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# Do it yourself

**Solar collectors â€“ hot water systems**

For the last twenty years, use of solar collector technology has become common in Cyprus, Israel, Greece and other countries that have a lot of sunny days during the year. In Croatia, especially in its southern regions, using of solar collectors started recently. In sunny areas it is possible to save up to 80% of energy for hot water, sometimes even more, while in those less sunny areas savings can vary from 50% to 60%. In Austria, for example, with less sunny days, state greatly helps in the installation of solar collectors.

Solar systems for water heating consists of the solar collector (or more of them), heating reservoirs (heat-isolated water heater with heat regulators) and other equipment (pumps, thermostats, tubes, etc.).

The solar collector is isolated box with a transparent side, below which are tubes with water passing through. The pipes are connected to the sheets, so-called wings which make up the entire interior surface of the collector. Cheaper and less efficient kind of sheets are those from aluminum, whereas those more expensive but more efficient are made from the copper. Wings are painted in black and are attracting solar radiation that passes through the transparent side and hits the black surface of the metal wings and converts into thermal energy. This thermal energy is transferred from the metal wings on the tube (because of physical connection) and heats the water that passes through them. Heated water pressure drains into the reservoir where heat accumulates. It is important that the tank is well isolated and on warm place because it reduces energy loss. The temperature in the collector depends on the season and the amount of solar radiation in the area. During an average sunny summer day temperature in the collector reaches from 60 °C t o 80 ºC, while during the cold but sunny winter day temperature vary from 50 °C to 65 ºC, during the warm and cloudy day from 20 °C to 30 ºC and while during cloudy and cold day 10 °C to 15 ºC. While the temperature in t he collector is higher than temperature that comes in, energy os being saved. Hot water heated in the collector is used in a household for washing dishes, laundry, bathing and showering.

For the purposes of a household smaller solar system, consisting of 2m ² to 6m ² collectors surface and the wa ter tank with 200 to 300 liters, is enough. However, it is worth to install a larger system for example 10 m ² t o 12m ² of collector area with a tank from 750 to 1000 liters. This system can accumulate enough energy e ven during the winter and be connected to central heating system so that it is possible to heat the space, especially when the object is well isolated and there is an additional energy source for example wood (biomass), gas, etc. This method of heating is called active solar heating and it can significantly reduce heating bills.

Simpler solar systems so called thermo-siphons are easy to be made and what is very important â€“ can be mad e cheaply.



**Picture 1. Thermo-siphon principle**

Thermo-siphon solar system uses the natural occurrence of lifting the warmer fluid (in this case water) so that these systems do not need a pump that pushes the medium through the collectors, but the tank must be located above the solar collectors (approximately 60cm).

Organization ZMAG (Zagreb) together with the NGO Green Action (Zagreb) build this kind of system in 2004 and Green Action so far renewed and improved it.

**Self building of solar collectors**

If we take into account the current price of fossil fuels (oil, gas and coal) and electricity EVERY financial investment in solar equipment installation will be paid off. Payback time will most likely be from 8 to 12 years. Solar equipment manufacturers often provide a guarantee on your equipment for 20 years. That means, if the payback period is 10 years, next 10 years energy that is being produced is for free. Since it is a simple technology, there is no reason why solar systems wouldnâ€™t last much longer than 20 years. If we take int o account the energy price increase that awaits us in the near future, payback time will be even lower. You are probably wondering if this technology is so profitable, why it is not more widespreaded? The greatest obstacle for the rapid spread of solar composition is relatively high initial financial investment. At this point the market can offer various types of solar collectors and systems. Prices vary from less expensive and less effective (eg, ordinary flat plate collectors) to more expensive and very effective (eg, evacuated tube collectors). However, the average household solar system costs about 2800 â‚¬, which is still high for the ave rage citizen. As the system is larger and better, proportionaly increases its price.

Another important reason for using solar panels is savings in CO2 emissions. Using solar collectors per year three-member family could save about 2000 kWh (depending on the area and the need for hot water) which means more than half tone of CO2. Examples from other countries show that they recognized the importance of renewable energy sources and are helping individuals to easily overcome the starting financial obstacle. In Slovenia great support have been received for the installation of solar equipment (visit http://www.aure.si) while in Austria you can get a coupon on the street with which you can achieve a subsidy of 50% for the installation of a solar technology! However in our country this kind of practice do

not exist, but it does not mean that solar collectors must remain inaccessible to us. One of the ways to outwit the problem is that we try to engage ourselves in self-construction of solar collectors. In this way, great cost savings can be achieved because we create ourselves one component of the solar system and we by the rest of the equipment. Well presented self-build collectors can be just as effective as the average models of purchased collectors. Most importantly, they can be built by using of simple hand tools. The average price of materials for one collector is about 150 â‚¬. Price will depend on what material will be ins talled, aluminum or copper wings, polycarbonate panels or solar glass. So we combine our cash needs with opportunities and available materials.

**Building of flat plate solar collector**

There are numerous ways of making solar panels at home. We'll show you a design that we took of the Center for Alternative Technology - CAT from Wales in the UK. Although design is not perfect and we ourselves saw many opportunities for improvement, we believe that the process of making is simple and appropriate for beginners. A collector we will make has a surface of 2 m ². For hot water in the household m ost likely will be needed two or three so it's best to instantly buy materials for making all planned collectors. If you buy the rest of the solar equipment, the installer of solar system will assess how great composition you need and what is the appropriate surface of the collector.

**NOTE: For simple calculating the number of collectors/household surface you can use following method**

**â€¢ Winter, collectors surface = number of persons / (m ²)**

**â€¢ Summer, collectors surface = number of persons/2 (m ²)**

Of course this calculation is made on the basis of the average moderate use of hot water, and using solar panels with medium efficiency. Accurate assessment has to be made on the individual needs for the hot water, geographical location that is the average annual insulation, efficiency of the system and the solar heating share.

**Note:** Most often you will not be able to buy materials in exactly given size. For example the size of the aluminum sheets may vary from the supplier, and the same is for glass or polycarbonate panels. Since the aim is to remain as little waste as possible, should be careful when purchasing materials. So in the process of building the collectors we have not given the fixed dimensions and size of individual components so you will need to calculate them accurately in accordance with the materials that you can get. The design is also flexible so that with a little help of the computation power you will be able to extract the maximum from

the purchased material.

It is good to collect on one place all needed materials and tools before the beginning of the work.

Tools and materials ready? We are ready for action! Building of a solar collector begins with the building of the heart of collector â€“ solar absorber. Solar absorber is key part of the collector and through it the energy of the sun converts in the heat. It is composed of the copper pipes (copper bars) and copper or aluminum wings. Aluminum tin for wings is cheaper, but the copper plate heat is better heat guide. It is best to calculate what is cost-effective: less expensive and less efficient collector or a more expensive and more efficient. The procedure of construction is almost the same except copper wings can solder to the pipes and get even better heat transfer properties of the tube with wings. Our experience has shown that when used aluminum tin should be careful that each wing will grip the pipe and is fastened securely.

**First step** is to build the copper grid as on the picture 2.

**Picture 2. Copper grid with aluminum wings**

An important pre-step is well-calculated measures of all components. A prerequisite for this is that we measure the internal wooden frame that will fit in the copper grid with wings - absorber. If the external measure is 2 x 1 meter, then the internal measures will be reduced by the thickness of the board (you may not find the exact board 2 cm thick). Suppose that the internal measures 196x96 cm (2 cm thick boards).

Absorber dimensions will be approximately 193.7 x 96 cm. Two inches should be left for the plastic support (at 1 cm above and below), and approximately three millimeters in length allow for longitudinal expansion. Of course, consider the right blade and measures that will later be placed. Absorber will have a total of 15 wings, three on each horizontal copper tube Ã˜15. And the distance between the vertical pipe will be the same.

**NOTE:** Before cutting the pipe measure following:

- Total length and total width of absorber based on the internal dimensions

- How many individual tubes Ã˜15 and Ã˜22 are included in the fittings

- How long does it leave room for the plastic support (usually 1 cm for each)

Draw all, measure and then cut the pipe.

Cut pipes with cutter as measured. Cut 5 pieces of 15 mm diameter and 10pieces of 22 mm diameter. Output and input pipe (Ã˜22 mm) should be longer than others to come out of the collector box 10 cm. On la rger table or on the floor arrange a copper grid. With wire for cleaning copper clean all the parts where the pipes include in copper fittings. Then you can start soldering. This would be the most difficult part of making the collector for the beginners. If you have opportunity it would be good to learn how to solder with someone who has experience (eg. plumber). If not experiment with the remains of copper pipes and try until you get a combination that does not flush.

**Soldering:**

1. Ensure that all pipes are inserted in the end fittings.

2. With solder lubricate cleaned compounds. In the beginning, do not skimp on the fall, because the quality of the compounds depends on it, a too small amount of lubricate can lead to the compounds that flush. In the time you will realize how much lubricant is enough.

3. Heat the tube with burner which should be soldered. Do not go directly over the flame for future circuit because the paste will burn. Instead, close the flame to the connection point. Depending on outside temperature enough will be to heat approximately less than one minute.

4. Wire for soldering lean on the connection point. If the tube is properly heated wire will melt and enter the pores between the copper pipes. Compound is soldered when a drop appears on the bottom of the circuit.

When you solder all joints, it is necessary to check whether grid empty somewhere. Wait until the last compound cool and pour water into the grid and check all connections. If possible, check the grid under the pressure of tap: first fill the grid with water and shut one end, and then on the other end attach a tube with water under the pressure. Compounds that leak sold again, but first dry well each end of the pipe.

**Second step** is the preparation of aluminum fins. The wings are rectangles cut from aluminum plate with a slot in the middle. They arrange on the copper grid so slot adheres to the copper pipe.

**Picture 3. Well soldered compound**

Since you need 15 wings to be arranged on a copper grid which should correspond to the internal dimension of the framework you need to calculate the dimensions of a wing and all of them cut to size. Slots in the middle of wings will be made with a special tool created for this function in particular.

Once you create it, you can use it again.

**Example of calculation of measures:**

So, we have three wings on each tube, length of a single wing we get if we first measure what is the length of copper tube Ã˜15 after soldering (from the T fitting to the T fitting) and divide by three. We will get about 60 cm.

**NOTE:** The first and last tube is shorter due to the gear and angle fittings. So will the two wings of these tubes be shorter.

Width of the wing is a bit more demanding to calculate because we count how many will be taken after bending, that means after making grooves in the middle.

First: the absorber width is 96 cm (if you want to be sure that will fit put 95.8 cm).

In width we have 5 wings which means 19.16cm. It should be a lenght of a folded wing. So, the not folded wing should at least half size longer than the radius of Ã˜15 is.

According to the formula O=2rÎ , follows:

Volume: O = 2 x 0,75 x 3.14 = 4.71 cm

Half of volume: 2.35 cm

Difference: Î” = 2.35cm â€“ 1.5cm = 0.85 cm

This means that the final width of blade failure 19:16 + 0.85 = 20cm

This may seem complicated but it is not in reality. In addition there will not be a big problem if the wings overlap inside the absorber, or a little space between them. It is important that the entire absorber can fit in a wooden frame.

**Tool for depressions on the wings consists of a base and pads:**



**Picture 4. Tool for depression**

1. The stand is made up of iron in U profiles, which are placed at a distance of 16 mm and fixed together in that position (can be welded or connected by screws to a wooden or metal surface). The stand is long as the wings but can be a little longer.

2. Pads are made up of pieces of hard and took board which is as long as fins, that is affixed by screws copper pipe filled with sand.

With a ready tool for the slots, you can form your aluminum wings. Bending is quite simple - cut piece of sheet lay on the stand so that future slot is exactly in the middle of the wing length. At the plate put a piece of impalement (with the pipe down) and hit with a hammer until it creates the impression on copper pipes - a slot. Slot should be about half as deep tube or slightly more.

Aluminum fins, furthermore, should be attached to a copper grid. Out of metal debris form a metal strip sizes up to about 2 x 6 cm, which means that for every wing needs two aluminum wing strips. At both ends of the strip drill hole as well as on the appropriate places on the wings. Then insert in the hole on wings and strips rivet which is pressed with the riveting tool is pressed so that it is spread and firmly connected on both plates.

**Picture 5. Soldering copper fins on copper tubes**

All the wings should be soldered on a grid as on the picture 5.

In designing a solar absorber with copper wings making process is the same to mounting on the pipe. Copper wings do not need rivets they are attached by soldering on the bars which is the same way that you connect the grid itself. First clean the surfaces to be joined, then apply a paste, but this time one that is already inside solder paste. When the flap firmly attach to the pipe you just need to warm up the torch circuit from one end to another and that's it! If you do not have this paste, you can solder with ordinary.

The solar absorber is almost done! It takes more to paint it with mat black paint, which must be resistant to high temperatures. You paint only the top of the absorber with no rivets. When copper absorber it is best to paint the side where are the pipes because they are directly exposed to the sun light. It will take two layers of paint to fully cover the reflective surface of aluminum.

**Figure 6. Painting of solar colector**

**The third step** is the preparation of the wooden frame. You need to make a wooden frame as in picture 6. Be sure to measure external wooden frame fit the aluminum plate (2000x1000) to place on the back.

**Picture 7. Wooden frame**

Compounds is best fastened with bolts (80x6mm or similar) and wood glue. After you create the box, set the back of the aluminum sheet, which will serve as the back. Attach it to jack screw (20x4mm) each about 20 cm, the first light hitting the metal to wood. Before installing the absorber must be treated with a framework for the protection of wood color. 2 coats are sufficient quality and overall, and a light coating of boats or other varnish that is resistant to atmospheric influence. After the frame is dry, put thermal insulation - mineral wool 5 cm thick, wool and aluminum foil over (a little thicker than the kitchen) that will serve as a physical barrier between the solar absorber and mineral wool and will reflect some heat back to the absorber. Attach the aluminum foil to the inside edge of the stapler frame.

Now everything is ready to set the absorber. Before putting the holes must be drilled for the inlet and outlet pipe with diameter of 22 mm. It is best to pass on the absorber and outline a framework where to drill the holes. Absorber has to stand between the insulation and the underside of the transparent plate on the top.

Ideally, when the absorber as little touches top and bottom and edges so that as little heat is lost. When you drill the holes for the inlet and outlet pipe should be cut and a triangular piece of wood so that the absorber can sit in a box. After inserting the absorber paste back the triangular pieces of wood and attach scrw so that the absorber canâ€™t fall out of the box.

Only then you can seal the absorber with triangular pieces that stick and mix of sawdust and "DRVOFIX". That he would not advance within the framework, it is necessary to reinforce it with the plastic holders for tubes that connect the screws on the wooden frame.

For the stretching temperature (do not forget, your absorber will heat every day, and cool at night) it is necessary to leave about 3mm space from the top and bottom so you can â€œworkâ€• in length (spread and collect).

**The fourth step** of making a solar collector is a set of glass or polycarbonate panel. The last step of making a solar collector is putting the glass or polycarbonate panels.

**There are two ways of setting.**

1) So the transparent plate "fits" within the wooden frame

If you calculated well the external dimensions, transparent panels should match the internal dimensions of the wooden frame so that the plate easily, "intrusion" into the interior of the box. How plate wouldnâ€™t act ually broke into the box, you need to put bars to the inside on which plate "sits". Then the edges (left, right and top, not on the bottom so it will be easier to drain rain and snow) placing wooden slats (or aluminum profiles) which will keep the plate canâ€™t fall out of the box. Rails must also protect the protective paint for woo d, and the connections between rods and plates should also be sealed with silicone.

2) So that the transparent plate "sits" on the wooden frame

External dimension of the transparent plate should than match the external dimensions of the wooden frame so that the panel â€œsitsâ€• on the box. After this, the structure has to be closed with aluminum L profiles at the edges (left, right and top). Aluminum profiles are easy to cut with saw for metal, and attaches to the lateral edge of small wood screws. When setting up the glass ensure that the glass does not slip down because of its weight. This is solved by setting the two "hook" -the carriers to the bottom edge of the collector. Hooks is easy to make from the remains of copper pipes, which are cut in half the length of a hammer and flatten

easily shaped and processed. After placing transparent plate, edges between the glass and aluminum have to be sealed with silicone sealant.

In both cases the panels should be 5-10 cm longer than the edge of the bottom for straining water from the collector.

**Note:** Both methods are suitable, only the principle of the aluminum profiles is easier because internal strip as a carrier is not needed.

**Congratulations! Your first solar collector is done!**



**Picture 8. Solar collector made by members of NGO Green Home and ZMAG**

**Installation and connection of the collector on the solar composition**

To collect the most solar radiation collector should face the south and possibly choose a place that has no shade. Pitch angle is calculated roughly by the collector if you use it more in the summer, the slope is the geographical width - 10 degrees, meaning about 35Ëš in our regions, or in the winter geographic width + 10 de grees, meaning about 55Ëš. If using the year we put signs around the mean angle that corresponds to the va lue of latitude. The reason for this is that the apparent path of summer sun is higher and the intrusion angle is greater so we have to "laid" collectors more. The same with the winter sun, where the path is lower and we have to raise the collector more of the country.

Connecting the collector tank is quite complex (unless you are very skilled with installation), so it's best to let the professionals, especially if you purchase the tank and other equipment. Another possibility is to create the rest of the composition of the do-it principle. We attach a draft so you can make yourself a simple structure for storing solar heat. It is important to know that in this part of the pressure that does not normally occur in water installations, which means that the water on the final status out under less pressure. But if you put the tank to a higher position than shower, water will begin to flow sufficiently high pressure that you can take a shower. According to our experience this composition will be sufficient for 3-4 people to shower in the warmer months.

**Picture 9. Simply connection of a thermosiphonic solar system**

The text was prepared based on information and knowledge of NGOs ZMAG and Green Action, Croatia.