

## Renewable Wind

### Wind Basics

#### Energy from Moving Air

Wind is simply air in motion. It is caused by the uneven heating of the Earth's surface by the sun. Because the Earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates.

#### The Daily Wind Cycle

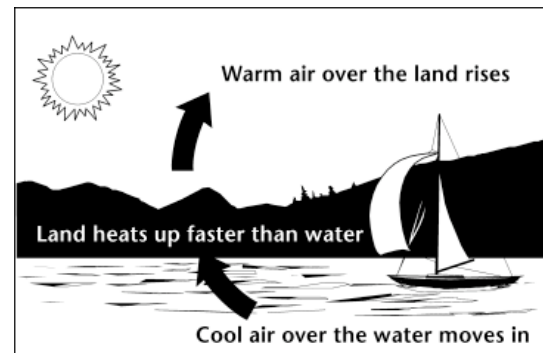
During the day, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air rushes in to take its place, creating wind. At night, the winds are reversed because the air cools more rapidly over land than over water.

In the same way, the atmospheric winds that circle the earth are created because the land near the Earth's equator is heated more by the sun than the land near the North and South Poles.

#### Wind Energy for Electricity Generation

Today, wind energy is mainly used to generate electricity. Wind is a renewable energy source because the wind will blow as long as the sun shines.

**How Uneven Heating of Water and Land Causes Wind**



# Electricity Generation from Wind

## How Wind Turbines Work

Current Map of U.S. Wind Capacity

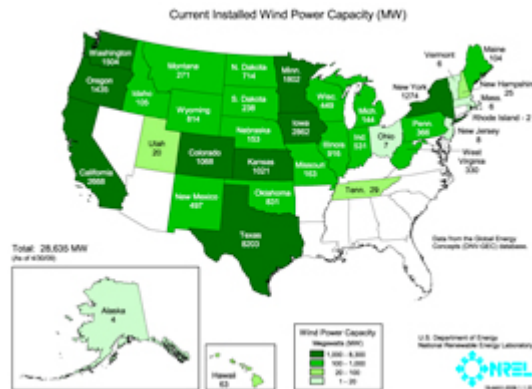
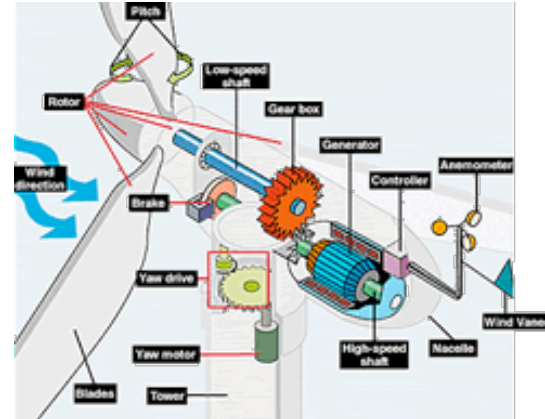


Diagram of Windmill Workings



Note: [See progress of installed wind capacity between 1999 and 2009](#)

Like old fashioned windmills, today's wind machines (also called wind turbines) use blades to collect the wind's kinetic energy. The wind flows over the blades creating lift, like the effect on airplane wings, which causes them to turn. The blades are connected to a drive shaft that turns an electric generator to produce electricity.

With the new wind machines, there is still the problem of what to do when the wind isn't blowing. At those times, other types of power plants must be used to make electricity.

## Wind Production

In 2008, wind machines in the United States generated a total of 52 billion kilowatthours, about 1.3% of total U.S. electricity generation. Although this is a small fraction of the Nation's total electricity production, it was enough electricity to serve 4.6 million households or to power the entire State of Colorado.

The amount of electricity generated from wind has been growing rapidly in recent years. Generation from wind in the United States nearly doubled between 2006 and 2008.

New technologies have decreased the cost of producing electricity from wind, and growth in wind power has been encouraged by tax breaks for renewable energy and [green pricing programs](#). Many utilities around the country offer green pricing options that allow customers the choice to pay more for electricity that comes from renewable sources to support new technologies.

## Where Wind is Harnessed

### Wind Power Plants Require Careful Planning

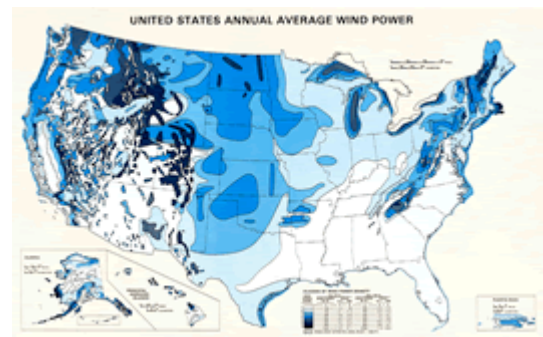
Operating a wind power plant is not as simple as just building a windmill in a windy place. Wind plant owners must carefully plan where to locate their machines. One important thing to consider is how fast and how much the wind blows at proposed locations.

As a rule, wind speed increases with altitude and over open areas that have 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.

### Wind Speed Is Not the Same Across the Country

Wind speed varies throughout the United States. 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

Map of U.S. Wind Resources



Source: National Renewable Energy Laboratory, U.S. Department of Energy

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.

Fortunately, these seasonal variations are a good match for the electricity demands of the regions. In California, people use more electricity during the summer for air conditioners. In Montana, people use more electricity during the winter for heating.

## **Major Wind Power Locations**

Wind turbines (sometimes called wind machines) generated electricity in 31 different States in 2008. The States with the most wind production are Texas, California, Iowa, Minnesota, and Oklahoma.

## **International Wind Power**

Most of the wind power plants in the world are located in Europe and in the United States where government programs have helped support wind power development. As of 2008, the United States ranks first in the world in wind power capacity, followed by Germany, Spain, and China. Denmark ranks ninth in the world in wind power capacity, but generates about 20% of its electricity from wind.

**Wind Turbines in the Ocean**



## **Offshore Wind Power**

Conditions are well suited along much of the coasts of the United States to use wind energy. However, there are people oppose putting turbines just offshore, near the coastlines. People think the wind turbines will spoil the view of the ocean. Right now, there is a plan to build an offshore wind plant off the coast of

Cape Cod, Massachusetts.

Wind is a renewable energy source that does not pollute, so some people see it as a good alternative to fossil fuels.

## Types of Wind Turbines

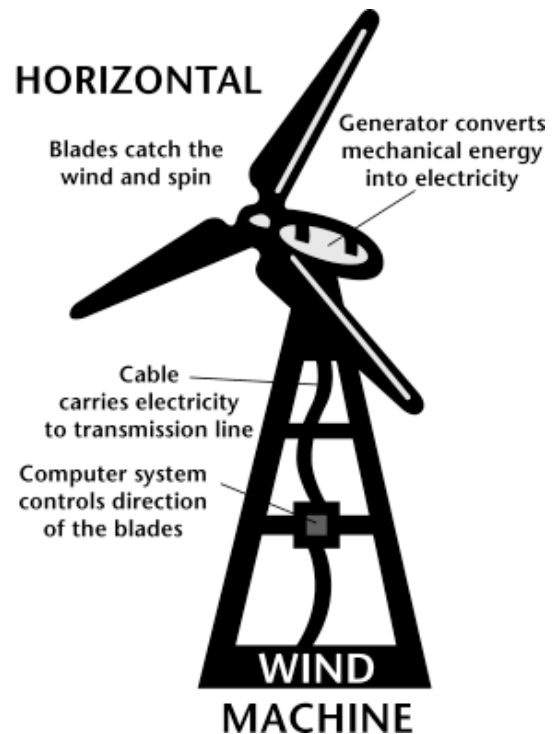
Darrieus Vertical Wind Turbine in Martigny, Switzerland



Photo credit: Wikimedia

Commons author Lysippos

Horizontal wind machine.



There are two types of wind machines (turbines) used today, based on the direction of the rotating shaft (axis): horizontal-axis wind machines and vertical-axis wind machines. The size of wind machines varies widely. Small turbines used to power a single home or business may have a capacity of less than 100 kilowatts. Some large commercial-sized turbines may have a capacity of 5 million watts, or 5 megawatts. Larger turbines are often grouped together into wind farms that provide power to the electrical grid.

## **Horizontal-axis Turbines Look Like Windmills**

Most wind machines being used today are the horizontal-axis type.

Horizontal-axis wind machines have blades like airplane propellers. A typical horizontal wind machine stands as tall as a 20-story building and has three blades that span 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 Turbines Look Like Egg Beaters**

Vertical-axis wind machines have blades that go from top to bottom. The most common type — the Darrieus wind turbine, named after the French engineer Georges Darrieus who patented the design in 1931 — looks like a giant, two-bladed egg beater. This type of vertical wind machine typically stands 100 feet tall and 50 feet wide. Vertical-axis wind machines make up only a very small share of the wind machines used today.

## **Wind Power Plants Produce Electricity**

Wind power plants, or wind farms, as they are sometimes called, are clusters of wind machines used to produce electricity. A wind farm usually has dozens of wind machines scattered over a large area. The world's largest wind farm, the Horse Hollow Wind Energy Center in Texas, has 421 wind turbines that generate enough electricity to power 220,000 homes per year.

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.

## **History of Wind Power**

### **The Oldest Windmills Were in Ancient Persia**

Since ancient times, people have harnessed the wind's energy. Over 5,000 years ago, the ancient Egyptians used wind to sail ships on the Nile River. Later, people built windmills to grind wheat and other grains. The earliest known windmills were in Persia (now called Iran). These early windmills looked like large paddle wheels. Centuries later, the people of Holland improved the basic design of the windmill. They gave it propeller-type blades, still made with sails. Holland's windmills are world renowned.

**Traditional Dutch-type Windmill**



American colonists used windmills to grind wheat and corn, to pump water, and to cut wood at sawmills. 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.

## **Windmills Make a Comeback in the Wake of Oil Shortages**

The oil shortages of the 1970s changed the energy picture for the Country and the world. It created an interest in alternative energy sources, paving the way for the re-entry of the windmill to generate electricity. In the early 1980s, wind energy really took off in California, partly because of State policies that encouraged renewable energy sources.

## **Wind Energy & the Environment**

### **Wind: A Clean Fuel**

In the 1970s, oil shortages pushed the development of alternative energy sources. In the 1990s, the push came from a renewed concern for

**Wind Farm**

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 is an economical power resource in many areas of the country.

Wind is a clean fuel; wind power plants (also called wind farms) produce no air or water pollution because no fuel is burned to generate electricity. Growing concern about emissions from fossil fuel generation, increased government support, and higher costs for fossil fuels (especially natural gas and coal) have helped wind power capacity in the United States grow substantially over the past 10 years.



### **Drawbacks of Wind Machines**

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're a beautiful alternative to conventional power plants.