CALIFORNIA STATE SCIENCE FAIR
2009 PROJECT SUMMARY

Name(s)

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Project Number

S0817

Project Title

Building a Model to Optimize Solar Water Heating Requirements Given a Site's Observed Solar Flux

Abstract

Objectives/Goals

The goal of this project was to develop a computational model which would evaluate the effectiveness of a solar water heater in preheating water for hot tub or home hot water use, based on year-long timeseries of local solar irradiance and air temperature data.

Methods/Materials

The MATLAB program first read the short wave, long wave, and air temperature values for each sample interval in the year. Next, the program looped through each 10 minute interval, and, using the environmental data, the physical constants specific to the solar collector, and the solar collector temperature calculated in the last interval, calculated the incoming solar energy, incoming black body radiation, the conductive loss of the collector, and the black body losses of the collector to determine the change in temperature of the collector and hot tub/water storage unit for the current interval. The heat in the collector was mixed into the tub/hot water storage unit when the collector exceeded the storage temperature by two degrees. At the end of the solar day the amount of energy which would be necessary to bring the stored hot water to the desired temperature was calculated. This value was stored for each day and used in the economic analysis of the model.

Results

The program showed reasonable temperatures for the collector, heat losses and gains, and estimated required energy costs throughout the year long sample period. Net losses or gains due to black body radiation tended to be small in the day and dominant at night, however at a time when the system wasn't active. The data showed clear seasonality in heating savings and temperatures of the collector, as the collector contributed much more energy to the hot tub/ water heater in the higher solar irradiance summer months.

Conclusions/Discussion

The program predicted an optimum number of solar collectors, which was two for the solar collectors and consumption model used in this study, for both the hot tub and hot water models. The model provided a means of assessing the collector / storage system throughout an annual cycle accounting for air-temperature-dependent conductive losses, and cloud dependent long wave losses for the solar collector / storage systems. Overall, the program made useful predictions for the optimal number of collectors for the chosen coastal site in Monterey, California based on local environmental observations.

Summary Statement

The project uses a year long environmental dataset to determine the optimal number of solar water heating collectors to heat water for a hot tub and dometic hot water use in a given location.

Help Received

A local meteorologist, Dick Lind, provided the sample dataset that we used.