Chapter Twelve
Solar Cooking, Food Drying, and Water Purification

Solar Cookers

There are a variety of solar cooker designs in use around the world. Most models are based on simple design principles and can be built using common materials by most anyone. Construction plans for common models are available from a number of organizations, either for free or at a low cost. Commercially-manufactured solar cookers can also be purchased from a variety of sources (see the Resources list at end of this chapter).

There are basically three types of solar cookers- parabolic, box, and multi-reflector. Parabolic reflector ovens focus solar energy on the cooking area, producing higher temperatures than the other types of cookers. The intense heat produced enables food to be fried, which is not possible with the other types of cookers. The disadvantage of these cookers is that they must be frequently repositioned to keep them focused on the sun. They are also susceptible to being blown over in the wind, since they are somewhat top-heavy.

Simple solar box cookers utilize well-insulated boxes, often made from cardboard and covered with a piece of glass. Cooking pots are placed inside the box, which can reach temperatures above 200°F on sunny days. Solar box cookers often have a single reflector, used to focus additional sunlight into the box. These cookers have been successfully used in many situations around the world, and have been one of the most popular solar cooker designs for many years. Their simplicity is one of their greatest virtues, as they can be built by almost anyone at a very low-cost. Box cookers need to be repositioned about once an hour, which makes them more convenient to use than parabolic cookers.

Figure 12.1: The Casa Juliana solar cooker, designed by David Omick, reaches temperatures above 400°F, *Andy McDonald*

Multi-reflector cookers come in two varieties, those that use an insulated box and those that use a plastic baking bag. Multi-reflector box cookers achieve temperatures between 300°F and 400°F, depending upon the model, location, and sky conditions. They typically use a well-insulated box covered with glass, similar to the simple box cooker, but the box top is often angled to face the sun. This allows for greater collection of solar energy. These cookers do not need to be re-positioned as often as box cookers, but depending on the time of day and the type of food being cooked, it's still a good idea to reposition them every 60 to 90 minutes. The higher temperatures they

Figure 12.2: Joe Radabaugh's Heaven's Flame multi-reflector solar box cooker, *Solar Cookers International*

Figure 12.3: Parabolic solar cooker *Solar Cookers International*

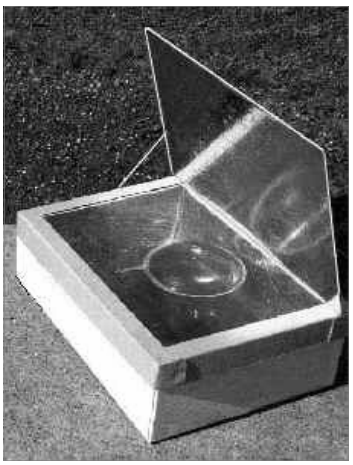

Figure 12.4: Classic solar box cooker, *Solar Cookers Int'l*

Figure 12.5: Solar oven saleswoman, Maina Manunure, in Zimbabwe
Solar Cookers International

Figure 12.6: The Villager, a large oven for institutional cooking
Solar Cookers International

Figure 12.7:
The Bernard reflective box cooker
Solar Cookers International

Figure 12.8:
The SOS Solar Sport Cooker is sold commercially in the US and abroad, *Solar Oven Society*

achieve enable them to cook a wide range of foods, including beans, rice, meats, bread, baked goods, and vegetables.

The reflectors on solar ovens can be made with simple materials such as cardboard, plywood or sheet metal laminated with a reflective material like aluminum foil. Mirrors, polished aluminum, or mylar can also be used to increase the cooker's solar heat gain. The added expense of using these more reflective materials must be weighed against the fact that simple aluminum foil reflectors work very well. Multi-reflector solar cookers typically have four reflectors (one on each side of a rectangular opening), although some models use eight reflectors.

Solar box cookers can be insulated with a wide variety of materials, including cardboard, newspaper, and straw. The outer box can be made from cardboard or other more durable materials, such as plywood, sheet metal, or moulded fiberglass. The cost of a solar cooker depends primarily on the materials with which it is made. The simplest cookers can be made at home at a very low cost, while sophisticated

Figure 12.9: A multi-reflector cooker on Taquile Island, Peru.
Joshua Bills

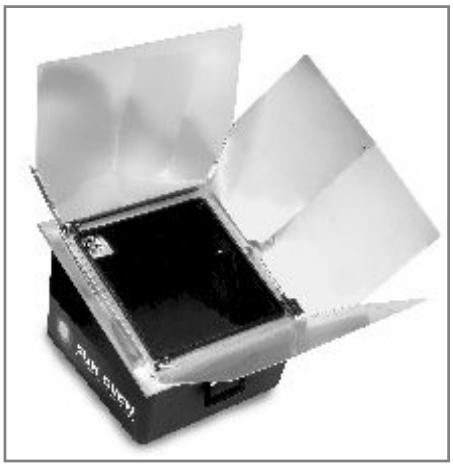

Figure 12.10: The Sun Oven, a commercially-available solar oven
Sun Ovens International, Inc.

Figure 12.11: A basket cooker at the Centre for Rural Technology in Nepal.
Solar Cookers International

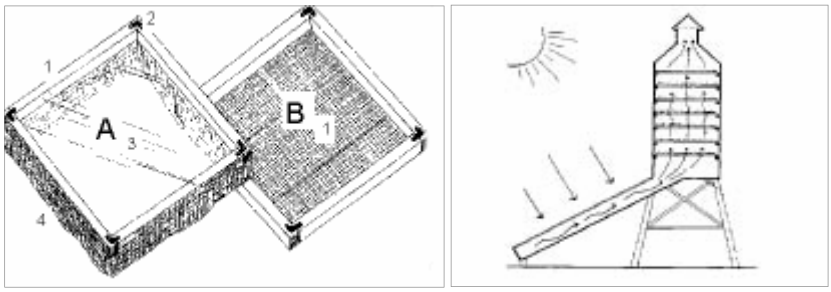

Figure 12.12: On left, Leaf for Life's simple solar food dryer. On right, a solar collector provides warm air to a stack of drying trays.
David Kennedy

manufactured models cost over $200. Both types perform very well, but the more durable and manufactured models will last longer and will be more resistant to weathering (which can make using the cookers more convenient).

The other type of multi-reflector cooker, promoted by Solar Cookers International and known as the Cookit, does not use a box at all- it uses a plastic baking bag set inside of a small reflector dish. The reflector dish is typically made of cardboard panels laminated with aluminum foil, and a black pot is placed inside the baking bag. This cooker is one of the simplest, least expensive, and most-portable varieties, yet still achieves temperatures in the mid 200's °F.

Solar cookers offer a number of advantages apart from the fact that they require no fuel or electricity. They are actually a labor saving device. Foods like rice and beans can be placed in the cooker early in the day and removed in the evening ready to eat. This can greatly reduce time spent preparing dinner, freeing one to do other things while dinner is cooking. By cooking outdoors, the solar cooker also keeps the kitchen cooler on hot summer days.

The Solar Oven Society (Figure 12.8) and Sun Ovens International (Figure 12.10) are two organizations that manufacture solar ovens for sale in the US and around the world. Both organizations are focused on halting deforestation and improving the lives of people in developing nations who rely on wood as a cooking fuel.

Solar cookers can also be used to pasteurize water. The Water Pasteurization Indicator (WAPI), available from Solar Cookers International, enables water to be reliably pasteurized in solar cookers, providing a free source of safe drinking water (see section on Solar Water Pasteurization later in this chapter).

Solar Food Drying

Solar food dryers can be used to dry vegetables and fruits at the home and commercial scale. Simple solar dryers can be easily built by most people using common materials such as lumber, wire mesh, insect screen, and plastic sheeting or glass. Leaf for Life, a non-profit organization that promotes improved nutrition through eating vegetables, offers plans for a simple solar leaf dryer (see Figure 12.12, drawing on left). This dryer consists of an upper panel glazed with plastic sheeting and a lower panel covered with wire mesh. The lower panel supports the drying greens and allows for ventilation, while the upper panel collects the sun's energy. A band of insect screen wraps around the edge of the two panels, preventing insects from entering the dryer.[1]

Leaf for Life offers plans for an improved solar food dryer (see Figure 12.13) which can dry a greater variety of fruits and vegetables. This model dries foods more quickly and works well on cooler and cloudier days.[2]

A different solar food dryer model (Figure 12.18) sandwiches the drying racks between two sheets of black metal and a sheet of glazing. The sheet of metal below the drying racks has raised ridges running from the bottom to the top of the dryer, enabling air to flow through the racks. The glazing rests on top of the upper metal panel, concentrating the sun's energy. The dryer must be located in an unshaded location and tilted at an angle, which will allow the heated air to rise through the dryer and out the top. Screened openings prevent insects and animals from entering the dryer and disturbing the drying food.[3] Each of the above-mentioned solar food dryers are used regularly in Kentucky to dry a variety of vegetables.

Another solar food dryer design uses a drying box attached to the top end of a solar collector. Multiple trays of food can be placed in the box, which has a chimney to facilitate proper air flow. Leaf for Life reports that the stack of trays in this design reduces airflow in the dryer, which often results in uneven drying and moldy food.[4]

Figure 12.13: Leaf for Life's improved solar food dryer
David Kennedy

Figure 12.14: Rainmaker solar water distiller
SolAqua, Inc.

Solar Water Purification

Many people lack access to safe drinking water or do not trust the quality of their water supply. In the United States, various water treatment systems are available, and many people now purchase bottled water, at relatively high prices. Many common water treatment systems, however, rely upon outside energy inputs, chemical disinfectants, and/or pressurized water to achieve purification. Two methods of purifying water using solar energy are available, and they operate without the use of electricity, fuel, or chemicals and do not require water under pressure. These methods are solar water distillation and pasteurization.

Solar Water Distillation

A solar water distiller (or solar still) purifies contaminated water through evaporation, separating the water from contaminants such as bacteria, micro-organisms, algae, salts, sediments, and other particulates. "Solar stills are highly effective in bringing water to the proper temperature. Water doesn't have to be boiled to be distilled. Simply elevating the temperature to a point near the boiling level will adequately increase the evaporation rate."[5] Solar stills are used by individual families, neighborhoods, and entire villages to provide safe drinking water in places such as West Texas, Mexico, the Bahamas, and Saudi Arabia.

"A solar still…is essentially an insulated, dark-colored container or shallow pan, covered by a sheet of clear glass or plastic that is tilted slightly to let the fresh water that condenses on it trickle down into a collection trough. The still is filled with six to twelve inches of water, and the water is evaporated by solar thermal energy, which condenses the water vapor onto the glazing material. The glazing also serves to hold the heat inside the unit. Several companies in the U.S. make simple solar distillers that can provide about two gallons of distilled water per day in sunny weather."[6]

Solar distillation is not effective for removing volatile chemical contaminants from water, such as gasoline, which has a lower boiling point than water. If you suspect that your water may be contaminated with such chemicals, have your water tested to determine the best purification method.

Solar Water Pasteurization

Pasteurization kills disease-causing organisms that may be present in water by exposing them to high temperatures over a given period of time. The higher the temperature used, the less time required to achieve pasteurization. Organisms such as giardia, protozoan cysts, cryptosporidium, bacteria (such as *V. cholerae, E. coli, Shigella, Salmonella typhi*), rotoviruses, and the hepatitis A virus are all killed rapidly at 149°F (65°C). While pasteurization is commonly used to ensure the safety of commercially-produced milk and juices, it can also be used to disinfect water for drinking and cooking.

Solar pasteurization can be achieved without the use of fuels or electricity. Pasteurizers do not require filters, chemicals, or other components that must be replaced on an ongoing basis. These characteristics make this a valuable treatment option in remote locations without access to other power sources. Solar cookers and the commercially-made SWS solar pasteurizer each work effectively at treating biologically-contaminated water. According to a report from the National Renewable Energy Laboratories cited on the SWS website, "the effectiveness of the SWS pasteurizer is superior to chlorine, slow sand filtration, ceramic filters, roughing filters, and UV radiation."[7] A simple, inexpensive device known as a water pasteurization indicator (WAPI) can be used to determine when water has reached pasteurization temperatures. WAPI's can be purchased from Solar Cookers International (see Resources list at the end of

Figure 12.15: Solar water pasteurizer
Safe Water Systems

this chapter).

Pasteurization does not remove salts, minerals, heavy metals, chlorine, pesticides, or other chemicals that may be present in water. It is strictly used for disinfecting biologically-contaminated water. Before selecting a water treatment system, it is important to know which contaminants may be present in the water, to ensure the final quality of the treated water.

Figure 12.16: Mark Schimmoeller and Jennifer Lindbergh's passive solar cabin, with solar cooker on the left, *Andy McDonald*

Solar Cooking is a Mainstay in a Franklin County Home

Mark Schimmoeller and Jennifer Lindbergh live on a hilly, partially forested homestead in the northern part of Franklin County, Kentucky. They and their family have been using solar cookers on a regular basis for over ten yeas. Mark built the solar cooker that he and Jennifer use, based on a design he helped develop during a work project in Peru. This multi-reflector solar box cooker is insulated with cardboard and newspaper, has a glass lid, and a door in the rear panel. Four reflectors made from plywood and aluminum foil concentrate the sun's energy inside the box, cooking the food.

The solar cooker is a mainstay in Mark and Jennifer's home from March through October. On nearly every day that's at least partly sunny, a main portion or their whole dinner is cooked outside with the sun's energy. Some of the foods they most commonly cook in the solar cooker are beans, rice, potatoes, and other vegetables. Mark is a writer and works from home, which makes it convenient for him to put food in the cooker at mid-morning and to reposition the cooker a couple of times during the day. They find that the solar cooker is a time-saver, because they can do other things while their main dishes are cooking outside. When the evening comes, they bring in the pots from the solar cooker and maybe add a few final touches to their meal. This helps them to get dinner prepared more quickly.

Mark's mother, sister, and some friends also use solar cookers on a regular basis. The dishes they prepare include casseroles, omelets, lasagna, pasta, tomato sauce, breads, cakes, cookies, granola, soups, pizza, and fruit canning. Mark's family-members are mostly vegetarian so they do not cook meat dishes, but the solar cooker does cook meat without any trouble. During his work in Peru, meat was commonly cooked in the solar cookers he built with Peruvian families.

A Solar Home, both Simple and Sophisticated

In January 2001 Mark and Jennifer moved into their 288 square foot post-and-beam cabin, which they had been building for the previous 18 months. Their cabin is off the grid and has no utility connections- neither water nor gas nor phone. The cabin was sited and designed to make optimum use of the sun's energy. Two 75-watt solar panels were installed on the roof before they moved into the house. The long south face of the house has windows carefully located to provide passive solar heating during the cold months, while the overhang was designed to prevent unwanted solar heat gain during the warm season. Open space in the yard around the cabin hosts the solar cooker and a solar water heater, both of which are used on a regular basis from March through October.

Since moving into their cedar cabin, Mark and Jennifer have built an addition onto the south and east portions of the house. The addition has doubled the area of the house (not counting a new root cellar beneath the addition). To accommodate additional electrical needs in the addition, another 75-watt PV panel was added to the roof, along with a new battery bank. The addition has enhanced the original passive solar design, by including thermal mass in the form of a Solar Slab, a concrete slab designed to circulate solar-heated air around the cabin.

The couple installed a third solar electric system to service a small (10'x16') guest cabin on their land. This 100-watt array provides electric lighting, can run small appliances like a radio or laptop computer, and operates a telephone answering machine (the guest cabin also serves as a phone booth).

The initial 150-watt solar array installed on the cabin powers a small, super-efficient DC refrigerator and two compact fluorescent lights, which can each be used for about 4 hours per day. They also have a stereo CD player which they occasionally use. (They have a radio with a built-in solar panel and battery which works very effectively). The cabin is wired for 12-Volt DC power and they have a battery back-up. The 75-watt PV panel installed on the addition was designed to power additional lighting, an attic fan, house fan, and a very efficient washing machine. The attic fan has its own small PV panel that runs it whenever the sun is shining. A switch enables the fan to be powered at night from the batteries.

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Jennifer and Mark have been very happy with the performance of their solar electric system. It has never run low on power, even in the dead of winter and the refrigerator, while small, meets their needs. "Honestly, I've been surprised at how well the solar system works," commented Jennifer. "Before we moved into the house I had thought that relying on solar energy would require some kind of sacrifice- and I was ok with that. But the reality has been that we have all the electricity we need, there's very little maintenance required (although I must confess, Mark does the maintenance), and the system just works really well."

The PV system at the guest cabin has also functioned well. The one problem they had was finding an answering machine that would operate on 12V DC at the proper amperage. They use a cigarette lighter adapter to plug the answering machine directly into the 12V power supply.

The solar water heater is a variation on the solar cooker, utilizing a large insulated box covered with glass but lacking reflectors. Since Mark and Jennifer do not have running water, they heat their water in a large pot inside the water heater, then carry the pot into the house for washing and bathing. (In the winter time they just keep the pot on the wood stove.) Mark's family also uses a solar food dryer, which he built for drying vegetables and herbs.

Figure 12.17: PV panels power the Schimmoeller-Lindbergh residence, *Andy McDonald*

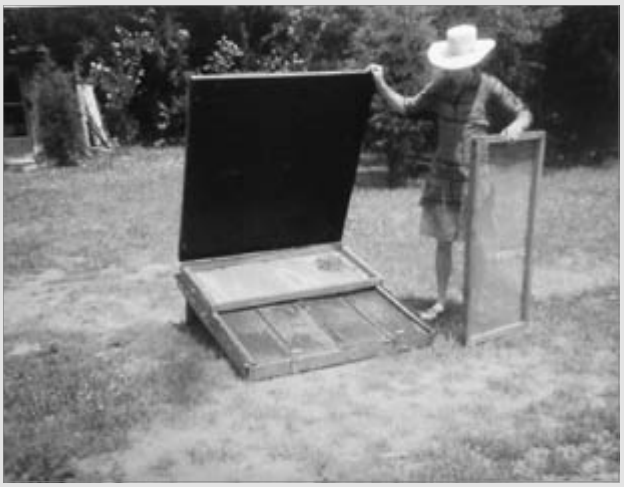

Figure 12.18: Mark Schimmoeller with his solar food dryer, *Chris Schimmoeller*

End Notes

1. Leaf for Life, CD-ROM, November 2002. Leaf for Life's publications are available at: www.leafforlife.org. They can be contacted at 260 Radford Hollow Rd., Big Hill, KY 40405, Tel: 859-986-5418.
2. David Kennedy, "Five a Day the Sun Dried Way," Leaf for Life, Big Hill, Kentucky, September 2002. Available at www.leafforlife.org
3. Dryer design courtesy of Larisa Walk, Rt. 3, Box 163A, Winona, MN 55987
4. David Kennedy, p.2.
5. Scott Sklar and Kenneth Sheinkopf, *Consumer Guide to Solar Energy*, Bonus Books, Inc., Chicago, 1995, pp.88-89. Contact information for SolAqua, manufacturers of the solar water distiller shown in Figure 12.14, can be found in the Resources list at the end of this chapter.
6. Ibid, p.90.
7. Information available at: www.safewatersystems.com/General%20Pages/Frames%20Page.htm. Contact information for Safe Water Systems, manufacturers of the water pasteurizer shown in Figure 12.15, can be found in the Resources list at the end of this Chapter.

RESOURCES: Solar Cooking

Publications

"A Solar Cooker," Mark Schimmoeller and Andy McDonald, self-published, Frankfort, Kentucky, 1996.

Cooking with Sunshine: The Lazy Cook's Guide to Solar Cuisine, L. Anderson, Our House Publishing, 1994.

Cooking With the Sun: How to Build and Use Solar Cookers, B. Halacy & D. Halacy, Morning Sun Press, 1992.

Heaven's Flame: A Guide to Solar Cookers, J. M Radabaugh & B. Root, Home Power Publishing, Oregon, 1998.

Solar Cooking: A Primer/Cookbook, Harriett Kofalk, Book Publishing Company, Tennessee, 1995.

Solar Cooking Made Easy, D. Stutzman, The Sunshine Cooks, 1980.

Solar Cooker Manual, Ron Alward, Brace Research Institute, MacDonald College of McGill University, Ste. Anne de Bellevue, Quebec. No date.

Organizations

Solar Cookers International
1919 21st Street #101
Sacramento, CA 95814
(916) 455-4499
www.solarcookers.org

Solar Cookers International (SCI) has headquarters in Sacramento, California, USA and an office in Nairobi, Kenya. Since its founding in 1987 SCI has spread solar cooking skills and technologies where they are needed most. Over 30,000 families have benefited directly from SCI's field projects and countless others have used SCI's resources to learn how to make and use solar cookers and teach others to do the same. Their website offers numerous publications for sale and other resources.

Solar Oven Society
3225 Hennepin Avenue East
Suite 200, Minneapolis, MN 55413
(612)623-4700
www.solaroven.org

The Solar Oven Society (SOS), manufacturer and distributor of the SOS Sport Solar Oven, works in the United States and developing countries to provide solar cooking technology, demonstrations, training, assembly, service, wholesale & retail sales, and to introduce other solar technologies.

Sun Ovens International, Inc.
39W835 Midan Drive
Elburn, IL 60119 USA
(630) 208-7273 or (800) 408-7919
www.sunoven.com

SUN OVENS International, Inc. is striving to develop and implement comprehensive solar cooking programs that will radically decrease the developing world's dependence on fuel wood and dung as the primary cooking fuels while benefiting the environment, raising the standard of living and improving the health of the poor worldwide. Manufacturers and distributors of the Sun Oven solar cooker.

RESOURCES: Solar Food Drying

Publications

A Survey of Solar Agricultural Dryers, Brace Research Institute, Technical Report T99, MF 07-283, 1975.

"Build PM's Solar Food Dryer," J. Hoffman, *Popular Mechanics*, (51:1) pp. 100-101, 128, January 1979.

"The Design, Construction, and Use of an Indirect, Through-Pass, Solar Food Dryer," D. Scanlin, *Home Power*, (No. 57) pp. 62-72, February/March 1997.

"Dry Your Own Fruits and Vegetables: The Dryer That Is Powered by the Sun, Stove, or Electricity," *Mother Earth News*, (No. 136), February/March 1993.

"Five a Day the Sun Dried Way," David Kennedy, Leaf for Life, Big Hill, Kentucky, September 2002.

How to Dry Food, D. DeLong, H.P. Books, 1992.

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Solar Convection Grain Dryer, Volunteers in Technical Assistance (VITA).

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Solar Food Dryers: Their Role in Post-Harvest Processing, B. Brenndorfer et al (Ed.), Commonwealth Science Council, 1987.

(continued on next page)

Solar Food Dryer: Preserves Food for Year-Round Use Using Solar Energy, R. Wolf, Rodale Press, Emmaus, PA, 1981.

Organizations

Leaf for Life
260 Radford Hollow Rd.
Big Hill, KY 40405
(859)986-5418
www.leafforlife.org

Leaf for Life helps people improve their health by showing them ways to make better use of vegetables, especially leaf crops, in their diets. Much of their work revolves around two techniques for converting leaf crops into more versatile and valuable foods: solar drying of leaf crops and making leaf concentrate. Their web site provides publications explaining how to build and use a solar leaf dryer.

Solar Cookers International

See Solar Cooking Resources for more information.

RESOURCES:
Solar Water Purification

Safe Water Systems
2800 Woodlawn Drive, Suite 265
Honolulu, HI 96822
(808)539-3937
www.safewatersystems.com

Manufacturers of the Sol Saver and Family Sol Saver solar water pasteurizers.

SolAqua, Inc.
P.O. Box 4976
El Paso, Texas 79914-4976
(866)765-2782 or (915) 822-1132
www.solaqua.com

SolAqua provides solar water distillation products, do-it-yourself distiller kits, plans, and consulting. They manufacture and sell the Rainmaker™ 550 solar water distiller.

Solar Cookers International

See solar cooking resources for more information.