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Wind Energy Basics

Wind power is a renewable resource that has exciting potential for the future. Wind is created by the sun's uneven heating of the earth's water and land surfaces. Land absorbs more heat than water. As long as the sun shines, the wind will blow, creating a source of power or electricity for our use. Today modern wind turbines are appearing on our horizon on land and on sea. As with any source of energy, there are advantages, disadvantages, and challenges to using the wind. Wind turbines can be loud, troublesome for birds and neighbors. However, wind is free, and clean, making it an increasingly important source of energy as countries across the world set goals for a more sustainable future.

Wind Energy and Wind Power

Wind is a form of **solar energy**. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain. bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern **wind turbines**, can be used to generate **electricity**.

How Wind Power Is Generated

The terms "**wind energy**" or "**wind power**" describe the process by which the wind is used to generate **mechanical power or electricity**. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like.

Wind Turbines

Wind turbines, like aircraft propeller blades, turn in the moving air and power an **electric generator** that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Wind Turbine Types:

Modern wind turbines fall into two basic groups; the **horizontal-axis** variety, like the traditional farm windmills used for pumping water, and the **vertical-axis** design, like the eggbeater-style Darrieus model, named after its French inventor. Most large modern wind turbines are horizontal-axis turbines.

Turbine Components:

Horizontal turbine components include:

- **blade** or **rotor**, which converts the energy in the wind to rotational shaft energy;
- a **drive train**, usually including a gearbox and a generator;
- a **tower** that supports the rotor and drive train; and
- other equipment, including controls. electrical cables, ground support equipment, and interconnection equipment.

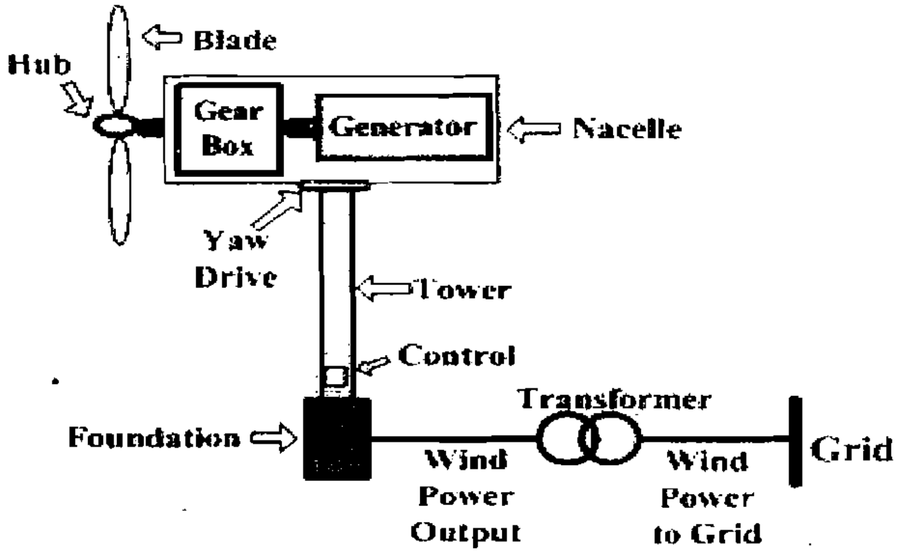
Horizontal Axis Wind Turbines

In the wind turbine business there are basically two types of turbines to choose from, vertical axis wind turbines and horizontal axis wind turbines. They both have their advantages and disadvantages and the purpose of this article is to help you choose the right system for your application.

Horizontal axis wind turbine dominate the majority of the wind industry. Horizontal axis means the rotating axis of the wind turbine is horizontal, or parallel with the ground. In big wind application, horizontal axis wind turbines are almost all you will ever see. However, in small wind and residential wind applications. vertical axis turbines have their place. The advantage of horizontal wind is that it is able to produce more electricity from a given amount of wind. So if you are trying to produce as much wind as possible at all times, horizontal axis is likely the choice for you. The disadvantage of horizontal axis however is that it is generally heavier and it does not produce well in turbulent winds.

Vertical axis wind turbine

In comes the vertical axis wind turbine. With vertical axis wind turbines the rotational axis of the turbine stands vertical or perpendicular to the ground. As mentioned above, vertical axis turbines are primarily used in small wind projects and residential applications.Vertical-Axis-Wind-Turbine This niche comes from the OEM's claims of a vertical axis turbines ability to produce well in tumultuous wind conditions. Vertical axis turbines are powered by wind coming from all 360 degrees. and even some turbines are powered when the wind blows from top to bottom. Because of this versatility, vertical axis wind turbines are thought to be ideal for installations where wind conditions are not consistent, or due to public ordinances the turbine cannot be placed high enough to benefit from steady wind.



Wind turbine diagram

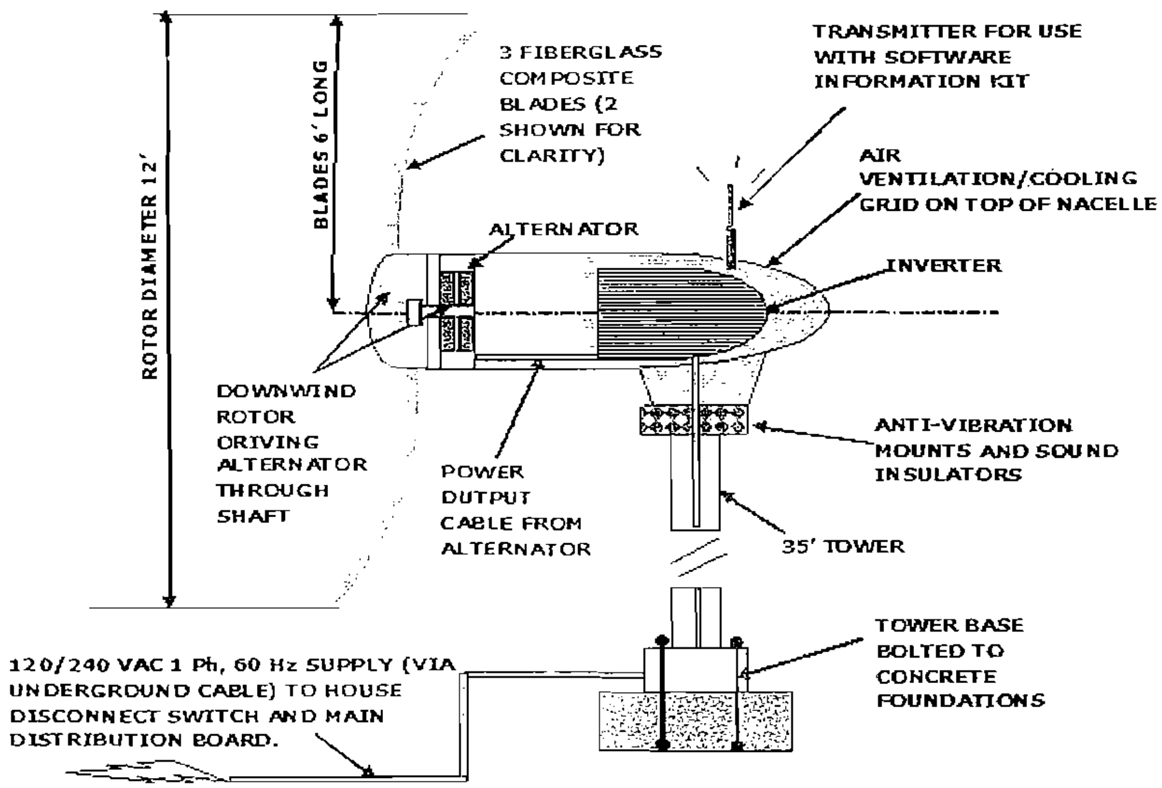
Turbine Configurations:

Wind turbines are often grouped together into a single wind power plant, also known as a **wind farm**, and generate bulk electrical power. Electricity from these turbines is fed into a utility grid and distributed to customers, just as with conventional power plants.

Wind Turbine Size and Power Ratings:

Wind turbines are available in a variety of sizes, and therefore power ratings. The largest machine has blades that span more than the length of a football field, stands 20 building stories high, and produces enough electricity to power 1,400 homes. A small home-sized wind machine has rotors between 8 and 25 feet in diameter and stands upwards of 30 feet and can supply the power needs of an all-electric home or small business. **Utility-scale turbines** range in size from 50 to 750 kilowatts. Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping.

WORKING COMPONENTS;



SKYSTREAM 3.7 RESIDENTIAL WIND TURBINE RATED CAPACITY 2.4kW

Drawn by Willie Scott 21/10/2010

The Sky stream has the following features:

1. Blades – These are swept blades and designed to be quiet, efficient, and safe. Their main advantage is in their shape and their tip speed being electronically controlled.
2. Real-time Monitoring - This is enabled by software supplied by Skystream, which when downloaded transmits the turbine operating and output values and conditions wirelessly, through an on board transmitter.
3. Alternator – This is a unique neodymium permanent magnet, non-slotted design which is directly driven by the turbine rotor.
4. Rectifier – Converts the current and voltage to household suit supply from grid.
5. Noise Reduction – Noise reduction is achieved by the electronic control of blade tip speed. The direct drive requires no gearbox, and anti-vibration bolts between the nacelle mounting and the tower provide additional quieting.
6. Tower – The 35' tower enables the turbine to use optimum air currents. This is the same height used for wind socks at aerodromes.

Advantages and Disadvantages of Wind-Generated Electricity

A Renewable Non-Polluting Resource:

Wind energy is a **free, renewable resource**, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of **clean, non-polluting, electricity**. Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases. According to the U.S. Department of Energy, in 1990, California's wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide, and 15 million pounds of other pollutants that would have otherwise been produced. It would take a forest of 90 million to 175 million trees to provide the same air quality.

Cost Issues:

Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires a **higher initial investment** than fossil-fueled generators. Roughly 80% of the cost is the machinery, with the balance being site preparation and installation. If wind generating systems are compared with fossil-fueled systems on a "life-cycle" cost basis (counting fuel and operating expenses for the life of the generator), however, wind costs are much more competitive with other generating technologies because there is no fuel to purchase and minimal operating expenses.

Environmental Concerns:

Although wind power plants have relatively little impact on the environment compared to fossil fuel power plants, there is some concern over the **noise** produced by the rotor blades, **aesthetic (visual) impacts**, and birds and bats having been killed (**avian/bat mortality**) by flying into the rotors. Most of these problems have been resolved or greatly reduced through technological development or by properly siting wind plants.

Supply and Transport Issues:

The major challenge to using wind as a source of power is that it is **intermittent** and does not always blow when electricity is needed. Wind cannot be stored (although wind-generated electricity can be stored, if batteries are used), and not all winds can be harnessed to meet the timing of electricity demands. Further, good wind sites are often located in **remote locations** far from areas of electric power demand (such as cities). Finally, wind resource development may compete with other uses for the land, and those **alternative uses** may be more highly valued than electricity generation. However, wind turbines can be located on land that is also used for grazing or even farming.

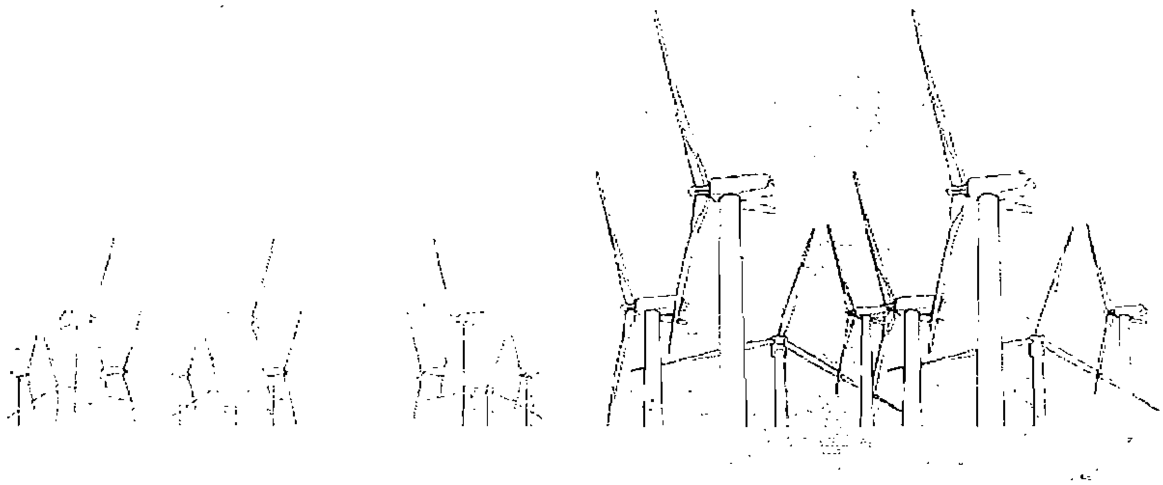
➢ WIND ENERGY MANAGEMENT PROCEDURE:

Wind power is a renewable resource that has exciting potential for the future. Wind is created by the sun's uneven heating of the earth's water and land surfaces. Land absorbs more heat than water. As long as the sun shines, the wind will blow, creating a source of power or electricity for our use. Today modern wind turbines are appearing on our horizon on land and on sea. As with any source of energy, there are advantages, disadvantages, and challenges to using the wind. Wind turbines can be loud, troublesome for birds and neighbors. However, wind is free, and clean, making it an increasingly important source of energy as countries across the world set goals for a more sustainable future.

Activity 1 – draw a wind diagram

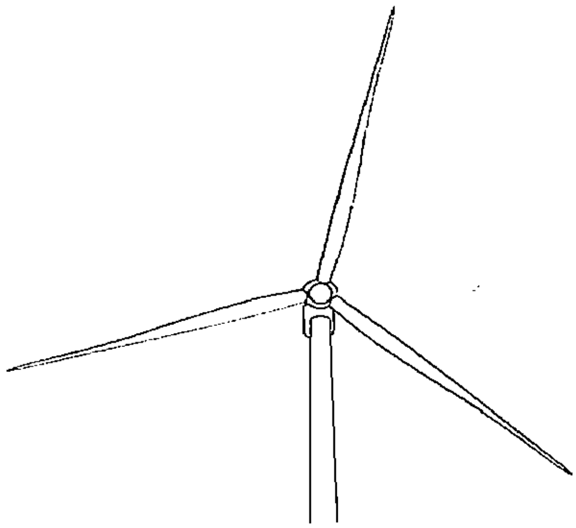
Wind blows. While March is considered by many the month that comes in 'like a lion', winds are constantly moving across the surface of the earth all year round. Wind is moving air. Sometimes we can see the effect of wind on waves in a lake or clouds moving in the sky. What other ways do you have of telling if the wind is blowing? The sun heats the air when it shines on the earth. Land heats up faster than water. Cool air moves over the water and onto the land. Warm air rises over land. Draw a diagram of air movement over land and water dotting warm air red and cooler air blue. Be sure to show the sun!

Activity 2 – Capture the wind:



Design and make a mini wind turbine (pinwheel). If possible, try reusing existing materials such as paper from an old magazine or newspaper. You will need a straw, a push pin, a square piece of paper, colored pencils or markers and scissors. First cut out a square from your magazine/ newspaper or paper. Color both sides. Next fold your square corner to corner; using your scissors, cut into each fold about 2/3 of the way toward the center. Now fold every other fold into the center of your pinwheel. Put a pin through the points of the center through your paper into the straw. Test your pinwheel by blowing on it. Now take your pinwheel outside and catch some wind.

Activity 3 – Be a wind detective:



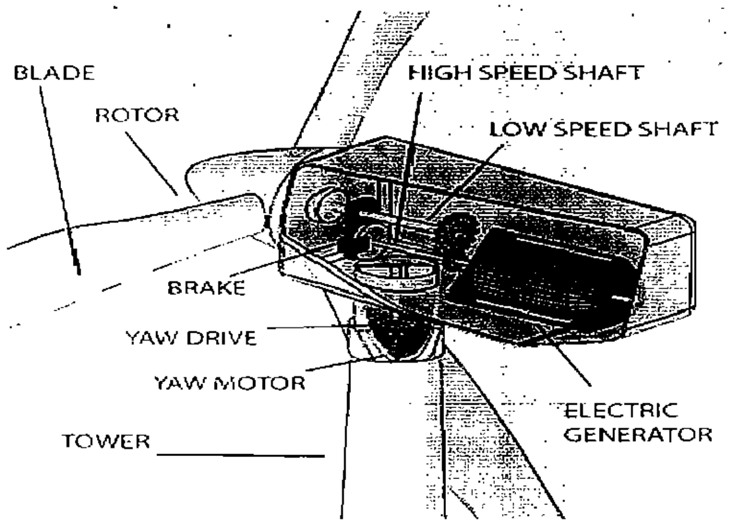
Where does the wind blow? Where does the wind blow the strongest and longest? Take a look at the following Interactive Energy Map.

Wind Potential Map

Find the state that has 4% of its power from wind. What state powers more schools from the wind than any other?

Now identify three locations in the U.S. that could be used for wind farming. Remember that wind farms can be on both land and sea. Consider the wind potential and access to the power grid. Take into account how the wind farm may affect its neighbors. Write a short paper about the importance of wind power and propose a new wind farm near your community.

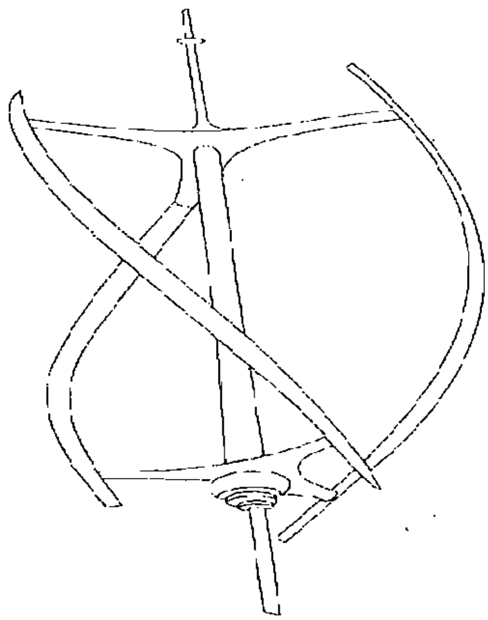
Activity 4 – diagram a wind turbine



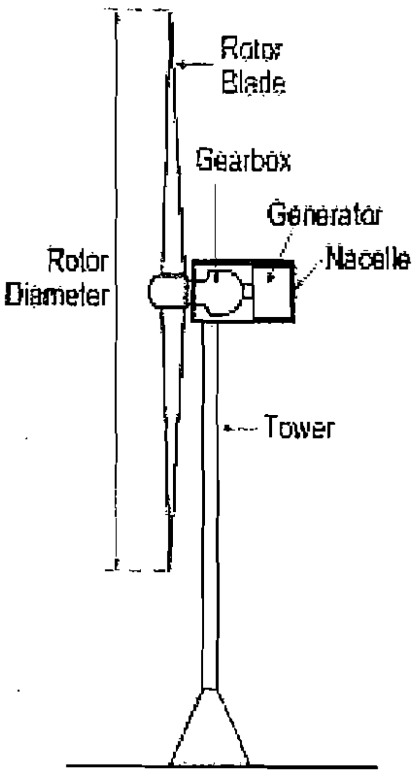
Charles F. Brush, one of the founders of the American electrical industry built what is thought to be the first automatically operating wind turbine. Considered the world's largest at fifty feet in diameter with 144 rotor blades, it surprisingly only generated enough to power batteries at 12 kW. Dane Paul la Cour is credited with learning that fewer rotor blades turned more quickly and created more electricity.

Using this wind turbine diagram, make a sketch and label the parts of a wind turbine. The **tower** provides the structural support for the rotor or turning blade. The **foundation** secures the tower to the ground, ocean floor or building. The **nacelle** connects the rotor to the tower and allows it to turn with the wind. The **transformer** changes the turns of the rotor into electricity.

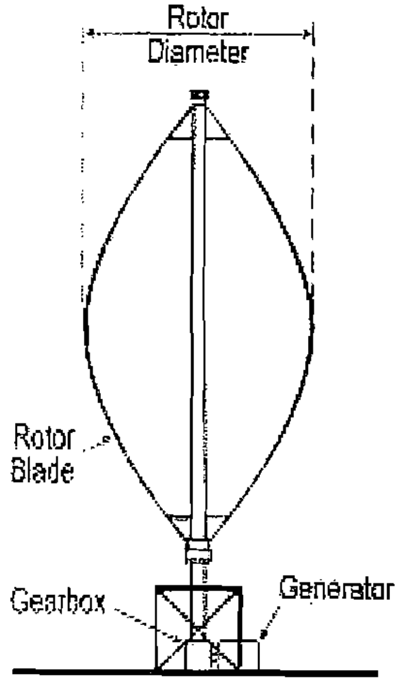
Activity 5 – Design a wind turbine



Research the different types of wind turbines and the electricity they generate using the Internet. Document at least five different kinds. Surprisingly, turbines can be oriented horizontally or vertically. Some are open, some enclosed. Some have rotary fins while others have spiral fins. Look at different manufacturers of wind turbines and compare their cost, energy output, and material make up. Then, sketch your own wind turbine design with each of the five main parts: tower, nacelle, transformer, rotor, and foundation. Can you think of ways to improve a wind turbine? Will you use new materials? Will you generate more electricity? Will you choose to give a vertical wind turbine a new look? Will you be using a number of small turbines or one larger turbine? Write a paragraph about your turbine concept, describing the basic idea and how the wind turbine will affect its surroundings and contribute energy to the



Horizontal Axis



Vertical Axis

Solar power is arguably the cleanest, most reliable form of **renewable energy** available, and it can be used in several forms to help power your home or business. **Solar-powered** photovoltaic (PV) panels convert the sun's rays into electricity by exciting electrons in silicon cells using the photons of light from the sun. This electricity can then be used to supply **renewable energy** to your home or business.

To understand this process further, let's look at the solar energy components that make up a complete solar power system.

The roof system

In most **solar systems, solar panels** are placed on the roof. An ideal site will have no shade on the panels, especially during the prime sunlight hours of 9 a.m. to 3 p.m.; a south-facing installation will usually provide the optimum potential for your system, but other orientations may provide sufficient production. Trees or other factors that cause shading during the day will cause significant decreases to power production. The importance of shading and efficiency cannot be overstated.

In a **solar panel**, if even just one of its 36 cells is shaded, **power production** will be reduced by more than half. Experienced installation contractors such as NW Wind & Solar use a device called a Solar Pathfinder to carefully identify potential areas of shading prior to installation.

Not every roof has the correct orientation or angle of inclination to take advantage of the sun's energy. Some systems are designed with pivoting panels that track the sun in its journey across the sky. Non-tracking PV systems should be inclined at an angle equal to the site's latitude to absorb the maximum amount of energy year-round. Alternate orientations and/or inclinations may be used to optimize energy production for particular times of day or for specific seasons of the year.

Solar panels

Solar panels, also known as modules, contain photovoltaic cells made from silicon that transform incoming sunlight into electricity rather than heat. ("Photovoltaic" means electricity from light — photo = light, voltaic = electricity.)

Solar photovoltaic cells consist of a positive and a negative film of silicon placed under a thin slice of glass. As the photons of the sunlight beat down upon these cells, they knock the electrons off the silicon. The negatively-charged free electrons are preferentially attracted to one side of the silicon cell, which creates an electric voltage that can be collected and channeled. This current is gathered by wiring the individual solar panels together in series to form a solar photovoltaic array. Depending on the size of the installation, multiple strings of solar photovoltaic array cables terminate in one electrical box, called a fused array combiner. Contained within the combiner box are fuses designed to protect the individual module cables, as well as the connections that deliver power to the inverter. The electricity produced at this stage is DC (direct current) and must be converted to AC (alternating current) suitable for use in your home or business.

Inverter

The inverter is typically located in an accessible location, as close as practical to the modules. In a residential application, the inverter is often mounted to the exterior sidewall of the home near the electrical main or sub panels. Since inverters make a slight noise, this should be taken into consideration when selecting the location.

The inverter turns the DC electricity generated by the solar panels into 120-volt AC that can be put to immediate use by connecting the inverter directly to a dedicated circuit breaker in the electrical panel.

The inverter, electricity production meter, and electricity net meter are connected so that power produced by your solar electric system will first be consumed by the electrical loads currently in operation. The balance of power produced by your solar electric system passes through your electrical panel and out onto the electric grid. Whenever you are producing more electricity from your solar electric system than you are immediately consuming, your electric utility meter will turn backwards!

Net meter

In a solar electric system that is also tied to the utility grid, the DC power from the solar array is converted into 120/240 volt AC power and fed directly into the utility power distribution system of the building. The power is "net metered," which means it reduces demand for power from the utility when the solar array is generating electricity – thus lowering the utility bill. These grid-tied systems automatically shut off if utility power goes offline, protecting workers from power being back fed into the grid during an outage. These types of solar-powered electric systems are known as "on grid" or "battery-less" and make up approximately 98% of the solar power systems being installed today.

Other benefits of solar:

By lowering a building's utility bills, these systems not only pay for themselves over time, they help reduce air pollution caused by utility companies.

For example, solar power systems help increase something called "peak load generating capacity," thereby saving the utility from turning on expensive and polluting supplemental systems during periods of peak demand.

The more local-generating solar electric power systems that are installed in a given utility's service area, the less capacity the utility needs to build, thus saving everyone from funding costly additional power generating sources.

Contributing clean, green power from your own solar electric system helps create jobs and is a great way to mitigate the pollution and other problems produced by electricity derived from fossil fuel.

Solar-powered electrical generating systems help you reduce your impact on the environment and save money at the same time!

SOLAR ENERGY:

Solar energy works by capturing the sun's energy and turning it into electricity for your home or business.

Our sun is a natural nuclear reactor. It releases tiny packets of energy called photons, which travel the 93 million miles from the sun to Earth in about 8.5 minutes. Every hour, enough photons impact our planet to generate enough solar energy to theoretically satisfy global energy needs for an entire year.

Currently photovoltaic power accounts for only five-tenths of one percent of the energy consumed in the United States. But solar technology is improving and the cost of going solar is dropping rapidly, so our ability to harness the sun's abundance of energy is on the rise.

A 2017 report from the International Energy Agency shows that solar has become the world's fastest-growing source of power – marking the first time that solar energy's growth has surpassed that of all other fuels. In the coming years, we will all be enjoying the benefits of solar-generated electricity in one way or another.

How Do Solar Panels Work?

When photons hit a solar cell, they knock electrons loose from their atoms. If conductors are attached to the positive and negative sides of a cell, it forms an electrical circuit. When electrons flow through such a circuit, they generate electricity. Multiple cells make up a solar panel, and multiple panels (modules) can be wired together to form a solar array. The more panels you can deploy, the more energy you can expect to generate.

What are Solar Panels made of ?

Photovoltaic (PV) solar panels are made up of many solar cells. Solar cells are made of silicon, like semiconductors. They are constructed with a positive layer and a negative layer, which together create an electric field, just like in a battery.

How Do Solar Panels Generate Electricity?

PV solar panels generate direct current (DC) electricity. With DC electricity, electrons flow in one direction around a circuit. This example shows a battery powering a light bulb. The electrons move from the negative side of the battery, through the lamp, and return to the positive side of the battery.

With AC (alternating current) electricity, electrons are pushed and pulled, periodically reversing direction, much like the cylinder of a car's engine. Generators create AC electricity when a coil of wire is spun next to a magnet. Many different energy sources can "turn the handle" of this generator, such as gas or diesel fuel, hydroelectricity, nuclear, coal, wind, or solar.

AC electricity was chosen for the U.S. electrical power grid, primarily because it is less expensive to transmit over long distances. However, solar panels create DC electricity. How do we get DC electricity into the AC grid? We use an inverter.

What Does a Solar Inverter Do?

A solar inverter takes the DC electricity from the solar array and uses that to create AC electricity. Inverters are like the brains of the system. Along with inverting DC to AC power, they also provide ground fault protection and system stats, including voltage and current on AC and DC circuits, energy production and maximum power point tracking.

Central inverters have dominated the solar industry since the beginning. The introduction of micro-inverters is one of the biggest technology shifts in the PV industry. Micro-inverters optimize for each individual solar panel, not for an entire solar system, as central inverters do. This enables every solar panel to perform at maximum potential. When a central inverter is used, having a problem on one solar panel (maybe it's in the shade or has gotten dirty) can drag down the performance of the entire solar array. Micro-inverters, such as the ones in SunPower's Equinox home solar system, make this a non-issue. If one solar panel has an issue, the rest of the solar array still performs efficiently.

How Does a Solar Panel System Work?

Here's an example of how a home solar energy installation works. First, sunlight hits a solar panel on the roof. The panels convert the energy to DC current, which flows to an inverter. The inverter converts the electricity from DC to AC, which you can then use to power your home. It's beautifully simple and clean, and it's getting more efficient and affordable all the time.

However, what happens if you're not home to use the electricity your solar panels are generating every sunny day? And what happens at night when your solar system is not generating power in real time? Don't worry, you still benefit through a system called "net metering."

A typical grid-tied PV system, during peak daylight hours, frequently produces more energy than one customer needs, so that excess energy is fed back into the grid for use elsewhere. The customer gets credit for the excess energy produced, and can use that credit to draw from the conventional grid at night or on cloudy days. A net meter records the energy sent compared to the energy received from the grid. Find out more about net metering here.