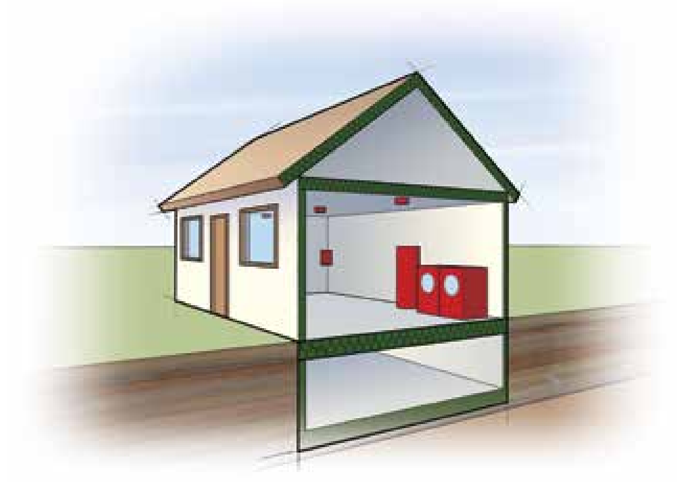


Energy-Efficiency Basics

By **Seth Masia and Carly Rixham**

It's cheaper to save energy than to make energy. If you want to offset $100 a month in utility bills, the right place to start is not with a solar array on the roof, but with insulation under it.

First, Look at Your Heating and Cooling Bills

Whether you battle high heating or cooling expenses, a quality roof and windows, good insulation and proper sealings are important in maintaning a controlled climate. Most homeowners can save 20 to 25 percent by caulking air leaks around windows, doors, foundations and soffits. Check the attic insulation, too. It's cheap to add an extra layer of batting or blown-in cellulose. It's more expensive to swap out old single-pane or metal-frame windows for more efficient modern insulated triple-pane wood- or vinyl-frame windows. The cheapest fix of all is to renew weather-stripping around all doors and window sashes, and put insulating covers on pet doors.

Spending $2,000 on insulating upgrades may cut heating costs by 50 percent and pay for itself in about three years. The U.S. Department of Energy (DOE) website (energysavers.gov) includes interactive worksheets to help you figure out how much more insulation you may need (depending on your climate), how much it may cost and, depending on what you're paying for heat energy today, how long the payback period may be.

Heating and cooling systems can usually be improved. Be sure to change the furnace air filter quarterly. Get ductwork cleaned and air leaks sealed, and make sure that ducts are insulated at least to local codes. Your ductwork should be set up to heat (or cool) recirculated air from inside the house, but the furnace should draw combustion air from outside — you don't want to burn fuel using air you've already paid to heat.

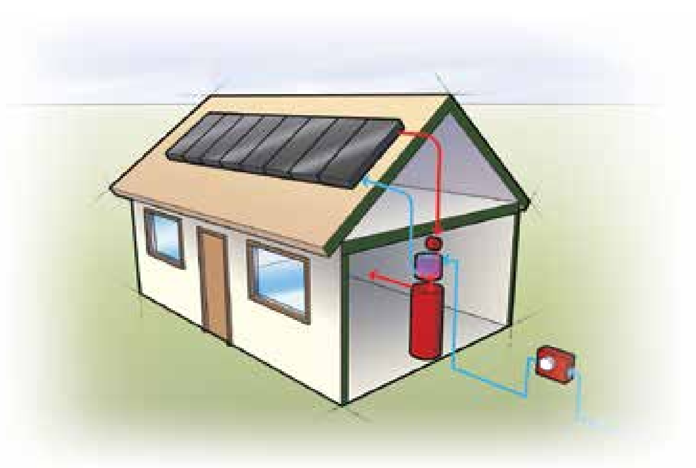
If you heat with oil or electricity, consider installing a modern high-efficiency gas furnace or ground-source heat pump. A $6,000 investment in insulating and HVAC improvements might pay for itself in five or six years.

Not sure where to start? The most direct way to find cost-effective fixes, especially in an older house, is with a professional energy audit. Check with your utility company to see if they offer free or reduced-cost audits. Standard price for this service is $200 to $400. It may include a blower-door test to locate air leaks.

Look Into Energy-Efficient Appliances

The typical refrigerator built in 1980 costs about $154 in electricity to run for a year, at today's average rate of 11 cents per kilowatt-hour. A modern high-efficiency refrigerator runs for about $55 a year. The average homeowner would save $99 a year — enough to pay for the refrigerator in a few years. A new water-heating system may be cheaper still.

Read the full article at solartoday.org/solar-basics.



Solar Water-Heating Basics

Edited by **Barry Butler, Liz Merry** and **Diana Young**

In most parts of North America, the best bang for your solar energy buck is with domestic solar water heating (DSWH). It's a no-brainer in the desert Southwest and in semitropical Florida and Hawaii.

A complete DSWH system can be installed for $4,000 to $7,000, depending on its size, complexity and the climate. These systems are now eligible for the 30 percent federal tax credit. At today's energy prices, over the life of the system, the cost to operate is about 20 percent lower than a conventional gas water heater and 40 percent lower than an electric one. As gas and electricity prices rise, DSWH will look like a better and better deal. The benefits are much greater since solar energy avoids 2,400 pounds of CO_2 per year and provides a secure domestic source of hot water.

Solar water-heating systems come in two flavors: passive and active. In warm climates, a simple passive system can provide plenty of hot water.

Passive Solar Water-Heating Systems

Passive systems are installed in areas where freeze protection is not an issue. The most common types are integral collector storage (ICS) and thermosiphon systems.

In an ICS (or breadbox) system, cold city water flows into a rooftop collector. The collector holds 30 to 50 gallons of water in a serpentine pipe with a heat-capturing coating. Hot water from the collector flows directly to a conventional water heater; in effect the sun does most of the work usually performed by the water heater's burner. As hot water is withdrawn from the water heater, cold water is drawn into the collector, driven by pressure in the city water pipes.

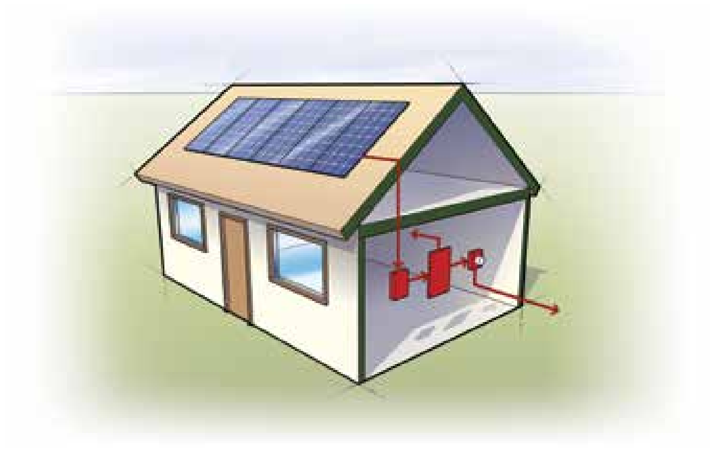
A thermosiphon takes advantage of the fact that water rises as it's heated. Solar-heated water in a flat-plate collector rises through tubes and flows into the top of an insulated storage tank. Colder water at the bottom of this tank is drawn into the lower entry of the solar collector. Water thus flows in a continuous loop, continually reheating during daylight hours. When a hot water tap is opened in the house, hot water flows from the top of the storage tank, and is replaced with cold city water flowing into the bottom of the storage tank.

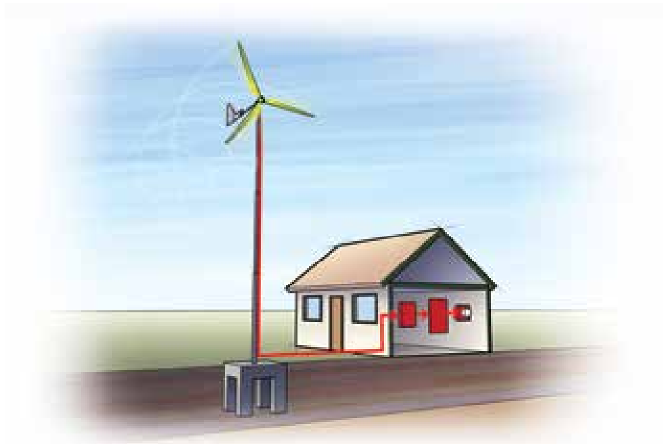
Although the system is simple, thermosiphons put an 800-lb storage tank high on the roof, which should be reinforced to support it. Other solar water-heating systems put the storage tank at ground level or in the basement, where it's not a structural challenge.

Active Solar Water-Heating Systems

Active systems use an electric pump to circulate water through the collector. In warm climates, a direct (or open-loop) system is practical: City water goes into an insulated storage tank. A pump draws water out of the storage tank to pass through the solar collector and go back into the tank.

Read the full article at solartoday.org/solar-basics.





ILLUSTRATIONS BY KURT STRUVE

Solar Electric System Basics

Edited by **Joseph McCabe, P.E.**

A basic home photovoltaic (PV) system consists of weather-protected panels, also called modules, fastened side-by-side on a racking system to form an array. The PV modules produce direct current (DC), which flows to an inverter. The inverter changes DC voltage to alternating current (AC) for the household electric circuit.

Excess power from the inverter may flow out of the house through the utility company's electric meter, into the city-wide grid. The utility will credit the outflowing electricity against electricity purchased from the grid at night. This process is called net-metering.

In an off-grid system, common in remote locations, DC power flows from the modules through a charge controller (also called a regulator), an electronic device that produces a smooth flow of current at the desired voltage. From the charge controller, the power can go to a set of storage batteries and then on to the inverter, as needed.

Most home systems today use crystalline silicon PV modules because they produce the most power in the limited space available on a house roof (cheaper thin-film modules are common in large industrial arrays).

Crystalline PV cells use silicon, a little bit of boron and phosphorus along with anti-reflection materials and a screen printing of electrically conductive grid lines on the top and a coating of aluminum on the bottom to collect the electrons.

Thin-film modules are made from very thin layers deposited on an electrical conducting surface. These materials may originate as silane gas for amorphous silicon, cadmium and tellurium for CdTe, or copper, indium, gallium and selenium for CIGS. The deposition techniques may include sputtering, co-evaporation in a vacuum, electro-deposition, sintering or other techniques. Many variations of thin-film materials are being investigated for low-cost manufacturing and higher solar-to-electrical efficiencies.

Installation Location

Location is critical to PV performance. The array should face the sun. This usually means due south, though if you have a heavy air-conditioning load in the late afternoon you may want to point the array southwest. The array should not be shaded during any part of its productive day. The array should be tilted upward at the correct angle to optimize seasonal exposure — typically at the angle of your latitude so it gets sunlight at a right angle at the spring and fall equinoxes. Some arrays can be made adjustable for varying the angle at different seasons.

Microinverters

Many new grid-tied systems feature microinverters, typically attached to the rack underneath the PV modules. These systems harness power at the module level, rather than the system level.

Read the full article at solartoday.org/solar-basics.

Wind System Basics

By **Mick Sagrillo**

It seems that everyone is interested in wind turbines, an intriguing technology that converts the kinetic energy in the moving wind to useful electricity. Let's look at the steps required to see if a small wind system (defined as up to 100 kilowatts in nameplate capacity) is in your future.

Step 1: Examine why you want a wind system. Energy independence? Lock in future energy costs? Return on investment? Do your part to mitigate global climate change? Support the renewables industry? Power an electric vehicle? Set an example for your family and community? Put your money where your values are?

These are valid reasons for installing a wind turbine. Your goals will affect the system you choose, the amount of money you are willing to spend, and the time you are willing to commit to being your own utility.

Step 2: Quantify the amount of electricity you use now. Most people put up only one wind turbine and they usually want it to generate the amount of electricity they consume over the course of a year. Cost-effectiveness changes with increasing size — the bigger the turbine, the more you spend on the installation, but the cheaper the cost of electricity will be over the life of the system. Matching the size of the system to your annual load maximizes the value of your investment if you can't sell the excess.

Step 3: Reevaluate how you use electricity and why. It's always cheaper to save energy than it is to generate it, so streamline your consumption. The most cost-effective way is to alter your electricity-use habits — turn off lights in unoccupied rooms, mind the thermostat, put "vampire" electronics on a switchable power strip. But habits are hard to change. Investing in high-efficiency appliances makes excellent sense. The rule of thumb is that every $1 spent on efficiency saves $3 in wind system costs.

Step 4: Determine how much fuel (wind) you have at your site. The best way is to hire a small-wind site assessor to evaluate your site and wind resource. This service may be available for a fee from a local wind installer, but be sure to shop around. You want an assessment of your wind resource, not a sales pitch for a particular turbine or manufacturer. Consider this akin to hiring a building inspector to evaluate a house you are interested in buying. The inspector's job is to evaluate the condition of the house and report back to you so you can make an informed decision as to whether or not the house is a wise investment. During this process, the inspector represents your interests only, as should a wind site assessor, and present you with unbiased information to evaluate.

Read the full article at solartoday.org/solar-basics.

Find more solar basics, on topics including ground source heating and cooling, passive solar building and working with a solar contractor, at solartoday.org/solar-basics**.**