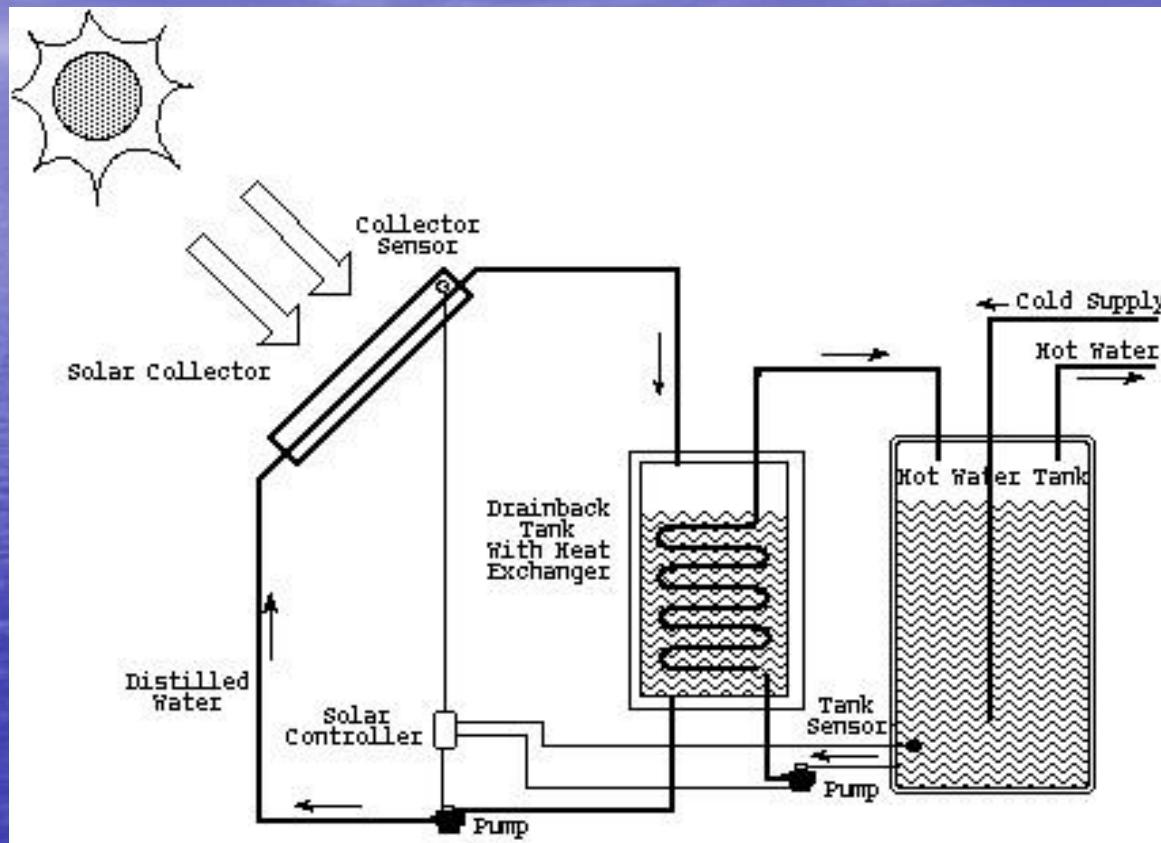


Solar Water Heating Systems



Dr. Bharat Sutaria

Topics Overview

- Types of heating systems
- Hardware
- System applications
- Financial analysis & Economics
- Recommendations
- Case studies

Advantages

- Simple to construct and install
- No or negligible running cost
- Almost maintenance free
- Cost is low & economically competitive with electric water heating systems
- It saves time and high grade form of electric energy
- Require the low temperature up to 100 °C can be achieved by simple flat plate collector.

Four Types of Heating Systems

Natural circulation or thermo-syphon solar water heaters

Forced circulation solar water heating system

Direct or Open Loop System

Indirect or Closed Loop System

Active System

Passive System

Open & Closed Loop Design Characteristics

Open Loop System

- Solar heated water flows directly into existing water heater, or secondary storage tank
- Used in household and pool applications
- Water flowing across panels is what comes out of the faucet

Closed Loop System

- Antifreeze (glycol) is used along with a heat exchanger to transfer heat
- More common in household applications
- Liquid flowing across panels does not mix with faucet water

Open Loop System Comparison

✓Advantages

- Less expensive type of system, no heat exchanger implementation
- Easier to interface with current system
- Good efficiency
- Good for warm climates where freezing is unlikely

• Disadvantages

- System can freeze in cold climates
- System can overheat
- Pipes do not completely drain when not in use
- Repair is expensive!
- May be more difficult to fit to existing system

Closed Loop System Comparison

✓ Advantages

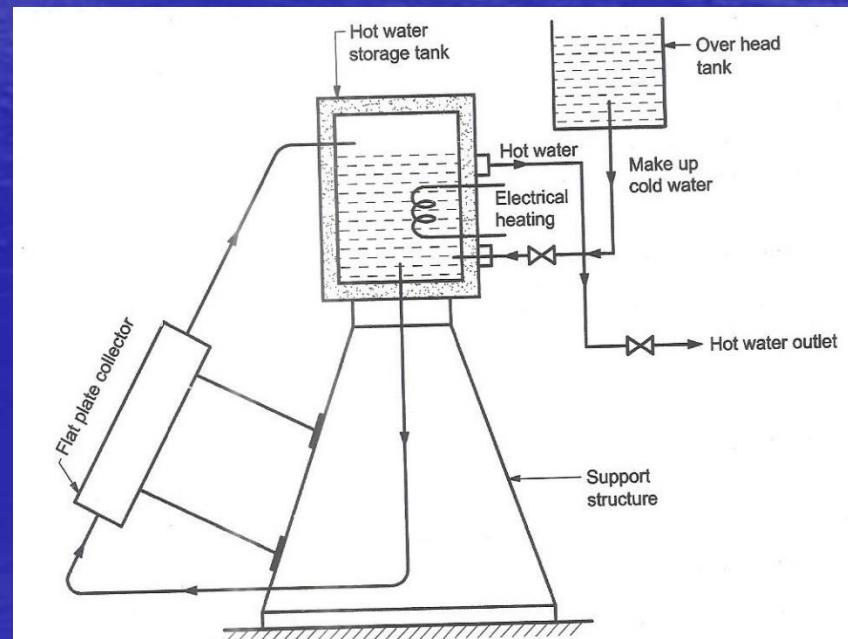
- Will not freeze
- Will not overheat
- Good for cooler climates where freezing is likely
- Pipes drain when system is not working

• Disadvantages

- Must purchase antifreeze
- Must implement heat exchanger
- May be more difficult to fit to existing system

Passive Systems

- Simple, small capacity (up to 200 liters)
- Main components are:
- Flat plate collector, hot water storage tank, over head tank and supporting structure, piping, elbow, valve etc.
- Very heavy & Ugly to look at
- Will not freeze
- Utilizes thermo-syphon
- Not very efficient—especially in low intensity sunlight

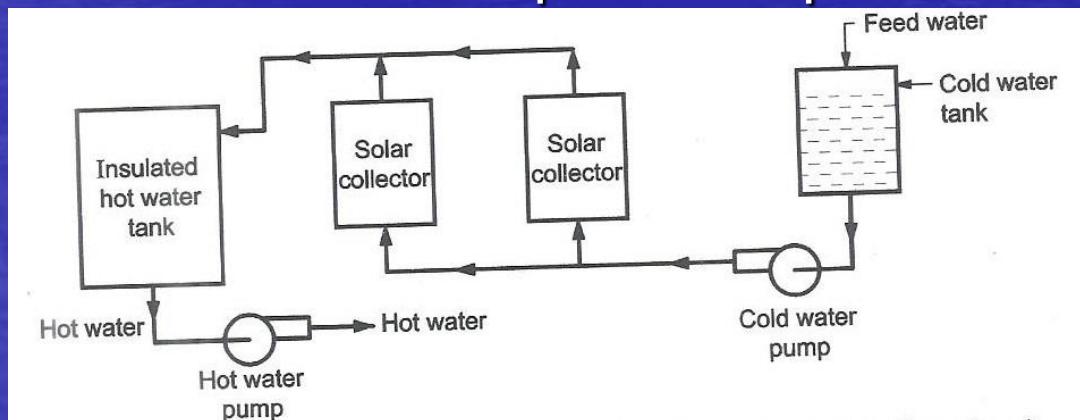


- Flat plate collector is installed facing south at an inclination equal to the latitude of the place of installation.
- Well insulated water tank with pipe having thick insulation are connected at the two ends of the flat plate collector.
- Tank is placed 30-60 cm height relative to top of solar collector.
- Supply a cold water as make up water from over head tank to the hot water storage tank.
- Entire system is well supported on a structure.

- As water is heated in the flat plate collector due to incident solar radiation, hot water rises up and flows naturally to the storage tank due to decrees in its density.
- Colder water from the bottom of storage tank having higher density replace the hot water.
- Thus density difference of hot and cold water provides a driving force to setup natural convection for circulation of water through a storage tank and the solar collector.
- Passive system does not need any mechanical device to circulate the water in the systems.
- To provide hot water during long cloudy periods or rainy days an electrical heating system is provided as back up systems.
- It is more necessary particular in place having cold climates where solar radiations are low.

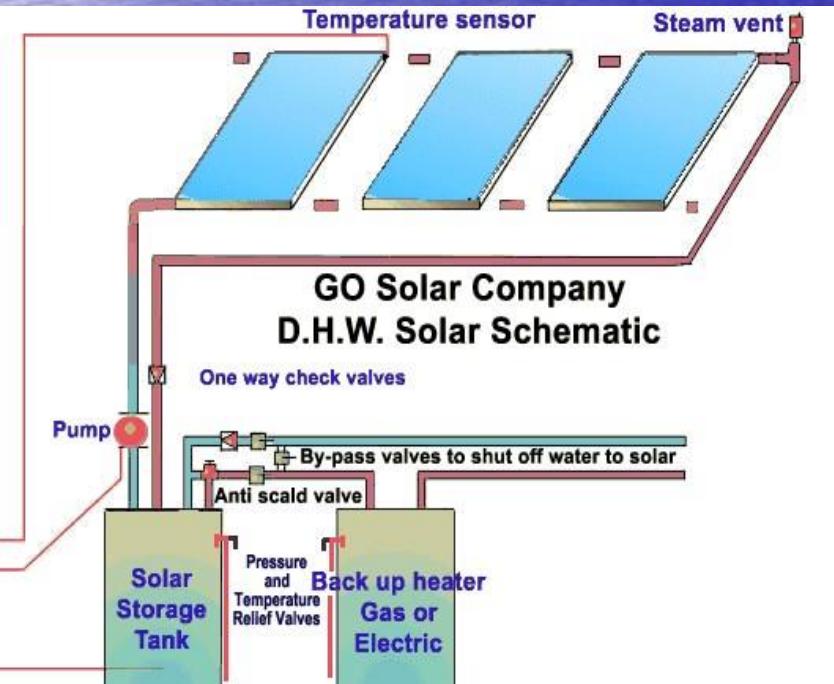
Force circulation water heating system (open loop)

- Component of the systems are cold water tank, pump, array of the solar collectors, insulated hot water tank and pump
- Cold water is pumped from cold water tank to solar array of solar collector.
- The heated water from collectors flows into the insulated hot water tank from where it is drawn with the help of the pump for use.
- Proportional flow controllers are used to vary the pump speed so that the hot water flows out at the required temperatures from the solar collectors.

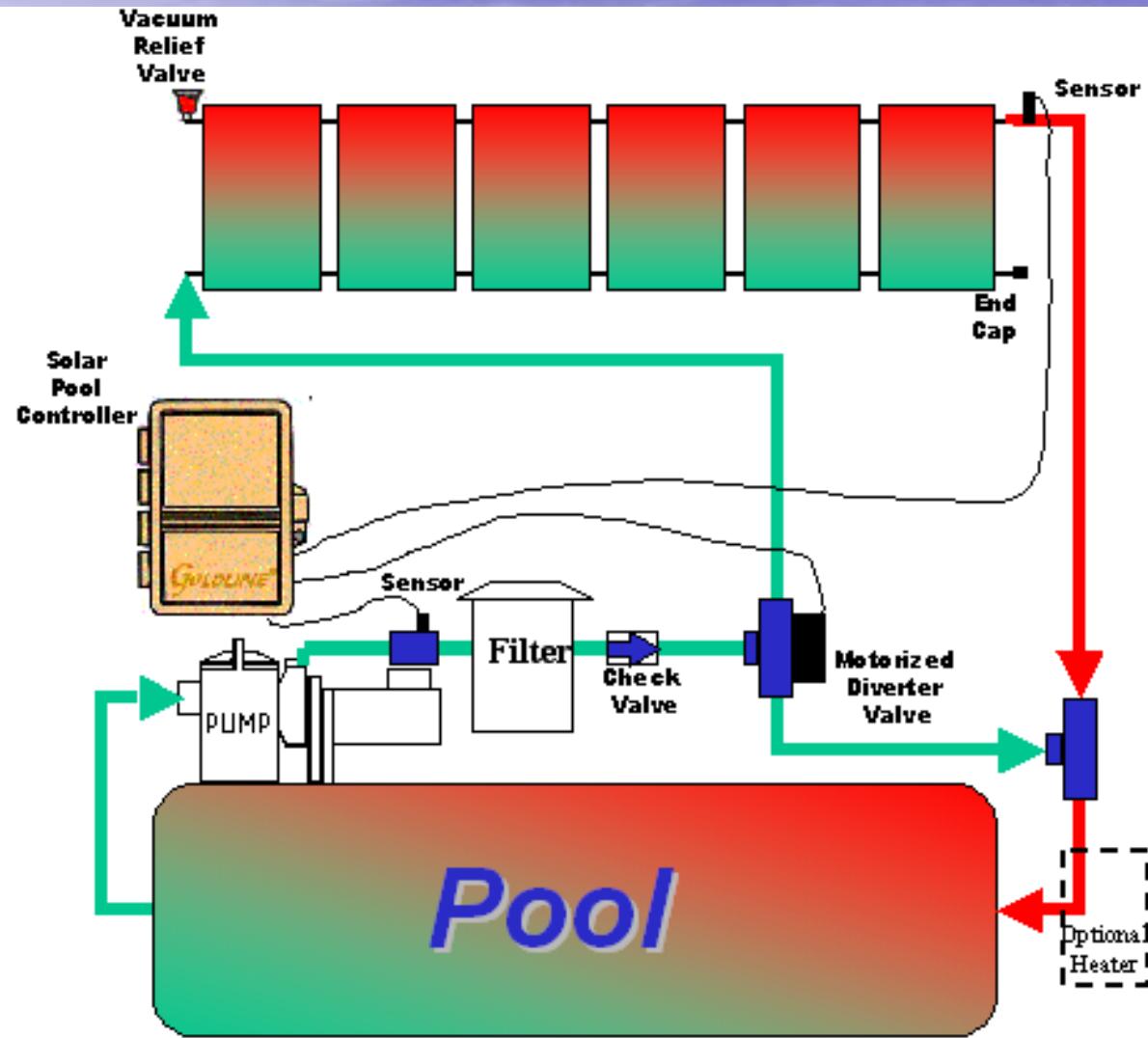


Open Loop System Household Application

Solar heated water runs directly into a secondary storage tank, or an existing hot water heater.

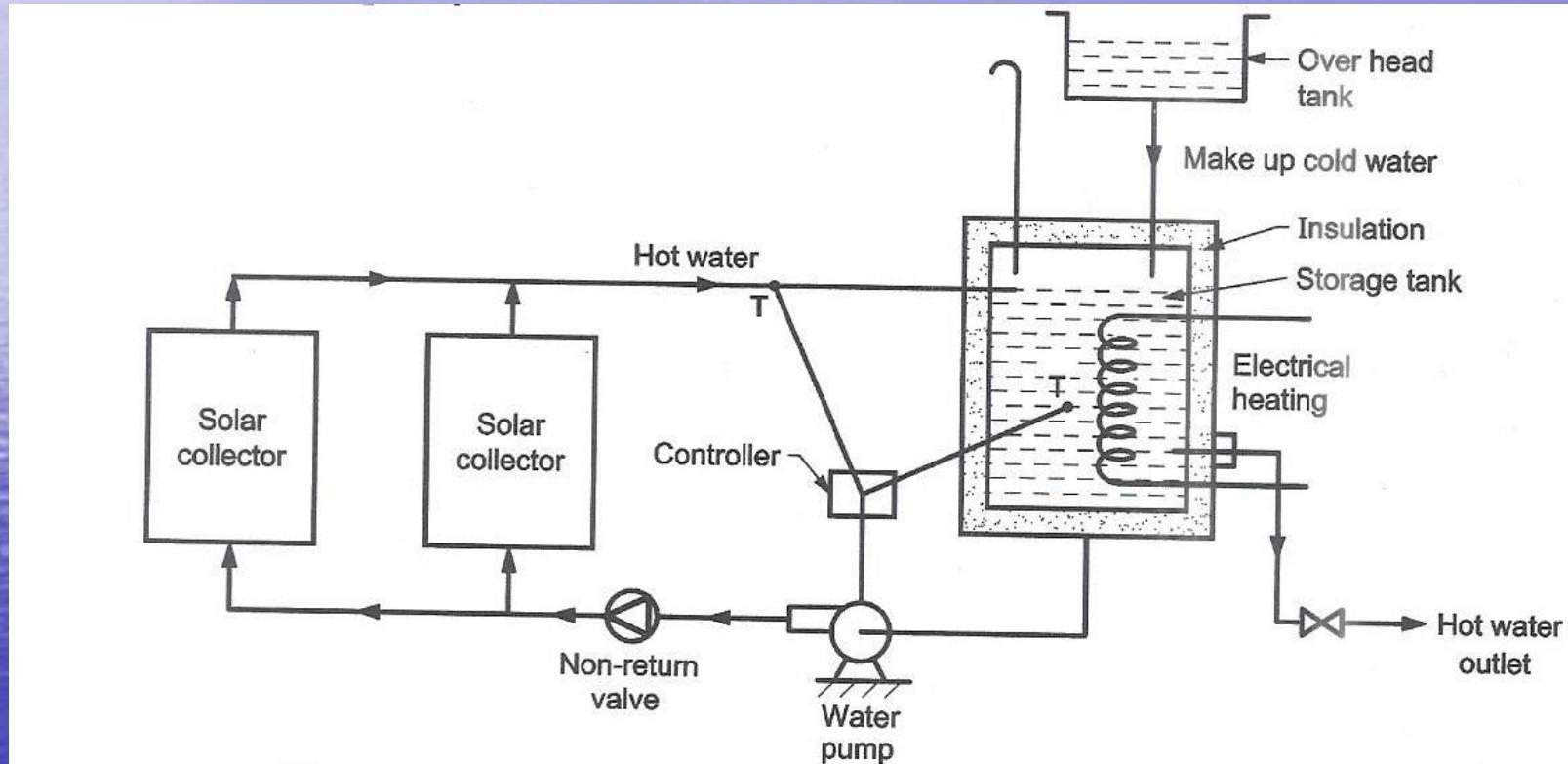


Open Loop System Swimming Pool Application



Open loop drain
back systems
pumps pool water
up to panels and
gravity brings it
back down

Force circulation solar water heating systems (closed loop)

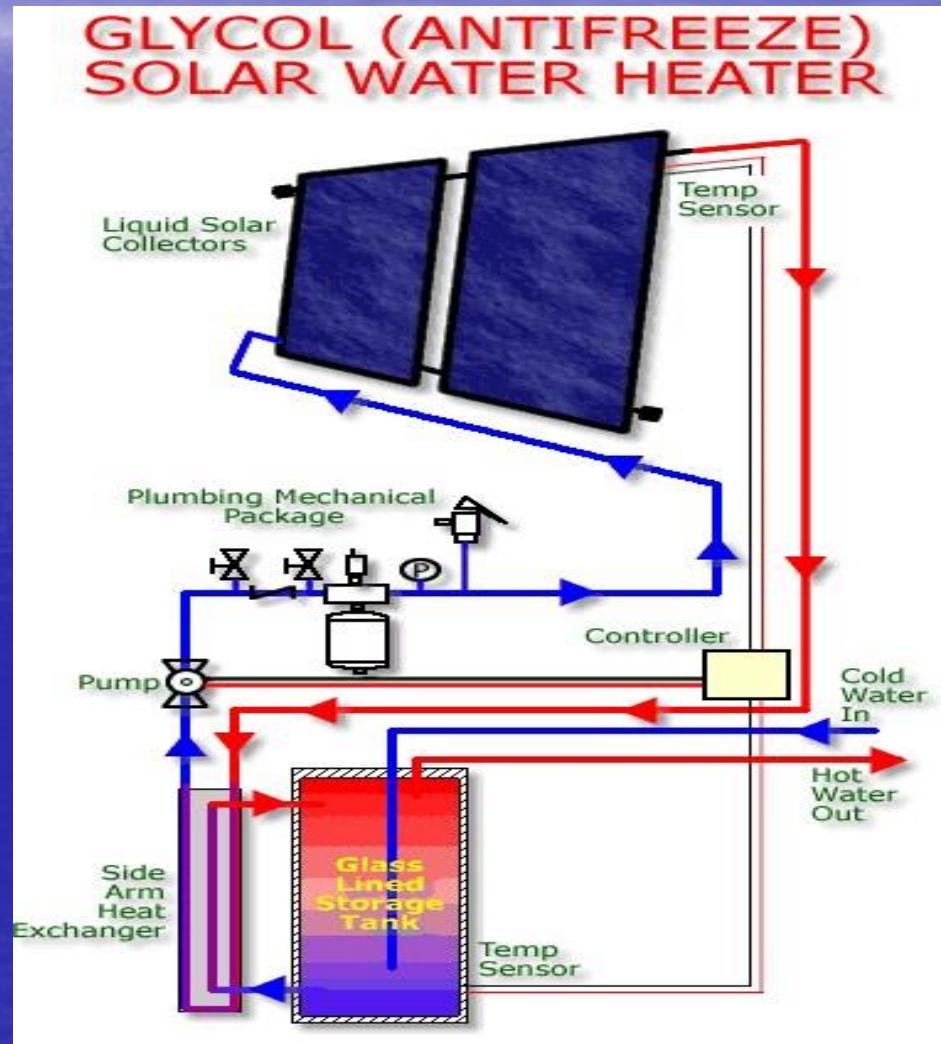


Forced circulation solar water heating system

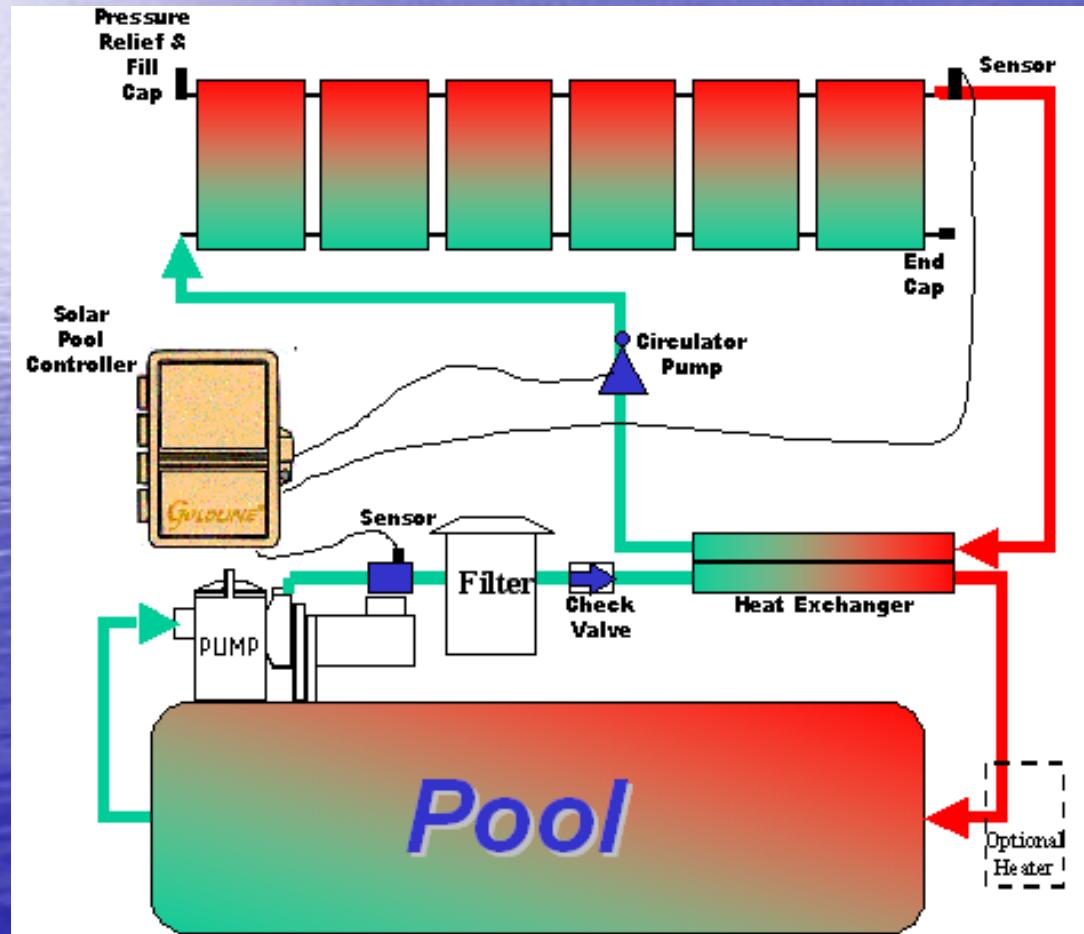
- When hot water requirements are large as in case of hotels, hospitals etc. Natural water systems are not suitable.
- Forced circulation system is active system which uses a mechanical pump to circulate the hot water. Advantage of systems is that hot water tank place any convenient location.
- Pump is generally controlled by electronic differential controller which stops and starts at predetermined temperature differential between the solar hot water temperature in the storage tank and solar collector outlet temperature.
- Water from storage tank is pumped through an array of solar collectors. When water gets heated in the collector, it flows back into storage tank.
- Non return valve is provided in the solar collector to prevent the reverse flow of hot water through the cold solar collector at night.
- Presently solenoid operated ball valves are preferred which operate only when pump is under operation.

Closed Loop System Household Application

Closed loop system in which glycol is heated and circulated through a heat exchanger to transfer heat to water



Closed Loop System Pool Application



Closed loop systems prevent chemically saturated pool water from coming in contact with solar panels.

Hardware Components

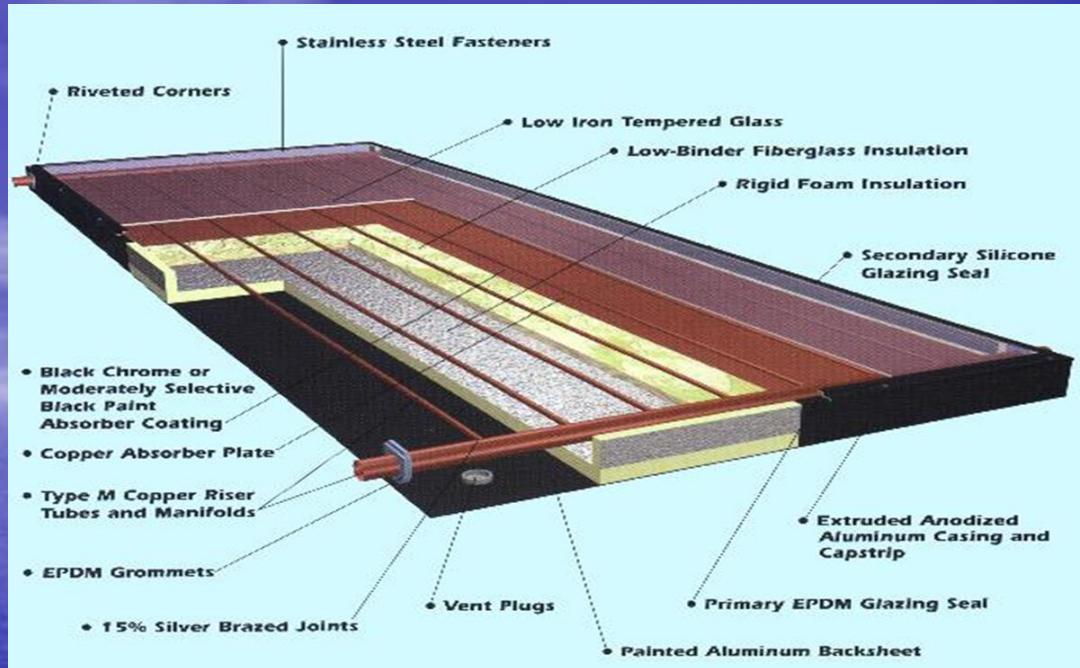
- ✓ Heat Exchanger
- ✓ Glycol (antifreeze)
- ✓ Solar Panels
- ✓ Circulation pump
- ✓ Differential Controller
- ✓ Pipes & Sensors

Heat Exchangers

- Used to transfer heat from exchange medium to water



Solar Panels



Futuristic looking



Cold day in Vermont

Differential Controllers & Sensors

- Differential Controllers allow flow of solar heated water into storage tank if temperature differential is within a specified range.



Differential Controller



High temp. differential controller

- Sensors relay water temperature data to controller which determines if solar heated water should be circulated to raise water temperature.

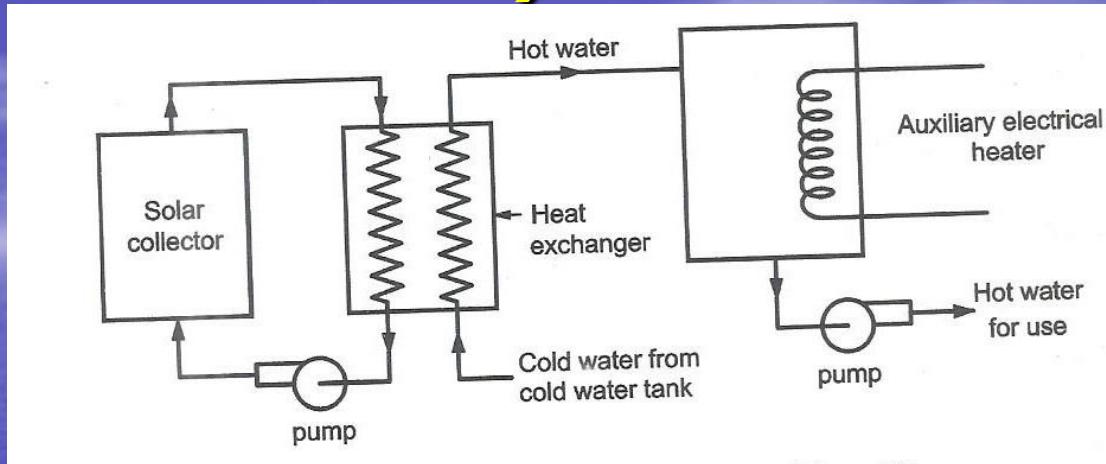


Bolt-on sensor



Screw-in sensor

Glycol (Antifreeze)



- ✓ To avoid the freezing of water in pipe
- ✓ Protect the systems due to freezing (1) to drain water from collector manually through the gate valves provided at the bottom of solar collector or permit the reverse flow of hot water from storage tank at night at very slow rate. (2) by use of anti freeze solution
- ✓ Make sure your antifreeze has corrosion inhibitors!
- ✓ Unless you wish to shorten the life of your system.

Circulation Pumps



Industrial size pump

- Pumps circulate water through solar panels. They are activated by the differential controller when it senses too large a differential between hot water supply and water coming from panels.



Residential pumps

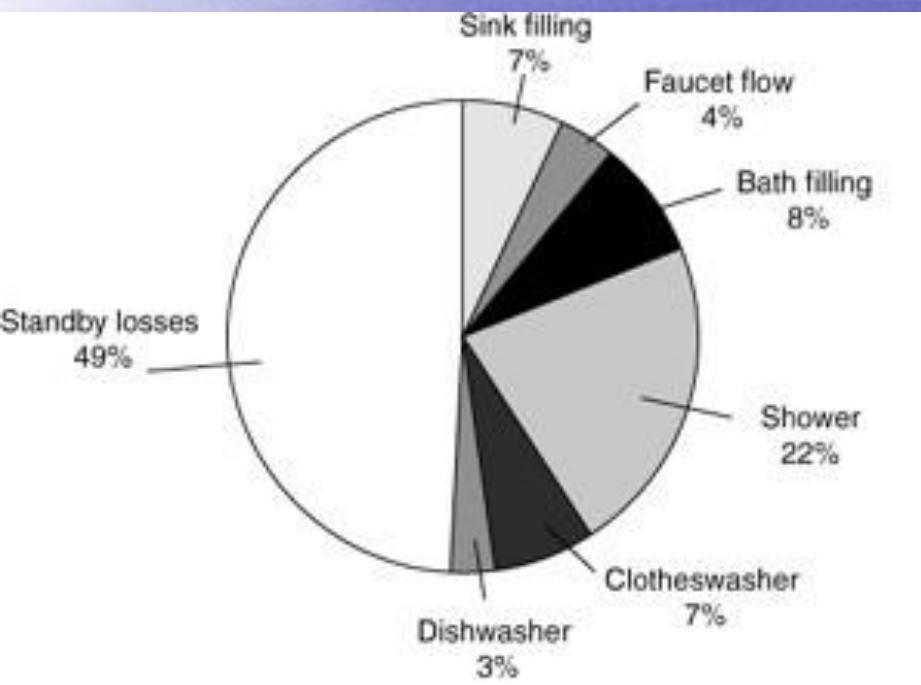
Two types of pumps:
AC & DC

Pipes

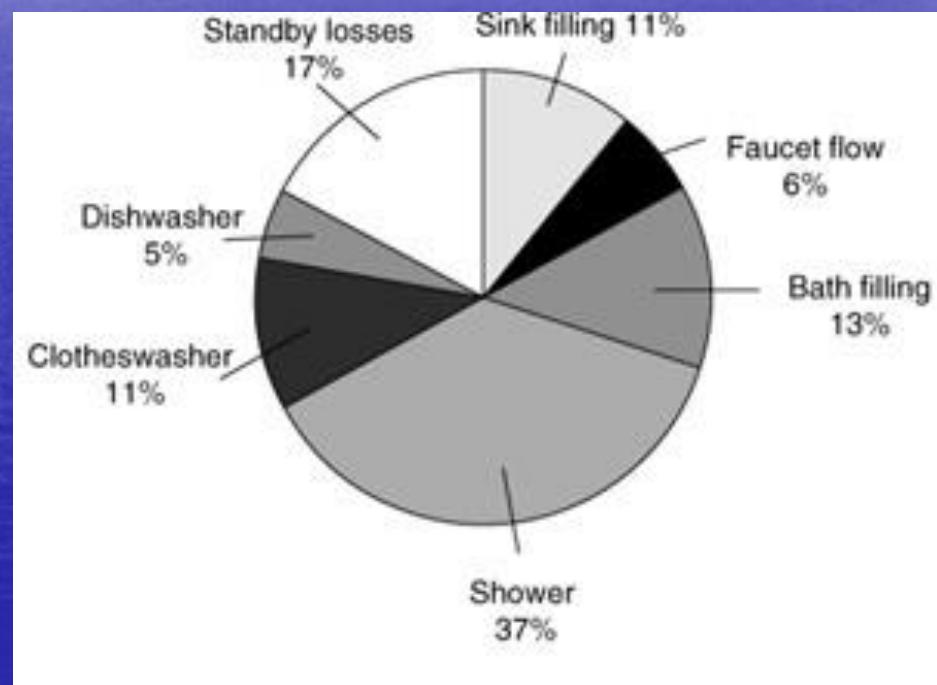
- Pipes should be well insulated to maximize efficiency
- Preferably made from copper



Domestic Hot Water Heating Statistics



Energy losses in electric water heaters

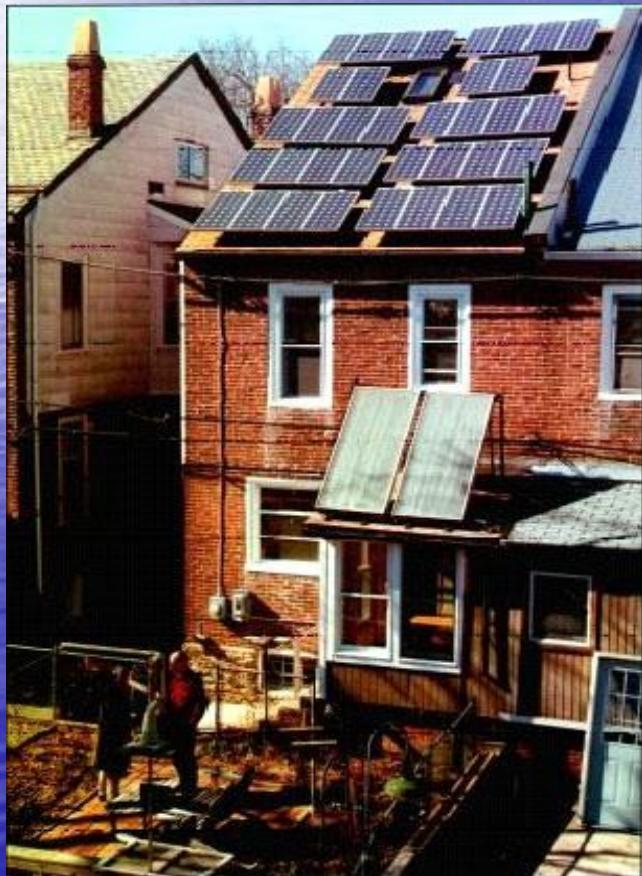


Energy losses in gas water heaters

Case Study #1

Joyce & Andy

Melrose Park, PA.



Two 3'x7' roof mounted drain-down solar hot water collectors provide hot water on sunny days. On cloudy days a gas hot water heater is available to assist if needed. A water submeter measures all domestic hot water. A gas submeter measures all gas used by the MorFlo water heater

System Type	Drain-down hot water system
Collectors	Two 3'x7' by Sunworks*
Circulator-Pump type	DC from Heliotrope General
PV System capacity	10 watt
Solar Tank Brand & Capacity	Bradford White, 65 gallons
Back up heating method and Tank	MorFlo Gas water heater

Case Study #2

Gaithersburg, MD.

This 400 square foot array heats an indoor swimming pool in Gaithersburg saving the owner substantially on her propane bill each month. The array was originally to be located on the roof of the pool house, but we chose to locate it on top of a 50 foot storage shed about 170 feet from the house. Pipes were trenched from the array to the pool pump room where the solar heat is transferred to the pool water via heat exchanger.



Conclusion & Closing Thoughts

- Solar heating is efficient
- Pays for itself in less time than any PV systems
- Tax incentives are more appealing PV systems
- Carefully consider your times of hot water consumption