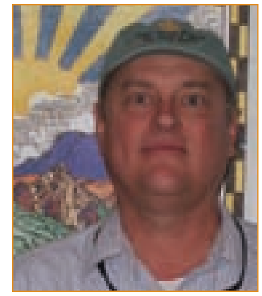
# Solar Solutions

**Bristol Stickney, technical director, Cedar Mountain Solar Systems, Santa Fe, N.M.**



## Bristol's six principles of good solar hydronic design

# Collector efficiency and the SRCC

I have said many times that if you don't get the first five principles right, the last one does not matter. Yes, I am speaking of the E-word, *Efficiency*.

Many people use this term in casual conversation, without understanding what it means. It is really a simple relationship between the total energy (fuel) available and the useful portion of it that is put to good use. Divide the useful energy delivered by the energy available and you get Efficiency, expressed as a fraction or as a percent. It is often abbreviated using the Greek letter Nu ($\eta$). The confusion starts when people are not clear about what is available or how much is useful. Even worse is when they confuse Effectiveness with Efficiency, such as the fellow that recently told me that his flat plate solar collectors get boiling hot, so they must be really efficient.

To add to the confusion, the thermal efficiency of a solar heat collector is not static: It changes as the operational conditions change. This can make a fair comparison of one collector to another really difficult, since panels come in different sizes, are made of different materials and can be used in countless different climates and temperature applications. Clearly there is a need for a standard way of testing and comparing solar heat collectors and, in the United States, that standard is maintained by the Solar Rating and Certification Corporation (SRCC). Let's take a closer look at collector efficiency and the vast repository of solar collector data that is the SRCC.

### The SRCC

The Solar Rating and Certification Corporation (SRCC) is our national solar heating test facility. It was founded in 1980 as a non-profit organization whose primary purpose is development and implementation of certification programs and national rating standards for solar energy equipment. They administer a certification, rating and labeling program for solar collectors and a similar program for complete solar water heating systems. (We will cover complete systems in a future article.) The rating and labeling has become more important to installers and owners in recent years, since this is now required for the solar equipment to qualify for solar tax credits in the U.S. The labels themselves can be useful when making an energy performance comparison, since they show a standard performance rating similar to those found on appliances and cars.

The SRCC database is the one place where all these ratings can be found side by side for an easy and useful comparison. This information is free on the SRCC website at www.solar-rating.org and includes a complete list of all the test results for all the collector manufacturers available on the U.S. market. New products entering the U.S. market must submit to SRCC testing, or they will not qualify for most solar subsidy programs. The list is regularly updated; new products are listed as their testing is completed. The SRCC website does a good job of explaining themselves and their programs, so feel free to check it out.

Free publications are available for download on this website. The ones that cover solar collector ratings from A to Z in PDF format are:

1. *Summary of SRCC Certified Solar Collector and Water Heating System Ratings,* a 50-page publication listing the performance ratings for solar collectors and systems;

2. *Directory of SRCC Certified Solar Collector Ratings,* a 279-page publication that includes construction and rating information on certified solar collectors.

There is also a lot of information on solar water heater system ratings, which I hope to cover in more detail in the future.

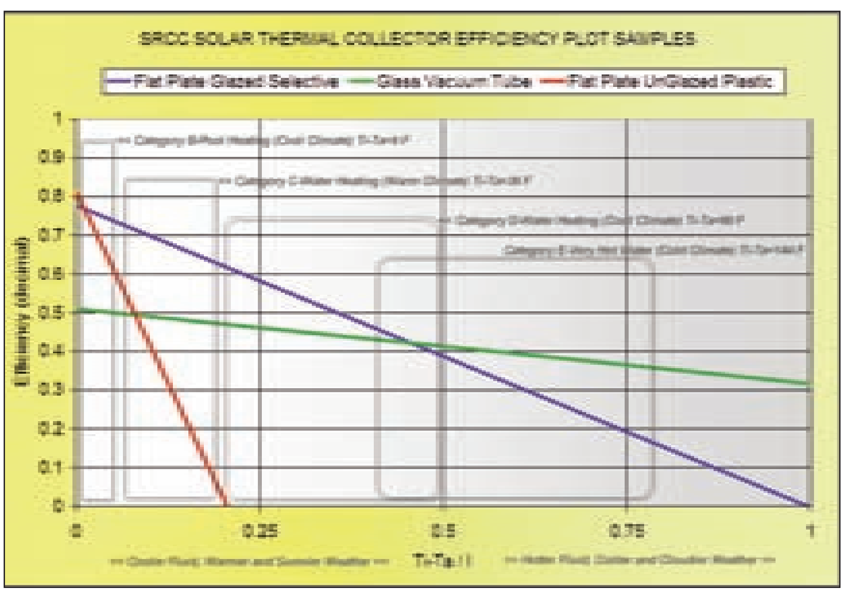



*Figure 1. For most of the common solar heating categories, the flat plate glazed collector performs better than the glass vacuum tube collector, with a higher collector efficiency.*

### Efficiency vs. Effectiveness

Effectiveness has more to do with user satisfaction and with how well the equipment does its job. This includes everything that the owner needs in order to feel satisfied with the equipment, including the cost-effectiveness and comfort temperatures. When we succeed in providing solar heating components that are effective, the owners have little to complain about. Be aware, however, that the owner's perception may be mistaken, as in the example I mentioned earlier. The fellow that commented how

*Continued on page 46*

Continued from page 44

Figure 2

| COLLECTOR THERMAL PERFORMANCE RATING | | | | | | | |
|---|---|---|---|---|---|---|---|
| Megajoules Per Panel Per Day | | | | Thousands of Btu Per Panel Per Day | | | |
| CATEGORY ( Ti-Ta) | CLEAR DAY 23 MJ/m²·d | MILDLY CLOUDY 17 MJ/m²·d | CLOUDY DAY 11 MJ/m²·d | CATEGORY ( Ti-Ta) | CLEAR DAY 2000 Btu/ft²·d | MILDLY CLOUDY 1500 Btu/ft²·d | CLOUDY DAY 1000 Btu/ft²·d |
| A (-5°C) | 31 | 23 | 16 | A (-9°F) | 29 | 22 | 15 |
| B (5°C) | 30 | 22 | 14 | B (9°F) | 28 | 21 | 14 |
| C (20°C) | 28 | 20 | 13 | C (36°F) | 26 | 19 | 12 |
| D (50°C) | 25 | 17 | 10 | D (90°F) | 23 | 16 | 9 |
| E (80°C) | 21 | 13 | 6 | E (144°F) | 20 | 13 | 6 |

A-Pool Heating (Warm Climate) B-Pool Heating (Cool Climate) C-Water Heating (Warm Climate) D-Water Heating (Cool Climate) E-Air Conditioning

"efficient" his collectors must be, because they got boiling hot, was actually being fooled by an impressively high temperature that he thought should be very effective. On the contrary, the general rule is that a cool collector is an efficient collector. When the collector stays cool on a sunny day, it means that the solar heat is being carried away by the coolant and is not building up in the collector. In fact, extremely hot collectors quite often indicate a coolant pump failure, with a corresponding collector efficiency of zero.

Efficiency is calculated by dividing the "useful energy out" by the "energy available." In the case of the solar heat collector, the energy available is the solar radiation that arrives at the collector aperture. This can change from moment to moment, with passing clouds and other shading conditions. The useful energy out is the net thermal energy embodied in the hot fluid (coolant) leaving the collector outlet pipe. A cold outdoor air temperature surrounding the collector tends to draw more heat out of it, so cold ambient temperatures can lower the useful energy delivered.

When this situation is boiled down mathematically, it turns out that there are only three things you need to know to evaluate the collector efficiency for any heating application:

How hot is the fluid you want to heat? (**Ti**),
How cold is it outdoors? (**Ta**),
How sunny is it (**I**)?

So the Collector Efficiency (η) is directly linked to these three values, which can be combined as follows:

**(Ti - Ta)/I** [a.k.a. **(P)/I**, as seen on the SRCC ratings pages]

**Ti** is inlet fluid temperature,
**Ta** is ambient temperature, and
**I** is solar radiation at the collector surface. [**I** stands for solar *Insolation.*]

The SRCC publications provide collector test results in publications 1 and 2 (above), which include the slope and the intercept data for each collector tested. The slope and the intercept allow you to draw a straight line on a graph that defines the collector efficiency for any conditions of **(Ti - Ta)/I**. I have done this in Figure 1 for three collectors I found listed in the January 2009 Directory; a flat plate glazed, a flat plate unglazed and a glass vacuum tube collector. The intercept is the point found on the vertical axis and the slope is the (negative) Rise over Run of the line as it runs downhill to the right.

Please note that this only describes the collector thermal efficiency, which is the solar collector by itself. This is not to be confused with the system thermal efficiency, which is complicated by pump and control "parasitic" energy consumption, heat loss from piping, heat exchanger efficiencies, heat storage losses, etc., etc. This article is limited to the solar collector. We hope to cover more system efficiency issues in the future.

**Making sense of SRCC collector ratings**

The SRCC requires each solar collector to be tested using a standard series of procedures known as the OG100 test. (Not to be confused with the OG300 test for solar water heaters systems.) This includes a torture test that proves that the collector can stand up to high temperature solar stagnation and other harsh conditions. The final results include not only the slope and intercept of the Collector Efficiency graph but also the heat output of the collector under five different standard temperatures and three different solar Insolation conditions. These ratings represent solar heating jobs that range from very easy to very difficult and are presented as categories A, B, C, D and E, respectively.

Category A: Pool Heating (warm climate) Ti-Ta = (-9) F
Category B: Pool Heating (cool climate) Ti-Ta = 9 F
Category C: Water Heating (warm climate) Ti-Ta = 36 F
Category D: Water Heating (cool climate) Ti-Ta = 90 F
Category E: Very Hot Water (cold climate) Ti-Ta = 144 F

Results from each category are presented for standard solar conditions known as:

Clear Day - 2,000 Btu per square foot per day
Mildly Cloudy - 1,500 Btu per square foot per day
Cloudy Day - 1,000 Btu per square foot per day

A collector that is capable of producing heat under all of these standard test conditions will have 15 heat output ratings from which to choose. A sample is shown in Figure 2. These results appear in the SRCC Directory (publication 2 above) as two tables; one metric and one in Btu. In summary information (publication 1 above), only the Clear Day Category C results are shown for comparison.

On Figure 1, you will notice that I have drawn rectangular boxes on the graph that represent where the different solar/temperature categories are. The SRCC lists the solar availability in more than 50 major U.S. cities, and it is inter-

Continued on page 48

*Continued from page 46*

esting to note that they all fit within each of the gray boxes. For example, if you have a Category C heating job, the collectors seen in this figure will perform to the left side of the Category C box in Albuquerque or Los Angeles and to the right side of the box in Seattle or Boston.

**Collector comparison**

Whether you use the SRCC Data Tables or Plot the Efficiency Graph, you can see that this data allows a useful comparison between collectors. Keep in mind that while the graph data is normalized per square foot of collector, the table data is not. The tables show the heat output of each whole collector, and some collectors are bigger than others. So, you can divide by the net aperture area to make a comparison per square foot.

The examples shown in Figure 1 present an interesting result. For most of the common solar heating categories, the flat plate glazed collector performs better than the glass vacuum tube collector, with a higher collector efficiency for these models. (Both of these collectors are from the same manufacturer.) So, if the price of the vacuum collector is much higher than the flat plate, the extra expense may not be worth it, unless you are to the right side of Category D or in the Category E area. The SRCC publications include some descriptions of how to use the data to make other useful comparisons. ■

In this series of articles, I have been making the case that the key ingredients for solar/hydronic design and installation can be divided into six categories, listed below, roughly in order of their importance.

1. RELIABILITY
2. EFFECTIVENESS
3. COMPATIBILITY
4. ELEGANCE
5. SERVICEABILITY
6. EFFICIENCY

The success of any solar hydronic home heating installation depends on the often-conflicting balance between any of these six principles. Finding the balance between them defines the art of solar heating design.

*Bristol Stickney, partner and technical director at Cedar Mountain Solar Systems in Santa Fe, N.M., has been designing, manufacturing, engineering, repairing and installing solar hydronic heating systems for more than 30 years.*





**See contact information on page 69**