the business of selling electricity were the only ones who could use their systems' electricity. Solar energy equipment could reduce their bills from grid-connected electric companies, but that was about it.

Now some areas are starting to use distributed power generation. Under such arrangements, private owners of solar energy equipment can let any solar-generated electricity flow through the grid system. If the private owners wind up sending more power through the electric grid than they use, they could get a credit or other reimbursement from the utility company.

Such arrangements make solar energy systems more attractive for homes and businesses. They also help utilities meet peak power demands. Nonetheless, only limited areas offer distributed power metering. As its availability expands in the United States, people will have more incentive to add solar energy capacity to their homes and businesses.

Pros and Cons

Most environmental advocates applaud solar power. For starters, solar energy is one of the cleanest energy alternatives. As they produce electricity, solar energy facilities do not emit pollutants or greenhouse gases. (However, some energy and resources still go into manufacturing and installing the equipment.)

Solar energy is inherently renewable, since each day brings more sunlight. The flip side, of course, is that solar energy facilities stop generating energy at night. Unless scientists and engineers develop reliable ways to capture and store excess electric power on a large enough scale, most users will need some backup power for nighttime use. Advanced battery designs could potentially provide a way to store energy collected during the daylight hours.

Some solar concentrating thermal plants could also deal with the nighttime issue by using heat energy stored earlier in the day. Although the Sun will have set, the oil, molten salts, or other fluid that absorbs heat from the solar concentrators will stay hot, especially if the material is insulated well. If it were still hot enough, that heat energy might produce electricity at night.

Facilities could also switch over to natural gas for running generators at night. Burning natural gas does emit some carbon dioxide and other pollutants. However, the quantities will be lower than they would be if coal or oil powered the plant, or if a plant ran on natural gas alone.

Seasonal variations also play a role. During winter, for example, parts of Alaska and northern Europe get fewer than six hours of sunlight each day. Nevertheless, the times when solar generating facilities produce the most electricity coincide with the highest demands for electric power. During summer, for example, afternoon sunlight hours correspond roughly to times when air-conditioning needs are greatest. Even the long daylight periods in Alaska match up with increased power demands at the height of the state's tourist season. Thus, solar power's variability makes it well suited for generating electricity during times of peak demand.

Of course, the Sun does not strike the earth with the same intensity in all places. A square meter of PV cells in Phoenix, Arizona, might generate up to 7 kilowatt-hours of electricity per day. Those same PV cells would produce roughly half that much electricity in New York City. In Moscow, Russia, they would produce only 2 kilowatt-hours per day. Therefore, in areas with less intense sunlight, solar energy facilities will generally be less efficient. It will take longer for solar-generated electricity in those areas to pay back investments in equipment.

On the other hand, solar energy can provide electricity where conventional sources have not. Approximately 1.6 billion people—roughly one-fourth of the world's population—have no access to plug-in electric power. In particular, large areas of developing countries lack the infrastructure necessary to deliver electricity from central power plants. Yet even areas far from any grid can use solar technologies to meet some of their energy needs. Thus, geography presents both benefits and disadvantages.

Area requirements for solar energy also spark debate. Solar concentrators, PV cells, and other equipment need space to collect the sun's energy. Supporters say that even a small amount of the sunlight striking our planet has the potential to generate huge amounts of electric power. As former vice president Al Gore told the Senate Foreign Relations Committee:

> [I]f we took an area of the Southwestern desert 100 miles on a side, that would be enough, in and of itself, to provide 100 percent of all the electricity needs for the United States of America in a full year.

Information from the Department of Energy supports Gore's estimate. Nonetheless, 10,000 square miles is more than the total combined land area of Rhode Island, Delaware, and Connecticut. The states of New Jersey, Vermont, Massachusetts, New Hampshire, Maryland, and Hawaii each have less than 10,000 square miles of land area too.

On the other hand, 10,000 square miles is less than 3 percent of the United States' total land area of approximately 3.5 million square miles. The country need not devote an entire 10,000 square miles to solar energy, in any case. No one type of energy is likely to supply all of the United States' electricity any time in the foreseeable future. Not even the U.S. PV industry has proposed meeting 100 percent of the country's energy needs with solar power!

Improvements in efficiency can also reduce the land area needed to generate electricity from solar energy. So far, most PV cells have converted barely one-fourth of the Sun's energy striking them into electricity. Now researchers are exploring ways to push that figure above 40 percent.

Solar panels are increasingly popular in different parts of the world.

"This technology has the potential to change the way electricity is generated throughout the world," said University of Delaware researcher Allen Barnett. In 2007 he and other researchers announced an innovative PV cell design with an energy conversion efficiency of 42.8 percent. Research projects are seeking to improve solar concentrating thermal facilities too.

Another idea for dealing with the land-area issue comes from Cool Earth Solar. This California company has suggested floating thousands of balloons with solar concentrators and PV cells inside. The company claims its concept can "reshape solar energy" by making large-scale solar energy generation practical.

Rooftop installations are a more down-to-earth example of how to deal with the area issue. Businesses and homes can install equipment on their rooftops to capture the sun. Meanwhile, people can still live and work in the buildings below. The same land area thus serves multiple purposes.

The "Bottom Line"

Sure, sunlight is free. Until recently, though, the price for solar-generated electricity has been much higher than for electricity that is generated by other means. At times, electricity from PV cells has cost more than four times that of electricity from coal-fired power plants. Compared to wind power, the price has been roughly twice as high.

The high cost of PV cells has been one reason for the high cost of solar-generated power. According to the Department of Energy, PV cell modules cost about $50 per peak watt in 1980. (A peak watt or watt peak is a measure of how much electric power a unit can produce.) By 2008 comparable costs had dropped as low as $3.

As technology advances have lowered costs for PV cells, users' bottom-line electricity prices have fallen. Advances in technology for collecting solar thermal generators will likely reduce users' prices for that electricity as well, even though that technology has its own equipment costs.

Until now, users have also had to pay almost all the costs for solar energy equipment up front. The longer users could spread out those costs over time, the lower the cost per kilowatt-hour would be. Due to perception and, in some cases, accounting considerations, most people try to spread their costs over shorter periods.

Nonetheless, solar energy prices are becoming more competitive. By 2008, the Department of Energy reported, bottom-line costs for producing PV solar energy fell to between 15 and 25 cents per kilowatt-hour. In some areas tax breaks or other government incentives have brought the figure down to 11 cents or less.

Anticipated caps on carbon emissions and other government actions will likely make coal-generated electricity less attractive in the future. Then solar energy will become more competitive in price.

Renewable Portfolio Standards and Alternative Energy Portfolio Standards should increase solar generating capacity. These are state laws or rules that require a certain amount of energy sold to come from renewable or alternative energy sources. As of 2009, all but fourteen states had adopted such standards or goals for alternative energy. The state requirements or goals give utilities an incentive to add solar energy to their portfolios—either through their own generating capacity or through distributed power options.