Flat-Plate Solar Collector Efficiency (Hottel–Whillier–Bliss)

Efficiency and useful heat of a flat-plate solar water collector from irradiance, inlet and ambient temperatures and the collector's F_R(τα) and F_R U_L.

Method: Hottel–Whillier–Bliss equation (Duffie and Beckman, Solar Engineering of Thermal Processes, ch. 6)

Input parameters

Unit system: SI

Parameter	Value	Unit
Solar irradiance on the collector	800.00	W/m²
Inlet water temperature	40.000	°C
Ambient temperature	30.000	°C
Optical intercept F_R(τα) From the collector's test report. ISO 9806 reports often give η_0, a_1, a_2 on the mean fluid temperature: convert them to the inlet-temperature form F_R(τα), F_R U_L first (Duffie and Beckman).	75.000	%
Loss slope F_R U_L	4.5000	W/(m²·K)
Collector aperture area	2.0000	m²

Calculated results

Parameter	Value	Unit
Efficiency	69.375	%
Useful heat	1,110.0	W
Reduced temperature	0.012500	m²·K/W
Inlet temperature at zero output	163.33	°C

Notes for this case

- Linear efficiency line from the test report; second-order loss terms and incidence-angle effects are not included.

Formula and method

$$\eta = F_R(\tau\alpha) - F_R U_L \frac{T_i - T_a}{G}, \quad \dot{Q}_u = \eta G A, \quad T_{stag} = T_a + \frac{F_R(\tau\alpha)\, G}{F_R U_L}$$

Variables

G	Solar irradiance on the collector	W/m²
T_i	Inlet water temperature	K
T_a	Ambient temperature	K
$F_R(\tau\alpha)$	Optical intercept F_R(τα)	-
$F_R U_L$	Loss slope F_R U_L	W/(m²·K)
A	Collector aperture area	m²
η	Efficiency	-
$\dot{Q}_u$	Useful heat	W
$(T_i - T_a)/G$	Reduced temperature	m²·K/W
T_{stag}	Inlet temperature at zero output	K

Method and standards

Hottel–Whillier–Bliss equation.

Assumptions and limits

- Steady state, linear loss, on the inlet temperature. Test reports to ISO 9806 usually give η_0, a_1 and a_2 on the mean fluid

temperature; those must be converted to F_R(τα) and F_R U_L before use here.
- With F_R U_L = 0 the zero-output temperature is not defined and is not shown.

References
- Hottel–Whillier–Bliss equation (Duffie and Beckman, Solar Engineering of Thermal Processes, ch. 6)

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online
https://calc.firecad.com/mechanical/heat-transfer/solar-collector-efficiency

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Reopens the calculator with the inputs of this report.