Chapter Eleven
Space Heating with Active Solar Energy Systems

Solar space heating systems can be either active or passive. Passive systems use building components such as floors, walls, and sun spaces to collect and store heat. Often, small fans distribute heat, but mechanical equipment and the use of outside energy are kept to a minimum.

In contrast to passive systems, active space heating systems rely on hardware such as rooftop collectors to collect and distribute heat. They use air or a liquid that is heated in the solar collectors and then transported by small electric fans or pumps or by thermosiphon effect, to storage. Solar heat is stored in water tanks or rock bins to provide heat during sunless periods.

Quantity of Heat Provided

Active solar energy systems are usually designed to provide from 40 to 80 percent of a home's yearly heating needs. Data from systems installed through a government demonstration program, however, indicates that active space heating systems are most economical when they are designed to handle about 50 percent of a home's heating requirements. A system sized to provide much more than this would not be economical because some of the extra capacity would only be used during the coldest days. The rest of the time, the extra equipment would be idle.

Backup Heating

Heat not provided by the solar system will have to come from a backup system, which is usually a conventional furnace. (Backup systems are required by most building codes and mortgage lenders anyway). Homeowners can choose from furnaces that use two or three types of fuel and then select the one that is currently most economical. Solar systems and backup systems will sometimes share the same duct work. Some HVAC companies and manufacturers may object to their equipment sharing the same heating path with other heating equipment, so it is advisable to check with your heating equipment representative to make sure you do not violate any specifications or warranty conditions when planning to use existing HVAC ducts for a solar air-heating system.

A common heat delivery system also can be used when adding active space heating to an existing house. But in all cases, the backup heating system should be capable of supplying 100 percent of the home's heating requirements for periods of cloudy weather when little solar heat is available.

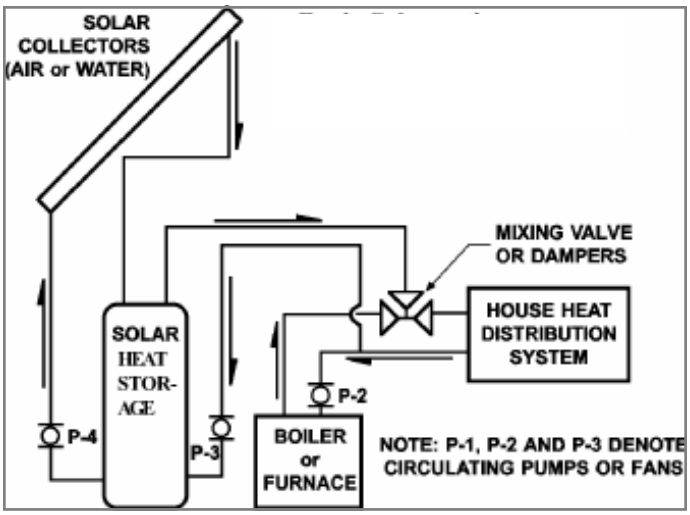

Figure 11.1: Basic schematic of active solar space heating system

Collector Mounting

Solar collectors usually are mounted in rows, on the roof or the south wall of a house. Collectors may also be ground mounted on a collector support structure.

Collectors should face true south, not magnetic south, which is what a compass shows. (For details on siting issues, see Chapter Five.) However, a deviation of 30 degrees or less from true south will not substantially reduce system performance. Collectors should be tilted at an angle equal to your latitude, plus 15 degrees above horizontal. Between 9 am and 3 pm, collectors receive the most radiation and should not be shaded by trees, buildings, hills, or any other obstructions. Performance can be significantly reduced if even a small portion of the collector area is shaded.

Air Systems

Air solar systems include collectors, fans, ductwork, controls, and usually a thermal storage system. An air system can heat the air in a home without heat exchangers or thermal storage. Larger air systems typically use thermal storage. For example, heat can be stored in a bin of small rocks one to three inches in diameter. These systems can be effective, but it is extremely important that they be kept free of moisture. Any moisture in rock bins or holding tanks can

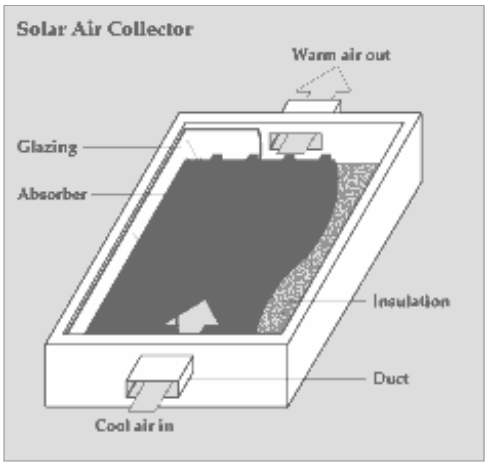

Figure 11.2: Solar air collector

enable mold and bacteria to grow, which can cause serious health problems. One alternative to rock storage is an air-to-water heat exchanger, which stores excess energy in water rather than rocks. A heat exchanger eliminates the problems with rock storage and provides a way to heat domestic water when the system is not being used for space heating.

Liquid Systems

Liquid solar systems include collectors, storage tanks, pumps, pipes, heat exchangers and controls. These systems operate similar to an air system except that liquid – rather than air – is heated in the collectors. Thus if the house has forced air heating, a heat exchanger is required to transfer the heat from the solar-heated liquid to the air.

Liquid systems usually use water to store solar heat. One to two gallons of water are needed for every square foot of collector. The tanks used to store water can be made of concrete, steel, or fiberglass-reinforced plastic. Tanks should be insulated to a value of R-19 or better.

The water in the storage tank is heated in one of two ways. In an open loop system, it is circulated directly through the collectors. In a closed loop system, the water is heated indirectly by a heat transfer fluid such as an antifreeze solution. The transfer fluid absorbs heat from the collector. The fluid then passes through a heat exchanger that transfers the heat to the water inside the storage tank. Thus, the antifreeze solution and household water are kept separate.

It is also possible to connect the solar system to small heat exchangers in individual rooms if the backup system is on a room-to-room basis; for instance, if electric baseboard heating is installed in individual rooms. These small heat exchangers are available as standard plumbing units in various sizes and contain their own blowers.

The temperature of the fluid in a liquid solar system reaches 90°F to 120°F. Conventional heating systems heat water from 160°F to 180°F. Therefore, if baseboards or radiators are used with solar heating, the surface area of the radiators should be significantly increased.

Radiant In-Floor Systems

The method of heat distribution most compatible with active systems is radiant slab heating. Radiant slab heating uses plastic, rubber or copper pipes embedded in a concrete floor and can operate effectively at relatively low temperatures. When solar-heated water circulates through the pipes, the floor heats up and then radiates its heat to the room.

Inserting a sizeable insulated solar-heated liquid storage tank between the solar collectors and the slab floor typically improves the percentage of solar contribution, simply by adding storage remote from the floor. In such a system, the building occupants can have more influence over the floor's temperature, using a thermostat to control circulation of solar-heated fluid through the slab. This strategy works particularly well when the slab is also used for absorbing passive solar heat from a large bank of south-facing windows. During or immediately after a sunny day, the slab will not need heat from the active solar system, but during long cloudy periods when passive solar gains do not occur, the thermostat will trigger circulation of the solar-heated liquid from the storage tank to the slab. This strategy also works when the slab's radiant distribution pipe systems are "zoned" in a passive solar building, allowing heated fluid to warm slab areas in rooms which do not directly benefit from passive solar effects on sunny days.

In-floor heating systems are beginning to catch on in different parts of the country. Although the Romans used wood-fired in-floor heating systems 2,000 years ago, systems for modern homes have not been popular until recently. Fifty years ago, many systems were installed using copper tubing. Unfortunately, prospective customers shied away because of leakage problems resulting from corrosion, poor soldering and

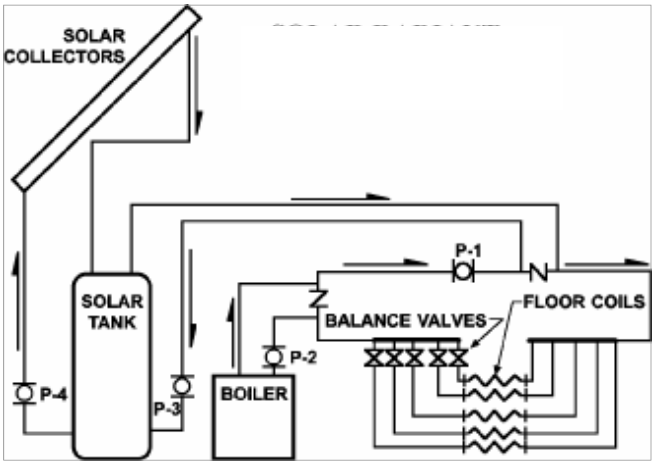

Figure 11.3: Solar radiant in-floor system

shifting slabs. With the advent of tough, low-cost plastic and rubber tubing, these systems are beginning to become popular again. With the proper design and installation, in-floor systems can be among the most efficient and comfortable heating systems available.

In-floor heating systems use moderate water temperatures to keep from scalding bare feet. These temperatures coincide with the temperatures easily reached in solar water heating systems. Typical inlet water temperatures range from 100°F to 125°F, which is precisely the range where active solar systems excel. Rather than heating a large water or rock storage tank, a concrete slab floor can be used to store the heat and slowly release the heat as needed.

Radiant floor heating systems can increase the efficiency of liquid collectors by reducing the collector operating temperatures to below the levels common to domestic solar water heating systems. As a result, they are more efficient since they lose less heat to the cold outside air.

Controls

Solar controls use sensors, switches, and motors to operate the system and to provide backup heating when the solar system cannot meet heating requirements. Other controls are used to prevent extremely high temperatures or to protect against freezing.

The heart of the control system is usually the differential thermostat. The thermostat measures the difference in temperature between the collectors and storage unit. When the temperature in the collectors is at least 10 to 20 degrees higher than the temperature of the storage unit, the thermostat will turn on a pump or fan to circulate heat to storage, or directly into the house.

Control systems vary in function, performance, and expense. A basic control system would perform the necessary functions to operate the solar system in three or four different modes. Some control systems monitor the temperature at different parts of the system to determine how the system is operating.

Maintenance

Periodic maintenance on the system can help prevent major problems. Solar systems are mechanical systems not unlike standard heating or cooling equipment in a home. Just as those systems require periodic maintenance, solar heating systems do as well. Maintenance manuals with recommended maintenance schedules should be included with each system.

Adapted with permission from "Space Heating with Active Solar Energy Systems," North Carolina Solar Center at North Carolina State University, Factsheet SC120, June 2000.

Pioneering Kentucky House Integrates Passive and Active Solar Heating

The Raven Run Solar House near Lexington, Kentucky, integrates active and passive solar heating systems. This home was designed and built during the mid-1970's by architect Dick Levine, co-director of the Center for Sustainable Cities at the University of Kentucky, and has been his home ever since. The home includes three solar heating systems. The active system uses patented multistage air collectors designed and built by Levine on-site. The heat collected by these collectors is stored in rock bins beneath the first floor of the house. The passive solar system utilizes "Sundows," rows of glazing that alternate with the active solar collectors on the south face of the house. The Sundows allow sunlight to enter the home for direct heating and lighting. Insulated shutters are closed at night to conserve heat within the home. The third system is an attached greenhouse, which provides additional heating as well as fresh vegetables and a lush greenspace within the house throughout the winter.

Figure 11.4: South face of the Raven Run Solar House. The permanent yet moveable ladder system allows for easy window maintenance and also provides shading during the summer months, *Dick Levine*

Figure 11.5: The solar design allows ample daylight into the home, as shown in these photos of the living room and central staircase, *Dick Levine*

RESOURCES: Space Heating

Publications

Active Solar Heating Systems Design Manual, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA, 1988.

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Modern Hydronic Heating, John Sieganthaler, Delmar Publishers, 1995.

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Solar Water Heating, Bob Ramlow & Benjamin Nusz, New Society Publishers, British Columbia, 2006.

Organizations

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