Own Your Power!

A Consumer Guide to Solar Electricity for the Home

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Contents

About this guide: The U.S. Department of Energy (DOE) receives numerous inquiries each year from consumers interested in solar electricity. This guide answers their frequently asked questions about benefits, system basics, choosing a system, financial incentives, warranty, and insurance issues. It is not meant to be a technical guide on how to design or install a system. Homeowners will need to consult with an experienced solar contractor to determine the best system for their climate and home's energy needs. Some resources for consumers are also provided. DOE does not endorse any products in this guide.

Benefits of Solar Electricity

Solar electricity saves money, adds value to homes, and reduces air pollution.

Solar homes in California with SunPower Suntiles® integrated into their roofs.

Rising energy prices and growing environmental concerns are making solar electric systems more attractive to homeowners. A solar electric system reduces high energy costs and keeps your home up and running during power outages. The advantages to buying a solar electric system include:

- Saving a significant amount on your electric bill
- Increasing your home's appraisal value
- Enjoying reliable, clean, free power for 25 to 30 years
- Helping to boost our economy by creating jobs and new solar companies.

Quick Tip

A solar electric system can save tons in greenhouse gas emissions. The U.S. Environmental Protection Agency estimates the average two-person home emits approximately 41,500 pounds of greenhouse gases during a year.

Most solar electric systems last 30 years and pay for themselves in 4 to 5 years after tax credits and rebates. That means homeowners can enjoy free electricity for years. If you install batteries to back up your solar electric system, it will provide emergency power in areas with frequent storms, hurricanes, and other natural disasters. In addition, going solar adds value to your home. According to the Appraisal Journal,* a solar electric system increases your home's value by $20 for every $1 in annual utility bill savings, which means a system almost pays for itself with the appraisal value increase in some cases. See the Costs and Financial Incentives section. Solar power reduces America's dependence on foreign oil and fossil fuels, making our nation more secure while reducing air pollution and greenhouse gases.

*Evidence of Rational Market Valuations for Home Energy Efficiency, The Appraisal Journal, October 1998 and 1999.

Solar Electricity Basics

Solar electric panels capture light from the sun and convert it to clean power.

This solar home in Davis, California, uses EnergyTiles® made by BP Solar.

Solar electricity is produced by changing sunlight to power using the photovoltaic (PV) effect. The PV effect causes an electrical current to flow through a solar cell when exposed to sunlight. Solar cells power everything from calculators and remote highway signs to homes, commercial buildings, and large power plants. Solar cells power all satellites in space, making them responsible for the world's communications products.

Quick Tip

A south-facing roof is most effective, but a roof over a carport, garage, or porch that receives no shading from other buildings or trees will work well.

Solar companies make solar panels by combining many solar cells together. Several solar panels combined make a solar array. When solar panels are strung together in series and combined with other components, they become a solar electric system or solar array. A solar electric system can meet part or all of a home's electricity needs, offsetting 25% to 50% of most homeowners' power with solar electricity.

Types of Solar Panels

There are two conventional types of solar panels: crystalline silicon and thin film. The most common solar cell material is crystalline silicon, but newer materials for making solar cells include thin-film materials such as amorphous

silicon and cadmium telluride. More recently, solar companies have begun to use plastic and aluminum foil to produce solar electricity, but it may be several years before these new products become available to consumers.

Silicon Solar Panels

These rigid panels come in two types: crystalline (made from a single large crystal) and polycrystalline (made from blocks of silicon that contain many small crystals). Silicon solar panels are the most efficient on the market, but also the most expensive. They are also the best-performing panels in low-light conditions. Although polycrystalline solar cells are slightly less efficient than the single-crystal type, silicon solar panel efficiencies average about 33%.

Thin-Film Solar Panels

These flexible solar panels are made by spreading silicon and other solar-producing materials in a very thin layer (about the thickness of a human hair) directly onto a large plate that is usually made of glass or ceramics. Less efficient than silicon solar panels, thin-film solar panels are also less expensive to produce. The thin material of these solar panels makes them ideal as building-integrated solar products such as solar shingles and tiles. The most successful thin-film materials are amorphous silicon, cadmium telluride, and copper indium diselenide. Efficiencies range from 10% to 19%.

Future Solar Panels

New solar materials that are emerging include lightweight foil-based panels, plastic collectors, and hybrid solar electric/solar water heating collectors. The new hybrid systems capture hot air from the solar electric panels and use it to heat water. Except for the hybrid systems, most of the new materials are not available to homeowners.

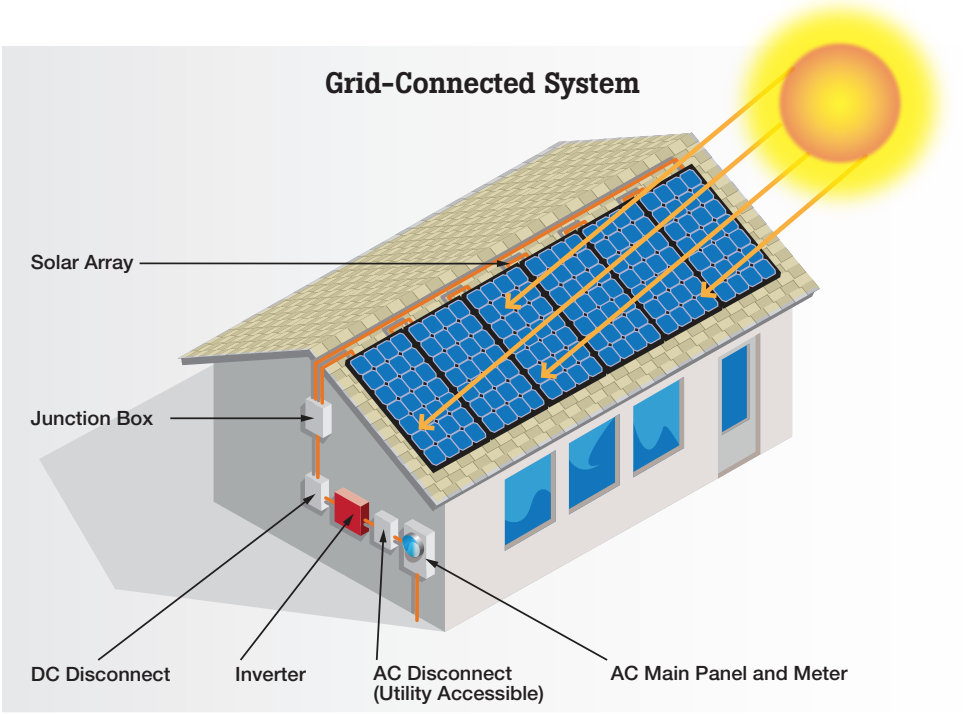
Types of Solar Electric Systems

A solar electric system is typically made up of solar panels, an inverter, a battery, a charge controller, wiring, and support structure. The three most common types of solar electric systems are grid-connected, grid-connected with battery backup, and off-grid (stand-alone). Each has distinct applications and components.

Grid-Connected

In this system, the solar panels are connected to your local utility electrical grid to complement your normal power supply from your utility company. Grid-connected systems consist of:

- Solar panels mounted on the roof
- An inverter to convert electricity produced by the system from direct current (DC) energy into alternating current (AC) energy
- A junction box that connects the solar panel wiring to the breaker panel on the home
- A power meter that displays how much power the home produces and uses
- A disconnect switch that, for safety reasons, prevents the system from sending power to the grid during power outages (this is called ***islanding***).



Grid-Connected with Battery Backup

Very similar to the grid-connected system, this system adds a "battery bank" to collect the power generated from the solar panels. Power stored in the batteries can be used during power outages. The battery bank collects power produced by the solar panels, sends it to the breaker box, and then into the house power system. The components of this type of system consist of:

- Solar panels mounted on the roof
- An inverter to convert solar electricity from DC energy into AC energy
- A battery bank for power storage
- A charge controller to prevent overcharging the battery
- A junction box that connects the solar panel wiring to the breaker panel on the home
- A power meter that displays the amount of power used, produced, and stored in the battery bank
- A disconnect switch to prevent islanding during power outages.

Off-Grid or Stand-Alone

Off-grid systems are not tied to any utility power lines and are most common in remote areas where connecting to the utility grid is more expensive than purchasing an off-grid system. In off-grid systems, the solar electric system represents the home's main source of power. Batteries store unused solar energy for use at night. Generators, small wind systems, and other backup fuel sources are sometimes used as backup power when the solar power stored in the batteries is not enough to meet household needs. These systems consist of the following:

- Solar panels mounted on the roof
- An inverter to convert electricity produced by the system from DC into AC energy
- A rectifier (sometimes used to change AC to DC and back again to get the most use out of a system)
- A charge controller to prevent overcharging the battery
- A junction box that connects the solar panel wiring to the breaker panel on the home
- A junction box for backup power supply from a generator
- A power meter that displays the amount of power used, produced, and stored in the battery bank
- A disconnect switch to prevent islanding during power outages.

Power Produced by a Solar Electric System

Solar panels are assigned a rating in watts based on the maximum power they can produce under ideal sun and temperature conditions. You can use this rated output to estimate the number of panels you'll need to meet some or all of your electricity needs. However, the exact amount of energy produced by a solar electric system also depends on roof orientation and tilt, as well as other factors such as shading, dust, panel conversion, and wire losses.

In sunny climates such as California, an average 1-kilowatt system with optimal orientation and tilt will produce between 1,400 and 1,700 kilowatt hours per year. Many builders who install solar electric systems in their California housing developments estimate that a 2.4-kilowatt system will offset 40% to 50% of the electricity needs of an energy-efficient home. That number could be lower or higher depending on the amount of sunlight (regardless of climate) your home receives each year and the energy efficiency of your home. Many solar vendors now sell 2- to 3-kilowatt package systems for homes and can tell you how much energy will be offset by a system depending on your home's energy use, roof orientation, and other factors.

Resources

- ***U.S. Department of Energy – Consumer Guide: http://apps1.eere.energy.gov/consumer/***
- ***U.S. Department of Energy – PV Basics: www.eere.energy.gov/solar/pv_basics.html***
- ***U.S. Department of Energy – PV for Consumers: www.eere.energy.gov/solar/pv_consumers.html***
- ***Solar Energy Industries Association: www.seia.org/cs/about_solar_energy***
- ***California Center for Sustainable Energy: www.sdenergy.org***
- ***Florida Solar Energy Center (FSEC) – Solar Electricity Basics: www.fsec.ucf.edu***
- ***National Renewable Energy Laboratory – Learning About Renewable Energy: www.nrel.gov/learning/***

How To Choose a System

Your home's power requirements, roof type, and solar resource will determine system type and size.

A roof-integrated solar electric system on a home in San Jose, California.

Producing electricity by changing the photons in sunlight to clean power, solar electric panels work in all climates—even in space, which is a very cold climate. For solar electricity, the amount of sunlight your home receives is much more important than the temperature. Many states, such as Colorado, receive a great deal of sunlight throughout the year, despite the colder temperatures in the winter and spring. In fact, some vendors claim solar panels actually work better in colder climates because they don't overheat, which can cause performance issues.

When purchasing a solar electric system, the right choice will depend on how much sunlight your area receives, your budget, how much conventional power you want to offset with solar power, how much room you have on your roof or in your yard, and where the solar panels will be mounted.

Quick Tip

Quick Tip: Planning to repair or replace your roof? That's the perfect time to purchase a solar electric system because you want your roofing material to last as long as your system—about 25 years.

Roof Requirements

Before purchasing a solar electric system, homeowners need to determine available roof space and condition.

Space and Orientation

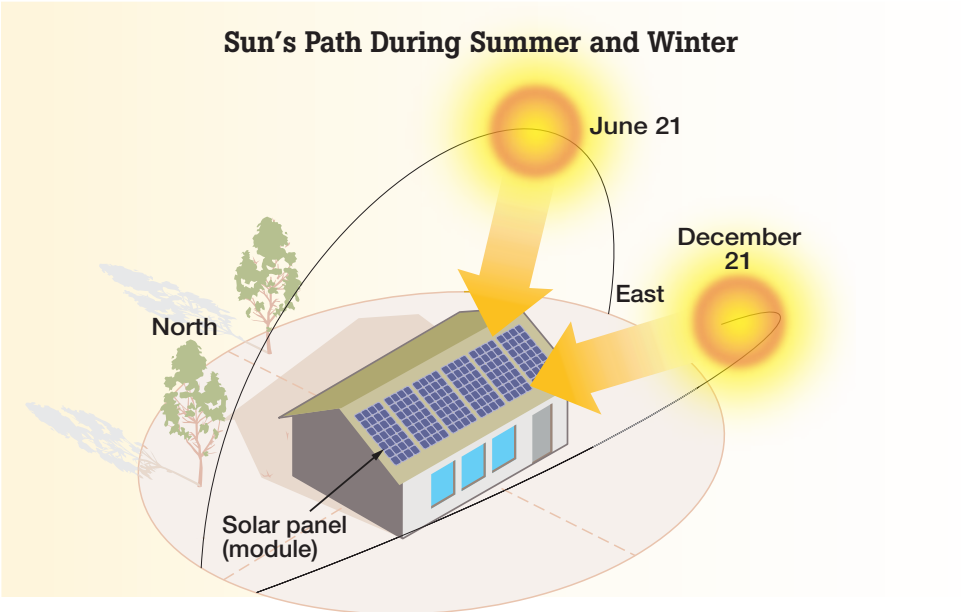
North America's sun follows a southern path. For maximum performance, your solar electric system needs about 100 square feet of unshaded south-facing roof or yard space for every kilowatt of electricity produced. Thin-film systems may require 175 square feet of space per kilowatt. If your roof does not face south, you can still use a solar electric system, but the performance will be about 5% less with a southeast- or southwest-facing system. Eastern, western, and northern exposures are not recommended for solar electric systems.

Roof tilt is also important to capture the path of the sun, but the requirements vary with location. Your solar vendor and installer should be able to calculate the proper tilt based on the solar resource for your area (the amount of sunlight your area receives). When a south-facing roof is not available, some people install solar electric systems on garage roofs or use them as window awnings and porch coverings.

Solar panels are usually roof mounted, but if you have a shortage of roof space, they can be mounted on a pole or in your yard. Solar panels can also be integrated into roof shingles and tiles. Some even come as "peel-and-stick" laminates for metal standing-seam roofs.

Condition

If your roof is more than 15 years old, you may want to consider replacing it when you purchase your solar electric system. Most solar vendors recommend using roofing material that will last as long as the system, which is about 25 to 30 years.



Make sure the roof can hold the weight of the system, which is estimated at 3 to 5 pounds per square foot, depending on the type of technology used and installation methods.

Shading

Shading a panel reduces its performance because it blocks sunlight. The most common items that shade solar panels are trees, chimneys, nearby buildings, and electrical cables, as well as heating and cooling equipment. Also check shading from pipes, skylights, and vents. To determine possible shading problems, consult a solar professional who uses a software program that can estimate site shading. Some people will examine a proposed location throughout the day and year to see how the area shading changes. For example, shading in an area can change from summer to winter because the sun's path changes.

Ground-Mounted Systems

If you don't have a south-facing roof or enough roof space, consider a ground- or pole-mounted solar system, which can be installed with the same orientation and tilt as a roof-mounted system. Ground-mounted systems are great for homes with large yards. Some systems come mounted on a tracker that follows the sun's movement.

Installation and Maintenance

Before purchasing a solar electric system, homeowners need to be aware of issues that affect system installation and maintenance.

Warranties and Insurance

Most solar electric systems come with a 25-year warranty, but maintenance may be required to comply with a manufacturer's warranty. Inverter warranties are usually 10 years, and you can reasonably expect to have to replace the inverter during the life of the system. Most homeowner insurance policies will cover the systems, but check with your insurance agent to be sure. Also, be sure to ask your insurance agent if you need to be aware of any installation issues that could affect coverage for the roof, such as roof penetrations during system installation.

Zoning and Permits

Local zoning laws may restrict where you can place collectors on your home. Check with your city, county, or homeowner association to find out about any restrictions. Some states have solar access laws that may require a homeowner association to approve installation. Homeowners will need to obtain any local permits required before installation. Typically, your installer will assist you in obtaining permits and clearance from the city.

Maintenance

Proper maintenance of your system will keep it running smoothly. Most vendors recommend a yearly maintenance check by your installer, but you should carefully review the maintenance instructions shown in the system manual with your system

provider. Systems with electrical components usually require replacement parts after 10 years. Solar panels may need to be cleaned in climates with infrequent rainfall.

Installation

Using a professional, licensed contractor to install your solar electric system can prevent problems with the system caused by improper installation and maintenance. Professional installers can also help with paperwork for tax credits and rebates. The North American Board of Certified Energy Practitioners (NABCEP) maintains a list of certified system installers. The U.S. Department of Energy sponsors a Web site called Find-Solar.org that provides a list of local certified installers by zip code and company name. Both are listed in the Resources section.

Questions to ask any solar energy dealer and installer include:

- What experience and certification do you have?
- How long have you been in business?
- What do you know about zoning, electrical requirements, and codes?
- Are your installers NABCEP certified?
- Do you handle paperwork for federal and state incentives?
- Do you offer maintenance service?
- Are you a member of any solar trade organization, such as the Solar Energy Industries Association?
- What warranties do you offer?
- What payment options do you offer?
- Do you offer packaged systems?

Resources

- ***U.S. Department of Energy – Making Your Own Clean Electricity: www.eere.energy.gov/consumer/your_home/electricity/index.cfm/mytopic=10510***
- ***U.S. Department of Energy – Considering a Small Solar Electric System: www.eere.energy.gov/consumer/your_home/electricity/index.cfm/mytopic=10730***
- ***FSEC – Certified PV Modules: www.fsec.ucf.edu/en/industry/testing/PVmodules/pv_flashtest_list.htm***
- ***FSEC – Certified Systems: www.fsec.ucf.edu/en/industry/testing/PVsystems/certified_systems/index.htm***
- ***Find a Solar Installer: www.find-solar.org***
- ***NABCEP: www.nabcep.org***
- ***Energy Calculators and Software: www.eere.energy.gov/consumer/calculators/homes.html***

Costs and Financial Incentives

Many financial incentives are available to homeowners to offset system cost.

A 1-kilowatt solar electric system was integrated into the roof of each of the 77 units in this housing development in San Diego, California.

Purchasing Considerations

Purchasing a solar electric system represents an investment with many benefits. Besides raising the property value of your home ($20 for every $1 in utility bill savings), a solar electric system provides savings on your monthly utility bill. As energy bills continue to rise, and in some states double, financing a solar electric system can give homeowners security in knowing their energy bills will remain virtually the same for years—it's the monthly payment on the system. Most systems pay for themselves within 5 years after rebates and tax credits, so homeowners enjoy free energy for years to come.

Example Savings and Property Value Increase for a Solar Electric System

Average monthly utility bill	**$100 per month**
Estimated system size required	**4.48 kW**
System cost (at $9 per watt national average)	**$40,320**
Estimated system cost after tax credits and rebates (Colorado)	**$12,544**
Estimated first year utility bill savings	**$518 to $988**
Estimated increase in property value	**$10,360***
Estimated monthly payment on system (6.5% Annual Percentage Rate, 30 years)	**$79**

*If based on average annual utility savings over 25 years of $869 to $1,658, property value increase is $17,380.

Energy Efficiency Can Help

Before purchasing a solar electric system, try some energy-saving strategies to help lower your electricity bills to get the most out of your existing system. The U.S. Department of Energy provides an online consumer guide, listed in the Resources section, that includes energy efficiency and cost-saving measures for homes.

Costs

Solar electric systems cost on average $8 to $10 per watt installed, but new technologies are bringing the costs down every year. Federal and state incentives give consumers tax credits and rebates for the purchase of a solar electric system to reduce the cost. Some vendors are now selling the systems at "after-rebate" prices and completing all the paperwork themselves. Before rebates and tax credits, the average 2-kilowatt (2,000-watt) system will cost between $16,000 and $20,000. However, the cost per watt usually goes down as the system size increases, so a 5-kilowatt system may be installed for $35,000 ($7 per watt). Depending on where you live, after rebates and tax credits, the cost for a 5-kilowatt system may be reduced to $2.50 per watt or $12,500.

Federal and State Incentives

The numerous incentives for buying a solar electric system include:

- Federal tax credit
- State tax credits
- Utility rebates
- Property tax credits in some states.

In October 2008, the federal tax credit was extended for another 8 years, now allowing for a tax credit up to 30% for residential and commercial solar installations. Tax credits and utility rebates vary by state. Check the Database of State Incentives for Renewable Energy (DSIRE) for a list of these incentives. DSIRE includes information about which states won't increase your property taxes for the purchase of a solar electric system. Find-Solar.org has a cost calculator that includes federal and state incentives for your area. Both organizations are listed in the Resources section.

Net Metering

Many states have net metering laws that require utility companies to give homeowners credit for excess power produced by their solar electric systems. That means your local utility gives you credit for every kilowatt-hour of solar power not consumed by your home, reducing your electricity bill by the same amount. Your meter essentially spins backward when excess power is produced. Generally, homeowners receive credit at higher rates during the summer when their systems are producing the most power and at lower rates during the winter when their systems aren't producing as much solar energy. Many states offer net metering, but New Jersey and Colorado are rated among the best for net metering policies.

Financing

If you can't purchase a system outright, consider financing the system. Several resources are available for financing a solar electric system, including:

- Home refinance
- First mortgages
- Banks (many will finance for less than prime rate)
- Construction loans
- Home equity loans
- Solar vendors (some now finance the systems themselves).

Mortgage loans and home equity loans offer several advantages: longer terms, lower interest rates than conventional bank loans, and tax-deductible interest. In addition, adding a solar electric system to a loan at the same time that you build, buy, or refinance will reduce paperwork and simplify the purchase. Other benefits to financing the cost of a solar electric system include a low monthly payment on the system and locked-in electricity costs for the next 25 years.

Resources:

- ***U.S. Department of Energy – Energy Savers: www.energysavers.gov/***
- ***U.S. Department of Energy – The Economics of a Small Solar Electric System: www.eere.energy.gov/consumer/your_home/electricity/index.cfm/mytopic=10750***
- ***U.S. Environmental Protection Agency – Federal Tax Credits: www.energystar.gov/index.cfm?c=products.pr_tax_credits***
- ***DSIRE: www.dsireusa.org/***
- ***FindSolar Cost Estimator: www.find-solar.org***
- ***Solar Energy Industries Association: www.seia.org/cs/the_investment_tax_credit_itc***

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