Simplified Sizing Procedure For Solar Domestic Hot Water Systems

Florida Solar Energy Center

FSEC-GP-10-83
Revised April 1992

The following procedure was developed to size residential solar water heating systems in Florida.
See last page for limitations and assumptions.

Hot water demand and tank size

Step 1. Using Table 1, estimate daily hot water use (GALLONS) and select a nominal tank size (TANK SIZE).

_______________ gal/day
GALLONS (1)

_______________ gal
TANK SIZE

Table 1. Hot water demand and tank size

Average GALLONS and minimum TANK based upon number of people **or** bedrooms:

People	(or)	Bedrooms	GALLONS	Minimum TANK SIZE (Gallons)
1			20	40
		1	30	30
2			40	40
		2	50	52
3			55	52
4		3	70	80
5			85	80
		4	90	100
6			100	100
		5	110	120
7			115	120

(Add 15 gallons for each additional person.)
(Add 20 gallons for each additional bedroom.)

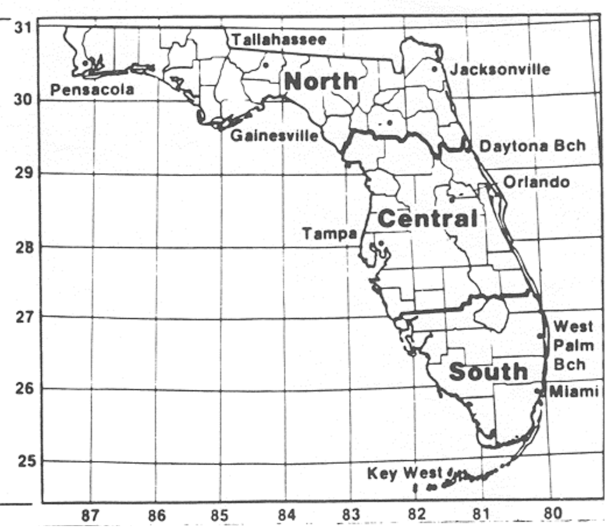
Step 2. Using Figure 1, determine the proper cold water temperature (COLDTEMP) for location.

_______________ °F
COLDTEMP (2)

Figure 1. Cold water temperatures

Region	COLDTEMP
North Florida (1, 2, 3)*	68°F
Central Florida (4, 5, 6)*	72°F
South Florida (7, 8, 9)*	76°F

* Correspond to regions for the Florida model energy building code.



Step 3. Calculate how much energy is needed (BTUNEED) to heat the water to 122°F.

BTUNEED = 8.34 x GALLONS x (122 - COLDTEMP) x Standby loss factor

BTUNEED = 8.34 x ________ x (122 - ________) x ________   ______________ Btu/day
(Step 1) (Step 2) (Table 2) BTUNEED (3)

Table 2. Standby heat loss from storage

Type of tank insulation	Standby loss factor
1-in. foam or 2.5-in. fiberglass (R = 8 - 9)	1.20
2-in. foam (R = 16 - 17)	1.12

(Use linear interpolation to obtain standby loss factor for insulation materials having other R -values.)

Table 2 is to be used for sizing systems with FSEC rating. If SRCC rating is used and if there are no other backup tanks then use a standby loss factor or 1.0.

Example: A thermosiphon water heater with its storage tank containing a back-up element has an SRCC rating. There are no other back-up tanks for the system. In this case use a standby loss factor = 1.0

Example: The same thermosiphon water heater system is used as a preheater to another back-up tank. The element in the thermosiphon tank may not be connected. In this case use a standby loss factor from Table 2 corresponding to back-up tank insulation levels.

Collector Sizing

Step 4. Determine penalty factors that affect sizing.

a. Select the System Factor from Table 3. ______________ System Factor (4a)

b. Select the proper Tilt Factor from Table 4. ______________ Tilt Factor (4b)

c. Select the Orientation Factor from Table 5. ______________ Orientation Factor (4c)

Calculate the overall penalty factor (PENALTY) for the combination of all three individual effects:

PENALTY = System Factor x Tilt Factor x Orientation Factor

PENALTY = ____________ x ____________ x ____________   ______________
(Step 4a) (Step 4b) (Step 4c) PENALTY (4)

Table 3. System factors

System configuration	System factor
Direct system with no heat exchanger.	1.20
Indirect system with a heat exchanger between collector and storage tank.	1.30
Systems with SRCC system certification and Q_{NET} rating.	1.00

Table 4. Tilt factors

Collector tilt			Tilt factors		
Tilt angle	Roof pitch	Roof tilt	North Florida	Central Florida	South Florida
0° to 3°	0	0°	1.25	1.22	1.19
3° to 7°	1 in 12	4.8°	1.15	1.14	1.12
7° to 12°	2 in 12	9.5°	1.09	1.08	1.06
12° to 16°	3 in 12	14.0°	1.05	1.04	1.03
16° to 20°	4 in 12	18.4°	1.02	1.01	1.01
20° to 25°	5 in 12	22.6°	1.00	1.00	1.00
25° to 30°	6 in 12	26.6°	1.00	1.00	1.00
30° to 37°	8 in 12	33.7°	1.01	1.01	1.02
37° to 43°	10 in 12	39.8°	1.04	1.05	1.06
43° to 50°	12 in 12	45.0°	1.08	1.10	1.12

Table 5. Orientation factors

Collector orientation	Orientation factor
South or nearly south	1.00
Southeast or southwest	1.15
East or west	1.40

Step 5. Calculate the rating requirements of the solar system (RATREQD) to provide 70% of the annual hot water energy needs using the formula:

RATREQD = BTUNEED x 0.70 x PENALTY

RATREQD = ________ x 0.70 x ________
(Step 3) (Step 4)

________ Btu/day
RATREQD (5)

Step 6. For the collector selected, record the thermal performance rating at the intermediate temperature (BTURATING) in Btu/day and the gross collector area (GROSSAREA) in square feet from the required FSEC label.

Collector Manufacturer ____________________

Model No. ____________

Thermal Performance Rating at the Intermediate Temperature (Btu/day) or SRCC Q_{NET} or Q_{NET} equivalent*

________ Btu/day
BTURATING (6a)

Gross Collector Area (ft²)

________ ft²
GROSSAREA (6b)

Estimate the number of collectors needed using:

NUMBER = RATREQD / BTURATING = (Step 5) / (Step 6a)

____
NUMBER (6c)

Step 7. Select the actual number of collectors to be used. This is the nearest whole number to (6c).

____
NO. COLLECTORS(7a)

The total area of the collector array is:

TOTAL AREA = NO. COLLECTORS x GROSSAREA

TOTAL AREA = ________ x ________
(Step 7a) (Step 6b)

________ ft²
TOTAL AREA (7b)

*For those systems that are SRCC certified use the SRCC Q_{NET} rating here. Systems with only an FSEC test and certification may get an equivalent SRCC Q_{NET} from FSEC Testing & Operations on request.

Based upon the actual number of collectors to be used, compute the solar fraction (SOLAR FRACTION):

$$\text{SOLAR FRACTION} = \frac{0.70 \text{ X NO. COLLECTORS}}{\text{NUMBER}} = \frac{0.70 \times \underline{\qquad\quad} \text{ (Step 7a)}}{\underline{\qquad\quad} \text{ (Step 6c)}} = \underline{\qquad\quad} \text{ SOLAR FRACTION (7C)}$$

If the solar fraction (Step 7c) is less than 0.65, the collector array is undersized. Consider either adding another collector or using a different model/size collector.

This procedure has several constraints:

1. The procedure is valid only for Florida
2. The procedure is based on sizing solar systems to provide between 65% and 75% of the heating load; i.e., a solar fraction of between 0.65 and 0.75. A solar fraction of 0.7 is estimated to be optimum for most installations and, in particular, for solar collectors with a tilt angle of approximately 20° to 25° (mounted parallel to the 4-in-12 or 5-in-12 pitched roofs that are common in Florida). The 20° - 25° collector tilt angle provides for an aesthetic installation and meets 100% of the hot water needed in summer and 50% in winter. Systems can be sized to maximize lifetime savings by providing a larger solar collector that will produce a solar fraction of 0.9 or higher. To achieve this solar fraction, the collectors will need to be installed at a tilt angle of between 40° and 50°.
3. The hot water delivery temperature of 122°F in step 3 was obtained by FSEC from analysis of two years of actual experimental data. The 122°F delivery temperature is consistent with Florida law, which requires that hot water thermostats be set no higher that 125°F. It is also consistent with electric water heater energy consumption data as measured by Florida Power and Light Co.

   Automatic dishwashers may not clean dishes very well at 122°F. However, most dishwashers have a cycle that uses an electric element in the dishwasher to boost the water temperature to about 140°F.

This form was developed by Subrato Chandra with the assistance of David Block, Mukesh Khattar, David Lahart, Tim Merrigan, Jerry Ventre, and Ingrid Melody.