Integrated Collector Storage

**Last Updated:** 06/29/2016

**Scope**

Install an integrated collector storage (ICS) solar hot water system.

- 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.
- Choose an ICS system if you are installing a solar hot water system in a southern or warm climate that does not experience freezing temperatures at any point during the year. (See the Climate section for more information.)

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

A passive integrated collector storage (ICS) solar thermal water heating systems are common in the southern–belt areas of the U.S. An ICS is a self-contained unit integrating the solar collector and hot water storage of 30-50 gallons.

![Figure 1. Integrated collector storage (ICS) system.](image)

These systems are passive type since no pump or controllers are needed. These units pre-heat mains incoming water before it is routed to the primary water heater storage unit supplying hot water into a building. Some people prefer the simplicity of these systems because there is little or no maintenance required. ICS units can also be plumbed in series to feed tankless electric of gas water heaters where it is boosted to end point of use. Storage on these systems may be a large single tank or a series of four inch (4 in.) tubes, usually copper with selective paint acting as the absorber. Because of the thickness and volume of water contained, chances of freezing are minimized. ICS units do not usually require freeze protection if installed in lower southern regions. However, outdoor exposed plumbing lines to and from the ICS unit may require larger diameter with heavy insulation or freeze valve for protection. If an ICS unit is used for direct hot water consumption it is mandatory to use an anti-scald valve, whereas used in series with a secondary tank it may not be required.

Installation of an integrated solar water heating collector 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 an Integrated Collector Storage 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. 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) maintains a data base 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), the International Association of Plumbing and Mechanical Officials (IAPMO), 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) provides a national database on their website that lists certified solar contractors. In addition, the Solar Energy Industry Association (SEIA) 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 an integrated collector storage (ICS) 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.
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 ($)</th>
<th>Natural Gas Consumption (Therms/Yr)</th>
<th>Annual Cost ($)</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>$463</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).*

Freezing

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. Integrated collector storage (ICS) units with 4 in. diameter tubes have an advantage over thermosyphon systems. ICS collectors avoid freezing under prolonged low temperature periods due to their large mass and with the help of a glazed layer and insulated frame walls.
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 integrated collectors 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.

**Retrofit:** 2009, 2012, 2015, and 2018 IECC

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.)

**2009, 2012, 2015, and 2018 IRC**


**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.

**Retrofit:** 2009, 2012, 2015, and 2018 IRC

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).
Access to some references 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.

Case Studies
None Available

References and Resources*

1. **2009 IECC - International Energy Conservation Code**  
   **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:** May, 2014  
   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.

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. Residential Solar Hot Water 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.

14. 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.

15. 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.
Florida Solar Energy Center, lead for the Building America Partnership for Improved Residential Construction (BA-PIRC), a DOE Building America Research Team