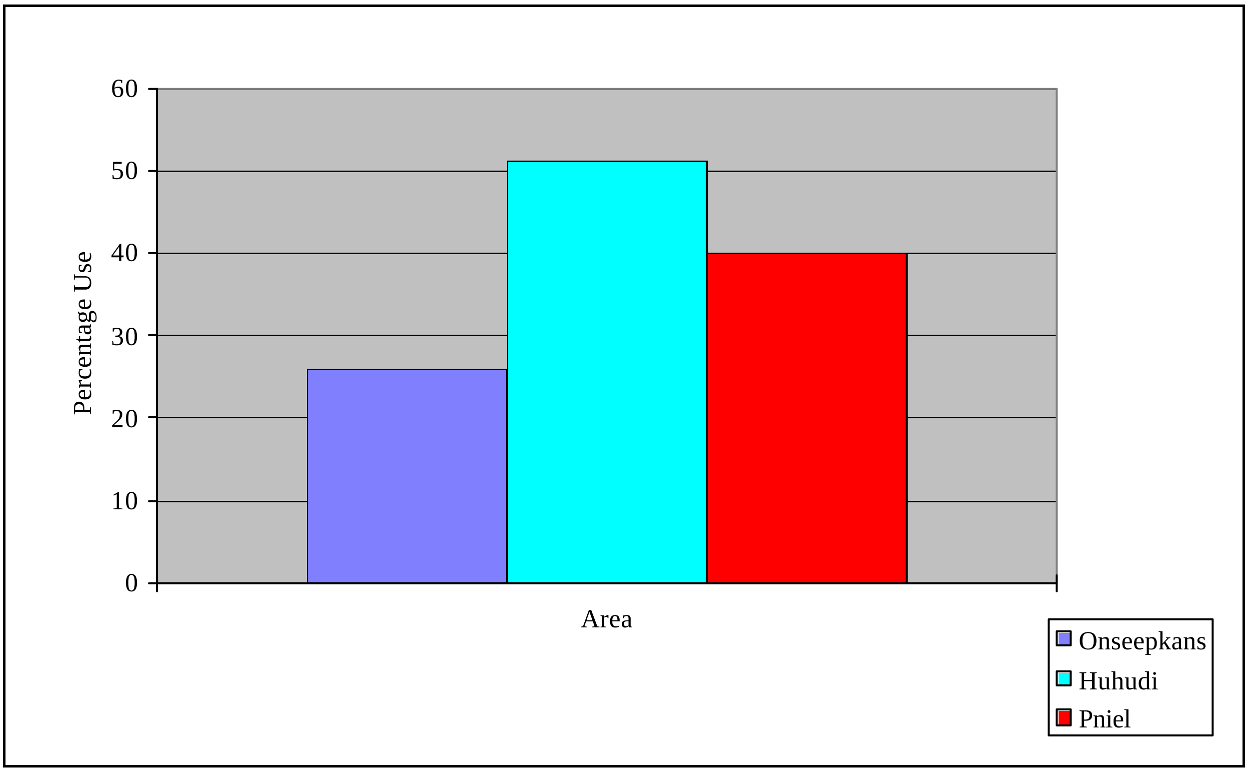
- on 38% of all days families used solar stoves at least once,
- families used the solar stoves to prepare 19% of all meals corresponding to 35% of all cooked meals (not all meals that families eat require cooking),
- users were satisfied with the results of 93% of all solar cooking attempts.

The use of solar stoves was quite different from one study area to the other (**Figure 10**). Rural Onseepkans where much fuel is collected (i.e. wood) has lowest use rates. The township Huhudi where much fuel is bought shows highest user rates. Pniel takes an intermediate position.

Possible explanations for the specific use rates in each area are:

- Monthly energy expenditure was the highest in Huhudi, which also had access to electricity. By using solar stoves regularly, tangible savings in terms of monetary expenses on energy as well as specific expenses on electricity could be achieved. This may have motivated households to use their solar stoves.
- Onseepkans is a very poor area where people can not afford to cook for every meal. Therefore, cooking opportunities were less than in the more well-off area of Huhudi.
- A mixture of commercial fuels and collected wood was being used in Pniel, with monetary savings clearly realised. Moreover, Pniel is slightly better off than Onseepkans and households cooked more often and regularly baked bread in the solar stoves.

Figure 10
Use of solar stoves in the three test areas



Source: SCFT

Figure 10 illustrates the higher percentage of use in Huhudi as compared with Onseepkans and Pniel. The higher use rate in Huhudi was attributable to the bigger savings potential due to the high use of commercial fuels in the area. The use rates in Pniel and Onseepkans were regarded as acceptable.

The stove most used by small families was REM5, followed by ULOG and Sunstove. For large families, the most used stoves were SK12, followed by Schwarzer 1 and REM15. For details see **Table 1**.

Table 1
Use rate of solar stove models by housholds

	Small families			Large families		
	REM5	Sunstove	ULOG	REM15	SK12	Sch1
% of days use	42	28	34	40	50	43
% of all meals	19	17	18	17	22	23
% of cooked meals	34	32	33	31	41	42

Source: SCFT

This table illustrates average use rates by small and large families per stove type but clear stove preferences emerged per area. In Onseepkans, the ULOG and SK12 were the favorites while the REM5 and SK12 were popular in Huhudi and the REM5 and Schwarzer stoves were the most popular in Pniel.

For the use rate of individual solar stove models the households offered specific explanations:

- The REM5 was considered to be the fastest solar stove, the easiest to handle and the strongest one (refers to durability).
- The SK12 was considered to cook the tastiest food (soft porridge, samp, cows' feet) as well as the fastest solar stove.
- The Schwarzer I cooked the best porridge and saved the most money (according to Pniel responses).

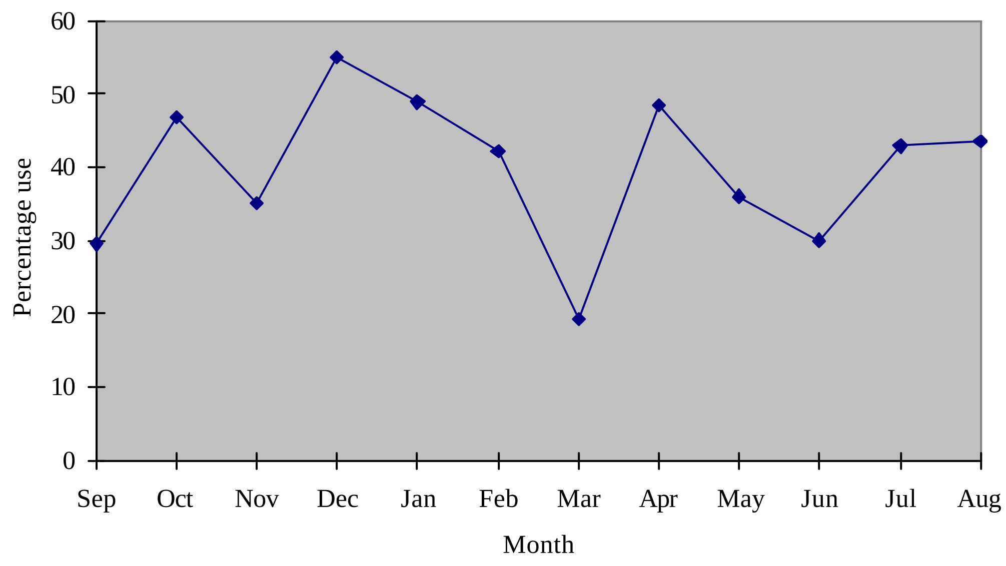
There are differences in the use rates between the various stoves, but they are not enormous. This suggests that users, despite having clear preferences for particular solar stove models, "take what they can get". In other words, if a family has a certain solar stove placed with them, it may not be their favorite stove, but they will still use it. In response to poor access to fuel, users will take advantage of an additional, freely available fuel source, whatever that fuel source may be.

Figure 11 depicts the solar stove use frequency (indicating use at least once per day) over the 12-month placement period, for all models of solar stoves tested.

The use rate shows a peak in December, with good weather and a popular time for cooking during the Christmas period when visitors and migrant workers are around. The home visit of migrant workers and other family members can triple the number of people to be cooked for. Thus, additional food and energy for preparing it is required over the Christmas period. Moreover, cash bonuses enable families to purchase more food, again increasing the need for cooking fuels.

A dip in March when the weather was bad indicates strong use-dependence on weather. Windy conditions in August and September also influence the use of solar stoves, particularly the models, which are sensitive to wind such as the REM5 and SK12. What is further notable is the fact that solar stoves were used all year round, although lower use rates are evident during the coldest winter month of July. This is in contrast with the perception that solar stoves cannot be used in winter.

Figure 11
Use of solar stoves by families / households during one year



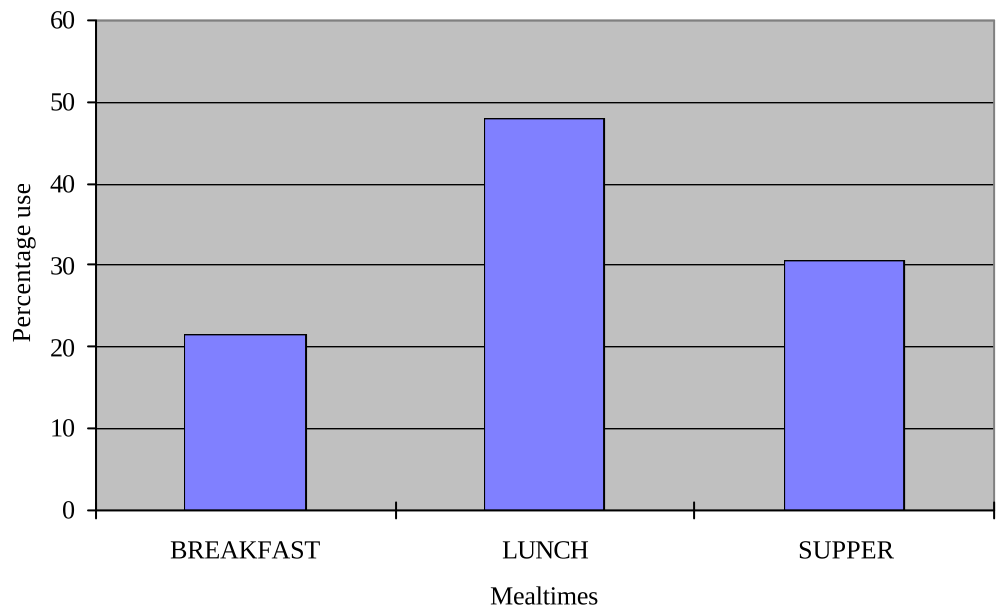
Source: SCFT

One of the common criticisms regarding solar stoves is that they cannot be used for preparing morning and evening meals. During the social acceptance test, substantial use was made of the solar stoves for all three meals of the day. **Figure 12** informs on the solar stove use rate for different meals, over all stove types and study areas.

As expected, lunch use, when the sun is strongest, is most frequent, breakfast use is lowest, and supper use lies in between. Because of the extremely favorable weather conditions in the test areas (very high temperatures, clear skies and no rain in the morning) solar stoves were also used for preparing breakfast from about 7:30 am. It was further possible to prepare one dish for supper after the cooking of the lunch was completed (after 2:00 p.m.) or alternatively, food was cooked with the lunch food and kept aside for dinner.

Solar stove promoters have often offered solar cooking as a solution to replace all other cooking options, stop the use of fuelwood and other biomass fuels and one, which would halt environmental degradation. In a complete departure from this viewpoint, the SCFT promoted the use of solar stoves as part of the mix of energy carriers and appliances already in use by households. In other words, solar cooking was offered as an additional cooking choice. It was not to replace any form of cooking but to enhance the choices of households.

Figure 12
Use of solar stoves for breakfast, lunch, and supper



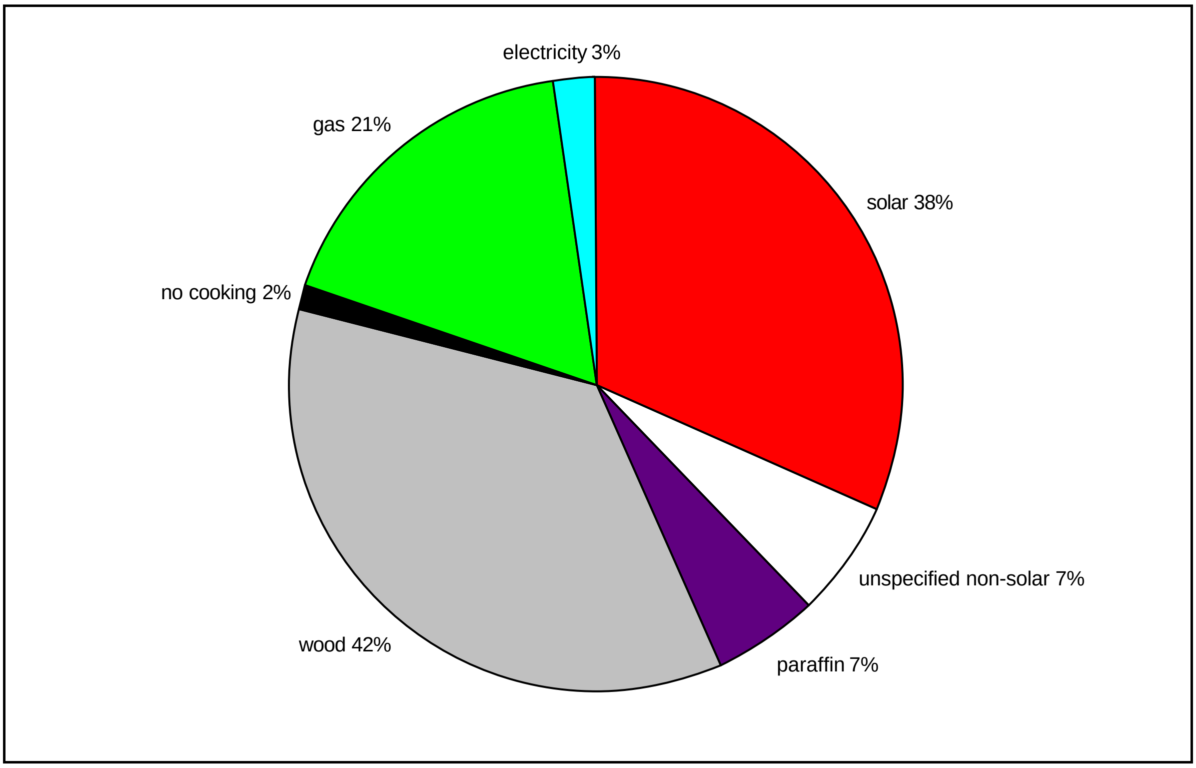
Source: SCFT

While it is interesting to know how often solar stoves are used, it is necessary to compare the use of solar stoves with the use of non-solar ways of cooking to put the use figures into perspective (**Figure 13**).

Solar stoves, along with wood (open fires, wood-stoves and coal-stoves fueled with wood combined), are the most used cooking appliances amongst test user families. These are followed by stoves fueled with gas, paraffin, and electricity; understandably, electricity use appears to be very low since only one out of three test areas is grid connected. In 7% of the cases non-solar stoves were used but the fuel type was not specified. On 2% of all days, no cooking took place.

These results indicate acceptance of solar stoves by family test users ("acceptance" of solar stoves being defined here as "solar stoves are used as much as or more than other cooking options in the household"). Acceptance does not imply that all other cooking options are replaced by solar stoves. Rural households, just like households in cities, traditionally use a variety of cooking options (on the average 2.5). This is not likely to change by the introduction of a new technology, as the example of the microwave oven confirms. Figure 2 further implies that solar stoves are accepted because it has been integrated into the multiple fuel use pattern of households.

Figure 13
Frequency of daily use of different cooking appliances



Source: SCFT

4.2 Savings

Average household expenditure on fuel in the three test areas is R50 per month. Average monthly energy expenditure in Huhudi, Pniel and Onseepkans is R66, R46 and R31 respectively. The breakdown of these averages is presented in **Table 2**.

Table 2
Average monthly expenditure for fuels in the three test areas (ZAR)

	Huhudi	Pniel	Onseepkans
Wood	5	16	17
Paraffin	16	12	3
Gas	18	18	11
Electricity	27	0	0
Total fuel expenditure	66	46	31

Source: SCFT

Table 2 illustrates that the fuel mix differs from region to region, with households in Huhudi, Pniel and Onseepkans allocating most of their energy expenditure to electricity (41%), gas (39%) and wood (55%) respectively. The range of expenditure on household energy between different income groups is one exception, positively correlated with income. The lowest income group allocates between ZAR 21 - 49 to their monthly energy needs, while the highest income category (i.e. monthly income above ZAR 1,000) spends between ZAR 30 - 108 per month.

The low total expenditure on fuel in Onseepkans (ZAR 31) can be explained by the relative poverty and the high reliance on collected wood as the fuel of choice in that area. When wood is purchased, however, it represents a higher expenditure item than is the case in both Huhudi and Pniel.

Results for fuel consumption and savings are presented in **Table 3** and **Table 4**. The first table shows the actual reduction in fuel use for gas and paraffin; electricity has been excluded from this analysis due to an inadequate sample size. With paraffin there is a larger reduction in fuel use in summer than in winter. In fact, use almost returns to its pre-test average during winter, suggesting that households use this fuel for purposes other than cooking such as lighting and space heating.

Table 3
Fossil fuel consumption and savings by households

Average fuel use (per capita/per day)			
Fuel type	Pre-solar stove placement	Summer after solar stove placement	Winter after solar stove placement
Paraffin (liter)	0.149	0.071	0.129
Gas (kg)	0.133	0.055	0.061
Fuel savings			
Fuel type	Summer	Winter	Average
Paraffin (%)	53	14	33
Gas (%)	59	54	57

Source: SCFT

The difference in summer-to-winter fuel use reduction is even higher in fuel wood (**Table 4**), which is not surprising since wood is widely used for space heating. With gas, the savings values for summer and winter are about the same, suggesting that gas is only used for cooking.

Table 4
Fuel wood consumption and savings by households

		Average fuel wood use (per capita and day)	
	Pre-Test	Summer	Winter
User group (kg)	1.63	0.94	1.47
Control group (kg)	1.42	1.27	1.99
		Fuel wood savings	
	Summer	Winter	Average
User group (%)	43	10	-
Control group (%)	11	- 40	-
Corrected savings (%)	36	36	36

Source: SCFT

Table 5 provides the results for the corresponding total average (over all users and all fuel types), stating that the overall fuel savings are 38%. Considering solar stoves are not a "stand-alone" option and that a vast majority of families use more than one fuel type for cooking (the parallel use of up to 4 different non-solar fuel types has been reported), these fuel savings are considerable. During the placement period, test users (about 60 households) have saved almost 60 tons of wood, more than 2 tons of gas, and over 2000 liters of paraffin.

Table 5
Average savings for all fuels by households

	Savings (%)	Weight
Paraffin	33	0.28
Gas	57	0.16
Wood	36	0.56
Unweighted total average	42	-
Weighted total average	38.4	-

Source: SCFT

Individual fuel savings can also be seen in table 5 with the highest percentage savings achieved for gas (57%), wood (36%) and paraffin (33%) in descending order.

The results for the average monetary savings are not homogeneous for the three test areas. Savings are highest in Huhudi, where fuels are mostly bought and the township is electrified, and lowest in Onseepkans, where collected wood is an important fuel source. Pniel with its intermediate fuel mix falls in-between. For details see **Table 6**.

Table 6
Average monetary savings by households in the three test areas

Indicator	Pniel	Onseepkans	Huhudi
Weighted average all fuel saving (%)	36	40	39
Average monthly fuel expense (ZAR)	46	31	66
Average monthly fuel savings (ZAR)	17	12	26

Source: SCFT

When the average monthly fuel savings from Table 6 are compared, it seems that Onseepkans benefited less than Huhudi and Pniel because of the lower average monthly fuel savings. However, because the area depends on collected wood as a fuel source, time savings should also be considered.

Probably there are two aspects to potential time savings associated with the introduction of solar cooking:

- Time saving which results from the reduction in wood gathering
- Potential time savings to be gained in the actual cooking process itself

Although most solar stoves cook more slowly than fuel stoves, they require very little attention once the food is in the stove.

Freed from the time-consuming task of cooking and wood collection, women may concentrate more on child care and domestic activities, training and educational programs, social networking (an important rural livelihood strategy), as well as leisure. Where children are the main wood gatherers, the time saved can be spent on school work or play.

The economic benefits associated with time savings can be significant if the time is spent on productive, income generating activities. Since primarily women are involved in cooking and wood collection, the extent to which they participate in agriculture and other economic ventures will determine the magnitude of the associated benefits. However, the potential for economic benefits depends on the opportunities available for increasing earnings and output.

Time-savings, calculated using the result for wood reduction with the introduction of solar stoves is 36 %. Therefore, families could save this amount of the time previously allocated to wood collection. Since households spend, on average, three hours collecting wood per trip, for up to one trip per day, as a theoretical indication, families can save up to 33 hours per month.

The time saving associated with cooking itself was estimated as well: if a family saves 15 minutes in supervision time per solar cooked meal, this amounts on the average to 5 hours per month. This estimate is only valid if the user does not have to come home specifically to start cooking. In this case the time savings would be offset by the longer heat-up times of some of the test stoves compared to fuel stoves.

4.3 Social impacts

The use of solar stoves fits in with the multiple fuel use pattern of households: people are used to switch between fuels and appliances and the availability of solar stoves represents a broadening of choices to women in terms of satisfying their cooking requirements. By providing an additional energy choice, savings were achieved that benefited women and children as well as social networks.

The impact of solar stoves on the household economy is dependent on the organization of the household economy and the extent to which the household is linked to the wider economic network. For example, the gender review conducted in 1997 concluded that in Onseepkans, impacts of solar cooking would for the most part, remain at the household and community level because of the extreme remoteness of the village.

To determine the impact of solar stoves on women, the impact of solar stoves had to be analyzed in terms of women's access and control of resources, women's productive and reproductive roles as well as women's role in community management and politics.

In all three test areas, women had adequate access and control over resources within the household and to a slightly lesser extent in the community. Resources are seen as financial means, time, social networks, community politics, community management and productive activities.

Control over household finances varies between families, and is to a large extent dependent on household formations. Absent male heads of households provide for greater control over household resources by the woman. This was specifically noticeable in Onseepkans and Pniel. Also in Onseepkans and Pniel, where pensions and migrant remittances form the basis of the household income, the opportunities for female control of finances is greater than in Huhudi. However, the decision to make large and/or expensive purchases would have to be made in consultation with husbands if they are providing money to the household. A threshold amount of about R50 was found, i.e. any purchases over this amount would need to be decided upon jointly by husband and wife. Moreover, women did indicate, that if they wanted to buy a specific item such as a solar stove, and if they could convince their husbands, they would be allowed to make the purchase. Therefore, they felt that reasonable requests would not be refused, and a solar stove was regarded as a reasonable request. In Huhudi men have a greater influence in household management and control of finances, as men are present.

Household social networks are a resource controlled by women. In all three communities women manage relationships between the households and other communities. Men do have access to social networks. However, men's networks seemed to have less impact on the daily survival strategies of the household. In Onseepkans, the solar stoves became a valuable resource for social networks as information on the access to the cookers and the preparation of food were exchanged. Savings achieved through the use of the solar stoves were invested in more food, which was shared among organized cooking groups. These cooking groups increased food security as well as the variety in the daily diet and indicated that they greatly benefited from the solar stoves.

In terms of their roles, women generally control the reproductive sphere and men control the productive sphere. However, women provide substantial input into subsistence agriculture (regarded as the productive sphere) in Onseepkans. These inputs are hidden in the sense that they do not provide automatic cash benefits. In Pniel, some women work in Barkly-West and Kimberley. In Huhudi women manage to secure employment in Vryburg and the informal economy. Nevertheless, the opportunities are severely limited. The combination in solar stoves of both the fuel and the appliance impacts on these activities. Women have more time for reproductive activities, especially engaging with social networks (**Figure 14**).

Figure 14
Gender workshop held in Huhudi

Source: SCFT

Women have control over household organization and labor. The use of solar stoves has necessitated a shift in cooking times and a re-organization of household labor. Collecting wood in Onseepkans and Pniel has become the responsibility of men and children, especially in Pniel where the collection has become more difficult. Women and children tend to collect small pieces of dead wood while men, often in groups, collect large branches and they often have to climb trees to cut branches.

The time for collection for both men and women is around three hours per trip. As a result of solar stove use, men and women have had to collect less wood, and their time savings are mostly taken up by socializing with their friends and family. Women have little control over men's time. The extra time available to children is also taken up by socializing and household duties. However, women have more control over the use of their children's time and can ensure that they help with household chores.

Statistics on use patterns for different meals show preparatory activities for cooking in Onseepkans, Pniel and Huhudi take place at different times during the day. In Onseepkans they are particularly early. This could be linked to the fact that the area is extremely hot and that household chores should be completed as early as possible before the hottest time of the day. Solar stoves were often used for preparing breakfast and while these activities were taking place, it was easy to prepare or even start cooking some of the lunch dishes. In Huhudi, supper was frequently prepared on the solar stoves, with preparatory activities for supper taking place during cooking lunch dishes. This can be ascribed to the fact that people spend less at home in the urban environment of Huhudi.

In terms of women's roles in community management and politics in Pniel, Huhudi and Onseepkans women have influence over institutions that directly affect the household such as the church, the clinic, schools, women's groups. However, women have very little access to community politics in Pniel and Onseepkans. In Huhudi members of the community rely on local organizations for local development. Wome n appear to be more involved in these organizations than women in the other two rural test areas. In all three study areas, solar cooking had no significant impact on women's roles in community and politics.

4.4 Solar stove model preference

The preference of family users for the different solar stove models was assessed in three independent ways:

- by use frequencies of the different solar stoves
- by the sales of the used solar stoves tested
- by user workshop voting results.

The actual use of the solar stoves is an important criterion to indicate user preference. **Table 7** shows use frequencies grouped by stove type and the use ranking. Most used solar stove for small families was REM5, followed by ULOG. For large families, it was SK12, followed by Schwarzer1.

Table 7
Ranking of solar stove models according to the use frequencies by households

	Small families			Large families		
	REM5	Sunstove	ULOG	REM15	SK12	Schwarzer1
Use						
Number of days (%)	42	28	34	40	50	43
Position	1	3	2	3	1	2
Cooked meals						
Number of meals (%)	34	32	33	31	41	42
Position	1	3	2	3	2	1
Overall ranking	1	3	2	3	1	2

Source: SCFT

Table 7 further illustrates that higher capacity stoves (faster solar stoves) are used more often than slower stoves.

The ultimate economic indicator of user preference for a given stove is the decision to buy it. Referring to the sales results of test stoves, a ranking was established (**Table 8**). It indicates which types of solar stoves were bought most.

Sales by stove type indicate strong regional preferences: Onseepkans users have bought mostly ULOG and REM15, Pniel users ULOG, REM5 and SK12, Huhudi users REM5 and SK12. Collectively, the most sold stove for small families is REM5, followed by ULOG. For large families it is SK12, followed by REM15.

In total, 51 solar stoves were bought by user families at the end of the field-test period. A limited number of stoves were available because only 20 of each type were used in the field test. The stoves were sold at different prices to families who participated in the test:

- Sunstove ZAR 43
- ULOG ZAR 113
- REM 5 ZAR 130
- SK12 ZAR 257
- REM 15 ZAR 474
- Schwarzer 1 ZAR 2,090
- Schwarzer 2 ZAR 2,536

The prices were calculated based on the material cost of the solar stove, less a substantial discount because the solar stoves were considered to be second hand.

Table 8
Ranking of solar stove models sold after the social acceptance test

	Small families			Large families		
	REM5	Sunstove	ULOG	REM15	SK12	Schwarzer1
Onseepkans						
Number of units sold	1	0	6	7	2	0
Sales position	2	3	1	1	2	3
Pniel						
Number of units sold	5	1	5	1	7	0
Sales position	1	3	1	2	1	3
Huhudi						
Number of units sold	9	1	1	2	3	0
Sales position	1	2	2	2	1	3
Three test areas						
Total sales	15	2	12	10	12	0
Overall ranking	1	3	2	2	1	3

Source: SCFT

From Table 8 it can be clearly seen that regional differences existed in terms of preferred solar stove model. Households in Onseepkans preferred the ULOG because it looks like a piece of furniture when stored in the house. Because of the severe low levels of household income, people don't own a lot furniture in Onseepkans, and they preferred the solar stove which added a piece of furniture to their homes. In the urban setting of Huhudi, houses are small, crowded and very close to one another. In this setting, households preferred the REM5 because it is easy and small to store inside the house. The SK12 were popular in 2 out of the three test areas. Onseepkans preferred the REM 15 above the SK12, mainly because it had two pots.

Since there was a possibility that specific solar stove models could be oversubscribed, a waiting list system was established to make sure users could buy the solar stove of their choice. A deposit ensured the name of the interested family on the waiting list and once the full amount was paid, stoves were given on a "first paid first served" basis. In the case were not enough solar stoves were available of a specific type in the area, additional stoves were transported from an area of excess supply. All solar stoves were refurbished after the field test and Kimberley Engineering Works carried out the minor repairs required.

The stoves for small families were all sold. Thus, no solar stoves were available to supply additional demand generated in the test areas. They only became available one year after the end of the social acceptance test. By that time much of the interest had waned, people had moved away and the interest that remained in the test areas did not translate into any sales.

Based on results from the sales of test solar stoves, some preliminary conclusions for large-scale production could already be formulated:

- One solar stove model will not be adequate to serve a diverse market and fulfill different user requirements and demands.
- Early price sensitivity of solar stoves emerged in the zero sales of the Schwarzer 1 model. Although families reported that they liked the stove, no purchases were made due to its high price.
- There is also an indication of the tendency of solar stove users to progress to more efficient models as their experience with solar stoves grows. Low sales of the Sunstove indicate the tendency of users to opt for larger, more efficient models once they have experienced all possible options.
- There is a clear need to fully understand the reasons or motivation for user purchase as a reliable basis to mount any marketing campaign.

At the official end of the year-long social acceptance test a closing workshop and farewell ceremony was held in each test area. Approximately 30 men and women alike attended the morning-long workshop. But only women as the major users of the stoves could vote for their favorite solar stove. The voting results flag important information on user preference. The test users became real solar cooking experts and, at the time of the workshop, had accumulated practical comparative experience with all corresponding stove models. The voting exercise is illustrated in **Figure 15**.

Figure 15
Voting for your favourite solar stove, Onseepkans

Source: SCFT

The voting criteria excluded the price for two reasons:

- The manufacturing cost of the solar stoves was extremely high since all were basically manufactured individually as prototypes.

- The prices that the solar stoves were sold for at that time were considered to be discounted prices because the stoves were not new.

Thus, the voting results indicate user preference based on performance and capacity of the solar stoves only. The desirable characteristics were performance, capacity, quality, handling, maneuverability, and similar aspects. The positive votes have been added; negative votes were subtracted to arrive at aggregate voting figures per solar stove and by test area. These data have been converted into ranks (**Table 9**).

Table 9
Ranking of the preference for solar stove models in two test areas

	Small families			Small families		
	REM5	Sunstove	ULOG	REM15	SK12	Schwarzer1
Onseepkans votes	- 4	1	40	25	16	17
Onseepkans ranking	3	2	1	1	3	2
Pniel votes	30	9	15	36	16	15
Pniel ranking	1	3	2	1	2	3

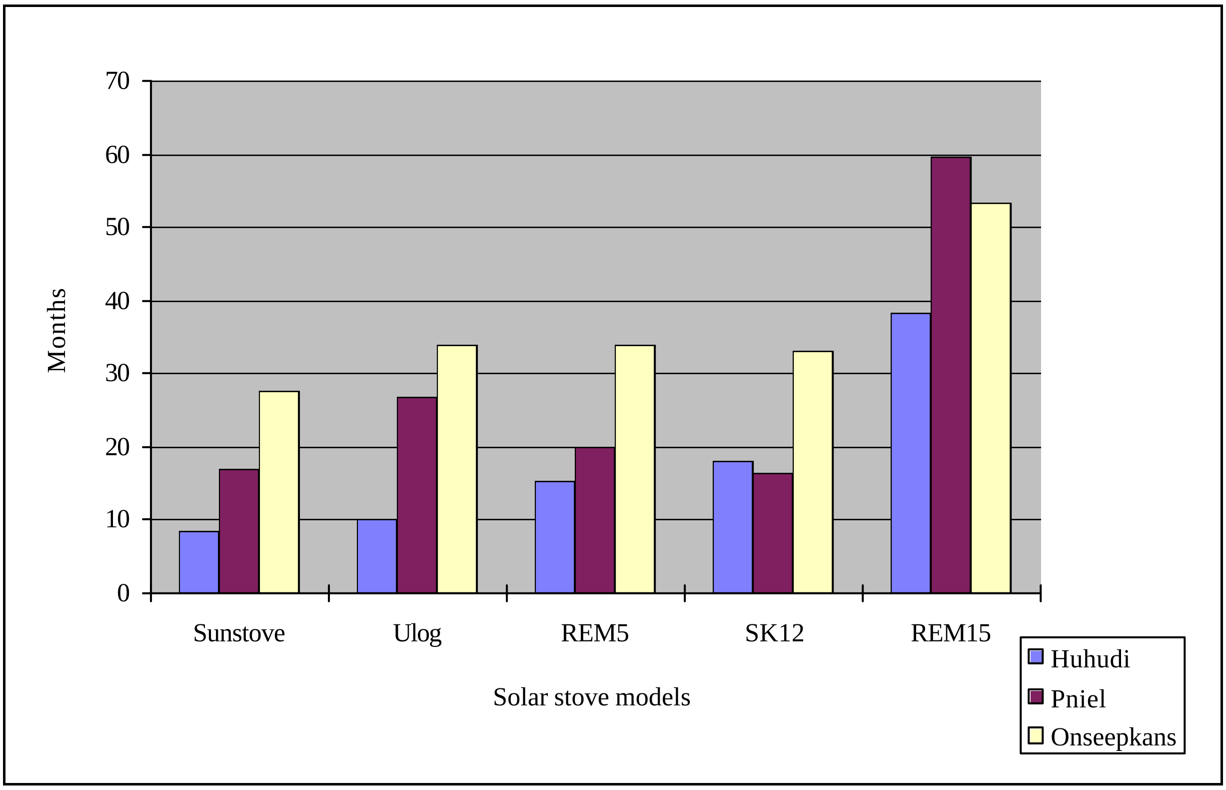
Source: SCFT

Best voted stoves for small families were ULOG in Onseepkans, and REM5 in Pniel. For large families, best voted stove in Onseepkans and Pniel is REM15. The voting results corroborate the test stove sales ranking. No voting took place in Huhudi because the technique was developed on the basis of fieldwork conducted in Huhudi.

4.5 Affordability

Household affordability is described here in terms of the pay-back period. This is the time it takes for the cumulative savings in fuel expenses per household to offset the cost of purchasing a solar stove. The results (for all but the two most expensive models) are presented in **Figure 16**. They show the situation at the end of the social acceptance test (Phase 1 of the SCFT), i.e. take into account the prevailing cost and prices as well as the test areas.

Figure 16
Payback periods for various solar stove models and test areas, Phase 1



Source: SCFT

The payback periods ranged from 8 months to 5 years (2 years on average), depending on the test area and stove model.

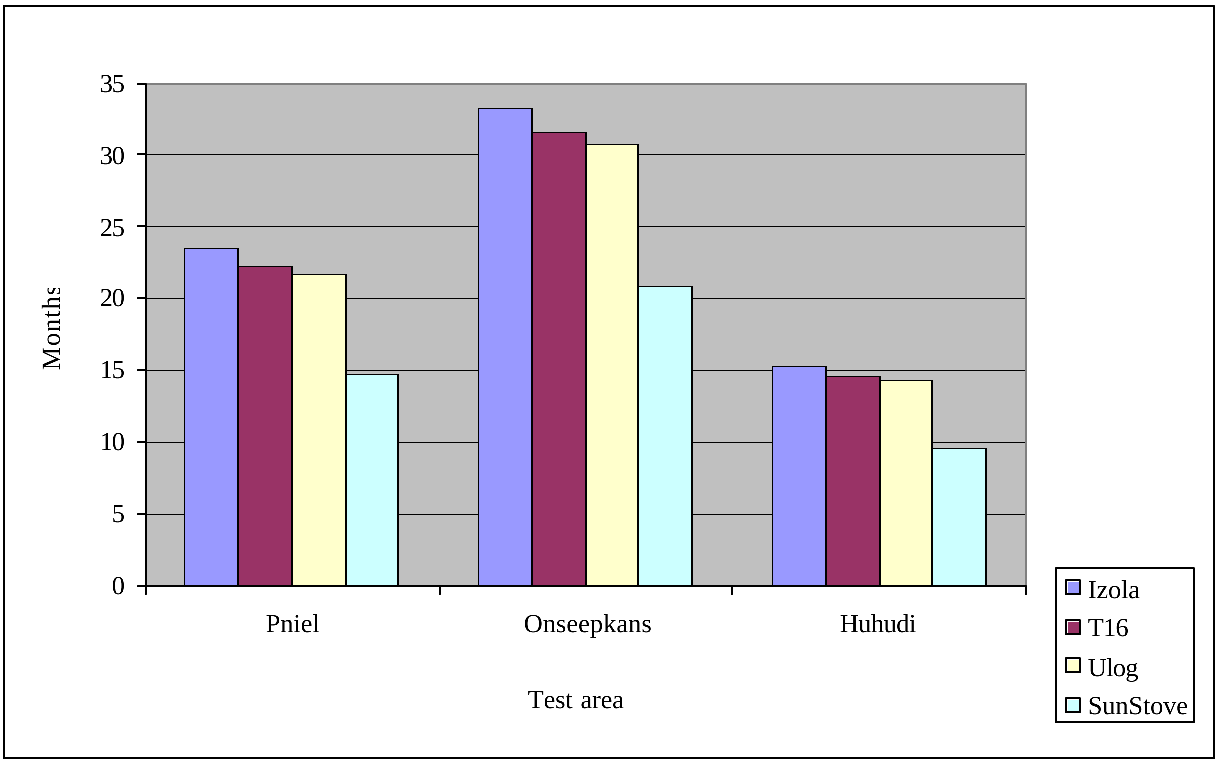
The payback period analysis does not take into account the non-monetary gains associated with solar cooking. They can be quite substantial. Safety, convenience, time savings and social status derived from using solar stoves may all have high value to potential purchasers, and may in fact be more important than the direct monetary savings associated with a reduction in other fuel use.

During Phase 2 of the SCFT, a reduction in the manufacturing cost of the solar stoves was achieved. This was mostly due to:

- The simplification of the solar stove designs and structures, and
- Material savings;

As a result, solar stoves could be offered to the market at much lower prices than in Phase 1. The Phase 2 retail prices, i.e. the prices paid by the customer, resulted in significantly shorter payback periods (**Figure 17**).

Figure 17
Payback periods for various solar stove models and test areas, Phase 2

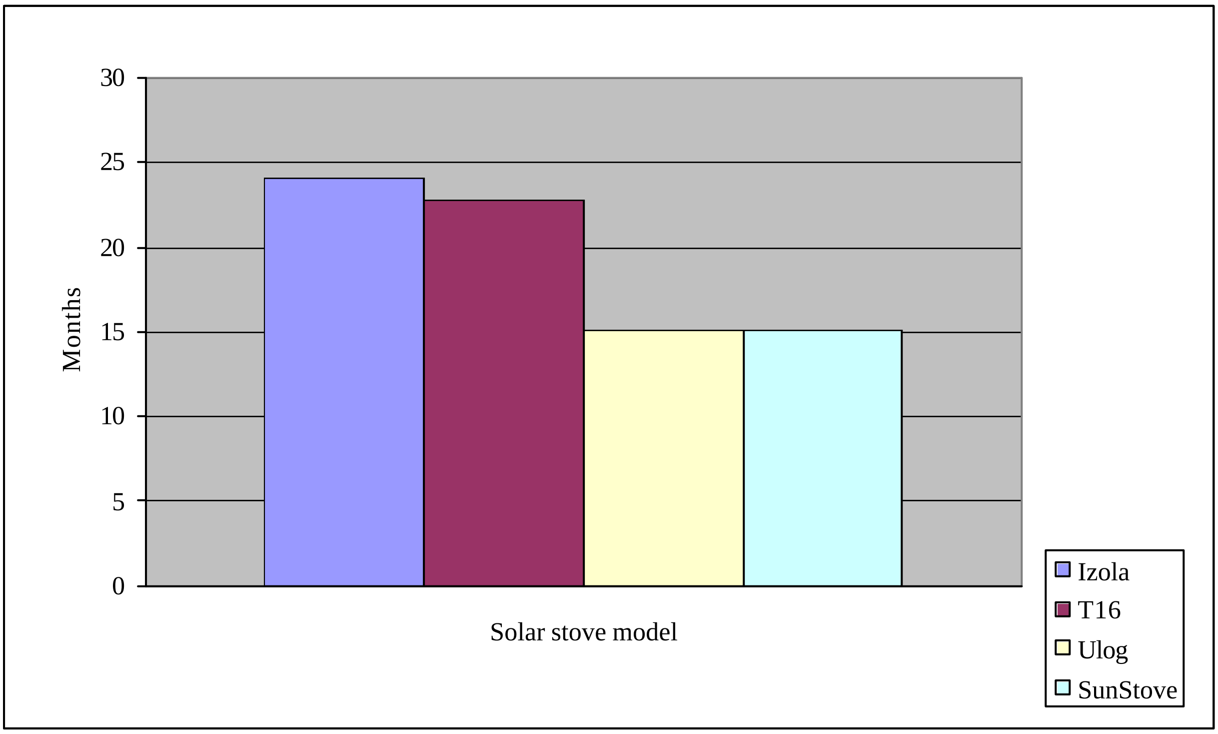


Source: SCFT

The payback period in Onseepkans is longer due to the fact that less commercial fuels are used, resulting in a lower monetary expenditure on energy carriers. Because the area relies on collected fuelwood as the main energy source, non-monetary gains, in terms of time-savings for example, are considered to be important.

The issues of manufacturing costs and pay-back time was not only treated during Phase 1, but also during Phase 2 of the SCFT, see SCC Volumes 3 and 4 (**Figure 18**).

Figure 18
Average payback periods for various solar stove models



Source: SCFT

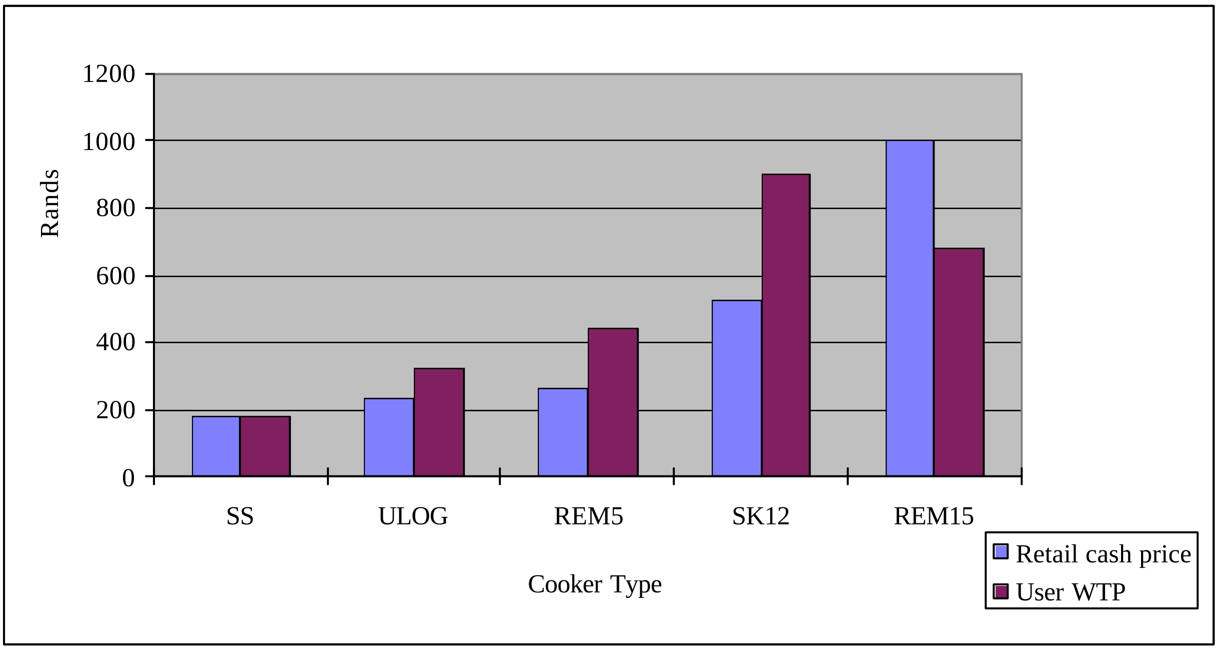
Initially, household willingness to pay (WTP) was determined through an independent marketing survey. Participants were directly asked what they would be prepared to pay for various stoves in cash and/or in monthly installments over the usual 24 months. The results of the responses were then compared to prices of solar stove in Phase 1 of the SCFT.

Figure 19 shows that for all but one solar stove model, the users indicated a WTP exceeding the retail price of the stove. This was regarded as significant, especially for the more expensive models such as SK12 and REM5. It surfaced the potential to sell solar stoves, even at a high price. It was further interpreted as user recognition of intrinsic value as well as the material cost of the solar stove.

As **Figure 20** shows, again, for all but one solar stove model, user WTP was higher than the calculated installment per stove, once more signifying the potential to sell solar stoves to the target market.

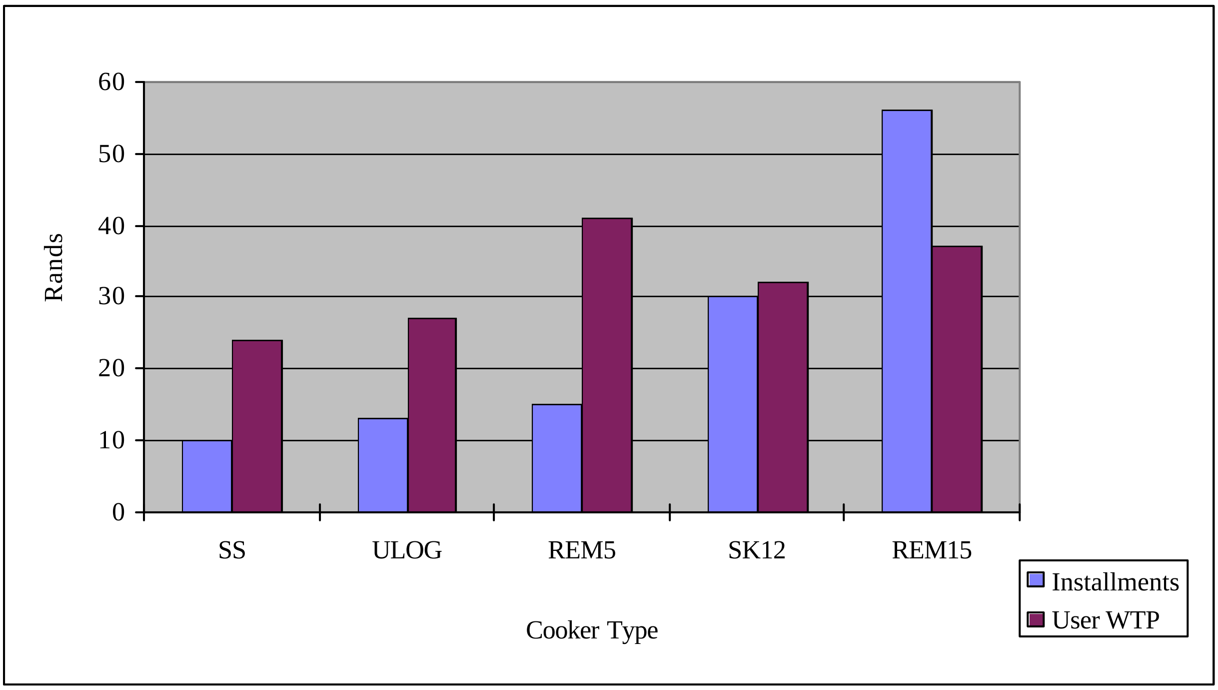
When the same responses are compared with Phase 2 prices, the results are somewhat different. They are depicted in **Figure 21** and **Figure 22**.

Figure 19
Relationship between retail cash price and user WTP (Phase 1 prices)



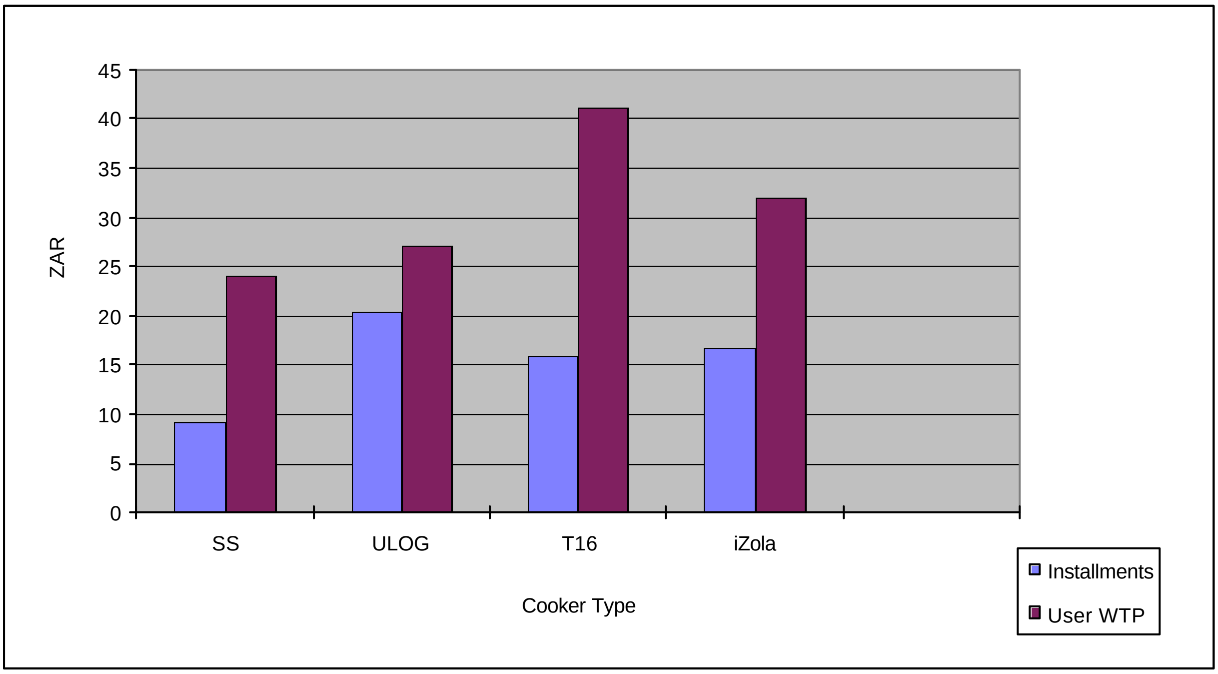
Source: SCFT

Figure 20
Relationship between monthly installments and user WTP (Phase 1 prices)



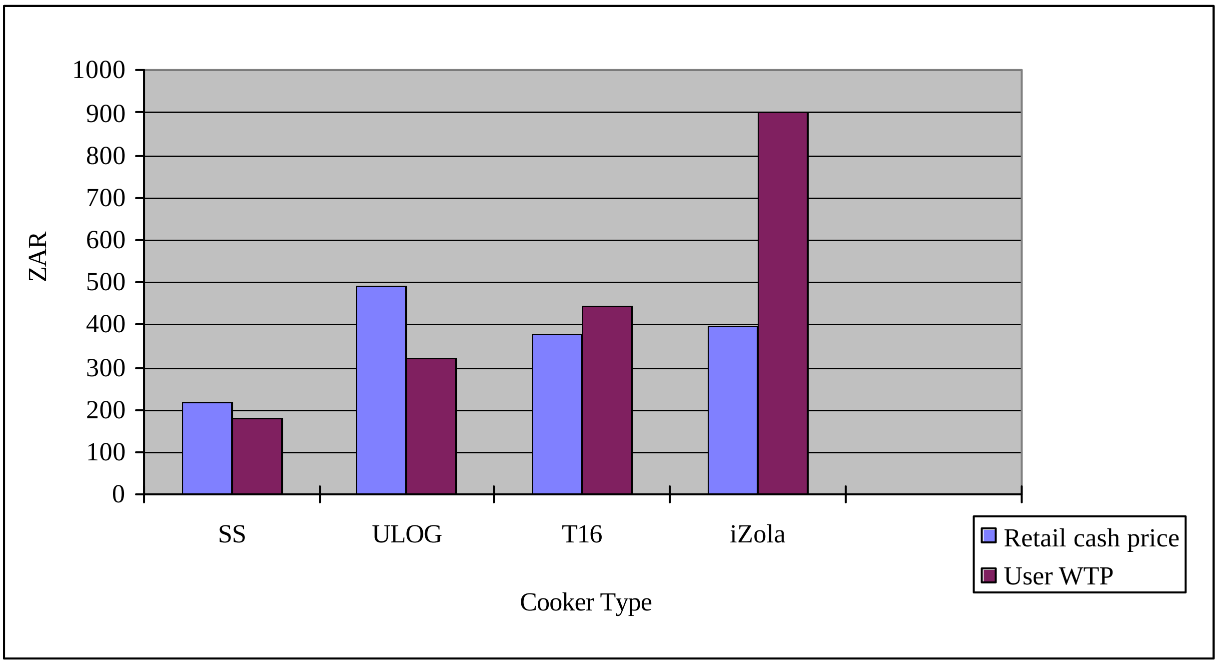
Source: SCFT

Figure 21
Relationship between monthly installments and user WTP (Phase 2 prices)



Source: SCFT

Figure 22
Relationship between retail cash price and user WTP (Phase 2 prices)



Source: SCFT

Based on the lower prices of solar stoves achieved during Phase 2 the WTP versus the price is even more favorable as is the case with monthly installments.

However, caution should be applied. The WTP to purchase a solar stove at an indicated price and the purchase intention were investigated on numerous occasions (during Phase 1 field work in in-depth discussions, independent market research carried out by Markinor, conjoint analysis, potential end-user questionnaire surveys as well as anecdotal discussions during demonstrations and exhibitions). Results from these investigations have been consistently optimistic but did not necessarily translate into actual sales. This fact permits to draw various conclusions:

- What people say they will do and what people actually do are often different things.
- Data collection methods such as interviews and questionnaires may lead respondents to provide the answers they think you want to hear.
- Responses of purchase intention and WTP should be used with caution, especially if they can not be verified and adjusted against actual sales.

People may immediately think solar stoves are a great idea, but it takes a very long time to convince them to actually make a purchase. This emphasizes the need for continuing awareness raising and marketing.

5 Results of the social acceptance test at institutions

5.1 Use rate

The method employed to evaluate the use of solar stoves at institutions differed from the one used to evaluate the use of solar stoves by families/households.

On only 104 days, questionnaire entries were received from institutions over the placement period (November 1996 to August 1997). As the time demands on the cooks are extreme and as there are no incentives for them to complete questionnaires, the responses were limited in number and weak in content. Independent observations by the monitors and supervisors are used instead.

From the baseline study and further fieldwork 8 institutions were selected for the field test at the start of the study. The respective institutional use rates are illustrated in **Table 10.**

Table 10
Use rates of originally participating institutions

Institution	Excluding holidays (%)	Only high interest (%)
Barkly West	19	-
Heidi Creche	37	31
Mmabane Creche	39	46
Moremogolo Pre-primary	4	-
Hoola Hoop Creche	0	-
Tiger Kloof	35	35
St Anne's Creche	0	-
St. Philomena	0	-
Total	17	37

Source: SCFT

As the schools are closed over the holiday period (December, Easter, July and September), taking account of the non-use of solar stoves during school vacations, the stoves were used on 17 % of the days visited.

The collapse of the state feeding scheme in the study areas between January and March 1997 negatively affected stove use at institutions, because funds were unavailable for purchasing food. If the institutions which required this funding to cook meals are excluded for the months in questions, the observed use of solar stoves is reduced to 16 % use on the days visited.

Because of the collapse of the state feeding scheme and resulting low use figures observed at participating schools, it was recommended (by GTZ / DME in 1997) to both limit the study to institutions where reasonable use and interest was observed and to place stoves at new institutions to seek "best practice" possibilities. This meant that by increasing the number of participating institutions, and hopefully the number of institutions using the stoves, more data could be collect and interpreted on the institutional use.

To determine which institutions should remain in the study sample, it was assumed that where institutions were observed to use solar stoves at less than half the use rate of households (i.e. less than half of 38% - or less than 19%) they were considered "disinterested" in solar cooking and those that used the stoves at more than half the rate of households were "interested" in solar cooking. Only 3 interested institutions out of the original 8 selected remained.

A further 6 new institutions were selected in Galeshewe outside Kimberley, Pofadder near Onseepkans and in Pniel during June and July (**Table 11**). To further evaluate the acceptance of the stoves at new institutions, the evaluation was extended by 6 months.

Table 11
Use rates of newly participating institutions

Institution	Sample size	Use (%)	Excluding holidays
Emmanuel	2	50	100
Kekane	4	33	67
Pofadder Creche	7	100	100
Saint Martin's	3	25	50
Pniel Primary School	15	46	44
Salvation Army	3	0	0
Total	34	42	60

Source: SCFT

By removing the stoves from the institutions where exceptionally low-use was found (i.e. stoves observed to be used less than 15 % of days visited and personnel showed no interest in continuing) and placing them with the new institutions, a series of interesting results were observed.

Taking into consideration the original institutions where interest was observed together with the new institutions solar stoves were used on over 50 % of all occasions when visited by the monitors or supervisors.

Table 12 shows which criteria affect the use of solar stoves at institutions. To distinguish between institutions that are seen to use the solar stoves at an acceptable level from those that do not, the following exercise was undertaken:

All criteria reported to affect solar stove use are listed and categorized into positive incentives (that are seen to encourage the use of solar stoves) and negative disincentives (that discourage the use of solar stoves at institutions). Each institution was allocated a score (=1) for each incentive and disincentive identified. The scores for each criteria are totaled and recorded as a percentage of the total possible under "% of interested institutions" and "% of disinterested institutions". Then, these percentages are ranked so that the criteria - both positive and negative - that affect the use of solar stoves at institutions can be assessed.

Table 12
Incentives and disincentives for the use of solar stoves by institutions

	Interested									Disinterested						
Criteria	Tiger Kloof	Heidi Creche	Mmabane Creche	Emmanuel	Kekana	Pofadder Creche	St Martin's	Pniel Primary	**% of interested inst**	Barkly West	Moremogolo Pre-pri	St Philomena's	St Anne's	Hoola Hoop	Salvation Army	**% of disinterested inst**
Incentives to use solar stoves																
Midday meal served		1	1	1	1	1	1		**75**		1	1	1	1	1	**83**
High motivation of cooks	1			1	1	1	1	1	**75**							**0**
Management incentive to save	1	1	1	1	1	1			**75**		1			1		**33**
Appropriate size (<50)				1	1	1	1		**50**				1	1	1	**50**
Incentives for cooks						1		1	**25**							**0**
Total	2	1	1	3	3	4	2	2	**-**	0	1	0	1	2	1	**-**
Disincentives to using solar stoves																
Lack of budget control by cooks	1	1	1						**38**	1	1	1	1	1	1	**100**
Lack of incentives for cooks	1		1	1	1		1	1	**75**	1	1	1	1	1	1	**100**
Disabling management style	1				1		1	1	**50**	1	1	1	1		1	**83**
Lack of security for cookers									**0**	1	1	1		1		**67**
Lack of budget control by org	1	1					1	1	**50**	1		1	1		1	**67**
Control exerted by outside org's								1	**13**	1	1		1			**50**
Distance to stoves too far	1							1	**25**	1		1	1			**50**
Collapse of feeding scheme		1						1	**25**	1		1	1			**50**
Pot capacity too small	1	1	1	1					**50**	1	1	1				**50**
Insecure budget for cooking				1	1				**25**	1	1					**33**
Lack of storge space		1		1					**25**	1	1					**33**
Inappropriate size (>50)	1	1			1		1	1	**63**	1		1				**33**
Total	4	5	1	3	2	0	2	5	**-**	9	5	6	4	1	1	**-**

Source. SCFT

For example, in the case of Tiger Kloof, 3 incentives that encourage the use of solar stoves were found: the preparation of a midday meal; the motivation of the cooks, and a management incentive to save money by using solar. At the same time 7 disincentives emerged; lack of budget control by the cooks, no incentives for the cooks to save money by reducing energy bills, disabling management style (i.e. top-down management), limited budget control by the institution, great distance to the stoves, pot capacity being too small and being an institution catering for over 50.

One disincentive or incentive cannot act as a stand-alone indicator for determining the success or failure of solar cooking at a given institution. The listed criteria interact either to create or distract from an environment that would support solar stove use. Furthermore, only two institutions supplied incentives to the cooks to use the solar stoves. In both cases, the cooks were members of the institutions and thus directly responsible for expenses. This is opposed to most cases were cooks are only employed by the different institutions and gain no direct benefit in the form of monetary savings by using solar stoves. The lack of incentives for cooks, resulting in a low motivation for them to use the solar stoves is probably a very important reason for low use of solar stoves in institutions.

The assessment of the field test with institutions allows a number of important conclusions:

- The overriding incentives for solar stove use are serving a midday meal (at 88% of all interested institutions), cooks that are highly motivated (75% of interested institutions), and a management incentive to reduce fuel expenditure (75%).
- Most institutions served a meal at midday but this, alone, is not an important enough reason to use the stoves as over 80% of the "disinterested" institutions did so. It is therefore considered to be a necessary pre-requisite.
- How many people are fed at the institution is not as important as the motivation of the cooks and managerial incentives to use the stoves.

Key reasons for not using the stoves are

- lack of budget control by the cooks (found to be the case at all (100%) of the institutions that are disinterested in using solar stoves).
- lack of incentives for the cooks (100%).
- disabling management style (83%).

Furthermore, an insecure budget for cooking, a lack of storage space for the stoves and catering for a large number are not found to be significant reasons for institutions not being interested in using the solar stoves.

While in-depth interviews show that the pot size and numbers fed are problematic in using solar stoves at the large institutions (>50 fed), this does not preclude institutions from being interested in using them, probably because of the high possibility of achieving monetary savings and the possibility to use more than one solar stove, thereby increasing cooking capacity.

Box 2
Case Study: A solar kitchen in Tiger Kloof School

Tiger Kloof School was one of the original schools included in the field test due to solar cooking activities at the school with Sunstoves, preceding the field test. In the end it presented a resounding success story for the acceptance of solar stoves in an institutions, although it was not exactly what was expected.

Disincentives for using the solar stoves to prepare food at the institutions outweighed the incentives. The school's kitchen was ultra modern, well equipped and had to cater for more than 100 students and staff members. The use of solar stoves was found too impractical and not feasible. However, the school staff and especially the headmaster was convinced of the positive aspects of solar cooking. When a new course in "Catering and Hospitality Training" was introduced at the school, the use of solar stoves for the training kitchen was investigated. The Schwarzer 2 cookers brought to South Africa for the field test were not being used. With the help of the designer of the Schwarzer 1 and 2, a solar kitchen was planned and built with four Schwarzer 2 stoves permanently installed.

The solution placed no additional burden on their already high energy bill and students had the added benefit on working hands-on with solar technology. After using the solar stoves for about one year, the school requested additional stoves to ensure that all learners have access to a solar stove. Since the size of the building does not permit the installation of more Schwarzer cookers, other stoves such as the REM15 and ULOG were donated. They are being used outside the kitchen on the concrete slab when they are needed.

The Tiger Kloof Solar Kitchen is an example of the long-term acceptance of solar stoves.

Source: SCFT

5.2 Willingness to buy

The independent market survey for institutions, based on 13 interviews, generated a series of interesting findings:

- Most respondents feel their institution would be “very likely to buy” a solar stove.
- Excluding significant regional differences, most prefer the SK 12.
- Pot size is an important criterion.
- Respondents would be prepared to pay between ZAR 1,000 and ZAR 1,500 for the most preferred stove.
- The number of people catered for (with hot meals) varied between 25 and 172.
- Where decisions are made at the institution, appliances are bought from the cheapest store.
- Appliances are usually purchased with a 12 to 24-month guarantee.
- If found to be faulty, most people at institutions would either contract a repair man, return the appliance to the store or phone the supplier and ask them to send a technician to repair it.
- Most respondents expect the stoves to be delivered.

The independent market survey team found it difficult to source appropriate institutions to interview. This supports the notion that low numbers of potential user institutions could be found in the selected project area of the North West Province and Northern Cape Province.

6 Long-Term Acceptance of Solar Stoves

6.1 Ex-post purchase study

The long term acceptance of solar stoves was tested during an ex-post purchase study carried out in the original 3 test areas with the original user families, more than 3 years after the field test started. Institutions were not included as the only institution, which bought a solar stove, the Pofadder Creche closed due to lack of funding. The purpose of the study was to conduct a post purchase analyses in terms of:

- Satisfaction of users, i.e. were their original expectations fulfilled, over three years after they had bought a solar stove
- Use of solar stoves, i.e. what are the reported current use rates of households in the different test areas and do use rates correspond to direct observation by the research team
- Durability of solar stoves and necessary repairs
- User preference based on practical experience with solar stoves, e.g. is it better to market a low cost solar stove as opposed to a high quality stove
- Induced interest in solar cooking developed in the test areas, measured through reported interest in solar stoves from other people in the test areas.

Of the 66 solar stoves sold to families after the acceptance test, 44 units were found more than 3 years later. Of the stoves that could not be located, 2 units had been loaned to family members outside the test areas and 2 users were absent at the time of the visit. In some cases, families moved away or because of a death in the family, the stove was divided with other belongings among siblings in other areas. In general, the solar stoves were in good condition. Mostly minor repairs had been performed on 21 stoves. In total, 6 households were directly observed to use their stoves for the duration of the field visits (2 days per area). Five households in Onseepkans and one in Pniel were observed to be using their solar stoves.

Based on the findings of the ex-post purchase study, the total average solar stove use rates decreased since 1996/97, except in Onseepkans were they have increased. The direct use observation result was compared with the results from the questionnaires. However, a use figure of 31% (solar stoves are used on 31% of all days) does not mean that on 31% of all visits the solar stoves are found in use; they could have been in use on the day of the visit, before or after the visits. The duration of the visits and of the use of solar stoves must be taken into account. Thus, 6 use observations correspond to an average use rate of 30 – 40% (under the following assumptions: 50 observations concerning 43 cookers, average use duration one hour, average duration of observation 30 minutes).

Furthermore, users were requested to specify first, whether they would buy a solar stove again and second, whether they would buy the same solar stove again. The majority (about 90% or 40 out of 44 respondents) would buy a solar stove again and the majority would buy the same stove again.

Across the test areas reasons for not wanting to buy another solar stove were:

- user is too old
- user moved to town
- user not satisfied with baking results.

The reasons given for not wanting to buy the same solar stove again were:

- user would buy a bigger solar stove model
- stove does not have a baking tray
- other stove has a faster heat up time
- people said good things about the other stove
- easier to move (wheels), more comfortable
- higher use position.

All REM15 and all but one SK12 are still in use and their users would buy the same model again, whereas part of the users of the other models would prefer to buy another model. Main reasons for the acquisition of a specific stove model were:

- ULOG Can be stored inside / good looks
- Sunstove Lightest / cheapest
- SK12 Big capacity
- REM5 Fast
- Rem15 Convenient handling

When asked why they had bought a solar stove (independent of model), the most cited reasons were monetary savings in fuel expenses and convenience (time savings, unattended cooking, additional "fuel source").

Key conclusions reached based on the outcome of the ex-post purchase study were:

- Use rates decreased in winter when the elevation is lowest, limiting the available solar input power; this increases heat-up times while lowering maximum temperatures.
- The decrease in use rate is particularly strong for the two slower solar stove models, the ULOG and the Sunstove. Acceptance is low once performance of the stove falls below a certain level.
- The decrease in winter use rates concerns mostly Pniel and Huhudi where practically all fuel is bought. In Onseepkans where most of the firewood is collected, the drop in winter use rate is less dramatic.
- High capacity stoves are used more frequently than the low capacity stoves.
- The use of solar stoves is dependent on a certain minimum per capita pot capacity, which should be in the order of 1 to 2 liters per capita.
- Since convenience might be a more potent motivation for solar stove use than cost savings, an awareness and marketing campaign should emphasize the convenience of solar stoves.

6.2 Additional inquiries to verify user rates

To establish commercial viability of solar stoves, high quality products need to be available to potential customers. Benefits of solar stoves need to be communicated to end users to convince them to make a purchase, via a marketing strategy employing various marketing instruments. This requires a clear understanding of the potential usefulness of solar stoves to owners, in the short and long-term. One argument is that the cost of the solar stove will be amortized through energy savings over a period of time. However, since the long-term use of solar stoves has been difficult to study, this fact was not easy to prove. In addition, this endeavor was often based on use rates established during a study period when they may be higher than normal.

Based on recommendations from an evaluation mission in July 2000, it was requested that further work be carried out to clarify some of the issues raised during the ex-post purchase evaluation and to shed further light on the long-term acceptance of solar stoves.

The aims of the follow-up study were:

- to better understand the reported use rates in comparison with those experienced during Phase 1 of the SCFT

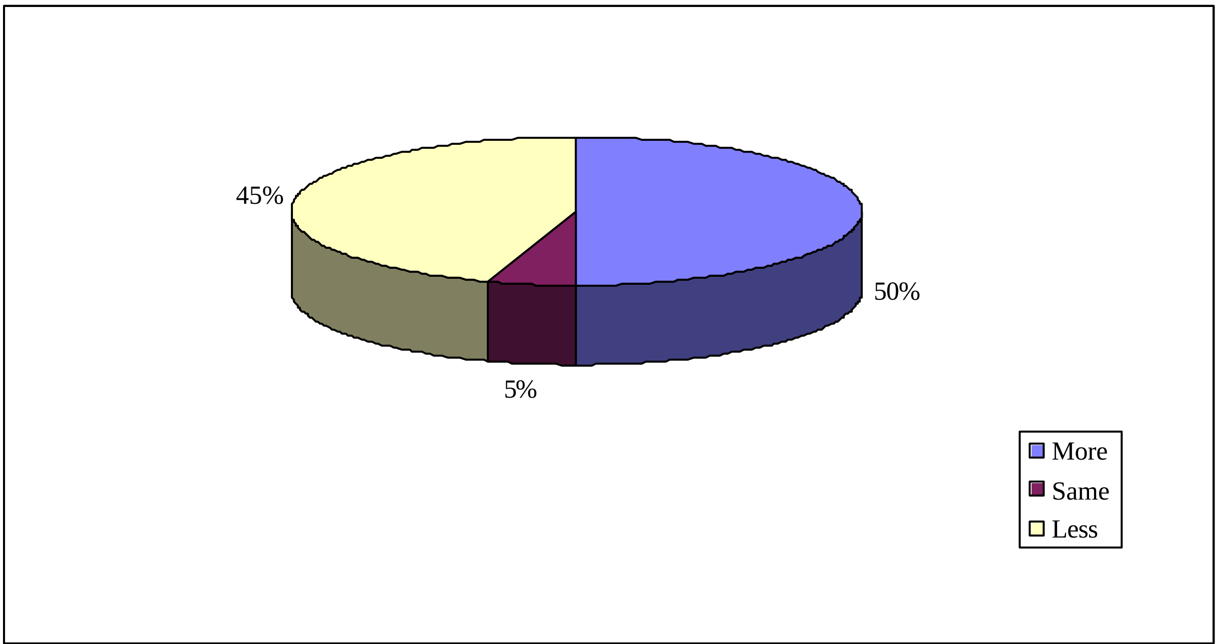
- to attempt to understand the reasons for the increase or decrease in use rates as reported by households

- to establish if a discernable trend exists regarding use rates over time, linked to specific solar stove models, i.e. is one model more likely to be used over a longer period and why?

Data collection took place through a structured questionnaire. In total, 41 questionnaires were completed, compared to 43 completed during the ex-post purchase study. Where possible, the same people were interviewed as for the ex-post purchase study, although this was not always possible due to people being away, working, being ill or having moved. It should be noted that the use rates are reported as opposed to observed, i.e. reported use rates cannot be verified by direct observation.

The reported use rate in comparison with Phase 1 use rates is illustrated in **Figure 23.**

Figure 23
Reported use rates of solar stoves in comparison with Phase 1



Source: SFPT

Of the total sample, 50% of users reported that they were using their solar stoves more than during Phase 1, 5% reported that their use rate remained the same and 45% reported that they were using the stoves less.

In terms of the reported use rate per area, there are quite some differences: In Huhudi, 59% of the respondents used their solar stove more, while 41% reported that they used it less. In

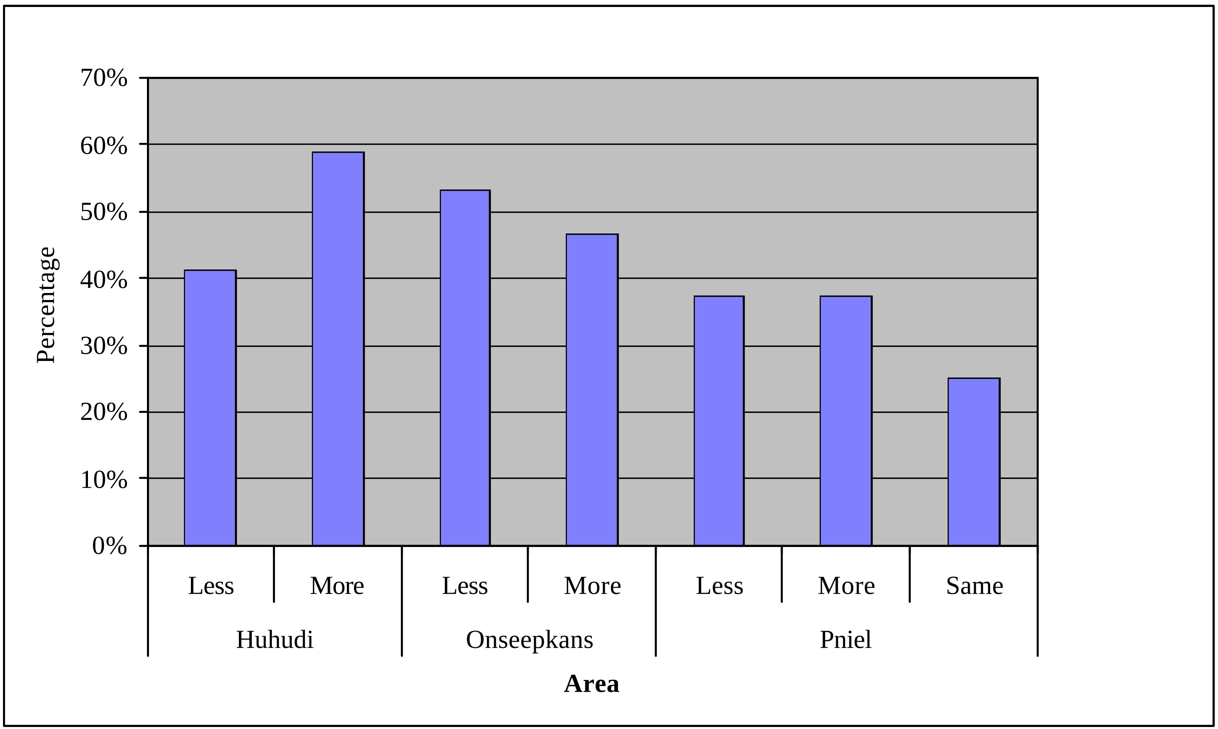
Onseepkans, 47% used it more, while 53% reported a decrease in their use rates. In Pniel, 38% each reported increased and decreased use. The use rate per area is illustrated in **Figure 24**.

The most important reasons for the solar cookers being used more were:

- people understand the stoves better after a period of use
- they have become comfortable with the stoves
- they can save on fuel

All reasons achieved the same score (20), but when looked at in more detail, the most important reason for increased use, transpired as fuel savings.

Figure 24
Reported use rates of solar stoves in test areas in comparison to Phase 1



Source: SCFT

Key reason why solar stoves are used less were:

- there is nobody at home to watch the stoves while they are cooking
- some stoves are too slow to meet set time expectations

Other reasons given in order of score is that it is too much effort to carry the stoves outside, that the people now have electricity to cook with, and that the stove is too difficult to use. Thus, the main reason for increased solar stove use was fuel savings while the main reason for decreased use was the fact that no one is at home or available to use the stove. Other important factors are changed circumstances in terms of increased availability of fuels as well as increased effort to use the solar stove due to age.

In terms of the specific model of solar stove, which were reported to be used more per area, the REM 15 was reported to be used more by 5 respondents, the REM 5 also by 5 , the SK by 4, the ULOG by 4 and the by 2. Based on these responses it is difficult to establish a clear trend of increased use of a specific solar stove model. It does seem however, that the higher performance stoves such as the REM 5, REM 15 and SK12 are used more than the lower performance stove such as the Sunstove and ULOG, supporting the earlier finding that stove acceptance is low once performance falls below a certain level.

From the analysis of the reported use rates of solar stoves in comparison with use rates during Phase 1, it can be concluded that

- respondents in Onseepkans reported decreased use rates, Huhudi reported increased use rates and Pniel reported an equal increase and decrease in use rates
- no evidence was found that one solar stove model is clearly more used than another, thereby indicating a higher level of acceptability for all solar stove models over a longer period of time
- the study delivered only a snapshot of solar cooking activities at a specific time. Household dynamics as well as circumstances may fluctuate and change over time, influencing use rates, i.e. no one being at home to use the solar stove because of temporary employment or the availability of electricity.

More than half of the respondents reported that they were using their solar stoves more than during Phase 1. This seems to indicate that the long-term acceptance of solar stoves has been established in the test area.

The reason for the social acceptability test carried out during Phase 1 was to answer two simple questions: Are solar stoves used and are solar stoves accepted as a cooking option in households and institutions?

The results of Phase 1 indicate acceptance of solar stoves by family test users - "acceptance" of solar stoves being defined as "solar cookers are used as much as or more than other cooking options in the household”. However, acceptance does not imply that all other cooking options are replaced by solar stoves but rather that solar stoves become one of the appliances used within the multiple appliance use patterns of most households. Rural households, just like households in cities, traditionally use a variety of cooking options.

Based on the identified positive potential for solar stoves, Phase 2 of the SCFT commenced in 1999, focusing on the manufacture and marketing of solar stoves in South Africa.

7 Lessons Learnt

The key messages from Phase 1 of the SCFT regarding solar stoves for households are:

- Solar energy is a promising option capable of being one of the leading energy sources for cooking under specific conditions

- The high use rate of solar cookers, at par with wood and above other fuels, indicates acceptance of solar cooking by families
- Each model of the solar stoves has its own supporters. An obvious, universal, single choice does not emerge
- Considerable fuel and time saved by the use of solar stoves generate reasonable pay-back periods, except for the most expensive stoves
- While causing shift in cooking times and reorganization of household labor, the use of solar stoves does not disrupt social relationships
- Macro-economic impacts calculated and extrapolated from user results are positive
- All test cookers needed technical improvements and have undergone adaptations. The adapted solar stoves served as a basis for local production

Regarding the use of solar stoves by institutions it is evident that the original institutions participating in the field test did not maximize the use of the stoves available to them. Seven issues were identified which influence the potential use of solar stoves in institutions:

- Human resources: Is there adequate personnel in the institution to use solar stoves or are the already overburdened few persons available further taxed with a new technology. For example, teachers often act as cooks in the absence of money to employ additional staff.
- Financial resources: Are there enough financial resources to enable the institutions to use solar stoves, i.e. can they afford to buy food or are they dependent on a feeding scheme. Do they have an adequate understanding of savings, can they determine monetary savings and do they have control over any savings generated.
- Communication channels and methods: Institutions which employed a more open, less autocratic management style and communicated well with cooks and kitchen staff lead to a higher use rate of the solar stoves. Kitchen staff should not feel forced to use solar stoves as this leads to resentment of the technology.
- Attitudes to work: In some institutions kitchen staff and cooks had not been paid for several months. This lead to negative attitudes towards their work and towards solar stoves, which were viewed as an unnecessary, additional burden. However, even in institutions where cooks had not been paid but where they still had a positive attitude towards their work, they were also more positive towards the solar stoves.
- Decision-making structures: Institutions with complex, distant decision-making structures were less inclined to use solar stoves than those with less complex structures. This could be the case because communication is in general more open, making it easier to motivate kitchen staff to use solar stoves.
- Wealth of the institution: This is similar to financial resources but not exactly the same. Relatively well-off institutions in terms of equipment, food, and financial resources were less

willing to use the solar stoves because convenience (through using faster stoves) outweighs savings.

- Institutional support networks: Institutions which are well supported from outside, for example a church were more willing to use the solar stoves, possibly because of added motivation.

Thus, the information gleaned from the participating institutions suggests that human resources, attitudes to work, decision-making and communication form the basis of the non-use of cookers. Monetary issues are not the most important problem as the schools have sufficient funds from the state feeding scheme to buy food. The lack of incentives for cooks to use the solar stoves, especially if they are not being paid or being paid a poor salary is an additional disincentive. The available time to cook in the morning before 10 am also posed a problem, especially in winter months. Lack of available wood and the requirement of parents and children to collect wood for school use is a major incentive for the use of solar stoves. It was evident that the larger institutions lack the required flexibility to change cooking technologies, and the smaller institutions lack the required skills to implement changes.

Specific management criteria were developed to determine by means of initial scan if solar stoves will be successful in selected institutions. Although these were specific to conditions in the test areas in South Africa, they would probably be replicable in other countries as well:

- Type: The type of institutions was important; schools, street vendors and shebeens proved more successful than restaurants, clinics and hospitals.
- Size: Institutions feeding between 20-50 people per day or more are only suitable if it is spread out through the day. These numbers were ideally suited to the stove capacity but also to the labor required to use solar cooking.
- Financing: Institutions should have sufficient funds to feed "clients" from a secure source. However, there should be a need to save on cooking budgets, which gives a direct benefit back to the institution or even the cook. A prepared budget would be a positive sign as well as mechanisms to monitor it.
- Space: Institutions should have adequate space in the sun for cooking. Storage space may also be required, especially if security is a problem and stoves need to be locked away at night. The stoves should also be used close to the kitchen and/or serving area to minimize additional effort required to move food between stoves and kitchen.
- Management: Should have sufficient human resources to manage, purchase and cook food. There should be management structures in place capable to monitor and record savings.
- Team work: There should be some degree of successful co-operation amongst the staff to facilitate the smooth introduction of a new technology and cooking procedure for the institution. Some form of appropriate training program would be a positive sign.

Specific perceptions, which may influence the acceptance of solar cooking were recorded. They differed widely from the commonly cited perceptions such as dangers of theft, poisoning, unwillingness to cook outside and in the sun as well as the plethora of negative issues often attributed to solar cooking (**Table 13**).

Table 13
Perception of solar cooking

Perception themes	Perceptions from users
Health	Solar cooking keeps the vitamins in the food, it is not "cooked to death". It is "soldiers' food"- for fit people. Solar stoves prevent indoor pollution.
Quality of food	The food is clean because there is no smoke. Solar stoves cook beans, samp, split peas and other grains well. Only the SK12 manages to burn the porridge, which is preferred.
Quantity of food	The solar stove cannot cook a meal requiring many types of food and large quantities of food such as the Sunday meal on its own. Other cooking appliances are required. Initially visitors were attracted to households with solar stoves forcing the household to prepare larger quantities of food.
Social networks	Solar stoves do not contribute to story telling, as it is done around a fire. In Huhudi, solar stoves removed the need for borrowing and lending fuels, which may lead to a breakdown in social networks. In Onseepkans, the solar stoves promoted interaction between households and strengthened social networks in that people could cook more food to share.
Weather conditions	Solar stoves will not operate in cloudy weather - "when the sky is dirty". Dust could be a problem when pots are removed from the stoves.
Environmental resources	Wood is a scare resource and costs the households time and money. Solar stoves operate with the "eye of God" while wood stoves operate with the "tools of the devil"
Status symbols Operational aspects	Solar stoves contribute to the status of the household. There is jealousy amongst those who do not have stoves. Due to lids being easily blown open by the wind, some users resorted to the use of bricks and tires to keep lids down. This detracts from the aesthetic quality of the stoves.
Child development	Children are able to look inside the pot without opening the lid (REM5). Children like to play in the "mirrors" (reflectors). The stoves are safe for children as they can not burn.

Source: SCFT

These conclusions, particular regarding the micro and macro economic impact, were the basis for recommending the implementation of Phase 2 of the SCFT, i.e. the manufacture and marketing of solar stoves in South Africa.

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