

A Three Tank Integral Passive Solar Water Heater (IPSWH)
Designed by David Bainbridge

The three tank heater shown in these plans can be built and installed in about 40 hours for about \$500 worth of new materials. A careful search for salvaged tanks and other materials can reduce the price to less than \$100.

The heater plans are drawn for a ground installation, the easiest and most practical location for this type of heater. This water heater can also be installed on a flat roof or special heater deck without changing the plans. However, make sure the roof will support 1,400 pounds. This can usually be done by spreading the load across several of the roof trusses or beams, locating the heater over interior walls, or adding new support columns.

Modifying the heater box will allow you to mount this heater on a sloping roof. Make sure the roof can support the load; most roofs cannot without added bracing. You can also flush mount the assembly by setting the tanks in the attic. For further details consult the Integral Passive Solar Water Heater Book by David Bainbridge, \$11.50 from Passive Solar Institute, P.O. Box 722, Davis, CA 95617.

Step 1: Heater location

The first step in building the three tank heater is determining a good location for the heater. The best spot is usually on the south side of the house on the ground near the existing water heater.

Some solar prospecting may be necessary to find a good site. This can be done with Solar Site Selector. Appendix 1 of the IPSWH Book describes how to build your own, or where to buy one. A site facing more to the SE or SW is usually acceptable - particularly where the heater will be used primarily in the summer.

While selecting the site keep in mind the connection to the existing plumbing. Try to make the hookup as simple as possible with short pipe runs.

Step 2: Building Permit (if required)

Contact the local building inspector and determine whether a building permit is required. If so, apply for one using this plan set and a location sketch.

Step 3: Material Collection

Because the IPSWH industry is just beginning to develop, it may take a while to assemble the necessary materials. The list of suppliers included here should be of assistance. Local hardware, plumbing, and solar supply outlets may have everything - so try them first. Finding tanks has been one of the common obstacles - unless you are willing to use recycled tanks. If only gas heater tanks are available, you will have to revise the plan dimensions to fit them in.

A Note on Recycled Tanks:

New tanks are generally recommended unless cost is a major concern. Using recycled tanks can save \$250.

First, strip the heater jacket and examine the used tank before buying and dragging it home. Only about one in three is usable and the more serious defects will be obvious. Pay particular attention to the welded seams which are generally the first place to fail. Electric tanks may also leak where the element mount is tack welded on, so inspect carefully.

Take home the tanks that appear to be good and clean the outside. Then remove the fittings, using penetrating oil if necessary. If they won't come out with reasonable force

then leave them in unless you absolutely need to have them out for your plumbing hookup.

With the fittings off, tilt the tank so the sun shines in a bottom or side hole. You should be able to see the reflection from the glass lining. By rotating the tank carefully you will see most of the inside. An intact lining gives much better odds for tank longevity.

Now rinse out the tank using water, a little detergent and/or mild acid to remove rust, salts, and mineral deposits. A considerable amount may come out even with a good tank so keep at it.

When it seems clean you are ready for a pressure test. First block all except one of the holes with plugs. Attach the garden hose to a hose nipple fitted in this last hole and turn it on. If you have an air compressor (or are willing to haul the tanks to the gas station) you can build an adapter to test the tank with air. If you have a portable compressor, an air test adapter would enable you to test the tanks in the junk yard before you buy them. Run the tanks up to at least local water pressure, 70 to 140 psi.

If the tank leaks (either now or later) you may be able to successfully patch it. Epoxy patching has been used

with some success. Patch before painting or sand to the metal if it was already painted.

When there are no leaks, your tank passes the pressure test. The next step is to wirebrush the exterior. Then paint the tank with rust preventive paint such as zinc chromate or red lead primer. A new sacrificial anode will help extend the life of the system.

After all materials are assembled, you are ready to begin construction of the heater. Read the instructions first. Take your time. Enjoy yourself. Field verify all measurements before cutting. Measure twice, mark twice - and cut once.

Step 4: Foundation

The heater can be built on a variety of footings. The choice will depend on your skill, available materials, climate, and building requirements. The plans show pier block supports but a perimeter footing or slab could also be used. The heater can also be mounted on an existing slab.

If a special support is needed to raise the heater into the sun, it can be used as the frame for a small garden shed or as an air lock entry to the house.

Step 5: Support Deck

After the footings are in, cut and nail together the support frames with 16 penny cc sinbers. Cut and nail on the 3/8 inch exterior plywood with 10 penny alvin and box nails. Paint it and let it dry before turning the frame over and nailing it to the footings. Now install ten 6-inch fiberglass bats (foil side up) and nail the 3/8 inch plywood on top of the frame (10 dgb). Paint it with primer and let it dry.

Step 6: Box Frame and Tank Support

Cut and nail together the back frame and nail it on the support deck (16 ccs). Put in a temporary brace to hold it in place. Build the side frames in place. Then add the tank support members.

Step 7: Tank Deck and Box Sides

Staple 6-inch insulation between tank support members with the shiny side up. Then cut 3/4 inch plywood to fit and nail down to tank supports.

Next staple insulation to box sides and cover them by nailing on 3/8 inch plywood (or masonite, waterproof sheetrock, etc.).

Step 8: Tank Support

Put in four 2 x 2 inch tank support blocks for each tank as shown. Test with tank to make sure spacing is correct for your tank. A 2 x 4 inch stop block goes at the bottom to keep the tank from sliding down. Check the tank before nailing it in. Drill holes in 2 x 2 inch for nails to prevent splitting. Paint with primer when completed.

Step 9: Tanks and Plumbing

You are now ready to install the tanks and plumbing. Place tanks in position and check clearances. Then make connections as shown. All galvanized iron to copper connections must have a plastic di-electric break to avoid corrosion.

Dip tubes, feel in opening for plastic, go toward deck. Drains go from side outlet near base. Pressure temperature relief valve and vacuum breaker go on high opening. Strap down tanks with plumber tape screwed to tank deck after all connections are made.

Clean copper fittings before joining with emery cloth (not steel wool). Use appropriate flux and solder.

Make connection to existing system as shown. Plan to minimize disruption (don't cut the water just before lunch).

Test system for 24 hours before covering up pipes - or pressure test if required by code. Insulate pipes with Armaflex or, better yet, urethane foam with an aluminum jacket. If Armaflex is used, paint areas exposed to the sun with appropriate paint.

Step 10: Back and Top

After all tests properly, staple 6-inch foil faced insulation to the back of the heater. Then cover the inside as you did the sides.

The top rests on ledger strips which need to be nailed to the studs on the sides of the box. Build the top frame on the ground from 1 x 6 inch wood. Put in 6-inch foil faced fiberglass batts and cover with 3/8 inch plywood. Paint the plywood and then turn it over and mount in top of heater.

Step 11: Finish Box Exterior

Now you are ready to finish the box exterior. The most common finish will be 3/8 inch exterior plywood. Use "Z" flazing at horizontal joints. Use wood strips to cover corners - after caulking cracks.

Siding, shingles, or stucco can also be used to match house exterior.

Step 12: Painting

Now seal all cracks inside the box and paint with flat black. Paint the back of the tanks but put selective surface tape on the tank tops. Use three 6-inch strips per tank. Use gloves and a roller (an old paint roller will often work). Watch out for edges as it is easy to get cut.

Step 13: Glazing

The glazing system described here is fiberglass sheet on a 2 x 2 inch wood frame that is screwed and glued together. Seal the wood before assembly with white paint. Let dry for two or three days. Lay a bead of silicone on wood and then nail fiberglass with gasketed roofing nails approximately four inches apart.

The fiberglass glazing is shown because it is light, easy to work with, and hard to break. Glass is a better choice if you feel comfortable working with it, or are willing to hire a glass company to install it. Tempered glass should be used. The heater is designed to accommodate two 46 x 76 inch double paned tempered glass units. These can be purchased as seconds for considerable savings.

Lay the glazing frame in on foam weatherstripping.

Step 14: Flashing

Now the flashing goes on. The bottom piece goes on first, then the two sides, and finally the sheet metal top cap. Screw the flashing on with brass screws. Caulk the bottom strip.

Step 15: Paint

The final step is finishing the exterior of the box with paint or stain. Prime the flashing properly before painting.

A Note on Freeze Protection:

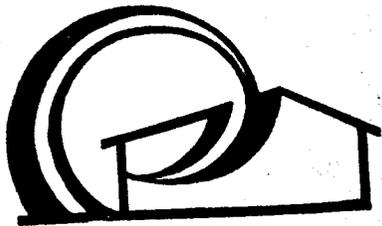
The three tank IPSWH will withstand occasional nights of 20 to 25°F without lids or additional protection. However, if temperatures stay at or below 30°F for several days it may eventually freeze. It should be drained in winter in areas where this is likely - or insulated lids should be installed and used.

The pipe runs are the most sensitive part of the system and should be very carefully insulated, preferably to R-12. Or, use heat tape in exposed spots. If the heater will be drained in the winter, make sure pipes will drain completely

by sloping the pipe runs at least 1/4 inch per foot towards the drain.

A Note on Movable Insulation:

Adding movable insulation can extend the performance of the IPSWH. Reflective insulated lids are probably the easiest option to install. A two part shutter is suggested. Use 1½ inch foil faced foam with aluminum skin and wood frame. Hinge half to top and half to bottom. Set to increase collection.



24 04
-1 1/2
22 1/2

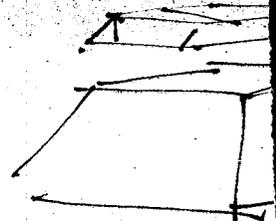
THREE TANK PASSIVE SOLAR WATER HEATER
DESIGNED AND DRAWN BY DAVID BAINBRIDGE
The Passive Solar Institute · P.O. 722 · Davis, Ca. 95616

CONSTRUCTION NOTES:

The assembly will weigh about 400 pounds empty. Build it in place or in sub-sections that will be easy to move.

STEPS

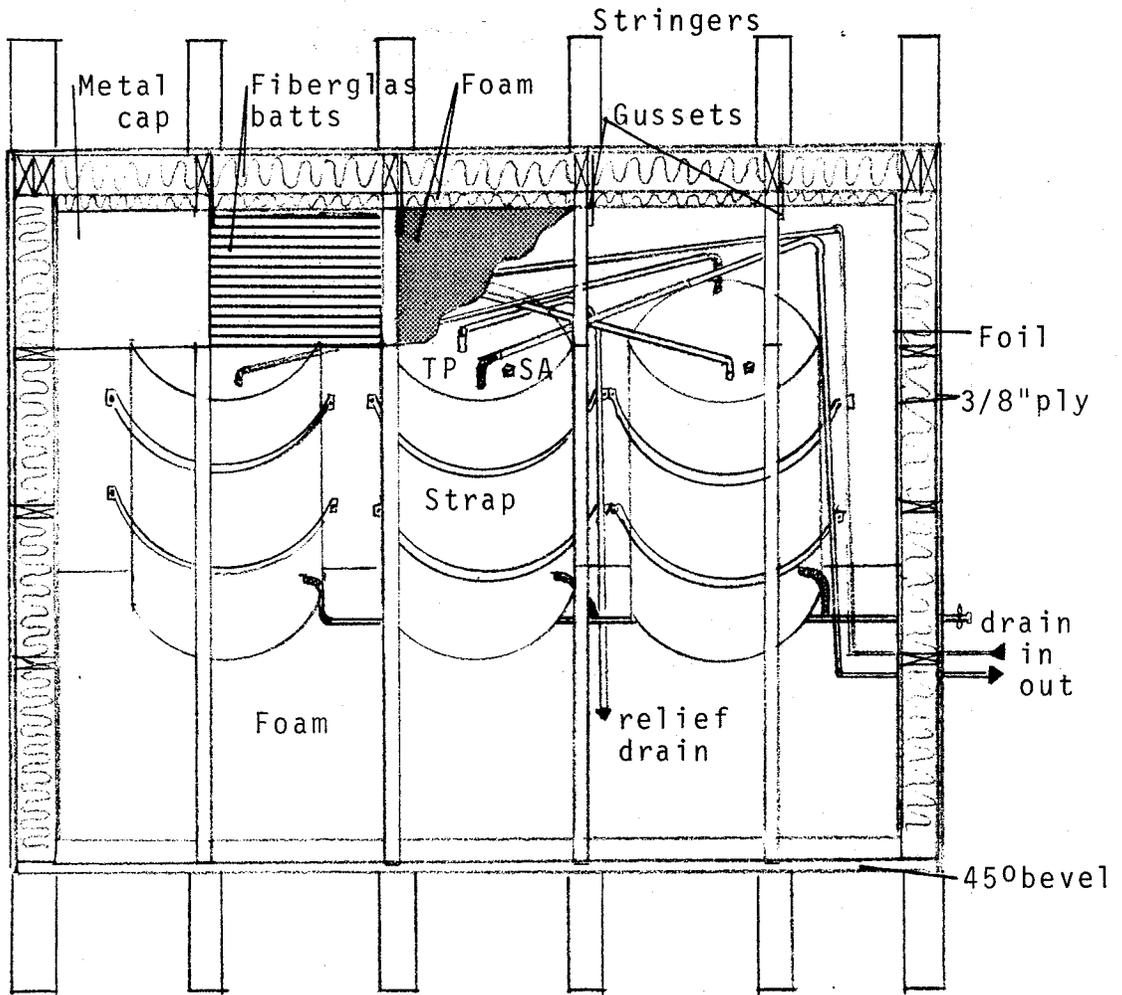
1. Put down 2"x4" redwood stringers for support. Full assembly will weigh 1400 pounds when full of water. Make sure your roof will carry it. If it can't then add a special platform or build it on the ground.
2. Assemble sides, bottom, and back using 2"x4" with 16d nails.
3. Put in tank support frame with 2"x4" using 16d nails. Then cut 3/4" plywood sheet to fit and install with 16d nails.
4. Cut out and nail in inside ends from 3/8" plywood. Glue on aluminum foil with contact cement or resin.
5. While glue dries wirebrush water tanks and paint with primer, flat black. If tanks are used pressure test before painting.
6. Insulate end walls and under tank deck with 3 1/2" foil faced fiberglass batts. Foil should face inside.
7. Put in tank support blocks. Each tank should have four support blocks 2"x2"x4", and one 2"x4"x4" stop block. Blunt nails by setting head on ground and tapping tip with hammer or drill to keep 2"x2"s from splitting.
8. Place tanks in position and check clearances. If all looks good then plumb system. All galvanized iron to copper fittings must have a di-electric break to avoid corrosion. Dip tubes (feel inside or look for plastic) go toward bottom or deck. Drains go from side outlet near base. Pressure temperature relief valve, vacuum breaker goes at highest opening. On used tanks check condition of sacrificial anode.
9. Test system for waterproof. If OK then add plumbers strap to hold tanks down. Screw to deck.
10. Install 2" foil faced foam to upper back and top on the inside. Use roofing nails or 16d nails with washers.
11. Cut and install 3 1/2" fiberglass batts behind foam.
12. Cut and install ends and back of enclosure. Screw upper back on to allow access to fittings if need be.
13. Install 2"x2" glazing support strips. Use metal L brackets to reinforce joints.
14. Paint all of the inside with flat black paint except for the foil surfaces.
15. Install glazing. Caulk and flash properly. Use brass or bronze screws.
16. Put on sheet metal top after caulking.
17. Trim corners and edges to suit. Then stain or paint to match.
18. Insulate pipe runs to heater and water supply. Foam with aluminum jacket best but armaflox with coating OK.



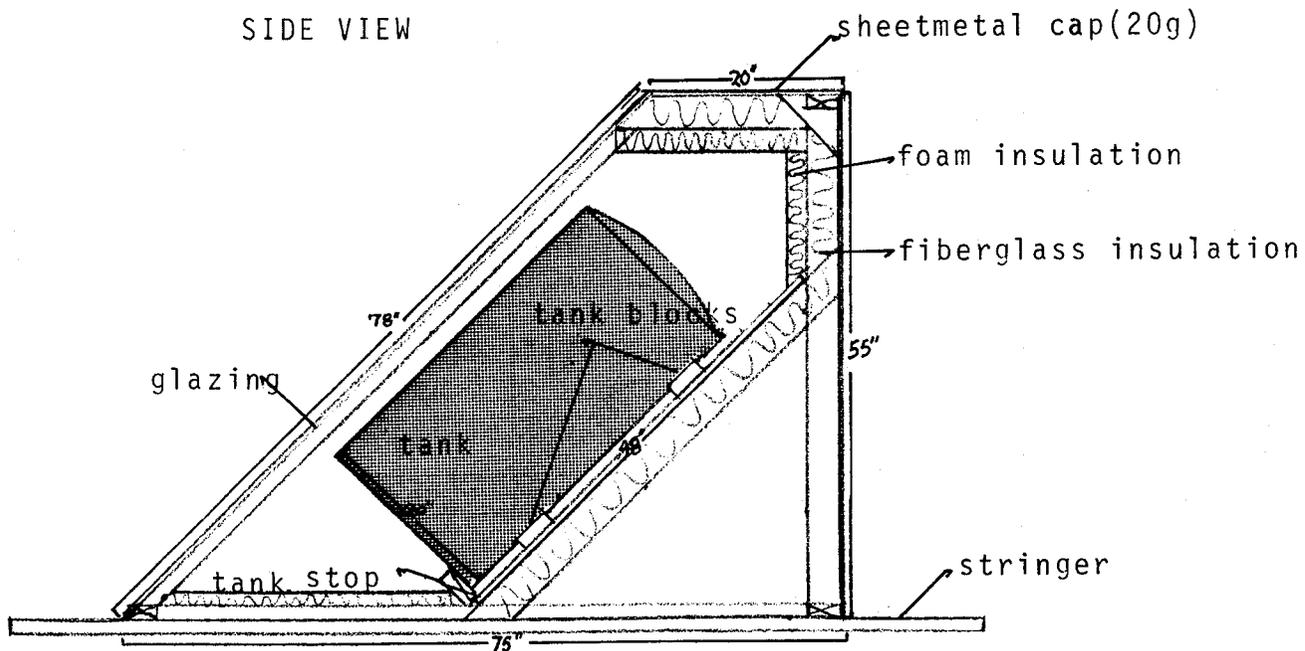
TOP VIEW

0 10 20

SCALE 20" per inch

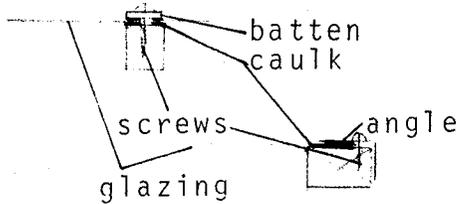


SIDE VIEW



NOTE: Field verify all measurements. Measure twice and cut once. Buy tank connections after building deck and laying out tanks. Flexible fittings make the job relatively easy. Plumbing can also be all done with gi pipe.

Glazing details: Use Kalwall Sunlite or equiv. (48" wide)



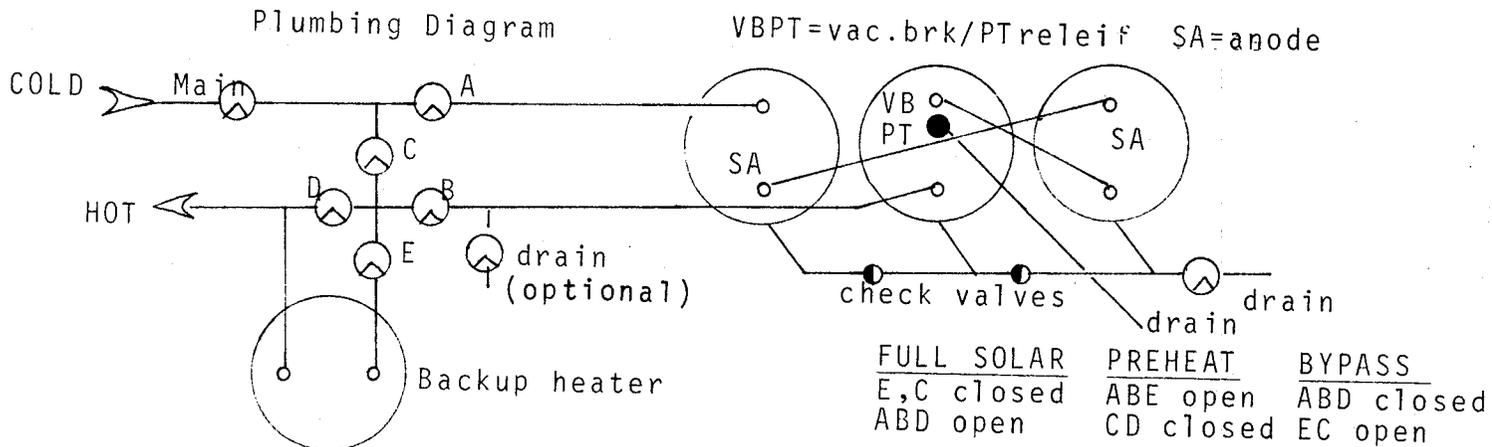
Materials: Check to fit your installation and hookup

- 48' 2"x4" redwood
- 125' 2"x4" df
- 32' 2"x2" df
- 5 4'x8' 3/8" ext. ply
- 1 3/4" ply
- 2" rigid foam, foil covered, 4'x8' sheet
- 1 roll 3/8" fiberglass paint, fl. black 1 qt
- paint, ext. 2 qts
- glazing 78"x96"
- 3 30gal tanks
- flex conn. 3/4" , misc. lengths 10
- galv. nipples, 3/4" 10
- PT relief/vac. brkr
- copper pipe, 3/4" type M to suit
- copper fittings, misc. to suit
- hose bib or freeze proof sill faucet, for drain
- pipe insulation
- caulk
- misc. screws and nails

HOOKUP:

The three tank passive solar water heater is usually connected as shown. This provides the best flexibility and operation.

The closer the heater can be installed to the existing heater the better. On the south wall near the water heater closet is ideal.



FREEZE PROTECTION:

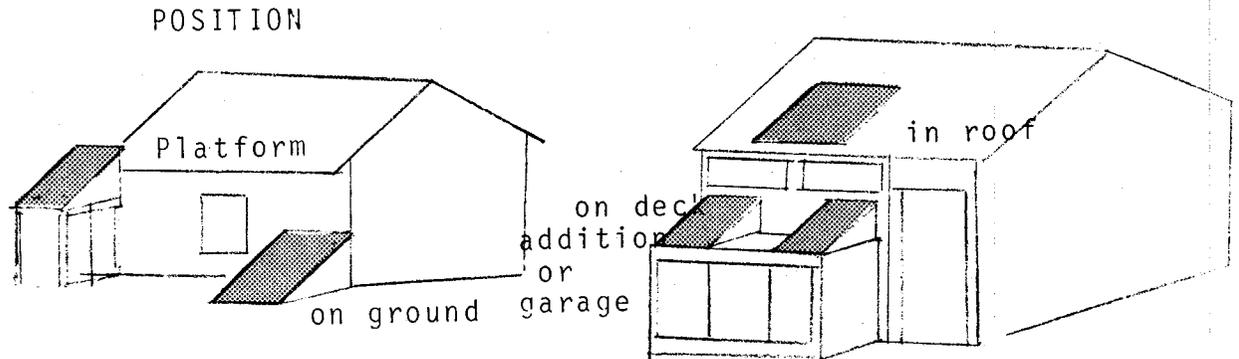
The high mass of the system makes the heater resistant to freezing. However, if the temperature will drop below 25°F or stay low it is best to drain the heater. The passive solar water heater could also be connected to a heat exchanger, double wall, and filled with anti-freeze.

BUILDING PERMIT

A permit may be required to build or install the passive solar water heater. Check before you build it. In some cases it will be treated like a normal water heater hookup and you will only be checked on the hookup to the lines.

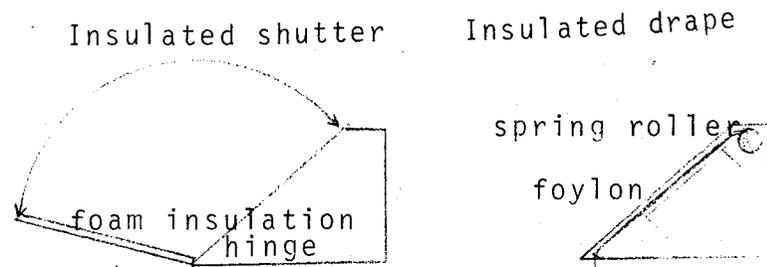
POSITION:

The passive solar water heater can be built on a flat roof or deck with the plans included here. With minor modification one can also be built in the roof or installed on a slanting roof.



USE:

A passive solar water heater provides the hottest water in the afternoon and evening. If you revise your use pattern to match the supply you can probably turn off the backup heater for several months every year. The system works best when the backup heater is off and by-passed. If you add insulated shutters or drapes you can improve the performance of the system considerably. Close them at night and open during the day.



INSULATED COVER:

Insulated shutters or drapery will retain heat at night and make the passive heater work better. If the heater is on the ground or easy to get to a fold-down, reflective, insulated shutter may be best. If the heater is hard to get to then a drape will be easiest. Either can be automated using freon transfer systems or photo-cells and motors.