

TOOLBASE™ TECHSPECS

Solar Water Heating Systems

MAKING THE SWITCH

What it takes to incorporate solar water heating...

Page 2

TECH CHECK

Steps to take if you decide to start using this building technology...

Page 2

FOOD FOR THOUGHT

What to consider to be sure solar water heating is right for your project...

Page 2

RESULTS FROM THE FIELD

Real-world demonstrations from AZ, MA, MD and WI...

Page 3

DOLLARS & SENSE

Average costs of solar systems...

Page 3

TECH @ A GLANCE

BENEFITS (+) / DRAWBACKS (-)

- + **AFFORDABILITY:** Solar energy is a readily available, renewable resource. Also, solar hot water heating systems may qualify for solar incentive programs.
- + **ENVIRONMENTAL PERFORMANCE:** Reduce dependence on non-renewable and polluting fuels
- + **MARKETABILITY:** Garner points from energy and green building programs
- **AFFORDABILITY:** There is often an increased first cost for hot water systems, and there may be increased maintenance needs
- **DURABILITY:** Increased complexity of water heating system may lead to increased maintenance and repair needs

MAKING THE SWITCH

You will need to establish a relationship with a new solar water heating trade contractor and coordinate with affected trades (e.g., roofer and plumber). In some cases, the plumber will install and maintain the system. The solar thermal industry has been around for decades and is well established. Solar equipment is mentioned directly in the codes and should not pose any obstacles with code inspectors.

INITIAL COST

Solar water heating systems cost more than conventional water heaters, ranging from about \$3,000 for a passive integrated collector storage system to \$8,000 for a conventional active system consisting of rooftop solar collectors, circulating pump, controller, and a storage tank with auxiliary heater. Keeping the system as simple as possible for the application, and considering system design during the planning stage of the home will help minimize costs and maximize payback. Federal, state, and local incentives can also mitigate costs.

OPERATIONAL COST

Solar water heating systems cost less to operate than conventional water heaters. In a typical home which spends between from \$400 to \$500 per year on water heating, a solar water heating system which has a solar energy factor of 2.0 (a typical electric tank has an energy factor of 0.86; gas tanks are about 0.6) would save between \$250 and \$300 annually depending on the cost of electricity or gas.

Depending on system type and complexity, maintenance costs are likely to be somewhat higher for solar water heating systems than for conventional systems. However, systems have proven to be very reliable. The advent of the Solar Rating and Certification Corporation (SRCC) program, which rates system components and performance, has helped ensure system reliability and performance. It is generally recommended that only SRCC-rated systems be installed.

CODE ACCEPTANCE

Chapter 23 of the International Residential Code covers installation requirements for solar water heating systems.

RESULTS FROM THE FIELD

Several PATH Field Evaluations and Building America Case Studies in varying climates across the country have evaluated installation costs and performance.

WARRANTY

Warranty varies by manufacturer and component. Typical warranties vary from 1 to 10 years, depending on the component, and cover manufacturing defects. Installers usually offer 1-year workmanship warranties.

THE BASICS

Solar water heating systems are defined by how water is moved (actively or passively) and how the water is heated (directly or indirectly). Active systems use pumps to move fluid through the collectors to the storage tank. Passive systems rely on either water pressure to move water through the collector to the storage tank—such as in an Integrated Collector Storage (ICS) system—or natural circulation—also called thermosiphoning—in which solar heated water circulates due to the density difference between hot and cold water to the storage tank. In passive systems using thermosiphoning the storage tank must be located above the collectors. Direct systems circulate potable water directly through a solar collector into a storage tank. Indirect (closed loop) systems circulate a separate fluid, typically a non-toxic antifreeze solution, through the solar collector to absorb solar energy. The energy from this fluid is then transferred to potable water by circulating through a heat exchanger within the hot water storage tank.

Although their initial cost is high, especially in the absence of financial incentives, and economic payback can be long, there are often less tangible benefits of using solar energy for water heating. Solar water heating systems provide protection against fluctuating utility costs; reduce environmental pollution; do not require combustion within the home; and employ an abundant, natural, pollution-free source of water-heating energy. Also, builders installing multiple systems can reduce costs below those reported here through economies of scale.

Solar water heating systems are well established in the building codes. Using certified systems and certified installers should help ease the approval process.



MAKING THE SWITCH

What is required to transition from your current building practices to using this technology?

Using solar thermal water heating systems does not require any drastic changes to roofline or architectural design. However, roof-mounted solar collectors need unshaded access to the sun to achieve best performance. Although optimal orientation is due South, systems can be oriented anywhere between due East and due West. Collectors should be mounted on a clear roof surface not on the southern arc shaded by dormers, vegetation, or other collectors.

The optimal tilt angle for a solar collector is an angle equal to the latitude. However, mounting the collector flush with the roofline (for improved aesthetics) will not greatly reduce system performance. A larger collector area may be necessary for a roof pitch that deviates greatly from the latitude.

Installation would ideally be performed by an installer certified by the North American Board of Certified Energy Practitioners (NABCEP). Certified installers have demonstrated the broad knowledge of plumbing and hydronic flow, solar geometry, safety, and electronic controls needed for a solar water heating system. However, since the program is somewhat new, there are relatively few certified installers as of early 2008.

The installation of a solar water heating system will need to be coordinated with and integrated into the work of the roofing, plumbing, and electrical contractors.

SRCC offers training videos for code inspectors regarding how the International Residential Code applies to solar water heating systems. Videos can be viewed online at www.solar-rating.org/education/video/srcc_video.html.

TECH CHECK

Below is a checklist of steps to follow in order to implement this technology in each of your projects.

- Find local NABCEP-certified installer, if possible.
- Work with installer to evaluate house plans with respect to suitability for solar collectors.
- Consult with installer to determine the best type of system for the application. Issues to consider include climate, roof area, complexity of the system, local water conditions, manufacturer preferences, pricing, and installation issues.
- Along with the installer, select an SRCC-certified solar water heating system.
- Identify federal or local programs to help defray the cost of the system.
- Organize a meeting with the solar installer and all trades that will be affected by system installation—site supervisor, roofer, plumber, photovoltaic installer, landscape designers (to avoid shading collectors as plants grow), and others as needed.
- Have installer test the system and clearly label all parts according to manufacturer's or local code requirements.
- Be sure to include the operational manual in your packet for the homeowners.

FOOD FOR THOUGHT

This section provides some things to think about before switching to this building technology – make sure it's the right choice for you.

- Solar thermal systems can work in almost any climate in the United States and, although historically used in retrofit applications, are ideal for new homes where installation can be planned and sequenced. Climate and other factors will determine the best type of system for the home. Local installers are your best resource for providing advice about the best SRCC-rated solar water heating system for your situation.
- Passive, ICS systems are typically the least expensive but can only be used in non-freezing climates.
- With incentives, solar technologies like solar hot water systems are increasingly cost effective, especially as utility rates increase. However, many solar hot water systems continue to be expensive without financial incentives. In many cases, it is more cost effective to first invest in improving energy efficiency in other areas, and then consider implementing solar systems.
- Before sizing a solar water heating system, look for ways to reduce overall hot water consumption—by installing low-flow showerheads and faucet aerators and purchasing ENERGY STAR clothes washers and dishwashers.
- For clarity, it is useful to have all parts of the solar thermal system on the house plans and to separate solar piping from potable water supply piping (and clearly label each).
- If you are not ready to install solar thermal water heating systems, consider making homes “solar ready” by having an unobstructed south-facing roof area, running copper piping or a conduit chase and controller wire from the roof to the utility area, mounting roof brackets before final roofing material is installed, and including space in the utility room for a solar storage tank.

RESULTS FROM THE FIELD

This technology has been used by other builders in real-world building situations – learn from their experiences.

**Bob Ward Companies, Bel Air, Maryland
(2006 Field Evaluation)**

- Two south-facing solar water heating panels collect solar energy in an indirect, active system with an 80-gallon storage tank. When hot water is needed in the home, preheated water from the storage tank flows through an electric tankless water heater (where its temperature is boosted, if necessary) and on to the fixture via a PEX manifold distribution system.
- The solar water heating system, which cost approximately \$7,500, qualifies for a 20% rebate through a federal solar program with additional rebates through the State of Maryland.
- The original gable roof was redesigned to provide south-facing roof area for the collectors.
- While typical regional construction uses about 4,400 kWh/year for hot water, this home is predicted to use 1,379 kWh annually, due to the solar water heating system.

**Armory Park del Sol, Tucson, Arizona
(2004 PATH Field Evaluation)**

- A custom-designed, active solar water and space heating system was installed and equipped for energy monitoring in an occupied home. The system consisted of four, 4x8 solar collectors in a drainback system with a 220-gallon storage tank and a tankless electric auxiliary water heater which served the domestic hot water supply and a hydronic space heating coil. System cost was approximately \$11,000.
- The integration of the solar water heating and HVAC system was complex, even for an experienced installer. Individual systems for water heating are much simpler to install and operate.
- Finding space for the additional equipment required by the solar system inside a relatively small mechanical closet was challenging.
- A few installation issues which led to poorer-than-expected system performance were discovered due to the energy monitoring.
- After system modifications were made, the solar thermal system was providing over 80% of the home's heating and water heating needs. In the summer, the solar thermal system supplies 100% of the water heating needs.
- Overall, factoring the solar thermal and solar PV systems, the homeowners pay about \$15 per month to operate the all-electric home.
- The solar heating design was revised and a second system was installed in a subsequent Zero-Energy Home (ZEH).

**Shea Homes, San Diego, California
(2003 PATH Field Evaluation)**

- Two homes in this evaluation used an ICS system, and one roof-mounted collector was installed; storage capacity was 40 gallons.

- Time of hot water use is crucial in passive solar thermal systems, because the solar heated water stored in the rooftop collector loses heat to the environment – especially after the sun sets. Thus, less solar heated water is available in the early morning, after a night of heat loss, than in the evening hours.
- Two solar thermal water heating systems contributed 23% and 34% to the hot water load at the homes which were monitored.
- Researchers determined that reconfiguring the tempering valve location could increase the solar contribution by 16% and 20% at the two homes.

**Mark Hopf, Builder, Hadley, Massachusetts
(Building America Case Study)**

- Two roof-mounted collectors with a PV-powered pump and an 80-gallon storage tank; total installed cost was \$7,800.
- Oil-fired boiler with heat exchange provides auxiliary water heating.
- Provided 61% of domestic hot water for family of four; annual energy savings was \$172.
- Recirculating pump drew down temperature of auxiliary tank, causing oil-fired boiler to activate even when solar tank was hot.

**Veridian Homes, Madison, Wisconsin
(Building America Case Study)**

- Two roof-mounted collectors with a conventional AC-powered pump and an 80-gallon storage tank; total installed cost was \$6,500.
- System provided 63% of hot water for a family of four, resulting in annual energy savings of \$86.
- A tempering valve needed to be moved after installation because, due to its location between the solar tank and auxiliary tank and low temperature settings, significant energy was lost from the storage tank.

**Civano, Tucson, Arizona
(Building America neighborhood)**

- Active, indirect, closed-loop system eliminated issues with local water's corrosiveness to copper.
- Long runs (up to 120 feet from collector to tank) reduced the effectiveness of the passive circulation system. For passive systems, collectors should be no greater than 20 feet from the storage tank. In this field study, pumps were added to improve the performance.
- Using conventional hot water recirculation methods, in which a timer or thermostat operates a pump which brings hot water instantly to faucets, caused excessive energy use with the solar thermal systems. The recirculation pumps pushed hot water into the solar collectors at night, where the water was cooled and subsequently reheated by the back-up heater.
- Original systems experienced problems with local water corroding the copper—which, coupled with high temperature, accelerated the development of pinhole leaks in the copper pipe. To compensate for local hard water, use a water softener, or use a closed-loop system that circulates glycol solution rather than tap water.

DOLLARS AND SENSE

Depending on system design, costs can range from about \$3,000 to \$8,000. One PATH Field Evaluation included a solar system that cost approximately \$11,000; this was a custom system that also included space heating.



DEFINITIONS

Drainback

A method for freeze protection in which fluid drains from the collector when solar energy is inadequate for heating the fluid.

Direct System

Solar thermal systems that circulate potable water through the solar collectors. These types of systems can only be used in drainback systems or in climates with no freeze potential.

Indirect System

Systems that circulate an antifreeze solution through the solar collectors rather than potable water. A heat exchanger, in turn, heats the potable water for storage.

Integrated Collector Storage (ICS) Systems

Solar heaters that combine the functions of collector and storage into one unit. Typically rooftop mounted, these systems store approximately 40 gallons of water.

North American Board of Certified Energy Practitioners (NABCEP)

Organization that offers a certification process for solar thermal installers, among other energy professional certifications.

Solar Collector

A special kind of heat exchanger that absorbs solar radiation and uses it to heat water which circulates through small pipes within the collector. Also called flat-plate collectors, solar collectors are typically mounted on a roof.

Solar Energy Factor (SEF)

A performance rating for solar water heating systems—the energy delivered by the system divided by the electrical or gas energy input. SEF ranges from 1 to 11, with higher numbers denoting more energy being delivered by solar energy.

Solar Rating and Certification Corporation (SRCC)

Organization which rates solar collectors and solar thermal systems based on expected performance.



The Partnership for Advancing Technology in Housing (PATH) is dedicated to accelerating the development and use of technologies that radically improve the quality, durability, energy efficiency, and affordability of America's housing. Managed by HUD, the PATH partnership includes the homebuilding, manufacturing, insurance and financial industries, and Federal agencies concerned with housing.

PATH addresses barriers to innovation, provides information on advanced building technologies, and advances housing technology research; making affordable, quality American homes a reality.

For more information on the PATH program, visit www.pathnet.org.

TechSpecs are prepared for PATH by the NAHB Research Center.



NAHB Research Center
400 Prince George's Boulevard
Upper Marlboro, Maryland 20774
www.nahbrc.org

RESOURCES

General information about solar thermal systems and their installation in homes:

ToolBase Services

Information on this building technology and many others brought to you by PATH and the building scientists at the NAHB Research Center

www.toolbase.org

Florida Solar Energy Center

1679 Clearlake Road
Cocoa, FL 32922-5703
321.638.1000

www.fsec.ucf.edu/en/consumer/solar_hot_water/index.htm

Resources including a step-by-step pictorial of Solar Thermal System Installation on an existing roof:

www.fsec.ucf.edu/en/consumer/solar_hot_water/homes/installation/index.htm

North American Board of Certified Energy Practitioners (NABCEP)

10 Hermes Road, Suite 400
Malta, NY 12020
518.899.8186

www.nabcep.org

Features a directory of certified installers

Solar Rating and Certification Corporation (SRCC)

c/o Florida Solar Energy Center (FSEC)
1679 Clearlake Road
Cocoa, FL 32922-5703
407.638.1537

www.solar-rating.org

Administers a certification, rating, and labeling program for solar collectors and a similar program for complete solar water heating systems; includes directories of rated systems

U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE) – Solar Energy Technologies Program

1000 Independence Ave. SW
Washington, DC 20585

www.eere.energy.gov/solar

U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE) – Building America Program

www.eere.energy.gov/buildings/building_america

Publishers of: *Building America Best Practice Series Volume 6. Solar Thermal and Photovoltaic Systems*, June 2007. Chapter 3, Solar Thermal Systems

www.eere.energy.gov/buildings/building_america/pdfs/41085.pdf