Solar CalPoly

Cal Poly's goal is to create a beautifully concise home tuned to the climate, detailed for modern living, proportioned and sized to travel across the country pulled by a single truck; to reduce our household's footprint on the land and make the most effective use of space and resources. Simple. Fundamental. Elegant.

Hot Water System

Comprehensive Assessment

The size, cost, reliability, performance, and maintenance requirements proved to be the driving factors in the design of the solar hot water system. F-Chart, a solar energy system analysis software program, was used to quickly assess the performance implications of different design decisions.

The design team initially considered the performance characteristics of direct versus indirect systems. Simulation in F-Chart showed that from an energy standpoint, implementation of an indirect system did not significantly decrease performance of the system. The slight decrease in solar fraction (annual fraction of energy provided by the sun) could easily be accommodated by a well-designed system. An indirect system provided two main benefits: reduction of fouling, which increases the operation life of system components, and freeze protection, which is crucial for any system located in freezing climates. While energy requirements for pumping can be higher in indirect systems, the additional energy consumption did not outweigh the risk of mineral buildup in the system, which would reduce efficiency and necessitate frequent replacement of system components.

Freeze protection for the system was also a requirement. The Solar CalPoly team decided to use a drainback system because of its reliability and ease of maintenance. When conditions are unfavorable for collecting solar energy, the pump is shut down and the fluid in the collectors and piping system flows into the drainback tank, protecting the system from freezing. Since the collector fluid is not exposed to freezing temperatures, distilled water will be used in the collector loop with minimal impact on the performance of the system. The disadvantage of the drainback system is the increased pumping cost, but this was deemed acceptable given the other advantages.

While the F-Chart simulations showed that both evacuated tube and flat plate collectors could meet the design requirements for the system, the geometry of the roof area and aesthetic considerations led to the decision to use two 4 ft. by 10 ft. flat plate collectors for a total collector surface area of 80 ft2 total. While evacuated tube collectors could achieve the same results using less area, the flat panels will closely match the size of the photovoltaic modules, providing a more uniform array pattern, which was a visual effect important to the architecture team. Additionally, the decision to utilize the lower cost and lower maintenance flat plate collectors satisfied the team's desire to design a system which would appeal to the greatest number of consumers possible.

The system design utilizes a storage tank with an integral heat exchanger. While the effectiveness of the heat exchanger is not as high as could be achieved with an external heat exchanger, the benefit of eliminating the extra pump was the overriding factor. The collector area is 80 ft2 and the storage tank volume is 80 gallons, so that the collector area to storage volume ratio is 1 gallon per square foot. Although this is below the design guideline of 1.5 to 2 gallons per square foot, F-Chart simulations predicted less than a 5% decrease in the annual solar fraction. Given that the decrease in performance was small and since a 120 gallon storage tank was not commercially available with an integral heat exchanger, the design team selected the 80 gallon storage tank. The storage tank also has a 4.5 kW electric resistance heating element to provide additional energy when the energy from the sun is insufficient to meet normal loads or when hot water loads in the house are especially high.

The control system contains two temperature sensors, one mounted in the solar storage tank and the other at the outlet of the collectors. When a large enough temperature difference exists between these two points, the pump switches on and circulates fluid through the collectors. A tempering valve placed after the hot water outlet of the storage tank ensures that water discharged from fixtures in the house does not scald the user.

The mechanical room is located adjacent to the bathroom. The short piping run allows for a very short warm-up period for hot water usage. Because the kitchen is on the other side of the house from the mechanical room, the warm-up period will be longer. To reduce the warm-up period for this part of the house, the most direct piping route possible was selected to minimize the volume of water in the pipe. One-half inch nominal diameter plastic piping was selected for the piping run to the kitchen. The smaller diameter piping will reduce the volume of water in the piping and since the plastic piping has a low thermal diffusivity, it will minimize the amount of thermal energy that goes into the pipe. In addition, all the hot water piping in the house is insulated with a minimum of ¾ inch pipe insulation to reduce heat losses and decrease warm-up time.

Simple. Fundamental. Elegant.