TIME IS RIGHT FOR SOLAR PANELS

Cut your home electric blls!

The sun floods the earth with energy. Solar panels generate electricity that is free of emissions that harm our atmosphere and costs nothing.
Now is the time for home owners to install solar power panels and to take advantage of the federal and state incentives while they last. This is true particularly in states such as California, Connecticut, New York, New Jersey, where current domestic electric power rates are in excess of 12c/kwh and rising.
Most home owners are confused by the flood of information currently directed at them by advertising and the media. Hopefully the following will help explain the issues, particularly the economics.

Solar photovoltaic cells (in short PV) are semiconductors, typically silicon doped with other elements that, when illuminated with light, provide electric power. All of us are familiar with calculators that require no batteries, powered by a small photo cell in a window.
The photovoltaic principle was discovered in 1954 in Bell Laboratories as a byproduct of the development of transistors. The first practical solar cells were developed in Exxon's Solar Power Corporation laboratories in 1973, in Linden, NJ. Individual PVs are combined into panels to provide the required voltage and power capability.

Solar panels for generating electricity have been around for over 40 years. Since the late 1970s, the US Coast Guard has installed solar panels on all navigation aids, in which they work under extreme weather conditions. In remote locations, such as the Caribbean islands and vacation cabins in state forests, solar panels combined with batteries have been used for lighting and air-conditioning power since the 1980s. In all these instances the solar panels have DC output and charge batteries during the day, which continue to provide power at night. However the cost was high and it was not economically feasable to use them in locations where low cost electric grid power was available.

Since the 1980s solar cell technology has improved rapidly, particularly in the last ten years. The increase in manufacturing capacity of silicon photovoltaic cells has very significantly reduced costs and the price of individual mono-crystalline silicon cells has now reached about $1.1 per watt of peak power, one tenth of the cost as recently as in the year 2000. At the same time the efficiency, cost and reliability of inverters, needed to provide the AC required to run home appliances, has dramatically improved. In addition, federal and state incentives have made the use of solar panels in individual homes and commercial establishments economically very attractive. However these incentives will soon be phased out.

Worldwide Germany is the leader in solar panel installations in spite of not having year round sunshine, followed by Japan. In the United States currently California has the largest number of solar installations, followed by New Jersey. With the exception of Seattle, the entire continental U.S. is much sunnier than Germany. Yet Germany had 17 times the installed solar base per capita in 2010! Fortunately the incentives recently provided by the federal and state governments have lead to a rapid expansion of solar power installations in the United States. It is reported that the number of solar panel istallations in the USA increased by 69% in the first half of 2011.

How does it work?

Light shining on the PV causes a voltage difference between the two terminals. The brighter the light the higher the voltage. If the two terminals are conected to a load an electric current flows. In a typical solar power panel a number of PV cells are connected together, typically 60 or 72. and mounted in an aluminum frame under a cover of tempered non-reflective glass, that is glass similar to the windshield in your car. The typical nameplate rating of a panel is 30 Volts, 8 Amperes, 240 Watts, all DC values. These are the

maximum values possible with brilliant sunlight perpendicular to the panel.
Be aware of the fact that most manufacturers quote the max DC output of their panels, typically 240 watts.

To provide usable electric power, the DC must be converted to AC. It was common for all the panels to be connected in series, then to a central inverter. Now it has become preferred for each separate panel to have its own micro-inverter and controller. Thus if any single panel or inverter develops a fault, the entire system is not shut down. It also makes it easy to modify or add to the system in the future.
The AC rating for the above example, with micro-inverter, is 215 Watts, 240 Volts, 0.89 Amperes; all AC values.

Several panels are attached to rails mounted on the roof. The electrical outputs are connected at junction boxes to a cable which runs to the electrical terminal box of your home. From there the power is fed directly to your lights and appliances.
If the power available from your solar panels is insufficient, the balance is drawn from the power company grid through your meter. You are billed only for the extra power.
If however, the power output from the solar panels is greater than currently needed by your home circuits, the balance is fed to the power grid causing your electric meter to run backwards, automatically providing a credit for the power you will draw from the grid at night.
The smallest desirable installation is 15 panels, typically arranged in 3 rows of 5 panels each, which requires about 275 sq.feet (25.5m²) of clear unshaded space on the roof. You should not consider anything smaller, its output of about 3.15kw is adequate to run a modern 4 ton central air conditioner

Detail of roof top solar panel installation showing mounting rails and electrical cabling
Courtesy of Corbin Solar Solutions LLC- http://corbinsolar.com

How much power is generated?

For over 50 years NOAA has been collecting solar data together with other climate information at weather stations throughout the USA. In other countries the information has been collected by the appropriate agencies. Therefore it is possible to make reliable estimates of the quantities of solar energy available at any time of the year, for any location.
A selection of the information collected over a 30 year period for several north American locations is shown in the following table. The solar insolation is measured in **kwh/m²/day** for a flat panel inclined at an angle equal to the latitude and facing directly south. The annual average is shown for the 30 years period, as well as the averages for a winter and a summer month. The max and min are the worst and best in the 30 year period. The worst will be for a month with exceptional rain or cloudiness, the best for exceptionally clear, sunny weather.

	Annual	Jan	July
ATLANTA 33.65°N			
ave.	5.1	3.8	5.7
min.	4.8	2.9	4.9
max.	5.4	4.9	6.2
BOSTON 42.37°N			
ave.	4.6	3.4	5.7
min.	4.2	2.5	4.8
max.	4.9	4.3	6.1
CHICAGO 41.78°N			
ave.	4.4	3.1	5.6
min.	4.1	2.1	5.0
max.	4.8	3.5	6.2
DENVER 40.02°N			
ave.	5.5	4.4	6.1

min.	5.0	3.6	5.2
max.	5.8	5.1	6.8
KEY WEST 24.55°N			
ave.	5.5	4.9	5.6
min.	5.2	3.8	5.1
max.	5.8	5.6	5.9
LOS ANGELES 33.93°N			
ave.	5.6	4.4	6.6
min.	5.3	3.3	5.9
max.	5.9	5.4	7.3
NEWARK, NJ/NEW YORK 40.70°N/40.78°N			
ave.	4.5	3.3	5.4
min.	4.2	2.6	4.9
max.	4.7	4.1	6.2
SEATTLE 47.45°N			
ave.	3.7	1.6	5.7
min.	3.4	1.1	4.8
max.	4.1	2.5	6.3
TUCSON, AZ 32.12°N			
ave.	6.5	5.4	6.4
min.	6.1	4.1	6.0
max.	6.7	6.4	6.9

To translate this data into practical numbers, assume a typical 3 kw installation, as described above, installed at an inclination of 41° facing directly south, close to Newark, NJ.
The installation consists of 15 panels. Each panel has a net area of 1.25m² for a total of 18.8m².
The total conversion efficiency is 15% for high quality modern panels. Then we get the following results:

Ave annual	12.7 kwh/day	Total :4,635kwh/year	min 11.8 kwh/day;	max 13.2 kwh/day
Ave January	9.3 kwh/day	Total:288kwh/Jan	min 7.3 kwh/day;	max 11.5 kwh/day
Ave July	15.2 kwh/day	Total:471kwh/July	min 13.8 kwh/day;	max 17.4 kwh/day

For other locations, multiply these numbers by the ratio of the output at the new location to that of Newark in the first table.
For larger installations, multiply the above results by the ratio of the new number of panels to 15.
For example, for an installation of 30 panels (6kw) muliply the above results by (30÷15)=2.0.

The ideal angle of inclination is equal to the latitude of the location. Small deviations are not significant. If the solar panels are installed at an angle 15° greater (for example 55° instead of 40° in New Jersey), the power generated in winter will be 9% more, in summer 10% less, or a 5% reduction over the whole year. If the angle is 15° less (25° instead of 40°). in winter the output power will reduced by 10% , in summer increased by 5%, for an overall average annual reduction of 4%.
The highest power output is obtained when the panels face directly south (Azimuth=180°). If they face more easterly, more power will be generated in the morning, less in the afternoon, The same is true if they face more to the west, more power will be generated in the afternoon, less in the morning.

- for Azimuth 180±25° the reduction in ave annual ouput power is less than 5%;
- for Azimuth 135° or 225° (SE or SW) the reduction is 17%;
- for Azimuth 90° or 270°, that is facing East or West, the reduction in output power is 26%.

Costs

For northern New Jersey, with current power cost of 16.7c/kwh, the reduced electric bill translates into an

average saving of $2.12 per day or $774 per year. In addition, in New Jersey, at this rate the consumer would receive 4.5 SRECs* worth at least $1,200 at the current rate (Dec 2011). however the value of SRECs will decline in the future.
At $5/W, the installed cost of a 3kW system is about $15,000. Currently there is a Federal home owners' solar tax credit of 30% of the net cost (after any other local incentive rebates), in this case $4,500.

Thus the net cost of the installed system in this example is $10,500. Therefore the system cost will be amortized in less than 6 years, considering the savings in electricity bills and the income from SRECs*.

However there are at present many companies offering leasing systems with no up-front capital cost. The annual leasing cost is usually less than the savings generated, so that the home owner will still see net savings in electricity bills. At the end of the lease period, the home owner owns the system outright. From that moment the panels will be generating free electricity.
Reputable solar panel producers guarantee their panels for 25 years. The output of high quality mono-crystalline silicon solar panels decreases to about 90% of peak power after 10 years, 80% after 25 years. After 25 years, a good quality 3kw. solar panel installation should still be providing about 2.4 kw of peak AC power.

Roof integrity

Home owners are also concerned about the effect of solar panels on the integrity of the roof. It is essential not to skimp on costs and to employ a certified contractor who specializes in solar panel installations on roofs.
The installation must be capable of withstanding high winds, snow and heavy rain. The electrical connections must also withstand the same conditions. The actual panels are supported on rails which maintain about 4 inches (10 cm) of space between them and the roof, spacing required for proper ventilation and cooling of the panels. The rails are bolted to the roof trusses with seals to prevent water ingress.

Recently a research team at UC San Diego Jacobs School of Engineering, discovered that the amount of money saved on heating and cooling costs could add up to a 5% savings on the total cost of the solar panels if factored in as energy saved. The panels shield the roof from direct sun light in the day and from radiation into space at night. In addition the flow of air in the space between the panels and the roof top also provides a cooling effect.
The protection from the elements provided by the solar panels also prolongs the life of composite roof tiles.
A recent study in California indicates that homes with solar panels sell faster and at 3 to 4% higher prices than comparable homes without.

Conclusion


Solar panels on power poles, New Jersey
Photo B.C.Biega

You may wonder why the electric power company is promoting home solar installations which will reduce their billing income. The reason is that all power companies are suffering from severe system overloads from air conditioning during hot summer weather. Providing additional power capacity close to the load provides relief for the distribution facilities which are already suffering from high temperatures.
For example, the New Jersey power company PSE&G installed 11 million 220 watt solar panels on existing poles along the streets in their area between 2009 and 2011. The units on a specific street feed directly into a/c units on that street, relieving pressure on the distribution system, as well as reducing the need to run expensive fossil fuel peak-power generating plants.

What about the future? Developments in solar panel technology are continuing. You may be confused by much of the terminology used in advertising and the media. New developments are in polycrystalline silicon and thin film solar panels. Both are potentially lower cost materials but are less efficient, therefore require much larger floor space than monocrystalline silicon cells for the same output power. They are

currently being used in large solar power farms, on roofs of large commercial buildings, in open fields, in deserts.
Solar roof tiles are also being developed, but it is not known how successful they will be, or what will be their longevity and efficiency.
Note: It is more efficient to heat hot water, for example for swimming pools, in direct solar water heaters.

Do not wait for lower cost future solar cell developments. Already now, hardware and construction labor costs account for more than 50% of the total cost of a roof-top installation. Present incentives cover almost 50% of the cost, but they will be phased out within the next couple of years.
DO NOT WAIT!

*** Definitions and units**.

- SREC = Solar Renewable Energy Credit. Certificates, issued for 1,000kwh generated. are traded on the open market.
- DC - Direct current, electricity provided by a battery, the current flows from the positive terminal to the negative terminal. Incandescent light bulbs will work on AC or DC.
- AC - Alternating current, the direction of current flow changes 60 times a second in north America, 50 times a second in most other countries. All motors and domestic appliances require AC.
- Watt - unit of power. 1 watt=1 volt x 1 ampere. kw = 1000 watts, Mw = 1000kw.
- kwh - unit of energy = 1kw of power provided during 1 hour. You pay for electricity by the kwh measured on your power meter.
- Solar cell efficiency = ratio of output DC power to solar insolation, ranges from 14% to 17% in modern monocrystalline silicon cells.
- Converson efficiency = ratio of output AC power to solar insolation = (solar cell efficiency)x(inverter efficiency), typically about 15% in present highest quality solar panels.

Reference: The insolation data is extracted from http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/redbook/sum2/14734.txt

This article is extracted from http://biega.com/solar.shtml, in which there are links to other references.