Hydropower

Wind Energy
- Wind Energy Basics
- How Wind Turbines Work
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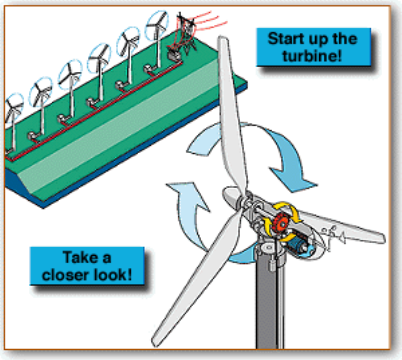
How Wind Turbines Work

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 vegetation. Humans use this wind flow, or motion energy, for many purposes: sailing, flying a kite, and even generating electricity.

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.

So how do wind turbines make electricity? Simply stated, a wind turbine works 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. Take a look inside a wind turbine to see the various parts. View the wind turbine animation to see how a wind turbine works.

This aerial view of a wind power plant shows how a group of wind turbines can make electricity for the utility grid. The electricity is sent through transmission and distribution lines to homes, businesses, schools, and so on.



Learn more about wind energy technology:
- Types of Wind Turbines
- Sizes of Wind Turbines
- Inside the Wind Turbine

Types of Wind Turbines

Modern wind turbines fall into two basic groups: the horizontal-axis variety, as shown in the photo, and the vertical-axis design, like the eggbeater-style Darrieus model, named after its French inventor.

Horizontal-axis wind turbines typically either have two or three blades. These three-bladed wind turbines are operated "upwind," with the blades facing into the wind.

Many wind farms have sprung up in the Midwest in recent years, generating power for utilities. Farmers benefit by receiving land lease payments from wind energy project developers.

Sizes of Wind Turbines

Utility-scale turbines range in size from 100 kilowatts to as large as several megawatts. Larger turbines are grouped together into wind farms, which provide bulk power to the electrical grid.

Single small turbines, below 100 kilowatts, are used for homes, telecommunications dishes, or water pumping. Small turbines are sometimes used in connection with diesel generators, batteries, and photovoltaic systems. These systems are called hybrid wind systems and are typically used in remote, off-grid locations, where a connection to the utility grid is not available.

GE Wind Energy's 3.6 megawatt wind turbine is one of the largest prototypes ever erected. Larger wind turbines are more efficient and cost effective.

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Advantages and Disadvantages of Wind Energy

Wind energy offers many advantages, which explains why it's the fastest-growing energy source in the world. Research efforts are aimed at addressing the challenges to greater use of wind energy.

Advantages

Wind energy is fueled by the wind, so it's a clean fuel source. Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas. Wind turbines don't produce atmospheric emissions that cause acid rain or greenhouse gasses.

Wind energy is a domestic source of energy, produced in the United States. The nation's wind supply is abundant.

Wind energy relies on the renewable power of the wind, which can't be used up. Wind is actually a form of solar energy; winds are caused by the heating of the atmosphere by the sun, the rotation of the earth, and the earth's surface irregularities.

Wind energy is one of the lowest-priced renewable energy technologies available today, costing between 4 and 6 cents per kilowatt-hour, depending upon the wind resource and project financing of the particular project.

Wind turbines can be built on farms or ranches, thus benefiting the economy in rural areas, where most of the best wind sites are found. Farmers and ranchers can continue to work the land because the wind turbines use only a fraction of the land. Wind power plant owners make rent payments to the farmer or rancher for the use of the land.

The Benefits of 20% Wind Energy by 2030

According to the American Wind Energy Association, if we increase our nation's wind energy capacity to 20% by 2030, it would...

Reduce Greenhouse Gas Emissions
A cumulative total of 7,600 million tons of CO_2 would be avoided by 2030, and more than 15,000 million tons of CO_2 would be avoided by 2050.

Conserve Water
Reduce cumulative water consumption in the electric sector by 8% or 4 trillion gallons from 2007 through 2030.

Lower Natural Gas Prices
Significantly reduce natural gas demand and reduce natural gas prices by 12%, saving consumers approximately $130 billion.

Expand Manufacturing
To produce enough turbines and components for the 20% wind scenario, the industry would require more than 30,000 direct manufacturing jobs across the nation (assuming that 30% – 80% of major turbine components would be manufactured domestically by 2030).

Generate Local Revenues
Lease payments for wind turbines would generate well over $600 million for landowners in rural areas and generate additional local tax revenues exceeding $1.5 billion annually by 2030. From 2007 through 2030, cumulative economic activity would exceed $1 trillion or more than $440 billion in net present value terms.

Disadvantages

Wind power must compete with conventional generation sources on a cost basis. Depending on how energetic a wind site is, the wind farm may or may not be cost competitive. 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.

The major challenge to using wind as a source of power is that the wind is intermittent and it does not always blow when electricity is needed. Wind energy cannot be stored (unless batteries are used); and not all winds can be harnessed to meet the timing of electricity demands.

Good wind sites are often located in remote locations, far from cities where the electricity is needed.

Wind resource development may compete with other uses for the land and those alternative uses may be more highly valued than electricity generation.

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

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History of Wind Energy

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 century, people in the Middle East were using 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.

Early in the twentieth century, windmills were commonly used across the Great Plains to pump water and to generate electricity.

Industrialization, first in Europe and later in America, led to a gradual decline in the use of windmills. The steam engine replaced European water-pumping windmills. In the 1930s, the Rural Electrification Administration's programs brought inexpensive electric power to most rural areas in the United States.

However, industrialization also sparked the development of larger windmills to generate electricity. Commonly called wind turbines, these machines appeared in Denmark as early as 1890. In the 1940s the largest wind turbine of the time began operating on a Vermont hilltop known as Grandpa's Knob. This turbine, rated at 1.25 megawatts in winds of about 30 mph, fed electric power to the local utility network for several months during World War II.

The popularity of using the energy in the wind has always fluctuated with the price of fossil fuels. When fuel prices fell after World War II, interest in wind turbines waned. But when the price of oil skyrocketed in the 1970s, so did worldwide interest in wind turbine generators.

The wind turbine technology R&D that followed the oil embargoes of the 1970s refined old ideas and introduced new ways of converting wind energy into useful power. Many of these approaches have been demonstrated in "wind farms" or wind power plants — groups of turbines that feed electricity into the utility grid — in the United States and Europe.

Today, the lessons learned from more than a decade of operating wind power plants, along with continuing R&D, have made wind-generated electricity very close in cost to the power from conventional utility generation in some locations. Wind energy is the world's fastest-growing energy source and will power industry, businesses and homes with clean, renewable electricity for many years to come.

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