CALIFORNIA EFFECTIVE AREA

SOLAR THERMAL COLLECTOR METRIC SPECIFICATION

Effective area (TESS, 2019) is a metric developed to normalize the area associated with water heating solar thermal collectors in the State of California. It adjusts the area of the collector to account for differences in the geometry of glazed flat plate and tubular collector types, and the performance of individual collector models. For example, it addresses the spacing between individual tubes and non-symmetrical geometry of tubular collectors. It also uses the measured collector performance equation based on gross area (A_g), and expands it to account for off-peak performance where the sunlight strikes the collector at an angle. The resulting effective area value (A_e) allows the performance of water heating collectors used in California to be compared using a single value.

Calculation Methodology

The effective of a given solar thermal collector is calculated using several climatic assumptions, and collector performance inputs as described below.

Assumptions

Several assumptions are made regarding climatic conditions corresponding to average conditions in the State of California.

Temperature Differential (T_i-T_a): $\Delta T = 20°C$
Beam Irradiance: $G_b = 550\ W/m^2$
Diffuse Irradiance: $G_d = 175\ W/m^2$
Total Irradiance: $G_t = 725\ W/m^2$

Collector Inputs

Inputs for the calculations use several collector parameters available from OG-100 certificates. The second-order efficiency equation coefficients, based on ΔT=(T_i-T_a), is used (where T_i is the inlet temperature to the collector and T_a is the ambient air temperature). These values are determined from laboratory testing of the collector to the methods in the ISO 9806-2017 standard, as specified by the ICC 901/SRCC 100 standard used with the OG-100 program.

Gross Collector Area (A_g)
Peak Hemispherical Collector Efficiency ($\eta_{0,hem}$)
Heat Loss Coefficient (a_1)
Temperature Dependence of the Heat Loss Coefficient (a_2)
Incident Angle Modifier (IAM_{xx}) , where xx is the angle of incidence in degrees

Different equations are used for flat plate and tubular collectors to calculate effective area. The flat plate equation makes use of the overall incidence angle modifier at 35 and 45 degrees (IAM_{35} and IAM_{45}). The tubular equation specifies both transverse and longitudinal IAM values since the collector is non-symmetrical. Specifically, it uses the transverse IAM at 30 degrees ($IAM_{T,30}$) and longitudinal IAM at 20 and 30 degrees ($IAM_{L,20}$ and $IAM_{L,30}$).

The equations are given for the calculation of effective area for both types of collectors below:

Flat Plate Glazed Collectors

$$A_e = A_g \left[\eta_{0,hem} IAM_{35} \frac{G_b}{G_t} + \eta_{0,hem} IAM_{45} \frac{G_d}{G_t} - a_1 \frac{\Delta T}{G_t} - a_2 \frac{(\Delta T)^2}{G_t} \right]$$

Tubular Collectors

$$A_e = A_g \left[\eta_{0,hem} IAM_{T,30} IAM_{L,20} \frac{G_b}{G_t} + \eta_{0,hem} IAM_{T,30} IAM_{L,30} \frac{G_d}{G_t} - a_1 \frac{\Delta T}{G_t} - a_2 \frac{(\Delta T)^2}{G_t} \right]$$

The effective area metric concept was developed by Jeff Thornton of Thermal Energy System Specialists, LLC (TESS) in 2020. Used with permission.