

A Homeowner's Guide to Solar Electric Systems



Producing your own electricity with a rooftop photovoltaic (PV) system can have several benefits, including buffering you from volatile energy costs and shrinking your carbon footprint. However, these systems are still relatively expensive despite declining prices in recent years. Today, a residential PV system will cost \$6 to \$9 per watt of output power (or about 20 to 35 cents per kilowatt-hour), including all subsystems and installation. And with typical household installations ranging from 1 kilowatt (kW) of peak capacity to over 5 kW, even a modestly sized system can exceed \$15,000. However, there are a number of rebates, tax breaks, and other incentives that can substantially reduce the cost of installing a PV system. And once installed, although the power electronics will likely require periodic replacement, the system can run virtually maintenance-free in any climate for 25 years or more.

A PV System in Detail

A typical PV system is made up of the array, the inverter, and a number of other components collectively referred to as balance of system (BOS).

Array. The array is a series of PV modules, which themselves are composed of numerous PV cells. The cells are made mostly of silicon or another semiconducting material that converts incoming light energy into electricity. Although there are many emerging PV cell materials and designs, those that are widely commercialized include single-crystal silicon, polycrystalline silicon, and thin-film modules made from amorphous silicon, cadmium-telluride, or other materials.

Inverter. An inverter is a power-conditioning device that converts the incoming direct-current (DC) power from the PV array into grid-compatible alternating-current (AC) power. Though the PV array and mounting structure will typically last for 25 years or more, most inverters are guaranteed for only 5 to 10 years. As a result, periodic replacement of the

inverter is an important consideration as you think about the economics of your PV system.

Balance of system. The BOS components include the mounting structure, wiring, switches, and a metering apparatus that facilitates grid integration (**Figure 1**, next page). Most of the PV installations today are in homes that are tied to the electric grid because adding batteries can significantly increase the cost and maintenance of a PV system.

Making Solar Energy Affordable

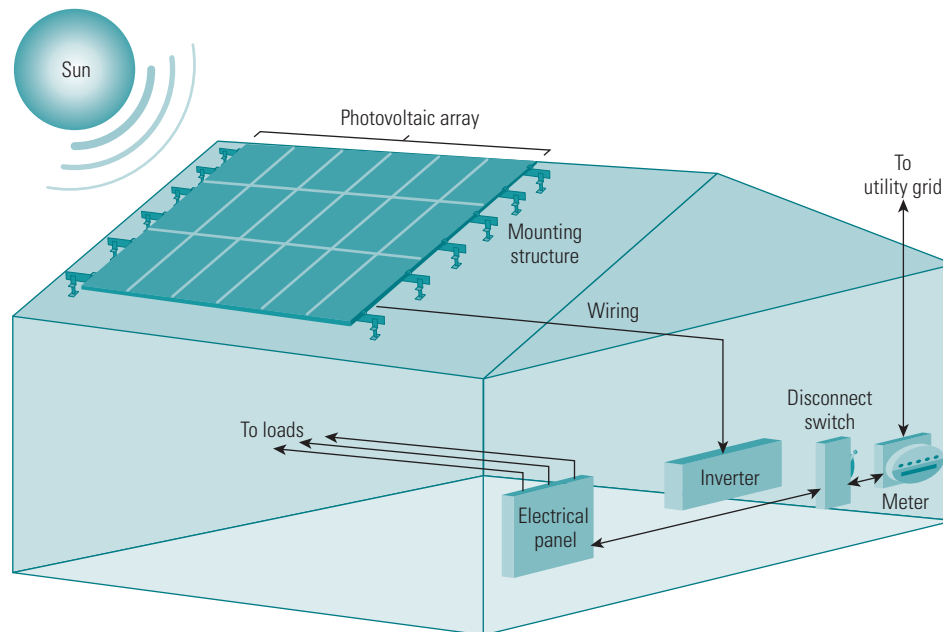
PV systems are more expensive than utility-generated electricity. In general, solar electricity costs 20 to 35 cents per kilowatt-hour (kWh) when the installed cost of the system is amortized over the lifetime of the system. However, there are several opportunities available to homeowners that make solar power more financially appealing.

Research available rebates. The U.S. federal government offers tax credits for the installation of residential PV systems. However, Congress frequently changes the terms and amount of these tax breaks, so checking the current status of any federal program is always a good idea as you evaluate the overall economics of installing your own system. A number of states, counties, and municipalities also offer additional rebates or incentives.

Check on net metering possibilities. Many states allow for net metering, meaning that homeowners are able to sell any excess power their PV systems generate back to the grid and get a credit on their utility bill. Net metering is particularly beneficial in households that are unoccupied during the middle of the day, when PV panels are collecting the greatest amount of sunlight.

The best place for homeowners to find local and national rebates and incentives, as well as information on net metering

FIGURE 1: Schematic of a residential grid-tied photovoltaic system
The key components of a residential photovoltaic system include the array, inverter, mounting structure, wiring, disconnect switch, and a meter that facilitates grid integration.



Note: The placement and type of disconnect switch will be determined by policies implemented by the local utility.

Courtesy: E SOURCE

is the North Carolina Solar Center's Database of State Incentives for Renewables & Efficiency (www.dsireusa.org), which provides information for programs across the United States.

Remember that efficiency is cheaper than PV. It is easy to get excited at the thought of generating your own electricity with a rooftop solar electric array. But it's important to remember that spending tens of thousands of dollars to generate electricity to power inefficient lights, appliances, and electronics doesn't make sense. So before installing a PV system, a home energy audit is a smart idea. Purchasing Energy Star appliances, lighting, and other electronics is also a good way to save energy. Even turning off the lights and minimizing air-conditioning usage will go a long way to reducing your overall energy needs and help you make a smaller, less-expensive PV system the best choice.

Evaluating Your Home for PV

When considering a solar electric system for your home, there are a few considerations you may wish to take into account, including the available solar resource, the condition of your roof, the size of the PV system, and any shade that could hinder system performance.

Available solar resource. Solar resource refers to the average annual amount of sunlight that reaches a given site. The greater the solar resource, the more energy a particular PV array will generate. For example, a system in the Pacific Northwest will generate less annual electricity than the same system in the Southwest. Because the feasibility of installing a PV system is closely linked with the amount of sunlight available, evaluating the solar resource at a given location is an important first step when considering a PV installation. A qualified contractor can provide this information for you, or you can do it yourself with a free

online calculation tool from the National Renewable Energy Laboratory called PVWATTS (http://rredc.nrel.gov/solar/codes_algs/PVWATTS). This tool allows you to quickly estimate system output throughout the year based on geographic location and system setup.

Condition of the existing roof. It's important that you evaluate the condition your roof prior to installing a PV array because the cost of repairs or a complete reroofing will be substantially greater once the array is in place. If the existing roof is in poor condition, the time to address that problem is before the array is installed.

Size of the system. Residential PV systems can span a large range in terms of capacity and price. The size of a PV system depends on many factors, including your budget, annual energy consumption, amount of usable roof space, orientation of home, nearby trees, and so forth. Working with a qualified contractor will help you select a system that best matches your needs.

Shading. A PV array that is even partially shaded will generate less electricity than one that is in direct sunlight.

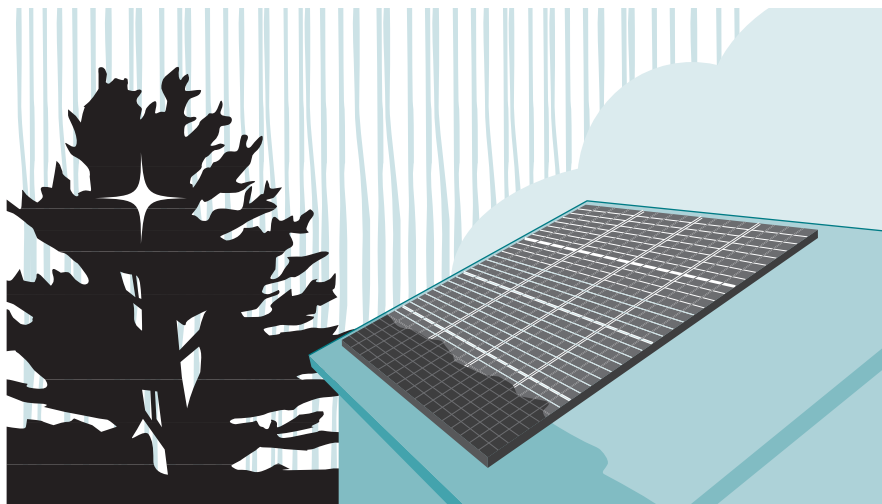
But what many people don't realize is the drop in electric output can be disproportionately larger than the amount of shade provided by a nearby tree or building due to engineering constraints in the construction of PV panels (**Figure 2**). However, it is important to realize that going outdoors and chopping down all the trees near your house to make way for a PV system would probably be a poor choice—without that shade, your home will get hotter in the summer and may require more electricity to cool. So though you may increase the capacity of your PV system, you might increase your electricity demand even more! Using software tools, a qualified contractor can easily assess the degree of shading a proposed array will experience throughout the year and determine the best PV design.

Selecting Qualified Installers

Once you've decided that you wish to install a PV system, the next important step is selecting the right contractor. But as the demand for PV systems has boomed in recent years, so too has the number of contractors

FIGURE 2: The effects of shading

The impact of shading on the power output of a photovoltaic array depends both on the portion of the array that is shaded and the electrical layout of the modules. In this array, if the four modules in each column were wired together in series and those four columns were wired in parallel, then the output of all four series strings would be reduced because each string contains one shaded module. If, however, the array were designed so that modules in each row are connected in series and the rows are connected in parallel to the inverter, the output of the top three rows would be unaffected by shading—and more power is delivered to the inverter.



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in the field who lack qualification or formal training in PV system design, installation, or relevant electric codes. Choosing a contractor without adequate PV-specific experience increases the risk that there could be design or installation mistakes.

Many state and local solar industry associations offer certification programs and maintain lists of certified contractors. But because these programs vary in terms of required training and testing, even a state-certified installer may not have a high level of experience and knowledge. And although some testing programs certainly are high quality, it may take a fair amount of work just to determine whether the certification a contractor presents is worth the paper it's printed on.

So how can you be assured that you're choosing a qualified contractor? Since 2003, the best indicator of contractor competence has been certification by the North American Board of Certified Energy Practitioners (NABCEP). This certification is given to PV installers who pass a rigorous exam and demonstrate that they possess a high degree of experience or education related to PV system design and installation. Several hundred contractors have received NABCEP certification and are listed in the NABCEP contractor database (www.nabcep.org). Another resource for finding local contractors and reviewing their certifications is www.Findsolar.com.

Selecting Quality Equipment

Even the best contractor is only as good as the hardware he or she installs. As a result, it is wise to confirm that your solar contractor is installing panels and an inverter that are certified by the California Energy Commission (CEC) or Underwriters Laboratories. Both organizations test solar components for performance and safety. To view lists of eligible equipment or to learn more about the testing procedures, you can refer to the CEC's directory of eligible solar electric equipment at www.gosolarcalifornia.org/equipment.

Maintenance Considerations

Once your PV array is installed, little system maintenance is required. The modules have no moving parts and usually carry a warranty of at least 20 years. Regular rainfall is often sufficient to eliminate dirt accumulation, but where rain is infrequent, occasionally rinsing the modules off with water will restore full-power operation. In some locations it's helpful (if it's possible) to remove snow from panels that have a particularly shallow slope.

Inverters require maintenance far more frequently than the modules do, but in most cases, the system owner's role is limited to monitoring the status indicators and notifying the installer that the inverter needs service.