UNIVERSITY OF COLORADO
SOLAR DECATHLON 2005

HOT WATER SYSTEM BRIEF CONTEST REPORT

Recognizing that the sun is an abundant source of clean energy that reaches the earth at an intensity of up to 1000 Watts/m^2, the University of Colorado will be showcasing top-of-the-line technology in which solar radiation is converted into heat for the purposes of heating the home and providing domestic hot water.

Solar Thermal System – Basics

Colorado's 2005 Solar Decathlon team has chosen to harness the sun's thermal energy with 4 arrays of 20 Mazdon evacuated tube collectors manufactured by Thermomax, as shown in Figure 1 below. These collectors have incredibly high efficiencies – about 60% over the course of an entire day. In addition, the evacuated tube collectors resist internal condensation and corrosion more effectively than their counterparts and have the ability to reach high temperatures in cloudy, windy, and sub-freezing ambient weather conditions. This high efficiency is achieved due to the lack of air inside the individual collector tubes, which results in minimal heat losses to the environment from the hot surfaces of the collector. With low thermal losses to the outdoor environment, more heat will be delivered to the storage tank. The heated water in the tank will be used for space heating via a hydronic radiant system and for heating the house's domestic hot water.

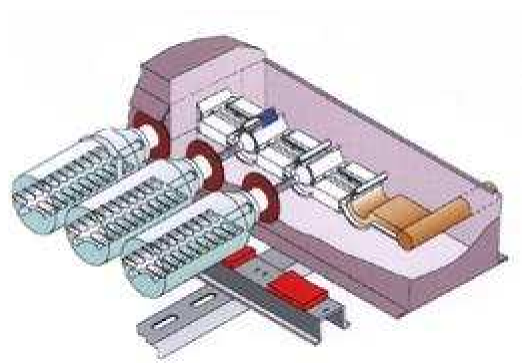

Figure 1: Thermomax Mazdon Evacuated Tube Cutaway View
Photo Courtesy of Thermomax Website

Solar Thermal Storage Tank

CU is showcasing a custom-made, 200-gallon, stainless steel solar thermal water tank made by Swhift, Inc. Inside the tank resides a copper coil heat exchanger through which solar thermal energy is transferred into the water.

A glycol/water mixture is circulated to the Thermomax collectors, where the fluid picks up the solar energy captured by them. The fluid then circulates from the collectors through a copper coil heat exchanger that is submerged inside the tank. The heat exchanger transfers the solar energy from the glycol mixture to the 200 gallons of water by simply conducting the heat through the walls of the copper coil.

The water stored in the tank will be circulated through the flooring of the house through a separate plumbing system that will radiantly heat the house during the winter. In addition, the water in the storage tank will be used to preheat municipal mains water (supply tank water on the Mall in D.C.) flowing to the domestic hot water tank.

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Domestic Hot Water System

As hot water is drawn through the home's showers and faucets, cold city water will flow into an A.O. Smith domestic hot water tank to replenish the water that was drawn down. However, before reaching the domestic hot water tank, the cold city water will begin its travels through a stainless steel, flat plate heat exchanger. Simultaneously, hot water from the 200-gallon solar tank will be pumped into the flat plate heat exchanger to serve as the source to the municipal water's sink. The municipal water will increase in temperature as it travels through the exchanger and the heat is conducted from the water of the solar thermal tank. As the city water exits the heat exchanger, it has effectively been preheated before it enters the domestic hot water tank. Should further heating be necessary, the water tank will use an auxiliary electrical heating element to top off and maintain this batch of water at 120˚F. As the electrical energy into the auxiliary heater comes entirely from the house's PV system, one could still refer to this water as "solar-heated."

Heating System

A hydronic heating system, also known as a radiant heating system, is employed to meet the home's heating needs, as shown in Figure 2 below. The house has been divided into three heating zones: the living room and kitchen, the bedroom and bathroom, and the mechanical room. Space temperatures within each zone are maintained by modulating the flow of warm water from the solar thermal tank through each of the zone's "floor circuits," or radiant water loops. The space temperatures in each of the zones are monitored with their own occupant-controlled, programmable thermostats.

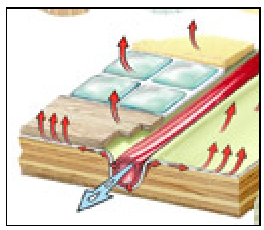

Figure 2: Warmboard Radiant Floor Cutaway View
Photo Courtesy of Warmboard Website

Proportional valves on each zone and a primary, variable-speed circulation pump are used to control the flow rate of water through the water loops in the flooring. The combination of modulating valves and a variable-speed circulator pump allows for balanced system pressures while minimizing the amount of pump energy required to deliver the hot water through the flooring.

A second variable-speed pump will operate in conjunction with the primary pump. This secondary pump will draw hot water directly from the solar thermal storage tank and precisely mix the hot water into the water loops to maintain a supply temperature of 95˚F to the zone. An auxiliary electric in-line heating element in the system will raise the temperature of the water to 95˚F only if the solar tank can not supply enough hot water into the loop. This 95˚F water will travel through the flooring underneath the zone and radiate heat to the space. By the time the water finishes it travel through the water loop, its temperature will have dropped to approximately 80˚F.

All of the pump and valve settings will be managed by a programmable logic controller (PLC). This device will measure the pressure and temperature at various points in the hydronic system and home. From these measurements, the PLC will go through a series of calculations to determine the appropriate pump speed and valve position. An output signal from the PLC will be sent to the pumps and valves in order to run the equipment at precise settings needed to keep the space comfortable. The PLC can be seen mounted on the West wall of the mechanical room, along with myriad other house system components.