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Assess Your Climate for Solar Power Use

By Rik DeGunther

1 of 7 in Series: The Essentials of Planning Your Solar Power System

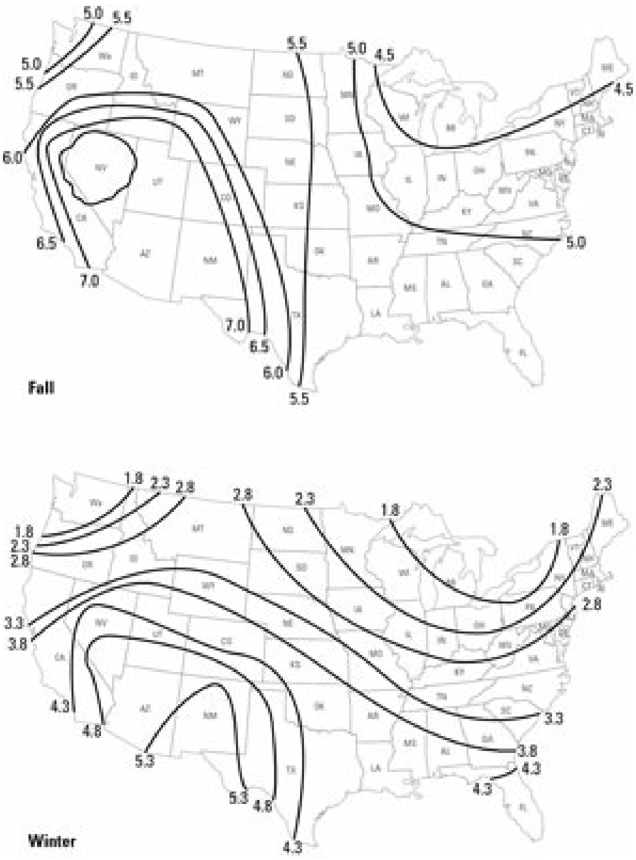
Good solar designers assess climate particulars to enhance system performance. Climate includes elements such as temperature, precipitation, and wind speed, among other things. When determining whether solar power is right for you, take a look at the following in your climate:

- **Sunlight:** Climate dictates how much sunlight you can expect annually. The Southwest gets the most sunshine per day in North America, and Canada and the northern states get the least. The sun is higher in the sky in the southern states, so the days are longer. The figures at the end of this article outline the average number of hours of sunlight that different regions of the United States get throughout the year.
- **Snowfall:** You want to locate your panels so they avoid being inundated with heavy layers of snow. For example, some locations on your roof will experience very shallow snow buildups compared with other parts of your roof.
- **Cloud cover:** Ultimately, cloudy regions provide less sunshine, making solar systems harder to justify. But that doesn't necessarily mean that solar is uneconomical, so if you live with a lot of clouds, don't despair.
- **Smog:** Air pollution and smog affect the amount of sunlight you can expect to receive. If you live in an area with heavy air pollution, expect less system output over an extended period of time.
- **Air density:** You get better solar exposure in the mountains than near sea level simply because the air is thinner and scatters less sunlight. You can make an approximate estimate of how clear your air is by simply observing how blue the sky is on a clear day. Thick air scatters more red light, and so the appearance of the sky is less blue and more white.
- **Temperature:** With PV systems, the lower the temperature, the happier the semiconductors, and the greater the output. You can get more system output on a cold, clear day than a sunny day.
- **Rainfall:** Wet, humid environments tend to cause corrosion in metals. Electrical connections are particularly susceptible, and they either fail entirely or their integrity is compromised, resulting in poor system performance. It's very important to seal equipment junctions properly.
- **Frequent fog:** If you're living in an area that's foggy and misty in the morning, orient your solar panels more westward to optimize the amount of sunlight you can achieve over the course of a day. Fog also causes a lot of moisture-related

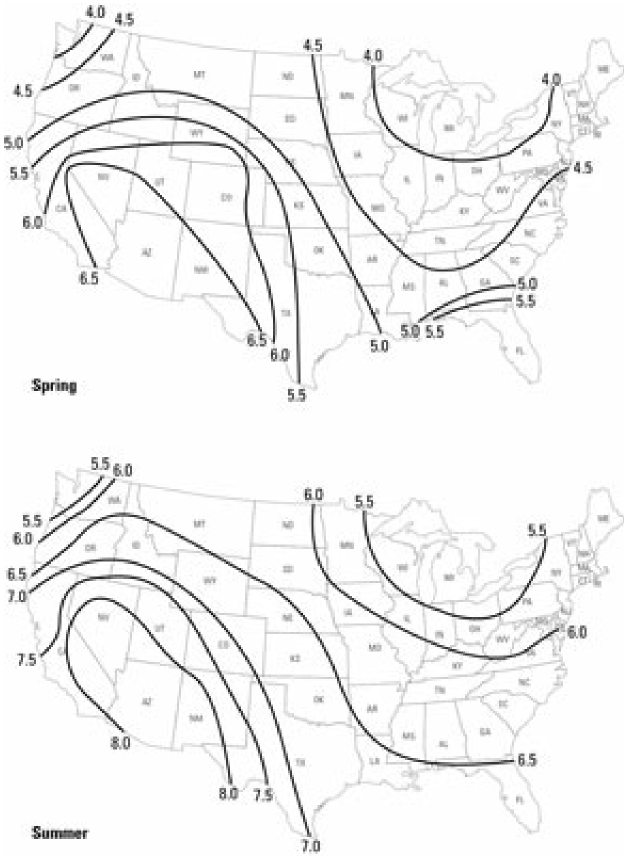
problems, such as corrosion.

- **Wind:** If you have a lot of wind, you need to consider where you mount your solar equipment for a couple of reasons:
  - Wind can tear equipment off of its mounting hardware and result in expensive repairs, not to mention dangerous conditions. Mounting schemes all have wind speed specifications.
  - Wind cools surfaces very efficiently. Solar water heating panels may heat the water very effectively, but it doesn't make much sense to install expensive solar panels without addressing wind cooling first.

Part of assessing climate is what you want your solar system to do for you. If you have a cabin in northern Minnesota, you probably won't be there much in the wintertime. And then you'll heat it using renewable wood. In the summer, you don't need to cool, and all you want to do is obtain some nighttime lighting and run a small, efficient refrigerator. In this case, a modest, off-grid photovoltaic system with a battery backup can do the job.



Hours of sunshine in the United States in the fall and winter.



Hours of sunshine in the United States in the spring and summer.

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Evaluating Solar Power Options: Plotting Your Sun Chart

By Rik DeGunther

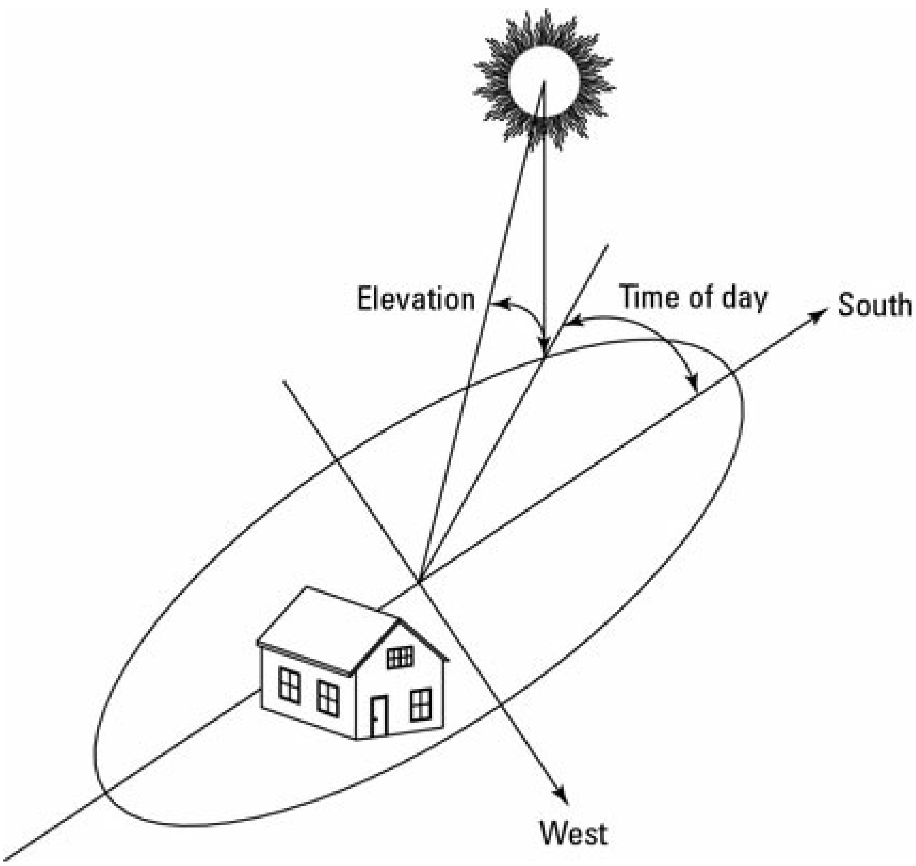
2 of 7 in Series: The Essentials of Planning Your Solar Power System

Plotting a sun chart tells you how much direct sunlight you can expect over the course of a day so you can determine whether solar power is a viable option where you live. Sun charts are easy to plot and provide a way to represent the movement of the sun across the sky. Here's how to create your own sun charts and how to use them to evaluate the amount of sunshine you can expect to receive at your home.

Chart the basic path of the sun

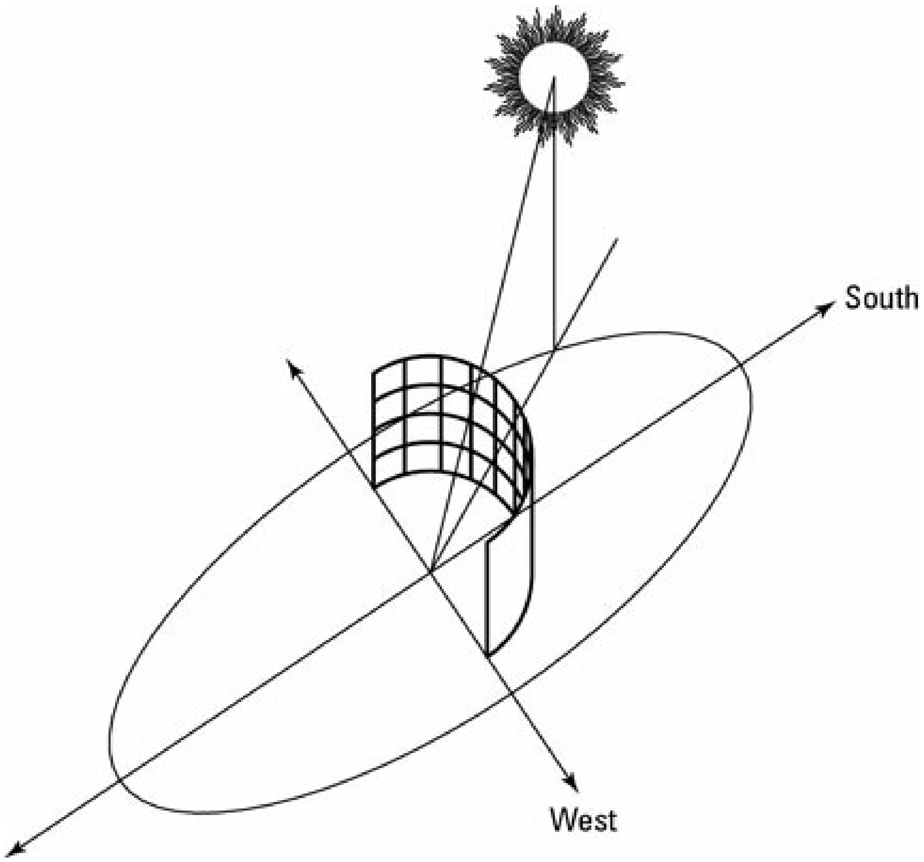
The position of the sun may be plotted with two angles: azimuth and elevation.

- **Azimuth** is the sun's angular distance from a fixed line; in the northern hemisphere, that fixed line will probably run directly south. Theoretically, at noon, when the sun is directly overhead, the azimuth angle is 0.
- **Elevation** is the angle created by a line parallel to the ground and a line going from the ground to the sun. If the sun is directly overhead, its elevation measurement is 90 degrees; when it sits on the horizon, the elevation is 0.



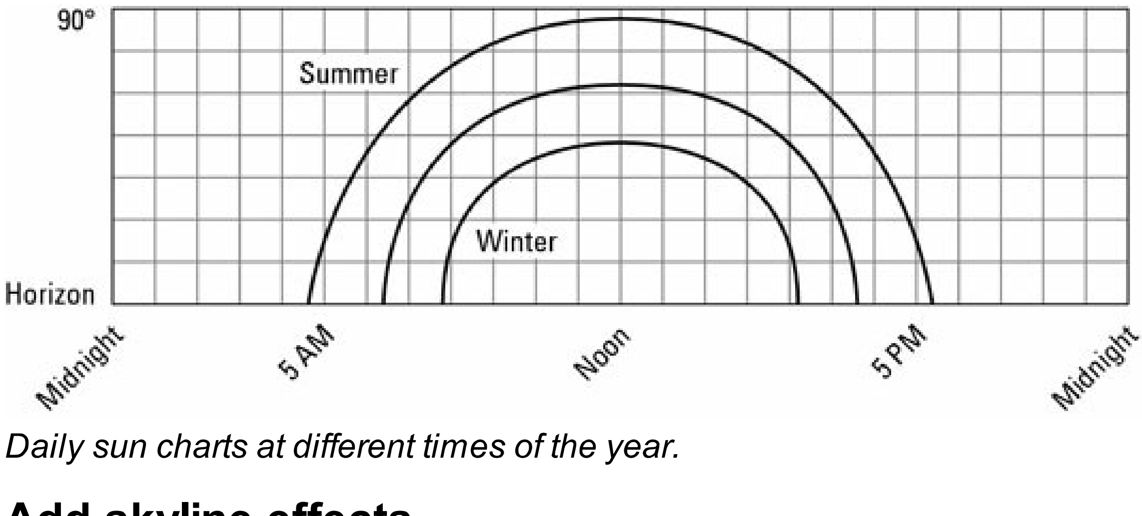
Plot the location of the sun in the sky.

Then create a graph of the sun's passage over the course of a day. Imagine a sheet of graph paper wrapped around your house. As the day progresses, you make dots where the suns shines on the graph paper.



Making a sun chart.

The following figure shows your sun chart looks like if you plot the movement of the sun. The arc in the middle represents either spring or fall. All other paths lie somewhere between the two extremes, represented by summer and winter solstice, which are the longest and shortest days of the year (June 21 and December 21, respectively).

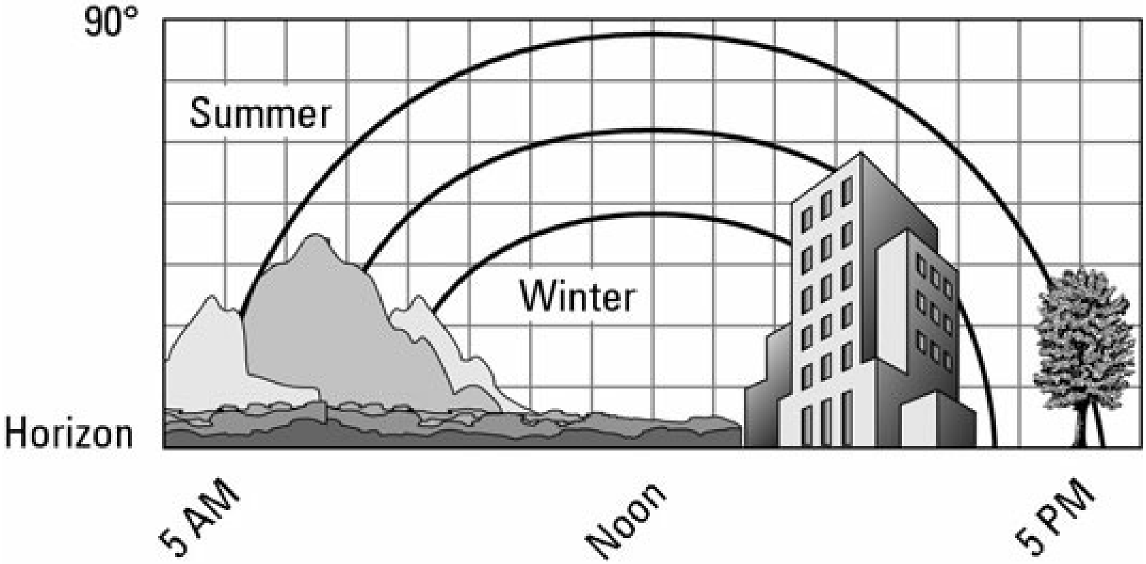


Daily sun charts at different times of the year.

Add skyline effects

You can easily add a skyline impediments, which include horizon, buildings, trees, towers, and so on to your sun charts.

When the sun goes behind a mountain or a tall building, you don't get any direct sunlight at all. If the sun goes behind a tree, you may get some direct sunlight, but mostly you get shading. Impediments on the horizon also change the time of dawn and dusk. If a big mountain lies directly west of your house, dusk falls a lot earlier.



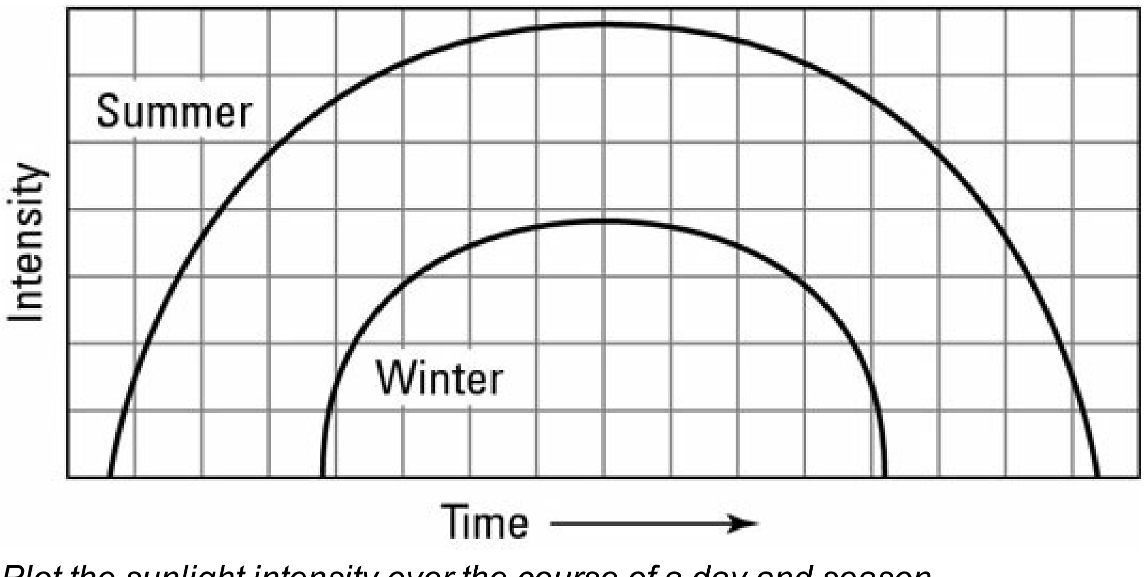
Add skylines to a sun chart.

You can either buy (very expensive, and you only need it once) or rent ($25 per week) a Solar Pathfinder, which works as follows: You stand at the site you want to measure, aim the device south (it has a compass), level it (it has a bubble level), and then read the shade reflections on a domed indicator.

Note sunlight intensity

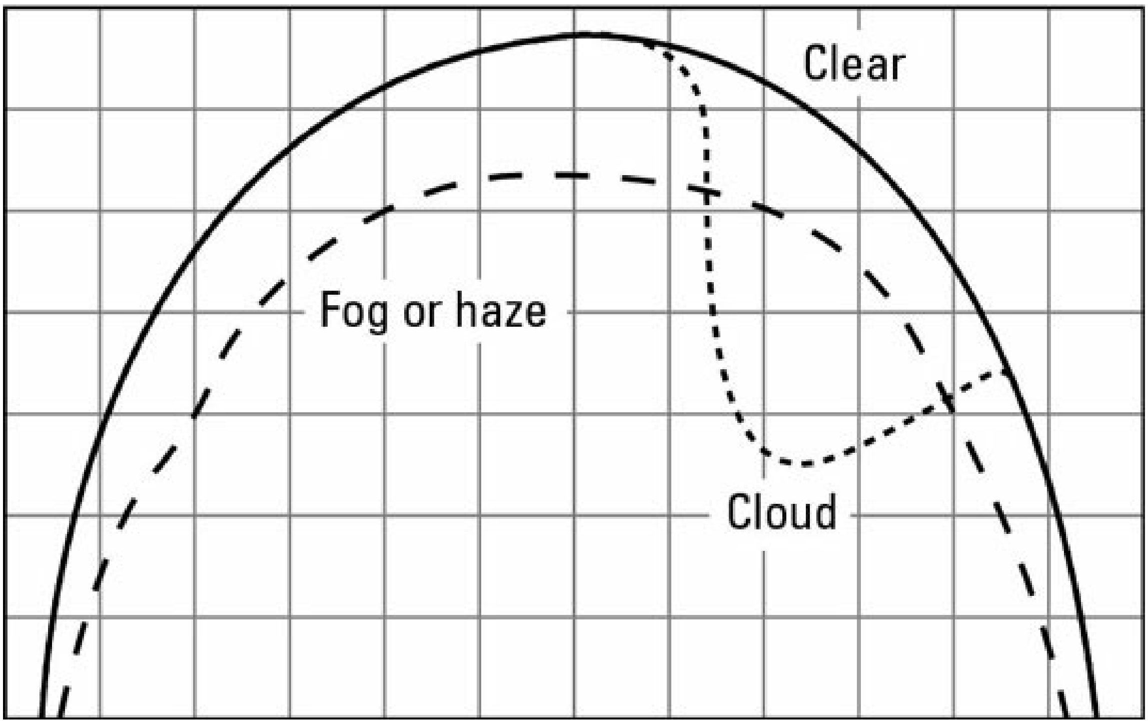
When the sun is lower in the sky, solar radiation must pass through more atmosphere, and it's therefore reduced by scattering and absorption.

The sun is the most intense when it's directly overhead. And summer sunlight is much stronger than winter.



Plot the sunlight intensity over the course of a day and season.

Sunlight likewise changes along with the weather. If your climate is often foggy or hazy in the morning, the charts show a very shallow curve on the left-hand side, and then when the fog burns off, the chart goes back up to normal.



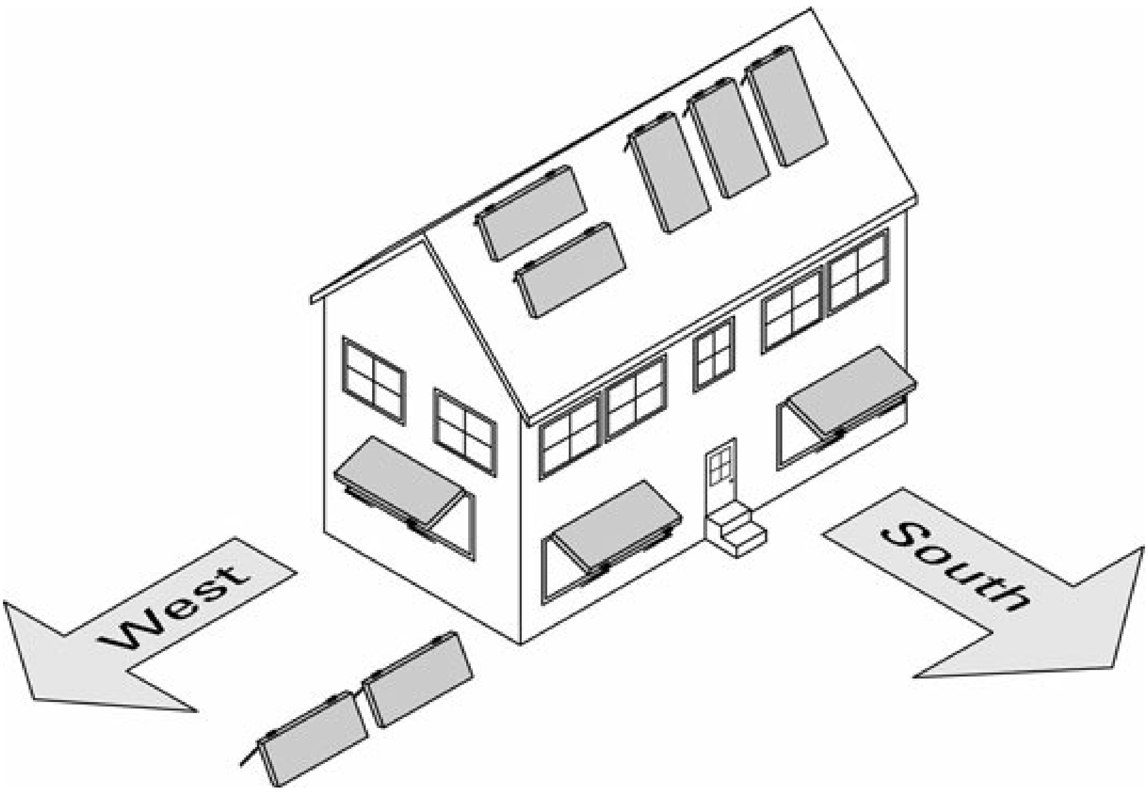
Sunlight intensity varies with weather conditions.

Deciding Where to Mount Your Solar Panels

By Rik DeGunther

3 of 7 in Series: The Essentials of Planning Your Solar Power System

After assessing your solar power needs and the amount of solar gain you can expect, you can turn your attention to mounting your solar collectors to gather as much sunlight as possible. You always have a number of choices for mounting, and the best choice depends not only on maximizing exposure over the course of a year, but also on cost and practicality. County codes require panels to withstand very high wind speeds, and conforming to this requirement can sometimes mean thousands of dollars in engineering and equipment. When all is said and done, simplicity reigns.



Standard collector mounting options around your house

In most cases, you may not have much choice. If your roof faces southwest and its pitch is 45 degrees, you'll end up mounting them on your roof, unless you want to get into some really odd-looking and expensive mounting racks. Appearance does matter, especially to the neighbors who will be looking at your solar ingenuity. When mounting racks are visible, the effect is "industrial." Do you want your home to look like a factory?

The best orientations (in the northern hemisphere) face due south. As for altitude, the best bet is to orient the panels to the altitude of the sun in the middle of the equinoxes, or around March 20 and September 20. This angle depends on your latitude.

Identifying true south is not as simple as using a compass. Due to imperfections in the composition of the earth, due south rarely matches the compass reading. Here's a simple way to find due south without relying on a compass or on complex "magnetic declination" formulas. Your local newspaper publishes the exact time of dawn and dusk. Calculate the middle of these times; it should be somewhere near noon, but rarely right at noon. Stick a pole in the ground, and at the exact middle time between dawn and dusk, the shadow from the pole lines up with due south.

Installing a Solar Power System for Your Home

By Rik DeGunther

4 of 7 in Series: The Essentials of Planning Your Solar Power System

Installing a solar system to power your home is an involved process. Even though you'll be hiring a professional, it helps to understand what's going on. Expect the entire process of installing a full-scale photovoltaic (PV) system to take 90 days or more.

The following list outlines all the things you need to do:

1. **Perform an energy audit.**

   Some states require an energy audit before you can buy a solar system or before you can collect any available rebates.

2. **Review the physical installation options.**

   How much roof space will a system take up? Do you have a suitable roof, facing approximately south? If not, you may have to ground mount, which is more expensive, plus visually questionable for the neighbors. What condition is your roof in? If you need a new roof, you should probably take care of that first because the roof job will be a lot more expensive if you have to have the PV panels removed (the roofers will certainly not do it) by a solar contractor and then replaced at the end of the job.

3. **Decide how much to invest and how to finance it.**

   During the course of your energy audit, you collect a lot of financial information regarding energy costs and how they accrue in your household. You must also collect cost and performance estimates for PV systems, including costs, lifetimes, expansion potentials, warranty, and so on.

4. **Locate contractors and go out for formal bids.**

   Talk to as many contractors as you can. Get them to come to your house and look at your situation in some detail.

5. **Choose the best contractor and write the contract.**

   At this point, you'll probably have to write a check for a down payment.

   It's illegal, in most locales, for a contractor to charge for work that has not yet been finished. You should not have to pay a contractor in advance, which means that progress payments should be well defined and should match the work that has been done (not the work that's going to be done).

6. **Wait for equipment to arrive (it's rarely stock), approvals for building permits, subsidies, tax breaks and so on.**

Expect this to take up to six weeks or more.

7. **Allow for installation and inspections by the county and utility company.**

   Installations typically take a couple of days (ground mounts take a week or more). The county inspectors will look at your system and certify it.

8. **Wait for the utility to put in a new meter and connect to the grid.**

   When everything is ready, the utility company installs a new power meter and officially hooks you up. Now you're in the power generating business. Woohoo!

9. **Get a tutorial on how to operate your system.**

   Your contractor needs to walk you through the entire system and explain the hazards and proper operation. You should be aware of potential problems and how to identify them.

10. **Submit any paperwork to utilities, states, and so on for final rebate payments.**

    Rebates aren't payable until the system is in place and working properly. If your contractor is receiving the rebate directly, you don't need to do anything. If you're receiving it, you want to get it as fast as you can.

11. **Change your household habits to optimize system payback.**

    If you're on a tiered rate structure, or a TOU rate structure, you probably need to change some of your consumption habits in order to capitalize. Talk to your contractor about the things you can do, and if the system is not producing the way it was projected, why that may be the case.

12. **Maintain and repair the system.**

    Unlike most other financial investments, PV system problems are entirely yours to solve. Even if you're under warranty, you have to call the contractor and notify him; he has no idea of knowing when your system is broken.

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Should You Hire a Contractor to Install Your Solar Power System?

By Rik DeGunther

5 of 7 in Series: The Essentials of Planning Your Solar Power System

You could install your own photovoltaic (PV) solar power system. Many self-installed systems work just fine, and the owners are happy with the results. On the other hand, there are a lot of reasons to use a contractor. A PV system has many complexities, some of them very subtle. Experience counts for a lot.

Before you go DIY, first consider all the items on this list:

- You may not be able to connect to the grid with a self-installed system. Before you do anything else, check with your utility company and your county building department.
- You may not be able to get insurance for your home with a self-installed system. Check with your insurance company.
- Getting permits and inspections will be your responsibility. Visit your county building department and ask about the range of requirements you'll be expected to meet.
- Some equipment manufacturers will simply not sell equipment to anybody but licensed contractors.
- When selecting equipment, it's imperative that you understand the installation manuals. If they're poorly written or confusing, don't use that piece of equipment.
- You may not be able to save much by installing yourself. Contractors buy large quantities of materials, and they get much better prices, which they can pass on to you. In addition, installations can require expensive tools.
- You can probably find a contractor who will work with you on an installation.
- You won't get a ten-year installation warranty if you go it alone.
- If you don't understand electricity, forget installing the system yourself. There are a lot of dangers with a PV system, and you need to understand exactly when and where these dangers can rear their ugly heads.

Some manufacturers offer complete kits for solar PV systems. If you're going to install yourself, there are some big advantages in using kits.

- The design has been worked out, and it's going to operate the way it's supposed to (given that you mount and connect the equipment properly).
- You'll get all the parts that you need and they'll work well together.

- When you design and install your own system, and it's not working up to par when you finish, the manufacturers of the individual components are often reluctant to honor warranties. When you use a kit, the warranty terms are spelled out precisely; basically the only requirement is that you install the system properly, which is easy enough to prove by a simple visit to the site.
- With most kits, a customer service number is provided so that when you run into problems an expert can help you through the mess. Terms vary, so understand what kind of support you'll get and whether you have to pay.
- The price of a kit is very attractive, compared with buying separate components from separate manufacturers.
- Assembly instructions are well written and concise (they better be, or they won't sell many kits). They take you through every step of the process and they spell out the dangers and potential problems.

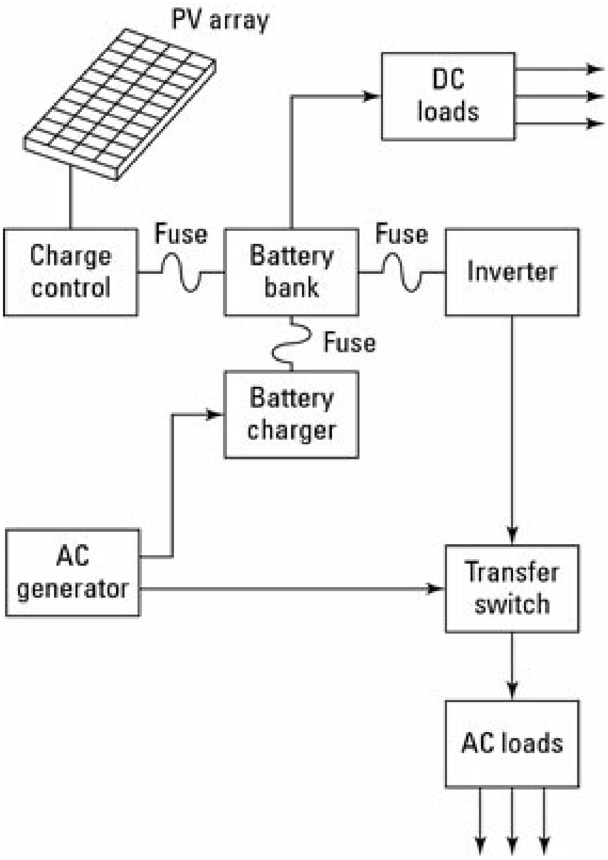
Of course, you still have to apply for your own permits and deal with inspectors on your own. Even if you're really good with electricity and tools and are capable of installing a kit system like a pro, that doesn't mean you're an expert at working through the permit process, which can sometimes take every bit as much time as installing the system itself. And it can be very frustrating, as most government bodies seem to be set up to serve the government bodies, not the "customers."

What You Need to Go Off the Grid

By Rik DeGunther

6 of 7 in Series: The Essentials of Planning Your Solar Power System

Off-grid solar PV systems are expensive, so find any means you can to reduce the energy requirements. Most off-grid houses use a wide range of energy resources, in sharp contrast to the typical all-electric suburban home. Solar hot water heaters are always good candidates because they're cheaper per kilowatt-hour than an off-grid photovoltaic system, and solar lighting systems are always wise. This variety can be an advantage in that you aren't completely disabled by power blackouts. In fact, you'll be completely impervious to power outages, and even if one of your resources goes down, the majority of your lifestyle will still be intact.



Off-grid solar electrical systems all use the same basic components, with other elements added according to need.

Here are the functions of each part:

- **Charge controller:** The charge controller feeds current into the battery bank at the required voltage. Good charge controllers draw the best performance out of the batteries and are very important for economics because they influence efficiency.
- **Battery bank:** The battery bank is typically made up of six or more individual

batteries connected with stout cables in either series or parallel arrangements.

- **Inverter:** The inverter changes DC to AC voltages suitable for use with household equipment. An inverter is optional if you use DC loads exclusively.
- **DC loads controller:** You may be using both DC (boat, RV, and auto appliances) and AC loads (standard household appliances). The DC loads controller maintains the proper currents and voltages into the DC loads.
- **AC generator:** As a backup power supply, the AC generator isn't strictly necessary but is usually part of any off-grid system in order to prevent blackouts when the sun is weak for extended periods.
- **Transfer switch:** The transfer switch alternates the power source between either the inverter output (when battery power is available) or the AC generator.
- **AC loads controller:** This device includes appropriate fuses and switching means and maintains the voltages and currents used by the AC appliances connected to the system.

Which type of current you choose depends on what you want to run. If it's just a few lights at night, with a coffee maker and a fan or two, DC is fine. However, the market for DC appliances is far smaller than 120VAC, so you may go for AC if you're using standard household appliances (which is the most common way to go and is cheaper and better because of the widespread availability of AC appliances compared to DC appliances).

DC, which is more efficient because batteries use direct current, is usually the choice for small cabins and small power systems. You can use DC appliances for RVs and boats, so envision your cabin like a big RV, and you get the picture. But DC also requires larger wire diameters, which can be very costly if you need to run lengths of more than 50 feet or so.

After you install a PV intertie system, you can completely ignore it for the most part. Keeping the solar panels clean is about the extent of your maintenance, and you don't really need to do that.

But when you install a system with batteries, you have to stay on top of things. The battery or battery pack is the core of any off-grid system, and it drives the system's cost. All action comes and goes from the battery, and much of the safety and control equipment is designed to protect either the battery or the balance of the system from the battery. You absolutely have to understand batteries, or you'll end up paying an arm and a leg for new ones all the time and you won't get decent performance out of the ones you have.

How Large Does Your Solar Power System Need to Be?

By Rik DeGunther

7 of 7 in Series: The Essentials of Planning Your Solar Power System

Switching to solar power can require a substantial outlay of money. At a minimum, you need to determine the following in order to get a good idea how much your standalone photovoltaic (PV) solar power system will cost:

- **The total watt-hours per day of energy you'll need:** Compile a list of all your appliances and devices and how many hours per day each will be run.
- **Define your peak instantaneous power output, measured in watts:** Determine which appliances you'll be running at the same time; add their power draws, in watts.
- **Figure out the duty cycle:** For example, a weekend cabin used for two days has a duty cycle of 2/7, or about 28 percent. A system used every day has a duty cycle of 100 percent.
- **Estimate how many hours of good sunlight a day you can expect:** Sunlight is difficult to estimate with much accuracy because it depends on the weather and on the time of year during which you're interested in using your system.

Here is an example of some of the calculations for an off-grid home in the mountains of Northern California. Here's what you need to keep in mind about this scenario:

- The duty cycle is 100 percent, and the house is used year-round.
- Worst-case expected sunlight per day is around four hours.
- A two-day power reserve is required because the backup generator is 20 years old and may or may not start, depending on its cantankerous mood.
- The system must output 120VAC.

And in case you're curious, here's how the owners are reducing their energy requirements:

- For heat, they use a wood-burning stove exclusively.
- Residents don't need electric-powered water heating because they use a solar water heater.
- Both the cooking stove and refrigerator work with bottled propane.
- The house is extremely efficient, with well-designed window overhangs, a sunroom on the southern front, and a modular design that enables the living area to be closed off from the rest of the house on the cruelest winter days.

- A solar attic vent fan is installed in the attic space, and a large solar-powered ceiling fan in the great room keeps the comfort level on the hottest summer days tolerable.

The following table shows the sample power load for the California cabin.

Energy Consumption in an Off-Grid Home

AC Device	Watts	Hours/Day	Watt-Hours/Day
Kitchen lights	120	6	720
Family room light	120	4	480
TV	70	3	210
Coffee pot	200	0.5	100
Clock radio	1	24	24
Table fan	15	6	90
Computer	100	7	700
Miscellaneous appliances	400	0.5	200

With this chart, you can do some of the following calculations for your load analysis. To calculate the last column, simply multiply the first two columns.

Calculation	Answer
Total energy needs in one day	2.5 kWh/day
Adjustment for inefficiency (10 percent)	2.8 kWh/day
Maximum instantaneous load	700 W
Duty cycle	100%
Total energy needs in one week	19.4 kWh/week
Power needed from PV panels (@4hrs/day)	700 W

Next, calculate battery size, which is specified in terms of amp-hours (Ah). Most batteries are 12VDC, but other sizes are also available. For this example, assume a 12VDC system.

1. **Take the total kWh/day, multiply this by 1,000 to get kWh/day, and then divide this value by the battery voltage.**
2. **The generator is old, so triple the result from Step 1 to account for the two reserve days.**

   To cover the two reserve days, the cabin owners need batteries that can hold three days' worth of charge.
3. **Multiply the minimum battery capacity from Step 2 by a factor of two.**

   Batteries last much longer when they're not drained of more than about 70 percent of their available energy.

Finally, they're going to need a larger PV module capacity in order to get the three-day reserve. It's okay to go without power a few times, and there's a backup generator, so if they double the size of the PV module capacity, they should be safe. Hence, the owners need 1,400 watts of PV.
