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Active solar heating systems

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Quick Facts

- Solar heating systems can be classified as "active" or "passive."
- The typical active system includes a solar collector array, heat transfer fluid, thermal storage unit, heat distribution system, auxiliary furnace and control devices for regulating heat collection, storage and distribution.
- The most common type of collector is the flat plate collector.
- Water, air or a solution of antifreeze in water can be used to transfer heat absorbed by the collector.
- Collectors should face south and be tilted with respect to a horizontal surface.
- The average total cost of an installed solar heating system is about $35 per square foot of collector.
- The optimum size for heat storage is related to collector area and climate.

Solar houses springing up in Colorado in ever-increasing numbers contain heating systems that are either "active," "passive," or combinations of both. Active systems consist of mechanical equipment designed to provide controlled collection, storage and distribution of solar heat. In contrast, passive systems generally have no moving machinery.

Components of Active Systems

An active solar heating system typically is made up of six components: the solar collector, the heat transfer medium, the heat storage unit, the heat distribution system, an auxiliary furnace and control devices regulating heat collection, storage and distribution. Many systems also include accessories for pre-heating domestic water, and a few are designed for cooling (Figure 1).

The solar collector absorbs incoming solar radiation and converts it to heat. The most common design currently on the market is a flat plate collector, which is essentially a glass-covered, well-insulated box containing a black-painted or specially coated metal absorber plate. This absorber plate can be made from such metals as copper, aluminum or galvanized steel, and it contains flow passages filled with heat transfer fluids like air or water which carry heat from the absorber to the storage unit. They also can deliver heat directly to the rooms of the house.

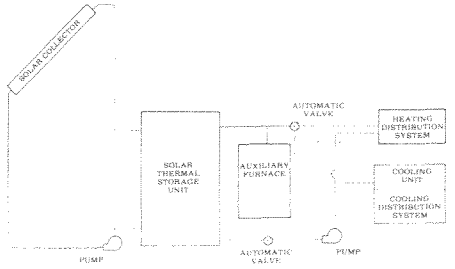

Figure 1: Components of a solar heating and cooling system.

In colder climates where freezing may be a problem, liquid-type collectors often use a solution of antifreeze as the heat transfer liquid. Figure 2 shows a flat plate collector that heats air. Liquid-type collectors look much the same (Figure 3) except that metal tubes through which the fluid circulates form part of the metal flat plate, or they are firmly bonded to it.

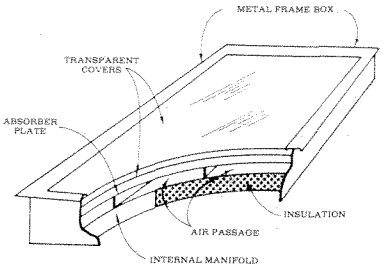

Figure 2: Air-type solar collector.

The absorber plate of a solar collector usually is protected by transparent glass or plastic covers that help to trap heat by shielding the plate from cooling winds and by preventing infrared (heat) radiation from passing back out to the surroundings. Glass panes are more durable than plastic although there is a slight chance of breakage if they are not properly attached to the collector. Two panes of glass often are used to improve the efficiency of collectors by further reducing convection and radiation losses.

Besides transparent covers, it is important to have a lining of insulation under the black metal plate to prevent heat losses through the back and sides of the collector. Heat may be lost from the absorber plate by radiation, conduction and/or convection. Absorber plates, their covers and insulation materials are the main components of the solar collectors you see installed on the rooftops of solar buildings or on separate stands located nearby.

Thermal storage units are essential components of solar heating systems because they make solar generated heat available for heating rooms at night and on cloudy days. A supplementary source of heat also is included because it becomes very expensive to meet high heating demands through the use of solar heating equipment alone. The

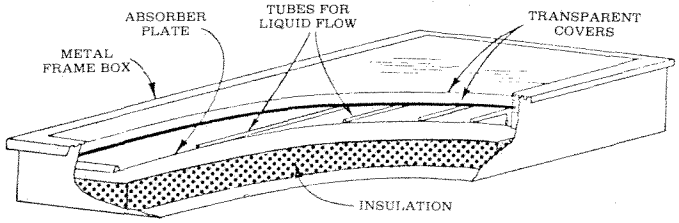

Figure 3: Liquid-type flat plate collector.

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building codes of most states, Colorado included, require that a conventional heating system be used as an auxiliary to the solar system.

How Solar Heating Systems Work

When the sun strikes the solar collector, the absorber plate heats up. So does the heat transfer fluid inside the collector. What happens next depends upon whether the solar heating system is an air-type (Figure 4), or a liquid-type (Figure 5).

In an air system, if heat is needed immediately, the hot air from the collector is directly circulated around the house through a network of ducts, blowers and dampers. If heat is not needed in the rooms right away, the air moves through the heat storage unit, which typically is a box filled with gravel of uniform size. Here, heat is transferred from the air to the gravel. At night or at times of low solar radiation, heating takes place by circulating cool air from the building through the warm pebble bed. Then, as heat from storage is depleted, relatively cool house air returns from the pebble bed to the collector for reheating.

In a liquid solar heating system, the process of providing house heat is slightly more complicated because the fluid used for heat storage (usually water) is not necessarily the same as the heat transfer fluid in the collectors (for example, a solution of antifreeze in water can be used). Both liquids circulate in separate pipe loops, and heat is transferred from one liquid to the other through a heat exchanger. If water is used as the heat exchange fluid, it circulates directly through the storage tank.

If the day is sunny but cold and the house needs to be heated, the heated fluid in storage is circulated through a coil. At the same time, house air moving over the coil picks up the heat from the warm pipes and the warm air is then circulated to the rooms. Alternatively, the hot liquid can be piped directly to radiators or fan coils located in individual rooms around the house.

Design and Sizing of Systems

The appropriate design and size of solar heating systems are important considerations if the systems are to function efficiently and save money on heating bills. Active solar systems are not designed to provide 100 percent of the house heat since the costs would be prohibitive. The main design factors to be considered are these:

- geographical location and solar availability
- position, tilt angle and type of collector
- type of heat storage system
- ratio of heat storage volume to collector area
- overall house heating needs
- type and price of conventional energy supply

The collector should face in a southerly direction and be tilted at an angle about 15 degrees greater than the latitude of the area if maximum possible solar energy is to be collected during the winter. CSU's solar houses in Fort Collins are located at 40.6 degrees north latitude and have collectors inclined at 45 degrees, a tilt somewhat less than ideal for solar heating. This angle was chosen so that the experimental solar cooling systems being tested can receive adequate solar radiation in the summer months when the sun is higher in the sky.

The cost of the collector that is chosen may vary from $7 to $15 per square foot. Added costs for heat storage, pumps, blowers and other accessories plus installation significantly increase the size of the investment. The average total cost of an installed system is about $35 per square foot of collector.

It is important to remember that a very large volume of heat storage will not increase the amount of solar heat available to the house because the quantity of heat supplied is limited by collector area. The most practical size of storage system for Colorado is one large enough to store all the solar heat that can be collected on one clear day in the winter and used during the night to heat the house.

A good estimate of storage volume is one to two gallons of water per square foot* of collector in liquid systems, or one-half to one cubic foot of pebbles per square foot* of collector in air systems. A house needing 500 square feet* of collectors as part of a liquid solar heating system should therefore have a storage tank with about 750 gallons* water capacity. The installed cost of a well-insulated storage tank would be between $500 and $1,500.

Whenever sufficient heat is not available to heat your solar home, the auxiliary heat source provides the balance. Clearly, solar heating systems operating in parts of the country where winters are colder and the sun is overcast for long periods of the year, provide less heat than comparable systems in Colorado.

**NOTE: To convert to metrics, use the following conversions: 1 gallon = 3.8 liters; 1 square foot = .09 square meter; 1 cubic foot = .03 cubic meter.*

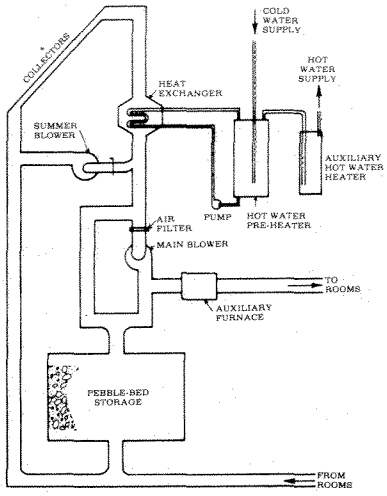

Figure 4: Solar air heating system.

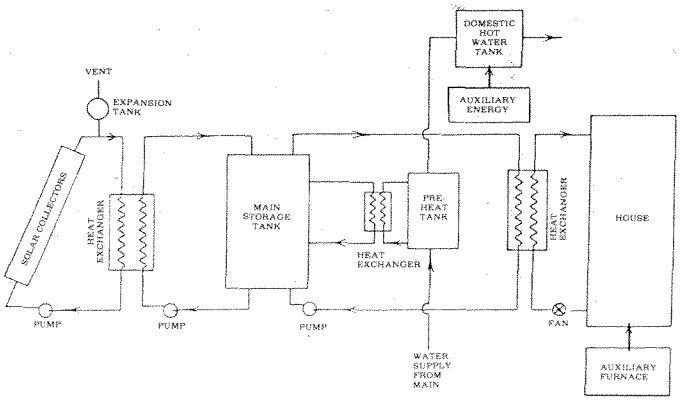

Figure 5: Solar liquid heating system.