A How-To Book by Sharon Cornet

How To Make a Solar Water Distiller

A Primer for Beginners

Make your own rain (solar distilled water via evaporation, condensation, and collection) using NO ELECTRICITY, NO PUMPS OR FANS, NO MOVING PARTS, NO FILTERS TO REPLACE, *using nothing but the sun's free energy!*

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WHAT IS A SOLAR WATER DISTILLER?

A solar water distiller ("still") is basically a simple, waterproof, insulated "box" that uses the sun's energy to distill water (even contaminated water that contains raw sewage!) using a piece of glass sealed on top that the sun shines through. The distilled water (called "product water") is then rendered safe for drinking and cooking, with absolutely no contaminants that are found in regular (potable or nonpotable) water.

Homemade solar water distiller

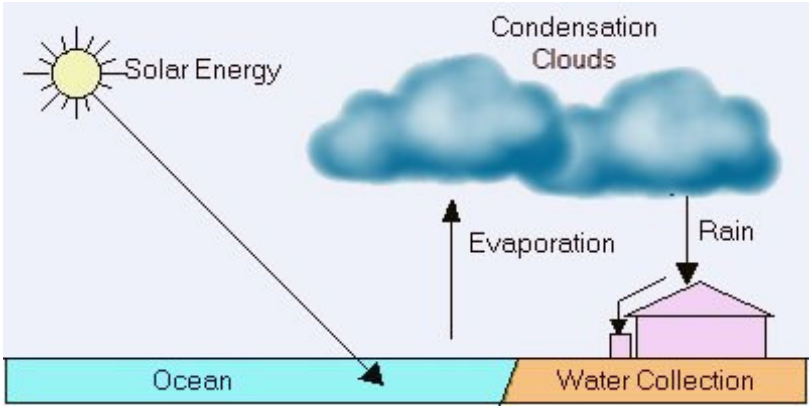
For still construction plans to make this still (cost usually runs between $200 - $300) you can send about $27 to the non-profit organization**:**

El Paso Solar Energy Association (EPSEA)
PO Box 26384 El Paso, TX 79926

or see their website at: www.epsea.org
Read to the end of this book before deciding whether you feel it is worth making this still.

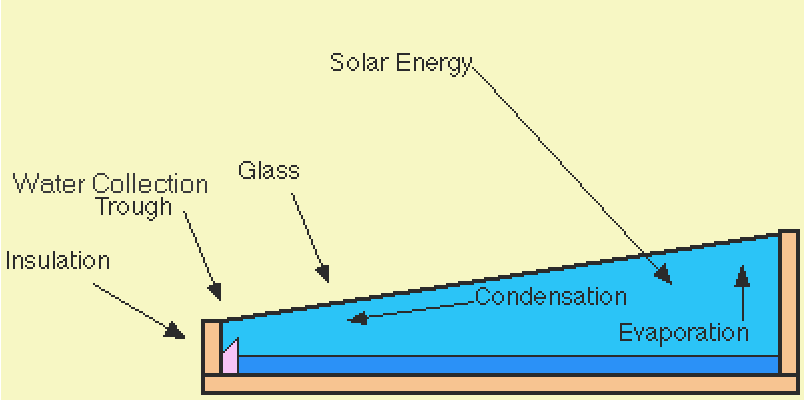
HOW DOES IT WORK?

Solar stills are JUST LIKE MAKING RAIN. In nature, the sun (solar energy) shines and heats the air and water (from the ocean and lakes, etc.) and causes the water to *evaporate* into the air as water vapor. Then it cools down and *condenses* in the sky as clouds and it finally falls as rain. You can catch this water in a container to use for plants or other purposes. It is well known that rain water is the most pure water on the planet (unless it has been contaminated by pollution in the air from cities and factories). Plants LOVE rain water and thrive on it. Our bodies do too.



How rain is made: Evaporation, Condensation, and Collection

A solar still, also called a distiller, makes pure water the same way rain is made. The sun's energy shines and heats the air and the water inside the still causing the water to *evaporate* and *condense* on the cooler glass above (the glass acts like a cloud). The water then drains down into a water-catching trough and out to a container. This distilled water, or product water, can then be used for cooking and drinking.



How stills work: Evaporation, Condensation, and Collection

HOW GOOD IS THE WATER?

The water that is made in these stills is of superior quality than bottled water because it is purified using the distillation process. It is some of the cleanest, most pure water you can get on the planet. And because the water is slowly evaporated, instead of rapidly boiled, the water tastes sweeter due to the natural process (vs. "forced distillation" done by boiling the water). When you buy bottled water you often get that "plastic" taste, and who said that the water that's been sitting in standard plastic jugs – after having absorbed some of the smells and toxins from the synthetic container it sits in - is still good for you? The best storage container is by far a glass container. Stainless steel, although more expensive, is even better since you don't have to worry about the glass freezing and breaking in the wintertime. Either way, the distilled water you get and store will be some of the best tasting water you will ever drink!

If you purchase over-the-counter water that has the label "Drinking water" it may only be TAP WATER! Still with dangerous chlorine, pollutants, and other toxic substances in it. "Purified water" means it's been run

through some type of filtration process, but this does not always take out all toxins. "Reverse Osmosis water" (known as RO water) is almost as close to distilled water as you can get; however, it takes 2 gallons of water to make every 1-gallon of RO water. This means that for every 100 gallons of purified that another 100 gallons of "muck" (dirty waste) water has been drained away into the sewers as waste. This is an incredibly inefficient way to produce pure water! Very wasteful indeed! Not to mention *expensive* because in RO systems there are costly filters to replace, and the machine to maintain.

In a solar water distiller there are no filters, no pumps, no fans, no moving parts to break down, and no electricity is even needed to run it! It is completely passive solar in design.

Solar distillation removes contaminants such as:

Salts

chlorine taste and odor

heavy metals

bacteria (e.g. coliform/cholera)

micro-organisms (e.g. E-coli, giardia, chryptosporidium)

sediments

sand

rust

fluoride

arsenic

These contaminants, and more, are all *completely removed*.

WHAT KIND OF APPLICATIONS ARE THESE STILLS GOOD FOR?

Solar stills are appropriate technology for any areas which have at least 5-6 hours of peak sunlight per day. This could be **your home**, at a cabin or your favorite camping spot, in border Colonias, rural areas, in the city, survival situations, in the mission field, on a remote island, in the desert, etc.

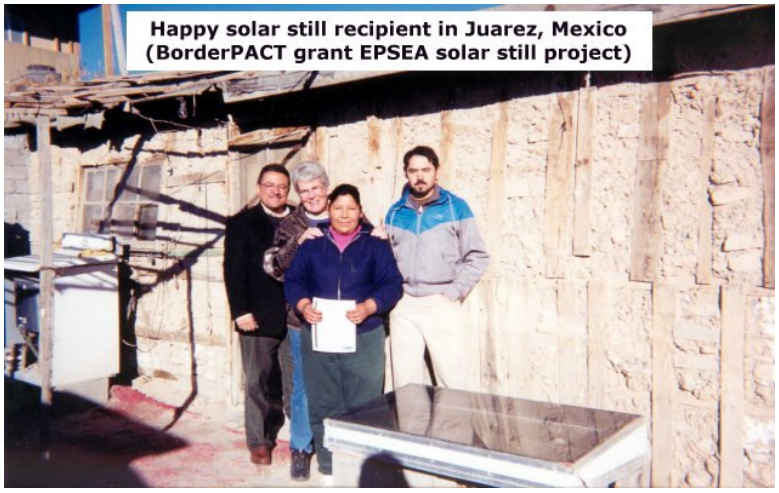
The smaller 2'x4' or 3'x3' sized (on average) stills will produce approximately 1 1/2+ gallons of **pure** water per day in the summertime and about half that in wintertime. The least expensive professionally manufactured still on the market is the **RAINMAKER™ 550** (which I'll go into more towards the end of this book) will typically produce most or all the cooking and drinking needs of 1-2 people (2 small stills, or 1 homemade larger (3'x6') still is usually enough for families).

In the late 1990's and also in 2000 & 2001, The El Paso Solar Energy Association (EPSEA) had a $100K grant from the Environmental Protection Agency (EPA) as well as two $10K grants from BorderPACT/CONAHEC to install a total of 107 stills in west Texas and southern New Mexico in areas that are challenged with water problems, specifically in rural border areas called Colonias.

Sharon Cornet with "David" (a still recipient) in front of his "Fidobe" (adobe & papercrete mix) house in New Mexico

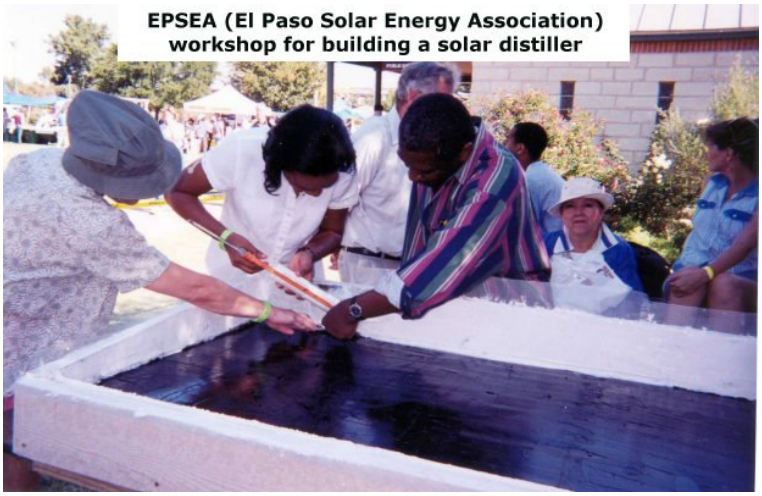
Colonias are unincorporated communities within 50 miles of the U.S.-Mexico border that lack infrastructure (no city water or sewers, although they do often have well water and septic tanks). Some colonias – such as the one in the picture above – do have city water, but their water supply, although treated, still has other contaminants not removed by chlorine alone, so a solar still was their best option for on-site potable water.

Many of these colonias are plagued with poverty and poor health conditions, although ranchers, farmers, and people of wealth also *choose* to live in these rural communities. Some of the diseases lurking in colonias include hepatitis, cholera, and tuberculosis, but only in some areas, depending on the particular colonia and their unique situation (based on geography, geology, topography, political and social/cultural influences, access to medical care, economic opportunities (or the lack of it), etc.). Many of the homes in the colonias of Mexico are made out of pallets and cardboard, or whatever cinder blocks or other materials they can get a hold of cheaply or for free.



Happy solar still recipient in Juarez, Mexico
(BorderPACT grant EPSEA solar still project)

Sharon Cornet (left of lady in yellow) giving presentation
on solar stills to colonia residents in Juarez, Mexico



EPSEA (El Paso Solar Energy Association)
workshop for building a solar distiller

In the U.S. the colonias tend to be populated with mobile homes or simple (often uninsulated) concrete block homes, but again, there are also exceptions depending on local and regional circumstances. In some of the more poor areas in colonias some of the houses do not have adequate septic systems (if at all) and/or no running water. Some of these areas have electricity and some do not (most do, although the "Colonia Laws" (specifically in Texas) do not allow certain areas to receive electricity any longer – if they do not have city water – so as to inhibit Colonia growth).

Grunge in the bottom of a 55 gallon drum (a common water storage container found in border Colonias). A solar water distiller will remove ALL non-volatile contaminants from non-potable water stored in containers such as these.

The stills are appropriate technology for these and other areas because they are site-specific, use no electricity to run, have a quick payback period, require no running water to work, get rid of all contaminants (including E-coli), have a life expectancy of 20+ years, and are easy to use and maintain. They are especially great for people with health problems, the youth or elderly, or pregnant women.

Still, some say that America has the cleanest water in the world! And yet we find all over the U.S. (not just in colonias) private wells are contaminated with bacteria, E-coli, lead, or other toxic substances, some of which are not removable with the use of chlorine. And is chlorine even healthy? With all of the chlorine in America's water supply (which is a product that *does not distinguish* between killing off living BAD organisms (bacteria, micro-organisms) and killing off living GOOD organisms (necessary bacteria in the human body, etc.) we are still told that it is perfectly fine to consume this potential poison (when ingested long-term).

• **A study by the California Department of Health** found that pregnant women consuming five or more glasses of municipal water had a 15.7% increased incidence of miscarriage. Doctors are saying drink eight glasses of water a day! *Source: Epidemiology report findings mentioned in the San Jose Mercury News, Los Angeles Times, and The Metro newspapers (Feb 1998)*

• **Fluoride is another issue.** Just because fluoride is promoted in toothpaste because it helps fight cavities, does that necessarily mean that it is **"SAFE"** to be ingesting on a daily basis? Municipal water that contains fluoride has been accepted and also avoided in

certain areas of the country because of this debate. It has been outlawed completely in many countries. The "safe" (highest acceptable - standards set in the U.S. by the Environmental Protection Agency (EPA)) level for ingesting fluoride is considered to be a count of **maximum concentration limit of 4 mg/L** in water tests. **Enamel fluorosis can occur when children are chronically exposed to fluoride at concentrations of 2 mg/L** or higher. Children with fluorosis are often found to have bone problems (since fluoride actually leaches calcium from the bones/teeth, making them weaker, not stronger), developmental problems, health problems, and white spots on their teeth (mottled) and skin due to the unnecessarily high levels of natural fluoride found in the water table. Children and adults who have had this problem were, amazingly, found only 45 minutes drive away from Deming, NM, where their (Deming's) claim is to have some of the cleanest and "best" water in the state! Due to geological reasons and old mines in the mountains, the village of Columbus, NM has high arsenic counts in their water. Plus Columbus has (found naturally) at least 200% higher than the maximum limit of fluoride concentrations (over 8 mg/L based on tests from 2001) in their groundwater. The village put in an expensive R/O system for residents to fill up their bottles for drinking/cooking, but some of the residents, thanks to the EPSEA solar water distillation project, have solar stills at their homes so they don't have to go down to the town square to fill up their bottles with clean water… they distill it on-site instead. Solar stills remove ALL fluoride from water, thereby removing the danger of ingesting it unnecessarily.

The best reasons for having a solar still are not always just the practicality of on-site water purification but the reasons behind what drives us to want purified water in

the first place…. our HEALTH is a big issue in our toxin-filled society today.

HOW CAN I MAKE ONE?

The great thing about solar stills is that you can "make your own rain" at any time on any sunny day. Stills can be bought from companies (such as www.Solaqua.com) or you can build the still yourself using a variety of materials available to you.

Basically, there are three ways to make stills. The cheap way, the better way, and the best way. If none of those options appeal to you there is always the option of buying one commercially made. Depending on whether or not you have some of the materials on-hand, just lying around your house may best determine if your still is going to wind up being less expensive or more expensive than purchasing a new one. Typically larger stills can be made for $200-$300. The process can be a bit time consuming so if you are in a hurry for a school science project you may want to reconsider and make a solar oven instead (information on this subject is available online, or via the "How To Make A Solar Oven" booklet at www.SunStar-Solutions.com). If all you need is a quickly made emergency or demo-still please read "THE CHEAP WAY" section next.

Some of the materials you ***may*** **need** to make a solar still could include: plywood, glass, food-grade sealant, nails or screws, nongaseous insulation, other misc. wood such as 2x4's, cement/concrete, UV resistant plastic (should not touch the product water as plastics give off toxins) for possible legs or for the box, stainless steel, UV resistant silicone tubing, couplers, valves, connectors, etc.

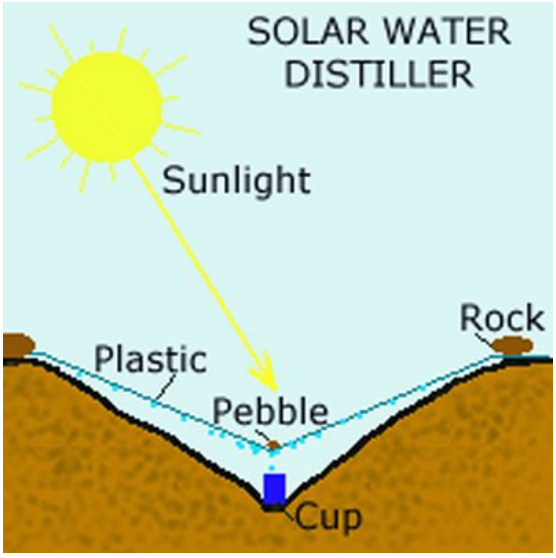
Some of the materials you will want to **avoid** are rubber (toxic), non-UV-resistant plastics (they degrade and become brittle in the sun plus can put toxins in the water), cork (breaks down), polystyrene (bead board – it gases off and crushes with weight on it), any synthetic materials which are not food-grade or FDA approved as "safe" for food contact (especially if heated since stills can get quite hot!), or any other material which you are unsure about. When in doubt, do some research and ask and find out! Now, to go on to the different ways to construct a still…

THE CHEAP WAY

The least expensive ways to build stills are by using materials you already have on hand. If you like to collect what other people consider as "junk" then you may already have a wealth of materials which can be quite handy in constructing your still. Usually, however, the cheapest stills are the ones that can be built (or "made") in just a few minutes. These are typically not permanent stills, but are meant for short-term use, such as survival stills or ones made for school projects or science fairs, or even roadside breakdowns.

If you have some clear plastic on hand, especially food-grade plastic (an extra-large oven cooking bag does nicely) you are half way there. You can make a FREE solar still anytime or anywhere, even if you are stuck out in the hot, dry desert, as long as you have a clean 5'X5' (or comparable sized) piece of clear plastic with you. All you have to do is dig a conical hole in the ground and put a cup/glass in the middle of the hole. Then you open up the plastic and stretch it out over the hole so that it covers the hole all the way (HINT: make sure your hole is not bigger than your plastic). You can

put sand or rocks over the edges of the plastic to hold it down so it doesn't blow away. Then put a pebble in the center of the plastic to make the plastic dip down in the center, right over the cup that is underneath. The sun will come through the plastic, heat up the air and the moisture that is in the earth, *evaporate* it and make the moisture *condense* on the plastic, which will then run down towards the pebble and drop into the cup. More water can also be made if vegetation or pieces of cactus are cut up and thrown into the hole before the plastic is put on. This gives extra moisture inside the hole so it can be "distilled" faster. In emergency situations, and during war, people have also urinated into the hole to add extra moisture. Remember that only pure H2O evaporates and condenses so there is no worry for contamination (as long as you remove the cup so you don't "splash" into it). In just a few hours you'll have some hot water to make tea, or let it cool down to drink it as pure water. Be careful not to burn yourself when you try this.



FREE solar water distiller out of a piece of plastic. Moisture from the ground collects and drips down into a cup.

Another survival option is to place a large piece of plastic (you may keep this in your car trunk or glove

box) over a small tree or bush that sits in the sun, especially if it is near a dried up creek bed or wash/draw/arroyo. Place the plastic over the tree/bush and cup it at the bottom so that when the sun shines through the plastic it will heat up the air underneath, causing the tree to get hot and "sweat". The tree, in trying to stay cool will give off water vapor and it will collect onto the plastic and run down into the cupped area of the plastic below. Be careful not to let it run out onto the ground or you will lose the condensate! Also, don't leave this type of still running too long or you'll dry out the tree and kill the poor thing. Also be careful of what type(s) of bush(es) and/or tree(s) you use as some give off odors and gases that can make the water taste bad, or even be bad for you.

THE BETTER WAY

One of the first ways I ever built a still many years ago was by first reading everything I could get my hands on concerning this subject (I highly recommend doing that).

Single Basin Still: I learned about the single-basin still (the easiest and quickest method, and most often the least expensive as well) where the water stands in one place and evaporates as the sun hits it. This is the type of still shown in a picture shown previously titled "How stills work." Here are some important rules in making a single basin style still:

• The water needs to be very shallow, perhaps ¼" to no more than 2" deep.

• It is best if the basin is black as dark colors absorb more light and heat up faster. Light colors (especially white or reflective metallic surfaces) reflect the light

and heat back *out* of the still. If the still is made out of concrete (thinner is best as it takes some time for the sun to heat a lot of mass (i.e. thermal mass)) then you can use black cement coloring in the concrete itself or also paint it black with a waterproof type paint. Be careful not to drink the water from the still until the paint has gassed off all the way. The main frame of the basin itself can also be made of wood with a waterproof food-grade liner of some sort. Some people also use glass to line the basin (with black underneath it) and seal the edges with food-grade silicone. This is a good idea but makes the still heavy and the glass may break easily if moved or something hits it.

• It is best if the glass that covers the basin is no more than 4”-6” above the surface of the water as too much air space can cause convection within the still, therefore making heat-loss a real problem.

• Make sure that the glass above the water is tilted at a 10-degree angle. Any more and convection occurs in the still; any less and the water will not slide nicely down the glass into the collection trough, but will drop back into the basin where it will become recontaminated. Vinegar is an excellent way to clean both the glass and the still basin if/when needed.

• Insulate the box with any water-resistant (non-paper) insulation such as aluminum backed rigid foam insulation. As long as the basin is sealed then gassing off (by the foam) should not be a problem. Remember that nothing can contaminate distilled water except what this ultra-pure water comes in contact with, OR toxic gases that are in the air and can permeate the water vapor itself. If you have volatiles such as gasoline, kerosene, or pesticides in the basin water then it WILL come through to the other side since volatiles have a faster evaporation rate than even

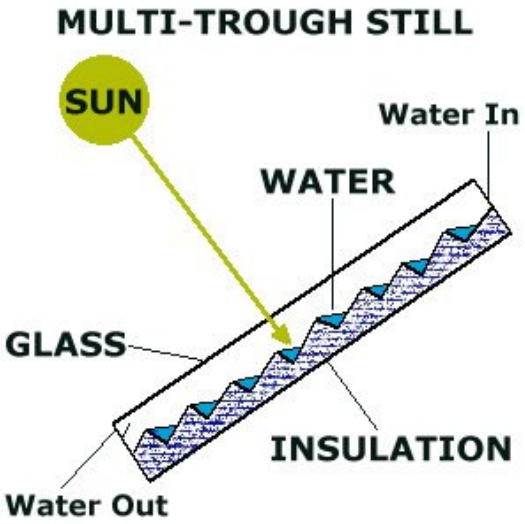
water does. If there is any worry of the possibility of a small amount of volatiles in the water, then a simple carbon filter can be placed in the water tube/line between the exit trough and your collection vessel.

• Make SURE to use a food-grade surface material such as stainless steel or food-grade silicone or even glass as the *collection trough* and for the *collection vessel*. The collection jug can be polybicarbonate such as those 5 gal plastic jugs but be aware that 140-180 degree Fahrenheit water is dripping out of the still at a constant rate all day long (especially in summer) and that it can absorb the taste of the vessel it is contained within. Polybicarbonate jugs also degrade in the sun over time so make sure to shade it with a box or piece of wood or heavy towel or other opaque material. This will also help cool the water faster as it will now be shaded. Some people have their stills placed lower to the ground (like on cement blocks or a wooden frame/legs) and then dig a hole to hold the jar/jug since the earth helps cool the water and shade the sides; however, the top will still need to be shaded or protected from sunlight.

• Always use food-grade silicone tubing for the inlet and outlets so that the tubes don't crack and break in the sun. Don't ever use regular garden hoses for the tubing as it has rubber inside and will make the water smell and taste terrible, and will poison the water.

The Multi-Level/Troughed Still: Another option to making a distiller is a multi-level or trough type still. This is where instead of one single basin you have multiple smaller basins underneath a single piece of glass. Typically these stills are slanted at an angle rather than laid flat. The smaller amounts of water in these long but thin basins/troughs allow for rapid

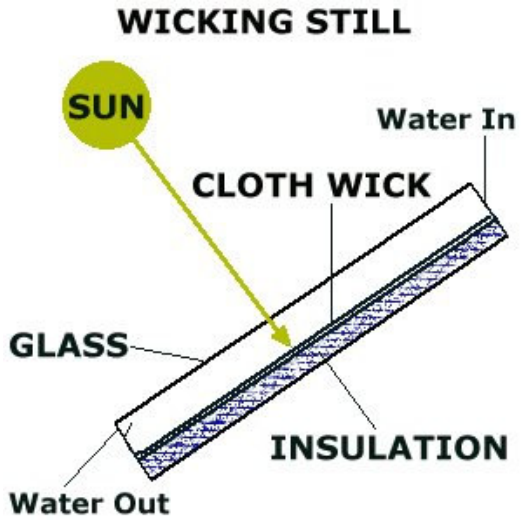
heating and evaporation of the water, but water must be added more often or the still will dry out too quickly. This can be done by a gravity feed tube or by automation and a drip-system. I personally have found these systems to require more maintenance and so I tend to stay away from them; however, some people love their quick evaporation and condensation rates for a higher volume of distilled water in the same amount of time (as compared to a single-basin still).



The Wicking Still: The wicking still is very similar in that it's a tilted still, however instead of troughs to hold the water there is a single piece of black cloth for wicking the water through the length of the still. Water is dripped into the top via a tube with tiny holes along its length. By the time it reaches the bottom of the cloth most of the water should have evaporated leaving a salty white brine which drains out the bottom. The condensed distillate is caught above - via a collection trough – is so it can stay separate from the brine.

Like the multi-level still this needs more upkeep and maintenance, especially because the cloth gets clogged quickly with salts and build-up (calcium carbonate) and

turns a bright WHITE, therefore the heat-absorbing qualities of the black cloth is quickly negated and one must open the still often to replace this cloth. Finding proper cloth such as burlap (fair to poor material) or something that "wicks" evenly is also a hindrance, although there are some natural or man-made shammies (i.e. chamois, or chammy) on the market that people use to wipe down their cars, which wick up water very efficiently. Check with the manufacturer, though, to find out whether their product gasses off or has any potential for poisoning the water.



THE BEST WAY

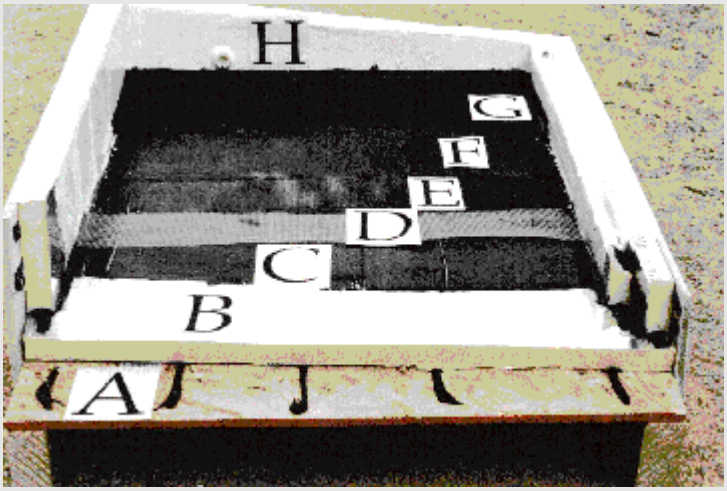
Horace McCracken was one of the first people in the country to really work with the design of solar water distillers. He originally used concrete in his still design, but it was found to be heavy and slow in producing water due to the great mass of the concrete. It has been found that putting the sun's energy into heating the WATER rather than the concrete is the best way to go concerning efficiency. Just to note, however, that once the mass of concrete is heated up you will get a little longer time in nocturnal water production. Once

the glass cools down from the night air, water tends to condense at a faster rate. Horace McCracken worked closely with the El Paso Solar Energy Association in helping to design the best stills possible for one of EPSEA's solar still grant projects. Horace wound up taking some of EPSEA's ideas also, and started producing more lightweight and portable stills after that.

If you turn back to the still mentioned on the first page of this book you'll see the picture there of a homemade still.

A cutaway of this still is shown here.

EPSEA Solar Still Cutaway



Source: http://epsea.org/const.html

A- Base is 2X4 and plywood/osb
B- Insulate 4 sides and bottom w/polyisocianate
C- Waterproof membrane - 1st coat silicone
D- Fiberglass screen
E- Imbed screen into silicone
F- 2nd coat of silicone
G- 3rd coat of silicone
H- Side walls and trough (right) same steps w/white silicone and install fill/overflow and outlet tubing.

This "EPSEA Still" is no doubt one of the best and time-proven ways to construct a still, however there are some things you should know before tackling this endeavor.

The "EPSEA" still utilizes food-grade silicone (DOW 999-A) which is a *special order product only*. Cost is about $10/tube and it takes about 24 tubes to make just the silicone "liner" of the still. Then the silicone needs to cure by outgassing (best if put out in the sun for a few wks/mos); the time can be reduced by setting it in the sun with the glass on (without water in it). When you pre-cure the silicone and if the still is run "empty" of water then the silicone can outgas causing an invisible film on the underside of the glass and the water production will go down to almost zero until it is properly cleaned off (glass cut off and flipped over, or else cleaned with liquid plumber and a soft scouring pad – use HEAVY RUBBER GLOVES and do NOT touch this stuff as it will burn your skin!) until the film is removed.

If you do not use food-grade products such as the DOW 999-A silicone then make SURE that what you do use is safe and doesn't leak. Some prefer to use stainless steel, however this can be quite expensive also and you must be sure to use high quality stainless (316 or better) because low quality stainless can pit and corrode over time.

Another item that is hard to get is the silicone tubing for the inlet and outlet tubes, as well as the overflow tubes on the still. The tubing itself is readily available however most companies that sell it do so in entire ROLLS rather than just a few feet (which is all you'd need). Why buy a $50 roll of tubing if you only need 3-5 feet of it?

A solar still Rainkit™ 990 (for the hard-to-find items) to make the EPSEA still can be bought from SolAqua for $245 http://solaqua.com/solaquakit2.html (KIT comes with the EPSEA still construction plans).

COMMERCIAL STILLS

I've watched most still companies (charging $800+ per still) come and go over the years. I have no indication as to whether the ones here today will still be here tomorrow so I'm going to tell you that in order to find them just do a search on the Internet.

There is one company that I'll mention here that makes stills and even has a 1 yr warranty on them. This is the **RAINMAKER™ 550** made by SolAqua. This is the same company who sells the KITS I just mentioned. They took the EPSEA solar still and improved upon it greatly, adding in awesome features such as a second overflow trough, a special one-piece silicone liner which has outgassing reduced from 60 days down to a mere 2 days! Now, if the still accidentally runs dry any film that may be there will just simply wear away and vanish. These stills are lightweight and easy to handle. The glass is now removable for cleaning. Stills can also be automated using sprinkler systems and connections available at your local hardware store. Once a unit is bought it can be set up in a matter of minutes.

RAINMAKER™ 550 Solar Still

For any further information or to purchase
one of these stills please see www.solaqua.com.

If you choose to build your own still, then good luck and have fun! The reward is clean tasting ultra-pure water for years to come!!!

OTHER HOW-TO BOOKLETS

HOW TO MAKE A SOLAR WATER DISTILLER

HOW TO MAKE A SOLAR OVEN

HOW TO DESIGN A PASSIVE SOLAR HOME

HOW TO MAKE HEATING/COOLING EARTH TUBES

HOW TO DISCOVER IS SOLAR OR WIND POWER IS BEST FOR YOU

HOW TO MAKE A TORNADO/HURRICANE-RESISTANT HOME

Please check for availability at
www.sunstar-solutions.com
or
www.lulu.com

About the Author

Sharon Cornet has served as past President (under last name “Eby” in 2001), Secretary, Editor and is/was a Board Member and Project Manager for the El Paso Solar Energy Association since 1990. She has managed several solar water distillation projects in TX, NM and Mexico. She has been involved in Earth Day Planning Committees in the past as well as in many conferences, speaking engagements (where she presented), workshops, and seminars across TX and NM. Sharon is self-employed, an ongoing student (of “life” as well as academia), a self-taught Webmaster, and researches and writes articles, reports, and booklets on numerous topics including basic How-To information on sustainable technologies, science and religious/spiritual/supranormal topics, and studies in cultural anthropology. She received her Associate of Arts degree in 2005, and earned a Certificate in Applied Anthropology from the University of Texas at El Paso in 2007, which included an internship with Border Interfaith (IAF Affiliate) where her focus was social justice and rural communities (border “colonias”). As of 2008 Sharon is/was pursuing her BA degree in Social Science with a concentration in anthropology.