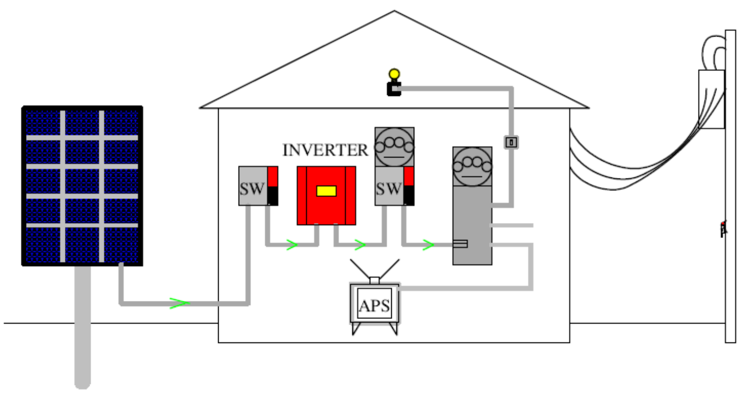
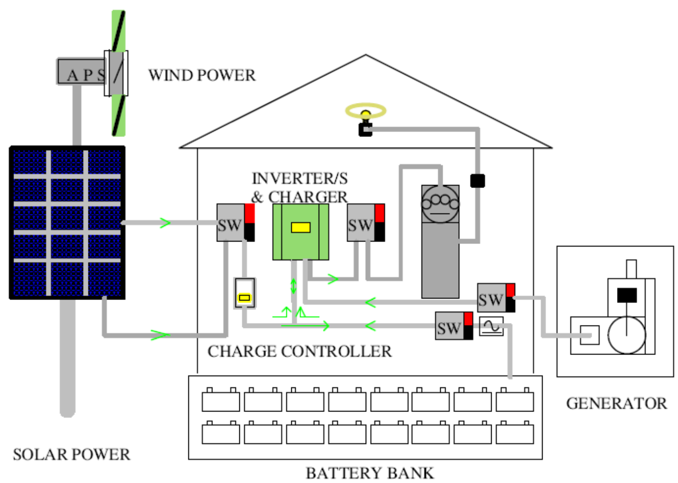
Off Grid & Battery Back-up Solar Electric Power System Frequently Asked Questions & Answers

Introduction

The following information helps answer the most frequently asked questions concerning off-grid, and Grid tie systems with back-up (battery and/or generator) hybrid solar electric power systems. Keep in mind that much of this information is "rule of thumb"; your individual situation, if analyzed in detail, may differ somewhat from the general application. If you are unfamiliar with solar systems please read the standard questions and answers found in the Grid tied Solar Electric Power FAQ's.



Grid Tied



Off Grid

Q. What is the difference between a Grid Tied system and an Off Grid system?

The main difference between the On Grid (Grid Tied) and Off Grid system is the method of energy storage for later use. On Grid, we bank energy for later use by passing excess energy production back to the grid in reverse of the energy consumption accounting system, thus applying credits for the energy that will be used later when the power production is less than the local loads require during overcast times or at night.

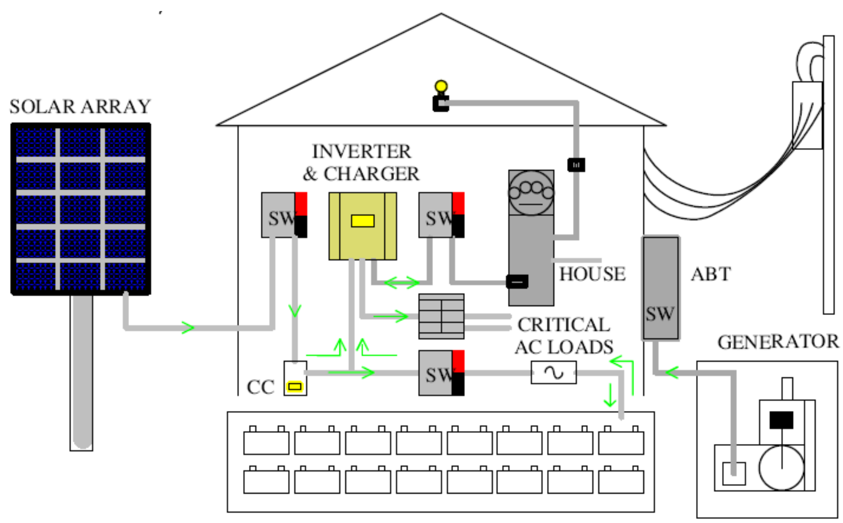
Off Grid systems are designed to meet 100% of the current demands of the attached appliances, and electrical loads, whereas the On Grid systems are designed to meet a portion of the energy consumed by the loads, On Grid systems allow the grid to meet the high current load demand, such as high rush currents needed to start the air conditioner compressor, or other motor driven loads.

This RUSH current can be 3 to 7 times the energy required to operate the appliance. In the Off Grid system the capacity of the system needs to be large enough to meet ALL current demands of all appliances to be connected to the solar power production system. If the current demand is not sufficient the connected loads will not function, or can be damaged.

Q: Is an Off grid system right for me?

Off-grid systems typically require a larger up-front investment than grid-tie systems. This is, in large part, due to the greater demands on the system.

Off Grid systems are typically used in remote applications in which utility power is not available, where running a line to the local utility grid is prohibitively expensive, or where a generator is not desirable.



Grid Tied with Battery Back-up

Q: What is a Grid Tied system with battery back-up (Hybrid)?

The Hybrid system takes advantage of the high efficiency of energy production of the On Grid system, but has a limited load demand battery storage bank to supply power to critical loads in the home like certain lights or a refrigerator. Normally these critical loads do not include the air conditioning unit.

Hybrid systems are designed to supply critical loads without the benefit of a solar charge cycle period, referred to as the days of autonomy (3 days is typical). The autonomy period is based on the load demand of the appliances to be operated and the length of time those appliances are to be in operation. Of course the system can be built large enough to power any device as long as cost is not a consideration.

If a generator is available to provide recharging of the battery bank, then the days of autonomy can be shortened, as the generator would be called on to offset the loss of access to the sun's power during extended cloudy periods.

Q: Is a Hybrid solar system right for me?

In general, these systems are best for applications in which backup power must be instantly available without interruption (for example, to power computers). These systems are also good for areas where power outages are a frequent occurrence, or an area where blackouts and brownouts are relatively common such as after a hurricane.

Q: What are the disadvantages of battery back-up systems (Hybrid)?

Hybrid systems typically require a larger up-front investment than grid-tie systems. Batteries are an additional expense, require maintenance, only last 5-10 years, decrease system efficiency and result in a more complicated system.

Many of our customers opt for a grid-tie system and purchase a standby generator with a properly installed manual transfer switch. For a given level of power output, generators are usually the least expensive option for backup power production. Generators provide the most reliable and cost effective source of extended backup power, eliminate the additional expenses related to batteries, and have backup power available for as long as they have fuel.

Q: What type of generator works best with a hybrid solar system?

The simplest solution is to install a relatively inexpensive generator in conjunction with a manual transfer switch. The transfer switch directs the source of power for critical loads from the utility (which is presumably down) to the generator - without back-feeding the electric grid. During a power outage the transfer switch is operated and the generator is started, thereby providing power to the critical loads in the house. Total costs for this type of installation are typically in the $3,000 to $7,000 range, with manual start gasoline generators at the lower end and auto-start propane/NG generators at the higher end.

More durable diesel powered generators, such as a 10,000 watt auto-start unit, can be purchased for about $10,000. This generator has higher quality power output, requires less maintenance, and has a much longer life. Since they don't require complicated carburetion, propane/NG generators are also good solutions for remote backup systems. With these higher price range generators one can install an automatic transfer switch and auto-start capabilities so that the generator automatically begins to supply your electrical loads in the event of a power outage. Note that, with most generator systems it will take several minutes for the generator to come online and provide adequate power.

Q: What are the basic elements of a battery based solar electric systems?

A battery based system is made up of several different components. These include solar panels, batteries and a charge regulator or controller, an inverter which converts the DC current to AC current; wiring; and mounting hardware or a framework.

Although a small amount of energy is lost in converting DC to AC (typical inverter efficiencies are in the range of 90 to 95%), an inverter makes solar generated electricity behave like utility power to operate everyday AC appliances, lights, and electrical equipment. Please note that you will need a special type of inverter if you want a battery backup system. For safety reasons most grid-tied inverters are designed to shut down completely if there is a power failure.

The charge controller prevents the solar panel or array from overcharging your battery.

Batteries are the energy storage for your system. Without batteries there is no way to store the energy your solar panels produce during the day and provide you with the energy you need at night. Typically loads receive their power from batteries instead of directly from the output of a solar panel.

The solar panel is the basic building block of the system. This is your battery charger. If you have several solar panels wired together you have created a solar array. The size of the solar array determines the amount of power or energy that will be produced.

Q: What type of battery is required for a battery back-up solar system?

The batteries used in solar systems are similar to car batteries, but are designed for deep cycling use in which a larger percentage of the capacity of the battery is used each night (and then fully charged up each day). Batteries designed for solar projects pose the same risks and demand the same caution in handling and storage as automotive batteries. The fluid in unsealed batteries is highly corrosive, levels should be checked periodically, batteries must be appropriately ventilated, and batteries should be protected from extremely cold weather. In practice we have found that when properly maintained batteries last for about 5-8 years, after which their capacity is significantly diminished.

Q. How are the batteries connected to reach my current demands?

The battery can be as simple as a 12 volt battery of moderate size, much like a car battery. The capacity, or the energy storage capacity, of the battery is directly related to its physical size. The larger the battery, the higher the capacity. A 7 Ampere Hour (AH) battery might be the size of an envelope box where as a 220 AH battery would be larger than a car battery. The battery bank is made up of several batteries connected together in series and parallel combinations to develop the voltage and current capacities needed for a particular system.

Two 12 volt batteries connected in series make up a 24 volt battery. This battery would have the same current capacity of either of the two batteries individually. If the 12 volt battery were to be rated for 12 volts at 220 AH then the series connected battery combination would be rated at 24 volts at 220 Ampere Hours. If we carry this out further, making a 48 volt battery by connecting the original two batteries in series with two more batteries in series (a total of 4 batteries) we make one 48 volt battery with a capacity rating of 220 AH.

Once the battery voltage is satisfied, by connecting batteries in series, we then consider the total battery Ampere Hour capacity needed. To meet this requirement we connect the 4 series connected batteries in parallel with 4 more series connected batteries, making a 48 volt battery with 440 AH capacity. And the process continues until the battery is sized to meet the load demand.

CAUTION - even a single cell battery at modest AH ratings has the ability to supply very high currents for short durations. Shorting the terminals of a battery will cause maximum current to flow, and the power will be dissipated in the load. Resistance is the limiting factor in the power transfer process. Without resistance, as in the case of a short circuit, maximum current flows for the duration of the batteries ability to contain the power developed during energy transfer process. This is limited by the physical construction of the battery and the duration of the short circuit. The battery can, and most likely will explode causing the contents of the battery, to be sent in all directions. This is a very serious mishap often resulting in major physical injury or death.

Q. Where do I need to consider storing the batteries?

During the charge cycle hydrogen is produced in the process, different types of batteries handle the gassing process differently, each process can be directly related to battery cost. The standard wet cell, commonly related to the car battery, just vents the gas into the air, normally the quantity is such that the concentration is not explosive. Sealed batteries will vent, but normally the gasses are contained, depending on the charge rate. In all cases one would want to consider a separated space for the batteries, certainly not within the living space.

Ideally, storage batteries would be placed in cool, dry and vented locations (batteries release hydrogen gas). Sheds or garages are good places. The contents of batteries should not be subjected to boiling or freezing. Freezing will only occur when the batteries are in a state of discharge.

ALTERNATIVE POWER SOLUTIONS

Q: What if there is hardly any sunshine for several days?

Different geographic regions provide various amounts of daily sunshine. It is recommended that an off grid system has enough battery power to account for five days of inclement weather. The American southwest averages 5 sunshine hours per day and the northeast receives about 3 hours of daily sunshine. More solar panels will increase the amount of power generated when the sun is shining.

A solar generating system with batteries supplies electricity when it is needed. The amount of electricity that can be used after sunset or on cloudy days is determined by the output of the solar energy modules and the storage capacity of the battery bank. Including more modules and batteries increases system cost, so energy requirements (both in terms of peak loads and the average duration of the loads) are carefully studied to determine optimum system size. A well-designed system balances cost and convenience to meet the needs of the particular application, and can be expanded if those needs change.

Q. How many solar panels will I need?

The number of solar panels required is directly proportional to the daily power required to supply the home. Because the available energy to be harvested from the sun is calculated based on the daily average of available solar energy, the energy production per square foot of solar panel surface for that harvest must be known. If we require more solar energy to be harvested then the solar panel surface area is enlarged by the addition of more panels within the system.

Typically, a solar panel that produces at 175 watts per hour represents about 14 square feet (1.3 m^2) of solar panel surface area. A 100% efficient solar would convert the standard 1,000 Watts/m^2 that strikes the surface of the earth into 1300 watts of solar energy. However, at 13.46% (typical efficiency for today's solar panel technology) the same panel produces the manufacture's rating of 175 watts. A 200 watt panel of the same quality is just physically larger (more surface area).

Two 87.5 watt rated panels (physically smaller), would produce 175 watts under the same conditions. As a result the total number of solar panels needed is a ratio of available solar energy, and the daily power consumed by the system loads. If this ratio is not properly calculated, including the DC to AC conversion process and system losses, the solar panels will fail to supply the batteries with the energy required to replace what is consumed by the loads on a daily basis.

The number of panels required depends on the energy harvest required to meet the needs of the system design.

Q: How is the size of my battery backup system determined?

Each piece of equipment or appliance in the home (draws) a specific amount of power expressed in Watts. Watts = the applied voltage expressed as E, times the current expressed as I, passing through the device (W= E x I or Watts= Volts x Amps for this example). While in operation this power is basically supplied by the systems batteries and the solar panel array which is sized to recharge or replace the energy drawn from the batteries during the normal periods of sunlight.

Power is related to the current capacity of the batteries (expressed in Ampere Hours or AH) and determines the length of time the energy can be drawn from the battery at a rate to allow normal operation of the loads attached. The amount of energy consumed during the daily period must be put back into the batteries, or the batteries will eventually discharge below a usable level causing the system to fail.

A 100 watt lamp consumes power at a rate of 100 watts per hour for the period of time it is on. If the lamp is on for 1 hour it consumes 100 watt hours. In order to make the power available later to turn on the lamp we must recharge that 100 watt hours back into the batteries plus about 12% (112 watts) for applicable system losses.

The lamp consumes 100 watts at 120 volts so while the lamp is on the current required is relatively small (100W/120V = 0.83 amps). The power that comes from a battery is at a lower voltage, in this test case at 24 volts. Therefore, the current flowing from the battery for the period of time the lamp was on would be 4.67 amps (112W/ 24V = 4.67 amps).

In Houston we have 4.8 hours (annual average) of peak solar energy production to replace the power consumed by the lamp back into the battery. Therefore to size the solar panels required to charge the batteries at a rate to reflect the available hours of solar production is 112 watts / 4.8 hours = 23 watts/hour. So one 24 volt solar panel (typical panel voltage) rated at 28 watts can be used to keep the battery charged.

Of course that battery capacity must capable of supplying the power needed based on the total time that the devices are being used, and at the power supply rate to match the energy that is pulled out of the battery. With larger loads, like a window AC unit, more current is needed at a higher rate of power supply. This then requires a larger battery storage system.

The inverter (converts the battery power from DC to standard AC power) also needs to be sized to meet the load demand, not only the constant load, such as a light, but also the surge load caused when starting motors such as those used in an air conditioner fan and refrigerator compressors. It takes about 3 to 7 times as much energy to start the motors as it takes to operate them. For instance a 5000 BTU WINDOW AC unit requires 1,465 watts to operate but it may require 4,395 watts for a short duration to start.

If the battery systems demand capacity is not built large enough to start the motors the motor will not start.

Q. What information do I need to provide on the appliance or load listing in order to design my battery backed solar system?

To begin the design process you must list all items you are considering to power using your battery backed system by the item name, the power rating of the device, and the length of time (hours) during the week the item will be in operation.

The power consumption information can be found on the manufactures tag in the same locations as the model and serial number. The power consumption may be listed as watts or the amount of current draw in amps. Most appliances require 120 volts and some requires 240 volts (110 & 120 volts are considered to be the same in this instance as are 220 & 240 volts).

Q: What maintenance is required for a battery backed solar electric system?

Battery backed solar electric systems are elegantly simple. Maintenance includes:

- Checking your deep cycle batteries every few weeks to make sure they have enough distilled water

- Occasionally checking the connections between the solar modules and the inverter(s), and tightening them when applicable.

Q: What is the best way to monitor the charge status of a solar system?

Battery volt meters are the most common way to monitor the charge status of a solar system. However, battery voltage readings can be inflated depending on charge and discharge rates. For this reason, an amp-hour meter is the most accurate way to monitor the system charge status.