

# Solar Solutions

*Equipment prices are rising, but so is the cost of power*





Roof-top solar PV systems like those pictured on the two homes (above left) can supplement or even replace grid power. The south-facing roof in this North Carolina home (above right) combines a large solar water heater at the top of the roof with a 10-kW solar photovoltaic system along the bottom two thirds of the roof.

## By Maureen McIntyre

**D**enver-area builder Scott Dittman of Equity Custom Homes has been building houses for 20 years, but until this year he had no experience with rooftop or ground-mounted solar photovoltaic (PV) panels.

"We've been doing the green basics for a long time—energy efficiency, low-VOC paints, recycled-bottle carpet, etc.," says Dittman. "But a new material or technology has to be both feasible and reasonable to get my attention." So, when Colorado voters passed Amendment 37 in November 2004, solar got a lot of people's attention, including Dittman's. The measure requires Colorado's largest utilities to use renewable resources to provide a percentage of their retail electricity sales. Today, as an incentive to encourage consumers to install solar PV systems to generate their own household power, Xcel Energy, Colorado's largest utility, offers residential customers a \$2.00-per-watt cash rebate, in addition to a \$2.50-per-watt, one-time payment for renewable energy credits. Combined with the federal tax credit, it was enough to convince Dittman to install a 1-kilowatt PV system on a house his firm showed on the 2006 Metro Denver Parade of Homes. Dittman also decided to install a solar thermal system (to heat water) to further take advantage of the solar resource and an additional federal tax credit. (For a summary of tax incentives, visit [EnergyStar.gov/index.cfm?c=products.pr\\_tax\\_credits](http://EnergyStar.gov/index.cfm?c=products.pr_tax_credits).)

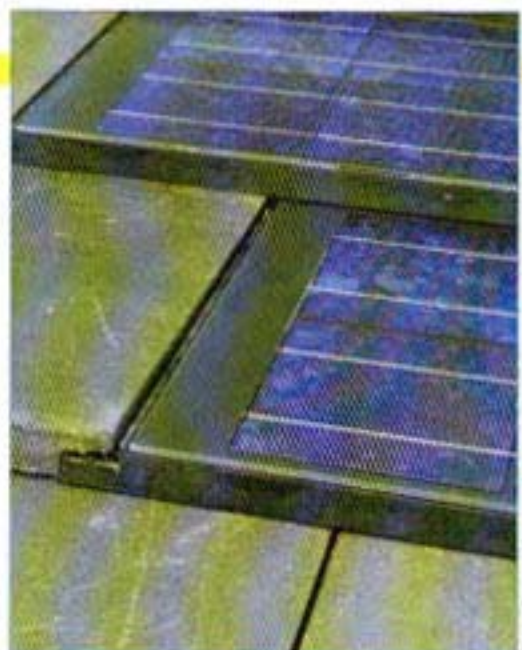
For his company's first foray into solar, Dittman chose a ground-mounted solar PV system to generate electricity and a roof-mounted solar thermal system for hot water. Roof-mounted solar water heaters can be mounted flush against a roof and still be effective. However, depending on the home's orientation and geographic location, PV systems may need to be tilted up to get the most out of the sun. This higher profile makes them unsightly in some people's opinions. Dittman chose to ground-mount his PV systems to help hide them and to accommodate some local covenants and zoning regulations. For his show home, Dittman was able to claim that just these simple systems eliminated more than 2,000 pounds of CO<sub>2</sub> emissions each year. Plus, the home will generate a great deal of its own electricity, a sure marketing advantage because buyers correctly perceive that electric prices will continue to climb.

## Integrating Roof PV Panels

Bronwen and Jeff Martin have just built a 6,000-square-foot house near Charlotte, North Carolina. They wanted to meet most of their energy needs with solar, but they also wanted a traditional-looking home, especially on the north side, which faces the road. Ground-mounting a PV system is just one way to ease concerns over aesthetics. A remarkable number of solar modules (the individual units that collect the sun), like those from Schott and Sharp Solar, can be integrated into concrete roof tiles so the panels are as unobtrusive as possible. Other integrated roof modules, like those from Open Energy Corporation, can be integrated into the roof tile system and are strong enough to walk on or to endure snow loads.

The Martins worked with Solar Design Associates (SDA) in Harvard, Massachusetts, a solar design firm founded in 1974. The result was a gable-to-gable, eave-to-eave building-integrated solar thermal and PV roof installation. The panels they used were from Schott. "By serving as both building envelope material and power generator," says SDA's Steven Strong, "building-integrated solar systems can provide savings in materials and electricity costs and an aesthetically pleasing roof or facade."

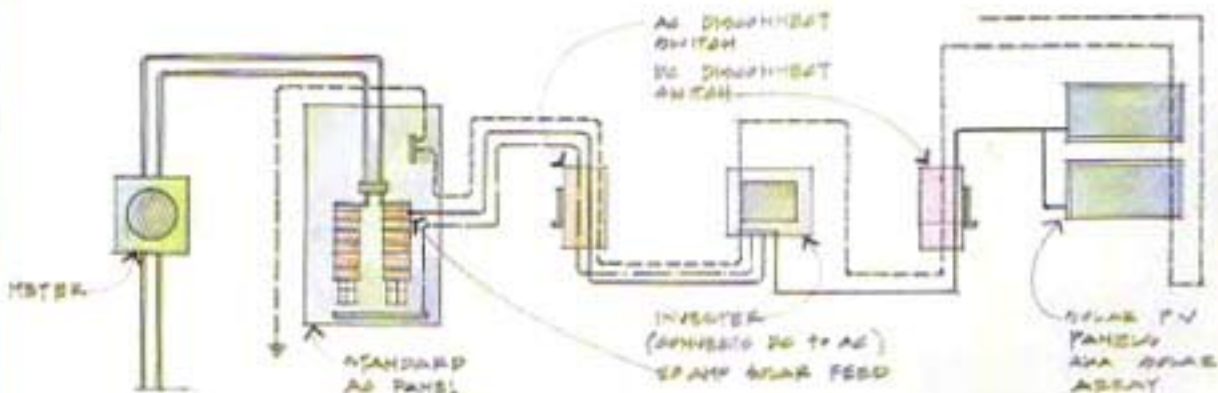
These essentially eliminated a \$349 monthly electrical bill, which includes powering a hot tub and cutting the lawn with an electric lawn mower. (The house is valued at \$1 million.)



Open Energy Corporation

Solar PV modules can be easily integrated into concrete roof tiles to be as unobtrusive as possible.

Continued —



SOLAR PV ARRAY

SOUTH FACING ROOF

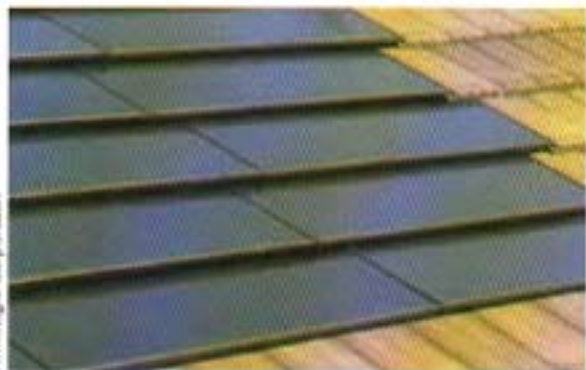


The power from a roof-top solar array is fed through an inverter that converts DC to utility-grade AC power. The AC power is then fed to the house load center through a dedicated circuit breaker. (Your solar contractor should be familiar with the National Electrical Code [NEC] Article 690.) Inverters for grid-tied systems without battery backup are designed to turn off when grid power goes down to protect utility-line crews doing repair work.

## TYPES AND SIZING OF SOLAR PANELS

There are two types of solar-energy systems: grid-tied systems that feed PV power into your service panel, so electricity generated by the sun can work alongside electrical power from the grid, and off-the-grid systems that can supply electrical power to homes in remote locations. This article focuses just on grid-tied systems without battery backup, which are the most common and least expensive systems. (They make up 80% of today's residential solar market.) Including battery backup for solar PV systems can increase the cost of a grid-tied solar-energy system by about 25%, so this makes sense only where there are frequent utility outages or critical pieces of electrical equipment that must keep running.

There are two basic kinds of solar modules: those that are integrated into the roof, typically as part of a concrete-roof-tile system, and those that are mounted on brackets that stand off from the roof or the ground. Most bracket-mounted modules are about 3x5 feet, weigh about 3–5 pounds per square foot, and generate about 200 watts. Modules integrated into the roof tile tend to be about the size of the concrete roof tiles, or about 36x18 inches. Depending on their color (they can come in colors other than black), integral roof tiles can generate about 1,000 watts per 100 square feet. They weigh about 400 pounds per 100 square feet.



These integrated PowerLight SunTiles™ serve a dual purpose as roofing material and electricity generator. Tiles like these can produce around 1,000 watts per 100 square feet.

To determine how many modules you will need to create an array that will make a meaningful power contribution to a house, use the following approach. For retrofits, obtain a series of power bills and determine how many kilowatt hours (kWh) were consumed over the course of the year. (For new homes, area averages will provide this data, but be sure to calculate in high-load appliances.) Divide the kilowatt hour number by 365 to reveal the average daily consumption for the home. If the consumption is 15 kWh per day, divide that figure by the number of hours of sunshine received in your geographic area (see the calculator Web site below to determine regional sunshine hours), which can vary widely and be as low as two or three hours in northern climates or cloudy areas. If there are three sunshine hours in your region, then the solar-energy system has to generate 5 AC kW of power to provide 100% of your electrical consumption. If you have an integrated roof tile solar PV system that generates 1,000 watts for every 100 square feet, you will need 500 square feet of modules. (Visit [Redc.nrel.gov/solar/calculators/PVWATTS/versions/](http://Redc.nrel.gov/solar/calculators/PVWATTS/versions/) to perform your calculations using local data.)

Keep in mind that with a grid-tied system, you are not trying to replace grid power 24 hours a day—that's impossible without a sizable battery-backup PV system. You are designing a system to contribute energy to the home and lower monthly electrical bills, even though the system's output will spike and dip over the course of a day or season. Three other factors to consider: there will be line loss experienced by all electricity running through wires; there will be loss of power to the inverter; and there will be loss to the overall efficiency of the solar panel, which may vary from module to module and be affected by such factors as dirt on the face of the modules.



These solar PV roof tiles from Open Energy Corporation (here and below right) can be integrated into concrete roof tile systems. They come in a range of colors and are sturdy enough to endure snow load or someone walking on them once there are installed.

Once the modules are properly wired together, the power from the solar array is fed through an inverter, which converts DC to utility-grade AC power. The AC power is then fed to the house load center through a dedicated circuit breaker. (Your solar contractor should be familiar with the National Electrical Code (NEC) Article 690, which outlines required practices for solar photovoltaic installations.) Inverters for grid-tied systems without battery backup are designed to turn off when grid power goes down, to protect utility-line crews doing repair work. For systems with battery backup, inverters are made that automatically disconnect from the utility grid so solar panels can continue to supply your home's critical loads with an independent source of power in the event of a blackout.



Open Energy Corporation



### PRICING A SOLAR-ENERGY SYSTEM

Most new solar PV systems are connected to the electric utility grid, and they hold the promise of lowering dependence on power from public utilities, which generate a great deal of power with coal. The federal government and many states offer incentives to install solar PV systems in the form of tax credits, so costs can be defrayed. That said, solar PV is expensive. For ballpark estimating, costs start at around \$18,000 for an average residence. Installed, for a PV system that makes a meaningful power contribution, or around \$9 to \$10 per watt for a 2-kilowatt (2-kW) grid-connected system, before incentives. (Seventy-five percent of a PV system is wrapped up in the cost of the modules.) Until system prices start to fall, it will take about 15 years, not counting financing costs, to pay back an \$18,000 PV system. If your home buyers have an average electric bill of \$100/month. The environmental contribution of solar PV is beyond dispute, however, because it's no secret that the power contributed by solar PV is much cleaner than what would otherwise be consumed; power generated largely from coal. Indeed, a 2-kW system on the house in Denver, in the case study cited at the beginning of this article, will eliminate 3,642 pounds of CO<sub>2</sub> emissions in the first year.



Once the modules are properly installed and wired together, the power from the solar array is fed through an inverter, which converts DC to utility-grade AC power.

## — Finding a Solar Contractor

Denver contractor Scott Dittman hired Boulder-based Namaste Solar to design and install his first solar PV system because the company's name kept coming up when he asked around for the best solar PV installers. When he contacted them, they were responsive and seemed to have a solid business. To design and install the solar thermal system on his Parade of Homes house, Dittman chose Industrial Solar Technology Corporation in Golden, Colorado. The company had been in business for over 20 years, so it seemed reasonable that they would be around to do maintenance or repairs if they were ever needed.

When Jeff and Bronwen Martin went looking for a solar contractor, their job was pretty easy: there was only one solar installer in the area. As solar moves into the mainstream, roofers, electricians, and plumbers will probably begin installing solar equipment. At the moment, however, you're probably better off finding a solar specialist.

If asking around doesn't turn up a solar contractor with a good reputation, local government agencies and community organizations which promote solar might be able to steer you to established solar companies. Members of local chapters of the Solar Energy Industries Association (SEIA) are good prospects. But also look for certification from industry groups as indicators of installers' commitment to their profession. The North American Board of Certified Energy Practitioners (NABCEP), for example, certifies PV installers and will begin certifying solar thermal installers in late 2006. Installers should offer a warranty on their installation, usually five years, and they should be able to explain the warranties on the components to you. Expect 20- to 25-year warranties on PV modules, 5- to 10-year warranties on inverters, 5- to 20-year warranties on solar thermal collectors, as well as 90-day to 5-year warranties on the other components of a solar thermal system.

"What you're looking for is a good, reliable businessperson, rather than just raw enthusiasm," says Leigh Seddon, president of Solar Works Inc., a 25-year-old solar company based in Montpelier, Vermont. "Get assurances from the installer that their work won't affect your building schedule and that the installer can interface seamlessly with the plumber and the electrician."

Seddon suggests that the general contractor have a kickoff meeting to explain the solar-energy system, especially if the other tradespeople involved are unfamiliar with the technologies.

## Lead Time and Rough-In

Success has brought challenges to the solar-panel industry. Shortages of silicon—a raw material in solar PV cells—and huge global demand have increased PV module prices and lengthened lead times. Solar Works' Seddon says that module prices have increased by 20% since last year, and lead times for modules that might have been four to six weeks last year can now stretch to six months. So, plan ahead.

## RESOURCES

- AMERICAN SOLAR ENERGY SOCIETY (ASES) [Aies.org](http://Aies.org)
- DATABASE OF STATE INCENTIVES FOR RENEWABLE ENERGY (DSIRE): Database of renewable energy and energy efficiency incentives [www.dsireusa.org](http://www.dsireusa.org)
- FIND SOLAR: A database of solar installers [Findsolar.com](http://Findsolar.com)
- THE NORTH AMERICAN BOARD OF CERTIFIED ENERGY PRACTITIONERS (NABCEP): A source for certified PV installers (and solar thermal installers starting late 2006) [Nabcep.org](http://Nabcep.org)
- SOLAR ENERGY INDUSTRIES ASSOCIATION (SEIA) [Seia.org](http://Seia.org)
- SOLAR ENERGY INTERNATIONAL (SEI): Solar training in 17 locations as well as online courses [Solarenergy.org](http://Solarenergy.org)
- SOLAR RATING AND CERTIFICATION CORPORATION (SRCC): Independent solar thermal collector and system certifier [Solar-rating.org](http://Solar-rating.org)
- SOLAR TODAY MAGAZINE [Solutoday.org](http://Solutoday.org)

## SOURCE OF SUPPLY

- BP SOLAR [Bp.com](http://Bp.com)
- GE [Gepower.com](http://Gepower.com)
- KYOCERA [Kyocerasolar.com](http://Kyocerasolar.com)
- OPEN ENERGY CORPORATION [Openenergycorp.com](http://Openenergycorp.com)
- SANYO [Sanyo.com](http://Sanyo.com)
- SCHOTT [Us.schott.com/solar](http://Us.schott.com/solar)
- SHELL SOLAR [Shell.com/solar](http://Shell.com/solar)
- SHARP SOLAR [Solar.sharpsusa.com](http://Solar.sharpsusa.com)
- UNI-SOLAR [Uni-solar.com](http://Uni-solar.com)




Sharp Solar

If you have a client who is interested in a solar PV or hot-water system, but is not quite ready to pull the trigger, consider making your next house "solar-ready" with the proper rough-ins.

"We recommend steps that make the house PV-ready," says Blake Jones, president of Namaste Solar. "We keep vents off the south roof, leave extra space in the breaker panel, and run a conduit or chase from the south roof to the outdoor meter. These steps can make a future installation smoother and less expensive."

The same is true for solar thermal systems. Your customers will thank you if the plumbing is already roughed in when they decide to install a solar-energy system in a year or two.

 Maureen McIntyre is a freelance writer and editor based in Boulder, Colorado, and a contributing editor to Green Builder Magazine.