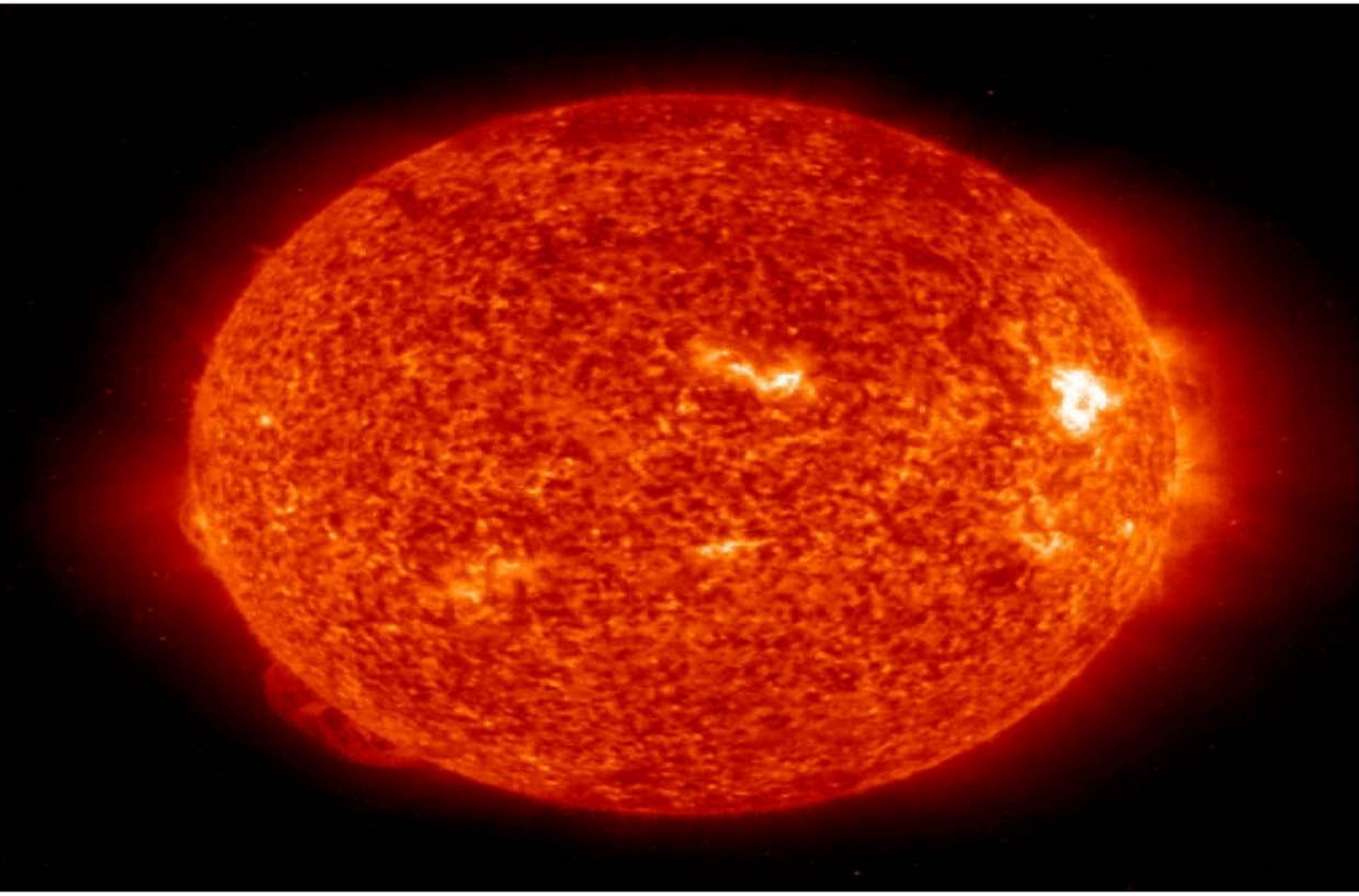
Solar Manual



HOW TO CONSTRUCT A SOLAR COLLECTOR

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WECF –Women in Europe for a Common Future

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We live in a rapidly changing world. Technological advances are increasing productivity and income, quality of life, and life expectancy. The truth is that technological development is focused on meeting the wants of rich consumers. Scant attention is paid to the vital needs of people in the developing world. The arrival of new technologies often results in a wider gap between rich and the poor. Yet some innovations fail to be applied in developing countries where there is real need.

WECF and its partner's projects aim to enable poor people to assess and respond to the challenges of new technologies, and to develop and adopt applications that improve their livelihoods.

Through our activities we:

- Enable poor people to assess the opportunities and threats presented by new technologies
- Identify and test potential opportunities for poverty reduction presented by new technologies
- Ensure that policies, regulations and institutions are favorable to poor people and can be influenced by poor people themselves

Preface

Use of solar energy offers a safe, environmentally less destructive technology that can usher in a new era of post-industrial development. Little attention has been paid by current generations of scientists, politicians and planners to develop a society that operates in a framework of environmental and social stability. In the mad rush to plunder the earth of its decreasing supply of non renewable resources, the planners of today's industrial world have forgotten the needs of future generations.

The energy we receive from the sun is our birthright like the air we breathe or the water we drink.Dependence on non renewable energy such as fossil fuels is no longer necessary. The exploitation of resources and people for economic growth is no longer necessary. The absurdities of our current high energy era can only be corrected if gentle policies of change are implemented.

It will take more than a few solar collectors to encourage people to live in harmony and bridge the gap between technical and social evolution.

Introduction

Solar radiation represents the earth's most abundant energy source. Apart from its direct form, solar energy is responsible for creation of other renewable energy sources such as wind, flowing streams and rivers, photosynthetic production of biomass, and thermal gradients in the ocean. Solar energy is being used by humankind from time immemorial for various purposes.

More recent applications of solar energy, like its direct conversion to electricity and transformation to thermal energy at various temperatures, have expanded its potential use enormously.

This energy resource has a number of characteristics that make it a very desirable option for utilization. The perennial source of solar energy provides unlimited supply, has no negative impact on the environment, is distributed everywhere, and is available freely.

In Georgia the annual global solar radiation is about 5 kWh/m2 per day with about 2100– 2200 sunshine hours per year.

Solar energy can be exploited for meeting the ever-increasing requirement of energy in our country. Its suitability for decentralized applications and its environmentally friendly nature make it an attractive option to supplement the energy supply from other sources. Through implementing solar energy programmes with the objective of providing electricity to the rural and remote areas, making energy available for pumping of water for irrigation and drinking water supply, generating thermal energy for water heating, cooking, distillation of water and for drying of farm products it is possible to enhance sustainable development of rural communities.

This manual discusses basic principles of solar collector design, as well as different construction material options depending upon the availibilty of materials and affordability of costs.

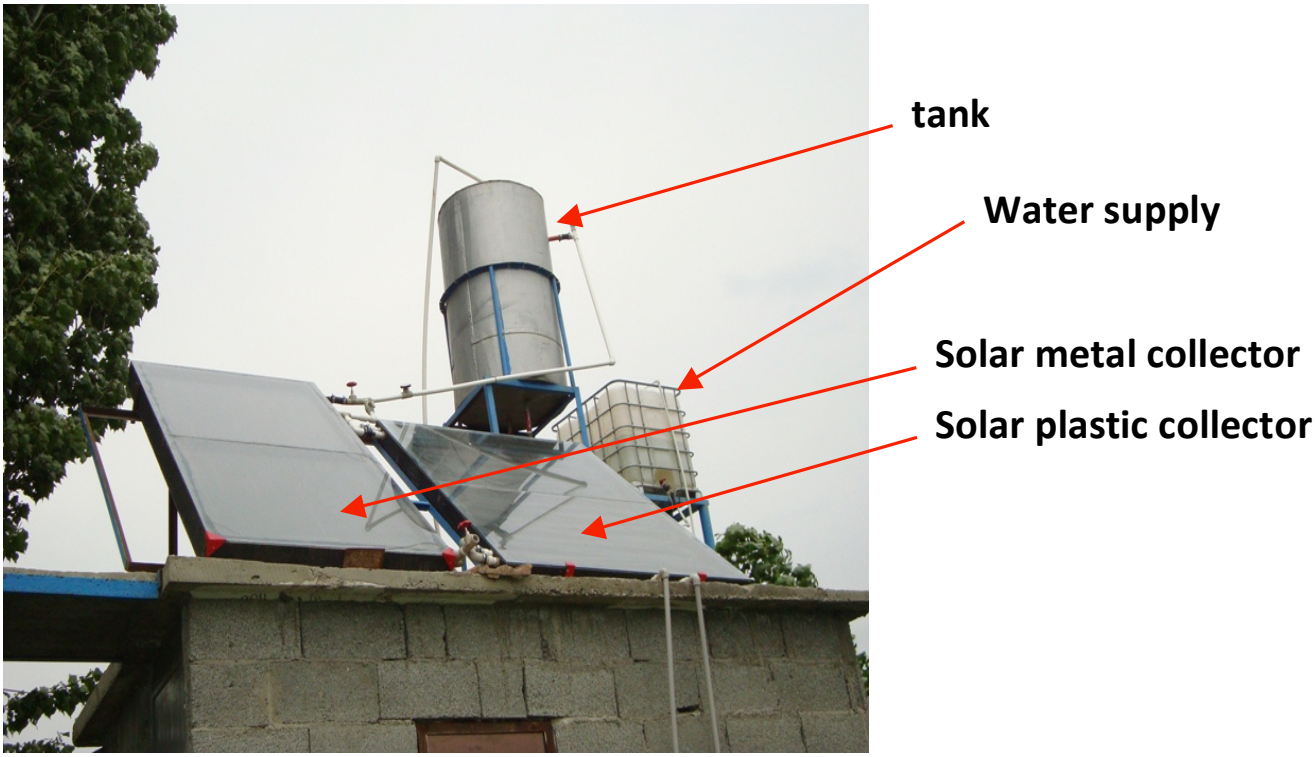
SOLAR COLLECTORS

Solar Hot Water Systems (otherwise known as Solar Thermal) use the sun's energy to heat hot water through solar collection panels.

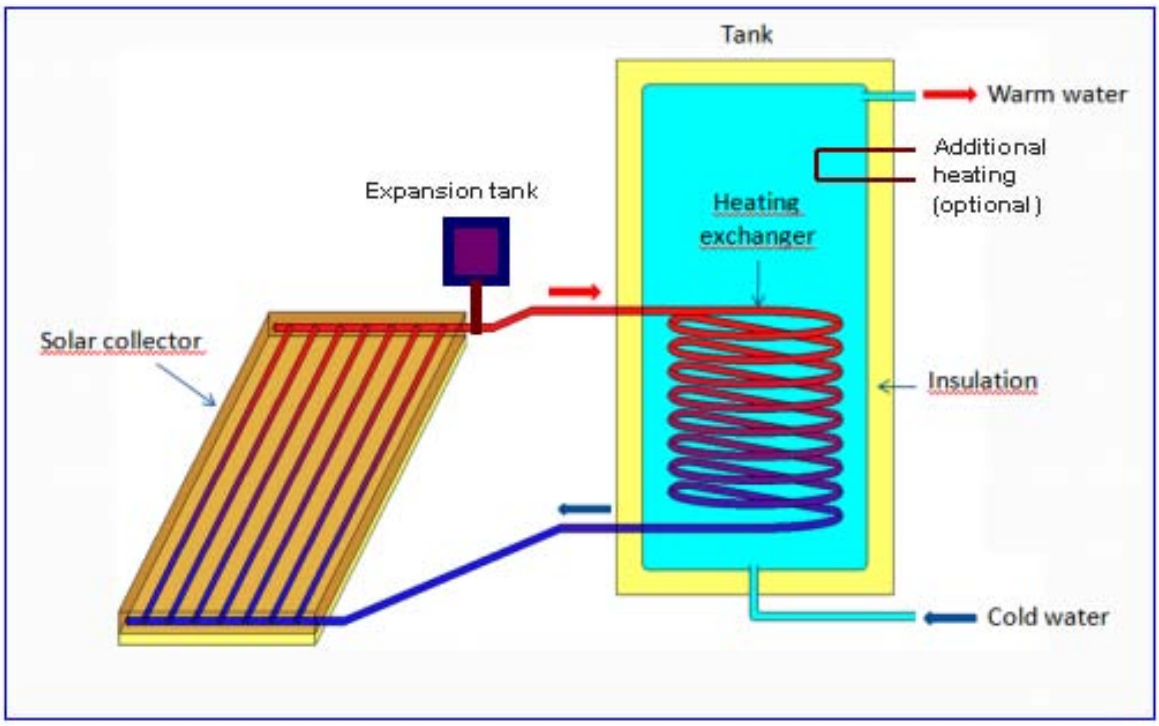
Solar thermal can be used in both residential & commercial applications, storing water in hot water cylinders until required. This system does not create pollution or harmful emissions and is extremely economical.

True Energy's solar hot water system works side-by-side with original water heating system to ensure hot water is always available from the most cost effective route available.

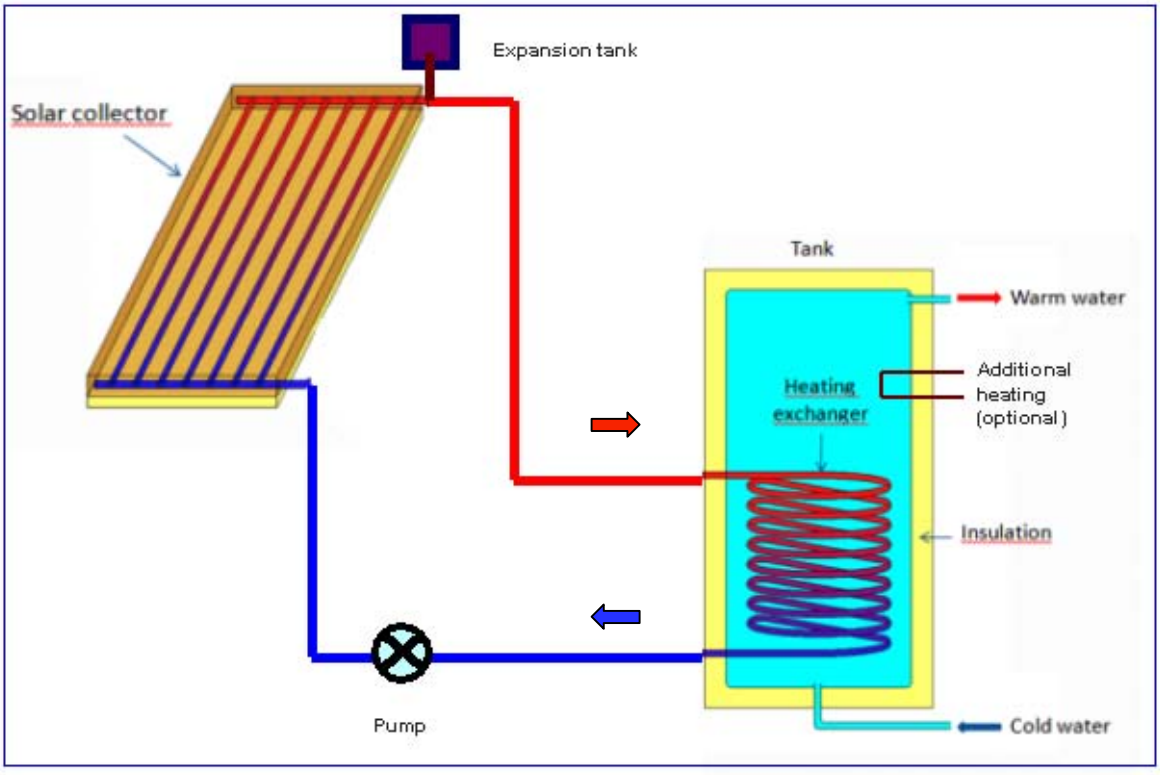
General Schemes of Solar Water Collectors



Pic1. Water solar collectors



Pic2. Passive Solar water heater scheme



Pic3 . Active Solar water heater scheme

Energy from sunlight in the form of heat is transferred to a water/antifreeze solution which is circulated through insulated pipes from the collector to the heat storage tank or vault. In the pictures, red color represents hot water/antifreeze. As this mixture is circulated around the solar storage tank it gives up it's heat to the supply of domestic hot water. On the return trip to the collector the water/antifreeze mix has been cooled by releasing its heat to the domestic hot water supply.

The storage tank water is used to preheat water used for domestic hot water. If the temperature of storage tank water is heated sufficiently additional conventional heating would not be required. The temperature difference between the solar storage tank water and the desired water temperature would determine the amount of conventional energy required to heat your domestic hot water.

Types of Solar Water Heaters

There are two basic types of solar water heaters, active and passive. Active systems depend on external power to run pumps to circulate the heat they gather; passive setups don't. Passive systems may be less efficient at any given moment, but they are much more undependable and cost less per unit of heat captured. Integral passive solar water heaters, also called batch heaters, are the simplest of the passive systems, and their reliability and independence from external power lead to long-term production at a very low cost.

Solar Hot Water Passive System

1. Easy to install and maintain
2. No moving parts
3. Storage tank must be installed above or close to collector
4. Uses no electricity
5. Will function during blackouts

Solar Hot Water Active System

1. Complex system
2. Pumps, valves & controllers assist in the prevention of freezing
3. Tanks do not need to be installed above or close to collectors
4. Uses electricity
5. Will not function during blackouts

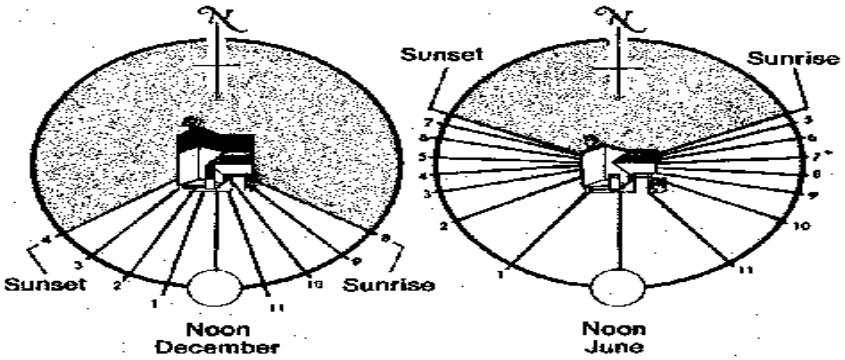
Location of Solar Collector

To get the full benefits of a solar heater you must have an area for the solar collectors that is large enough and has the proper exposure to the sun. A flat roof is ideal because the collectors can usually be oriented to face the sun directly very easily. If you install the collectors on a pitched roof, the ideal direction the roof should face is south. If the collector cannot be installed at the roof, it can also be installed at the ground near to the house. In any case, the collector always should face directly south.

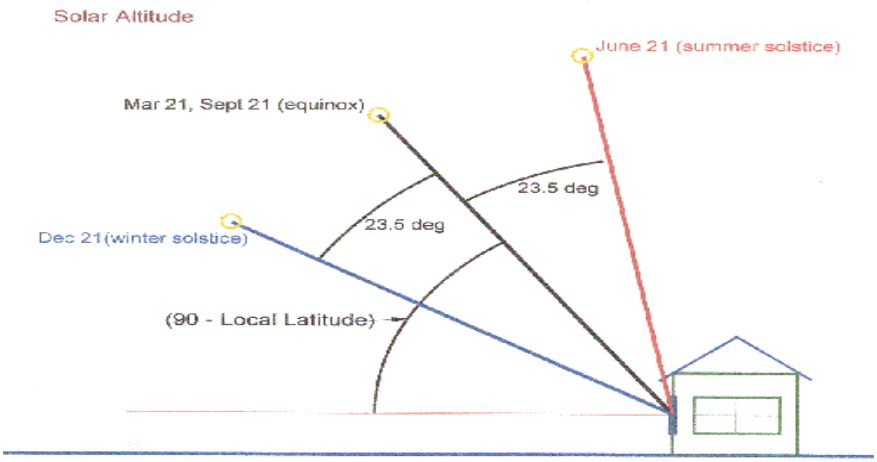
There are two basic questions to answer to determine if solar can work well at your location:

1. Does your location get enough sun?
2. Do nearby obstacles (trees, buildings, etc.) at your location block too much sun?

The first question depends on how cloudy your weather is. Within Georgia, almost all locations get enough sun to successfully use solar energy, but some are better than others.
In planning a solar collector location, it is important to make sure that the sun will shine on the collector during all the parts of the year that you want it to. That could be found out by the following site survey.

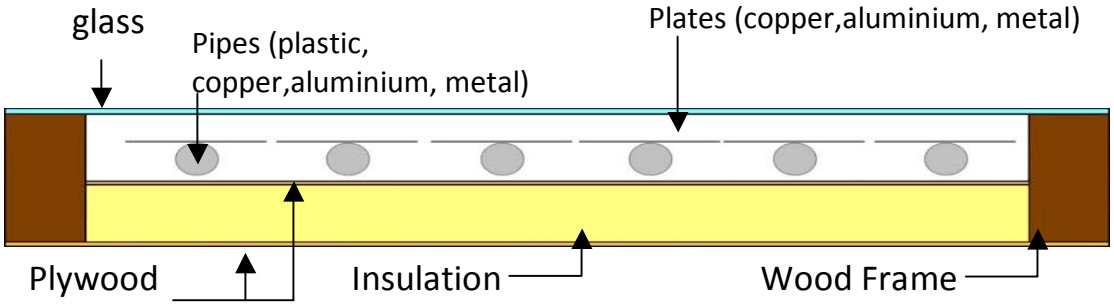


The diagram below shows sunrise/sunset positions for the summer and winter solstices, and the suns altitude at the solstices and equinoxes.



Construction of Solar Collectors

The basics of all kind and types of solar hot water collectors are: wood frame, plywood, insulation, glass cover



Pic1. Cut view of the solar panel

Dimension of collectors

Dimension of solar collector depends on:

- Amount of warm water needed
- Number of household members

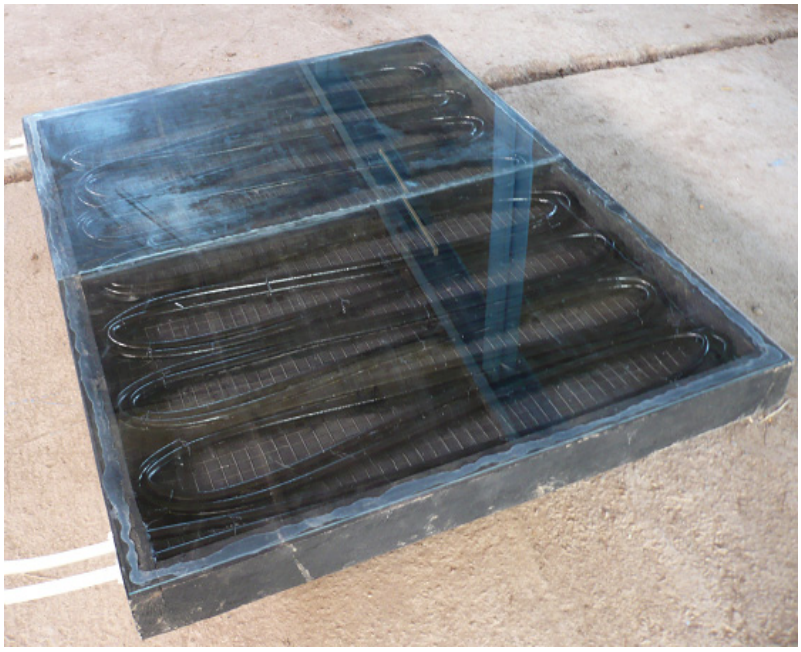
For each 50L of hot water 1 square meter of solar collector is needed.

Constructing Solar Collector with Plastic Heat Absorber

I. Materials for Collector

1. Pine beams 100 mm x 50 mm with few knots, 6 m
2. Wood strips 50mm x 50 mm x 4 m
3. Plywood 0.4 mm, 2 m^2
4. Insulation material, 2 m^2
5. Metal mesh 2mm, 2 m^2
6. Heat resistant plastic pipe (e.g. compound pipe for floor heating) 15-20 mm, 40 m
7. Galvanized nails with small heads, 0.5 kg
8. Sixteen drywall screws 80mm
9. 750g black paint (non-toxic; for inside paints e.g. pigment paint)
10. Half kilogram of solar varnish/lacquer
11. Glass for cover, 2 m^2
12. One tube silicone glue
13. Materials for plumbing

- Eight 3/4 to ½ adaptors
- Four ½ T's
- Six ½ X ½ X ¾ T's
- Two ¾ T
- One pressure relief valve



COLLECTOR BUILDING INSTRUCTIONS

Step 1. Cut framing boards

Step 2. Assemble frame

Step 3. Fasten collector bottom and sides

Step 4.Cover the bottom frame with plywood

Step 5. Drill inlet, outlet and vent holes

Step 6. Install insulation

Step 7. Cover the upper part of frame with plywood

Step 8. Install metal mesh for plastic absorber

Step 9. Paint the upper part with black paint

Step 10. Make the serpentine from plastic pipe

Step 11. Adjust the serpentine pipe to metal mesh in the frame and paint black

Step 12. Cover the frame with 4 mm thick glass using special metal bars or silicon glue

Step 13. Install plumbing outlets and inlets

Step 14. Connect the collector to the exchanger in the tank

Constructing Solar Collector with Metal Heat Absorber

I. Materials for Collector

1. Pine beams 100 mm x 50 mm with few knots, 6 m
3. Wood strips 50mm x 50 mm, 4 m
4. Plywood 0.4 mm, 2 m^2
5. Insulation, 2 m^2
6. Metal tin 1.5-2mm, 2 m^2
7. Metal pipe ½, 15 m
8. Metal pipe ¾, 2 m
9. Galvanized nails with small heads, 0.5 kg
10. Sixteen drywall screws 80mm
11. 750g black paint (non-toxic; for inside paints e.g. pigment paint)
12. Half kilogram of solar varnish/lacquer
13. Glass for cover, 2 m^2
14. One tube silicone glue
15. 2mm Welding die
16. Materials for plumbing

- Eight 3/4 to ½ adaptors
- Four ½ T's
- Four Six Four x ½ X ½ X ¾ T's
- Two ¾ T
- One pressure relief valve

COLLECTOR BUILDING INSTRUCTIONS

Step 1. Cut framing boards

Step 2. Assemble frame

Step 3. Fasten collector bottom and sides

Step 4. Cover the bottom frame with plywood

Step 5. Drill inlet, outlet and vent holes

Step 6. Install insulation

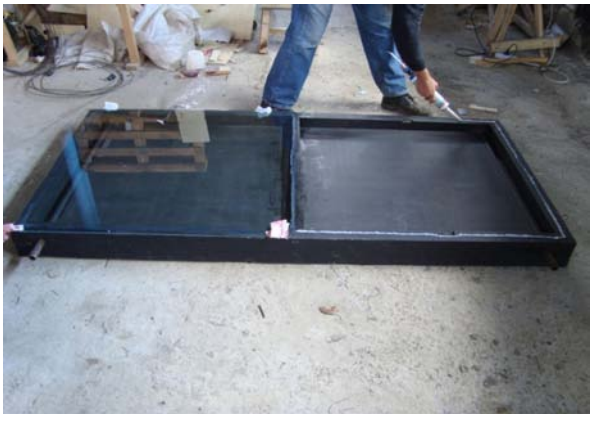
Step 7. Cover the upper part of frame with plywood

Step 8. Cover the frame and upper part with black matt paint

Step9. Drill 8 holes 12 mm in ¾ metal pipes at a distance of 11 cm

Step 10. Weld the ½ mm pipes to ¾ pipes

Step 11. Weld to each other the metal tin and the pipes



Step 12. Cover with black matt paint or solar lacquer the metal foil and pipes from both sides

Step 13. Install the absorber into the frame

Step 14. Cover the frame with 4 mm thick glass using special metal bars or silicon glue

Step 15. Install plumbing outlets and inlets

Step 16. Connect the collector to the exchanger in the tank

Step 17. Insulate the pipes and the tank (not insulated on the picture)

Constructing Solar Collector with Copper Heat Absorber

I. Materials for Collector

1. Pine beams 100 mm x 50 mm with few knots, 6 m
2. Wood strips 50mm x 50 mm, 4 m
3. Plywood 0.4 mm, 2 m^2
4. Insulation, 2 m^2
5. Copper foil 0.04-0.08 mm, 2 m^2
6. Copper ½, 15 meter
7. Copper pipe ¾, 2 meter
8. Galvanized nails with small heads, 0.5 kg
9. Sixteen drywall screws 80mm
14. 750g black paint (non-toxic; for inside paints e.g. pigment paint)
15. Half kilogram of solar varnish/lacquer
10. Glass for cover, 2 m^2
11. One tube silicone glue
12. 2mm Solding die
13. Materials for plumbing

- Eight 3/4 to ½ adaptors
- Four ½ T's
- Four Six Four x ½ X ½ X ¾ T's
- Two ¾ T
- One pressure relief valve

COLLECTOR BUILDING INSTRUCTIONS

Step 1. Cut framing boards

Step 2. Assemble frame

Step 3. Fasten collector bottom and sides

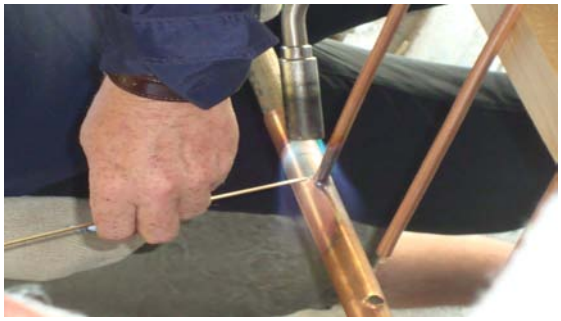
Step 4. Cover the bottom frame with plywood

Step 5. Drill inlet, outlet and vent holes

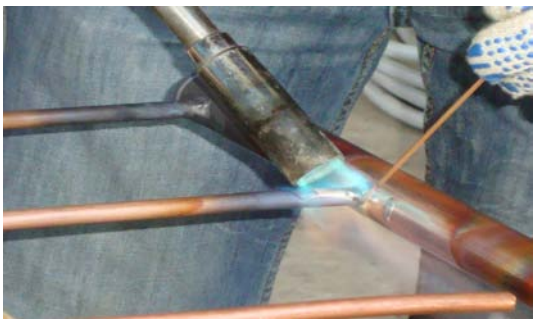
Step 6. Install insulation

Step 7. Cover the upper part of frame with plywood

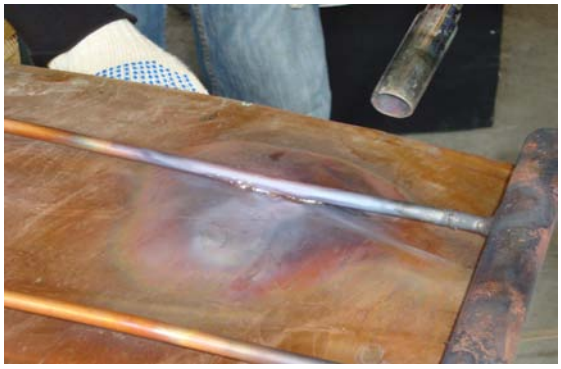
Step 8. Cover the frame and upper part with black matt paint



Step 9. Drill 8 holes 12mm in ¾ copper pipe In a distance ot 11 cm



Step.10. Weld the ½ mm pipes to ¾ pipes



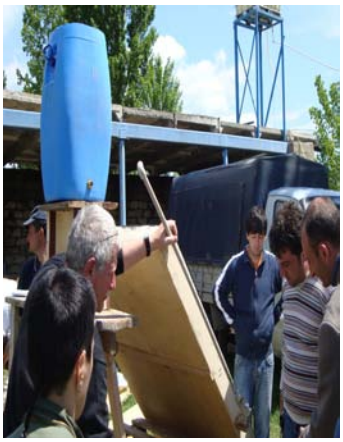
Step 11. Weld the copper foil and the pipes to each other

Step. 12. Cover with black matt paint or solar lacquer the copper foil and pipes from both sides

Step 13. Install the absorber into the frame

Step 14. Cover the frame with 4 mm thick glass using metal bars or silicon glue

Step 15. Install plumbing outlets and inlets



Step 16. Connect the collector to the exchanger in the tank

Step 17. Insulate the pipes (pipe insulation not on the picture) and the tank

Simple water tank without heat exchanger – hot water from collector goes in at the middle of the tank, and colder water goes back from the tank from the down part. Warm water for use always has to be taken from the upper part of the tank.

How to make a Solar Heat Exchanger

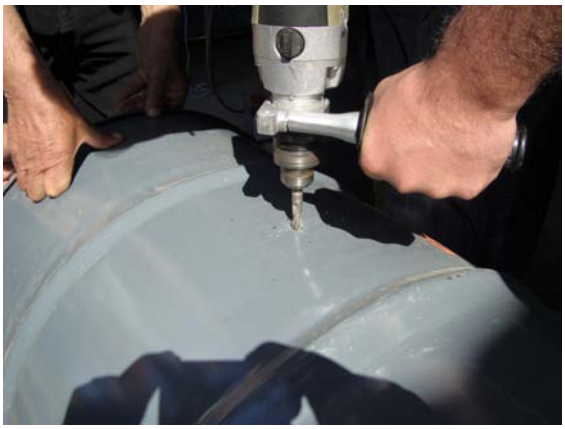
The heat exchanger consists of a water tank with a serpentine made of plastic tubes. Liquid from the collector circulates through the tubes and so the water in the tank is heated.

Materials for Heat Exchanger

1. Plastic compund Pipe (e.g. pipes for floor heating) 15-20 mm, 6 meter
2. Adapters
3. Antifreeze / glycol fluid for circulation – about 10 L

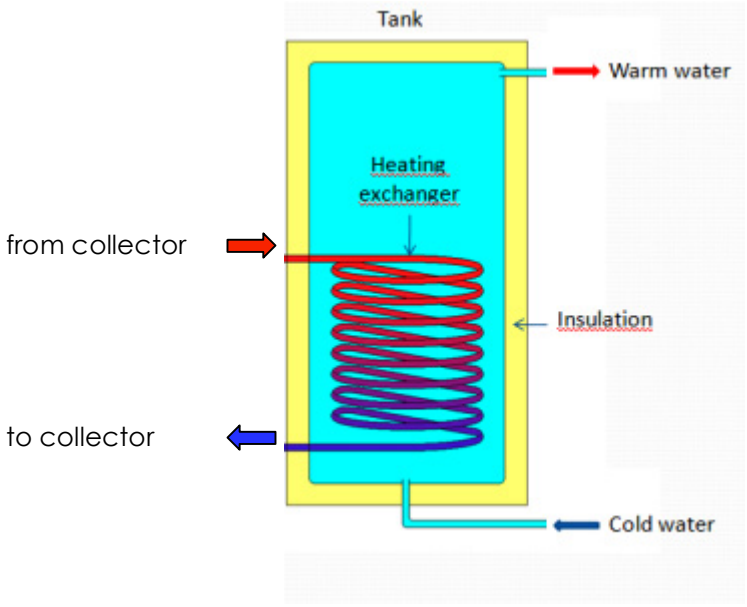
Step1. Make the serpentine

Step 2. Adjust the adapters at both ends of the serpentine



Step 3. Drill the holes for adapters to the heat exchanger in the tank on the down part and for the connection to the collector one hole on the upside (water out), one hole on the downside (water in)

Step 4. Put the exchanger into the tank and fix the ends with adapter plate (see also graphic below)



Step 5. Connect to the collector (upside: water in, downside: water out) and to the water suppy system (downside: cold water in from storage tank or water supply;
upside: warm water out to user)

Step 6. Insulate tank and pipes

Step 7. Fill collector with anti-freeze liquid

Step 8. Fill tank with water

Insulation

Insulation is essential:

- For the collector
- For the tank
- For the pipes

Types of insulation

- Natural (wool, straw, …)
- Mineral wool (dangerous for health!)

Practical hints

Silicone: The use of silicone for fixing the glass cover has the big disadvantage that the glass can hardly be removed without breaking if something has to be fixed inside the collector. For this reason, special metal bars are used e.g. in Germany, with a rubber sealing (see pictures below)

Black Paint: For painting the absorbing parts of the collector, a special solar lack is recommended, as usual black paints can evaporate when it gets hot and within a while the cover glass will be black. If there is no solar lack available, you should use where possible a non-toxic (water soluble) paint, e.g. pigment paint.
The paint has to be completely dry before you put the glass cover (to avoid condensation).

Insulation: If you use mineral wool, glass wool, etc. you should be aware of the fact that inhaling the fibers is dangerous for your health and can cause cancer. These materials should be carefully handled.

Costs of Solar Collectors

Solar Collector with Plastic Absorber

Materials	Measure unit	Amount	Price p/unit	Cost (€)
Wood frame	m^3	0.06	250	15
Ply wood	m^2	4	6	24
insulation	m^2	2	3	6
plastic pipes 25mm	m	36	1.2	43
Wire mesh	m^2	2	5	10
paint	kg	3	4	12
Glass	m^2	2	6	**12**
Total				**122**
Overhead costs[1]	%	10		11
Grand total				**133**

Solar Collector with Metal Absorber

Materials	Measure unit	Amount	Price p/unit	Cost (€)
Wood frame	m^3	0.06	250	15
Ply wood	m^2	4	6	24
insulation	m^2	2	3	6
pipes 1/2	m	15	1.2	18
pipes 3/4	m	2	2	4
metal foil	m^2	2	10	20
glass 4mm	m^2	2	6	12
paint	kg	2	4	8
solding				
Total				107
Overhead costs	%	10		11
Grand Total				118

[1] The overhead costs include costs for small items like screw, nails, electrodes, solding.

Solar Collector with Aluminum Absorber

Materials	Measure unit	Amount	Price p/unit	Cost (€)
Wood	m^3	0.06	250	15
Ply wood	m^2	4	6	24
insulation	m^2	2	3	6
pipes 1/2	m	15	1.8	27
pipes 3/4	m	2	4	8
aluminium foil	m^2	2	15	30
glass	m^2	2	7	14
paint	kg	2	4	8
solding				
Total				132
Overhead costs	%	10		13
Grand total				145

Solar Collector with Copper Absorber

Materials	Measure unit	Amount	Price p/unit	Cost (€)
Wood frame	m^3	0.06	250	15
Ply wood	m^2	4	6	24
insulation	m^2	2	3	6
pipes 1/2	m	15	4	60
pipes 3/4	m	2	7.5	15
ply copper	m^2	2	20	40
glass	m^2	2	6	12
paint	kg	2	4	8
solding				
Total				180
Overhead costs	%	10		18
Grand Total				198

Summary

There are many flat-plate collector designs but generally all consist of: (1) a flat-plate absorber, which intercepts and absorbs the solar energy, (2) a transparent cover(s) that allows solar energy to pass through but reduces heat loss from the absorber, (3) a heat-transport fluid (air, antifreeze or water) flowing through tubes to remove heat from the absorber, and (4) a heat insulating backing

Some types of collectors are specifically designed to contain potable water.

In areas where freezing is a possibility, metal collectors (with simple tanks without heat exchanger) must be carefully plumbed so they completely drain down using gravity before freezing can happen so that they do not crack.

Other recently developed collectors are freeze tolerant instead. These can freeze without damage because their water channels are typically made of food grade polymers such as silicone rubber, which is flexible and remains stable at temperatures of 200°C.

Other collectors are part of a sealed heat exchange system, rather than having the potable water flow directly through the collectors. A mixture of water and propylene glycol (which is used in the food industry) can be used as a heat exchange fluid to protect against freeze damage, up to a temperature that depends on the proportion of propylene glycol in the mixture. The use of glycol lowers the water's heat carrying capacity only marginally, while the addition of an extra heat exchanger may lower system performance at low light levels.

The efficiency of the Solar Collectors depends upon:

1. Your Location
2. The orientation of your roof
3. The angle that you position your collectors
4. The number of collectors used
5. How well you insulate the collector and the pipes
6. The size of your heat storage tank
7. The amount of insulation used on the heat storage tank
8. The amount of hot water used

OUR SUN and OUR FUTURE

Our Sun is about five billion years old and accounts for 99.9% of the total mass of this solar system. Most scientists are optimistic that we'll still have a functional sun billions of years from now.

DIAMETER: 1,390,OOO km REA:
MASS: 1.99 trillion, trillion, billion kg
SURFACE TEMPERA: 5,800 K
CORE TEMPERATURE: 15,600,000 K
ENERGY OUTPUT: 386 billion, billion mega watts/second
POWER LEVEL AT EARTH: 1.4 kilo watts / sq meter

Each second about 700,000,000 tons of hydrogen is converted to about 695,000,000 tons of helium and 5,000,000 tons of energy in the form of gamma rays. As it travels out toward the surface, the energy is continuously absorbed and re-emitted at lower and lower temperatures so that by the time it reaches the surface, it is primarily visible light

Even though solar energy is the largest source of energy received by the Earth, its intensity at the Earth's surface is actually very low due to the large distance between the Earth and the Sun and the fact that the Earth's atmosphere absorbs and scatters some of the radiation. Even on a clear day with the sun directly overhead, the energy that reaches the Earth's surface is reduced about 30 percent by the atmosphere.

When the sun is near the horizon and the sky is overcast, the solar energy at ground level can be negligible. It also varies from one point to another on the Earth's surface.

Nevertheless, in the 21st century, the sun's energy is becoming an increasingly attractive source for small amounts of direct power to meet human needs. A number of devices for collecting solar energy have been developed, and solar energy can be used in a variety of ways.

Distribution of Solar Energy on Earth Surface