

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. One example of this uneven heating can be found in the daily wind cycle.

The Daily Wind Cycle

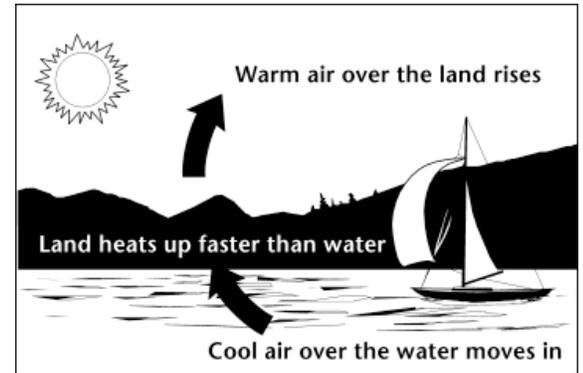
During the day, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air rushes in to take its place, creating wind. At night, the winds are reversed because the air cools more rapidly over land than over water.

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

How Uneven Heating of Water and Land Causes Wind



Source: National Energy
Education Development Project
(Public Domain)

source because the wind will blow as long as the sun shines.

Electricity Generation from Wind

How Wind Turbines Work

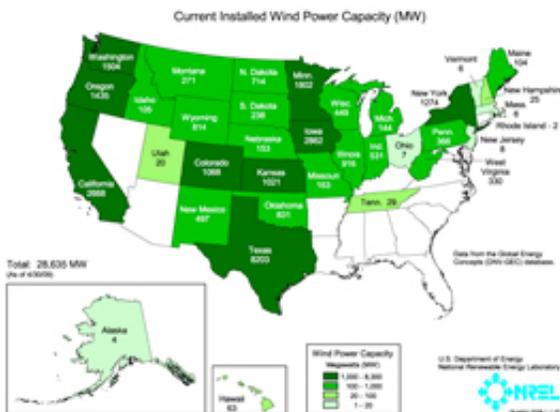
Like old fashioned windmills, today's wind machines (also called wind turbines) use blades to collect the wind's kinetic energy. The wind flows over the blades creating lift, like the effect on airplane wings,

Top Wind Power Producing States, 2011



Source: U.S. Energy Information Administration, *Electric Power Monthly*, Table 1.17.B (February 2012).

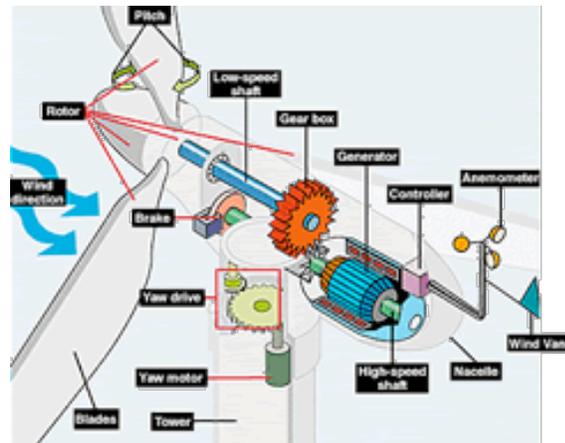
Map of U.S. Wind Capacity



Note: [See progress of installed wind capacity between 1999 and 2010](#)

Source: National Renewable Energy Laboratory, U.S. Department of Energy (Public Domain)

Diagram of Windmill Workings



Source: National Renewable Energy Laboratory, U.S. Department of Energy (Public Domain)

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 2011, wind turbines in the United States generated about 3% of total U.S. electricity generation. Although this is a small fraction of the Nation's total electricity production, it was equal to the annual electricity use of about 10 million households.

The amount of electricity generated from wind has grown significantly in recent years. Generation from wind in the United States increased from about 6 billion kilowatthours in 2000 to about 120 billion kilowatthours in 2011.

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. It is important to consider how fast and how much the wind blows at the site.

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

[Map of U.S. Wind Resources](#)

smooth, rounded hills, open plains or shorelines, and mountain gaps that produce wind funneling.

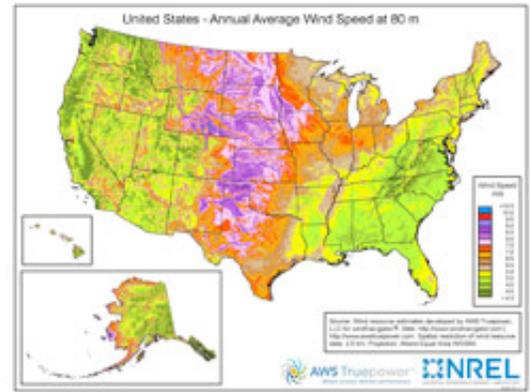
Top Wind Power Producing States, 2011



Source: U.S. Energy Information Administration, *Electric Power Monthly*, Table 1.17.B (February 2012).

Wind Speed Is Not the Same Across the Country

Wind speed varies



Source: National Renewable Energy Laboratory, U.S. Department of Energy (Public Domain)

Wind Turbines in the Ocean



Source: Stock photography (copyrighted)

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 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.

Major Wind Power Locations

Large wind turbines (sometimes called wind machines) generated electricity in 36 different states in 2011. The top five states with the largest generation of electricity from wind were Texas, Iowa, California, Minnesota, and Illinois.

International Wind Power

In 2009, most of the wind power plants in the world were located in Europe and in the United States where government programs have helped support wind power development. The United States ranked first in the world in wind power generation, followed by Germany, Spain, China, and India. Denmark ranked ninth in the world in wind power generation, but generated about 19% of its electricity from wind, the largest share of any country.¹

Offshore Wind Power

Conditions are well suited along much of the coasts of the United States to use wind energy. However, there are people who oppose putting turbines just offshore, near the coastlines, because they think the wind turbines will spoil the view of the ocean. 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.

¹2008 is most recent year data on capacity available as of June 29, 2011.

Types of Wind Turbines

There are two types of wind machines (turbines) used

Darrieus Vertical-Axis Wind Turbine in Martigny, Switzerland

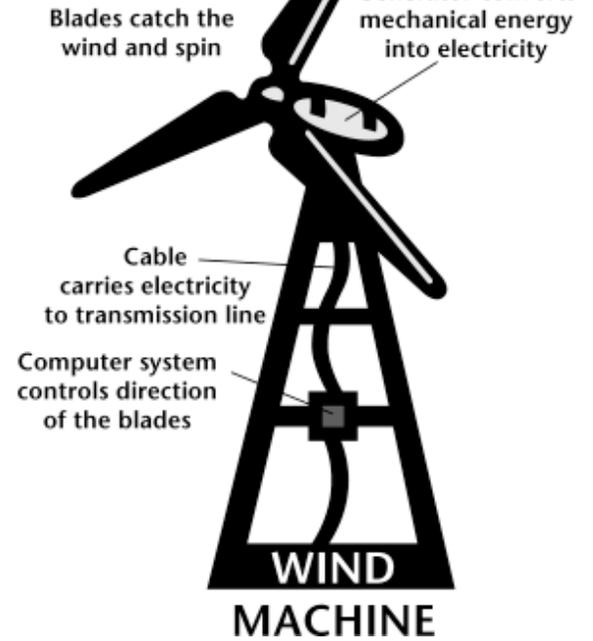
Horizontal-Axis Wind Machine

today,
based on
the
direction
of the
rotating
shaft
(axis):



Source: [Lysippos, Wikimedia Commons author](#) (GNU Free Documentation License) (Public Domain)

HORIZONTAL



Source: National Energy Education Development Project (Public Domain)

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 early recorded history, people have been harnessing the energy of the wind. Wind energy propelled boats along the Nile River as early as 5000 B.C. By 200 B.C., simple windmills in China were pumping water, while vertical-axis windmills with woven reed sails were grinding grain in Persia and the Middle East.

New ways of using the energy of the wind eventually spread around the world. By the 11th

Traditional Dutch-type Windmill



Source: Stock photography

century, people in the Middle East were using (copyrighted) windmills extensively for food production; returning merchants and crusaders carried this idea back to Europe. The Dutch refined the windmill and adapted it for draining lakes and marshes in the Rhine River Delta. When settlers took this technology to the New World in the late 19th century, they began using windmills to pump water for farms and ranches, and later, to generate electricity for homes and industry.

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.

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

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.

Wind Energy & the Environment

Wind: A Clean Source of Energy

Wind is a clean source of energy, and overall, the use of wind for energy has fewer environmental impacts than using many other energy sources. Wind turbines (often called windmills) do not release emissions that pollute the air or water (with rare exceptions), and they do not require water for cooling. They may also reduce the amount of electricity generated from fossil fuels and therefore reduce the amount of air pollution, carbon dioxide emissions, and water use of fossil fuel power plants.

A wind turbine has a small physical footprint relative to the amount of electricity it can produce. Many wind projects, sometimes called wind farms, are located on farm, grazing, and forest land. The extra income from the turbines may allow farmers and ranchers to stay in business and keep their property from being developed for other uses. For example, wind power projects have been proposed as alternatives to mountain top removal coal mining projects in the Appalachian mountains of the U.S. Off-shore wind turbines on lakes or the ocean may have smaller environmental impacts than turbines on land.

Drawbacks of Wind Turbines

Wind turbines do have negative impacts on the environment, but the negative impacts have to be balanced with our need for electricity and the overall lower environmental impact of using wind for energy relative to other sources of energy to make electricity.

Modern wind turbines are very large machines, and some people do not like their visual impact on the landscape. A few wind turbines have caught on fire, and some have leaked lubricating fluids, though this is relatively rare. Some people do not like the sound that wind turbine blades make. Some types of wind turbines and wind projects cause bird and bat deaths. These deaths may contribute to declines in species that are also being affected by other human-related impacts. Many birds are killed from collisions with vehicles and buildings, by house cats and hunters, and by pesticides.

Wind Farm at The Cerro Gordo Project,
West of Mason City, Iowa



Source: National Renewable
Energy Laboratory (Public
Domain)

Their natural habitats may be altered or destroyed by human development and by the changes in the climate that most scientists believe are caused by greenhouse gases emissions from human activities (which wind energy use can help reduce). The wind energy industry and the U.S. government are researching ways to reduce the impact of wind turbines on birds and bats.

Most wind power projects on land also require service roads that add to their physical impact on the environment. Making the metals and other materials in wind turbines and the concrete for their foundations requires the use of energy, which may be from fossil fuels. Some studies have shown that wind turbines produce much more clean electricity over their operating life than the equivalent amount of energy used to make and install them.