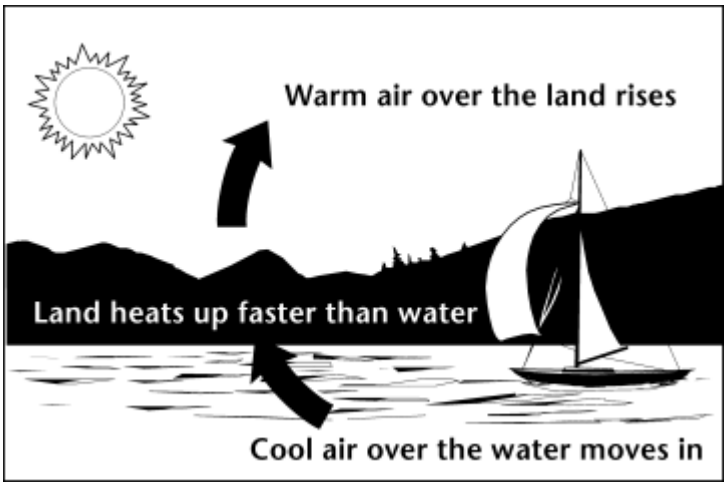
Wind Power — Energy from Moving Air

Wind is air in motion. It is produced by the uneven heating of the Earth's surface by the sun. Since the Earth's surface is made of various land and water formations, it absorbs the sun's radiation unevenly. When the sun is shining during the day, the air over landmasses heats more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air over water moves in to take its place, creating local winds. At night, the winds are reversed because the air cools more rapidly over land than over water. Similarly, the large atmospheric winds that circle the earth are created because the surface air near the equator is warmed more by the sun than the air over the North and South Poles. Wind is called a renewable energy source because wind will be continually produced as long as the sun shines on the Earth. Today, wind energy is mainly used to generate electricity.



The History of Wind

Throughout history, people have harnessed the wind in many ways. More than 5,000 years ago, the ancient Egyptians used wind power to sail their ships on the Nile River. Later, people built windmills to run equipment and grind grain. The earliest known windmills, in Persia (Iran), looked like large paddle wheels.

Centuries later, the people of Holland improved the basic design of the windmill. They gave it propeller-type blades made of fabric sails and invented ways for it to change direction so that it could continually face the wind. Windmills helped Holland become one of the world's most industrialized countries by the 17th century.

American colonists used windmills to grind wheat and corn, pump water, and cut wood. As late as the 1920s, Americans used small windmills to generate electricity in rural areas without electric service. When power lines began to transport electricity to rural areas in the 1930s, local windmills were used less and less, though they can still be seen on some western ranches.

The oil shortages of the 1970s changed the energy picture for the country and the world. It created an environment more open to alternative energy sources, paving the way for the re-entry of the windmill into the American landscape for electricity generation.

Windmill Mechanics

Windmills work because they slow down the speed of the wind. The wind flows over the airfoil-shaped blades causing lift, like the effect on airplane wings, causing them to turn. The blades are connected to a drive shaft that turns an electric generator to produce electricity.

Wind Machines Today

Today's wind machines are more technologically advanced than early windmills. They still use blades to collect the wind's kinetic energy, but the blades are made of fiberglass or high-strength materials.

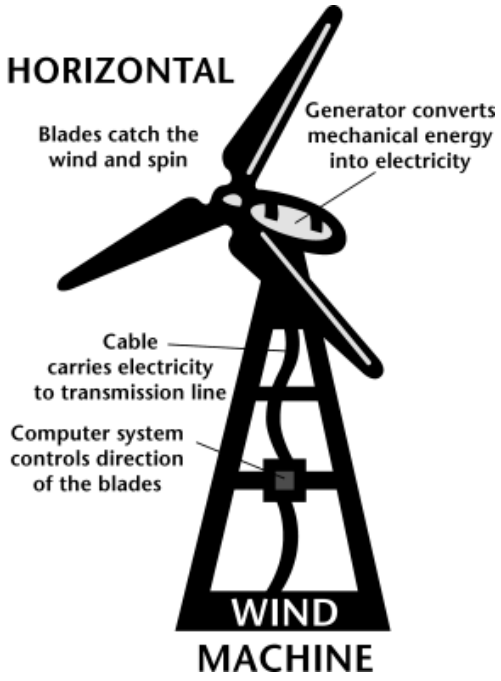
Engineers who design modern wind machines are still wrestling with the problem of what to do when the wind does not blow. Large turbines are connected to the utility power network — so some other type of generator picks up the load when there is no wind. Small turbines are sometimes connected to

diesel or electric generators, or sometimes have a battery to store the excess energy collected when the wind is blowing hard.

Windmill Types

Two types of wind machines are commonly used today, the horizontal–axis with blades like airplane propellers and the vertical–axis, which looks like an egg-beater.

Horizontal-axis wind machines are more common because they use less material per unit of electricity produced. About 95% of all wind machines are horizontal-axis. A typical horizontal wind machine stands as tall as a 20-story building and has three blades that span ~60 meters (200 feet) across. The largest wind machines in the world have blades longer than a football field! Wind machines stand tall and wide to capture more wind.



Vertical-axis wind machines make up just 5% of the wind machines used today. The typical vertical wind machine stands 30 meters (100 feet) tall and 15 meters (50 feet) wide. Each wind machine has its advantages and disadvantages. Horizontal-axis machines need a way to keep the rotor facing the wind. This is done with a tail on small machines. On large turbines, either the rotor is located downwind of the tower to act like a weather vane, or a drive motor is used. Vertical-axis machines can accept wind from any direction.

Both types of turbine rotors are turned by air flowing over their wing-shaped blades. Vertical-axis blades lose energy as they turn out of the wind, while horizontal-axis blades work all the time. At many sites, the wind increases higher above the ground, giving an advantage to tall horizontal-axis turbines. The small tower and ground-mounted generators on vertical-axis turbines make them cheaper and easier to maintain.

Wind Power Plants

Wind power plants, or wind farms, are clusters of wind machines used to produce electricity. A wind farm usually has dozens of wind machines scattered over a large area.

Unlike coal or nuclear plants, many wind plants are not owned by public utility companies. Instead they are owned and operated by business people who sell the electricity produced on the wind farm to electric utilities. These private companies are known as independent power producers.

Operating a wind power plant is not as simple as plunking down machines on a grassy field. Wind plant owners must carefully plan where to locate their machines. They consider wind availability (how much the wind blows), local weather conditions, proximity to electrical transmission lines, and local zoning codes.

Wind plants also need a lot of land. One wind machine needs about two acres of land to call its own. A wind power plant takes up hundreds of acres. On the plus side, farmers can grow crops or graze cattle around the machines once they have been installed.

After a plant has been built, there are still maintenance costs. In some states, maintenance costs are offset by tax breaks given to power plants that use renewable energy sources. The Public Utility

Regulatory Policies Act, or PURPA, also requires utility companies to purchase electricity from independent power producers at rates that are fair and non-discriminatory.

Wind Resources

Where is the best place to build a wind plant? There are many good sites for wind plants in the U.S. including California, Alaska, Hawaii, the Great Plains, and mountainous regions. Engineers say there is enough wind in 37 states to produce electricity. An average wind speed of 23 kph (14 mph) is needed to convert wind energy into electricity economically. The average wind speed in the U.S. is 16 kph (10 mph). Because of the availability of consistent wind, some companies are considering installing wind machines offshore. Scientists use an instrument called an anemometer to measure how fast the wind is blowing. An anemometer looks like a modern-style weather vane. It has three spokes with cups that spin on a revolving wheel when the wind blows. It is hooked up to a meter that tells the wind speed. A weather vane shows the direction of the wind, not the speed.

As a rule, wind speed increases with altitude and over open areas with no windbreaks. Good sites for wind plants are the tops of smooth, rounded hills, open plains or shorelines, and mountain gaps that produce wind funneling. The three biggest wind plants in California are located at mountain gaps.

Wind speed varies throughout the country. It also varies from season to season. In Tehachapi, California, the wind blows more from April through October than it does in the winter. This is because of the extreme heating of the Mojave Desert during the summer months. The hot air over the desert rises, and the cooler, denser air above the Pacific Ocean rushes through the Tehachapi mountain pass to take its place. In a state like Montana, on the other hand, the wind blows more during the winter.

These seasonal variations are a good match for the electricity demands of the regions. In California, people use more electricity during the summer when air conditioners are used for cooling. Conversely, more people use electricity in Montana during winter heating months.

Wind Energy Economics

On the economic front, there is a lot of good news for wind energy. First, a wind plant is far less expensive to construct than a conventional energy plant. Wind plants can simply add wind machines as electricity demand increases.

Second, the cost of producing electricity from the wind has dropped dramatically in the last two decades. Electricity generated by the wind cost 30 cents per kWh in 1975, but now costs less than five cents per kWh. New turbines are lowering the cost even more.

Wind and the Environment

In the 1970s, oil shortages pushed the development of alternative energy sources. In the 1990s, the push came from a renewed concern for the environment in response to scientific studies indicating potential changes to the global climate if the use of fossil fuels continues to increase. Wind energy offers a viable, economical alternative to conventional power plants in many areas of the country. Wind is a clean fuel; wind farms produce no air or water pollution because no fuel is burned.

The most serious environmental drawbacks to wind machines may be their negative effect on wild bird populations and the visual impact on the landscape. To some, the glistening blades of windmills on the horizon are an eyesore; to others, they are a beautiful alternative to conventional power plants.

Reading Source: Wind Energy — Energy from Moving Air, Kid's Page, Energy Information Administration, U.S. Department of Energy, Accessed October 12, 2005, http://www.eia.doe.gov/kids/energyfacts/sources/renewable/wind.html.