

Lavalux - Renewable Energies



## Alternative Energies

Learn how solar power can help you

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## Alternative Energy

Alternative energies, like solar and wind energy, are a growing market as fossil fuels will end at some point in the future. Population grows faster and with it the demand for electrical power. More and more residential and commercial customers are becoming aware of the benefits of alternative energy and its contribution for a green planet.

As we advance, more cities, states, and countries will adopt legislation and tax incentives in favor of alternative energies. [Click here to find more about this topic in for your locality.](#)

## Alternative Energy Selection

Selecting an energy system is not simple task. New products come to the market every day from different sources as energy technologies evolve. A balanced energy system, able to produce the required energy and investment payoff, is a challenging task for most of us. Talk to an energy expert is the first step in the system selection process.

When considering an energy system, many factors enter into the equation.

1. The geographical location - whether the place is suitable for solar or wind energy;
2. The utilization of the system - whether to produce electrical power or heat for water or the building spaces; for illumination or pumping water; the size and capacity;
3. The investment and tax benefits available; and maintenance cost to mention some.

The knowledge of how an energy system works and can produce is fundamental. For instance, solar energy works fine for most items but not for large electric appliances with heat element such as water heaters, dryers, electrical stoves or central heating systems. It is important, to define and calculate the energy system, to understand how it works and the expected results.

## Different Solar Systems

Solar systems to produce power are not the same as solar systems to produce heat. 62% of the grid energy is used in the residential and 42% in the commercial buildings for heating of water and spaces.

### Solar power to produce electricity

Solar power systems use solar panels to produce electricity and other components. Most power solar systems use an inverter, to transform DC current generated by the solar panels to AC current. Depending on whether the system is designed to be connected to a grid, a battery is not required.

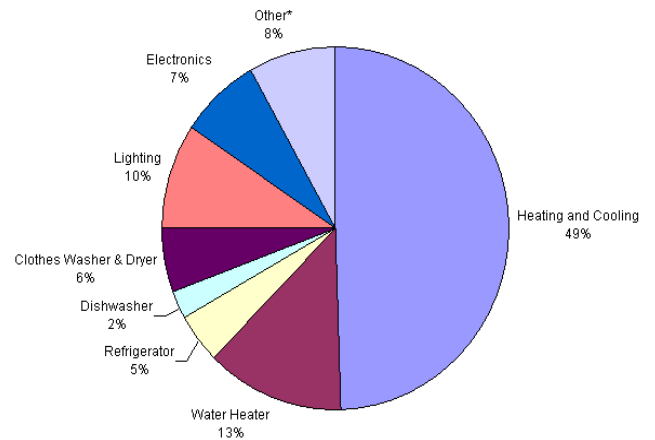


Figure 1 - Residential use of energy

### Solar thermal technology

Solar thermal technologies (also known as active solar systems) involve the conversion of solar radiation into heat and include the use of pumps or fans to actively transfer the heat to storage or for distribution directly to its intended use. The key component of any thermal solar system is the solar collector which absorbs the sun's radiant energy and transforms it into usable heat.

Various types of collectors are used in solar energy conversion, depending on the application and temperature requirements:

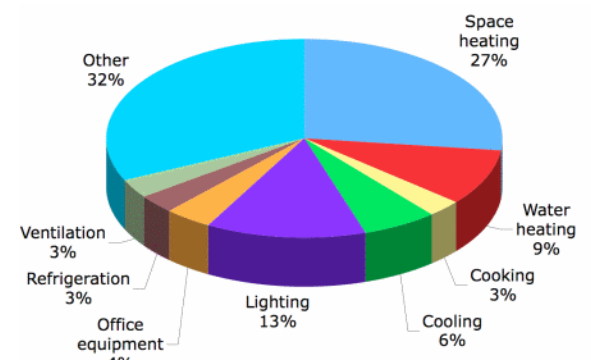


Figure 2 - Commercial use of energy

- Unglazed metal and plastic flat plate collectors are used for low temperature applications such as residential pool heating and ventilation air heating for commercial and industrial buildings
- Glazed flat plate and vacuum tube collectors are used for mid-range temperature applications such as domestic hot water and space heating and cooling applications.
- Concentrating collectors that focus the sunlight onto a much smaller area are used for higher temperature applications such as industrial process heat, absorption cooling, and large-scale solar thermal power applications to generate steam for electricity generation.

## **Solar System Benefits**

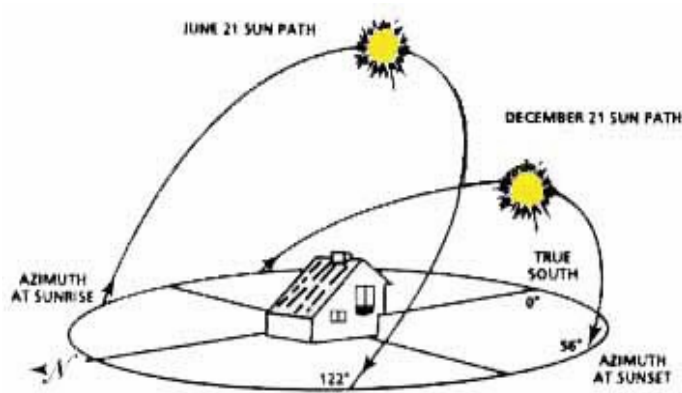
Based on the Solar Energy Research and Education Foundation, the USA receives more energy in the form of sunlight in less than 40 minutes than from all the fossil fuels burned every year. The average American family spends about \$1,500 per year on utility bills. This expense could be reduced from 10% to 90% percent depending on how the energy utilization and generation is handled. For residences, typically, 44% of the utility bill is for heating and air-conditioning. That alone emits over a half billion tons of carbon dioxide into the atmosphere each year, adding to global warming and health issues.

In many cases, solar power can reduce heating costs by about 50% when compared to the cost of heating the same house using electricity from the grid.

## Solar Orientation

Solar panels should be directed at solar south in the northern hemisphere and solar north in the southern hemisphere. Solar north or solar south, are not the same as the north and south as the magnetic compass indicates

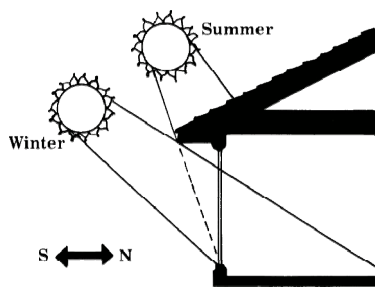
The sun rises in the east and sets in the west on two days of the year - the first day of spring and the first day of fall. The sun rises in the northeast and sets in northwest during the spring and summer months (northerly latitudes). The sun rises in the southeast and sets in the southwest during the fall and winter months (northerly latitudes). The sun reaches its peak (zenith) at a point due south of the observer (northerly latitudes). The time this occurs is defined as solar noon. The sun's zenith is closer to the horizon during fall and winter months, and is higher in the sky during spring and summer months. The sun rises earlier and sets later during the spring and summer months, with the opposite being true during the fall & winter months.



## Efficient Building Planning and Construction

It is a well-known fact but not often followed that a building facing south collects more solar energy during the winter months. However, it can also produce extreme heat on the west sides of the structure in the summer, causing a decrease in the benefits. A building project to take advantage of solar energy must take into consideration its orientation. The building can be oriented as much as 15° east or west of true south and still be energy efficient. The southern orientation of the building could vary by up to 30° from true south without significantly harming its heating season performance, but because such a large variance could seriously reduce cooling performance, it is recommended that the orientation should not vary by more than 15° either to the east or west of true south.

**Eave Projection:** The eaves or soffit width can make a big difference. By using the proper projection off the main structure for a particular location, the building can be mostly in the shade at 10:30AM in the summer, keeping it cooler, and be kept out of the shade during winter months, which keeps it warmer. Proper eave projections can also enable the use of more glass surfaces since that allows for winter solar heat, but also shade the same windows in the summer.



In June to July, when the summer sun moves from 65 to 75 degrees overhead between 10:30AM and noon, a south facing building with only a 36" eave or soffit on the south side will be virtually in the shade on the south side, will have little or no east side solar heat and will not have any solar heat on the west or north. Using a typical 12" to 16" soffit, the south side absorbs more heat, thus increasing cooling costs. Conversely, from December to January, the winter sun arcs at about 22-25 degrees in the sky, and the solar heat can help warm the south exterior and pass through the windows to warm the interior of the building.

**Landscape Features:** Trees can be very helpful or very restrictive for solar systems depending on how close they are to the structure and type of tree. Evergreen trees should ideally be kept on the west, north and northeast. Deciduous trees, which lose their leaves in the fall, are usually best on the south side, but for solar photovoltaic trees should not be too close to the building or too high. For passive solar energy, during the summer they can provide additional shading, and after losing their leaves in the fall they will permit winter sun to warm the building. Taking full advantage of trees and shrubs can provide shading, wind break and other benefits.

**Window Glass:** Energy efficient glass windows can help to keep summer heat from penetrating through the windows, especially on the west side, but also allow winter solar heat to keep your structure warmer. Other consideration is of double or triple pane windows to reduce heat and cooling losses. Low-E coatings (Low emission) windows should be considered.

For the west facing windows, the Low-E coating significantly reduces the amount of solar heat passing through to the interior of the building in the summer. When combined with sealed gases like Argon, double or triple pane, Low E coatings can either, keep heat in or out, and reduce ultraviolet ray penetration by up to 84%. The Low-E allows most natural light to enter freely, but absorbs a significant portion of short-wave heat energy. In the summer, long-wave heat energy is reflected back outside, lowering cooling cost. In the winter, internal long-wave heat energy is reflected back inside, lowering heating cost.

Unlike other insulating features of the home, the efficiency of windows is typically expressed in terms of U-value. U-value measures the conductivity of the window, this is the inverse of R-value, therefore, lower the U-value the better.

Using a lot of glass material may be aesthetically desirable, but balance should be maintained. Plain glass has a very high U value. Even high performance double and triple pane windows will still cause relevant losses, so this is a factor to consider. Too much glass on a particular side of a building can be very costly in lost energy efficiency. The idea should be to use enough glass material to keep the structure light and reasonably bright, but to understand that for every square foot of glass there is some relevant loss of heating and cooling efficiency. Windows on the north side should be few in number and small in size, to reduce heat loss from this exposure. The eave or soffit projections can be sized to enable the use of more glass, more efficiently.

**Wind Barriers:** The proper use of "wrap" or a wind barrier prior to final siding will help restrict unwanted air flow in the wall and ceiling cavities, but unless it's installed properly, it's a waste of money. This material can be very helpful, but all edge seams, cut ends, windows and doors openings must be sealed properly.

**Absorption Materials:** The use of stone, brick or tile in the interior can absorb winter solar heat during the day through window openings, and then slowly release it throughout the evening. Decorative water columns can also be used. However, unless it is also kept shaded in summer months, the effect can be negated. Solar angles throughout the year, window sizes, eave projections and total mass of the absorption material are all considerations.

**Insulation & Caulking:** Proper insulation and caulking during construction is obviously very important. One of the most important factors is to be certain the insulation is properly sized, but equally important is that it be installed correctly. We often see buildings with the correct thickness of material, but the installation is inferior. Many construction companies use low-cost labor to install the insulation, and the building owner ends up paying for it, over and over again in higher heating/cooling costs.

The required thickness of wall and ceiling insulation varies from area to area, but as a general rule, using fiberglass as a basis; 6" in the walls and 12" in the ceiling is the minimum. This generally means the outside frame walls will be made using a nominal 6" thick dimension. However, unless other construction practices are kept to the highest standards, the insulation properties are seriously diminished. Proper installation of insulation materials is critical.

Properly sealing joints and other areas to minimize air penetration into your interior of the building from the sill areas, corners, etc. can reduce drastically energy losses.

Fresh air exchange is important for any building. However, compared to typical construction which usually results in a fresh air exchange ratio of about 8 to 1 or even 10 to 1, a really energy efficient building will have about a 2.5 - 3 to 1 exchange ratio. A building should also have sufficient exhausting in kitchens, baths, etc. This is important to keep the air quality fresh and healthy. In contrast, a 10 to 1 ratio means you're literally just blowing in the wind - wasting all kinds of heat and cooling.

**Gas vs. Electric:** To "heat" with gas is more efficient than to heat with electricity. Electricity does well on inductive loads like motors and such, but resistive loads (heat elements) are better heated with

natural or propane gas. Gas should be preferred for central heating, hot water, kitchen range and oven and for clothes dryer.

**High Efficiency Appliances:** High efficiency refrigerators, water heaters, furnaces, air conditioners are available. Efficient appliances save money, reduces environmental impacts, and keeps the building cooler in the summer by eliminating the heat wasted by inefficient appliances. Energy efficient appliances are especially recommended for the use of alternative energy.

**Geothermal Energy:** Using relatively stable underground temperatures to assist heating in the winter and cooling a structure in the summer are very viable. A year-round average underground temperature of say, 50-55 deg. is sufficient to pre-warm fluid systems when outside temperatures may be hovering below freezing. The colder the outside air the more viable these systems are - if sized accordingly. Conversely, that same average underground temperature can cool fluids and be used to provide air conditioning.

The geothermal system uses the earth as a heat / cooling source and "sink". The heat is exchanged with the earth via a system of buried plastic pipes called the ground heat exchanger. In the winter, the fluid within the pipes extracts heat from the earth, carries it through the system and into the building. In the summer, the system reverses itself. Heat is pulled from the building, carried through the system and deposited in the cool earth. In addition waste heat from the system can be used to provide domestic hot water at no cost in the summer and at a substantial savings in the winter. The graphic image illustrates a "closed loop" system.

Caution is advised to use established industry methods and equipment for geothermal energy. One key point to remember is that air is a poor conductor. The air space is an insulator because air does not conduct well. So just forcing a whole lot of air through an underground trench loop may not be effective. Plus air can absorb unhealthy Radon gases, etc. If air is used, there must be an "exchanger" of some type for the circulated air to pass through, much like the heat exchanger in a forced hot air heating system or the exchanger in an air conditioning system. It is better to use a fluid to absorb ground temperature. If sized and built properly, a geothermal system can be extremely energy efficient.

**Lighting:** Regular incandescent bulbs produce about 5-7 times more heat energy than it does light. Compact fluorescent bulbs produce 5 times more light than heat. In addition, while most regular bulbs have an average life of about 800 – 1,000 hours of use, CFLs may last 8,000 to 10,000 hours. They take a lot less electrical energy to produce the same light output.

CFLs make sense, however they may be a little bulky for some lighting fixtures. LED lights are the newest lighting technology available. They may replace CFLs and halogen lights for flood or spot lights.

**Color & Materials:** The color or material used specially in the building façade should be considered. Darker colors absorb more heat in the winter, but also in the summer. The top four absorbing colors are black, red, brown and navy blue. Balance color and materials can make a difference in overall efficiency.

## Solar Systems Components

A simple solar system for power production uses solar panels, charge controller, battery and inverter. The solar panels charge the battery, and the charge regulator assures proper charging of the battery. The battery provides DC voltage to the inverter, and the inverter converts the DC voltage to normal 120 ACV. If 240ACV is needed, then either a transformer is added or two identical inverters are series-stacked to produce the 240 volts.

### Solar Panels Selection and Installation:

Solar panel output is stated in watts, and the wattage is determined by multiplying the rated voltage by the rated amperage. The formula for wattage is:

$V \times A = W$ , so 20 volts times 4 amps equals 80 watts

Considering a daily average of 6 hours of peak sun, an 80w solar panel produces an average 480 watt hour of power per day.

The intensity of sunlight on the solar panel, called "peak sun hours", varies throughout the day. Early in the morning and late-in-the-day sunlight produces less power than the mid-day sun. Cloudy days will produce less power than bright sunny days as well. When planning a system, the geographical area is rated in average peak sun hours per day based on yearly sun data. The average peak sun hours for various geographical areas is listed here: [Global Peak Sun-hour Maps](#)

Solar panels can be wired in series or in parallel to increase voltage or amperage. They can also be wired both in series and in parallel to increase both volts and amps.

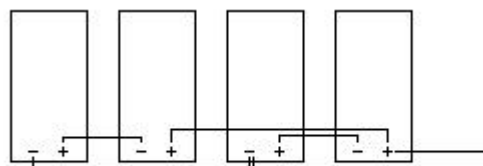
### Series connection

Series wiring refers to connecting the positive terminal of one panel to the negative terminal of another. The resulting outer positive and negative terminals will produce voltage the sum of the two panels, but the amperage stays the same as one panel. So, two 12 volt/3.5 amp panels wired in series produces 24 volts at 3.5 amps. Four of these wired in series would produce 48 volts at 3.5 amps.

### Parallel connection

Parallel wiring refers to connecting positive terminals to positive terminals and negative to negative. The result is that voltage stays the same, but amperage becomes the sum of the number of panels. So, two 12 volt/3.5 amp panels wired in parallel would produce 12 volts at 7 amps. Four panels would produce 12 volts at 14 amps.

Series/parallel wiring refers to doing both of the above - increasing volts and amps to achieve the desired voltage as in 24 or 48 volt systems. The following diagram shows a series / parallel connection. In addition, the four panels below can then be wired in parallel to another four and so on to make a larger array.



Two 12v/3.5A panels in series and two in parallel. This doubles the voltage and doubles the amps to make 24 volts and 7 amps.

## Charge Controller:

A charge controller monitors the battery's state-of-charge to assure the battery is always charged and protects the battery against overcharge. Connecting a solar panel to a battery without a regulator can seriously damage the battery is of risk concern.

Charge controllers (charge regulator) are rated based on the amount of amperage they can process from a solar array. If a controller is rated at 20 amps it means that it can be connect up to 20 amps of solar panel output current. The most advanced charge controllers utilize a charging principal referred to as Pulse-Width-Modulation (PWM) - which insures the most efficient battery charging and extends the life of the battery. Advanced controllers also include Maximum Power Point Tracking (MPPT) which maximizes the amount of current going into the battery from the solar array by lowering the panel's output voltage, which increases the charging amps to the battery - because if a panel can produce 60 watts with 17.2 volts and **3.5** amps, then if the voltage is lowered to say 14 volts then the amperage increases to **4.28** ( $14v \times 4.28 \text{ amps} = 60 \text{ watts}$ ) resulting in a 19% increase in charging amps for this example.

Many charge controllers also offer Low Voltage Disconnect (LVD) and Battery Temperature Compensation (BTC) as an optional feature. The LVD feature permits connecting loads to the LVD terminals which are then voltage sensitive. If the battery voltage drops too far the loads are disconnected - preventing potential damage to both the battery and the loads. BTC adjusts the charge rate based on the temperature of the battery since batteries are sensitive to temperature variations above and below about 75 F degrees.

## Battery:

The Deep Cycle batteries used are designed to be discharged and then re-charged hundreds or thousands of times. These batteries are rated in Amp Hours (ah) - usually at 20 hours and 100 hours. Simply stated, amp hours refers to the amount of current - in amps - which can be supplied by the battery over the period of hours. For example, a 350ah battery could supply 17.5 continuous amps over 20 hours or 35 continuous amps for 10 hours. To quickly express the total watts potentially available in a 6 volt 360ah battery; 360ah times the nominal 6 volts equals 2160 watts or 2.16kWh (kilowatt-hours). Like solar panels, batteries are wired in series and/or parallel to increase voltage to the desired level and increase amp hours.

The battery should have sufficient amp hour capacity to supply needed power during the longest expected period "no sun" or extremely cloudy conditions. A lead-acid battery should be sized at least 20% larger than this amount. If there is a source of back-up power, such as a standby generator along with a battery charger, the battery bank does not have to be sized for worst case weather conditions.

The size of the battery bank required will depend on the storage capacity required, the maximum discharge rate, the maximum charge rate, and the minimum temperature at which the batteries will be used. During planning, all of these factors are looked at, and the one requiring the largest capacity will dictate the battery size.

One mistake is ignoring the relationship between amps and amp-hour requirements of 120 volt AC items versus the effects on their DC low voltage batteries. For example, say a 24 volt nominal system and an inverter powering a load of 3 amps, 120VAC, which has a duty cycle of 4 hours per day. It has a 12 amp hour load ( $3A \times 4 \text{ hrs} = 12 \text{ ah}$ ). To determine the true drain on the batteries, divide the nominal battery voltage (24v) to the voltage of the load (120v), which is 5, and then multiply this times the 120vac amp hours ( $5 \times 12 \text{ ah}$ ). So in this case the calculation would be 60 amp hours drained from your batteries - not the 12 ah. Another simple way is to take the total watt-hours of your 120VAC device and divide by nominal system voltage. Using the above example;  $3 \text{ amps} \times 120 \text{ volts} \times 4 \text{ hours} = 1440 \text{ watt-hours}$  divided by 24 DC volts = 60 amp hours.

Lead-acid batteries are the most common in PV systems because their initial cost is lower and because they are readily available nearly everywhere in the world. There are many different sizes and designs of lead-acid batteries, but the most important designation is that they are deep cycle batteries. Lead-acid batteries are available in both wet-cell (requires maintenance) and sealed no-maintenance versions. AGM and Gel-cell deep-cycle batteries are also popular because they are maintenance free and they last a lot longer.

Temperature has a significant effect on lead-acid batteries. At 40°F they will have about 75% of rated capacity, and at 0°F their capacity drops to about 50%. Some battery manufacturers carry lead-acid batteries not as sensitive to low temperatures.

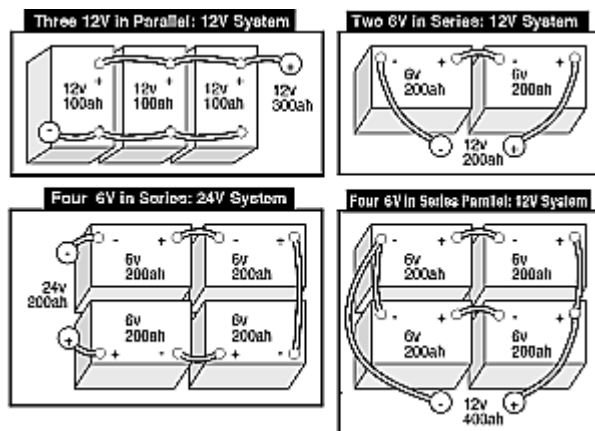
The battery storage capacity and the amount of electrical energy it can hold, are usually expressed in amp-hours. If one amp is used for 100 hours, then 100 amp-hours have been used. A battery in a solar power system should have sufficient amp hour capacity to supply needed power during the longest expected period of "no sun" or extreme cloudy conditions. In wind systems allowance for "no wind" days should be included. A lead-battery should be sized at least 20% larger than this amount. If there is a source of back-up power, such as a standby generator along with a battery charger, the battery bank does not have to be sized for worst-case scenario.

### Battery series or parallel connections

Series wiring refers to connecting batteries to increase volts, but not amps. If you have two 6 volt batteries like the Trojan L16 rated at 350 amp hours, for example, by connecting the positive terminal of one battery to the negative terminal of the other, then you have series wired the two together. In this case, you now have a 12 volt battery and the rated 350 amps does not change. If you were to series wire four L16's you'd have 24 volts at 350 amps, and so on.

## Parallel Wiring

Parallel wiring refers to connecting batteries to increase amps, but not volts. If you have two 6 volt batteries like the Trojan L16 rated at 350 amp hours, for example, by connecting the positive terminal of one battery to the positive terminal of the other, and the same with the negative terminal, then you have parallel wired the two together. In this case, you now have a 6 volt battery and the rated 350 amps increases to 700 amp hours. If you were to series wire four L16's you'd have 24 volts at 350 amps, and then parallel wire these four to the four other that are in series, then you'd have a 24 volt battery at 700 amps.



## Using an Inverter:

An inverter is a device which changes DC power stored in a battery to standard 120/240 VAC electricity (also referred to as 110/220). Most solar power systems generate DC current which is

stored in batteries. Nearly all lighting, appliances, and motors use ac power, so it takes an inverter to make the switch from battery-stored DC to standard power (120 VAC, 60 Hz).

In an inverter, direct current (DC) is switched back and forth to produce alternating current (AC). Then it is transformed, filtered and stepped to get it to an acceptable output waveform. The more processing is required, cleaner and quieter the output, but lower the efficiency of the conversion. The goal becomes to produce a waveform that is acceptable to all loads without sacrificing too much power into the conversion process.

Inverters come in two basic designs - sine wave and modified sine wave. Most 120VAC devices can use the modified sine wave, but there are some notable exceptions. Devices such as laser printers which use triacs and/or silicon controlled rectifiers are damaged when provided mod-sine wave power. Motors and power supplies usually run warmer and less efficiently on mod-sine wave power. Some things, like fans, amplifiers, and cheap fluorescent lights, give off an audible buzz on modified sine wave power. However, modified sine wave inverters make the conversion from DC to AC very efficiently. They are relatively inexpensive, and many of the electrical devices we use every day work fine on them.

Sine wave inverters can virtually operate anything. Your utility company provides sine wave power, so a sine wave inverter is equal to or even better than utility supplied power. A sine wave inverter can "clean up" utility or generator supplied power because of its internal processing.

Inverters are made with various internal features and many permit external equipment interface. Common internal features are internal battery chargers which can rapidly charge batteries when an AC source such as a generator or utility power is connected to the inverter's INPUT terminals. Auto-transfer switching is also a common internal feature which enables switching from either one AC source to another and/or from utility power to inverter power for designated loads. Battery temperature compensation, internal relays to control loads, automatic remote generator starting/stopping and many other programmable features are available.

Most inverters produce 120VAC, but can be equipped with a step-up transformer to produce 120/240VAC. Some inverters can be series or parallel "stacked-interfaced" to produce 120/240VAC or to increase the available amperage.

## Selecting your solar equipment

1. Determine whether you need the solar power for generate electricity or heat.
2. If the solar power is needed for electricity generation, the next step is to determine whether the solar system is on-grid or off-grid. Most on-grid systems do not require battery. The electrical power generated goes directly for use in the equipments or light.
3. Proceed to the AC load calculation, collecting information on the various equipments and devices you would be running on solar power. List the equipment or light, the quantity, the wattage (usually informed in the equipment tag) and the number of hours the equipment will be running. [Click here](#) to find average wattage per equipment if this information from equipment tab is not available.
4. Do the same above for any equipment running on DC.
5. Enter the information above in the Load Calculation Work-form provided.
6. The AC Total Power Requirement line, in the AC Work-form, shows yours AC total load plus 25% to compensate for inverter losses. Remember, the DC current generated by the solar panels must be converted to AC current by the inverter.
7. The line in that form "Total load (AC+DC) shows both loads added.
8. The next step is to select the inverter input in DC (12, 24, or 48V). Inverters are rated in continuous wattage and surge watts. Continuous watts are the total watts the inverter can support continuously. A 2000 watt inverter can power up to 2000 watts continuously. Surge watts are the power the inverter can support during a surge period to support starting loads as in a motor. A 3000 surge watts can handle up to 3000 watts.
9. Enter the input for the inverter selected (12, 24 or 48) in the proper field in the Load Calculation Work-form.
10. If your system has a battery, enter the compensation for battery loss as provided:
11. Enter the Peak-amps of the solar module. This information is provided:
12. The Work-form will determine the number of panels in parallel based on the information provided so far.
13. Enter the number of panels in each series based on the provided table;
14. The total number of solar panels required for the intended load, based on an array of parallel and series solar panels is calculated.
15. If your system has a battery, continue by filling the Work-form where indicated.
16. Enter the number of continuous cloudy days in your area.
17. The Work-form determines the battery amp-hours based on the information entered so far.
18. Enter the adjustment figure for winter temperature if you are using lead-acid battery, based on the information provided.
19. Enter the amp-hours of the battery you choose.
20. The Work-form determines the number of batteries in parallel to meet the load requirement.