Fully Mixed Solar Storage Tank Temperature After a Period

Temperature of a fully mixed hot-water storage tank after a period with solar gain, load withdrawal and losses to its surroundings, by Euler step and exact solution.

Input parameters

Unit system: SI

Parameter	Value	Unit
Mass of water in the tank	300.00	kg
Specific heat	4.1800	kJ/(kg·K)
Tank loss coefficient-area product	0.002000	kW/K
Temperature around the tank	15.000	°C
Tank temperature at the start	60.000	°C
Solar energy added during the period	0	MJ
Energy removed to the load during the period	0	MJ
Period	14.000	h

Calculated results

Parameter	Value	Unit
Tank loss during the period (Euler)	4.5360	MJ
Final temperature, one Euler step	56.383	°C
Final temperature, exact for steady rates	56.524	°C
Temperature the tank would settle at	15.000	°C
Tank time constant M c_p/(UA)	174.17	h

Notes for this case

- A fully mixed tank; real tanks stratify, which keeps the collector inlet cooler and the load supply hotter.

Formula and method

$$T_s^+ = T_s + \frac{\Delta t}{(Mc_p)_s}\left[Q_u - L_s - (UA)_s(T_s - T'_a)\right]$$

$$T_s(\Delta t) = T_\infty + (T_s - T_\infty)e^{-\Delta t(UA)_s/(Mc_p)_s}, \quad T_\infty = T'_a + \frac{(Q_u - L_s)/\Delta t}{(UA)_s}$$

Variables

M	Mass of water in the tank	kg
c_p	Specific heat	J/(kg·K)
$(UA)_s$	Tank loss coefficient-area product	W/K
T'_a	Temperature around the tank	K
T_s	Tank temperature at the start	K
Q_u	Solar energy added during the period	J
L_s	Energy removed to the load during the period	J
Δt	Period	s
Q_{loss}	Tank loss during the period (Euler)	J
T_s^+	Final temperature, one Euler step	K

$T_s(\Delta t)$	Final temperature, exact for steady rates	K
T_∞	Temperature the tank would settle at	K
τ	Tank time constant M c_p/(UA)	s

Method and standards

Energy balance of a fully mixed (unstratified) storage tank.

Assumptions and limits

- Fully mixed; constant gain and load rates over the period for the exact solution.

Report details

Report reference	FCC-3SCW-CHGE (the same inputs always give the same reference)
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Release checks	4 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/environmental/solar-thermal/solar-storage-tank-temperature

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.