



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

Introduction To Remote (Off-Grid) Power Systems

The Cost of a Remote Power System

The cost of a remote power system depends primarily on how much electricity you need. The amount of electricity you need is called your load. If your remote power system has a back up generator, the size of your load and the size of your remote power system determine how much of the time your generator runs. Asking how much a remote power system costs is similar to asking how much a car costs. The cost of a remote power system varies all over the place from a few hundred dollars to \$50 - \$60,000 and more.

Generator only

Cheapest initially, but this option costs the most by far in the long run. One light bulb will require the generator to be on and to be very inefficient. Generators require frequent maintenance (oil and filter change, check water, etc.) and eventually have high repair costs like a car. Generators are also very noisy, polluting, and they eventually die. Solar modules will probably last 50 or more years!!!!

Generator/Inverter system

A generator with inverter and battery bank. The next least expensive option, but more expensive in the long run than a mostly, or all, solar system.

Generator with some solar

More expensive initially, but less expensive in the long run than option's A and B.

Primarily solar with generator backup

Even more expensive initially, but less expensive in the long run.

Solar only

The most expensive initially, but the least expensive in the long run.

Solar DC only

If you have only a few appliances and they are all DC, then you may be able to get by with a very small solar system and no inverter. But this option is not generally appropriate for most people, since most people have many AC appliances and a fairly large load.



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

Comparing the Cost of Line Electricity with the Cost of a Remote Power System

When comparing the cost of line electricity to the cost of a remote power system, remember to include not only the cost of bringing in line electricity but also the cost of monthly electric bills over several years. When comparing the cost of mostly generator systems with a solar only system, remember to include the upward spiraling cost of fuel, maintenance and eventually a new generator. In contrast to generators, solar electric modules are warranted for 20 to 25 years, they will probably last 50 to 100 years. They require no fuel, little maintenance, do not pollute our air or put any more stress on our taxed-out environment, and they make no noise.

Reliability and Owning Your Own Utility

Remote power systems, especially solar only systems, have become so reliable that they very seldom are down. Typically owners of remote power systems have electricity while grid-tied electric customers are in the dark. The owner of a remote power system owns his or her own electrical power plant. For example, a 10 year economic comparison should consider the fact that after ten years you still own your own (if solar) very clean and quiet power plant, and it is still warranted for another ten to fifteen years!.

Get Some Solar Now and Add Later?

- You can add more modules later as long as the wiring, disconnects, charge controller and related system items are sized to accommodate more modules later, so plan ahead.
- Batteries can be added to later, but the entire bank will only function as well as the worst battery in the bank: So adding batteries after a year is not a good idea.
- Try to buy an inverter that will meet your needs several years from now. Generally speaking it costs a lot more to add an inverter, or an inverter and modules, later.



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

High Efficiency Appliances vs. Larger Solar System

Frequently thousands of dollars can be saved by spending more money on high efficiency appliances and less on your inverter, solar modules, batteries, and by reducing the size, wear, and run time on your generator, if one is used.

Load Change Suggestions

(Note: PV stands for photovoltaic. This is basically a more technical and specific way of saying solar electric.)

Fill out a [load sheet](#) in order to determine your load size. It is very common for purchasers of solar electric systems to go back to their load sheets after finding out the cost of a solar system large enough to supply the electricity demand on their first load sheet. Solar electricity is still initially much more expensive than line electricity. (However, solar electricity not only enables us to live remotely, but to generate our own electricity without polluting the air, creating nuclear wastes, strip mining coal, or exploiting national treasures.)

Use a solar, instantaneous propane, or propane hot water heater, a propane or high efficiency electric refrigerator/freezer, propane clothes dryer, and a gas range in order to reduce the size of your electrical load.

Convert AC and DC incandescent lights to energy efficient compact fluorescent (CF) lights with electronic ballasts. CF lights typically use one-quarter the energy of an equivalent incandescent light. Phillips and GE CFs are very high in quality and can be run off of a modified sine wave inverter. Ott-Lite Technology makes high-end CFs in various sizes with full-spectrum lighting for birds, plants.

Eliminate phantom loads (all non-battery clocks, VCR, TV, garage door opener, answer machine, furnace transformer...). Switched outlets can be used to eliminate most phantom loads. Furnace thermostats can be changed to line voltage, or a relay can be used to keep the furnace transformer from being on all of the time. If the furnace transformer is on all of the time, this will cause most inverters to be on all of the time, which uses a lot more electricity.

Consider replacing your blower motor with a high efficiency blower motor if you have a forced air furnace. For example, GE makes the ECM Programmable Motor, which can improve your blower efficiency by 1/3 to 2/3. This motor also has very little surge.



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

Mounting Methods

Stationary ground mount on a pole, ground rack, or on a roof: A pole mount is the least expensive. A GFCI is required for all residential house roof mounts; and the entire array will need to be removed and replaced when the roof is reroofed. Stationary mounting should include manual adjusting of modules (4 times per year). Modules should be mounted on theft resistant racks.

Tracking: passive, single axis, dual axis. We recommend Zomeworks passive trackers or the dual access electronic Wattsun Trackers. (However, even though the Wattsun Dual Access Trackers are generally reliable, there will eventually be some maintenance required. Some solar companies recommend against Wattsun trackers for this reason.) Using Colorado Springs, Colorado as an example, the solar electricity gained by using a Wattsun Dual Axis Tracker instead of a stationary mount (assuming the stationary mount is kept at a tilt angle of 38 degrees all year round) is: December +30%, July +55%, yearly +38%. Using the same latitude and changing the tilt angle of the stationary mount to 53 degrees, the dual axis advantage is 20% over the stationary during December. (Source: National Renewable Energy Lab)

Wire Sizing and Choosing A 12, 24 or 48 Volt DC System

The more voltage drop in a wire due to the resistance of the wire, the more power lost. We recommend that the wires in a solar electric system be sized large enough so that the voltage drop of the wires is 2% or less, and so that the over all voltage drop of the entire system is less than 5%.

Changing from a system voltage of 12 volts to 24 volts, or 24 volts to 48 volts, reduces voltage drop in wires by 50%., and reduces the power loss in wires by a factor of 4.

We usually recommend using the following to choose a system voltage size:

- If your long-term system total watts is less than 1500 watts, then use a 12 volt system.
- If your long-term system total watts is 1500 4000 watts, then use a 24 volt system.



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

- If your long-term system total watts is 4000 + watts, then use a 48 volt system.

Solar vs. Wind

Solar systems are much more economical than wind systems for homes generally in sunny places like California, unless you need a tremendously large amount of electricity. Wind becomes more economical than solar generally only if you need the electrical equivalent of several homes (i.e., grid-tie sellback or a lodge). In climates like California's it usually makes more sense to purchase a few more solar modules rather than to have a hybrid system. In considering a wind system it is important to de-rate for elevation, properly analyze wind speed, adjust the wind speed for the height of the tower, and then calculate the actual electrical output. In climates with little sun and lots of wind, wind systems are likely to be more economical than solar. Wind and solar can complement each other nicely throughout the year.

Choosing An Inverter: Modified Square Wave vs. True Sine Wave

True sine wave inverters provide electricity that is basically the same or better quality as utility-supplied electricity. True sine wave inverters therefore supply electricity that is compatible with virtually any appliance or electrical device. However, true sine wave inverters cost more than modified sine wave inverters. Thus modified sine wave inverters are commonly used. The following is a list of the electrical devices that can have difficulty running on electricity produced by modified sine wave inverters:

- Laser printers.
- Some fluorescent lights (Phillips compact fluorescent and electronically ballasted lights like the Osram EL15 seem to work best.)
- Some radios, especially AM.
- All Macintosh Computers are likely to overheat the power supply (except some older models). Note: Most computers work just fine on either a good quality modified sine wave inverter, or a true sine wave inverter. But occasionally a computer will crash (need to be rebooted) when the source of electricity is being switched from an AC source (such as utility or electric generator) to the inverter. A stand alone solar system sized large enough to operate year round without the need for a back up power source would, of course, never encounter this problem.



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

- Any power tool which employs "solid state" power or speed control. The components of some of these tools can be destroyed if powered by electricity supplied by a modified sine wave inverter.
- Some battery chargers for cordless tools will be destroyed (Makita is an exception)
- Some washing machines with electronic timers.
- Some stereo and audio equipment.
- Some TVs.
- Some new furnaces because they have microprocessors (computer chips) in their controls.
- X-10 home automation systems.

Even the very popular Trace SW Inverters, which are a refined modified sine wave inverter in which the sine wave is made up of very tiny steps, have problems running some appliances. Appliances that can have a problem with the electricity produced by Trace SW Inverters are:

- Some new furnaces because of the microprocessor in the furnace control. Note: In the event that a furnace does not operate properly, on either a modified sign wave inverter or a full sign wave inverter, the electricity to the furnace controller can be modified further by installing a power conditioner (also called a constant voltage transformer) on the line to the furnace controller only.
- X-10 home automation systems.

Other Advantages Of Trace SW Inverters

Trace SW Inverters include a gen start, which is compatible with most makes of generators, as a standard feature. Without the gen start an additional control would be needed to auto start. They also work with smaller generators than modified sine wave inverters.

When true sine wave is required, the Exeltech MX Series or XP Series inverters are the highest quality and have a mean time before failure of 21 years.

Charge Controllers And Low Voltage Disconnect

Charge controllers prevent the batteries from being overcharged. Low voltage disconnect (LVD) prevents the batteries from being discharged too far. Generally



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

even a high quality deep cycle battery, such as an L16, should only be discharged 20% to 50%. Batteries similar to the L16 will last a lot longer if they are discharged regularly only 20% to 50%. All solar electric systems, except possibly some small, one module, systems and DC water pumping applications, should have both a charge controller and a low voltage disconnect. Most inverters now have LVD built into them. Also, charge controllers, which have pulse with modulation will increase the life of batteries.

Maximum Point Power Tracking C.C.'s

The new Maximum Point Power Tracking C.C.'s can boost energy production up to 30% during winter with high voltage modules. The Solar Boost 50 by Blue Sky Energy, OutBack MX60, and others will handle up to 60 amps at 48 volts with 97% efficiency.

Batteries

- Car (very short life) — not recommended
- Marine (short life) — the bare minimum
- Golf cart ((5 to 8 years)
- Deep cycle L16s (7 to 10 years)
- Industrial (10 to 30 years)

* Note: years stated are achievable only with proper maintenance.

Batteries outgas during high rates of charging, and in rare instances can explode. Therefore, be sure to isolate the batteries from the inverter and charge controller. The batteries must also be vented unless they are sealed, VRLA, AGM, or gel cell. Use three series strings maximum (1 string is the best), or you may start to have problems equalizing the battery bank. A large battery bank with a lot of cells is more likely to have problems with a bad cell than is a large battery bank with fewer cells. So, the larger the battery cells, the less the likely hood of having a bad cell. Wiring from the battery bank must be from opposite terminals or the end batteries will wear out sooner than the other batteries.



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

Deep Well Pumps

Deep well pumps can be a real problem for solar systems. Not only do most deep well pumps use a lot of electricity, they also have an even larger need for electricity when they first start. The latter is called the electrical surge. Some inverters, especially the newer true sine wave inverters, are not able to handle the large surge of some pumps. Also, most pump installers install 230 volt AC pumps so that smaller wires can be used. Most inverters are 115 volts!



Generally speaking the deep well water pumps, which are most compatible with solar systems, are high efficiency DC pumps. DC water pumps are generally very efficient and they don't have to draw electricity through an inverter. Thus, less electricity is lost due to the inefficiency of the inverter, and electricity is supplied directly to the pump from solar modules or the batteries. This means that a smaller inverter can be used and that if an inverter ever fails, then the water pump will still run off of the batteries, assuming the batteries are being charged by solar modules.

AC deep well pumps can also be used, especially if they are 115 volts and 1 HP or less (Note: Three wire AC pumps plus ground require less electrical surge than two wire plus ground.) Larger, even 230 volt, AC pumps can be used with solar systems, however, a step up transformer or two inverters will be required, or water can be pumped into a cistern manually once a week, or so, using a generator. A DC pump can then be used to pressurize. (Note: Avoid AC deep well pumps, which have no control above ground. When the control goes bad the pump will have to be pulled.)



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

Things To Consider When Selecting A Gasoline, Propane or Diesel Driven Electric Generator

- **Sizing:** de-rate 4% for every 1,000 ft above 500 ft in altitude. The larger the generator the less time it will be on. Size an air-cooled generator so that it does not run for more than roughly four hours at a time. Liquid cooled generators can run for days without stopping at partial load, but they should only be run for a few hours continuously at full load. Size your generator large enough to simultaneously charge your batteries and run your loads.
- **Quality/longevity:** For example, water-cooled generators usually last 2 to 3 times as long as air cooled, 1800 RPM generators will last much longer than 3600 RPM generators.
- **Auto start**
- **Fuel Supply:** You must have a large (usually propane or diesel) tank in order for your generator to operate automatically.
- **Quality of the electricity produced:** Does the generator produce electricity that is exactly 60 cycles?
- **Noise level**
- **Fuel consumption**
- **Availability of a dealer who will repair your unit.**
- **Pollution**

An Example of the Maintenance Required on One of the Highest Quality Generators on the Market

- Kohler 10 KW Generator needs to have the oil and oil filter changed, water checked, etc. every 50 to 75 hours of run time. If the generator runs six hours per day on average, that means changing the oil, oil filter, etc. every 1 to 2 weeks. If a generator runs three hours per day on average, then the maintenance is every 2-3 weeks.
- Major repairs are likely to be required on this excellent quality Kohler water-cooled generator every 4 - 5,000 hours assuming the unit is well maintained, and depending on how many hours a day the unit runs. If the generator runs four hours per day on average, and if the unit is well maintained, major work would need to be done on the unit approximately every three years. (This is not guaranteed, this is just a rough average based on talking with a Kohler Service Manager.) If this generator is not well maintained, then it could need major work in less than six months.



Solar Wind Works

Renewable Energy Power Systems

P.O. Box 2511 • Truckee, CA 96160 • 1-877-682-4503 • Fax: 530-582-4603

- Most generators are air-cooled and include far less quality than the above generator. So most generators will require repairing much sooner than the above generator.

National Electrical Code

- Use only listed equipment and materials (when available) and pull a permit. Many solar system components on the market are still not listed.
- If you have questions, talk to **Solar Wind Works** or your inspector prior to purchasing and installing equipment so as to avoid problems later.
- The primary reason for the electrical code and inspectors is safety. Purchasing and installing a solar electric system, which meets code, has the added advantage of making it easier to get insurance with some insurance companies, and of selling the house later.
- Eliminate three wire circuits from any house using a solar electric system, whenever possible.

Other Thoughts

The first step in sizing a system, whether it is a solar system or a generator only system, is to fill out a load sheet. If you need a load sheet contact us and we will provide you with one. Once you have filled out the load sheet, mail, fax, or email it to **Solar Wind Works** and we will assist you with the design of your system.

We sell all of the components of solar electric systems, and also electric generators, high efficiency and propane refrigerators, freezers, high efficiency light bulbs, and many related products. We can provide prices on specific items.

We keep a record of all solar electric purchases by customer. So if later you want to add to your system, we have a record of what already exists. We are then better able to recommend additional items.