Solar Solutions

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Bristol's six principles of good solar hydronic design

Solar hot water systems and the SRCC

In my last article I introduced the SRCC, the Solar Rating and Certification Corporation, which serves as 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. In my last article, I endeavored to explain the Solar Collector efficiency ratings provided by the SRCC, and now I would like to talk more about the Solar Hot Water System certifications. Figure 10-1 shows a diagram of the steps a system must go through to earn a certification and rating using the SRCC OG-300 methods.

This information is provided here because rating and labeling has become more important to installers and owners in recent years. Certification is now required for the solar equipment to qualify for the solar tax credits in the US. It seems that the SRCC is becoming the national clearinghouse for solar heating equipment certification. The labels themselves may be used to make an energy performance comparison, since they show a standard performance rating similar to those found on appliances and cars. But like the other ratings, they are determined under certain controlled conditions for comparison purposes, and may not reflect actual performance when installed. So, remember that these test results represent controlled comparisons, not necessarily installed performance or any guarantee of performance.

The SRCC ratings are freely available on the SRCC website at http://www.solar-rating.org/. This includes a complete list of all the test results for all the collector manufacturers available on the U.S. market, as well as an ever-increasing list of solar hot water system ratings. New products entering the U.S. market must submit to SRCC testing or they will not qualify for most solar subsidy programs. The SRCC website does a good job of explaining themselves and their programs, which is beyond the scope of what we can cover here.

There is a lot of information on solar water heater system ratings included in the following PDF documents;

1. Directory of SRCC Certified Solar Water Heating System Ratings: A 369 page publication listing the test results for hot water systems submitted for certification.
2. Summary of SRCC Certified Solar Collector and Water Heating System Ratings: A 50 page publication listing the performance ratings for solar collectors and solar hot water systems.
3. Estimated Annual Performance of OG-300 Certified Solar Water Heating Systems: Many 30- to 50-page documents, one for each major U.S. city, over 50 cities provided.

Solar hot water system types

The solar hot water tests, known as the OG-300 standard, are provided for solar domestic hot water systems. According to the SRCC Directory, all the solar water heating systems tested by the SRCC fall into one of these four categories:

1. Forced circulation or "active systems" are those that use a pump to circulate the water or other fluid from the collector where it is heated by the sun to the storage tank where it is kept until you need it.
2. Integral collector storage (ICS) systems, or "batch" water heaters, combine the collector and the storage tank into one. That is, the sun shines into the collector and strikes the storage tank directly, heating the water.
3. Thermosyphon systems have a separate storage tank, located above the collector. Liquid (which could be water or an antifreeze solution) warmed in the collector rises naturally to the storage tank where it is kept until needed.
4. Self-pumping systems are those that use a phase change (liquid-vapor) or other passive means to cause the fluid in the collector to circulate and transport heat from the collector to the storage.

The ICS, thermosyphon and self-pumping systems are often called "passive" solar systems because they do not use

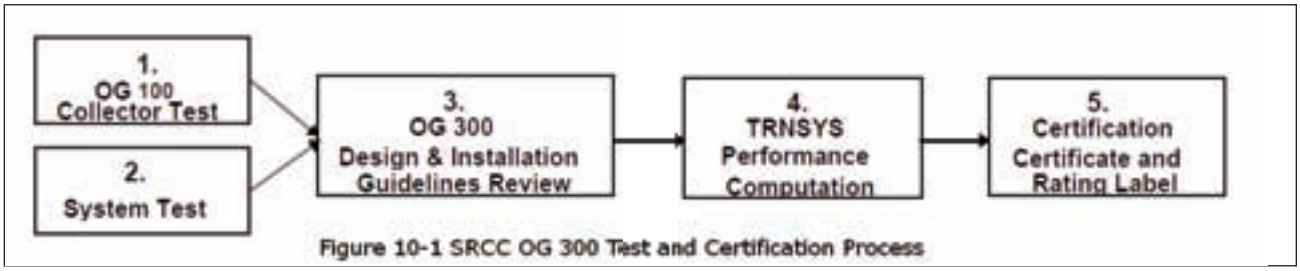

Figure 10.1 shows a OG-300 test flowchart of the steps a system must go through to earn a certification and rating.

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mechanical energy to move the heated water. All four types of solar water heaters work well when installed correctly, and it is interesting to compare the parasitic energy required by the different systems.

The test procedure

Before a System can be tested, its collectors must have been certified by the OG100 Solar Collector test described in the last article. The collectors can then be included in a packaged solar hot water system, which is set up and operated under the following test conditions:

Solar Radiation Profile	4,733 Wh/m2 – day	1500 Btu/ft2 - day
Environmental Temperature	19.7 °C	67.5 °F
Auxiliary Set Temperature	57.2 °C	135 °F
Water Mains Temperature	14.4 °C	58 °F
Total Energy Draw (QDEL)	43,302 kJ	41,045 Btu
Approximate Volume Draw	243 l	64.3 gal
Draw Rate	0.189 l/s	3.0 gpm

Number Of Draws: 6 - One at the beginning of each hour starting at 9:30 am

The solar water heater is exposed to moderate solar radiation, and six times during the day, hot water is drawn from the hot water tank. By the end of the day a total of 41, 045 BTUs has been drawn from the tank, amounting to around 64.3 gallons of hot water. During the test, the aqua-stat controlling the auxiliary heat (electric or gas) is set to maintain 135 F. Separate test results are provided for electric versus gas auxiliary heat since these represent different "systems".

The test results

The test results for the solar water heating system are distilled down to a rating that the SRCC calls the Solar Energy Factor (SEF). It is defined as follows:

SEF = QDEL / (QAUX +QPAR)

Where:

Figure 10.3. Each solar collector also will have a collector certification sticker from the OG 100 test.

Q = The mathematical symbol commonly used to represent Energy.

QDEL = Daily amount of energy delivered to the hot water load using the SRCC rating conditions, this value is 43,302 kJ/day. To convert to kWh, divide this value by 3,600.

QAUX = Daily amount of energy used by the auxiliary water heater or backup element, with the solar system operating (kJ/day). To convert to kWh, divide this value by 3,600.

QPAR = Parasitic energy: Daily amounts of AC electrical energy used to power pumps, controllers, shutters, trackers, or any other item needed to operate the SDHW system (kJ/day). To convert to kWh, divide this value by 3,600.

The SEF is similar to the "Coefficient of Performance" (COP) used to compare refrigeration heat pumps. The useful energy delivered is compared to the conventional energy consumed, and the result is a ratio that is typically greater than 1. So, for example a SEF of 3 tells you that 3 times more energy was delivered than was consumed by the heating equipment.

System comparisons

The SRCC publications include some descriptions of how to use the data to make other useful comparisons such as the Solar Fraction (SF), Energy Factor (EF), Solar Saving (QSOLAR) , Electric Backup (Kwhr) and Gas Backup (therms).

SRCC uses a computer model called TRNSYS to estimate the thermal performance ratings of solar water heating systems under specified conditions. A separate computer model for each system is developed from test data on some of the system components, manufacturer's literature on the others, and theoretical calculations. These ratings are based on conditions similar to the ones defined by the U.S. Department of Energy for testing conventional water heaters. The City by City Annual Performance Estimates are based on these computer models and are presented in terms of Energy Savings for each system compared to a conventional 50 gallon water heater (electric or gas). Keep in mind that these ratings are only estimates based on an assumed set of operating conditions and that your actual performance will vary depending your hot water usage pattern and actual weather conditions.

As shown in Figure 10-2, each certified solar water heating system will have a sticker on it.

The certification process

Certification is based upon the determination by SRCC that the system successfully meets its minimum criteria in the following categories:

1. Design
2. Reliability and durability
3. Safety
4. Operation and servicing
5. Installation
6. Operation and maintenance manuals.

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This is the part of the certification where the packaged system is inspected rather than tested, and there are dozens of items on the inspection checklist which can be seen on page 13 of the OG 300 Directory. Once the system is tested and passes inspection, it can then receive its certification, and each certified solar water heating system will have a sticker on it as shown in Figure 10-2. Each solar collector also will have a collector certification sticker from the OG 100 test, as shown in Figure 10-3.

Limitations

The OG 300 test seems to have been designed to compare all solar water heater systems of any size to a 50-gallon conventional water heater. This is useful for typical residential comparisons when that size hot water tank is appropriately sized. For larger water heater systems and for hydronic space heating systems, these ratings and comparisons are not relevant.

There are other debatable issues regarding the SRCC procedures, such as the way that the surface area for vacuum tube collectors is (mis)calculated, whether the hot water usage profile is realistic, and whether the temperatures during the test are representative of your actual installations. So, use these test results only as the guidelines that they provide. When comparing solar equipment, the SRCC could be your first stop for some easy comparisons, but it probably should not be your last stop. Other sources should also be consulted to get the complete picture, including details available from the manufacturers and suppliers, as well as the experience of other designers and installers. ■

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The views and opinions expressed in this column are those of the author and do not reflect those of *Plumbing Engineer* nor its publisher, TMB Publishing.

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.