INSTRUCTION MANUAL

EXPERIMENTAL ASSEMBLY AND INSTALLATION

OF A

LOW COST SOLAR WATER HEATER

ASBC

(SOSOL'S TRADEMARK FOR THE WATER HEATER)

Users Manual

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A Brazilian NGO founded in 1991 to promote
social improvements through the use of solar technology

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The SoSol team welcomes observations and helpful criticism for the improvement of this manual

Read all of this manual carefully before beginning to put together a ASBC

NOTE TO READERS WHO LIVE OUTSIDE OF BRAZIL and/or WHO ARE NOT FAMILIAR WITH BRAZIL

The ASBC solar hot water heating system has been and is being developed in Brazil, for use in Brazil. The present manual is written accordingly, and makes reference to construction methods and materials that may not be common or available in the reader's own country. But, certainly, they are available in some other form, and the interested reader is encouraged to develop modified systems based on conditions and materials readily, and inexpensively, available in his local.

To facilitate understanding of the Brazilian ASBC it is necessary to understand Brazilian building methods and bathing habits. We hope that the following paragraphs will help in this.

Brazilian building habits:

1. Nearly 100% of Brazilian buildings, be they one-room shacks or 20-storey skyscrapers, store their water in rooftop tanks and distribute to the points of use from this tank. The storage tank is fed from street mains or from wells. Almost never is the high-pressure street main water directed to the points of use, but only to the tank. There are many reasons for this, which are not important here, but the important thing is to realize that each dwelling stores its water in its own tank (traditionally made of fiber-cement but now of steel, fiberglass, or concrete).

2. Houses use PVC piping for all cold-water distribution and disposal, almost without exception. Metal piping is used only when building heights mean pressures that demand steel, iron, or copper piping. Copper and CPVC (high-temperature PVC) tubing are used only to conduct water heated to more than about 60º C. (The ASBC system generates hot water that does not exceed this limit.). Therefore, low-cost and flexible plastic piping and connectors are very common in Brazil.

3. Most hot water for bathing is heated by point-of-use electrical showerheads. These typically are fed by 220 volt circuits and heat the water with resistors of between 3,000 to 8,000 watts. While middle and upper-class dwellings may typically use small local boilers heated by electricity or gas, low-income family dwellings cannot afford this (wasteful) luxury; they use the electrical showerheads (frequently supplied by only 110 volts), and spend heavily on electricity (at least 25% of the monthly electric bill is due to use of these devices. The ASBC is intended for these families.

Brazilian bathing habits:

The typical Brazilian takes a (shower) bath at least once a day, sometimes twice. The bath is usually taken at the end of the day, between 18:00 and 20:00. This habit is directly responsible for the daily national electrical energy consumption strongly "spiking" during these hours. It also means that water heated by sunlight can/will be immediately used at day-end, a great recommendation for use of the ASBC.

Summary

1. Presentation

1.1 Purpose

This manual is part of one of the projects of the Sociedade do Sol, named Low Cost Solar Heating, or simply ASBC, in the Portuguese language. The ASBC is a project for free use by everybody. The technology, because of its simplicity, is not patentable. The project's principal objectives are: better living, preservation of the environment, energy conservation, possible generation of jobs, financial savings for the family and nation (8% to 9% of total electricity demand) and reduction of greenhouse gases –CO2. Therefore, the information contained in this manual may be used and freely passed on by anyone interested in the assembly of a ASBC system.

The main characteristics of the ASBC system are: Possibility of assembly on a do-it-yourself basis and use of low-cost materials found in most any construction materials store. This manual will help the reader to know the parts, tools and accessories needed to assemble a ASBC system with a capacity to heat 200-liters of water, and therefore attend to the hot water bathing needs of a family of 4 to 6 persons.

The Sociedade do Sol believes that in this way it will be helping this family to reduce its electricity needs in at least 30% from current levels of use, increasing self-esteem by the pleasure of producing at home a large part of the thermal energy used for bathing.

We hope that the reader will be able to put together his ASBC system with only the orientation provided by this manual. In case he encounters difficulty, SoSol is always available by phone or e-mail to answer any questions that may come up. At the same time, in case the reader is interested in better knowing this project, he is invited to participate in a course provided at the SoSol location in São Paulo, where, among other things, he will learn in hands-on detail how to put together a ASBC system.

1.2 The ASBC guarantee

It is important to emphasize that the ASBC is an experimental Project. All those who take on the responsibility of putting together their own ASBC, or to provide services to third parties, should know that it is not possible to guarantee the durability of the parts and temperature levels of the system, even considering the ongoing work of improving its technical and functional characteristics.

Included in guarantee's knowledge, the correct understanding of item 5.1 Drinking water coming from the ASBC, in an important part of this manual.

1.3 Background

The idea to accelerate development of the ASBC began after our team was invited by the government to participate in the São Paulo stand at the industrial fair of ECO-92, where the first prototype ASBC was presented to the public. At this event, two large environmental challenges were discussed: the reduction of polluting gases and the use of technology based on clean energy.

From 1992 to 1998 the team was dedicated to research to transform the prototype into a model for national application. With the opportunity to join CIETEC – Center for Incubation of Technology Companies of the University of São Paulo – in January of 1999, the development accelerated, and the first definitive model of ASBC was presented to the public at the end of 2001, a period of electricity blackouts and rationing of electrical energy.

The possibility of using or adapting the typical household shower-bath installation and the use of readily available low-cost materials was the basis for this advance. Included in these materials are:

- the point-of-use electrical shower heater,
- the water storage tank,
- extruded PVC ducted wall-boards
- Common PVC piping.

A return on investment within 4 to 8 months is permitted by a combination of low-cost materials with existing residential plumbing installations.

Today there are thousands of ASBC systems installed in various Brazilian cities, and a growing cadre of monitors providing orientation to communities of their region on how to assemble and install the solar panel systems. However, SoSol hopes to achieve, in the medium term, the goal of seeing a ASBC model on the roof of every Brazilian home.

2. The ASBC system

2.1. The principals of how the ASBC works

The ASBC has the same working principals as a traditional solar hot water system, only differing in the types of material used and the possibility of do-it-yourself construction.

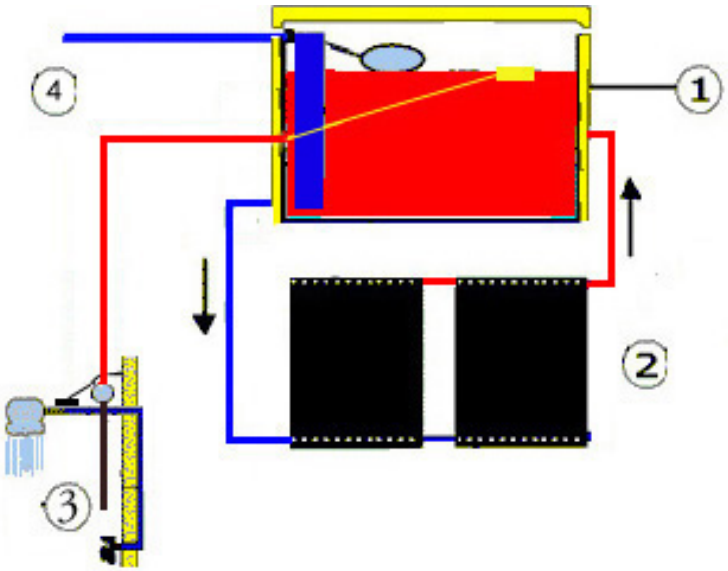
The working of a ASBC begins when radiant solar energy, light and infra-red, hits the black surface of the panels. The absorbed energy transforms into heat and increases the temperature of the water inside the panels. Heated water decreases in density and rises in the direction of the storage tank, starting a natural process of water circulation, called a thermal siphon. **For this to work, the storage tank must be higher than the panels.** This process is continual as long as there is a good solar radiation or until all the water in the system comes to the same temperature

The heated hot water is stored in an insulated tank, avoiding heat loss to the surroundings. With the ASBC, the thermal support system is provided by a point-of-use electrical shower heater controlled by a dimmer which permits fine-tuning of the temperature of the shower-bath. The piping interconnecting the panels, the storage tanks and the shower head may be done with the traditional brown cold water PVC piping normally used in residential hydraulic installations.

The working of the ASBC system is better understood if divided into four basic parts:

1- Storage tanks
2- Panels
3- Point-of-use electrical shower heater with a hot/cold mixer and a dimmer for thermal support.
4- General piping system

Figure 1. Representation of a residential ASBC.



2.1.1 Storage tank

Stores the water heated in the solar panels during the daylight hours. There are two floats inside which control the entrance and exit of water. There is also a piece used to direct the cold water, coming into the system from the street, to the bottom of the tank, reducing the water's velocity and avoiding turbulence and the mixing of hot and cold water. Besides the traditional float valve that controls water coming into the tank from the street, there is another float, called a 'fisher'. It picks up water with the highest temperature (normally at the top of the stored water mass) and carries it to the shower

Besides the traditional water storage tanks, other industrialized recipients, such as plastic barrels or Isopor® boxes (EPS) lined with plastic film, may serve as tanks. No matter what type of tank is used, all of them should have external thermal insulation in order to minimize heat loss to the sides and through the cover (top).

2.1.2 The panels – The principal component of a solar water heater

The solar panel heats the water. Sunlight, falling on the surface exposed to the sun, heats the water stored inside the panel and reduces this water's density, making it lighter than colder water. Thus, the water present inside the panels flows up to the (higher) storage tank, and, simultaneously, the colder, heavier water of the storage tank circulates down to the panel.

The ASBC panels are assembled with sheets of extruded and ducted PVC panels normally used as wall and ceiling coverings or panels. In a short time there will be available similar technology based on polypropylene ducted panels, which can withstand higher temperatures than PVC. The ASBC panels are different from others in that they do not use a box frame with a glass covering, used by traditional systems to obtain higher temperatures through a 'greenhouse' effect. The obligatory lack of a glass covering means the water does not get too hot for the integrity of the PVC component parts, but still hot enough (or even too hot) for normal bathing needs. This provides other advantages such as avoiding hot water injuries to children and allowing the use of cold water PVC piping, among others.

2.1.3 Hot Water mixer and the thermal support system

The mixer controls the solar-heated hot water arriving at the shower. In case this hot water is of a lower temperature than that desired by the user, he can increase the temperature using the dimmer to gradually increase the electrical energy arriving at the point-of-use electrical heater at the shower head. In traditional systems the thermal support is usually in the thermal storage tank, and the mixer requires inbuilt hot and cold piping.

2.1.4 Hydraulic system

The piping may be made with the normal brown PVC piping because of the natural thermal limits of the ASBC solar panels. This avoids using more costly and complex copper tubing or CPVC technology.

3. Assembling the parts of the ASBC system

To put together an ASBC system it is necessary to assemble some parts. The SoSol team has attempted to describe in detail all the steps needed to put together the principal parts of the system, illustrating each step of the process with photos. Follow the assembly steps correctly to assure the quality of your product.

3.1 Panels

An ASBC system can be designed to heat different quantities of water. In this manual we will show how to put together a system sized to provide 200 liters per day of hot water. The table below shows the quantity of panels needed depending on the region where the ASBC will be installed.

Region	Number of Panels (for 200L)
South / SP capital	3
Interior São Paulo state	2
Other Regions	2

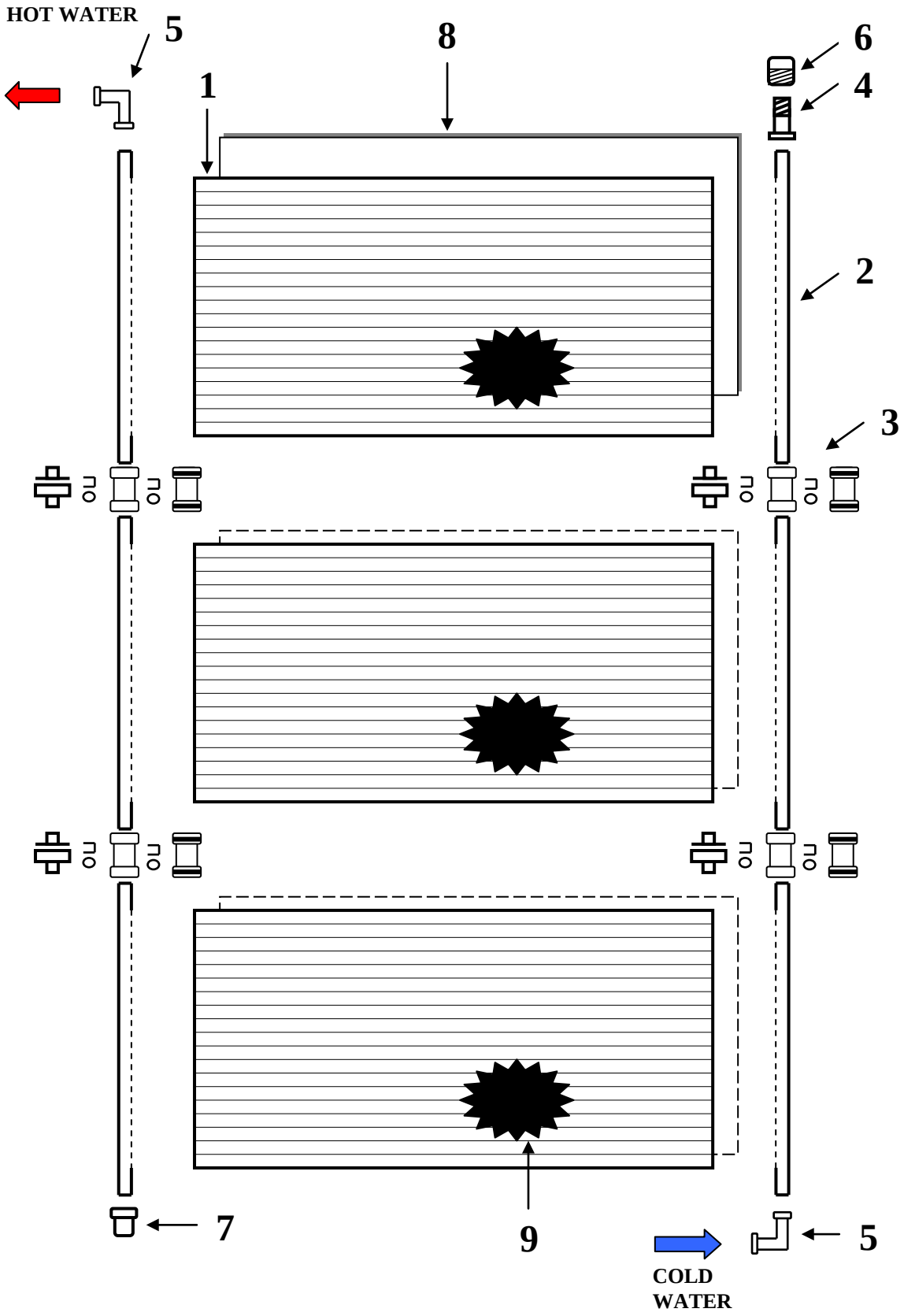
The main factors influencing the number of panels to be installed are climatic, such as pollution, humidity, Wind and temperature in each region. In some states of the Southern Region it is suggested that a sheet of Isopor® (EPS) be glued to the inferior surface of the panel, thus elevating the storage tank water temperature by about 3° to 4° C .

For systems of other sizes, maintain this same relationship: 1 panel or 1-1/2 panels for each 100 liters of water. If the temperature is too high, take away one panel; if it is not high enough, add one panel.

The following lists describe the parts, tools and accessories needed to assemble an ASBC panel. Next to each item, in the 'purpose' column, there is a number which helps to identify the parts as presented in figure 2.

Quant.	**Panel**	**Purpose**
1	Ducted PVC sheet 1.25 x 0.62 m	Part of panel (1)
2X	Brown PVC tubes 32 mm (ϕ ext.) and 700 mm length (2 per panel)	Part of panel (2)
2X	Brown PVC connectors 32 mm	To connect panels (3)
01	Brown PVC threaded adaptor 32 mm x 1"	For draining and maintenance (4)
02	Brown PVC right angle connectors 32 mm	Attach panels to PVC piping (5)
01	White PVC Cap with 1" thread	Close draining and maintenance adaptor (6)
03	Brown PVC Caps 32 mm	Seal panel points during pressure tests and permanently close the upper left point of the panel (7)
01	Isopor® sheet (EPS)	Thermal insulation and physical protection of panel (8)
Quant.	**List of tools**	**Purpose**
01	Measuring tape or folding ruler	Measure cuts on sheets and pipes
01	Soldering iron or electric drill with 3mm twist drill (for steel)	Make the guide holes on the 32mm PVC tubes (2)
01	2" brush or 5 cm roller	Paint the panels black
01	Small flexible spatula with a rounded point of the type used to mix a small coffee and sugar.	To apply the glue to the joint between the PVC panel and the PVC tube
01	Hacksaw with one end free	saw the PVC tubes lengthwise
Quant.	**List of accessories**	**Purpose**
01	Sandpaper #120	Sand and trim burrs. Sand surfaces before gluing
01	Metacrylic glue (2-part) of type Plexus 310. 30 grams per panel.	Glue PVC panel and 32mm tubes
01	Masking tape	Limits area to be painted
01	Old Newspaper	Provides support to panel middle while glue sets
01	Matt black paint (40 ml per panel)	Paint one side of the panels plus tubes
01	Flat board of 80 x 15 cm	Guide to support and hold the 32mm tube during sawing
08	4 cm nails	Secure the tubing to the flat board
01	Pencil	Draw sawing guide lines on tubing
01	70 cm ruler or other straight-edge.	Guides the pencil while drawing guide lines
01	Recent PVC piping catalog	Identify the pipe fittings

Figura 2. View of the parts used in the assembly of 3 ASBC panels

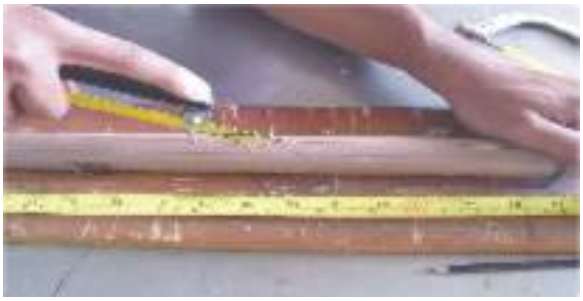


Panel Assembly Instructions

1. Put one of the 70 cm 32 mm tubes on the flat board. Use the pencil and the straight-edge to line out the area where the 61 cm x 1.1 cm cut will be made. (62 cm width of the ducted PVC panel less 1 cm = 61 cm). Centralize this cut on the tube so that the uncut ends of the tube are 4.5 cm each.

2. Make a hole or opening inside the marked area, large enough so that the free end of the hacksaw can fit in. This opening may be made with a heated soldering iron or with a hand-held drill with a 3mm twist drill point. If you use the soldering iron, be careful not to breathe smoke from the tubing plastic – it is toxic.

3. Place the hacksaw blade in the opening and start to cut. Make slow movements and follow the markings carefully to avoid making an opening that is too wide or too narrow (although, erring on the side of too wide is better). At the end-points of the opening, make a careful cross-cut to allow removal of the PVC strip.



4. Once the PVC strip has been removed, sandpaper the cut surfaces to remove burrs and sharp edges. Use a round (rat-tail) file to round out the ends of the cut and until the total length of the cut is 62 cm, which is the width of the ducted PVC panel.
Then clean all surfaces with alcohol.

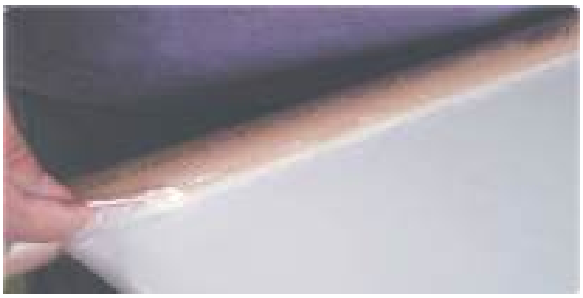
NOTE: Before going further with the assembly, repeat the sequence of steps 1 through 4 on another 70 cm length of 32 cm PVC pipe.

5. Lightly sand the ends of the ducted PVC panel.
Insert 0.5 cm of the panel in the opening of the tubes, one tube for each end.
Use a cloth soaked with alcohol to clean all the surfaces to be glued. Once cleaned, be very careful NOT to touch the surfaces to be glued.

NOTE: If you are going to join two or more panels you must assure that the tubing of the panels will match and join properly, without forcing or twisting the panel. To achieve this, use wooden slats to make a rigid jig or pattern so that, when glued, the tubing of each panel will be parallel and all panels will have tubes separated by the same distance.
This will permit attachment of one assembled panel with another.

6. Lay the panel on 11 mm of newspaper placed on a flat horizontal surface. This will maintain a correct positioning of the tubes in relation to the panel.
Prepare an adequate amount of the 2-part glue on a clean plate-like surface.
If the glue tends to "run" (Araldite glue) mix in a small amount of mineral talc powder to make it pasty.

7. Using the small spatula, place glue on the two upward-facing joints between the tubing and the panel.
After two hours, turn the assembly over and repeat the gluing procedure on the other side.
If using Araldite glue or isofitalic resin (as used in waterproof fiberglass), let the first glue dry overnight before turning the assembly over.



8. After 24 hours, and after performing the leakage test described in the next section, lightly sand one face of the panel and clean with an alcohol soaked cloth. Paint this face with the Matt black paint using a brush or roller, including the glued part and the upper side of the PVC tubing. Use masking tape on the tubes to obtain a clean appearance. Leave without paint 3 cm on the ends of each tube for attachment of pipe fittings

Leakage Test: Close 3 of the tubes with the 32mm caps and on the other put a 90° fitting with 3 meters of vertical pipe. Fill this up with water and during 15 minutes watch for leakage in the regions that were glued.
If leaks appear, reinforce the area with more glue and repeat the test.

Panel's Area and Weight: The surface area of each panel is 0.78 m2. Filled with water each completed panel weighs about 8 kilos. This information helps when determining the area needed for placement of panels and the weight that must be supported by the roof.

3.2 Thermal Storage Tanks

The thermal storage tank holds water and maintains its temperature for use in the shower. In traditional solar hot water systems these tanks have a cylindrical horizontal shape and are made of stainless steel or copper, with excellent insulation, and the water can attain temperatures of up to 85° C.

The SoSol team thinks it possible to use other materials, not just metal, for the thermal storage tank. In successful experimental tests the ASBC has used materials like: fiber-cement water boxes, thermoplastic and fiberglass boxes, as well as other types of industrial containers, which after some alterations do well as thermal storage tanks. In some cases, such as Isopor® (EPS) boxes, the container needs to be lined with a plastic film, readily available in bag form, to avoid seepage and/or contamination of the water.

Based on daily hot water needs, available space and financial resources, the end-user can choose what type of container to use in assembling his tank. Also, he can opt to install a new container just for the hot water or even use his existing cold water tank and adapt it to hold and provide both hot and cold water.

In case a new tank is installed, it is wise to choose a size and shape that is appropriate for the place where the tank is to be installed, always considering if it will be possible to transport the tank to its final place. If the choice is made to use the existing cold water tank it will be necessary to make some changes to it so that it can be used as a thermal storage tank. When the tank provides both hot and cold water we call it a virtual thermal tank.

The following is a description of the process for assembling a thermal storage tank using an asbestos cement box. In case another type of container is used the procedure is the same.

Description of the assembly of a *integral thermal storage* (only hot water)

Once the type of container is chosen you can begin the assembly process, which basically consists of opening holes in the container walls and installing PVC fittings for the flow and control of water entering and leaving.

1. With the tank empty and dry, make two 32mm holes in two opposite walls . The left-hand hole is for the exit of cold water going to the solar panels and the right-hand hole is for the return of the heated water. Install in these holes the 32mm PVC fittings with flanges and rubber sealing rings. The left hand hole (cold water out) should be placed as low as possible so that the total volume of water can be heated. The right–hand hole should be made halfway up the side of the container. (see the site > projeto ASBC > dicas técnicas > minuta de normas.)

2. Make a third hole with a 25mm diameter in a wall perpendicular to the previous two holes. The center of this hole should be at most halfway up the side wall of the container, not more. Install in this hole the 25mm fitting with flanges and a rubber sealing ring. The heated water stored in the tank will leave through this opening and go to the shower.

3. Make two more 25mm holes, one on the left side and one on the right side. Try to make these holes as high as possible in order to have as much water as possible stored in the tank. However, it is recommended that the center of these holes be no closer than 8 cm to the top rim of the tank.
In the left-hand hole install an intake float valve which will admit new cold water to the system whenever heated water is consumed. In the right-hand hole install a 25mm fitting with flange and rubber sealing ring; this is for overflow protection. Connect a pipe to this fitting and direct it to a place where the overflow will be readily noticed, should it occur because of a failure of the input float valve.

The tank will now have a total of 5 holes. The two upper ones are for the entrance of new water and for overflow protection. The three lower ones are for exit and entrance from the solar panels and for exit to the shower. A hole for consumption of cold water was not mentioned because this tank is exclusively for hot

Lastly, but not less important, there should be a good thermal insulation of the sides and the top of the tank. The efficiency of this insulation depends on the thickness and quality of the material used. The suggestion, always thinking in terms of low cost, is to use materials available for free in your community.

The following list describes the principal parts and components needed to assemble a thermal storage tank, with a description of the purpose of each item given to the right.

Quant	**Item**	**Purpose**
01	Asbestos-cement box, Fiberglass, EPS, others	Store the hot water
02	32mm through-wall fittings with flanges and sealing rings	Attach the pipes to/from the solar panels to the tank.
03	25mm through-wall fittings with flanges and sealing rings	Attach the intake float valve, the overflow pipe and the pipe exiting to the shower
01	Intake float valve, preferably with a threaded hose spout at the outlet.	Control water coming into the tank
01	Length of light plastic piping with a diameter of 7.5 to 10 cm	Directs incoming cold water to bottom of tank, reducing turbulence
01	Plastic float	Maintain the intake end of the flexible electrical conduit floating in the layer of hottest water.
XX	Thermal insulation material – sawdust, newspaper, Isopor®, dried grass, etc.	Insulate the tank top and sides
01	Roll of twine/ plastic packing tape	Bind the insulation to the sides of the tank
01	25mm yellow flexible electrical duct – about one meter long	Component of the “fisherman” that picks up the hottest water at the surface and carries it to the outlet taking water to the shower.
XX	PVC canvas sheet	Protects the tank insulation when exposed to the elements

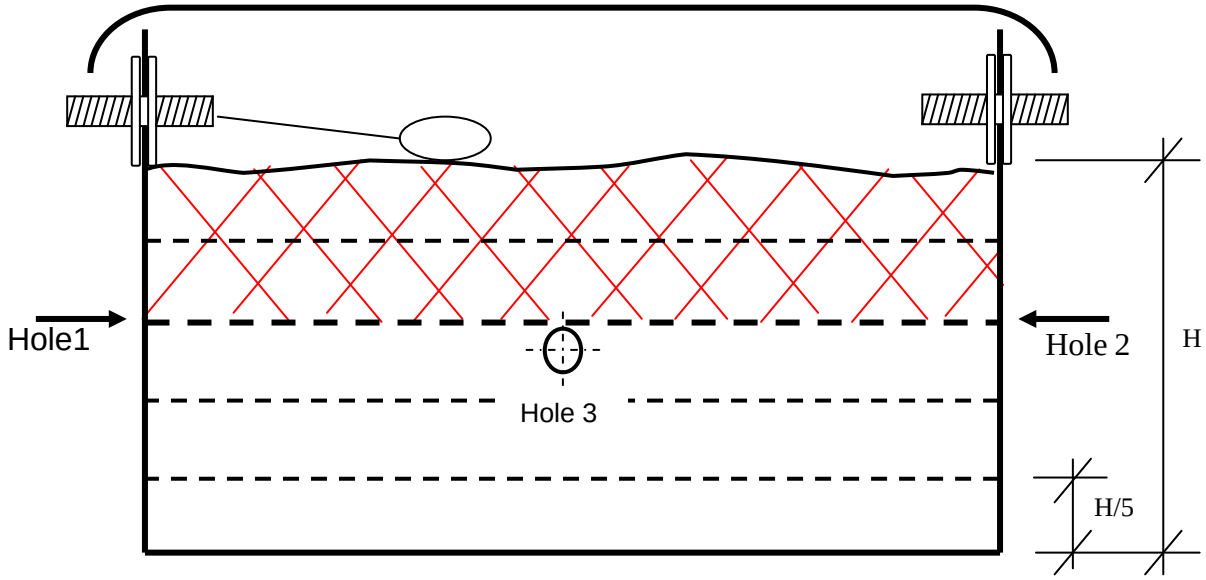
3.3 Assembly of the Virtual Thermal Storage Tank (for both hot and cold water)

The Virtual Thermal Storage Tank was developed for situations where it is not feasible to install one more tank, either because of lack of space or for financial reasons. In this case the existing cold water storage tank is modified in such a way that it can hold both cold water and hot water. This option is meant for houses having an existing tank of at least 500 liters. Using the principal of stratification, the upper layers of the body of water are hot and the lower layers are cold, all without the need for some kind of physical barrier to separate the hot and cold water.

The one difference between this tank and the tank already described is in the placement of the hole through which cold water runs to the solar panels. This hole is placed at the same level as the hole for the return of hot water from the solar panels, halfway up the side of the tank.

For example, consider a tank with a cylindrical, rectangular or square format, Measure the height from the bottom of the tank to the bottom of the float on the input valve at its highest point (or, when the valve is closed). Divide this height (H) in 5 equal parts (H/5). If the tank has 500 liters, each of these divisions would have 100 liters and if the tank had 1,000 liters each of the divisions would have 200 liters

Figure 3 – Position of holes in a hot/cold tank



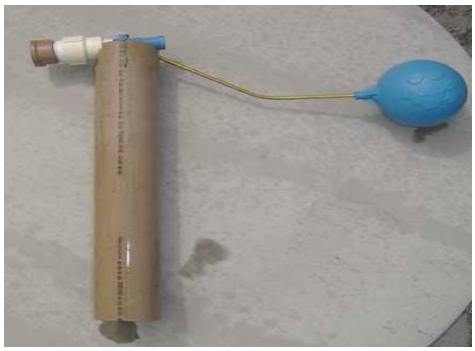
Take as a reference point the **heavy dotted line** in the illustration. It will become the bottom of your virtual thermal storage tank. Then, make the center of hole 1 on the left side (exit of cold water, going to the solar panels) 5 cm above this line.

The center of hole 2 , on the-right hand side (return of heated water from the solar panels), and hole 3, on the perpendicular side (exit of water going to the shower) follow the same orientation as for the integral thermal storage tank.

3.4 Accessory components of the thermal storage tank

The accessory parts control the flow of the water entering and leaving the system. They are assembled from tubing and connectors found in most hardware and building material stores. It does not matter what type of tank is used, it will always be necessary to install these parts if the system is to perform perfectly.

The first, called a *turbulence reducer*, is a plastic pipe of 7.5 to 10 cm diameter fitted to the outlet of the float valve (where new water comes into the system). Its function is to reduce the turbulence of the entering cold water, taking it to the bottom of the tank and preventing its mixture with the hot water stored in the higher part of the tank.



The second, the *fisherman*, is a group of parts consisting of flexible yellow electrical duct tubing and a float. This pair is connected to the inside of hole 3. It's purpose is to ensure that the pick-up of hot water is always coming from the top layer of the tank, even if this level is varying due to intake water shortage. The *fisherman* can be installed in many ways.

(See them on site>manuals>doubts and suggestions).

After the tank has been filled with water, be sure to check the float and the tubing of the fisherman to ensure that it continues to capture the hot water, even after movements due to use and water level changes. If the tubing gets above its float during use the flow of hot water from the tank to the electrical shower will be interrupted.

4. Installation of the ASBC system

4.1 Interconnecting the solar panels

After assembling the solar panels and the storage tank, the user should connect them using PVC tubing. In residential installations many users of the ASBC have reported that they do not use glue to fuse the pipes and parts, with good results. Without glue it is possible to make adjustments and rearrangements and, after tests, the joints can be permanently fused using PVC glue.

In residential systems the solar panels should always be connected in parallel, which means a continuous connection between all the upper pipes and all the lower pipes. The connections between the panels can initially be made without using PVC glue. The options for connecting the panels are presented below, and in figure 2 in section 3.1 Panels.

Table 3 – Ways to make connections

Connections using teflon tape	Facilitates the assembly and disassembly
Dry connections, without glue or teflon tape	Greater force required to join or take apart, resulting in a firmer connection
Connection with glue	Less force required; permanent joint, Standard for PVC

After joining the solar panels there will remain 4 open pipe end-points. Two will be used to circulate the water, one for entrance of cold water at the lower pipe (coming from hole 1 of the tank) and one, the upper pipe on the other side of the panel set, for return of heated water to hole 2 of the tank. 90º joints should be placed on each of these 2 points. The other two points will be sealed, with the upper pipe point receiving a fixed cap and the lower one, on the opposite side, a threaded adaptor and a threaded cap.

4.2 Securing and inclination of the solar panels

Once the position of the solar panels has been determined, and if possible with them facing north (south, if you are in the northern hemisphere), the user will tie or otherwise affix them to the wooden structure of the building's roof. This should be done with rigid copper wires, which will have a long life in the external elements, or with adjustable plastic supports, which unfortunately suffer rapid deterioration with the elements. (see the site>projetos>dicas tecnicas>minuta de normas

In case the solar panels are placed on a flat roof, the optimal inclination should be the latitude of the location plus 10°. For example, in São Paulo the latitude is 23°, and the inclination should be 33°. In the case of residences with roofs that do not achieve the suggested inclination (latitude plus 10 degrees), the eventual temperature difference may be compensated by the addition of one panel.

Before making the definitive fixture of the panels it is necessary that they be set with a slight lateral inclination (tilt). This will facilitate the elimination of air bubbles in the panels and piping, permitting them to naturally rise and pass through to the storage tank, here they disperse.

Laboratory tests have shown that for every 1 meter of panels, 2 cm of lateral inclination are sufficient to guarantee movement of the air bubbles in the piping.

Resuming, the side of the solar panels where the hot water leaves should be the highest part**.**

4.3 Connecting the solar panels to the storage tank

After securing the solar panels in their definitive position, make the connection of the panels to the storage tank. The tank must be above the level of the panels, and the greater the difference in height, the better will be the circulation of the water between the panels and the tank. It is necessary that the bottom of the tank be at least 5 cm above the highest part of the panels (the upper pipe), following the norms published on the site www.sociedadedosol.com.br

Therefore, for best circulation the tank should be as close to the peak of the roof as possible, and the panels should be as close as possible to the lower edge of the roof.

The difference in height, however, should never be more than 3 meters because of the pressure limits of the plastic ducting in the panels

The connection between the panels and the tank should be made with 32mm PVC piping and fittings. During the experimental phase of assembly the joining and separation of the pipes will be facilitated by the use of two turns of Teflon tape on the joints. Start the interconnection by joining hole 1 of the tank to the lower left outlet of the panel assembly. The return of the hot water goes from the upper right outlet to the flanged fitting in hole 2 at the tank.

It is essential that the piping going from the panels to the tank always rises and at no point dips down or even remains horizontal. The gases liberated by the water during its heating within the panels must move freely to the tank. If there is a high point along the path, air will accumulate and block the natural circulation of the water.

When the installation is complete it is a good Idea to paint all the piping exposed to the sun with matt black paint to protect the plastic from UV rays and prolong its life. If desired, this is also a good time to glue the PVC joints.

4.3.1 Insulation of the connection piping

Experience shows that piping with more than 3 meters should be insulated to minimize heat losses. Wrapping the insulation with a final outer layer of aluminum film or sheeting will protect and prolong the effectiveness of the insulation

4.3.2 Protecting the solar panels before they are filled with water

Direct sunlight falling on empty solar panels may heat them to the point where the plastic may start to deform. Panels should remain covered or otherwise protected until the system is filled with water and able to circulate. (See site > projetos ASBC > manuais > dúvidas e sugestões.)

The following list describes the principal parts and components needed to connect the panels and the thermal storage tank, with a description of the purpose of each item given to the right.

Item	Purpose
32mm brown PVC pipes	connect the panels and the thermal storage tank
32mm elbows	connect the panels and the thermal storage tank
Copper wire 2.5mm, baling wire, pipe clamps	Secure the solar panels on the roof
Teflon tape	Make temporary PVC piping joints more easily
Insulation material – newspaper, Isopor®, dry grass, rugs or blankets, etc.	Thermally insulate the piping
Aluminum sheets or foil	Protect exposed insulation from UV

4.4 Connecting the Thermal Storage Tank to the Shower

We still must connect the storage tank to the shower. This piping can be 20mm PVC. However, if the piping is going to run in or behind a wall or other construction, we recommend the use of copper, CPVC or other high temperature piping material. The use of these other materials will avoid having to change the installation in the future should the ASBC be substituted by another heating system providing hot water at a much higher temperature. The distance between the storage tank and the shower should be the smallest possible in order to reduce heat loss as well as the waiting time for the hot water to arrive.

4.4.1 Adapting the electric shower piping

There are 3 possible configurations for the interconnection between the storage tank and the shower. The user will choose which one better serves his residence and will plan the connection accordingly.

The **first,** and most esthetic, is to build the new hot water piping into the wall of the shower area, with a new faucet to control the hot water flow. The piping coming from the storage tank is connected to this installation. Within the wall there should be a 90° "T" with ½" threads for connection of the hot and cold pipes, thus making a 'mixer'. Leaving this "T" is only one pipe taking the mixed water to the shower head. All inbuilt material should be for high temperatures, with insulation for the hot pipes. International norms say that the hot water faucet be placed to the left of the cold water faucet.

The **second** possible configuration is very similar to the first, but the piping will be apparent, coming down from the ceiling to a point, probably near the cold water faucet, where the hot water faucet will be placed. The exposed pipe will then return to the height of the shower and enter a "T" newly installed between the cold water pipe in the wall and the aluminum shower-head pipe, thus making a kind of 'mixer'.

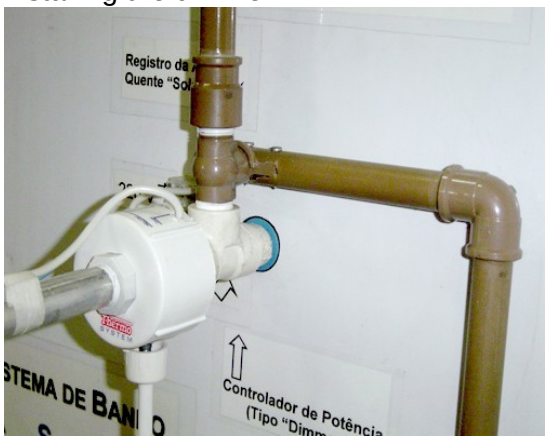
The **third** option is a half-way mix between the first two, with less wall-breaking than the first and more esthetic than the second, as well as more economical. Only one hole is necessary in the ceiling, for the descending hot water pipe. A 20mm PVC spherical valve, turned by a 'butterfly' handle, is placed at the end of this pipe. A "T" is placed between the wall cold water outlet and the shower-head pipe, as in the second option, and the valve is attached to the center of the "T". To open and close the valve a length of 20mm PVC piping is attached to it and descends to a point where the user can move it back and forth to control the flow of hot water (see illustrative photo). This extension should not be too long to avoid children hanging on it.

4.4.2 Placing a shutoff valve on the cold water supply

In homes where the user wants to use the ASBC heated water to take a morning shower it is necessary to keep the stored water at a maximum temperature. But this is hard to do if there are nocturnal showers being taken, for the water used is immediately replaced by cold water, which brings down the temperature of the stored hot water during the night. The solution is to install an accessible valve on the incoming cold water supply, which can be closed at night before bathing and opened again in the morning after bathing.

4.5 Connecting a dimmer to the electrical shower

On rainy or cloudy days the hot water temperature may be less than desired, and the user will wish to turn on his electric showerhead. But, these heaters usually have only two levels of heating, which may be much more power than is required to bring the bath water to an acceptable temperature. This wastes energy and money. The solution is a dimmer, which will vary in small increments the amount of electrical power going to the shower heating elements. Thus, the ser will draw only the amount of electricity needed to bring the water to a desirable temperature. The dimmer is installed in series with the electrical shower supply wires. Read the manufacturer's instructions before installing the dimmer.



4.6 Other types of Thermal Support – the Boiler

Residences that already have a boiler (cylindrical thermal storage vessel, usually with its own electrical or gas heating element), can use it as thermal support to complement the heating of bath water.

Install a normal ASBC system, as described above, with either a virtual storage tank or an integral thermal storage tank. The heated water leaving this ASBC system should enter the boiler through its normal cold water entrance. Thus, the boiler will use less heating energy in bringing the bath water to the desired temperature. For economy, you should regulate the boiler temperature control to approximately 45° C.

4.7 Parts and accessories for interconnection

The following list describes the principal parts and accessories needed to make the connections between the thermal storage tank and the electric shower head.

Quant	Part	Purpose
01	Electronic Dimmer	Controls the power going to the electrical shower head
02	90° "T" with ½" threads	Mix the hot and cold water and lead it to the shower
01	½"butterfly valve	Controls flux of hot water to the shower
01	½"PVC tubing, about 1 meter long	Put together the lever to move the butterfly valve
01	½" PVC caps	Put together the lever to move the butterfly valve
02	1/2" Brown PVC 90° elbows	Put together the lever to move the butterfly valve
xx	20mm (1/2") Brown PVC piping	Connect the storage tank to the shower

4.8 Filling the ASBC

Open the valve that controls street water going to the system. The storage tank will start to fill, an when the water reaches the level of the 32mm outlet for cold water (hole 1) it will start to flow to the solar panels. In a few moments the panels will be filled and the water will rise in the tank until it reaches the other 32mm inlet (hole 2). If the tank is a virtual thermal storage type, with both hole s 1 and 2 at the same level, you should avoid having water running into hole number 2 because this could form large air bubbles within the panels that could impede the natural circulation of heated water in the panels.

Uncover the panels and make sure that there are no leaks either above or below the panels. Let the water rise in the tank until the float valve naturally closes down the entrance of water.

4.9 Use of the ASBC

When bathing, the user should first open the hot water control. In case the water is not hot enough the user can heat it further electrically by using the dimmer for fine adjustments until it reaches the desired temperature. In this way he will use only the electricity really necessary for agreeable bathing.

The cold water control (faucet) will only be used when the user wants to reduce the temperature of the water that has been heated by the sun, or when he wants to take a cold shower.

5. Final Comments

5.1 Drinking water coming from the ASBC

The ducted panels from which the solar panels are made have additives in their basic composition, which may alter the drinking quality of the water. Based on tests and chemical analysis carried out at IPEN the presence of additives is detectable only during the first 4 weeks of use of the panels. In later weeks the additives concentration were below levels permitted by law.

The Sociedade do Sol recommends that during the first 4 weeks water from the ASBC should not be used in food preparation and that it should not be swallowed during bathing.

As another cautionary step, it is advisable to change all the water in the tank if it has been inactive for more than 7 days (holidays, empty house, etc.). Still hot water, even in a dark recipient, may encourage development of microorganisms

5.2 Operational concerns

By its very nature the ASBC is still an experimental product. Suggestions and new ideas to facilitate making the parts and assembling the system arrive every day from all over Brazil. You are encouraged to send suggestions and comments which could result in a more efficient ASBC.

On the other hand, some people have difficulty interpreting the manual or other problems and are not satisfied with the heating furnished by the system. For them we suggest attention to the following before definitively desisting from putting the system into operation:

- Look for leaks in the panels and the piping
- Verify if the panels are very hot all over. If so, there may be air bubbles in panels and pipes, impeding the circulation of the water.
- Verify that the piping and ducts are not clogged with newspaper or rags.
- Review the inclination of the panels and the return pipes.

5.3 Maintenance

The ASBC equipment does not need constant repairs and maintenance. However, the following care is recommended during use:

Solar Panels

Visual inspection: Once a year look for cracks or ungluing on the black surfaces and glued regions, without forcing them.

Black surface: The panels should get a new coat of paint from time to time, depending on the region of Brazil and the incidence of sunshine. The black matt paint may last up to 4 years when exposed to the elements.

Internal cleaning of the system: Once a year unscrew the 32mm (1") white cap at the bottom of the panels. The water in the storage tank will run out through this opening. Observe the color of the water. In the beginning it will be brownish, due to deposits of mud and other materials within the ducts and piping. The water will shortly run clean, and the cap can be replaced. Don't forget to put Teflon tape on the threads to avoid small leaks.

Excess force while turning the cap: **Always hold the pipe with a pair of pliers when screwing or unscrewing the cap to avoid twisting the pipe and perhaps breaking the glue lines between the ducted panels and the pipes**.

Thermal storage tank

External visual inspection: Every six months take a careful look at its state, including leaks. If the tank is made of Isopor® (EPS) without protection from the sun and elements it can suffer rapid deterioration and deformation.

Internal visual inspection: Observe the working of the PVC accessories. If the tank is made of lined Isopor®, verify the quality of the plastic film.

5.4 Suggestions for finding supplies

TYPE OF MATERIAL	SUPPLIER/ADDRESS/CONTACT
Piping PVC pipes and connectors	**Tigre Standard** In all hardware and construction materials stores
Ducted PVC wall and ceiling panels Measuring 1250 x 620 x 10 mm	**Medabi**l São Paulo Office (011) 3812-3322 **Confibra** Head Office (019) 3887-2677
Thermal Insulation	
EPS Sheets, 15mm special for panels	**Div Term,** w/ Nilza, (011) 3662 0288 R. Camaragibe 216, Barra Funda S.P.
Expanded polyethylene sheets of 5 and 10 mm for tanks and tubing	**Vicente Mercadante** 011 3845 1611 / 085 2750100
Bubble-wrap sheets For insulation	**Vicente Mercadante** 011 3845 1611 / 085 2750100
Other Insulators Newspaper, bagged sawdust, dry grass, carpet liner, etc.	
Storage Tanks Water reservoir boxes Tigre standard 250,310,500,1000 liters	In all hardware and construction materials stores
DIMMERS for electric shower control	
Dimmer of 5.4 and 6.4 KW	**Martronic**, Sr. Marcos (011) 3621 2052 / 2045
Dimmer Thermo systems	**Botega,** c/ Eng. Francimar (048) 626-4630
Electric Showers with integrated *Dimmer*	
Electric Shower special for ASBC	**Botega,** c/ Eng. Francimar (048) 626-4630
Electronic Shower	**Zagonel**, (049) 366 1326 **Sintex**, (049) 366 1326
Plastic Film and bags for storage tanks	
Vinimanta VMP 55ML Impermeable tank liners	**Sansuy**, com Ângelo (011) 3759-7866

Vinilona Weather cover for outside tanks	**Sansuy**, com Ângelo (011) 3759-7866
Glues	
Plexus 310 (Metacrylic Bicomponent).	**Maxiepoxi** w/ Sérgio or Cláudio, (011) 5641 5608, R. Gibraltar, 212 Sto. Amaro SP
Made by Vantico (previous Ciba). Plexus is offered in two parts of a minimum of 250 grams each. Monitors may purchase larger quantities, divide them into smaller portions, and provide them to the final users putting together their solar panels.	
Araldite Profissional 24 horas glue	**Maxiepoxi** w/ Sérgio or Cláudio, (011) 5641 5608, R. Gibraltar, 212 Sto. Amaro SP
Made by Vantico (previous Ciba). Suggestion is to purchase 100 grams of the adhesive and 80 grams of the hardener additive, enough for 7 panels. During the preparation you should add mineral talc to prevent runniness.	
Isophtalic Resin	Resin and fiberglass suppliers
Various manufacturers. Provides a good bond with PVC. We recommend using boat resin with an anti-UV additive. Get orientation from the supplier.	