Solar Solutions

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Bristol's six principles of good solar hydronic design

Part 6: Collector Efficiency and the SRCC Ratings

So far in this series of articles we have been discussing the key ingredients for solar/hydronic design and installation. They can be divided into six categories, listed below, roughly in order of their importance.

RELIABILITY – EFFECTIVENESS – COMPATIBILITY
ELEGANCE – SERVICEABILITY – EFFICIENCY

The success of any solar hydronic home heating installation depends on the balance between all of these principles which often conflict with one another. Finding the balance between them defines the art of solar heating design.

In previous articles I have mostly emphasized the importance of the first five principles with explanations and examples. My point has been that a solar/hydronic heating system is hardly worth building unless it first adheres to the first five principles. This leads us now to focus on the 6th Principle in more detail, and more specifically, Collector Efficiency. The heart of any Solar/Hydronic heating system is in the thermal collectors. In a system where the other five principles are well thought-out, high collector efficiency is of course desirable. Let's take a closer look at this topic.

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Collector efficiency

Collector thermal efficiency can be broadly defined as the fraction of available solar energy converted into useful heat during a known period of time. This value can be calculated (by measurement or modeling) instantaneously, hourly, daily or averaged in other ways. The efficiency is not actually fixed, but changes with the weather and other factors. There are three main variables that can alter the efficiency of any heat collector during its normal operation. They include:

- Collector fluid inlet temperature (Ti) degrees F
- Outdoor ambient (air) temperature (Ta) degrees F
- Solar radiation intensity (a.k.a. Insolation) (I) Btu/hr-s.f.

Collector fluid inlet temperature (Ti) is determined by the heating job. If you are heating a pool, the temperature returning from the pool to the collectors may be around 85F. When directly heating a warm mass floor, the return fluid may be around 105F. When heating a domestic water tank, the return fluid might be 125F. When charging up a heat storage tank for higher temperature fan coil or fin tube applications, the fluid returning to the collector might be 180F.

The higher return temperatures have a negative effect on collector efficiency. That is why the common wisdom among solar designers has always been, "A cool collector is a happy collector." If you can think of ways to keep your solar fluid cooler, this will result in a higher thermal collector efficiency, which means more heating energy collected per day. My favorite scheme is to use the concrete mass of the warm floors directly to keep the collector fluid cool. Also, in DHW systems, using a slightly larger hot water storage tank will tend to keep the solar fluid temperature cooler, while still providing useful DHW temperatures.

Warm Outdoor ambient (air) temperature (Ta) has a positive effect on a solar heat collector. The warmer the weather is outdoors, the more efficient the collector will be. This is because the heat loss from the collector to the outdoors is driven by the temperature difference between the inside of the hot collector and the outdoor air. Heat flows from hot to cold, and the greater the difference, the faster it flows. This is known as the back-loss from the collector. It includes the heat lost from the glass cover, the insulated back, and the side frames of the enclosure around the hot absorber plates, tubing and manifolds.

Solar radiation intensity (a.k.a. Insolation) (I) drives the solar heat collection process. So, as you might expect, the more intense the solar radiation is, the higher the efficiency will be (all other things being equal).

These three efficiency variables can be combined into a single expression of collector performance known as the "inlet fluid parameter" (p) which can be calculated from the formula:

$$p = (Ti - Ta) / (I) \qquad \text{(Equation 1)}$$

Solar Collector Efficiency is most properly expressed as a function of this parameter. Information is available from most collector manufacturers that makes use of this mathematical relationship. Figure 1 shows how this information is commonly presented, in the form of a graph.

Credit for Original Graphics goes to Caleffi Idronics #3, Jan.2008, Fig.16, page 12.

SRCC Ratings

In November of 1980 the Solar Rating and Certification Corporation (SRCC) established its certification and rating program for solar collectors. In the United States, the

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SRCC is now the national clearing house for standard comparative test results of solar heat collectors and packaged solar water heater systems. Solar Tax credit rules in the U.S. generally require an SRCC rating in order to qualify for any tax credit. You can go to the SRCC web site (http://www.solar-rating.org/) to make sure that your client is getting a certified collector that qualifies for tax credits.

The scope of the SRCC program includes swimming pool and recreational heating, space heating, and water heating. When testing and certifying Solar Heat Collectors, they follow a set of procedures referred to as the OG-100 standards. When testing Solar Water Heater Systems, they use a standard procedure known as OG-300. The program tests the durability of the solar equipment and determines the thermal performance under prescribed rating conditions. By following the same standards for every solar product, the results yield a reasonably fair side-by-side comparison.

The following four documents are available as free downloads on the SRCC web site at http://www.solar-rating.org/ratings/ratings.htm. They provide specific information and comparative results on the collectors and water heating systems certified under the various SRCC certification and rating programs.

1. Summary of SRCC Certified Solar Collector and Water Heating System Ratings. This publication lists abbreviated performance ratings for solar collectors and systems, typically one line of results per product tested.

2. Directory of SRCC Certified Solar Collector Ratings. Presents construction and rating information on certified solar collectors. This is more of a full and complete listing of the test results, typically one page of results for each product tested.

3. Directory of SRCC Certified Solar Water Heating System Ratings. Presents schematics and ratings for certified solar water heating systems, presented as one page of information per solar water heater system tested.

4. Annual Performance of OG-300 Certified Systems. Provides estimated annual performance of SRCC certified systems for various locations. This is interesting comparisons of the performance of solar water heater systems in different U.S. cities.

If you are new to the SRCC test reports and interested in comparing Solar Collectors, I recommend starting with the OG-100 Summary of the collector test results (number 1 above). Two useful collector ratings appear in the OG-100 Summary:

• The efficiency graph results (given as a “slope” and an “intercept”) per square foot of collector, and

• The daily collector heat output in

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category "C" conditions, which are moderate operating conditions, allowing a quick comparison of one collector to another.

All results published by the SRCC are given in both Metric and U.S. conventional units.

Using the Ratings

The Collector Efficiency results produced by the SRCC do not include the actual efficiency graphs, but rather, the mathematical descriptions to allow you to draw your own graph. If you are good with computers, you can program a spreadsheet to draw the graphs for you. Figure 1 has some points labeled as "slope" and "intercept" to indicate how those numbers, provided by the SRCC, apply to the lines on a graph. The "slope" is the rise over the run, just like framing the slope of a roof. For example, a slope of -0.5 means that as the line is drawn from 0 to 1 on the horizontal (x) axis, it drops by 0.5 units on the vertical (y) axis. The "intercept" is the point where the sloping line crosses the vertical axis (y axis). Since efficiency graphs always drop downwards as they move to the right, they are always given a negative slope.

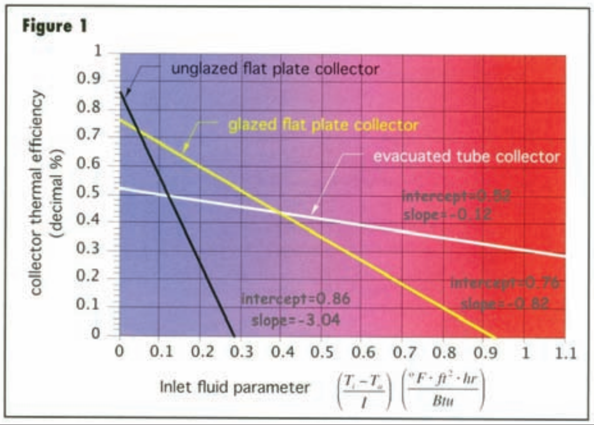

Figure 1 shows three sample efficiency graphs.

Figure 1 shows three sample efficiency graphs, and the comparison is striking. We can see the efficiency performance of a glazed flat plate collector compared to a vacuum tube collector and an unglazed flat plate pool collector. As you move to the right, the value of "p" increases, which means more severe conditions for our collectors. (Colder ambient air, hotter inlet fluid, and/or more cloudiness.) The slope and intercept values provided by the SRCC tests can be graphed and compared in this way. It is interesting to note that for the sample collectors in Figure 1, the flat plate glazed collector performs with a higher efficiency than the vacuum tube collector anywhere to the left of "p" equal to 0.40. This is one compelling reason why we still use a lot of flat plate collectors in our region of Northern New Mexico, since our solar collector conditions are typically on the left side of this graph.

The Heat Output rating provided by SRCC is very easy to use and compare. If one collector puts out 23 kBtus per Day and another puts out 21, it is easy to see who the winner is. You still need to consider if the collector sizes are the similar and if there are significant differences in cost, mounting hardware or piping hardware. But, you can see how useful it is to have standard test results for comparison.

Regional conclusions will vary

Your final collector performance is very climate-dependent and also dictated by the number and type of heating loads attached to the solar heating system. The efficiency charts and heat output ratings shown here can be very helpful in making an informed decision. But it is also easy to misinterpret this kind of information. So, read the explanations provided in the SRCC documentation for a better understanding of the methods and limitations of their test results. ■

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