SOLAR COOKING COMPENDIUM

Volume 4

The solar cooking toolkit:
Conclusions from the South African Field Test for future solar cooking projects.

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Abstract

The valuable experience accumulated by the SCFT can be applicable to other projects in other situations. To enable replicability, specific "tools" were developed based on experience to date. In particular, the importance of acceptance and adaptation to local conditions, of technical characteristics, but also of price, durability, handling, as well as user support, after-sales service and product credibility was reconfirmed. The tools are presented as questionnaires/fact sheets on the following aspects:

- A simplified thermal performance test method;
- Assessing technical characteristics of solar cookers;
- Adapting solar cookers to local conditions;
- Structuring planned solar cooker projects; and
- Impact monitoring

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 fuel wood 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 fuel wood 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, fuel wood 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, multidisciplinary 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 favouring 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 endeavour. It involves many players with various tasks and responsibilities.

The challenges, accomplishments, and lessons learnt in implementing the SCFT in South Africa have been channelled 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

BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung
CDM	Clean Development Mechanisms
CEF	Central Energy Fund
CO_2	Carbon dioxide
DEM	Deutsche Mark
DME	Department of Minerals and Energy
ECSCR	European Committee for Solar Cooking Research
EDC	Energy Development Corporation
FAO	Food and Agricultural Organization
FWC	fuel wood for cooking
GEF	Global Environment Facility
GHG	greenhouse gasses
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IR	Infra red
MP	meal portion
RSA	Republic of South Africa
SABS	South African Bureau of Standards
SCFT	Solar Cooker Field Test
SCC	Solar Cooking Compendium
SESSA	Solar Energy Society of South Africa
USD	United States Dollar
W	Watt
WSSD	World Summit on Sustainable Development
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

1. The experience accumulated by the SCFT (Solar Cooker Field Test) has touched on a great number of different issues related to domestic and institutional cooking in general, and on solar cooking in particular. The validity of this experience is not limited to SA. *Mutatis mutandis*, it can be applied to other projects, in other situations.

2. Volume 4 of the SCC (Solar Cooking Compendium) - contrary to the other volumes - does not relate the SA experience, but attempts to shed light on just what can be concluded from this experience for other projects, in other regions, implying other cooker models and/or different objectives. The "tools" presented below are based on this experience.

3. In particular, the SCFT has shown or reconfirmed the importance of acceptance and adaptation to local conditions, of technical characteristics, but also of price, durability, handling, as well as user support, after-sales service and product credibility.

4. Although care must be taken not to "over-generalise", the following SCFT insights should be of value in other, different situations:

   - the best dissemination strategy: the long term goal being commercial dissemination, preferably using existing channels.
   - the target market: rural families, possibly after a detour via pioneer trend-setters.
   - the most adapted solar cooker: important progress has been made towards low price, high performance, durability, low weight, uncritical tracking; the remaining problem being that each of these goals being met by one or several models, none of the models meeting all criteria.
   - the best way to produce the cooker: the goals being low cost, immediate delivery, high quality standards, the difficulty being to find the ideal producer.
   - the question of the choice of production being local or as efficient as possible.
   - the degree of final assembly / kit: how much final assembly can or should be expected from the user ?
   - partner selection: the goal being a complete take-over by local market actors, from investment over product selection and adaptation to distribution and after-sales; the question being how to find these partners.

5. The potential market for energy-efficient cooking appliances (solar cookers being but one solution amongst others) is as vast as it is difficult to access. Changes in appliances and fuels have major impacts on the lives and the environment of those who use low-efficiency, high emission devices for cooking. This concerns one half of humanity - directly.

6. The main ambition of this volume is to be of practical relevance. Thus, the findings are discussed in the text of this document, and presented as ready-to-use[1] questionnaires / fact sheets called "tools", concerning the following main issues:

Tool 1 - thermal performance

7. A simplified solar cooker test method using a minimum of equipment is proposed. The result sheet serves a triple purpose: memento of test method for the testers, result log and detailed technical presentation of results.

Tool 2 - technical characteristics

8. Quality, handling and safety

Tool 3 - adaptation to local conditions

9. Adaptation of solar cooking in general and of different types of solar cookers to a given local situation

Tool 4 - structure of planned solar cooker projects

10. As a memento for the proposer of solar cooker projects, and as listing of project selection criteria.

Tool 5 - monitoring logs

11. A one month data collection sheet for the efficient monitoring of the use of different cooking techniques, as well as a single-shot questionnaire for users and control group, concerning other aspects and impacts of solar cooking.

12. It should be noted that, while these tools have been drawn up on the basis of project experience, they have not yet been tested in practice.

[1] the corresponding form sheets can be photocopied from this report.

1. Tool 1: Simplified test method of solar cooker thermal performance

The experience accumulated by ECSCR (European Committee for Solar Cooking Research) in the technical test of 25 different solar cooker models and the SCFT field test of 7 different solar cooker models has not only served to compare the merits of the cookers involved: for future (commercial or cooperation) projects, this experience can be used as a basis for the **recommendation of solar cooker models** which have not been part of either test. This recommendation must be selective to minimise the risk of piling up unsold cookers or creating negative publicity by unhappy users, or angry clients and traders.

It is clear that new models must be considered in order to profit from technical progress. Solar cooker development is progressing in several directions:

- in the low-price segment (panel cookers and basic boxes)
- in concentrators (small to large)
- in stylish and practical up-market boxes.

In parallel, there is a revival of basic solar cooker R&D, directed at optimisation of components or specific heat transfers. Results of this work can be used for different cooker models, in the sense of lower prices or higher performance. These results do not stay confined to solar cooker circles, but are submitted to and accepted by reviewed journals such as *Solar Energy*. Last not least, a growing part of these efforts originates from "new" countries (such as Argentina or Ethiopia), as opposed to regions with a tradition in solar cooker research (Europe, Southern Africa, India, North and Central America).

The "traditional" countries have reached a certain level of solar cooker expertise (see test methods proposed, discussed and adopted by Funk, Mullik, SABS – South African Bureau of Standards, ECSCR), and normally have access to the corresponding test equipment. The "new" countries must often do with less. The simplified test procedure fits in this framework.

1.1 Basis: the ECSCR method

The simplified test method presented here is based on the ECSCR test procedure which has been developed as a comprehensive tool to create results useful for users, for potential cooker buyers, developers and other professionals such as project planners and evaluators.

The ECSCR method relies on basic but state-of-the-art test equipment, such as:

- multi-channel data logger with data transfer to a computer
- slim temperature sensors (at least 2 per tested cooker) for accurate measurement without sensor-induced heat-loss

- precision sensors for direct and diffuse irradiance, ambient temperature, wind speed
- electronic scale for pot load measurement.

Also, the method needs, depending on the number of cookers to be tested, a voluminous storage for water and oil at 40°C, a small hill of buckets, an after-test oil disposal possibility - and a disciplined and coordinated team of qualified testers.

For the first official test of 25 cookers conducted at the Plataforma Solar de Almeria (Spain), this meant test equipment in the order of 30,000 US$, plus a 500 m² platform with power and water supply, next to a shaded office to protect data acquisition and operators, two trucks to bring in cookers and hardware, 6 testers and the appropriate clear sky without strong wind - all this within the allocated one-week stretch.

Figure 1
A row of boxes during the ECSCR test in Almeria

Source: Synopsis

Clearly, a simplified version in terms of test equipment would be welcome. A proposal is presented below. On the other hand, this simplified method, since it does not record ambient parameters, does not produce results with the same precision as the ones produced with the "full version". Whenever possible, the full version should be applied - if possible controlled by parallel measurement of a reference cooker with known characteristics.

1.2 Proposal: the simplified thermal test method

A simplified test procedure is proposed here. A detailed description is presented in Appendix 1. It is important to note that, while equipment is minimal, experimental care and precision must be of a high standard.

Minimum test equipment requirements are:

- a clock or watch with minute graduation
- a graduated recipient or measuring jug
- a bucket per tested pot
- a thermometer (precision 1°C) for ambient and liquid temperatures (of the liquid to be loaded into the cooker). For ambient temperature measurements, the thermometer has to be carefully shielded from sunlight and IR radiation without blocking the air flow.
- a separate mercury thermometer (one per test pot, precision 1°C) for pot content temperatures, fitted onto pot wall or lid through a hole, sealed with silicone, placed in a way readings can be taken without opening neither cooker nor pot lid. Temperature measurements after opening the pot lid and stirring the liquid with the thermometer cause uncontrollable heat loss and are misleading.
- a protractor for the measurement of solar elevation.

Irradiance and wind speed are not measured, but described. For all but the "windy conditions" test, wind should be feeble to nil. For all tests, sunshine should be clear with less than $1/10^{th}$ of cloud cover. Since "clear" sunshine is somewhat elastic, the results cannot be expected to be of high quantitative precision. It is preferable to use the method to compare different cookers; simultaneous comparison between cookers is more reliable since conditions are the same for all tested cookers.

The thermal tests comprise the measurement of the most important thermal characteristics, i.e. speed of heat-up, maximum temperature and daily cooking capacity:

- "hot start" heat-up of water from 40 to 80°C, and to 97°C (results in water mass, time, W)
- "cold start" heat-up of water from 40 to 80°C, and to 97°C (results in water mass, time, W)
- maximum temperature in oil (°C)
- continuous cooking (litres per day)
- cooking under windy conditions: repetition of the "cold start" heat-up of water from 40 to 80°C, and to 97°C (result is whether a change compared to no-wind conditions is observed).

Cookers are loaded with water or oil at 40°C, to half the nominal pot volume or following manufacturer's specifications.

Results are to be entered into a thermal test sheet as reproduced on the following page. This sheet serves a triple purpose:

- Memento of test method for the testers
- Result log
- Detailed technical presentation of results.

The sheet is not meant to be a stand-alone technical information of thermal cooker performance for the general public.

1.3 Comparison of thermal test methods for solar and other cooker types

There is one fundamental difference between solar cookers and other cookers: solar cookers do not consume fuel - so there is no way to determine impacts on fuel consumption directly. Inversely, a test method for fuel cookers cannot be limited to thermal power output, but must address input-related issues such as:

- the exact nature of the fuel and its combustion enthalpy (how much energy does the fuel contain, taking into account its particular composition, such as the degree of humidity in wood.)
- the combustion efficiency under given conditions (incomplete combustion being responsible for most of the indoor air pollution and non-CO_2 GHG emissions)
- the heat transfer efficiency (how much of the produced heat actually ends up in the pot content?).

Also, in the case of wood stoves, efficiency depends on a number of additional parameters:

- Power setting
- Advancement of the combustion process
- Fire tending (e.g. continuous or batch refuelling).

Now, solar cooker thermal testing poses its own problems, in particular those related to environmental parameters (diffuse irradiance, solar elevation, wind, etc.) which have been discussed above.

Given these numerous particularities, it is probably preferable to keep separate standards for thermal testing of solar and of other cookers.

Tool 1: Solar cooker thermal test sheet

Name of cooker:				
Physical description of cooker				
Type of cooker (tick):				
concentrator ( )	box coooker ( )	flat plate collector cooker ( )	other, specify:	
Dimension in transport position (before final assembly):				
Dimension in transport position (after final assembly):				
Dimension in operating mode:				
Weight:		Number of pots:	Total pot volume:	
Can ordinary pots be used?			yes ( )	no ( )
Are/is pot(s) part of the cooker?			yes ( )	no ( )
Are/is pot(s) removable?			yes ( )	no ( )
Are/is pot(s) supplied with cooker			yes ( )	no ( )
Safety and ergonomical aspects				
Safety : risk to users and bystanders				
Are burns by the cooker **in normal use** possible (contact with hot pot or its contents, with other hot parts				
of the cooker, burns by steam, burns or blinding by concentrated sun-light)?				no ( )
If yes, specify:				
Is mechanical injury by the cooker **in normal use** possible (sharp angles, etc.)?				no ( )
If yes, specify:				
Are burns by the cooker **in failure situations** possible (e.g. toppling over and spilling of hot food)?				
				no ( )
If yes, specify:				
Is mechanical injury by the cooker **in failure situations** possible (e.g. collapse of structure or cooker				
parts, breaking glass, etc.)?				no ( )
If yes, specify:				
Is injury by the cooker due to **instability** possible (e.g. wind / during stirring food)?				no ( )
If yes, specify:				
Safety : risk of material damage				
Is damage by the cooker **in normal use** possible (concentrated sunlight sets fire to structures, damages				
caused by overboiling or escaping steam, food spoils, etc.)?				no ( )
If yes, specify:				
Is damage by the cooker **in failure situations** possible?				no ( )
If yes, specify:				
Is damage by the cooker possible when **not in use** (risk of fire, i.e. when parabolic cooker is put against				
a housewall in a position to concentrate light onto an inflammable structure)?				no ( )
If yes, specify:				

2. Tool 2: Solar cooker technical characteristics

2.1 The prospective user reaction

While thermal characteristics of a solar cooker are a key selection criterion, other criteria also play an important role. In fact, a cooker should be well noted across the board. Few users will settle for a practical cooker that won't cook - or for a super-performer that will fall apart within a few weeks. Although, if the price is right, some might be tempted to compromise - which is OK provided everybody concerned can make an informed choice.

Concerning these issues, it is important not only to identify the objective characteristics, but also to foresee the user reaction, i.e. the perception of these characteristics. One of the foremost requirements for the testers is therefore to see the different cookers through the eyes of the user, to predict their reaction.

An example for this is the perception of the weight of box cookers. Anything under a certain limit (around, say, 6 to 7 kg) is considered "light", anything over another limit (say, 20 kg) "heavy"; what is in-between (this is the case of most models) is perceived "heavy" by some and "light" by others, depending on practical features, e.g. if one has to reach down to the ground to grab it and if there are no ergonomic handles; or if it is on wheels and at ergonomic height.

2.2 The objective characteristics

A check-list of the main qualitative cooker characteristics is presented in this section. This list is formatted as questionnaire; it should be filled out by one or several testers with practical experience in the use of solar cookers, and concerns two groups of issues:

- the salient features of the cooker, such as dimensions, weight, pot capacity, etc...
- potential problems with handling, durability and safety.

The test crew judges and tick-marks potential problems. This activity should be conducted after the thermal tests - when testers had the opportunity to experience potential problems first hand.

Tool 2: Technology Characteristics – Qualitative Issues

Name of cooker:			
Physical description of cooker			
Type of cooker (tick):			
concentrator ( )			
Dimension in trar box coooker ( )	flat plate collector cooker ( )	other, specify:	
Dimension in transport position (after final assembly):			
Dimension in operating mode:			
Weight:			
Can ordinary pots be used?	Number of pots:	Total pot volume:	
Are/is pot(s) part of the cooker?		yes ( )	no ( )
Are/is pot(s) removable?		yes ( )	no ( )
Are/is pot(s) supplied with cooker		yes ( )	no ( )
		yes ( )	no ( )
Safety and ergonomical aspects			
Safety : risk to users and bystanders			
Are burns by the cooker **in normal use** possible (contact with hot pot or its contents, with other hot parts			
of the cooker, burns by steam, burns or blinding by concentrated sun-light)?			
If yes, specify:			no ( )
Is mechanical injury by the cooker **in normal use** possible (sharp angles, etc.)?			
If yes, specify:			no ( )
Are burns by the cooker **in failure situations** possible (e.g. toppling over and spilling of hot food)?			
If yes, specify:			no ( )
Is mechanical injury by the cooker **in failure situations** possible (e.g. collapse of structure or cooker			
parts, breaking glass, etc.)?			
If yes, specify:			no ( )
Is injury by the cooker due to **instability** possible (e.g. wind / during stirring food)?			
If yes, specify:			no ( )
Safety : risk of material damage			
Is damage by the cooker **in normal use** possible (concentrated sunlight sets fire to structures, damages			
caused by overboiling or escaping steam, food spoils, etc.)?			
If yes, specify:			no ( )
Is damage by the cooker **in failure situations** possible?			
If yes, specify:			no ( )
Is damage by the cooker possible when **not in use** (risk of fire, i.e. when parabolic cooker is put against			
a housewall in a position to concentrate light onto an inflammable structure)?			
If yes, specify:			no ( )

Are the instructions easy to follow?	yes ( )	no ( )
Are all necessary parts in the package?	yes ( )	no ( )
Are spare parts included?	yes ( )	no ( )
Are the necesssary tools for assembling included?	yes ( )	no ( )
Is the assembly of the cooker definitive?	yes ( )	no ( )
If not, can the cooker easily be disassembled?	yes ( )	no ( )
Ergonomics : setting up and storage		
Does the cooker take much place for store when not in use?	yes ( )	no ( )
For cookers which need to be moved: what are the skills, time , etc. involved? Specify:		
For stationary cookers: what are the skills, time , tools, etc. involved concerning setting up and weather		
protection when not in use? Specify:		
Ergonomics : use		
Are operating instructions included?	yes ( )	no ( )
Are the instructions easy to follow?	yes ( )	no ( )
Is the access to the pot(s) easy?	yes ( )	no ( )
Detail of access steps to pot(s) for filling, stirring, tasting, etc.:		
Is the stirring of the pot(s) possible (includes mechanical stability for two-handed stirring)?		
	yes ( )	no ( )
Is emptying of the pot(s) easy?	yes ( )	no ( )
Is cleaning of the pot(s) easy?	yes ( )	no ( )
Is cleaning of the other cooker components easy?	yes ( )	no ( )
If tracking is necessary: describe tracking procedure, frequency and ease:		
Quality and maintenance aspects		
Absorbing surfaces		
Are they durable in heat, steam, moisture, UV radiation?	yes ( )	no ( )
Are they durably resistant (food spills, cleaning agents, sand, protected from animals, rain)?		
	yes ( )	no ( )
Reflecting surfaces		
Are they durable in their respective environnement (animals, heat, steam, rain, sand,UV radiation, etc.?		
	yes ( )	no ( )
Are they fragile?	yes ( )	no ( )
Glazing		
In case of glass: is it of adequate thickness, well mounted, tempered (particularly for glass potentially		
exposed to thermal shock, such as interior glazings)	yes ( )	no ( )
If not, specify:		
In case of plastics: is it resistent to maximum stagnation temperatures, steam, wind, UV; is the fixing		
adequate (initial shrinkage, thermal expansion)?	yes ( )	no ( )
If not, specify:		

Thermal insulation		
In case of foam:		
is it resistant to stagnation temperature (e.g. Styrofoam)?	yes ( )	no ( )
can outgassing occur (e.g. PU-foam…)	yes ( )	no ( )
In case of wools:		
is it sufficiently protected against condensation and rain?	yes ( )	no ( )
are there well-designed evaporation outlets?	yes ( )	no ( )
can insulation fibers escape and be breathed in by the user?	yes ( )	no ( )
In case of loose materials: is settling down prevented?	yes ( )	no ( )
In case of organic materials:		
is it sufficiently protected against condensation and rain?	yes ( )	no ( )
are there well-designed evaporation outlets?	yes ( )	no ( )
can rotting occur?	yes ( )	no ( )
can colonization by animals (rodents, moths) or other organisms (fungi…) occur?		
	yes ( )	no ( )
Other components		
Are there any components subject to rot (e.g. wood, cardboard, etc..)?	yes ( )	no ( )
Are these components adequately protected?	yes ( )	no ( )
Are there any components subject to rust (e.g. non-galvanized or non-treated iron, steel)?		
	yes ( )	no ( )
Are there any components likely to suffer from overheating or UV damage (paints, plastics…)?		
	yes ( )	no ( )
Are there parts that can be damaged by relatively probable outside agents (e.g. stray goats, playing		
children, falling lids, etc.)?	yes ( )	no ( )
Are there other fragile parts or parts with a probably limited lifetime?	yes ( )	no ( )
Is the casing rainproof?	yes ( )	no ( )
Maintenance		
Is there a maintenance scheme included in the marketing or dissemination strategy?		
	yes ( )	no ( )
Is there an operational warranty?	yes ( )	no ( )
If yes, what does it cover?		
Do operating instructions include a description of all replacable and fragile parts?		
	yes ( )	no ( )
Do they give step-by step instructions how to replace parts?	yes ( )	no ( )
Comments		

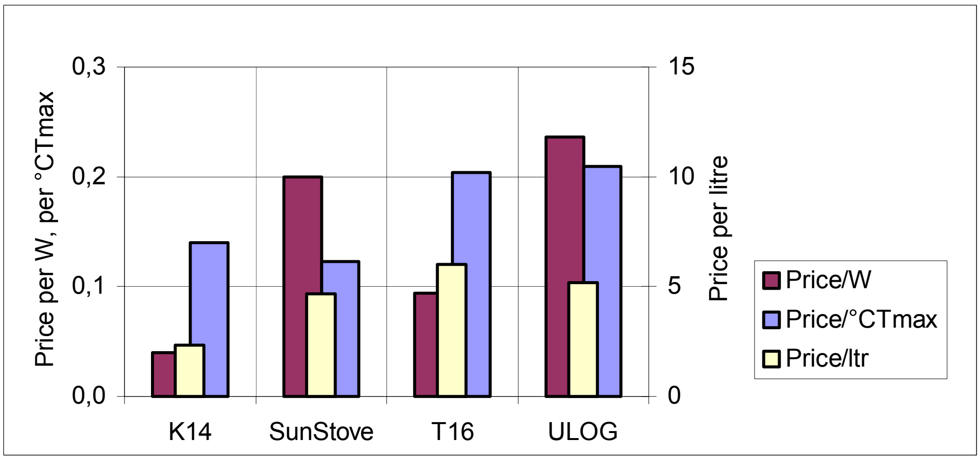
3. Price comparison of different solar cooker models

This section presents a method for direct comparison of the price[2] of different solar cooker models, in terms of three important parameters:

- price per unit of thermal power: the price is divided by the maximum power in W.
- price per unit of maximum temperature: the price is divided by the maximum temperature in °C.
- price per unit of pot capacity: the price is divided by the nominal pot capacity in litres.

Figure 2 shows a comparison of these prices for the case of the cooker models of SCFT SA Phase 2.

Figure 2
Comparison of solar cooker ex-factory US$ prices for different models



It can be concluded that a cooker can be considered "expensive" if:

- a peak Watt or a degree of maximum temperature costs more than 20 US cents
- a litre of pot capacity costs more than 10 US$.

This comparison allows a price rating according to different user priorities.

[2] ex-factory price estimates in $ for 10.000 units per year (SCC values)

4. Tool 3: Adaptation to the local situation

For reasons to be discussed later, cooking energy projects will be a high priority project type in the energy sector. Solar cookers could play an important role in many of them, depending on local conditions. Therefore, a procedure to decide if solar cookers are a viable option is of great importance**.** The procedure should be based on the accumulated experience, e.g. by the identification of criteria conducive to success or failure.

These criteria should shape projects from the earliest planning stages on, and should be at the basis of terms of reference for project identification and planning missions (see Tool 4 in the next section). Ideally, they should cover all issues that need to be investigated to determine if solar cookers can be an viable technical option. For projects implying both solar and other cookers, these criteria can be used to decide for which part of the target group solar cookers are an interesting option.

First necessary condition is that the local situation is known. This is the object of Tool 3 which has two parts:

- 3a), a short questionnaire about the different issues concerning the adaptation of solar cooking to the local situation, as perceived by the potential users,
- and fact sheet 3b) containing the interpretation of the 3 a) results by the proposer of the project.

This fact sheet serves a multiple purpose, apart from presenting facts, it can be used as a probe to assess the degree of understanding by the proposer of the considerable complexity of solar cooking projects; it can also guide the attention of proposer towards critical issues, such as:

- Is there enough sunshine?
- Are typical dishes and cooking techniques adapted to solar cooking / to specific cooker types? This includes practical verification that all or most typical dishes can be prepared on the cookers in question; an example of such a verification is the "practical cooking test" which was held in 1996 in Silverton in the beginning of Phase 1 of the SCFT. A variety of traditional dishes was test-cooked on the different cooker models in order to check whether the cookers actually fit the local meals (**Figure 3**).
- Number of cooked meals per day: the higher the number, the higher the potential benefits of fuel saving devices.
- Number of meals cooked between 9 a.m. and 4 p.m.: this is solar "primetime".
- Number of eaters? The higher the number, the higher the potential benefits of fuel saving devices.

- Number of eaters relatively constant? This allows a good fit of the cooker capacity and optimum fuel economy.

- Problems with cooking at present, such as fuel availability, cost, collection time, safety, smoky kitchen. If there are no problems, the user will be less motivated to change.

- Solar cooking adapted to typical habitat, i.e. ideally a secure, protected spot is available, exposed to the sun all day, easily accessible from the existing kitchen or cooking space. This is one of the most important and most under-rated criteria.

- Climate and the corresponding weather resistance of the cooker, if there is available space to leave the cooker outside and no risk of theft.

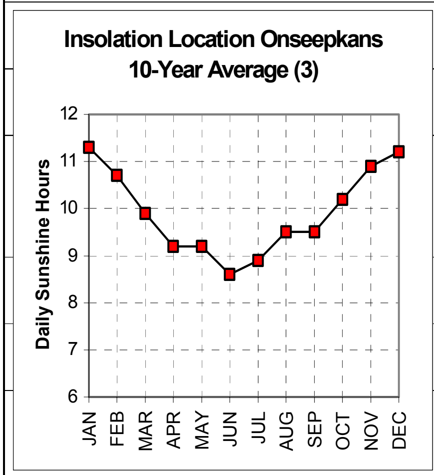
- Cooker size (and capacity in agreement with the average and maximum number of eaters), "collapsibility" and transportability allow easy inside storage every night.

The most important information on the local conditions can be compiled in form of "cooking profiles" (see in **Figure 4** the example of a cooking profile established during the SCFT). It should be noted that cooking profiles can be established not only for solar cookers, but for all types of cookers and fuels.

Figure 3
SCFT practical cooking test in Silverton

Source: Synopsis

Figure 4
Example of a cooking profile

GTZ-DME SOLAR COOKER FIELDTEST SOUTH AFRICA	
Cooking Profiles Families (State : January 1997)	
Location	ONSEEPKANS (Northern Cape), on the Oranje River and the border with Namibia, 8 km long with 3 settlements (Melkbosrand, Viljoensdraai, Sending), 50 km from Pofadder. Surrounding: green belt on the Oranje with agricultural plots, otherwise semi-desert.
Typical Housing	river reed houses with corrugated iron, partly fenced in, occasionaly vegetable gardens
Income	average income/month: 650.-R; most of the families are in the income bracket of 250.- to 500.-R/month (2)
Household Members per Family	1 to 14 (2)
Dishes	porridge, soft porridge, rice, vegtables, meat, entrails with other innards and head, pulses, fish, bread, "rusks", spaghetti, soup, macaroni, potatoes, tea, eggs, milk (1)
Cooking Techniques	boiling, frying, baking, simmering, steaming (1 and 2)
Preparation Techniques	cutting up, soaking (e.g. pulses), stirring (e.g. porridge dishes need to be stirred vigorously), rice is added to cold water (1)
Start of Cooking	morning: between 6 and 10 o'clock; noon: between 10 and 13 o'clock; evening: between 16 and 20 o'clock (2)
End of Cooking	morning: between 7 and 11 o'clock; noon: between 11and 14 o'clock; evening: between 18 and 21 o'clock (2)
Meal Times	morning: between 7 and 11 o'clock; noon: between 12 and 14 o'clock; evening: between 19 and 21 o'clock (2)
Existing Cooking Equipment	mainly wood stoves or three-stone fires, some gas cookers, hardly any kerosene cookers; some families have more than one cooking facility, e.g. wood and gas cooker (2)
Cooking Area	mainly in the house or covered areas (even open fires), rarely outside (1)
Number of Cooking Pots	often 2 pots with ca. 5-8 l capacity (1)
Fuel (bought/collected)	mainly wood (mostly collected along the river, some bought); little kerosene ("paraffin") and gas (1 and 2)
Fuel Costs	1 l kerosene = 1.-R; 9 kg gas bottle = 38.- R; 1 bundel of wood (ca. 15 kg) = 7.-Rd (2)
Weather Conditions	October until March very sunny; April/May partially cloudy and windy; June/July partly sunny, partly light rains; August very sunny and windy, very little rain; September sunny, sometimes cloudy and windy (2)
Suitable Place for Solar Cooker	area close to kitchen, fear of theft of food or damage to the cooker (1)
Interest of Families to Acquire Solar Cooker (e.g. on credit)	yes (1)
Annual Daily Average Insolation	6100 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, Pofadder station (4) W D Cowan (ed), "RAPS Design Manual", EDRC, University of Cape Town, 1992

Tool 3a: Adaptation to the local situation (Questionnaire)

Proposer:				
Project title:				
Proposed project country / region:				
Name of the family / institution				
Address				
Number of cooked meals / eaters				
For how many persons do you cook usually?			adults:	children:
Is the number of eaters relatively constant?			yes ( )	no ( )
How many meals do you cook usually per day?				
How many meals do you cook usually between 9 am and 4 pm?				
Cooking / eating time				
Morning - cooking starts at:			meal served at:	
Noon - cooking starts at:			meal served at:	
Evening - cooking starts at:			meal served at:	
Typical dishes and cooking techniques (boiling, frying, etc.)				
Morning				
Dish:			Cooking technique:	
Dish:			Cooking technique:	
Noon				
Dish:			Cooking technique:	
Dish:			Cooking technique:	
Dish:			Cooking technique:	
Evening				
Dish:			Cooking technique:	
Dish:			Cooking technique:	
Dish:			Cooking technique:	
How many pots do you use per meal?				
Your present cooking equipment (tick)				
open fire ( )	wood stove ( )	improved wood stove ( )	charcoal ( )	gas ( )
kerosene ( )	other, specify			
Do you cook	indoors ( )	outdoors ( )		
Cooking at present				
Is fuel difficult to find?		yes ( ) partly ( ) no ( )		
How much do you spend on cooking fuel (wood and other fuels) per week				
in time (e.g. fuel collection):			in money:	
Is smoke a problem in your kitchen?			yes ( ) partly ( ) no ( )	
Is safety a problem?			yes ( ) partly ( ) no ( )	
Space adapted for solar cooking				
Do you have a protected sunny spot?			yes ( )	no ( )
From when to when does the sun shine there?			from………..	to………..
Is there an easy access from your existing kitchen or cooking space?			yes ( )	no ( )
Do you have a space to leave the solar cooker outside?			yes ( )	no ( )
Do you have a storage space?			yes ( )	no ( )
Might theft be a problem?			yes ( )	no ( )
Comments				

Tool 3b: Adaptation to the local situation (Fact sheet)

Proposer:		
Project title:		
Proposed project country / region:		
Typical weather conditions		
Duration of sunny season in month per year:	Frequent high winds: yes ( ) no ( )	
Weather conditions favourable for solar cooking?	yes ( ) partly ( ) no ( )	
Typical dishes and cooking techniques (boiling, frying, etc.)		
Dish:	Cooking technique:	
Dish:	Cooking technique:	
Dish:	Cooking technique:	
Preparation of typical dishes with the proposed solar cooker(s) was verified in a "practical cooking test" :		
yes ( ) no ( )		
Number of cooked meals / eaters		
Average number of cooked meals per day:		
Average number of meals cooked between 9 am and 4 pm:		
Average number of eaters:		
Average number of eaters relatively constant?	yes ( )	no ( )
Problems with cooking at present		
Fuel availability ( )	Fuel collection time ( )	Cost ( )
Safety ( )	Smoky kitchen ( )	Other:
Solar cooking adapted to typical habitat		
Has the typical habitat:		
a spot exposed to the sun all day?	yes ( )	no ( )
an easy access from existing kitchen or cooking space?	yes ( )	no ( )
a space available to allow leaving cooker outside?	yes ( )	no ( )
a storage space?	yes ( )	no ( )
Characterictics of proposed solar cooker(s)		
Is / are the solar cooker(s)		
adapted to meals, meal schedules and number of eaters?	yes ( ) partly ( ) no ( )	
adapted to weather conditions?	yes ( ) partly ( ) no ( )	
adapted to habitat?	yes ( ) partly ( ) no ( )	
Comments		
Reasons for the geographical choice of the project region:		
Reasons for the choice of solar cooking:		
Reasons for the choice of the cooker model:		

5. Tool 4: Structure of planned solar cooking projects

Solar cooking projects, in the past, have come in different forms; they were of different ambition. Typical goals were to:

- check the adaptation of a given cooker model to a given situation
- demonstrate a small number of cookers in a given place
- put a small number of cookers at the disposal of users
- demonstrate the possibility of local production by container production of a small number of cookers
- import cooker kits to be assembled locally
- demonstrate solar cookers to producers, market players, investors, institutional clients, decision-makers, with the objective to involve these targets in a commercial market introduction venture
- introduce solar cookers directly into the market.

It is clear that well planned and financed market introduction efforts would be a direct way to a sustainable dissemination of solar cookers - but perhaps not the only way. At this point, it would not make sense to limit projects to certain types, and this for two reasons:

- The experiences made so far do not definitely favour one or several approaches over all the others.
- The interested public will most likely continue to submit - and often sponsor - small scale solar cooker projects.

On the other hand, solar cooker projects, in order to be selected, should meet certain criteria:

- they should be planned, implemented and documented in a way that - success or failure - their experience will serve later projects
- their approach should be open, i.e. contain several alternative solutions that might serve as "spare tires" in case of need: several different solar cookers or other cooker types, etc.

Tool 4 is a "tick list" questionnaire, to be addressed to the authors of project proposals. It will help to structure proposals and attract attention to essential issues right from the start. Also, a colour code for the evaluation of this questionnaire by decision-makers is included. This code is based on subjective experience and not on any methodological basis. The entries coded in green do not normally pose problems; they can be important prerequisites for further activities. Yellow entries signal potential problems:

- to actually alleviate fuel problems on a larger scale by limited size projects is a high ambition.
- local production implying actual technology transfer - as opposed to local assembly or "container production" - can take many wrong turns and depends on finding and motivating the right partners; the same applies to market introduction.
- impact analysis will be discussed below (Tool 5).
- as for target groups, solar cooker projects find easier interest with users, media and public sector than with manufacturers and distributors.
- although no serious proposer would confess ignorance concerning the target groups or local partner, these issues are mentioned as a reminder.
- as for monitoring, a compromise between precision and economy of means must be found (see Tool 5).

Only one issue is flagged in red: the *a priori* selection of cooker models instead of the choice of the cooker according to local conditions; the reason is not that the use of pre-selected models is a guarantee for failure, but rather an indication of a lopsided motivation: the goal should not be the dissemination of a given appliance, but the compliance with the interests and needs of users and other stakeholders.

The different issues listed in Tool 4 should be part of the terms of reference for the planning of solar cooker projects.

Tool 4: Structure of planned solar cooker projects

Proposer:			
Project title:			
Proposed project country:			
Main project objectives (tick and specify)			
Adaptation check ( )			
Cooker demonstration ( )			
Alleviate fuel problems ( )			
User acceptance check ( )			
Prepare local assembly ( ) or local production ( )			
Prepare market introduction ( )			
Market introduction ( )			
Impact analysis ( )			
Main target groups (number according to priority and specify)			
Users ( )			
Institutions ( )			
Agencies or NGOs ( )			
Manufacturers ( )			
Distributors ( )			
Investors ( )			
Public sector ( )			
Media ( )			
Have the situation and motivations of the main target groups been taken into account and how?			
Local partners identified / contacted / associated in planning:			
Previous experiences in domestic energy:			
Cookers selected y ( ) / n ( ) and selection criteria			
	Type/model	Number	Selection criteria
Cooker 1			
Cooker 2			
Cooker 3			
Cooker 4			
Proposed monitoring, evaluation and publication of results			
Monitor. method	"tool kit" ( )	other ( )	specify:
Percentage of cookers monitored:			
Responsible for monitoring:			
Responsible for evaluation:			
Comments			

6. Tool 5: Monitoring

6.1 Solar cooker use rate monitoring

Apart from "secondary" energy consumption, solar cookers do not cause fuel consumption or emissions (see paragraph 7.2). To estimate their impact on consumption or emissions, it is necessary to calculate the consumption or emissions that would have occurred if the same meals would have been prepared on other stoves.

Thus, monitoring of the use - not only of solar cookers but also of other stoves - is the basis for the assessment of the impact of solar cookers on the economic and environmental condition of their users. To this end, a ready-to-use method has been developed. This method is valid for all types and models of cooking appliances and appliance-fuel combinations. It should be noted that pure energy and/or emission saving devices (such as "hay boxes" - **Figure 5**) have to be evaluated in conjunction with the cooking appliances they are used with.

The method is based on the daily logging of cooked meals prepared in a selected group of households. The following data are recorded, for at least one month per season, over a one-year time span:

- the type of stove used for the preparation of each meal, or the information that no cooked meal was prepared
- the number of portions served for each meal.

The relative simplicity of the base data (number of MP – meal portion, and stove type, compared to direct fuel consumption measurements) allows for auto-monitoring by the user - with guidance, help and control by monitors. From a project point of view, this means less invasiveness, a lesser burden on the users time and patience, and lower cost. A monthly monitoring log (Tool 5) is shown below.

Figure 5
The competition: improved wood stove, hydrogen cooker and hatbox

Tool 5: Monthly monitoring log domestic cooking

Household:					Month:	Year:
Number of adults: / children:						
Available cookers: three stone ( ) / improved wood stove ( ) / gas ( ) / paraffin ( ) / electric ( ) / solar ( )						
Meal log	Morning		Noon		Evening	
	Cookers used	Number eaters	Cookers used	Number eaters	Cookers used	Number eaters
Day 1						
Day 2						
Day 3						
Day 4						
Day 5						
Day 6						
Day 7						
Day 8						
Day 9						
Day 10						
Day 11						
Day 12						
Day 13						
Day 14						
Day 15						
Day 16						
Day 17						
Day 18						
Day 19						
Day 20						
Day 21						
Day 22						
Day 23						
Day 24						
Day 25						
Day 26						
Day 27						
Day 28						
Day 29						
Day 30						
Day 31						
Key: three stone (T) / improved wood stove (W) / gas (G) / paraffin (P) / electric (E) / solar (S) / No cooking (NC)						
Comments						

6.2 Monitoring of other aspects

There are a number of other important aspects concerning the use of solar cookers, such as perception, gender and health issues. A questionnaire system has been developed and applied in the framework of the SCFT. On the basis of the test experience, the questionnaires were adapted and concentrated for use in other situations, to be presented by monitors:

- to solar cooker users, after at least 6 months of use
- to control group families.

In contrast to the daily rhythm of the MP use rate monitoring (see paragraph 6.1), these questionnaires are to be presented only once. The corresponding form sheets are shown in **Appendix 2 : Adapted solar cooker questionnaire system**.

7. Evaluation

Based on the MP monitoring data, the following direct results can be calculated for the sample:

- the number of cooked meal portions (MP) per capita and per year
- the yearly number and percentage shares of MPs prepared on a given fuel-appliance combination
- the average household size (see cross-check below).

To estimate the cooking related impacts on fuel consumption and GHG (green house gases) emission for a given reference region, the following additional input data are needed:

- number of households in the reference region
- impact data (fuel consumption, GHG emission, etc.) per MP of a given fuel-appliance combination, each fuel-appliance combination causing characteristic impacts. These data can be determined directly for the reference region. Alternatively, literature values can be used.

A useful cross-check: the average household size in the reference region can be compared between MP results and statistical data.

The method is not limited to the determination of impacts of a given fuel-appliance combination; it can be used to study the effect of fuel- and appliance switching, as well as the effect of the introduction of an additional cooking technology such as solar cookers.

7.1 Basic assumptions

- **Proportionality of fuel consumption to the number of MP**

One of the main assumptions of the MP-based, domestic cooking impact assessment is that, on the average, all impacts of a given fuel-appliance combination are proportional to the number of meal portions prepared on this combination, or, more precisely:

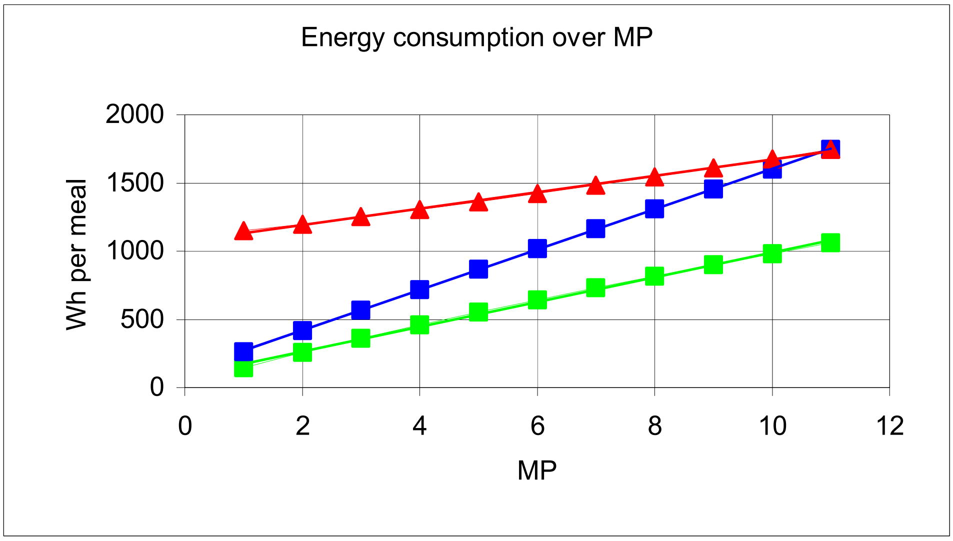
- impacts caused by a given fuel-appliance combination are proportional to fuel consumption
- fuel consumption is proportional to the number of MP prepared.

Assumption 1 does not seem problematic. The validity of assumption 2, the proportionality of fuel consumption to the number of MP, depends on available kitchen equipment. **Figure 6** shows, for a household size of 11, and for a standard meal (heat-up of 0.5 litres of water-equivalent per MP, boiling maintained for 60 minutes) the calculated dependence of delivered energy consumption on the number of meal portions, for three cases:

- independently of the number of eaters, the same pot and the same thermal power are used; in this case (red triangles in **Figure 6**), a meal for one eater needs more than half of the fuel than a meal for 11 eaters and consumption is linear, but not proportional to the number of MP.
- pot size and thermal power vary with the number of eaters: in this case (blue squares in **Figure 6**), fuel consumption is proportional to the number of MP.
- pot size and thermal power vary with the number of eaters; also, unlike in the other cases, thermal power is reduced to a minimum value as soon as boiling is reached (green squares in **Figure 6**). In this case as well, fuel consumption is proportional to the number of MP but on a lower level.

It can be concluded that fuel consumption is proportional to the number of MP prepared, except in extreme cases, when unnecessarily big pots are used and maximum power is maintained during the whole cooking process.

Figure 6
Calculated dependence of energy consumption on MP



- **Do energy efficiency gains guarantee actual energy savings?**

Another important assumption is the interpretation of energy savings by more efficient cookers as corresponding impact reductions; e.g. we assume that the fuel saved for cooking is not burned for heating which would annihilate the reduction. This issue is discussed below.

- **"Secondary" energy consumption**

The energy consumption caused by the use of a cooking device is not limited to the energy directly used, but includes also energy consumed "up-stream" in the process, from the mining over transformation to transport of energy carriers. This energy consumption is hidden and marginal in the case of collected wood; for commercial energy carriers, it can contribute largely to fuel cost and consumption. It should be included in the impact assessment. Examples concerning all types of cookers (fuel-fired, electric, solar) are:

- Energy consumption **for appliance production, marketing and transport.** This should not cause an important contribution, at least for the case of relatively light, durable appliances.

- Energy consumption for **fuel transport, gas leaks, grid losses**. To give orders of magnitude: trucking of wood over distances shorter than 100 km needs less than 1% of additional energy, grid losses in industrialised countries are in the order of 10%.

- **Primary-to-final energy transformation** losses (by refining, charcoal kilns); in industrialised countries, theses losses are in the order of 30%. Basic charcoal kilns lose in the order of 80%.

- For electricity from thermal power plants: the unavoidable **thermo dynamical losses** (in the order of 60%).

- **The GHG impact of biomass cookers - CO_2 recycling by plant growth**

Concerning the CO_2 impact of the burning of biomass, it is a common misunderstanding that only fossil fuels contribute to the rising level of CO_2 in the atmosphere. In this sense, the use of biomass for fuel is frequently characterized as CO_2-neutral. In fact, biomass use for fuel can be, but it is not always CO_2-neutral.

The global consumption of fuel wood for cooking (coded FWC) can be divided in a direct part (FWCD: wood felled or harvested for cooking – only this direct part is assumed to cause a net increase of CO_2), and an indirect part (FWCI: by-products from wood cut for other purposes but used for cooking – this part is assumed to be CO_2-neutral):

$$FWC = FWCD + FWCI \qquad (1)$$

This equation can be solved using available data (FAO[3]): FWC is calculated by multiplying the number of fuel wood users with the per-capita consumption of fuel wood for cooking, whereas the direct production of fuel wood for cooking FWCD is obtained from the direct production of fuel wood FWD minus the direct fuel wood production for non-cooking purposes (such as process heat for craft and industry) FWnCD:

$$FWCD = FWD - FWnCD \qquad (2)$$

Under the given assumptions[4], close to 50% of the CO_2 emissions caused by fuel wood for cooking can be considered CO_2-neutral.

7.2 Remarks on error margin

As usual, we distinguish between two types of errors:

- "statistical" errors caused by random variation of energy use, occurring even in the most homogenous sample. As an example: the radio program was so riveting that the cook could not concentrate on cooking. Or: the goats broke out of the compound and started feeding on the neighbours' sweet peas; the cook had to bring the goats back in and to pacify the irascible neighbour while the food burned beyond recognition. Result in both cases: the family had to eat bread and jam. Events like these are utterly unpredictable and lead to scatter in the cooker use rate. For this reason, surveys are made on well selected samples of sufficient size to reduce this scatter to acceptable levels.

- "systematic" errors due to approximations, erroneous assumptions or misunderstandings which are immune against raising of sample sizes. Systematic errors, in complex issues, usually dominate the error sources; in this case it does not make sense to blow up the sample size; it is preferable to identify and - if possible - neutralise the main error sources (see discussion for the CDM context in [5]).

In fact, some of the main error sources are well known:

- The **baseline assumptions**: what would have happened if the project had not taken place? This uncertainty concerns primarily large-scale projects covering a large number of users, to the extent of inducing changes in potential control groups. For small-scale projects, the monitoring of control groups gives more reliable baseline information.

- **Fallout** due to technical failure or wear. Assumptions for useful life of different cooker models vary from 1 to 15 years; an often observed extreme being 0 years (cooker never used). Fall-out must be monitored.

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[3] FAO, 1999, World Resources 2000 - 2001, Table FG.3.

[4] *Cf.* Grupp, M. in www.synopsis.org

[5] Ministry of Housing, Spatial Planning and the Environment of the Netherlands: Standardized baselines… for Selected Small-scale CDM Project Activities. December 2001

- Uncertainties in **cooker use rate** - see the section on MP methodology.

Other error sources are just beginning to find attention:

- **Replacement effect**: part of the fuel saved for cooking might be burned for heating which would reduce energy savings. This is a so-called "replacement effect" and concerns, in the case discussed here, the increasing fuel consumption for space heating due to a decrease of lost heat caused by higher efficiency appliances. Low efficiency cookers heat the kitchen which is a plus in cold climates. SCFT SA Phase 1 control group data actually showed a 57% increase in wood consumption in winter compared to summer - probably due to space heating. It cannot be expected that even a hypothetical 100%-efficiency cooker could reduce winter wood consumption below space heating needs.

- **"Rebound" or "take-back" effect**, defined as the increased use of energy services as a result of the decrease in energy cost. Domestic cooking should show negligible rebound effects, due to low demand elasticity: whatever the fuel cost, cooking is an unavoidable necessity. On the other hand, even if fuel is free and abundant, cooking needs do not increase dramatically: users - rich or poor - prepare roughly the same number of cooked meals per day, using roughly the same amount of energy delivered into the pot. This is confirmed by the fact that wood users were not observed to react to falling fuel costs with increased cooking activity (SCFT Phase 1). A possible exception are fuels which have other uses than cooking, such as electricity with its universal applications, and gas and kerosene which can be used for lighting. These polyvalent, high demand elasticity energy carriers are at higher risk to counteract energy savings than wood.

8. Conclusions

The SCFT test experience has produced various insights into the specifics of solar cooking and solar cooker projects. This volume presents conclusions for projects in other countries and / or using different cooker models. Practical propositions are made concerning the following issues:

- **thermal performance**: a simplified solar cooker test method is proposed, for use with simple and affordable test equipment. The results of this method can be used as one of the basis elements for the selection of cooker models.

- **technical characteristics**: an assessment system concerning quality, handling and safety is proposed, as second basis element for the selection of cooker models.

- as third basis element for the selection of cooker models, an assessment system is proposed concerning the **adaptation to local conditions**, adaptation of solar cooking in general and of different types of solar cookers in particular.

- for the analysis of the viability - and eventually for the selection - of planned solar cooker projects, a tool for the systematic description of the **project structure** is proposed.

- for the quantification of impacts on fuel consumption and GHG emissions of the use of different (solar and other) cooker types, a daily monitoring system for the **use rate** of these cookers is proposed.

- a once-monthly monitoring system for different **social impacts** of solar cooker use is proposed.

- propositions are made on **evaluation** as a basis to compare the impacts of the different cooking options. In particular, the different error sources for this impact assessment are discussed. Particular attention is paid to a number of little known effects influencing the results of fuel efficiency improvements, in terms of fuel savings and the corresponding impacts on emissions. These effects (i.e. "replacement" and "rebound" effects) can strongly reduce actual fuel savings caused by energy-efficient appliances.

It is pointed out that the rebound effect has only a minor impact in the case of domestic cooking: efficiency improvements in cooking appliances should be to a large extent transformed into actual energy savings, contrary e.g. to the case of lamps, where efficiency improvements have a tendency to be absorbed by higher use instead of causing energy savings.

As a consequence, selection of energy-savings related development projects should include the criteria discussed here. While part of these criteria are widely accepted by now, the last mentioned effects have not found attention in this context before. And yet, rebound and similar effects can reduce energy savings reached by the use of energy efficient appliances - which can be avoided by selection of the right type of appliances, e.g. cookers and - within the category cookers - energy sources with low demand elasticity (biomass, solar) instead of polyvalent high demand elasticity energy sources (electricity etc.).

In doing so, care must be taken to avoid acceptance problems; many users would prefer to be linked up to a - hypothetical - grid instead of banking on decentralised energy supply modes - a wish that might never be granted. The user must be made aware that unbridled central-supply energy growth will be ancient history in the near future.

Appendix 1 : Simplified solar cooker thermal test procedure

1. Status of this Appendix

The present Appendix contains the proposal of a simplified version of the solar cooker thermal test method of the European Committee for Solar Cooking Research (ECSCR).

2. General Procedure

All cookers are tested following the same procedure.

As for tracking (orientation according to the sun's position), if not specified otherwise, all tested devices (apart from fixed cookers) are tracked, either following manufacturer's specifications or according to "solar common sense": "point" concentrators every 15 minutes, other cookers every 90 minutes. Cookers should be "pre-set", i.e. oriented to the azimuth in the future optimum position at mid-interval. Cookers that are designed for fixed installation are not tracked. In all cases, tracking frequency (plus the frequency of other necessary user intervention) must be noted.

For the thermal tests, **clear weather without or feeble wind** (sunshine with negligible cloud cover, max. 10% of the sky covered with clouds) is needed in order to yield reproducible results. The influence of wind on the thermal performance of solar cookers can be very important. Wind can cool down any hot parts of the cooker more efficiently than still air, or inject air through gaps in the pot lid, thus creating heat loss, particularly by additional evaporation. Appreciation of wind speed has to be noted ("nil", "feeble" or "strong").

Additionally, a test under windy conditions should be performed.

The most important tests, in the sense of a minimum test campaign, need four clear days.

Experience shows that even for one tested cooker, the presence of at least two testers (one for writing the protocol, the second for manipulating the cooker) is necessary. For each three to five supplementary cookers, an additional tester is required.

3. Practical Procedure

3.1 Experimental Set-Up

This method is proposed for cases where the **use of data acquisition** is **not possible.** Minimum test equipment requirements are:

- thermometers, precision 1°C, or thermocouples with a handheld meter (for ambient temperature and liquid temperatures of the liquid to be loaded into the cooker)
- a graduated recipient or measuring jug (precision better than 10 ml per litre)
- a bucket per tested cooker pot
- a clock or watch with minute graduation
- a protractor for measuring the elevation of the sun.

The parameters should be noted manually every 10 minutes.

If use of a data acquisition is possible, refer to the ECSCR method.

3.2 Placing of Thermometers or Temperature Sensors

Thermometers or temperature sensors have to be placed carefully in order to yield correct results.

Sensor cables should not create additional heat loss.

As a rule, thermometers or sensors should be placed through the pot walls. Therefore, holes must be drilled for their correct placing. Exceptionally, thermometers can be placed through the pot lid.

Care should be taken to define and stabilise the thermometer or sensor position. Holes can be made above the liquid level and sealed by silicone glue.

The thermometers or sensors must be placed and stabilised well within the liquid.

3.3 Loading of the Cookers

In order to load all tested cookers at the same time, with water or oil of identical temperature, it is practical to follow the following procedure:

- – with **water**, have a (e.g. solar) water heater of sufficient capacity nearby; fill water for all cookers into a barrel or barrels near the tested cookers; mix to obtain 40°C; fill the water for each cooker or each pot into a bucket using a graduated vessel; place bucket next to the corresponding cooker; at filling time, open cooker (for boxes), empty bucket into pot, close cooker immediately.

- – with **oil**, preheat bottles in a water bath or by exposition to the sun, then, follow the same procedure as with water.

3.4. Basic Test Requirements

Environmental parameter requirements are:

- Ambient temperature between 25 and 35°C

- Clear sun

- No wind or feeble wind, except for special wind test.

Cookers for use in tropical countries are tested at a maximum solar elevation of more than 70° ("high elevation"); for other cookers, lesser elevations can be accepted; in all cases, maximum elevation has to be noted.

These requirements are not to be understood as absolute. For tests where they are not precisely met, this has to be clearly indicated.

3.5 Heat-Up Time: Water - Hot Start

The cooker with pot(s) is preheated for 2 hours, starting 9:00 (all times are given as solar times, i.e. 12:00 is solar noon), point concentrators are not pre-heated - pots can be damaged. The water is filled in at 11:00, at an initial temperature of around 40°C. The initial temperature is noted. Load is half of the nominal volume of the pot(s) delivered or recommended by the manufacturer.

First result is the time taken to heat up the water to 80°C. If the cooker does not reach 80°C, the maximum temperature and the time it takes to reach it, is the result.

Second result is the time taken to heat up the water to boiling temperature minus 3°C, depending on the altitude of the test site (the reason for not using the boiling temperature itself is that the determination of the exact time when the water reaches boiling temperature is difficult, particularly when heat-up is slow, when the water in the pot is stratified and, last not least, when temperature sensors have an error margin in the order of 1°, such as in the case of thermocouples). If the cooker does not reach this temperature, the maximum temperature and the time it takes to reach it is the result. The test is interrupted at 13:00.

3.6. Heat-Up Time: Water - Cold Start

The cooker (including components like storage etc.) is initially cold. Therefore, **the cooker has to be carefully protected against pre-heating by the sun.** It is loaded with water of 40°C to half of the nominal volume of the pot(s) delivered or recommended by the manufacturer. **After taking off the sun protection**, the cooker is exposed to the sun at 11:00.

First result is the time taken to heat up the water to 80°C. If the cooker does not reach 80°C, the maximum temperature and the time it takes to reach it, is the result.

Second result is the time taken to heat up the water to boiling temperature minus 3°C. If the cooker does not reach this temperature, the maximum temperature and the time it takes to reach it, is the result. In this case; the test is interrupted at 13:00.

3.7 Maximum Cooking Temperature

Maximum cooking temperature is understood as maximum temperature that a cooker can reach in practical use under favourable, but realistic conditions.

The cooker is loaded with oil to half of its nominal pot volume.

The cooker is exposed to the sun at 11:00. Initial oil temperature is 40°C. The initial temperature is noted.

Should the oil temperature reach 200°C, the test is stopped and the time since test start is taken as the result. Otherwise, the oil temperature at 13:00 is the result.

3.8 Continuous Cooking Test

Water is filled in at an initial temperature of 40°C. The initial temperature is noted. Load is half of the nominal pot volume.

The water is brought to boiling temperature minus 3°C. After this, the pots are emptied completely and the procedure is repeated. The test is stopped when the cooker does not reach boiling temperature minus 3°C any more.

Result is how many litres of water can be brought to boiling temperature minus 3°C during the day, as well as the temperature of the last charge (when 97°C were not reached), and the time this last charge reached maximum temperature.

3.9 Wind test

For testing the cookers under windy conditions (medium to strong wind), the repetition of the „cold start“ heat-up of water is required.

4. Presentation of Results

Results are presented in the Tool 1 form sheet.

Appendix 2 : Adapted solar cooker questionnaire system

Questionnaire for Solar Cooker Users			
Date:		Name of Interviewer:	
		Region:	rural ( ) urban ( )

Respondent's name and address (Post code, phone, if possible):		
Person who answers is	female ( )	male ( )
Number of people in household:	..........adults	..........children
Type of solar cooker in use:		
Which type of meals do you prepare in your solar cooker?		
Do you use your solar cooker for anything else (e.g. iron, heating of water, baking) ?	yes ( )	no ( )
If yes, specify:		
Do you collect or buy fuel for cooking (specify type of fuel)?		collect ( )
	buy ( )	both ( )
If you buy fuel: how much money do you think you save on fuel by using your solar cooker?		
.........per day	or	.........per week
or ....per month		don't know ( )
If you collect fuel (e.g. wood, dung): how much time do you think you save by using your solar cooker?		
.........hours per day	or	.........hours per week
or ....hours per month		don't know ( )

Please indicate what you like, dislikes and problems that you relate to the cooking fuels that you are using:

WOOD What do you like about it?	What don't you like, which problems do you have?
COAL What do you like about it?	What don't you like, which problems do you have?

GAS						
What do you like about it?			What don't you like, which problems do you have?			
KEROSENE						
What do you like about it?			What don't you like, which problems do you have?			
ELECTRICITY						
What do you like about it?			What don't you like, which problems do you have?			
SOLAR COOKER						
What do you like about it?			What don't you like, which problems do you have?			
OTHER FUELS, specify						
What do you like about it?			What don't you like, which problems do you have?			
How much did you pay for your solar cooker?						
Did you pay						in cash ( )
			in monthly installments ( )			over ( ) months
			other type of financing (please specify):			
Who in your family took the decision to buy a solar cooker?						wife ( )
			husband ( )			both together ( )
			somebody else ( )			don't know ( )
Where did you get your solar cooker from?						
Did the use of the solar cooker provoke any change in your daily life (e.g. having more time or more						
money, less contact with other persons, curious neighbours coming, less heat in the house, less						
indoor pollution, more time for involvment in family or community, etc.)?						
			yes ( )			no ( )
If yes, please specify type of change:						

If yes, do you consider that this change is positive or negative? Please, specify why:
Only relevant if cooker in use was not assembled when bought:
Who assembled your solar cooker?
If user assembled the cooker himself:
Did you have any problems with assembling your solar cooker? yes ( ) no ( ) If yes, please specify:
Did your solar cooker need repair? yes ( ) no ( )
If yes, where did you get your solar cooker repaired?
Was the repair successfull? yes ( ) no ( ) If not, why?
How did you first hear about solar cookers? press ( ) TV ( ) shop ( ) by word of mouth ( ) solar cooker demonstration ( ) other, specify:
Comments:

Questionnaire for Control Group						
Date:		Name of interviewer:				
		Region:		rural ( )		urban ( )
Respondent's name and address (post code, phone, if possible):						
Person who answers is				female ( )		male ( )
Number of people in the household:				..........adults		..........children
Who is the breadwinner in the household?						
Who makes decisions about buying items such as stoves?						wife ( )
husband ( )						both together ( )
somebody else ( )						don't know ( )
Which cooking appliances do you currently use?						open fire ( )
wood stove ( )			coal stove ( )			gas stove ( )
kerosene cooker ( )						electric stove ( )
other, specify:						
What do you like concerning these cooking appliances, what don't you like?						
Do you cook outdoors in winter ( )				in summer ( )		both ( )
Do you cook indoors ( )					Do you cook indoors and outdoors ( )	
Do you collect fuel for cooking (e.g. wood, dung etc)?				yes ( )		no ( )
Do you buy fuel for cooking (e.g. wood, gas, etc)?				yes ( )		no ( )
Do you collect and buy fuel for cooking ?				yes ( )		no ( )
Are you aware of solar cookers? (It is a way to cook which does not need any fuel, only sunshine, but						
you still need another type of fuel, e.g. for cooking during the rain season)						
				yes ( )		no ( )
If yes, where did you get the information?						
Would you be interested to use a solar cooker?						very ( )
						medium ( )
						low ( )
						don't know ( )
Do you know where you can buy a solar cooker?						
Comments:						