Calculation of collector efficiency and annual savings

To determine the amount of energy produced by a single collector and calculate the size of a solar system, we should know the average collector efficiency over the whole year. At this article will guide you how to do this.

Calculation of the annual efficiency of a collector will use a standard formula. However, to use this formula it is required to know the following data first:

- Local sun insolation level
- Collector Size
- Average Cold water temperature
- Average Ambient air temperature
- Average Collector Manifold temperature

The local insolation level can be get from your local meteorology department's website or report, or you can click here to check braves website for some available data, or from any other publishing or organization such as NASA. (http://eosweb.larc.nasa.gov) Here we will take Guangzhou of China as a sample. And for collector, we choose SOLARSHINE-SSC-02-2.0A as example.

Insolation Level: From the government report, the average annual insolation level of Guangzhou is 4.2Kwh/m^2/day.

In Guangzhou, the sunshine hour in averaged over the full year is around 6 hours/day. Dividing the average insolation level by the number of sunshine hours, that in Guangzhou, it would receive an average of 700Watts/m^2 of insolation averaged across the full year.

Average Cold water temperature: 21.5℃
Average Ambient air temperature: From the website of CMA (China Meteorology Administration), annual average air temperature is 22℃

Collector Size:
In this case it is important to use the collector absorber area; the area in which solar gain can be converted to heat energy. The absorber area of each collector is 1.76m^2

Average Manifold temperature:
The average manifold temperature is the same as the average annual water temperature flowing through the collector outlet port after heating. A figure of 50℃ is used as a realistic estimate. The difference between the manifold temperature and the ambient temperature is a major factor in determining the heat lost from the collector to the outside, and therefore the efficiency of the collector.

Collector Efficiency – Average over full year:
Solar water heater performance is often presented in an efficiency chart, constructed from a set of three performance variables. Also, using these variables we can calculate the solar conversion efficiency of a panel at a specific point in time and a set of environmental conditions.

The Three performance variables for SSC-02-2.0A collector as follows:
Conversion Factor: $\eta 0 = 0.773$
Loss Coefficient: $a1 = 4.0$ W/(m^2K)
Loss Coefficient: $a2 = 0.003$ W/(m^2K^2)

Put these values into the standard efficiency formula:

$$\eta(x) = \eta 0 - a1 \times (X) - a2 \times G \times (X)^2$$

Where:
X = (Tm – Ta)/G
Tm = Manifold Temperature
Ta = Ambient Temperature
G = Insolation Level in Watts/m^2
As calculated earlier, the average annual insolation level is 700 Watts/m^2

Therefore:
X = (50-22)/700
X = 0.04

Plugging 'X' into the main equation:
η (x) = 0.773 – (4 x 0.04) – (0.003 x 700 x (0.04)2
η (x) = 61%
This means that over a year, 61% of the total energy provided by the sun can be converted to heat energy.

Average energy and heating cost savings over full year:

To work out the energy output of the collector over one year we need to know:
Average insolation - 4.2 kWh/ m^2/day
Absorber surface area - 1.76 m^2
Average efficiency -61%

Each day, a single collector will collect:
Irradiance x collector absorber area x efficiency
4.2kwh x 1.76m^2 x 61% = 4.51kWh

If divided this figures by one sq. meter, than one sq. meter out put 2.56Kwh/day.

Over the year, if use one collector in Guangzhou, it will collect 4.51 x 365=1646 kWh of energy. This will offset the energy previously required from your gas or electric heater. If the water is heat by electric water heater, the electricity price in Guangzhou is around US$0.1/Kwh. That means, for one year, a solar collector will save your heating cost 1646x0.1=US$164

The more expensive of the electricity power is, the more saving you will get!

Version: 1.1

Solarshine
Expert of solar hot water

www.solar-shine.com