

3. **FRAMEWORK FOR TECHNOLOGY DESCRIPTION**

3.1 *Types of solar cookers*

Solar cookers utilise the simple principles of reflection, concentration, glazing, absorption and the greenhouse effect to produce heat. Various types of solar cookers exist, harnessing one or more of these principles. The types are:

- Solar box cookers or solar ovens
- Parabolic reflector cookers
- Indirect types of solar cookers

Each cooker type will be described under the following headings”

- ✍ Physical description
- ✍ Target market
- ✍ Cost range
- ✍ Life time
- ✍ Unique characteristics

Solar box cookers or solar ovens

Physical Description

A solar box cooker is an insulated container with a multiple or single glass (or other transparent material) cover. This kind of cooker depends on the “greenhouse effect” in which the transparent glazing permits passage of shorter wavelength solar radiation, but is opaque to most of the longer wavelength radiation coming from relatively low temperature heated objects. Mirrors may be used to reflect additional solar radiation into the cooking chamber (Alward, 1982:28). A double-walled insulated box can also serve to hold the heat inside the cooker. Some types of solar box cookers have been used as “do-it yourself” kits, assembled by households following simple instructions or bought in a complete assembled form as found in India (Ministry of Energy, 1983:4). This paper, however does not recommend the home construction route but rather a commercial manufacturing process to ensure high standards of quality.

Disadvantages of solar box cookers include a slow cooking process due to low temperatures. Advantages include simplicity of construction and operation with minimal attendance required during the cooking process. The cookers are also more stable, can keep food warm for a long time, produce no glare and present no risk of fires and burns (ECSCR,1995:4) The speed of cooking depends on the cooker design and thermal efficiency.

A solar oven is somewhat similar to a hot-box cooker in that it is an insulated container with a multiple or single glass cover. Oven cooking chambers are generally smaller than hot box interiors and the glazed cover is also considerably smaller. The major difference is in the mechanism for directing solar radiation to the cooking area.

Solar ovens use several mirrors to reflect additional radiation into the cooking cavity. Due to increased radiation penetration and decreased cooker area for heat losses, very high temperatures can be achieved (Alward, 1982:50). The ovens generally have to be moved periodically throughout the day and therefore, require more attention than solar box cookers. They require more sophisticated materials and are more expensive than solar box cookers.

Target market

The target market for solar box ovens is households, typically consisting of between 2-8 persons.

Cost range

Solar box ovens can cost anything between \$0 and \$150 depending on the type and quality of material used.

Life time

The life span of solar box cookers depends on the type and quality of material used. Home-made cookers, utilizing recycled material will obviously not last as long as cookers made of more expensive materials and manufactured in a workshop utilizing proper tools.

Unique characteristics

Solar box cookers are ideally suited to preparing dishes, which require a long, slow cooking time. They are normally used flat on the ground but if preferred, can be placed on a table or a chair to make it easier to use.

Parabolic reflector cookers/ovens

Physical description

Spherical parabolic cookers are direct concentrating cookers with a dish-type reflector directing most of the intercepted solar radiation to a point of focus. The cooking vessel is supported at this focus point, thus creating a heating situation very similar to traditional open fire cooking (Alward, 1982:79). The concentrators can vary in form from shallow to deep dish shapes and they can have a continuous reflecting surface or be made out of concentric rings, which are supported to focus the radiation. Dish-type concentrators require direct sunlight to function and must be frequently orientated towards the sun (Mullick, *et al.*,1991:139). Advantages include high cooking temperatures, virtually any type of food can be cooked and short heat-up times are possible. Disadvantages are their size, cost, the risk of fires and burns and the inconvenience to adjust the cooker. Most direct-focusing cookers are also unstable at wind speeds exceeding 10km/h (Khalifa *et al.*, 1983:141) and are sometimes considered inconvenient to use because the glare can be uncomfortable to the cook (Lush & Campbell, 1985:5; ECSCR,1994:4).

Target market

Parabolic solar cookers are suitable for households and small institutions and can typically cook for 6-20 people.

Cost range

Parabolic solar cookers are generally more expensive than box cookers because more expensive materials are used. A cost estimate would be between \$20 - \$300.

Life time

Parabolic solar cookers have a long life span, since materials such as aluminium, steel and stainless steel are usually used.

Unique characteristics

Parabolic solar cookers require accurate tracking and orientation for optimum performance.

Indirect solar cookers

Physical description

In indirect solar cookers the pot is physically displaced from the collector and a heat transferring medium is required to convey the heat to the cooking pot. The solar Garg steam cooker and the Brace steam cooker are of this type (Khalifa *et al*, 1984:819). Steam is produced by flat-plate collectors or concentrators and piped to a chamber containing the cooking pot. The cookers however, seldom reach temperatures above 100°C and a problem exists with internal condensation on the top glazing collector.

A second example of an indirect solar cooker is the German Schwarzer cooker. The heat transfer medium is oil (peanut or sunflower) and the cooker is designed with 2 non-removable pots and a heat-regulating gauge in the larger model. The oil is circulating in the solar collectors and around the pots to provide the heat required for cooking. Schwarzer cookers can be incorporated in to the construction of the kitchen so that the solar collectors are outside and the pots inside the kitchen. (See photograph below) Advantages of the cooker are fast cooking times, large pot volumes, and the possibility to regulate cooking temperature. Disadvantages are the size of the cooker, which makes it difficult to manoeuvre, high cost, non-removable pots, which makes cleaning and dishing food difficult.

Target market

The target market is mostly small to medium institutions but also affluent households.

Cost range

Generally, indirect cookers are more expensive due to more expensive materials being used as well as increased component requirements. A cost estimate would be between \$250 - \$500.

Life time

Indirect cookers have a long lifetime expectation due to expensive materials used.

Unique characteristics

The solar cooker can be incorporated into the kitchen design, which would enable the cooking process to take place inside the kitchen.



3.2 Technical attributes of solar cookers

A technology framework for describing the various attributes of solar cookers would need to incorporate technical as well as socio-economic aspects. The framework for technical evaluation of solar cookers was developed by the European Committee for Solar Cooker Research (ESCR) for use in their technical evaluation of solar cookers in 1994, Almeria Spain. The evaluation criteria as well as an example of one of the cookers evaluated is provided below:

Cooker Name	REM 5
Type	Conductive box
Prototype price ca. DM	
Dimension of cooking pot (cm)	88 x 101.5 x 96
Pot(s) and capacity of pot(s)	1 removable pot (5 liter)
Test pot content	2.5 liter
Aperture surface	0.36m ²
Heat-up (water)	
-cold start (40°– 80°C)	48 minutes
-cold start (40°– 96°C)	66 minutes
-hot start (40°– 80°C)	22 minutes
-hot start (40°– 96°C)	42 minutes
Max temperature (oil)	147°C after 130 minutes
Continuous cooking	Boils 12.5 liter of water in a day
Minimum tracking frequency	105 minutes (96°C) / 165 minutes (80° C)
Unattended cooking/maximum temperature	130 minute / 96°C
Heat –up low elevation	Reaches 90°C
Heat loss without sun	90 minutes oil 96°C, 35 minutes water 80°C
Heat loss open lid	Cools from boiling too 80°C in 5 minutes
Comments	Excellent thermal performance for a box cooker, average pot content for aperture surface, requires tracking only rarely
Handling	One-step pot access, tracking easy, easy to operate, cooker easy to transport, user instructions included
Safety	No safety problems identified
Application	Cooker for families
Reasons for selection for field test	Conductive, high performance box, will tell if consumers prefer over classical boxes

The framework was expanded (Biermann, 1997) to include the following aspects:

- User friendliness
 - Positive Aspects
 - Weak Points
- Durability problems
- Proposed Improvements
 - Urgent Improvements
 - Longer Term Improvements

An example of a cooker classification utilizing an expanded framework is provided in table, below. The classification included the ECSR classification explained in table, above. The description will use the same box cooker (REM 5) as example. Additional criteria included were:

1. **Technical Description:** Box cooker with a conductive absorber, three external reflectors and single glazing. Comes with a 5 liter pot and a baking form which can be used simultaneously. Visual pot content control. Folds down to a suitcase size unit, which can be carried with the help of a shoulder strap.
2. **Materials and Specification:** 3mm aluminium absorber, epoxy absorber surface, glass wool insulation. Exterior case and reflector support polycarbonate “flute board”. Glazing 4mm tempered low-iron glass. Reflector material 0.3 mm anodised aluminium. Reflectors mounted on steel hinges and maintained, in part, by aluminium profiles. Assembly techniques: silicone glue, rivets, screws, mostly protected by aluminium L-profiles. Rubber fasteners hold together the absorber part and exterior case. Pots: aluminium (external surface epoxy) and black enamelled steel. Galvanised steel handles, adjustable nylon strap.
3. **Safety problems:** No safety problems were identified
4. **User Friendliness:**
 - 4.1 Positive Aspects
 - REM 5 is easy to carry and to store in the closed “suitcase” position.
 - The glazing allows visual control of the pot content, which avoids unnecessary opening of the cooker and the corresponding heat loss.
 - The heat-up is relatively fast
 - The cooker can be used with several pots or baking forms simultaneously
 - REM 5 is being used also for other heating purposes (e.g. heating up of a flat iron for ironing).
 - Tracking (adjusting the cooker to the sun’s position) is simple (no elevation tracking) and is required only rarely.
 - 4.2 Weak Points
 - The cooker is low on the ground which forces the user to bend down for opening and closing the cooker, stirring and tasting the food;
 - The low position together with the absence of a separate lid for the 5 liter pot (the cooker glazing serves as a lid) can cause dust entry on opening in windy conditions

- The opening mechanism is somewhat unwieldy which is also related to the low position of the cooker
- Dirt, water and insects can enter into the polycarbonate “fluteboard” channels of the cooker case and the external reflectors which is detrimental to the cookers’ aesthetics.

3.3 *Durability problems*

Durability of cookers used in the field test was evaluated during an “Ex-post purchase evaluation study” (Palmer Development Consulting and Synopsis, 2000). In all 21, of the 44 cookers identified required repairs. All but one cooker could be repaired on site – none of the cookers was beyond repair. The report concluded that “the useful life of the cookers are in (intensive) use”.