NORTH CAROLINA
SOLAR CENTER

SOLAR CENTER INFORMATION

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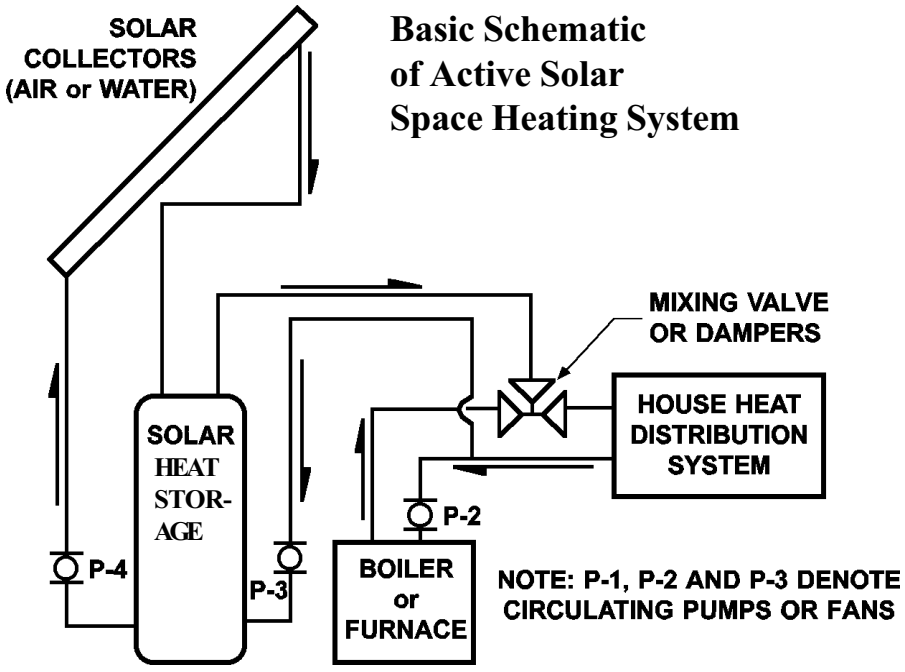
Space Heating with Active Solar Energy Systems

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 effects, to storage. Solar heat is stored in water tanks or rock bins to provide heat during sunless periods.



Basic Schematic of Active Solar Space Heating System

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. Usually, a solar system and backup system will share the same duct work.

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% of the home's heating requirements for periods of cloudy weather when little solar heat is available.

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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 fact sheet "Siting of Active Solar Collectors and Photovoltaic Modules"). 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. Between 9 a.m. and 3 p.m., collectors receive the most solar 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 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.

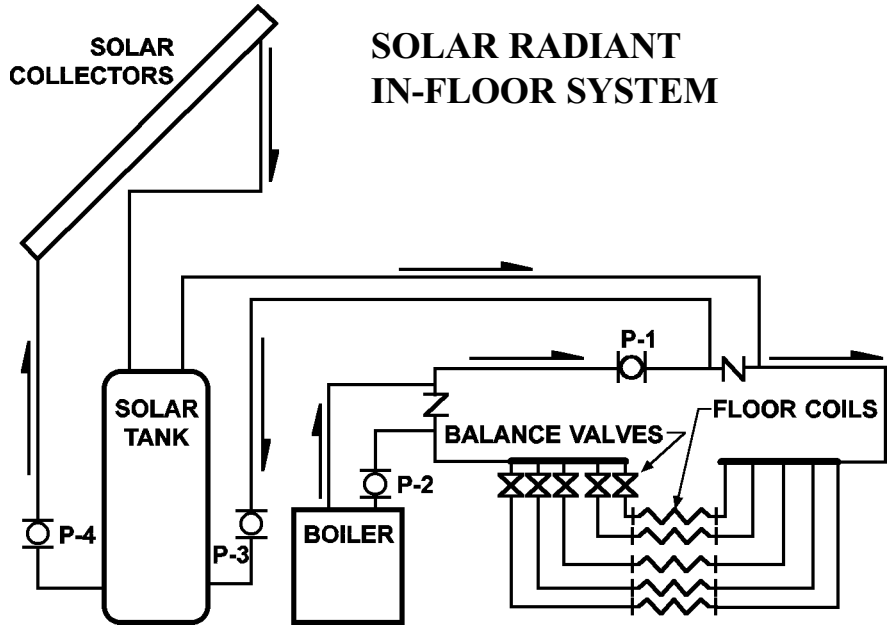
It is also possible to connect the solar system to small heat exchangers in individual rooms if the backup system is on a room-to-room basis; for instance, if electric baseboard heating is installed in individual rooms. These small heat exchangers are available as standard plumbing units in various sizes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

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 poor soldering and 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 low 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.

Economics/Tax Credits

There are a wide range of prices for active space heating systems depending on the system components and capabilities. Active solar sytems offer the greatest return on investment to homeowners who would otherwise heat with electricity. North Carolina tax credits and other incentives can significantly reduce their cost. Under current law, a homeowner can take a tax credit of 40% of the price of a solar system upto a maximum credit of $1,500. For businesses and industry, the tax credit is 35% of the system cost upto a maximum credit of $25,000.

References

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

Active Solar Heating Systems Operation and Maintenance Manuals. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 1990.

Brooks, Bill. *Solar Assisted In-Floor Heating Systems*. Louisville, KY: Builder Review Magazine, February 1990.

Engineering Principles and Concepts for Active Solar. Golden, CO: National Renewable Energy Laboratory, 1987.

Friedlander, Matthew. *Premium Heating with Radiant Slabs*. Harrisville, NH: Solar Age Magazine, April 1986.

Siegenthaler, John. *Hydronic Radiant Floor Heating.* Newtown, CT: Fine Homebuilding Magazine, November 1996.

Siegenthaler, John. *Modern Hydronic Heating.* Delmar Publishers, 1995.

Stein, Jay. *Hydronic Radiant Floors for Beginners.* Owner and Builder Magazine, September 1989.

National Resources

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
1791 Tullie Circle, N.E.
Atlanta, GA 30329
(404) 636-8400 Fax: (404) 321-5478
E-mail: ashrae@ashrae.org
Web: www.ashrae.org

American Solar Energy Society
2400 Central Ave., Unit G-1
Boulder, CO 80301
(303) 443-3130 Fax: (303) 443-3212
E-mail: ases@ases.org
Web: www.ases.org/solar

Energy Efficiency & Renewable Energy Clearinghouse/ Network (formerly CAREIRS)
P.O. Box 3048
Merrifield, VA 22116
(800) 523-2929
Toll-free: 1-800-363-3732 Fax: (703) 893-0400
E-mail: doe.erec@nciinc.com
Web: www.eren.doe.gov

Florida Solar Energy Center
1679 Clearlake Road
Cocoa, FL 32922-5703
(407) 638-1000 Fax: (407) 638-1010
E-mail: webmaster@fsec.ucf.edu
Web: www.fsec.ucf.edu

Hydronic Radiant Heating Association
123 C Street
Davis, CA 95616
(530) 753-1100 Fax: (530) 753-4125

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401
(303) 275-3000 Fax: (303) 275-4053
E-mail: webmaster@nrel.gov
Web: www.nrel.gov

Solar Energy Industries Association
122 C St., N.W., 4th floor
Washington, DC 20001
(202) 383-2600 Fax: (202) 383-2670
E-mail: info@seia.org
Web: www.seia.org

Solar Thermal Design Assistance Center
Sandia National Laboratories
Mail Stop 0703
Albuquerque, NM 87185
(505) 844-3077 Fax: (505) 844-7786
E-mail: dfmenic@sandia.gov
Web: www.sandia.gov/Renewable_Energy/solarthermal/dufdac.html

Take advantage of the state tax credit for solar energy!

North Carolina offers a personal tax credit of 35 percent of the construction, equipment and/or installation costs for renewable energy systems, including passive solar, active solar and photovoltaics. The maximum credit per year per system varies by technology, with any excess credit able to be carried over to the next year for up to five years. The maximum credit is $10,500 per photovoltaic system, $3,500 for passive or active space heating systems, and $1,400 for solar water heating. Maximum credits of $10,500 are also available for wind, biomass, and microhydro applications.

For commercial and industrial installations of renewable energy equipment, the corporate tax credit per year and per system is 35 percent, with a maximum credit of $250,000, with carry-over of excess credit for up to five years. The credit covers all renewable energy technologies, including solar, wind, daylighting, biomass, and microhydro applications.

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Division Energy
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North Carolina Solar Center
Box 7401, NCSU, Raleigh, NC 27695-7401
(919) 515-3480, Toll free in NC: 1-800-33-NC SUN
Fax: (919) 515-5778
E-mail: ncsun@ncsu.edu
Web: www.ncsc.ncsu.edu

Energy Division, NC Department of Commerce
1830A Tillery Place, Raleigh, NC 27604
(919) 733-2230, Toll free in NC: 1-800-662-7131
Fax: (919) 733-2953
E-mail: ncenergy@energy.commerce.state.nc.us
Web: www.state.nc.us/Commerce/energy

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