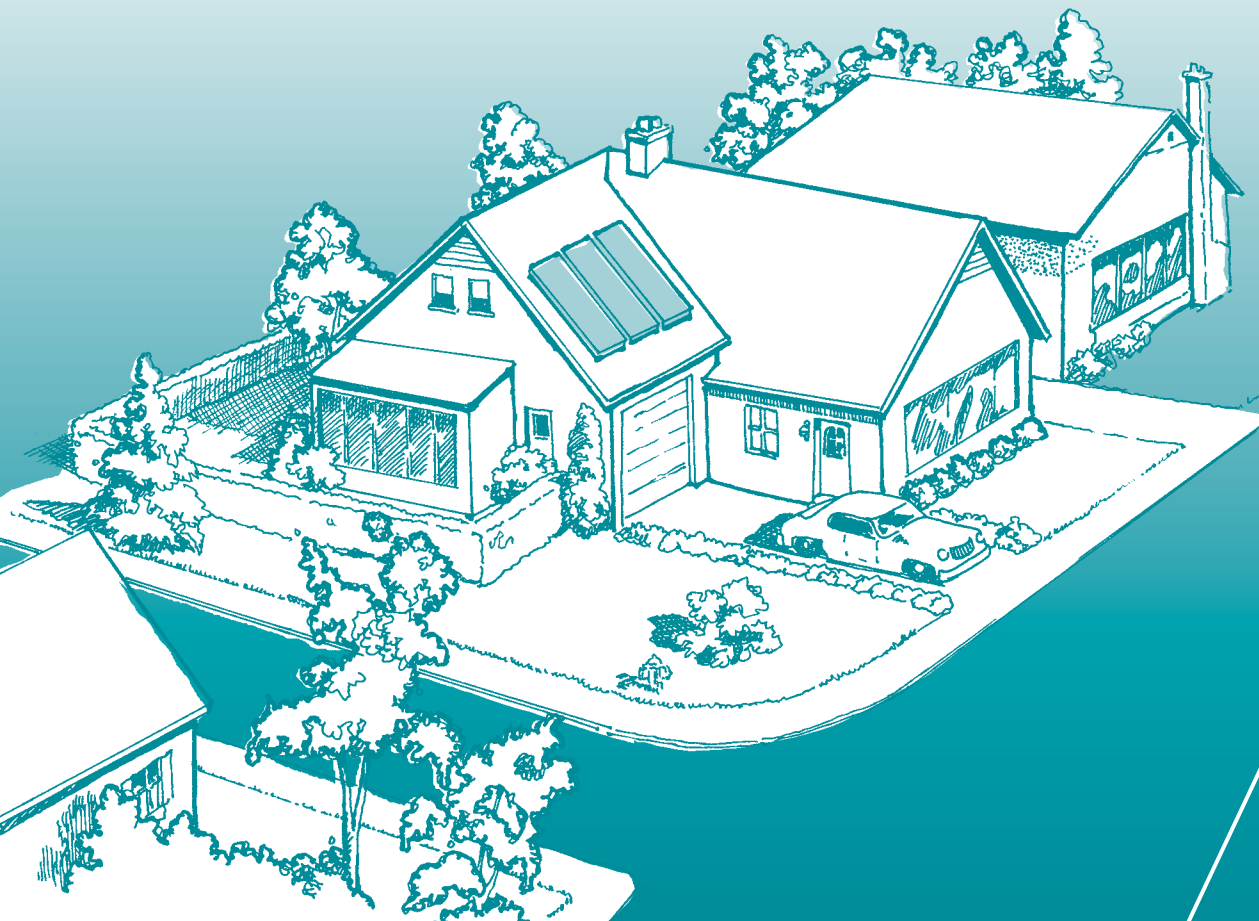




Solar

Water Heating Systems

A Buyer's Guide



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Canada

This digital mosaic of Canada, produced by Natural Resources Canada (Canada Centre for Remote Sensing), is a composite of individual satellite images. The differences in the density of vegetation are illustrated through shading.

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Solar Water Heating Systems: A Buyer's Guide

Prepared for Natural Resources Canada with the assistance of Michael Noble, EnerWorks, London, Ontario

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Les chauffe-eau solaires : Guide de l'acheteur

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About this Guide

This Guide has been prepared to assist consumers with the purchase of a solar water heater, also known as a Solar Domestic Hot Water (SDHW) system, for their home. Some of the topics covered in the Guide include: benefits of solar water heating, how a solar water heater works, selection of a product and dealer, installation and operation of a system, and product and dealer selection. The Guide is not a “how to” manual on installing a solar water heater.

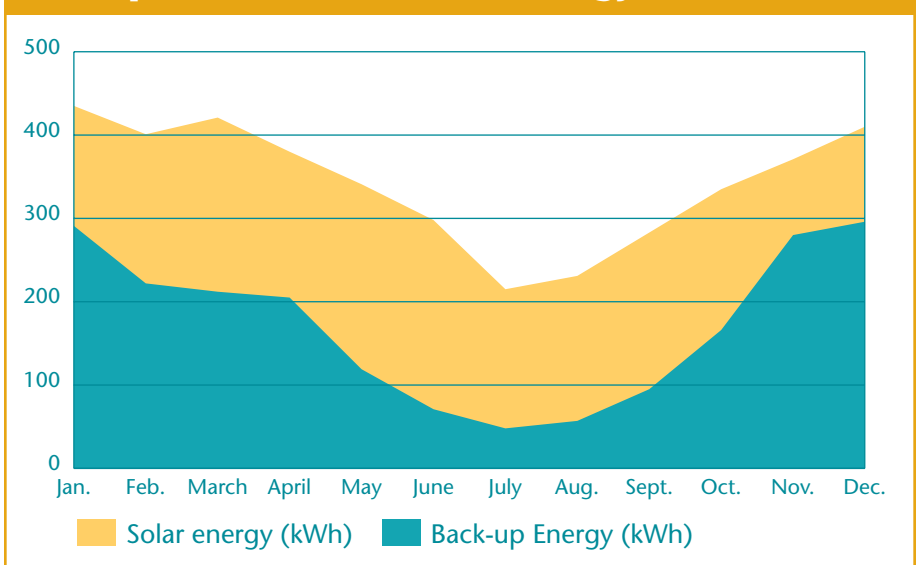
Benefits of a solar water heater

What are the benefits of a solar water heater?

Solar water heaters provide you with several benefits over conventional water heaters. You will reduce your hot water heating costs. You will also be directly reducing greenhouse gas emissions (carbon dioxide, CO₂, released into the atmosphere), thereby contributing to a healthier environment.

The energy you can expect to save by switching to a solar water heater depends on several factors such as the size of the collectors and storage tank, appliance efficiency, amount of sunlight in your region and, very importantly, the amount of water you use. A typical solar hot water system will reduce annual energy costs by 40 to 50 percent. You can expect that a solar water heater will provide you with 1500 to 3000 kWh of energy per year, depending on your hot water usage and regional climate. The map on page 4 shows approximate energy savings for various places in Canada.

Example of Annual Solar Energy Contribution



Domestic water heating contributes approximately 6 million tonnes of CO₂ each year toward Canada's greenhouse gas emissions. By installing a solar water heater, you can make a difference. In fact, a solar water heater will eliminate up to 2 tonnes of CO₂ emissions per year, in proportion to your energy savings.

What is in a solar water heating system?



7 Potential portion of water heating energy savings obtained by installing a solar water heater. Figures assume a freeze-protected system with 6 m² of single glazed flat plate solar collectors and two 270 litre (60 gallon) hot water tanks. Simulations were completed with WATSUN 13.2 software, and use local climate data.

Most solar water heaters consist of solar collectors mounted on the roof of a house; a pump for circulating the heat transfer fluid; a heat exchanger for transferring the heat to storage; and one or two storage tanks for storing solar-heated water for periods when there is no sun.

For more details on how energy is produced, see the section entitled *How does a solar water heater work?* on page 13.

Will we always have hot water?

Modern solar water heaters are well suited for the Canadian climate because they produce energy when the outside temperature is well below freezing. They also have mechanisms that protect them from freezing in the winter and from overheating on hot sunny days. Nearly all systems use the existing water heater as a backup energy supply to ensure that there is always a supply of hot water.

Is our house suitable for a solar water heater?

Most solar water heaters can easily be retrofitted to your existing water heater. Inside your home, you will need a small space adjacent to your existing water heater for the solar-heated water storage tank and the heat transfer unit that is connected to the collectors. Having a storage tank for your solar-heated system will reduce the likelihood that you will run out of

hot water in your home. However, most small systems, for example systems with 3 m² of collectors, do not come with a storage tank.

The best location for the collectors is on an unshaded, south-facing roof or wall. For excellent performance, solar collectors should face due south and be set at an angle of 18°–50° from the horizontal plane. Collectors can also be mounted on a sturdy frame near your home, or can be integrated into the roof of a storage shed. The solar collectors typically require a flat mounting area of about 3 m² for each collector. Most installations require one to two solar collectors.

A small path is required for the piping which connects the solar collectors to the storage unit. The piping usually can be installed through closets, cold air returns, wall cavities, and along the outside wall of the home.

What will a solar water heater do to the appearance of our house?

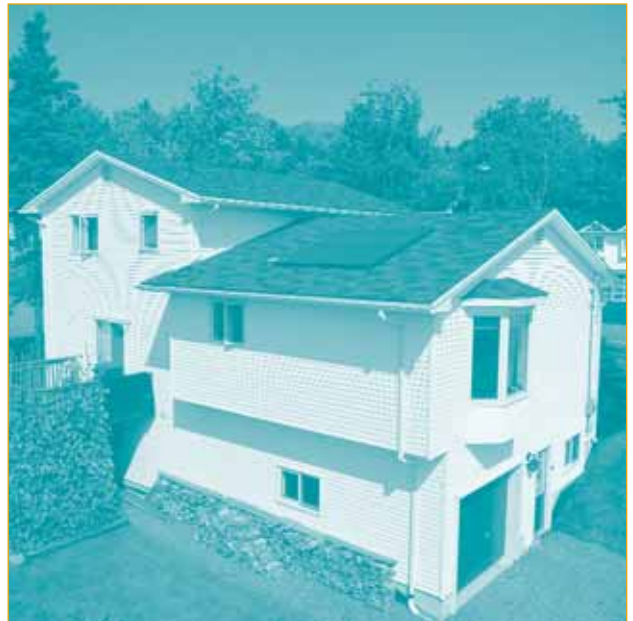
Components for solar water heaters are located outside and inside your home. Properly installed solar water heaters will not detract from your home's appearance or disrupt your normal household routines.

Taking a small amount of time to examine the different possible locations for the solar collector array can make a large difference on the visual appeal of the final

installation. On the outside of your home, the largest visible component is the solar collector array. Solar collectors look similar to low-profile skylights. Modern solar collectors are usually finished in an attractive aluminum casing with a glass cover. Collectors are 10 to 15 cm in thickness and require a flat area of about 3 m² each.

Special frames to raise the collector off the roof are usually not desirable and, in most cases, the improved performance of the system may not justify the additional cost. On the other hand, installing the solar collector at a shallow angle may compromise winter performance and will not assist in snow removal. Mounting the collector flush with the roof contributes to a neat installation and ensures the collector will not contribute to additional wind or snow loading.

The only other part of a solar water heater that may be visible on the outside of your house is the insulated piping connecting the solar collectors with the solar storage unit. A good installation will pass this tubing through a special roof flashing in an unobtrusive place. Sometimes cathedral ceilings or special wall construction require that



Glazed flat plate collectors installed on a Nova Scotia home.

the piping be run along the outside of the house to a more convenient entry point. In this case, a downspout can be installed to hide the piping, to avoid any negative impact on the appearance of the house.

What type of solar water heater should we buy?

Solar water heater dealers are equipped to provide you with information on currently available models. They will advise you in selecting the best model for your needs and help select a suitable location for the system. In most cases, dealers can also offer complete installation services. Before contacting a dealer, however, you should become familiar with the various types of solar water heaters and their suitability for your needs.

A variety of solar water heater designs are available for consumers. There are variations in collector styles and component arrangements, as well as different methods of freeze and overheating protection.

If you are planning to use a solar water heater year-round in Canada, it must be protected from freezing in the winter and overheating in the summer. Solar water heaters that meet the Canadian Standards Association (CSA) International guidelines have automatic controls to prevent overcharging the solar heater (i.e. to prevent potential scalding water temperatures). The following are common system types (the first two can be freeze-protected in the Canadian climate):

- “Antifreeze” systems use special fluid to transfer heat from the collector to a heat exchanger in the storage unit. These systems are fully freeze-protected, prevent contamination of the hot water, and can operate in all climate conditions. Snow will slide off the collector as the sun begins to warm them. On days with

heavy snowfall, performance can be increased by removing the snow off the collectors.

- Drainback systems automatically drain the collectors when they are not collecting solar energy or when the temperature of circulating water is 3°C or less. Make sure that the system’s minimum temperature rating is appropriate for your climate.
- Thermosiphon systems do not have freeze-protection, and are popular for cottages where water heating is needed only in the summer. These solar water heaters are often less expensive than models incorporating freeze-protection.

What do we need to know before we contact a dealer?

Before meeting with your dealer, you should review the following questions.

Do we need a year-round or a seasonal solar water heater?

This depends on when you will be using the residence where the solar heater is installed. Year-round solar water heaters can withstand the extremely cold temperatures often experienced in Canada. These types are recommended if the residence is used throughout the year, and is in a climate requiring freeze-protection. Seasonal solar water heaters are designed for use in climate conditions not requiring freeze-protection. Seasonal solar water heaters tend to be less

expensive than solar water heaters sold for year-round use because they do not require equipment to protect the solar collectors and outside piping from extreme freezing temperatures.

Year-round solar water heaters

Year-round solar water heaters are more convenient and fail-safe because they can operate in all climate conditions. Because these solar water heaters operate all year, they normally provide more solar hot water than a seasonal water heater. These products require maintenance comparable to conventional water heaters. Maintenance will ensure good performance and increase your energy savings.



Thermosiphon solar water heater at Camp Queen Elizabeth, Beausoleil Island on Georgian Bay, Ontario. Courtesy of Solcan Ltd.

Seasonal solar water heaters

If your family does not use the residence during the wintertime, you should consider buying a seasonal solar water heater. Seasonal solar water heaters are ideal for summer vacation homes, and for warmer regions not requiring freeze protection. Ideally, they are designed for use only during the spring, summer and fall. For cottage use, a seasonal unit with a safe low temperature rating of 5°C or 0°C is usually adequate. For residential use, a seasonal unit with a safe low temperature rating of 0°C or -10°C should be chosen. In some West Coast communities, a -10°C seasonal solar water heater can be used all year, but in most parts of the country it can only be used for about eight months of the year. Good examples of seasonal solar heaters are batch heaters or integral collector-storage systems. Seasonal solar water heaters must be shut down and drained when the temperature drops below the water heater's safe low temperature rating.

What are the available system sizes?

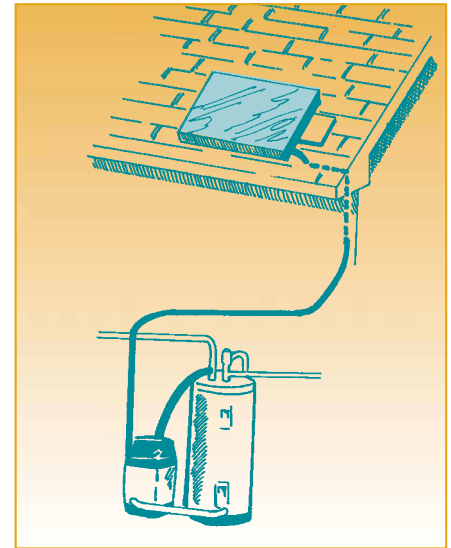
The easiest way to determine the optimum size for a solar water heater is to match the size to the number of occupants in the home and their water use. As well, consider planning for the needs of future occupants. The average hot water usage for your house will also depend on the number of appliances requiring substantial amounts of hot water such as dishwashers, washing machines, whirlpools or hot tubs.

A solar water heater usually comes in three standard sizes and corresponds to your daily hot water use: 150 L/day; 225 L/day; and 300 L/day (See *Table of Yearly Energy Requirement for Water Heating* on page 15 to determine the system size you will need). These sizes vary according to the volumes of hot water the heaters are designed to deliver on an average day and are not a rating of their maximum output.

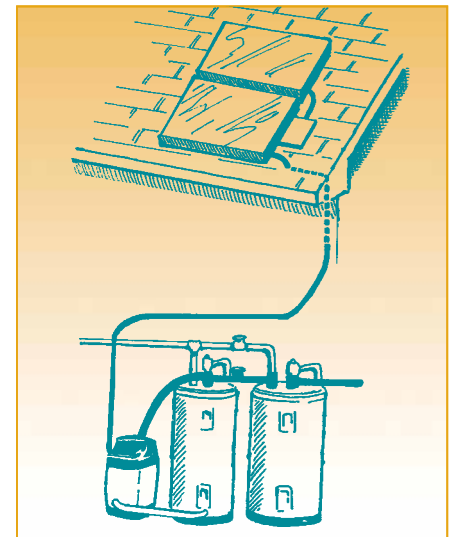
Where should the solar water heater be installed?

Your solar water heater dealer will have the expertise to provide you with proper site and installation recommendations. However, before making your final decision, look at your options. Take into account the appearance of the collectors in each possible location.

Ideally, the mounting location should remain unshaded for at least 80 percent of the time between 9:00 a.m. and 3:00 p.m. during the winter and summer. For seasonal units, only the summer period is critical. Shading can come from your own house, from trees or shrubs on your property, and from neighbouring buildings and trees. If the solar water heater is to be used during the winter months, take into account that the shadows are longer during the winter months, because of the lower position of the sun. At noontime during the winter months, a six metre high tree or building can produce a shadow of ten metres or more, which can significantly shade a collector mounted on the ground or a wall. It is also important to note that

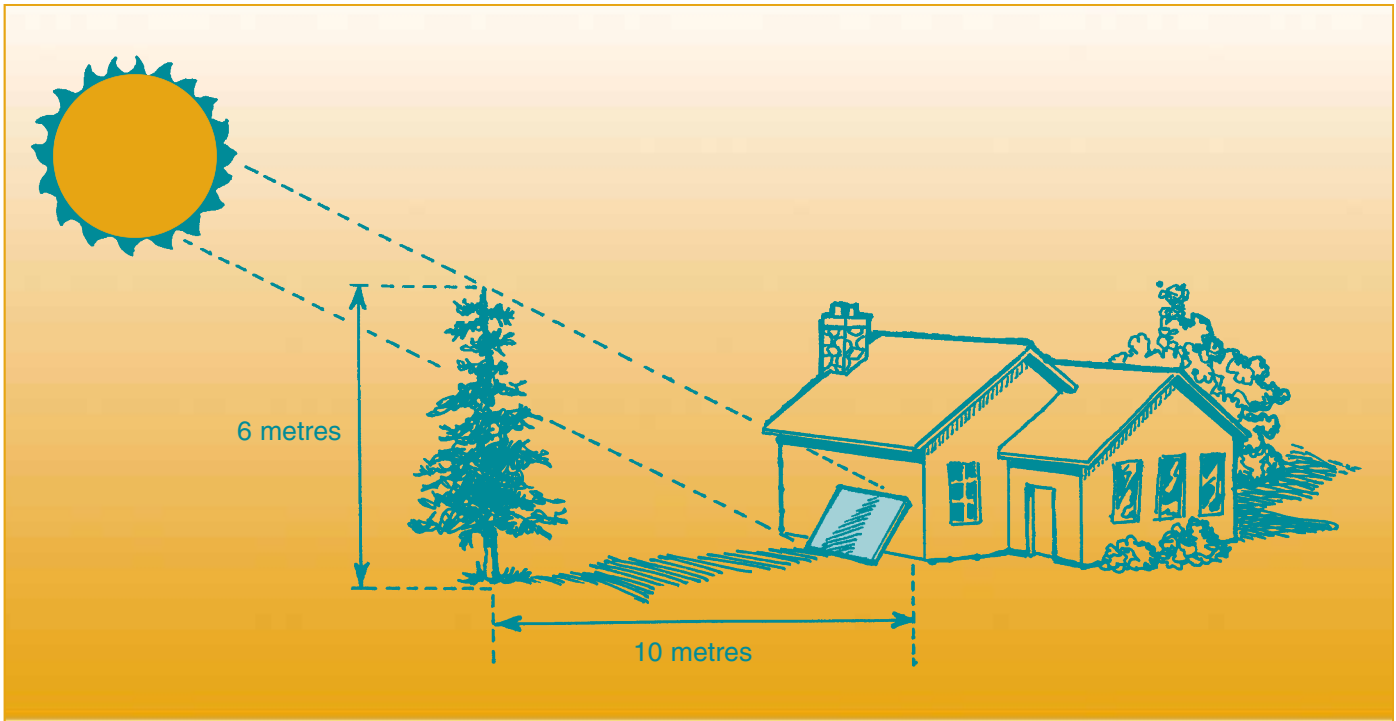


Small systems often come with a heat exchanger and a combined solar preheat and auxiliary tank.



Most medium to large systems have both an auxiliary tank and a solar preheat tank with a heat exchanger.

in most Canadian municipalities there are no laws that prevent a neighbour from building or planting something that could shade your collectors.

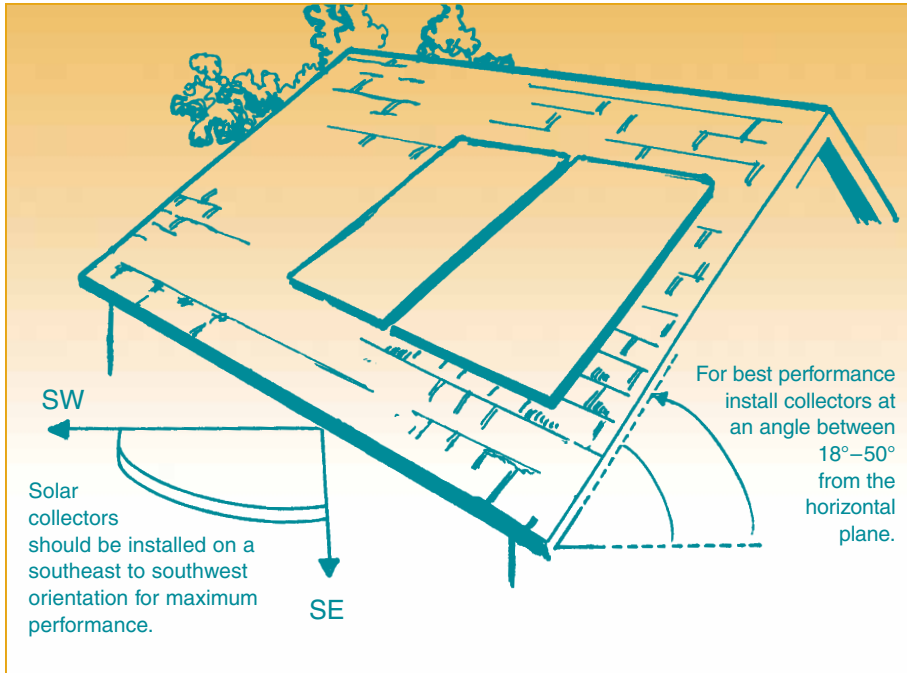


7 *The sun is much lower in the winter than in the summer. Therefore, a six-metre tree or building can significantly shade a collector mounted on the ground or on a roof, even at a distance of 10 metres.*

A suitable roof or wall location should be about 6 m² in area and should face between southeast and southwest. In most of Canada, excellent performance can be obtained with collectors that are mounted between 18° and 50° from the horizontal. Most roofs have a minimum slope of 18° and are usually the preferred location for solar collectors. If no suitable roof or wall location is available, then a ground-mounting frame is recommended. Snow coverage and the seasonal changes in the sun's position should be considered for year-round installations.

To reduce heat loss, all mounting locations should allow the connecting insulated collector pipes to pass through the roof or wall, preferably at a point adjacent to the collector. The pipes should be able to pass unseen through closets, walls or floor spaces, to the basement or hot water plumbing area. Piping bundles mounted on the exterior of the house should be protected in a sleeve such as a downspout. This will protect the insulation from ultraviolet degradation, decrease heat losses, and ensure the installation does not detract from the

appearance of the house. Some systems use piping that combines the supply and return lines and sensor wire into one bundle, thereby making installation much easier.



7 Solar collectors should be positioned facing southeast to southwest.

Finally, check that there are no zoning restrictions in your community that might restrict the placement of solar collectors. Some areas might also require a building permit. Your installer should be able to assist you with these issues.

How do we **select a dealer?**

A good dealer will help you select a solar water heater that meets your specific needs. The dealer should provide all necessary operating information, explain maintenance requirements, and in the case of seasonal water heaters, the operating temperature limits. If you plan to complete your own installation, the dealer should supply you with well-documented instructions and fully explain the system's warranty.

If possible, restrict yourself to dealers who can offer a warranty on both parts and labour and who have a successful track record of satisfied customers. If possible, ask to view a solar water heater installed by the dealer in your community.

Consultation with a dealer should include a visit to your home so the dealer can make an accurate estimate of the installation cost and help you make the final decision on where the collectors and the storage unit should be placed.

When choosing a solar water heater to meet your basic requirements, consider the following:

- year-round or seasonal use;
- best placement of the solar collector array; and,
- size of the system.

Choose a solar water heater that:

- meets current CSA standards or will be approved by your local building inspector;
- has warranty coverage; and,
- has support from a local dealer or installer.

Your purchase should include the same considerations as those involved in purchasing any new appliance:

- consider the dealer's reputation and experience;
- examine the limitations of the warranty;
- ask for photos or to view completed installations;
- inquire about follow-up service arrangements;
- review all contracts and agreements; and,
- obtain more than one written estimate.

Where do we find a dealer?

There are several resources you can use to assist in finding a dealer to meet your needs. The Canadian Solar Industries Association and the Solar Energy Society of Canada, Inc., both maintain databases on dealers and manufacturers in your area. Both of these organizations can be accessed through the Internet; details on how to find them are provided under the section *Where can we find out more about solar energy?* on page 18.

What should be expected of the installer?

The Canadian Solar Industries Association (CanSIA) maintains a list of solar water heater installers. It is highly recommended that you have your solar water heater installed by an experienced installer recognized by CanSIA.

When you have identified a dealer, ensure that the contract documents the terms of the installation and that all appro-

priate permits are obtained from local authorities. The contract should require the installer to start up the water heater, demonstrate to you that it is working as designed, and show you how to periodically check its operation.

In addition, before the installer leaves, you should go through the following checklist:

- You are fully satisfied that the solar water heater has been properly installed and that you fully understand how the appliance works.
- The installer has provided a signed checklist verifying that the installation has been checked for plumbing leaks, that roof and wall pipe penetrations are properly sealed, and that outside pipe insulation is properly jacketed and sealed against the weather.
- You have an owner's manual.

You should understand:

- how to shut down, isolate and drain the water heater in an emergency;
- how to check that the water heater is operating properly;
- how to drain a seasonal water heater in the fall and refill it before starting it up in the spring;
- how to carry out any routine maintenance, such as topping up fluid reservoirs;
- when to call a qualified solar technician to check or replace antifreeze; and,
- details of any warranty covering the installation.

What do we need to know to complete our own installation?

The cost of installing a solar water heater can be reduced if consumers carry out some of the work themselves. Installing a solar water heater that will deliver reliable performance (consistent with the performance rating) requires some experience in electrical, plumbing, and carpentry. It is important to complete the installation to CSA standards. Some specialized knowledge is required to mount solar collectors, prime the collector piping, install control sensors, and adjust the water heater. You should discuss the warranty limitations for do-it-yourself installations with your dealer. You are also responsible for meeting local building regulations and electrical and plumbing codes.

What maintenance should we do?

Routine checks and maintenance will ensure your savings are consistent.

Once your solar water heater is producing hot water, a monthly check-up is recommended. There are three easy ways to verify that your system is running well:

1. Look to see that the pump is operating when it is sunny.
2. Check carefully that the pipes are warm.
3. Review your energy bills to confirm your savings.

To ensure the water heater is collecting solar energy when the checks are made, complete the checks on a sunny day just after you use some hot water. Be careful, the pipes can be very hot! Maintenance of a solar water heater should be carried out according to the manufacturer's recommendations. Your solar water heater is an appliance. It should be maintained on a regular basis, like your other heating and cooling systems. If you have an antifreeze system, the antifreeze should also be checked every 1 to 2 years according to the manufacturer's recommendations. As well, if you carry out your own maintenance, ensure that the manufacturer's maintenance practices are followed, and that you use only recommended antifreeze for topping up or replacement.

You should ask your dealer for procedures to follow when you will not be using your solar water heater for extended periods of time. If you suspect a malfunction, contact your solar water heater dealer immediately.

How can we further increase the energy savings?

By timing your heavy hot water usage, you can increase the energy savings from your solar water heater. For example, by washing your clothes early in the day, between 9:00 a.m. to 3:00 p.m., you can maximize the energy savings benefits of your solar water heater. As well, you will give the system a chance to recharge during the rest of the day.

You can also introduce some simple conservation measures that will reduce your water heating bill, such as:

- installing low-flow shower heads;
- adding an insulating jacket to the hot water tank if it is not a high efficiency tank;
- insulating all hot water pipes;
- setting your back-up heater temperature to 50°C;
- changing washers in leaky faucets;
- using lower water temperatures for laundry; and,
- installing a separate hot water temperature booster on your dishwasher.

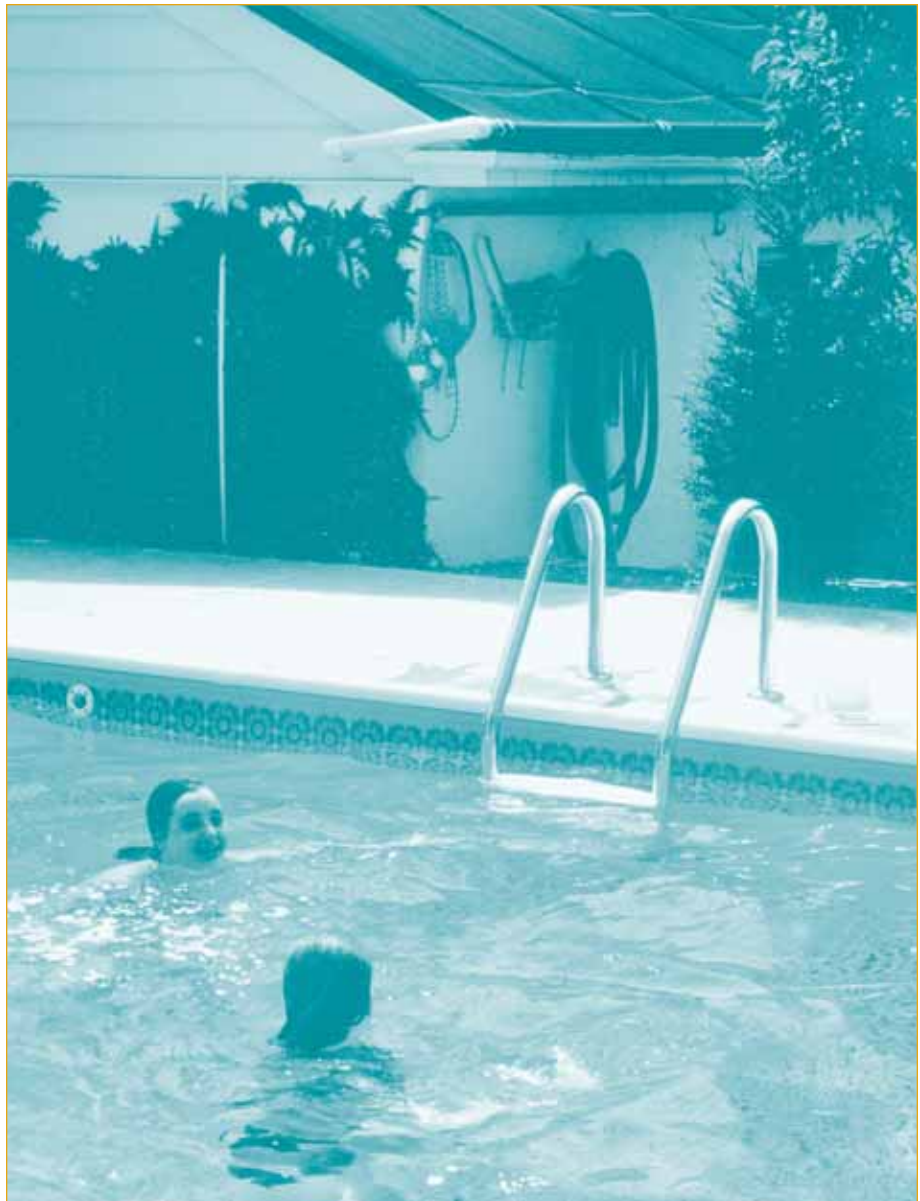
What other ways can solar energy improve the quality of the energy we use?

Solar pool water heating is a common use of solar energy. Unglazed plastic collectors are used to heat the pool water, substantially reducing energy costs. Solar water heaters can be less expensive than gas pool heaters. Natural gas or electricity heats approximately one third of all residential pools.

Passive solar heating incorporates the use of solar energy into the architectural design and selection of building materials, such as windows, to maximize the benefits of solar radiation.

Active solar heating can also be used to heat floors or the space of buildings. Applications include radiant floor heating and solar air heating systems, such as the Solarwall®, which preheats ventilation air to reduce heating costs and improve air circulation.

Photovoltaic systems convert the sun's energy into useable electricity. These systems are now being used to supply the electrical needs of residences that are separated from the electrical grid. Some homeowners also use photovoltaic modules to reduce dependence on utilities within grid-serviced areas.



*Unglazed solar collectors are commonly used to heat residential pools.
Courtesy of Taylor Munro Energy Systems Inc.*

How does a solar water heater work?

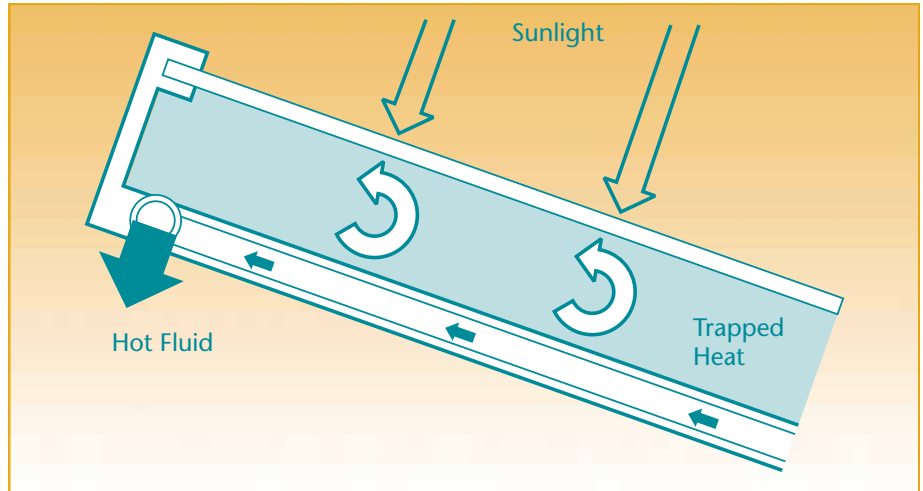
Solar water heaters perform three basic operations before the hot water comes out of your tap:

1. Energy Collection: Sunlight is collected and converted to heat energy.

The solar collector is mounted on or near your home facing south. As the sunlight passes through the collector's glazing, it strikes an absorbing material. This material converts the sunlight into heat, and the glazing prevents the heat from escaping in a similar manner to leaving a car parked in the sun with its windows rolled up. The temperature inside a glazed solar collector on your roof can easily reach 150°C when there is no heat transfer fluid flowing through it.

The two most common types of solar collectors used in solar water heaters are glazed flat plate and evacuated tube collectors. A glazed flat plate collector consists of a shallow rectangular box with a transparent glass "window" covering a flat black plate. The black plate is attached to a series of parallel tubes or one serpentine tube through which air, water, or other heat transfer fluids pass.

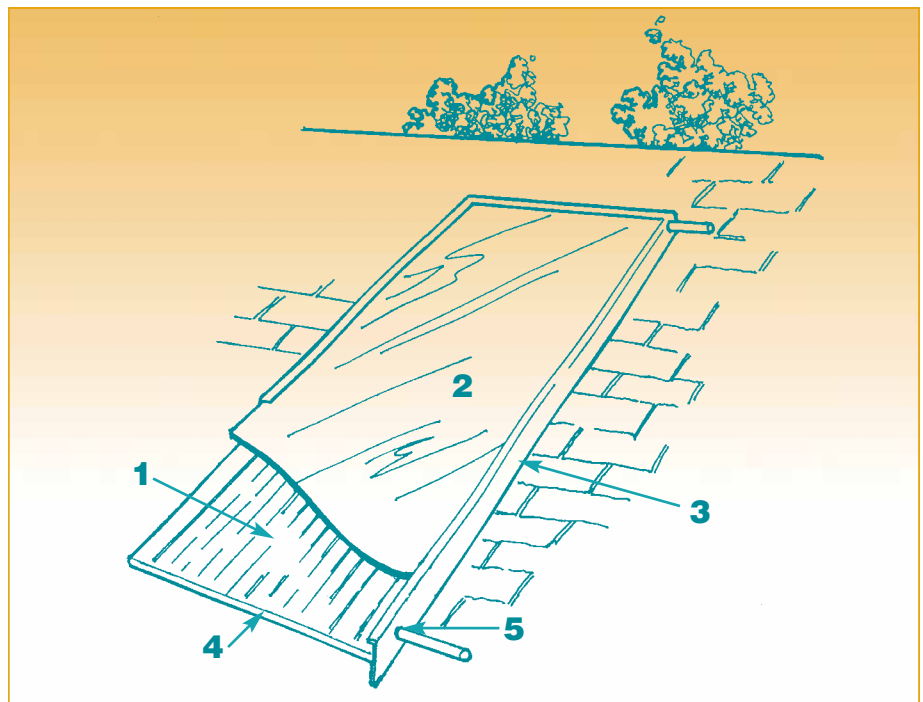
An evacuated tube collector consists of several individual glass tubes, each containing a black metal pipe through which the heat transfer fluid passes. The space between the pipe and the glass tube is "evacuated," so the air is removed.



☞ In a flat plate collector, sunlight is converted to heat and trapped by the "greenhouse effect".

Although uncommon, unglazed plastic collectors can be used as a seasonal solar water heating system. However, they are used mostly for pool heating.

Each collector has its advantages, and each can perform well if matched with the proper, well-designed, storage unit.



☞ Cutaway view showing glazed flat plate solar collector components
1. Metallic Absorber 2. Glazing 3. Housing
4. Insulation 5. Heat transfer fluid inlet

2. Energy Transfer: Circulating fluids transfer the collected energy in the form of heat to a storage tank.

Heat energy is transferred from the collector to the water storage tank. In some water heaters, hot fluid is pumped from the collector to the storage tank. The pump is powered by electricity that either comes from an electrical wall outlet or a small photovoltaic module located beside the collector.

In other types of solar water heaters, the sun heats the storage tank directly, so the fluid in the collector is heated and rises naturally to a storage tank above the collector. This type of solar water heater is often referred to as a thermosiphon system. It does not require an electric pump. Passive solar and solar photovoltaic-powered systems will continue to operate even if there is a power outage. The products that require electricity from a wall outlet will not operate during a power outage.

3. Energy Storage

Solar-heated water is stored in an insulated tank until you need it. Hot water is drawn off the tank when tap water is used, and cold make-up water enters at the bottom of the tank.

Solar water heaters tend to have a slightly larger hot water storage capacity than conventional water heaters. This is because solar heat is available only during the day and sufficient hot water must be collected to meet evening and morning requirements.

Determining your **energy savings**

Follow steps 1-5 to translate these energy contributions into dollar savings:

Step 1

Estimate your annual energy requirement for hot water heating from the table below. Read off the energy requirement of electricity, litres of oil or propane, or cubic metres of natural gas, depending on the fuel you use for heating your water. Write this value in Box 1.

Step 2

Find your (or one with a similar climate) location or the nearest location to you on the map of Canada on page 4. Write the percentage that corresponds to the potential portion of water heating energy saved in Box 2.

Step 3

Multiply Box 1 by Box 2. Write this figure in Box 3, which is your estimated energy saving in kWh, litres, or cubic metres.

Step 4

On a recent electricity, gas, oil or propane utility bill find the amount you paid and the amount of kWh, litres, or cubic metres of fuel used. If you are paying a fixed monthly rate, call your utility company for this information. Write the amount you paid in Box 4 and the amount of fuel used in Box 5.

Step 5

Multiply Box 3 by Box 4 and divide by Box 5. This is your estimated annual dollar savings from your solar water heating system.

Table of Yearly Energy Requirement for Water Heating

| Household Size (in persons) | 2 | 3-4 | More than 5 |
|--|--|--|--|
| Average Hot Water Usage | 150 litres/day | 225 litres/day | 300 litres/day |
| Suggested Solar Water Heater System Size | Small • no pre-heat tank • about 3 m ² | Medium • pre-heat tank • 5-6 m ² | Large • pre-heat tank • greater than 6 m ² |
| Equivalent? Existing Water Heater Tank Size | 180 litres (40 gallon) | 270 litres (60 gallon) | 270 litres high power output (60 gallon) |
| Estimated Annual Energy Required by Fuel Type | | | |
| Electricity kWh | 3400 | 5000 | 6600 |
| Natural Gas (m ³) | 500 | 740 | 1000 |
| Oil (litres) | 480 | 720 | 960 |

Calculating your Savings

| Box 1 | Box 2 | Box 3 | Box 4 | Box 5 | Answer |
|--|--|---|---|---|--|
| Yearly energy requirement for water heating in kWh, m ³ , or litres | Portion of energy met by a solar water heating system in your region (see map on page 4) | Potential energy savings by a solar water heating system in kWh, m ³ , or litres | Dollars paid for energy used (from a recent utility bill) | Amount of energy used in kWh, m ³ , or litres (from a recent utility bill) | Estimated annual savings from a solar water heating system |
| Example: 5000 kWh | Example: 47/100 | Example: 2350 kWh | Example: \$55 | Example: 600 | Example: \$215 |
| Your figure | Your figure | Your figure | Your figure | Your figure | Your figure |
| | x | = | x | ÷ | = |

Gigajoule (GJ): Unit of energy equal to 1,000 million joules, 950,000 BTUs, 278 kWh of electricity, 25.8 litres of oil, 26.9 m³ of natural gas, or 39.2 litres of propane.

Solar photovoltaic panel: A group of modules fastened together. The modules are made up of cells that convert light directly into electricity. The term “panel” is often used interchangeably with the term “module”.

Pre-heat system: Describes an add-on solar water heater, which can be installed with a conventional water heater.

Safe low temperature rating or minimum operating temperature rating: Outside temperature that defines the lower limit for freeze-protection of the solar water heater.

Solar collector: A device that absorbs solar energy and converts it into useable heat.

Solar contribution: Amount of solar energy that a solar water heater converts into hot water on an average day.

Solar Domestic Hot Water (SDHW) system: Describes a stand-alone residential solar water heater that is installed with a conventional water heater. It is also a name sometimes used by solar specialists for a residential solar water heater.

Solar fraction: Percentage of the total water heating load provided by the solar water heater.

Storage unit: Tank or vessel that stores the solar-heated water. Some systems have only a single tank, and use the same tank for storing solar-heated water and water heated with auxiliary energy. Other systems use two separate tanks for storing solar-heated water and water heated with auxiliary energy.

Where can we find out more about **solar energy?**

Natural Resources Canada
(NRCan)
Renewable and Electrical Energy
Division
Energy Resources Branch
580 Booth Street, 17th Floor
Ottawa, Ontario
K1A 0E4
Fax: (613) 995-0087
Web site:
<http://www.nrcan.gc.ca/redi>

or

Natural Resources Canada
CANMET
Energy Technology Branch
580 Booth Street, 13th Floor
Ottawa, Ontario
K1A 0E4
Fax: (613) 996-9418
Web site:
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