

# BREADBOX SOLAR WATER HEATERS

## ASPI Technical Series

### INTRODUCTION

Traditional water heating consumes approximately one-tenth of the average domestic fuel bill and normally the fuel is from scarce non-renewable resources. Western and developed nations use enormous amounts of heated water. Likewise, people in developing countries are now demanding the convenience of domestic water heating sources, and this is placing a still greater strain on World energy supplies. A proven method for furnishing over half of the world's hot water needs is by using the sun -- solar hot water heating. It is a proven technology and it need not be costly, so hot water is actually within the reach of most of the world's people with a minimum investment of money.

One example at the ASPI demonstration center is the TVA Solar Breadbox Water Heater. This device supplies hot water for the ASPI office from a fifty-gallon storage tank mounted in the solar heating system. It is a recycled water tank painted black and placed in a tightly insulated plywood box, with a transparent glass front side facing south to catch the sun's rays. The optional addition of a reflective surfaced lid and all inner parts of shiny surface increases the efficiency of the box.

### THE ASPI SOLAR WATER HEATER



Though other designed solar heating devices are quite complex, this heater has no pumps or extra gadgets except a pressure release (or pop-off) valve. Cold water replaces the evacuating heated water through a gravity-fed water storage system, and enters the solar heater installed on the hillside behind the ASPI office building. While not all our water needs are met in cloudy or cold time, this low-priced device furnishes between half to two-thirds of the annual domestic hot water needs for about five office people and two residents at a temperature which averages over 100 degrees Fahrenheit.

#### Choose:

A site which is accessible to those who wish to inspect the unit close at hand;

A design that will be visibly pleasing and in harmony with your building;

A size adequate for your water needs;

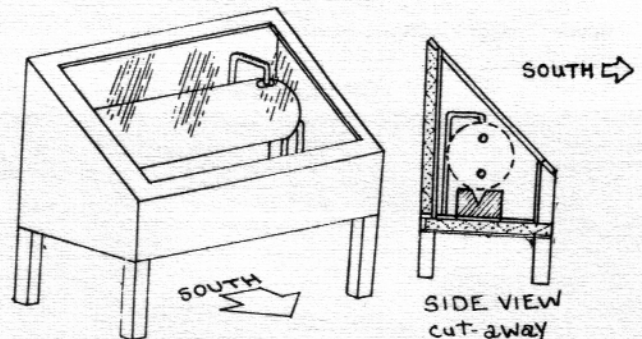
A back-up system that is also energy efficient and of low environmental impact.

### HOW DO LOW-COST SYSTEMS WORK?

Heating water by the sun is a challenge and comes free once equipment is in place. All forms of passive and active systems have been invented and installed, ranging from sophisticated active systems in wealthier homes to simple solar shower bags which handle the campers bathing needs. The range of complexity can be confusing for the beginner, but need not discourage those who could benefit from solar water heating.

The Breadbox System is straight-forward. Water is collected in a storage container that is also the solar absorbing water tank (black surface collector). This collector is insulated to preserve the heated water for use. The container is sealed and inlet and outlet pipes fitted to prevent water leakage. Because the hot water system is not functional on each day of the year, due to weather conditions, some sort of back-up system is required. ASPI uses solar water bags and wood fueled water heating systems as backup

### BASIC TVA BREADBOX DESIGN



## ADVANTAGES

Solar water heating systems can provide hot water at exceptionally low cost. The listing of advantages may hasten the installation of these very versatile devices. Good points include the following:

### ECONOMICAL:

As previously stated, the fuel is free for the taking. When the solar water heating device is low-priced and utilizes some recycled materials, the pay-back can be made in a single year. And when this heating method is coupled with hot water conservation measures the time for pay-back will be reduced even more.

### DO - IT - YOURSELF:

Solar water heating devices come in a great variety of designs, some requiring the design and advice of engineering experts, and others can be successfully built using ordinary building skills. The Bread-Box Solar Water Heater is simple to build and can be made in about two days using standard building and plumbing materials.

### VISIBILITY:

Solar water heaters stand out for others to see and appreciate. Photos of the 1906 San Francisco Earthquake showed solar water heaters on the rooftops of the various houses. We need visible conservation examples to be reminders of things we can do with materials and devices which have been proven after years of service.

### EASY TO MAINTAIN:

The system has few parts that can malfunction. It may have to be drained in very cold weather, but other than this little maintenance is required. Being small and compact it is accessible. Any leakage can be soon discovered and repaired.

### RECYCLABLE MATERIALS:

With ingenuity almost the entire device can be built with commonly found recyclable materials - insulation, box, tank, etc.

### MOVEABLE:

The system is relatively light weight and can be moved to new or better locations easily.

## MATERIALS

**Insulation:** Normal insulating fiber glass is the most popular material, but other insulating materials (straw, sawdust, hair, polystyrene foam, polyurethane, even newspaper) can also be used. The trick is with any insulating material is to keep it as dry as possible.

**Storage:** The tank can be of any size and really determines the size of the insulated bread box heater. Multiple tanks connected in series can also be used. One should not have more space in the box than necessary. Generally, used water tanks which do not leak can be obtained. The insulating jacket is removed and the metal tank is painted flat black using a good grade metal paint.

**Collector:** The insulated box may be but need not be a plywood of ample thickness so that it does not warp. This must be properly sealed, painted and any cracks must be caulked. Other building materials will suffice, but one is limited by those which allow a relatively moisture-free barrier.

One-half or three-quarter inch polybutelene piping can be used. Mixing materials for the pipes (i.e. using copper and plastic) can lead to cracks and breaks in the system and special care must be taken to seal all joints well.

## PREPARATIONS BEFORE CONSTRUCTION

A number of decisions should be made before beginning construction of the solar water heater:

- \* Site selection -- take a compass and determine the best location. Especially suitable is a south-by-southwest siting which is free from obstacles, such as buildings, evergreen trees, etc. (Slightly southeast directions are sometimes found to be adequate.) Build for the best solar gain and still at the shortest distance from point of heating to that of use, so that heat loss through pipes will be minimized. When building a new dwelling, the heater can be integrated into the roof/attic for better performance and aesthetics.
- \* Determine the box size based on water demand for the occupants of the building. Ball park estimates may be quite erroneous depending on the habits of the users. Keep tab for an appropriate length of time to determine hot water consumption. Strict conservation measures (efficient low-flow shower heads, heaters in the lines rather than storage tanks, conservative showering practices, etc.) should be used in conjunction with the solar heater.
- \* Obtain as many recycled materials as possible for building the system.
- \* Interest others to come, assist and learn during the actual construction period, preferably through a hands-on workshop.

## TOP-SIDE VIEW



## NOTE:

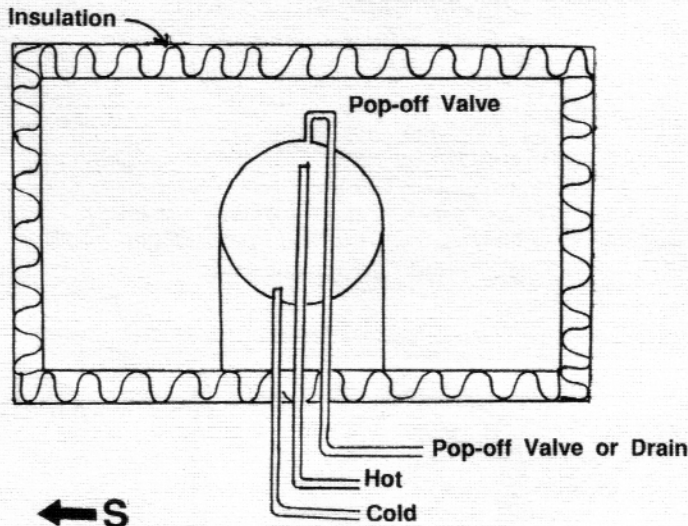
The support system (roof, rafters, frame, etc.) should be strong enough to hold the weight of the solar system **plus** the weight of filled tanks of water. Remember that 100 gallons of water plus the system will weigh at least a half of a ton.



## CONSTRUCTION

Several building steps are required:

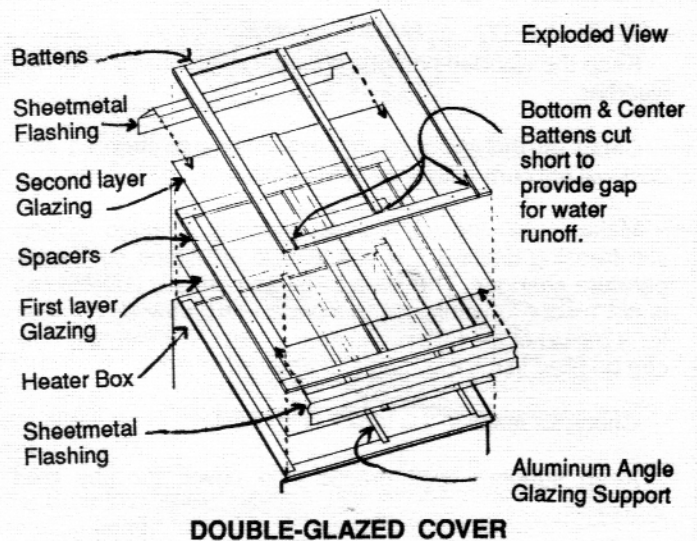
- Assemble all materials. If a specific day is designated for construction, knowing exactly what to do and what tools to have is quite important.
- Cut the container or "box" so that the tank(s) fit easily within it. This means cutting the four sides and the bottom so they all fit tightly together.
- Paint the tank(s) black with a metal based paint.
- Insulate the assembled box with 6-inch fiberglass insulation batts and cover with aluminum sheeting. We used recycled aluminum printing plates from the local newspaper office. Tack these into place and make firm with nails. Now mount the tank into the container and hold in place with metal strapping.
- Build a tight fitting insulated lid in areas where there are sub-freezing nights and hot water demand during this cold period. The lid should be made so it can reflect solar radiation when open. Side reflectors may also be added to intensify the solar radiation effects.
- Install the tank with fittings for water inlet and outflow and a pressure release valve and drainage outlet.



CUT-AWAY VIEW OF PIPE FITTINGS

### NOTE:

The solar heater can be integrated into a roof and/or attic of a new construction. ASPI removed the solar heater from the cordwood building roof fearing the heavy weight might weaken the structure. In its present location it can be maintained without constantly stepping on the fragile roof. If access can be reached without stepping on the roof proper (perhaps by a walkway) then use the space. We also found that carpenter ants congregated in the roof beneath the solar heater.



g) Construct a framed, preferably double-glazed cover for fitting on the front or south-facing side of the box. Bolt into place, flash and caulk to make this moisture proof. Make all edges smooth by inserting the proper trim so there is no standing water.

h) Construct legs and a stand on which the collection system will be placed and mount the box facing in the proper direction, tilted at 30° off the horizon. The box can either be made in a slanted shape or the entire equal sided box can be tilted in the direction of the sun by adjusting the leg size of the stand (the ASPI option).

i) Caulk and paint the entire wooden portion of the device.

j.) See that all fittings are in place and turn on the water.

### NOTE: Calculate Tank Size

Much depends on the amount of hot water needed. A 50-gallon tank is adequate for a family of four who practice water conservation. The shower length and volume is critical. With this in mind install water conserving showerheads and institute a practice of "army" style showers (wet down, soap up without water running, and rinse off). The solar water heater with limited tank size is not recommended for those desiring 15-minute or longer therapy showers. However, with clean safe water in short supply in many areas of the globe it would be beneficial for all of us to pay close attention to how carefully we use this precious resource.

### COSTS

3/4 inch or 5/8 inch plywood (3 sheets)	\$24
caulking (good grade)	12
glass sheeting	60
four by four stands poles	12
base of one by material	20
tank (if recycled possibly free)	50
insulation & flashing	14
nails and paint	10
pipes and fittings	15
flat black paint for tank	10

## MAINTENANCE

Keep the wooden portions adequately protected from the weather.

Clean off the glass cover occasionally so that dirt and dust will not curb efficiency of the device.

Make sure the device is properly drained during sub-freezing times if it is not able to withstand such temperature changes. The Bread Box as normally constructed is not meant to withstand temperatures below 25 degrees for a period of time. On cold, sunny days in winter the tank can be filled in the morning and emptied at night.

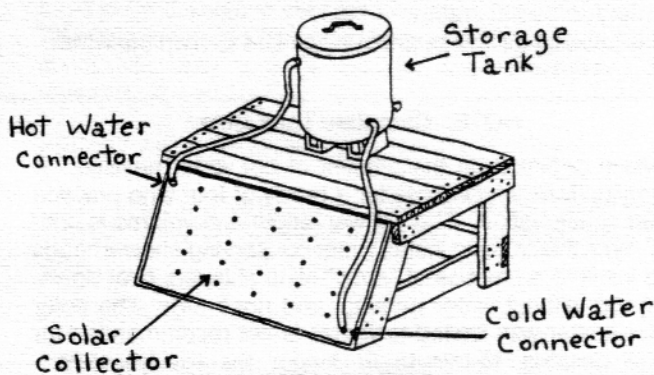
Check for leaks in the tank.

Keep supports well braced and check for any load problems.

Caulk around glass frame and all joints at the start of the solar season. Also, make sure pipes are well sealed and secure.

## OTHER DESIGNS

**VITA:** Volunteers in Technical Assistance describes a solar water heater that is essentially a portable container and black metal plate absorber to which water hoses have been connected. It is also low-priced and found useful in Third World nations. The absorbing collector is an envelope made of metal sheets and a storage tank. The collector has a slanted backing made of brick. Water is circulated through the thermosyphon principle. The sheeting however may be more difficult to bend and weld to the proper design



VITA DESIGN

**NCAT:** The National Center for Appropriate Technology has essentially the same style of Breadbox system as TVA except the box itself is slanted instead of the support system. Insulation, blackened tanks and piping follow the same principles as stated above. Write to NCAT, P.O. Box 3838, Butte, Montana 59701.

## PUBLICITY

Those who install solar heating units are the converted. Most people are not. So it is imperative that satisfied users make that fact known. Demonstration of higher priced system can be counter productive and so we urge Breadbox Heater builders to make the fact known:

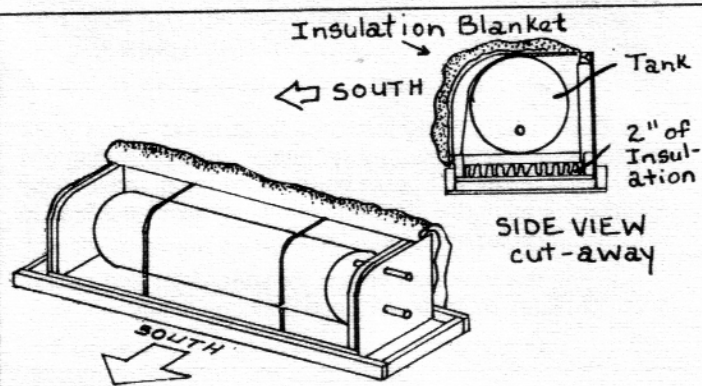
During Earth Day events

As projects for high school and grade school science fairs

To civic and church groups interested in saving the Earth Through media contacts and in articles and letters to the Editor

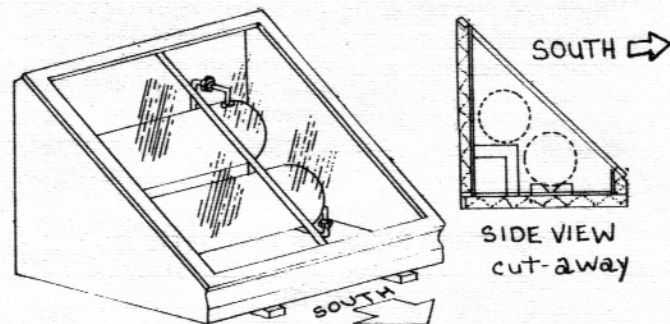
Among friends and relatives

And many other ways.



SANTA BARBARA DESIGN

**CAA Santa Barbara:** This California-based Community Action Agency has a Breadbox heating system with a container that has a top and front side composed of bent Kal-wall. There is less interior space than the TVA variety and less interior insulation and thus there is a trade off with no studies showing which is better for energy efficiency. This system is better suited for warmer climates where sub-freezing temperatures are usually rare.



NCAT DESIGN

## REFERENCES

"Breadbox Solar Hot Water Systems", 1981, National Center for Appropriate Technology, P.O. Box 3838, Butte, Montana 59702.

"Solar Hot Water and Your Home", National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, Maryland 20850.

"Solar Hot Water Heater", Volunteers in Technical Assistance, 3706 Rhode Island Avenue, Mt. Ranier, Maryland 20822.

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