

A Consumer's Guide

Heat Your Water with the Sun



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

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Getting help

Cover photo: The people living in this house enjoy hot water that is heated with a solar thermal system. (Courtesy of Industrial Solar Technology/PIX12964)

Photo opposite: Flat-plate solar collectors heat this pool in Oregon. The unglazed polymer collectors sit on top of a flat roof and provide shade to the patio below.

Heat Your Water with the Sun

Would you like to learn more about how the sun can help meet your home's heating needs without straining your budget?

Today's solar heating systems not only keep swimming pools warm—they can also heat much of your home's water and interior space. Their popularity is increasing, for several reasons. Solar heating systems are reliable, adaptable, and pollution-free because they use renewable energy from the sun. Many systems include sleek, attractive, low-relief collectors that people often mistake for skylights.

Did you know that solar heating systems work well in many different climates? Some applications, such as pool heating, are widely cost-effective today. The cost-effectiveness of other applications depends on specific circumstances, such as the type and cost of your usual source of energy. Today, special financing is available to help you purchase the system that's right for your home.

If you'd like to find out more about solar heating for your home or pool, this booklet is a good place to start. Here, you'll learn how solar heating systems work, how they're used, their benefits, and how to purchase one yourself. Please note, however, that this booklet isn't a technical guide to designing and installing a system. For that, you'll need to consult an experienced solar heating contractor; see "Getting help" in this booklet for more information.

A solar heating system is a substantial but rewarding investment. It can reduce your monthly heating bill while helping to protect our environment. Being informed and planning carefully will ensure that you've chosen the right system for you and your family.



Background

What is solar heating?

Solar heaters, or solar thermal systems, provide environmentally friendly heat for household water, space heating, and swimming pools. The systems collect the sun's energy to heat air or a fluid. The air or fluid then transfers solar heat directly or indirectly to your home, water, or pool.

Solar water heaters, sometimes called solar domestic hot-water systems, may be a good investment for you and your family. Solar water heaters are cost effective for many applications over the life of the system. Although solar water heaters cost more initially than conventional water heaters, the fuel they use—sunshine—is free. Solar heating technologies can be used in any climate. To take advantage of solar energy, you usually need to

have an unshaded area that faces south, southeast, or southwest, such as a roof. In some cases, a solar professional may recommend west-facing roofs for solar collectors.

The type of system you choose, including the type of collector and whether it is active or passive, depends on several factors. These include your site, the climate you live in, installation considerations, cost, and how you would like your solar heating system to be used.

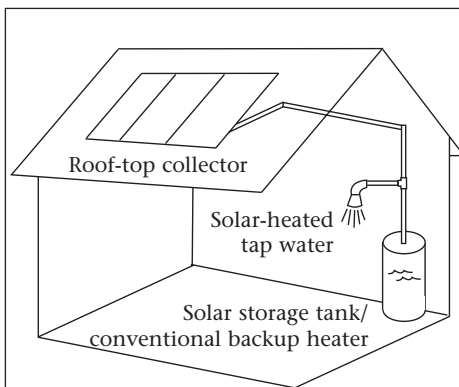
What are the basic components of a solar thermal system?

Solar water heaters and solar space heaters are made up of solar collectors, and all systems except pool heaters have some kind of storage. In pool systems, the swimming pool itself is the storage, and the pool's filtration pump circulates the pool water through the collectors.

Active systems also have circulating pumps and controls; passive systems work without this added equipment.

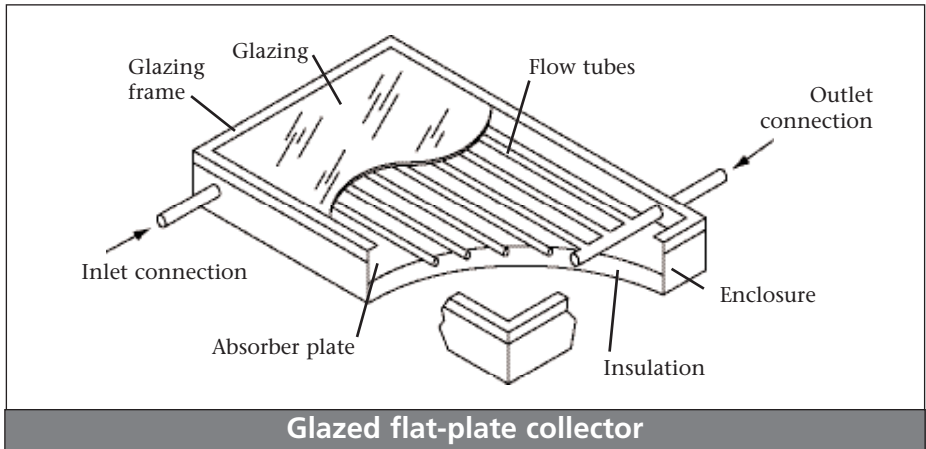
Three types of solar collectors are used for residential applications: flat-plate, integral collector-storage (ICS), and evacuated-tube collectors.

Flat-plate collectors like the one shown on page 3 are the most common type. Glazed flat-plate collectors essentially are insulated, weatherproofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer)



Swimming pools and your home may also be heated using solar energy

**Simplified representation
of a solar water-heating system**



Glazed flat-plate collector

covers. Unglazed flat-plate collectors are simply a dark absorber plate, made of metal or polymer, without a cover or enclosure. Unglazed flat-plate collectors made from polymer materials are typically used in solar pool-heating systems. See the photos on pages 1 and 7 and the diagram on page 9 for examples.

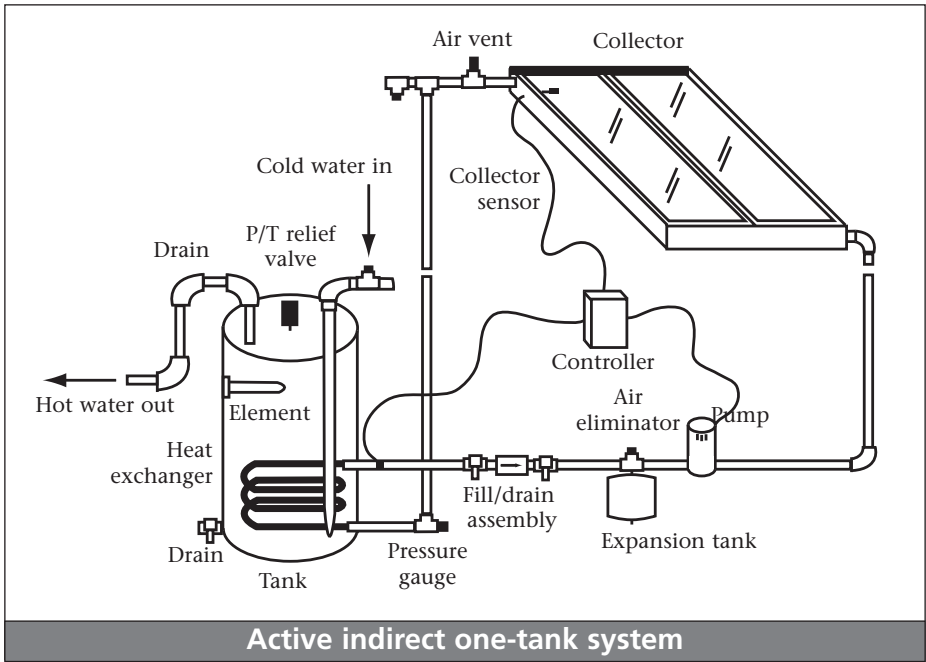
Integral collector-storage systems, also known as ICS or “batch” systems, are made of one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water, and then continues to the conventional backup water heater. ICS systems are simple, reliable solar water heaters. However, they should be installed only in mild-freeze climates because the outdoor pipes could freeze in severely cold weather.

Evacuated-tube solar collectors are usually made of parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin is covered with a

coating that absorbs solar energy well, but which inhibits radiative heat loss. Air is removed, or evacuated, from the space between the glass tubes and the metal tubes to form a vacuum, which eliminates conductive and convective heat loss. In the United States, evacuated-tube collector systems are used most frequently in commercial applications.

Most solar water heaters require a well-insulated **storage tank**. Solar storage tanks have an additional outlet and inlet connected to and from the collector. Active solar systems usually include a storage tank along with a conventional water heater. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In a one-tank system, like the one shown on page 4, the backup heater is combined with the solar storage in one tank.

Active solar water heaters use pumps to circulate water or a non-freezing heat-transfer fluid from storage tanks through the collectors. Active systems are usually



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more expensive than passive systems, but they are also usually more efficient.

Direct circulation systems use a pump to circulate household water through the collectors and into the home; they work well in climates where it rarely freezes. **Indirect circulation systems** use pumps to circulate a non-freezing heat-transfer fluid through the collectors and a heat exchanger. This heats water that then flows into the home. Indirect systems are popular in climates prone to freezing temperatures.

Passive direct solar water heaters, like the one shown on page 5, move household water or a heat-transfer fluid through the system without using pumps or electricity. Passive systems work during power outages, but they

should not be used in climates where temperatures often go below freezing. Passive systems are typically less expensive to purchase and maintain than other types of solar systems. They are also inherently more reliable and may last longer. However, passive systems are not usually as efficient as active systems.

ICS passive solar systems may be best in areas where temperatures rarely go below freezing. They are also good in households with significant daytime and evening hot-water needs.

Thermosyphon systems work because water flows through the system when warm water rises as cooler water sinks. In this system, the collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but

contractors must pay careful attention to roof design because the water in the storage tank is heavy. Thermosyphon passive solar systems are usually less expensive than active systems, but more expensive than ICS systems.

How have solar systems improved?

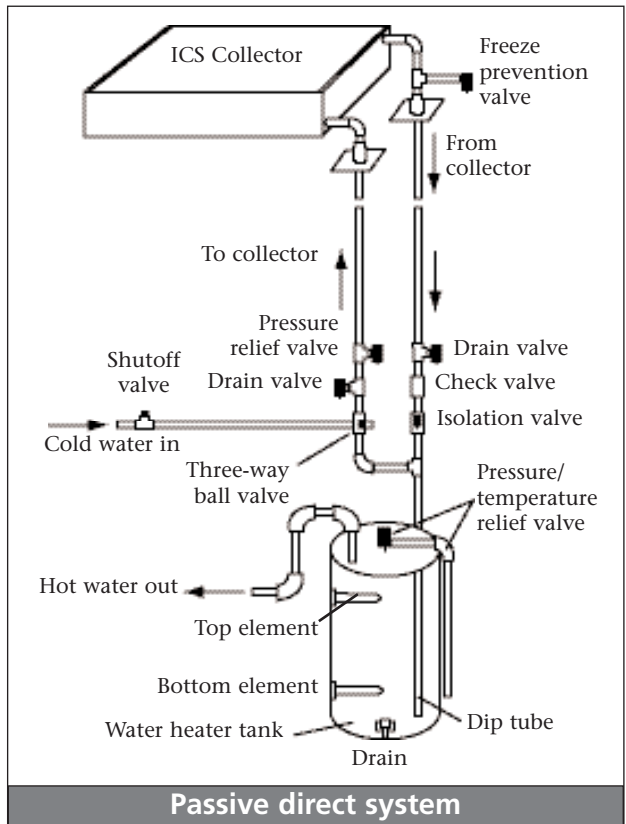
Since the early 1970s, the efficiency and reliability of solar heating systems and collectors have increased greatly and costs have dropped. Improvements to materials, a rating system for consumers, and more attractive designs have all helped to make systems more successful.

Low-iron, tempered glass is now used instead of conventional glass for glazing. Improved insulation and durable selective coatings for absorbers have improved efficiency and helped to reduce life-cycle costs.

The Solar Rating and Certification Corporation (SRCC) and the Florida Solar Energy Center (FSEC) certify and rate solar thermal systems and equipment. SRCC evaluates product reliability and rates the performance of solar water-heating systems by subjecting them to technical reviews. SRCC has a

directory of certified systems on its Web site along with system performance ratings. FSEC publishes similar information specific to Florida that is useful in other states with similar climates. See the “Getting help” section for contact information.

The appearance of the systems has also improved. Today’s collectors can usually be mounted flush with the roof for a streamlined system that looks like skylights. Unglazed polymer collectors for solar pool heating are now available in terra cotta colors as well as black, so homeowners can choose the color that will best match their home.



Investing in Solar Thermal Technologies

Why should I invest in a solar thermal system?

The first question many people ask when considering a home expense is, "How much will it cost?" The answer depends on the type of system, how you want to use it (water or pool heating, for example), and your geographic location. But most solar thermal systems cost between \$2,000 and \$4,500. Although this is usually more than the cost of a conventional gas or electric system, today's solar heating systems are cost competitive when you consider your total energy costs over the entire life of the system.

Your monthly gas or electricity bills will usually be lower and more predictable for as long as you own the house. Also, solar heating systems will insulate you from rising fossil fuel costs and protect you from fuel-price inflation over time. Investing in a solar thermal system could also increase the resale value of your home. Often, the entire initial cost of the system can be recovered when you sell your property. In addition, you will be earning an annual 6% to 25% tax-free rate-of-return on your investment, depending on how much hot water you use and how much energy you save.

Another important reason to invest in solar systems may be less tangible. When you purchase a solar heating system, you support technologies that are good for the environment. You are making a

conscious, responsible decision to help reduce harmful emissions from fossil fuels, while maintaining your quality of life.

How much will your solar heating system help the environment?

Depending on the type of conventional fuel used, replacing an electric water heater with a solar heater can offset the equivalent of 40% to 100% of the carbon dioxide emissions of a modern passenger car.

Carbon dioxide traps heat in our atmosphere, contributing to the greenhouse effect, which alters our planet's climate and ecological systems. Using solar energy in place of nonrenewable fuels may also reduce nitrous oxides and sulfur dioxides, which are components of smog.

Is my home a good place for a solar heating system?

The first consideration when building a solar thermal system is the site. If your site has unshaded areas and generally faces south, it is a good candidate for a solar thermal system. A professional installer can evaluate your roof as a location for collectors. If your roof doesn't have enough space, you can also install the system on the ground. Please refer to the system-sizing section of this booklet for more information on space requirements. The amount of sun that your site receives, how often temperatures dip below

freezing, and other factors will also affect the type of solar heating system you choose.

Before getting under way, you need to consider your homeowners association rules and neighborhood bylaws, also known as codes, covenants, and restrictions (CC&Rs). In Arizona, California, and Florida, state laws prohibit CC&Rs that restrict solar system installations. Nine other states have similar laws barring regulations that unreasonably limit solar energy use in planned communities. Some cities and counties have ordinances or require permits for home improvement construction, including solar system installation.

How big should my solar thermal system be, and which features should I look for?

Some of the answers to questions about system size and features depend on how you plan to use the solar system. Here, you'll find general information on sizing systems for water heating, swimming pools, and space heating. To locate more specific information, please see "Getting help" on page 17.

Sizing a solar thermal system for heating domestic water

Just as conventional water heaters come in different sizes, so do solar water heaters. Sizing your solar



Solar pool heaters are efficient and economical

water heater involves determining the total collector area and storage volume you need to meet 90% to 100% of your household's hot water needs during the summer. Solar-equipment experts use worksheets and computer programs to help determine system requirements and collector sizing.

Contractors usually follow a guideline of about 20 square feet (2 square meters) of collector area for each of the first two family members. For every additional person, add 8 square feet (0.7 square meters) if you live in the Sun Belt area of the United States, or 12 to 14 square feet (1.1 to 1.3 square meters) if you live in the northern United States.

For active systems, the size of the solar storage tank increases with the size of the collector—typically 1.5 gallons per square foot of collector. A small, 66-gallon system is usually big enough for one to three people; a medium-size, 80-gallon system works well for a three- or four-person household; and a large, 120-gallon system is appropriate for four to six people.

In recent years, homebuilders have begun including solar water heating systems as standard features in some subdivisions. The systems are the same size for every home, and they all work equally well. However, large families with greater hot-water demand find that a smaller percentage of their hot water is provided by the solar energy system.

Sizing a solar thermal system for heating swimming pools

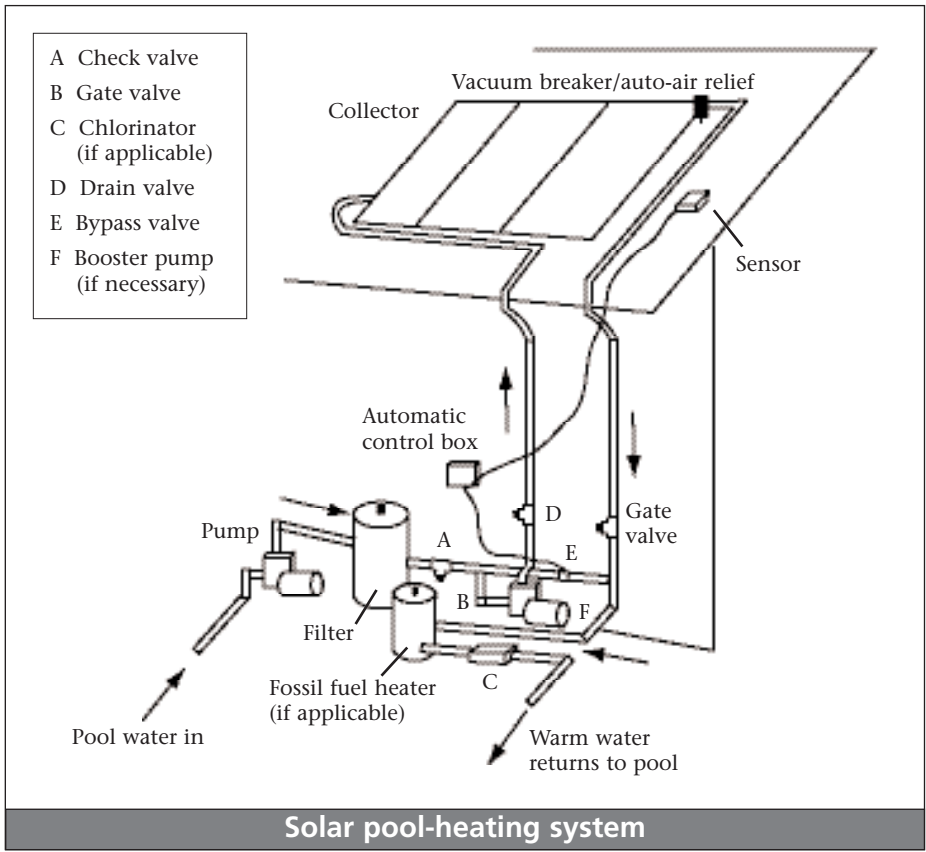
Heating your swimming pool with solar energy requires a collector that is 50% to 100% of the surface area of your pool. Your geographic location and other factors determine the exact size.

For example, a 15-by-30 foot swimming pool in Florida typically requires a collector that equals 100% of the pool's square footage, which translates to 450 square feet of unglazed flat-plate collectors. This is because many Florida swimming pool owners use their pools year round. In contrast, in northern California, most pools are used only 6 to 8 months per year, so systems are typically sized at 60% to 70% of the pool's surface area.

In general, adding more square footage lengthens the swimming season and allows owners to use the pool in colder weather. A pool cover or blanket reduces heat loss and helps maintain warm temperatures for a longer period.

Sizing a solar thermal system for space heating

In contrast to solar water heating, solar space heating usually requires a larger, more complicated system. Space-heating systems have to store heat for use when solar energy is least available and your house is coldest—at night and during the winter months. Solar space-heating systems are usually combined with water heating, and they are sized to accommodate both uses.



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The amount of solar collector area needed to heat your home depends on many factors. These include the available solar energy, collector efficiency, local climate, and heating requirements. Heating requirements are based on insulation levels, the house's airtightness, and the lifestyle of the residents. Generally, the area of solar collector is about equal to 10% to 30% of the floor area of the house.

How much money will my solar thermal system save, and how much will it cost?

Your savings depend on how your solar system will be used, as well as

the size and type of your system. Other factors can include the climate, the contractor, and the system rating. Your state may offer solar rebates or other incentives that will reduce costs.

Savings and costs for solar domestic water heating

Solar heating systems can save you money in the long run. FSEC studied the potential savings to Florida homeowners who use common water-heating systems, including solar, in comparison to electric water heaters. FSEC undertook this study because the initial installed cost of a solar water

heater is higher than that of a gas or electric water heater. FSEC wanted to explore costs and savings over time, beyond the initial installation period. The study found that solar water heaters offered the greatest potential savings. Annual utility costs for solar water heaters were 50% to 85% lower than those for electric water heaters.

The cost and benefit of purchasing a solar water heater vary from region to region, so check costs in your area. Depending on the price of the conventional fuel, a solar water heater can be more economical over the life of the system than heating water with electricity, fuel oil, propane, or even natural gas. That's because the fuel—sunshine—is free.

However, at historically low prices for natural gas, the total cost of owning a solar water heater with a backup natural gas heater may be more expensive than owning a natural gas heater alone. Nevertheless, as natural gas becomes more costly and its availability more volatile, solar water heaters become more economical. Solar water heaters are often quite cost-competitive in new homes.

In many places in the United States, homebuilders choose electric water heaters because they are easy to install and relatively inexpensive. Research shows that the average household with an electric water heater spends about

25% of its home energy costs on heating water.

If you are building a new home or refinancing because of a major renovation, the economics are even more attractive. Including the price of a solar water heater in a new 30-year mortgage usually amounts to between \$13 and \$20 per month. The federal income tax deduction for mortgage interest attributable to the solar system reduces that by about \$3 to \$5 per month. So, if your fuel savings are more than \$15 per month, the solar investment is profitable immediately. On a monthly basis, you are saving more than you are paying.

Savings and cost for solar swimming pool heating

A solar heating system for your pool usually costs between \$3,000 and \$4,000 to buy and install. This provides a payback of between 1.5 and 7 years, depending on the cost of the fossil fuel your system replaces. The actual cost and payback depends on your site, the type of system you choose, financing, and the length of the pool season.

Often, a payback cannot even be calculated, because many people choose not to heat their pool at all, given the extra \$300 to \$600 on their energy bill. A solar system allows these people to swim in a pool that was previously too costly to heat and too cold to use.

Savings and cost for solar space heating

The cost of a solar space-heating system depends on many factors, including the size of your house, how airtight it is, how much of your heat will be supplied with a conventional backup, the system you choose, and your site. In general, solar space-heating systems can provide 40% to 60% of your space-heating needs. These systems are most economical for consumers who would otherwise be heating with electricity, rather than with natural gas or other fuels.

But solar space heating is needed most when sunlight is least available, during the winter and at night—and needed least when sunlight is most available, during the summer and the daytime. So today's solar technologies are not likely to be a cost-effective solution for active solar space heating in most homes. However, a good alternative is to simply use passive solar building techniques. See the EERE Web site, www.eere.gov/solar, for more information.

How can I finance the cost of my solar thermal system? Are there incentives?

Financing

Financing the cost of your solar thermal system is not as tricky as it may seem. Although some special programs are available to help you purchase solar thermal technologies, most of the financing options are familiar ones.

One common way to finance a solar system is through your mortgage or through a home-equity loan secured by your home. Mortgage loans offer lower interest rates and longer pay schedules than conventional bank loans, and interest on your mortgage loan is tax-deductible. Financing your system when you apply for your mortgage—whether because you are building or refinancing—can make the application process simpler and less costly.

Conventional bank loans are another way to finance your solar system. However, your system is a long-term investment; this should be reflected in the pay schedule for the loan. Look for longer terms and lower interest rates, which will help keep your solar thermal system affordable.

Incentives

Many states have incentives for buying solar technologies. Check with your state or local energy office or your state departments of revenue or finance for information. Some electric utilities offer rebates to customers who install solar energy equipment because these installations help utilities reduce energy use during times of high demand.

You can also check the National Database of State Incentives for Renewable Energy (DSIRE). DSIRE is prepared by the North Carolina Solar Center. It provides information on financial and regulatory incentives to promote renewable energy technologies. For information, see “Getting help” on page 17.

What are the maintenance issues and repair costs for a solar thermal system?

The costs of maintaining your solar thermal system depend on the type of technology you choose and how often temperatures in your area fall below freezing. Properly maintaining your system will keep it running smoothly.

Passive systems do not require much maintenance. For active systems, discuss the maintenance requirements with your system provider and consult the system owner's manual. Plumbing and other conventional components require the same maintenance as conventional systems. Glazing

may need to be cleaned in dry climates where rainwater does not provide a natural rinse.

Regular maintenance on simple systems can be as infrequent as every 3 to 5 years, preferably by a solar contractor. Systems with electrical components usually require a replacement part or two after 10 years. Simple, regular system checks can also be effective. For example, one easy way to check the system is to carefully feel the hot-water pipes going into the storage tank after the system has been working on a clear, warm day. If the pipes are hot, your system is working properly.



Specialists can safely and efficiently install solar thermal systems

Industrial Solar Technology/PIX12963

Selecting a solar heating contractor

Who sells and installs solar thermal systems?

Depending on your area, the simplest way to find a solar thermal systems contractor is to look in the yellow pages under “Solar Energy Equipment and Systems—Dealers.” Most of the listings will probably be for solar water heating, photovoltaic (solar electric), or electric systems contractors.

You can also contact your utility company to get information on recommended vendors, or search on the Internet for solar water heating, solar pool heating, or solar space heating, depending on the application you are interested in installing.

Your state may have an active chapter of the Solar Energy Industries Association (SEIA), a trade association of contractors, distributors, and manufacturers. See “Getting help” for contact information.

How do I choose among solar thermal system providers?

One way to choose a contractor is to check your list of potential companies for the ones nearest you. Ask them what products and services they offer. Here are a few questions you might want to ask potential vendors.

Has your company installed solar thermal systems for solar water heating, pool heating, or space heating?

Choose a company that has experience installing the type of system you want and servicing the applications you select.

How many years of experience does your company have with solar heating installation?

Obviously, the more experience the better. A business that has been working with these systems for a long time will be more professional, know more about current technologies and recent advances, and be less likely to make costly mistakes. Request a list of past customers who can provide references.

Is your company licensed?

Having a valid plumber’s or solar contractor’s license is required in some states for solar thermal system installation. You can confirm licensing by contacting your state contractor licensing board. Local requirements may also include a local contractor’s license. Call your city and county for information on other required licenses.

For you to obtain certain rebates, your contractor may have to demonstrate special knowledge

about solar installations through one or more of the following:

- Possession of a solar contractor specialty license issued by a local building jurisdiction
- Certification in solar thermal systems by a group such as the state chapter of SEIA
- A letter from the solar heating manufacturer that indicates that the installer has the necessary experience and training to install solar systems.

Does your company have any pending or active judgments or liens against it?

As with any project that requires a contractor, due diligence is recommended. Your state contractor licensing board can tell you about any complaints against state-licensed contractors. The Better Business Bureau is another good source for such information.

How do I choose among bids? Is the least expensive the best deal?

It is usually a good idea to get more than one bid for installation of your solar system. Make sure that all the bids you receive are based on the same information and requirements. For example, comparing a bid for a system mounted on your roof with a bid for one mounted on the ground would not tell you how the two bids compare—it would probably tell you more about how the two types of installations compare.

One solution is to ask for bids on systems certified by the Solar Rating and Certification Corporation (SRCC). If possible, have each bid specify system type and size, energy output, maintenance requirements, and cost. Cost should include having the system installed and getting it up and running, as well as the cost of hardware, permits, sales tax, and warranties.

A system warranty is crucial in comparing bids. A solar rebate program may require a written installation warranty, for example a 2-year parts-and-labor warranty in addition to manufacturers' warranties on system components. The company may offer other, longer warranties, particularly on the collectors. However, solar systems are more than collectors; active systems include electronic components, pumps, valves, and wiring. Make sure you know what your warranty covers and that the company stands behind the full warranty.

If you have several bids, you may wonder if the lowest bid is the best deal. Sometimes it is not. A solar thermal system installer is in business to make money; overhead and operating expenses must be covered. A low price could be a sign of inexperience, or of a company without staying power. Contractors that expect to stay in business must charge enough to cover their products and services plus make a fair profit. Price is not the only consideration.

Before you put solar heating to work

Do I need a conventional system as a backup?

Whether you need a backup system for your solar thermal system depends largely on the type of system you choose and where you live. Solar water-heating systems almost always require a backup system for cloudy days and times of increased demand. This backup system is typically a conventional gas or electric water heater and may already be part of the solar system package. It may also be part of the solar collector, such as rooftop tanks with thermosyphon systems. For example, an integral collector-storage system (ICS) may be packaged with an instantaneous gas water heater for backup.

The ICS system stores hot water in addition to collecting solar heat, and the instantaneous water heater provides hot water when solar heat is not available.

Most people do not need or use a backup heater with solar pool heaters. In freeze-prone climates, solar pool heaters are used mainly in summer. Spas or hot tubs are an exception. Spa owners may use their solar system to heat both the pool and the spa, but will use a backup heater to get the spa to a higher temperature. In climates where it rarely freezes, pool heaters may be used year-round.

If you decide to install solar thermal space heating, you will almost



Rooftop collectors can be installed on most roofing materials

certainly need a backup system. Space-heating systems require a large collector area, significant storage volume, and a highly efficient building envelope to produce enough energy to heat your home at night and during the winter. Solar space heating usually provides 40% to 60% of your home's space-heating needs. A backup system ensures that your house is comfortably warm during power outages, cold snaps, and extended cloudy periods. Many building codes and mortgage lenders require a conventional backup space heater.

Will I need any permits or inspections?

If you live in a community with a homeowners association, check to see if any approvals, permits, or inspections are required. Always obtain the necessary approvals from the association before beginning construction. Homeowners associations, towns, cities, and counties usually have a legal right to require approval before building. However, some states have solar-rights laws that may apply if approval is denied.

You will probably need to obtain permits from the building department that has jurisdiction in your state, county, or city. Plumbing, building, and electrical permits may be required. These permits typically require a final inspection after the system has been installed. Check with your solar heating system contractor to find out whether

the price of obtaining permits and inspections is included in the bid and final cost estimate.

What about insurance?

If you are buying a solar heating system for your home, your regular homeowners insurance should cover your needs. However, if insurance coverage becomes an issue, please refer to "Getting help" on page 17.

Will I need warranties?

Warranties are an important factor in the bidding process and an important aspect of the system you choose. Make sure you know the warranties that your system manufacturer and installer offer for your equipment and hardware, as well as parts-and-labor warranties. Check to make sure the manufacturer can provide support and supplies if the installer is not available.

You can usually obtain a full-system warranty plus parts-and-labor for at least 1 to 3 years. This means you will not be responsible for system problems covered by the warranty in the first year or two of system operation.

Will I need a maintenance agreement?

A maintenance agreement may be part of your warranty. Have the contractor prepare a schedule of required or recommended maintenance before you purchase your system.

Getting Help

American Solar Energy Society (ASES)

2400 Central Avenue, Suite G-1

Boulder, CO 80301

www.ases.org

Phone: (303) 443-3130

Fax: (303) 443-3212

E-mail: ases@ases.org

Database of State Incentives for Renewable Energy (DSIRE)

www.dsireusa.org

Florida Solar Energy Center (FSEC)

Public Affairs Division

www.fsec.ucf.edu

Phone: (321) 638-1015

Fax: (321) 638-1010

E-mail: info@fsec.ucf.edu

National Renewable Energy Laboratory

Solar Energy Technology Program

www.eere.energy.gov/solar.html

Solar Benefits Model Software

www.eere.energy.gov/solarbuildings/sbm.html

Solar Energy Industries Association (SEIA)

1616 H Street NW, 8th Floor

Washington, DC 20006-4999

www.seia.org

Phone: (202) 628-7745

Fax: (202) 628-7999

Solar Rating and Certification Corporation (SRCC)

c/o FSEC

1679 Clearlake Road

Cocoa, FL 32922-5703

www.solar-rating.org

(See standards document OG-300)

Phone: (321) 638-1537

Fax: (321) 638-1010

E-mail: srcc@fsec.ucf.edu



Solar thermal technologies work in a variety of climates

About the Office of Energy Efficiency and Renewable Energy

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as vital new "energy carriers."

The Opportunities

Biomass Program—Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program—Homes, schools, and businesses that use less energy, cost less to operate, and, ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program—A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program—Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program—Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program—Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program—Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program—Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program—Utilizing the sun's natural energy to generate electricity and provide water and space heating

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The National Renewable Energy Laboratory,
a DOE national laboratory, produced this Consumer's Guide for:

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

December 2003 • DOE/GO-102003-1824

