Solar Hot Water Heater Thermosiphon

Scope

- First determine that the roof and utility room space are suitable for solar hot water components.
- Follow the requirements for all local codes.
- Choose an accredited solar water heating installation company.
- Size the system according to the home’s hot water demands.
- Mount the system on an unshaded, southern exposure if possible.
- Ensure that the roof mounting system avoids water intrusion and damage to the roof structure.
- Install a thermosiphon if you are choosing a low-maintenance solar hot water system that does not require a mechanical pump.

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
Description

Thermosiphon systems are passive with a storage tank located higher than the solar collector. They rely on passive natural convection where more dense cold water falls, moving hotter water to the storage reservoir at the top. Some systems come prepackaged with tanks pre-mounted to collectors. In these systems the tank sits on the outside of the roof. Other systems have tanks located inside attic spaces above the collectors. In the case of a direct system, potable water is used as the heat transfer fluid.

Passive direct thermosiphon systems are usually limited for use in coastal areas of Texas, southern California and Central Florida. (See the Climate section for more information.)

![Figure 1. Rooftop portion of a thermosiphon solar hot water system.](image)

Passive indirect thermosiphon systems are also available which utilize polypropylene glycol with a heat exchanger to avoid freezing. In warm climates, care must be taken to avoid stagnant conditions that can lead to the glycol overheating. In climates that freeze, the water pipes and tanks containing water must be in a conditioned space.

Installation of a thermosiphon solar hot water system on a roof requires proper connection to the roof substrate. The manufacturer-designed attachment kit provides long-term and secure attachment to the collector. It is inappropriate to use other building materials such as wood blocks to mount an integrated collector system.

To ensure that other components of the home are ready for a solar thermal system, use the following guides:

- **Utility Room Space**
- **Mounting Surface for Pumps and Gauges**
- **Solar Bypass Valve**
- **Solar Plumbing and Wiring Chase**
- **Architectural Drawing**

Install a Thermosiphon Solar Hot Water System

1. Select an approved manufacturer that has been certified and listed by an accredited institution such as the [Florida Solar Energy Center – FSEC](https://www.fsec.ucf.edu). Solar systems certified by SRCC (OG-300) may qualify for tax credit or additional rebate incentive programs. The North Carolina based organization [Database of State Incentives for Renewable Energy (DSIRE)](https://www.dsireusa.org) maintains a database map for state, local, utility and federal incentives and policies that promote solar renewable energy.

2. Size the solar thermal system accordingly to provide at least 50% of the homes’ water heating energy needs. Solar system selection should be certified by the [Solar Rating Certification Corporation (SRCC)](https://www.srcc.org), the [International Association of Plumbing and Mechanical Officials (IAPMO)](https://www.iapmo.org), or be labeled with Energy Star.

3. A solar thermal collector is preferably mounted on an unshaded southern exposure orientation; however, eastern or western orientations are not to be ruled out. The use of a sun chart or approved analysis tool is recommended to determine seasonal shading.

4. Solar water heating system installations should comply with local building and plumbing codes. Installation should be executed by a trained certified installer. The [North American Board of Certified Energy Practitioners (NABCEP)](https://www.nabcep.org) provides a national database on their website that lists certified solar contractors. In addition, the [Solar Energy Industry Association (SEIA)](https://www.seia.org) provides a map listing of products, companies and solar services.
5. Collector mounting on a roof substrate requires special attention to avoid water intrusion or damage to the roof structure. Builders and installers should take into consideration mounting and positioning of the collector to comply with wind zones, particularly in coastal areas.

6. Plumbing lines to the collector are to be kept at minimal length, preferably at 25 feet, and are usually routed through attics where they are continuous with sleeved insulation. Exterior plumbing lines are also possible with an architectural chase for better appeal.
Ensuring Success

Installation of a thermosiphon solar hot water system is no more difficult than the assembly of any other building component when proper design precautions are taken into consideration. Builders are encouraged to work with solar installers and manufacturers to select a package for high consumer acceptance. Building aesthetics and minimal use of floor space are a high priority to customers in new homes.

Selection of a solar contractor should be based on credentials, local company service territory, years of experience and trust. Warranty and maintenance agreement of at least two years is recommended.
Climate

The DOE Zero Energy Ready Home PV-Ready Checklist (Revision 07) is required only under the following condition related to climate (See the Compliance Tab for other exceptions):

- Location, based on zip code, has at least 5 kWh/m²/day average daily solar radiation based on annual solar insolation using the PVWatts online tool. See map below.

![Average Daily Solar Radiation Map.](image)

Water heating energy use varies according to the region and amount of hot water gallons used in a residence.

<table>
<thead>
<tr>
<th></th>
<th>Electric Consumption (kWh/yr.)</th>
<th>Annual Cost ($)</th>
<th>Natural Gas Consumption (Thermal/yr.)</th>
<th>Annual Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>4387</td>
<td>$648</td>
<td>244</td>
<td>$242</td>
</tr>
<tr>
<td>Colorado</td>
<td>4109</td>
<td>$453</td>
<td>227</td>
<td>$189</td>
</tr>
<tr>
<td>Florida</td>
<td>3317</td>
<td>$382</td>
<td>186</td>
<td>$339</td>
</tr>
<tr>
<td>Georgia</td>
<td>3282</td>
<td>$363</td>
<td>184</td>
<td>$295</td>
</tr>
<tr>
<td>New York</td>
<td>4729</td>
<td>$864</td>
<td>261</td>
<td>$356</td>
</tr>
<tr>
<td>Texas</td>
<td>3269</td>
<td>$362</td>
<td>184</td>
<td>$313</td>
</tr>
</tbody>
</table>

*Table 1. Expected annual energy use and annual cost ($), for a typical household using 60 gallons/day, for selected states. *Simulations performed in EGUSA (Colorado and New York water heater location in basement, others located in garage).

Overheating and Freezing

Solar thermal water heating system failures may originate from extreme cold and hot temperature conditions. Collector and pipe freezing is a major obstacle solar thermal systems face to avoid operation interruption and to ensure a long-term service life. Increased probability for pipe freezing is higher in mid and northern states, as shown in the figure below.

![Overheating and Freezing Map.](image)
Figure 3. Probability of at least one pipe freeze in 20 years.

Pipes should be insulated with a minimum of 1 in. insulation (closed cell preferred) and those exposed to ultraviolet (UV) should be protected by using a form a jacketing (UV inhibited acrylonitrile butadiene styrene (ABS), polyvinyl chloride (PVC) or aluminum). Passive systems may require a freeze valve for extra protection in regions above central Florida. Freeze exposed potable water piping may be avoided by using heavier insulation such as R-12.
Training

Right and Wrong Images
None Available
CAD
None Available
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Installation of a solar thermal system requires building code compliance. Requisites for code compliance may differ by area, city, or county. Refer to the local governing code ordinance for specific plumbing and electrical rules.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.
Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.
Exhibit 1, Item 7) Provisions of the DOE Zero Energy Ready Home PV-Ready Checklist are Completed.

DOE recommends but does not require solar thermal water systems. See the DOE Zero Energy Ready Home Solar Hot Water-Ready Checklist (Encouraged).

2009, 2012, 2015, and 2018 IECC

Section 401.3 A permanent certificate shall be posted on or near the electrical distribution panel that lists types and efficiencies of water heating, heating, and cooling equipment, as well as insulation R values, and window U and SHGC factors.


Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)


2015 and 2018 IRC

Appendix U (Appendix T in 2018 IRC) Solar Ready Provisions - Prepare the home for solar installations in accordance with these specifications.


Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.


Follow the requirements for solar water heating systems found in the IMC, Chapter 14, Solar Systems (Solar Thermal Systems in 2018 IMC).
References and Resources*

   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2009
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

2. 2009 IRC - International Residential Code for One and Two Family Dwellings
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2009
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2012
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

4. 2012 IRC - International Residential Code for One and Two Family Dwellings
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2012
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

5. 2015 IECC - International Energy Conservation Code
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2015
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

6. 2015 IRC - International Residential Code for One and Two Family Dwellings
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: May, 2014
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

7.
**2018 IECC - International Energy Conservation Code**  
Author(s): International Code Council  
Organization(s): ICC  
Publication Date: November, 2017  
Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.

8. **2018 IRC - International Residential Code for One and Two Family Dwellings**  
Author(s): International Code Council  
Organization(s): ICC  
Publication Date: August, 2017  
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

Author(s): Baechler, Gilbride, Ruiz, Stewart, Love  
Organization(s): Pacific Northwest National Laboratory, Oak Ridge National Laboratory  
Publication Date: June, 2007  
Report providing an introduction to current photovoltaic and solar thermal building practices.

10. **Building Codes and Regulations for Solar Water Heating Systems**  
Author(s): Department of Energy  
Organization(s): DOE  
Publication Date: June, 2012  
Website with consumer and contractor information about building codes and regulations for solar water heating systems.

11. **Dynamic Maps, GIS Data, & Analysis Tools (Webpage)**  
Author(s): National Renewable Energy Laboratory  
Organization(s): NREL  
Publication Date: September, 2014  
Website with prepopulated information about the United States renewable resources.

12. **Heat your Water with the Sun**  
Author(s): National Renewable Energy Laboratory  
Organization(s): NREL  
Publication Date: December, 2003  
Provides consumers with general information on solar water heating systems and how to select a contractor.

13. **Modeling and Test-and-Rate Methods for Innovative Thermosiphon Solar Water Heaters**  
Author(s): Burch, Shoukas, Brandemuhl, Krarti  
Organization(s): National Renewable Energy Laboratory, University of Colorado  
Publication Date: October, 2014  
This paper discusses model validation using data from three thermosiphon systems.

Author(s): North Carolina Solar Center  
Organization(s): North Carolina Solar Center  
Publication Date: September, 2014  
Brochure with information on residential solar hot water systems.

15. **Solar Water Heaters**  
Author(s): Department of Energy  
Organization(s): DOE  
Publication Date: May, 2012  
Website describing how solar water heaters -- also called solar domestic hot water systems -- can be a cost-effective way to generate hot water for your home.

16. **Solar Water Heating Installation Requirements, Energy Trust of Oregon, V 27**  
Author(s): Energy Trust of Oregon  
Organization(s): Energy Trust of Oregon  
Publication Date: August, 2013  
Outlines the minimum criteria for a solar water heating system installed by a Solar Water Heating Program trade ally under Energy Trust of Oregon’s Solar Water Heating Program.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-
dated media, such as web sites, are shown in the measure guide text.

**Contributors to this Guide**
The following authors and organizations contributed to the content in this Guide.

- National Renewable Energy Laboratory
- Pacific Northwest National Laboratory