SOLAR POWERED WATER HEATERS

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ECE 4803

HOME WATER HEATING

- The average American household uses 64 gallons of water each day
- The average household spends $400-$600 on water each year
- Water heating is the second largest expense in the home, accounting for 14-16% of utility bills

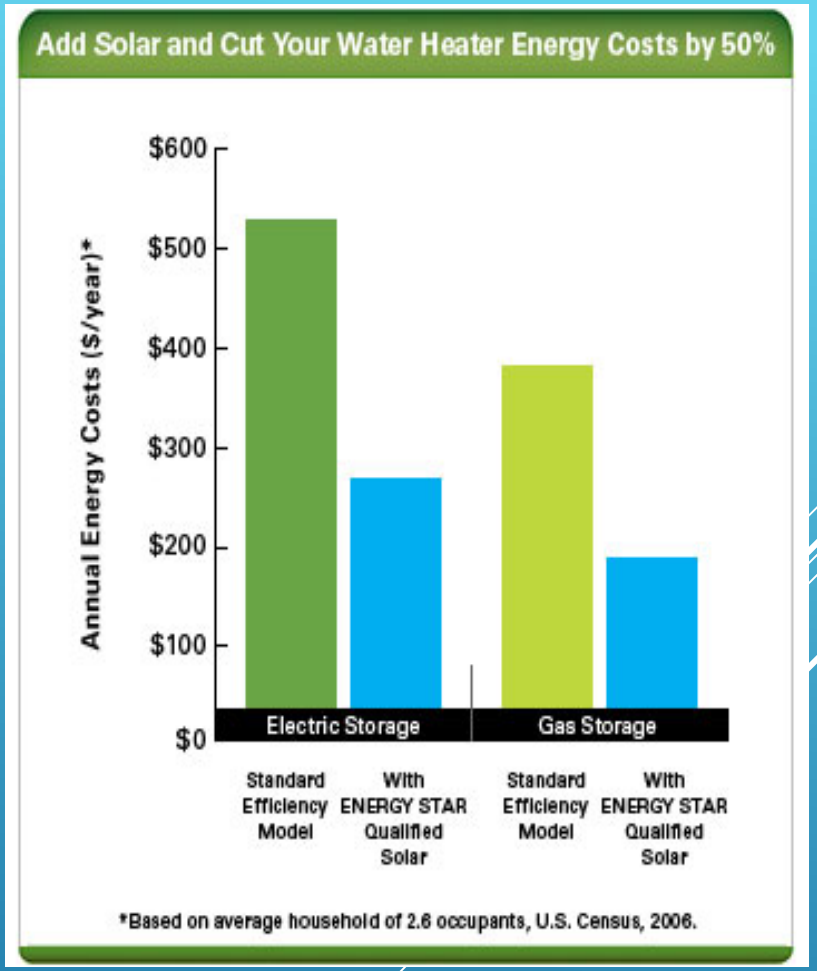
COST SAVINGS

- Cost savings depends on:
  - Hot water usage
  - System performance
  - Price of conventional fuels
- Solar power is independent of fuel price swings
- Usually reduces bill by 50-80%

COST SAVINGS

- Solar water heating systems usually cost more to purchase and install but save the consumer money in the long run

- Solar energy factor (SEF) and solar fraction (SF) are used to determine a solar water heater's energy efficiency



http://energy.gov/energysaver/articles/estimating-cost-and-energy-efficiency-solar-water-heater

SOLAR ENERGY FACTOR (SEF)

- The SEF is defined as the energy delivered by the system divided by the electrical or gas energy put into the system

$$SEF = \frac{Q_{DEL}}{Q_{AUX} + Q_{PAR}}$$

QDEL = Energy delivered to the hot water load: Using the SRCC rating conditions, this value is 43,302 kJ/day (41,045 Btu/day).
QAUX = Daily amount of energy used by the auxiliary water heater or backup element with a solar system operating, kJ/day (Btu/day). To convert to kWh, divide this value by 3,600 (3,412). To convert to therms, divide this value by 105,000 (100,000).
QPAR = Parasitic energy: Daily amounts of AC electrical energy used to power pumps, controllers, shutters, trackers, or any other item needed to operate the SDHW system, kJ/day (Btu/day). To convert to kWh, divide this value by 3,600 (3,412).

SOLAR FRACTION (SF)

- The Solar Fraction is the portion of the total conventional hot water heating load (delivered energy and tank standby losses) provided by solar energy

$$SF = 1 - \frac{EF}{SEF}$$

EF = The Energy Factor is the ratio of delivered energy to input energy for the reference electric auxiliary tank without a solar contribution. The balance of the energy is lost to the surroundings due to standby losses and conversion efficiency.

SOLAR SAVINGS (QSOLAR)

- QSOLAR is the equivalent energy savings
- The Solar Savings is the amount of the total conventional hot water heating load (delivered energy and tank standby losses) provided by solar energy minus any parasitic energy use

$$Q_{SOLAR} = Q_{CONV} * SF$$

QCONV = Daily amount of energy used by the auxiliary water heater or backup element without a solar system. The SRCC standard electric auxiliary tank has an energy usage of 47,865 kJ/day (45,369 Btu/day). The SRCC standard gas auxiliary tank has an energy usage of 72203 kJ/day (68,439 Btu/day).

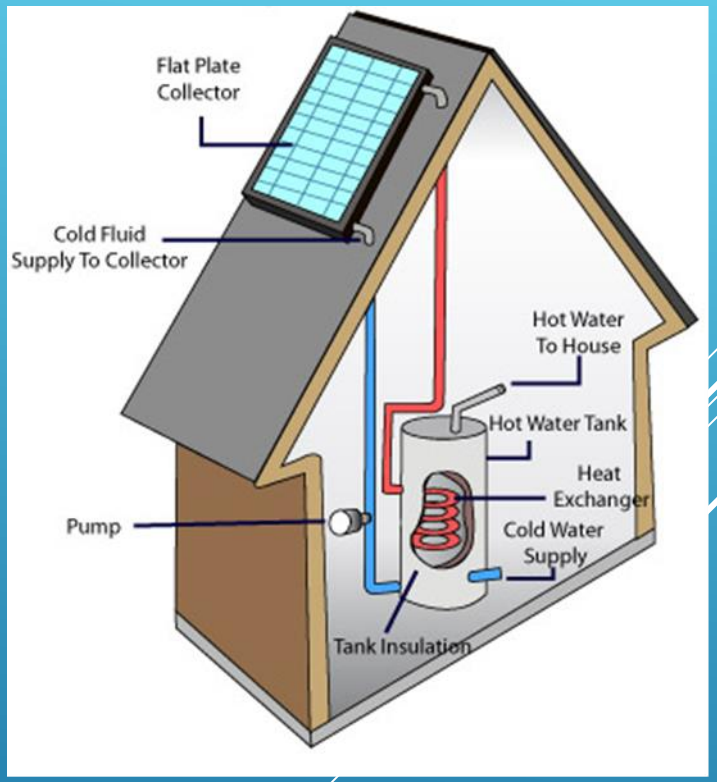
INSTALLATION

- For best results the heater should be installed so it:
  - Receives direct sunlight between 10am and 4pm
  - Faces south
  - Has a sturdy roof
- Can have a ground mounted device if the roof is unstable

http://www.solarpowerauthority.com/archives/2008/07/25/solar-water-heaters-on-roof.jpg

TYPES OF SOLAR WATER HEATERS

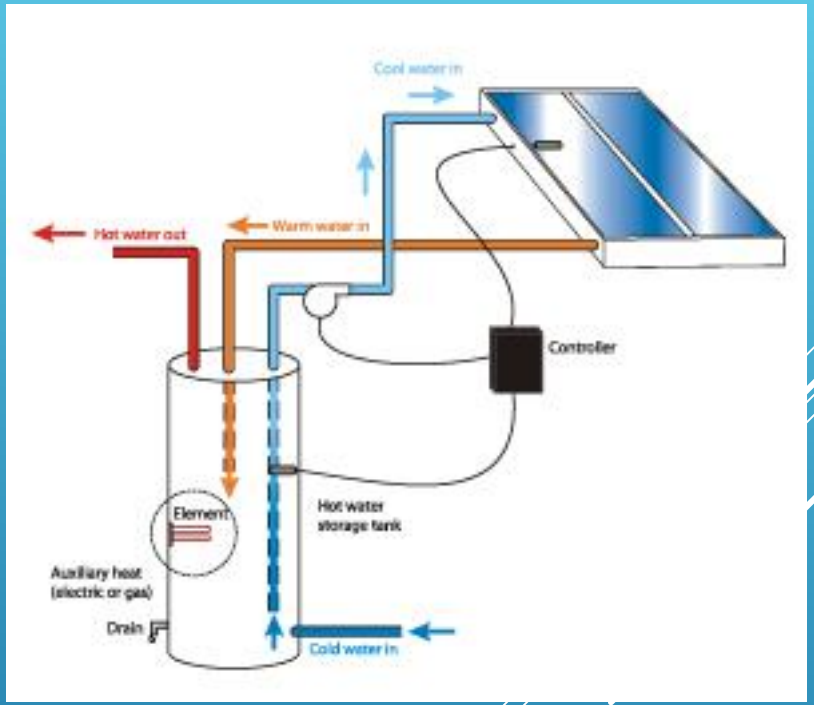
- **Active** – has circulating pumps and controls
  - Direct circulation systems
  - Indirect circulation systems
- **Passive** – has no pumps or controls
  - Integral collector-storage
  - Thermosyphon



http://www.markemeacham.com/core/images/des/water-heater/solar-water-heater-lg.jpg

ACTIVE SOLAR HEATING
DIRECT CIRCULATION SYSTEM

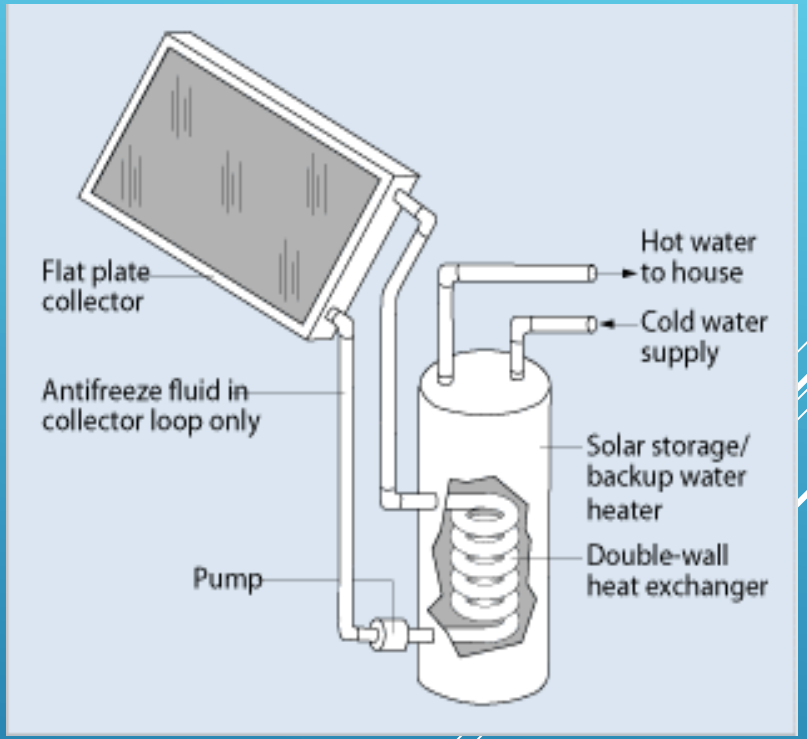
- City water flows into the storage tank, a pump draws the coldest water from the bottom of the storage tank into the collector where it is heated and returned to the tank. Hot water for use is drawn from the top of the tank
- Effective in warm climates



http://www.southface.org/default-interior/Documents/active-open-loop-system300.jpg

ACTIVE SOLAR HEATING
INDIRECT CIRCULATION SYSTEMS

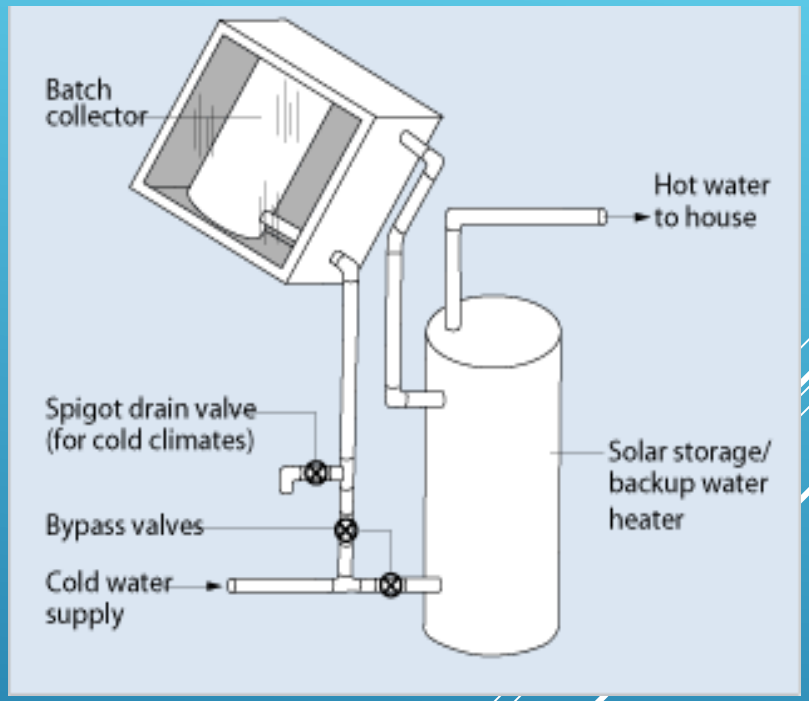
- Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger
  - Heat exchanger uses solar energy to heat a fluid (Hydrocarbon oils, Glycol/water mixtures, air) which then flows into the storage tank to the water
  - Popular in climates prone to freezing temperatures



http://energy.gov/energysaver/articles/solar-water-heaters

PASSIVE SOLAR HEATING
INTEGRAL COLLECTOR-STORAGE

- Cold water flows the a rooftop collector. Hot water from the collector flows directly to a conventional water heater. As hot water is withdrawn from the water heater, cold water is drawn into the collector.
- Effective in warmer climates
- Well suited for households with significant daytime and evening water needs



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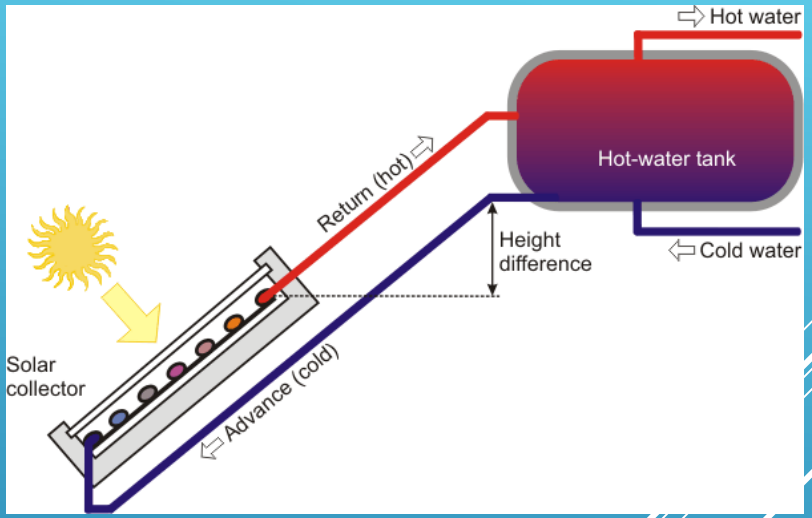
PASSIVE SOLAR HEATING

THERMOSYPHON

- Warm water flows from the collector into the tank, heating the rest of the water in the tank as it rises. Hot water is then drawn from the top of the tank for use
- Colder water from the bottom of the tank flows into the collector
- The collector must be installed below the storage tank so that warm water will rise into the tank
- Usually more expensive than integral collector-storage passive systems



http://www.appropedia.org/images/f/fe/Thermosyphon.gif

PASSIVE VS ACTIVE

- Passive solar water heating systems are typically less expensive than active systems
- Active systems are more efficient
- Passive systems can be more reliable and may last longer

TYPES OF SOLAR COLLECTORS

- Flat plate
- Evacuated-tube solar collectors
- Integral collector-storage

FLAT – PLATE COLLECTOR

- Typically consist of copper tubes fitted to flat absorber plates
- The most common configuration is a series of parallel tubes connected at each end by two pipes, the inlet and outlet manifolds. The flat plate assembly is contained within an insulated box, and covered with tempered glass

http://www.energystar.gov/index.cfm?c=solar_wheat.pr_how_it_works

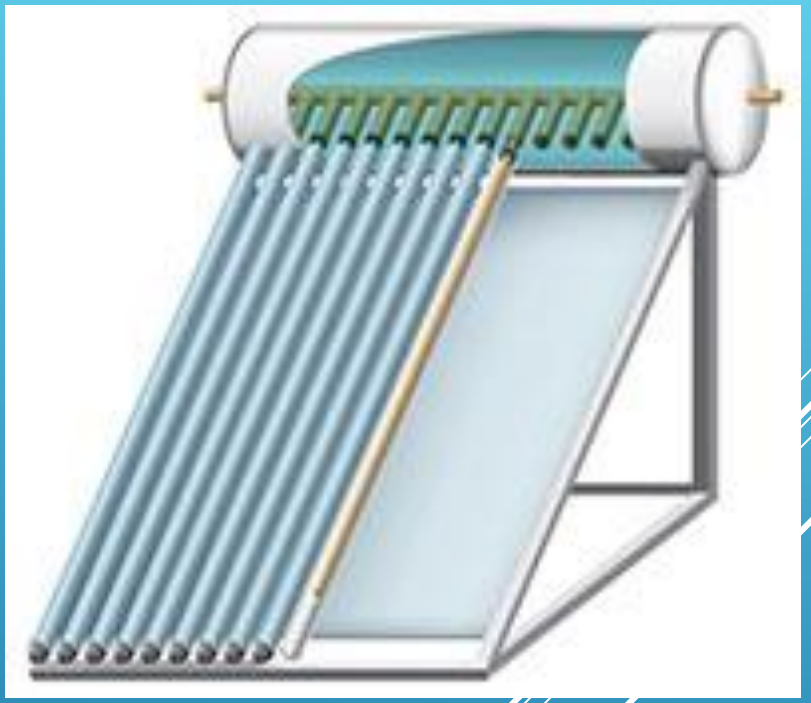
INTEGRAL COLLECTOR – STORAGE

- One or more black tanks or tubes in an insulated, glazed box
- Water is heated in dark tanks or tubes within an insulated box, storing water until drawn
- Not for cold weather climates because pipes can freeze

http://www.energystar.gov/index.cfm?c=solar_wheat.pr_how_it_works

EVACUATED - TUBE

- Parallel rows of transparent glass tubes, each tube contains a large glass outer tube and metal absorber tube attached
- The absorber tube contains the heat transfer fluid (Hydrocarbon oils, Glycol/water mixtures, air) which then flows into the tank to heat the water
- Effective in low temperature climates
- Expensive, common in commercial applications



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QUESTIONS?

REFERENCES

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