Appendix H: Solar water heating

The working principle of solar hot water systems is shown in Figure H1: examples of arrangements are given in Figure H2 (these do not show all possible arrangements and the procedures in this Appendix are applicable to any arrangements that follow the same principles).

Water from the cold supply is either fed (directly or via a cold feed cistern) to the preheat zone where it is heated by solar energy. Then the water passes to the domestic hot storage (separate hot water cylinder or upper part of combined cylinder) which is heated to the required temperature by a boiler or an electric immersion.

There are three main types of solar collector:
- unglazed: the overall performance of unglazed collectors is limited by high thermal losses;
- glazed flat plate: a flat plate absorber (which often has a selective coating) is fixed in a frame between a single or double layer of glass and an insulation panel at the back;
- evacuated tube: an absorber with a selective coating is enclosed in a sealed glass vacuum tube.

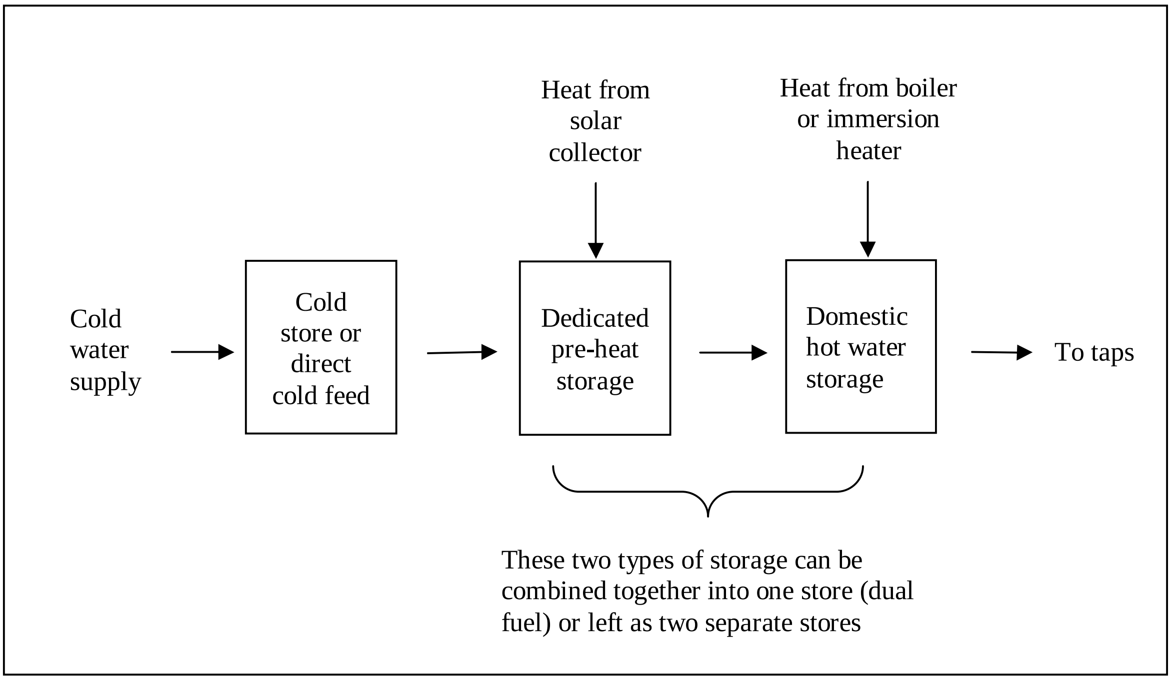
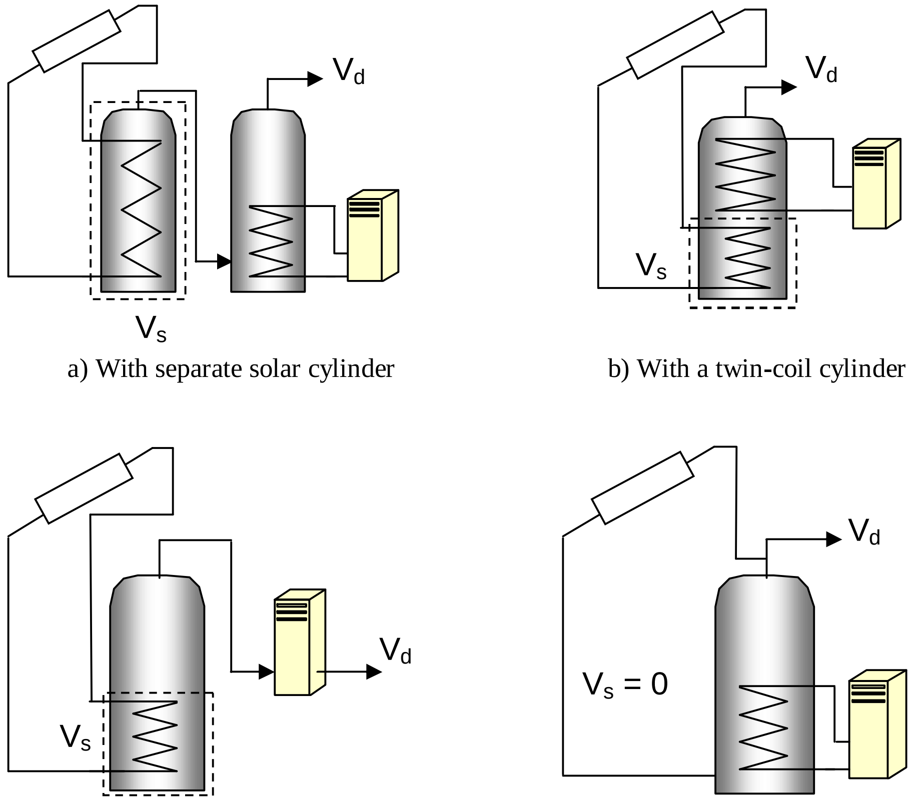


Figure H1: Working principle of solar water heating.



a) With separate solar cylinder

b) With a twin-coil cylinder

c) Combi boiler

d) Direct system

V_s (indicated by the dashed line) is the dedicated solar storage volume. See text below concerning the effective solar volume. V_d is the daily hot water demand.

Figure H2: Schematic examples of arrangements for solar pre-heating

The performance of a solar collector is represented by its zero-loss efficiency (proportion of incident solar radiation absorbed in the absence of thermal loss) and its heat loss coefficient (heat loss from collector to the environment per unit area and unit temperature difference).

The solar contribution to domestic hot water is given by

$$Q_s = S \times Z_{panel} \times A_{ap} \times \eta_0 \times UF \times f(a_1/\eta_0) \times f(V_{eff}/V_d) \qquad \text{(H1)}$$

where

- Q_s = solar input, kWh/year
- S = total solar radiation on collector, kWh/m²/year
- Z_{panel} = overshading factor for the solar panel
- A_{ap} = aperture area of collector, m²
- η_0 = zero-loss collector efficiency
- UF = utilisation factor
- a_1 = linear heat loss coefficient of collector, W/m²K
- $f(a_1/\eta_0)$ = collector performance factor = $0.87 - 0.034\,(a_1/\eta_0) + 0.0006\,(a_1/\eta_0)^2$
- V_{eff} = effective solar volume, litres
- V_d = daily hot water demand, litres
- $f(V_{eff}/V_d)$ = solar storage volume factor = $1.0 + 0.2 \ln(V_{eff}/V_d)$ subject to $f(V_{eff}/V_d) <= 1.0$

The collector's gross area is the projected area of complete collector (excluding any integral means of mounting and pipework). The aperture area is the opening through which solar radiation is admitted.

The preferred source of performance data for solar collectors is from a test on the collector concerned according to BS EN 12975-2, *Thermal solar systems and components – Solar collectors – Part 2: Test methods*. The aperture area, and the performance characteristics η_0 and a_1 related to aperture area, are obtained from the test certificate. If test data are not available (e.g. for existing installations), the values in Table H1 may be used.

The effective solar volume is:
- in the case of a separate pre-heat tank (such as arrangements a) or c) in Figure H2), the volume of the pre-heat tank;
- in the case of a combined cylinder (such as arrangement b) in Figure H2), the volume of the dedicated solar storage plus 0.3 times the volume of the remainder of the cylinder;
- in the case of a thermal store (hot-water-only or integrated as defined in Appendix B) where the solar coil is within the thermal store, the volume of the dedicated thermal storage.
- in the case of a direct system (such as arrangement d) in Figure H2), 0.3 times the volume of the cylinder.

Note. The overall performance of solar water systems depends on how the hot water system is used, e.g. daily draw-off patterns and the use of other water heating devices such as a boiler or an immersion. The procedure described here is not suitable for detailed design in a particular case. It is intended to give a representative value of the solar contribution to domestic water heating over a range of users.

Calculation of solar input for solar water heating

Aperture area of solar collector, m² *If only the gross area can be established reliably, multiply it by ratio in Table H1*			(H1)
Zero-loss collector efficiency, η_0, from test certificate or Table H1			(H2)
Collector heat loss coefficient, a_1, from test certificate or Table H1			(H3)
Collector performance ratio a_1/η_0	(H3) ÷ (H2)=		(H4)
Annual solar radiation per m² from Table H2			(H5)
Overshading factor from Table H3			(H6)
Solar energy available	(H1) × (H2) × (H5) × (H6) =		(H7)
Solar-to-load ratio	(H7) ÷ [(39) + (40)] =		(H8)
Utilisation factor if (H8) > 0, 1 - exp[-1/(H8)], otherwise enter "0" in box (H9) *if the cylinder is heated by a boiler and there is no cylinderstat, reduce the utilisation factor by 10%*			(H9)
Collector performance factor	if (H4) < 20 0.87 - 0.034 × (H4) + 0.0006 × (H4)² = else 0.604 – 0.0087 × (H4) =		(H10)
Dedicated solar storage volume, V_s, litres *volume of pre-heat store, or dedicated solar volume of a combined cylinder*			(H11)
If combined cylinder, total volume of cylinder, litres			(H12)
Effective solar volume, V_{eff} *if separate pre-heat solar storage or a thermal store, (H13) = (H11)* *if combined cylinder, (H13) = (H11) + 0.3 ´ [(H12) – (H11)]*			(H13)
Daily hot water demand, V_d, (litres) from Table 1			(H14)
Volume ratio V_{eff}/V_d	(H13) ÷ (H14) =		(H15)
Solar storage volume factor $f(V_{eff}/V_d)$ *(not greater than 1.0)*	1 + 0.2 × ln(H15) =		(H16)
Solar input Q_s	(H7) × (H9) × (H10) × (H16) =		(H17)

Note: (39) and (40) are box numbers of the main worksheet

Enter (H17) in (50) of main worksheet. If separate figures for solar input are required for the heating season (8 months) and summer (4 months) take 50% of Q_s as applying during the heating season and 50% during the summer.

Table H1 : Default collector parameters

Collector type	h_0	a_1	Ratio of aperture area to gross area
Evacuated tube	0.6	3	0.72
Flat plate, glazed	0.75	6	0.90
Unglazed	0.9	20	1.00

Table H2 : Annual solar radiation, kWh/m²

Tilt of collector	Orientation of collector				
	South	SE/SW	E/W	NE/NW	North
Horizontal	933				
30°	1042	997	886	762	709
45°	1023	968	829	666	621
60°	960	900	753	580	485
Vertical	724	684	565	427	360

Table H3 : Overshading factor

Overshading	% of sky blocked by obstacles.	Overshading factor
Heavy	> 80%	0.5
Significant	> 60% - 80%	0.65
Modest	20% - 60%	0.8
None or very little	< 20%	1.0
Note: Overshading must be assessed separately for solar panels, taking account of the tilt of the collector. Usually there is less overshading of a solar collector compared to overshading of windows for solar gain (Table 6d).		