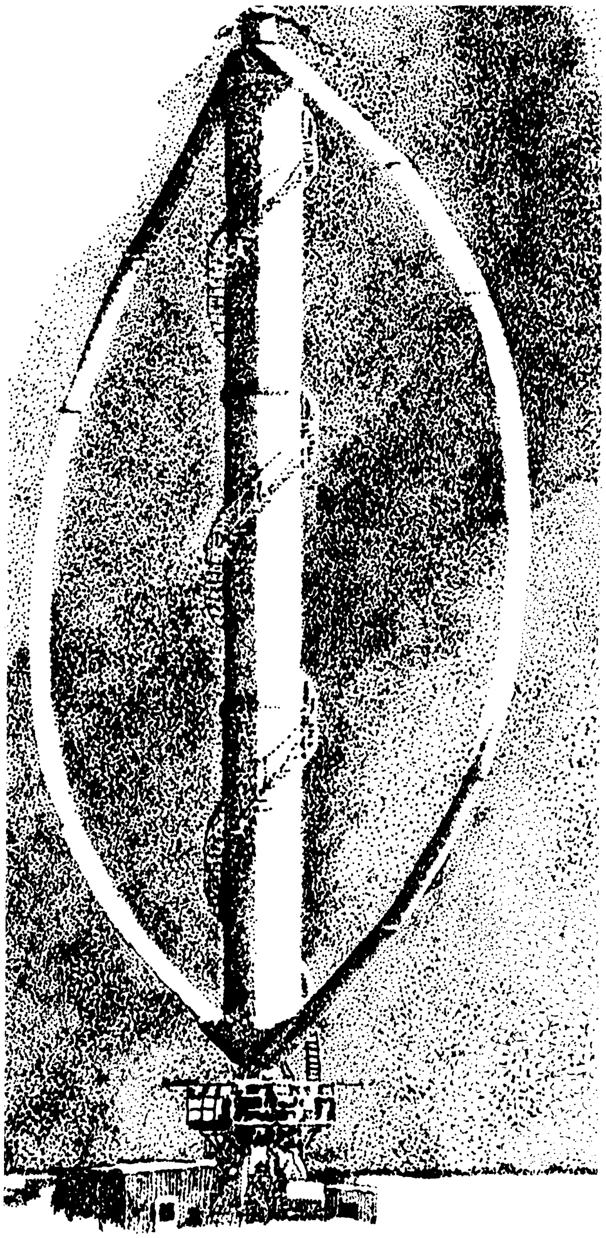
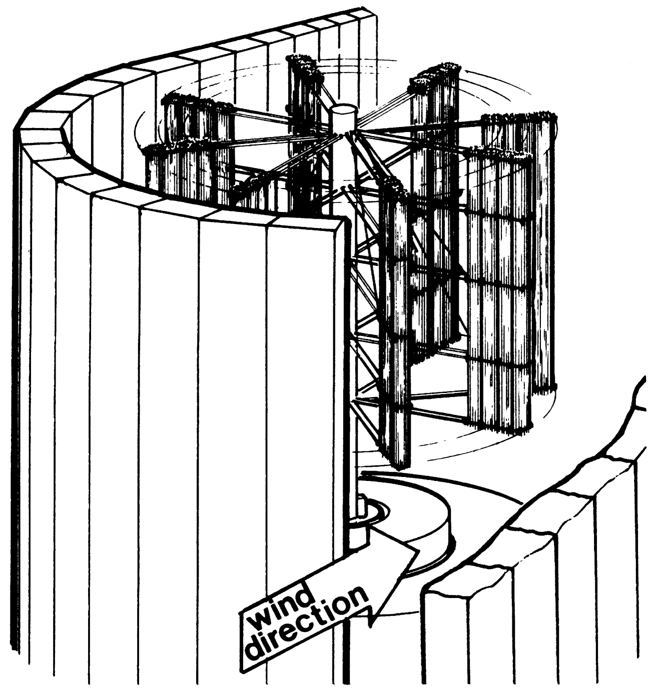
WHAT IS IT ?



This soaring white structure on the Texas Plains looks like a futuristic sculpture of some kind- - it is futuristic, but its concept is ancient.

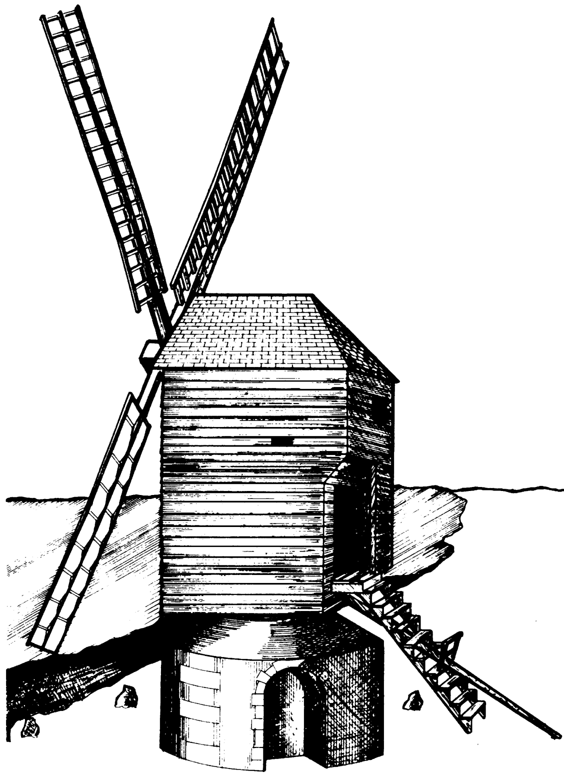
Based on wind power, this vertical axis wind turbine, called the VAWT Test Bed, generates electricity. The idea behind it, however, dates to 200 B.C. , when the first known wind machines were used by the Persians.

Those very early machines were devised to grind grain. A wooden shaft was mounted vertically in an open structure, with a grindstone attached to its lower end. Beams radiated from its upper portion, and bundles of reeds attached to them acted like sails, turning the shaft when the wind blew. Such vertical-axis windmills are the earliest on record, and their use spread throughout the Middle East long before the Christian era.



Later, primitive horizontal-axis windmills were developed and spread through the Mediterranean regions, where they are still used. They consist of as many as ten radial wooden beams rigged with small jib sails. During the Middle Ages, Crusaders brought the concept of wind machines home with them to northern Europe, and in subsequent years, the large Dutch-type windmills evolved. In the industrial age, the steam engine and then the introduction of electricity resulted in a decline in their use. However, the recent energy crisis and continued dependence on imported oil have generated U.S. interest in using the wind as a source of electrical energy.

Square-rigged sailing ships and the primitive windmills both use the principle of "drag," which is based on the idea of putting up a barrier to the wind, so that it will then move something else, like a ship or a grinding stone.



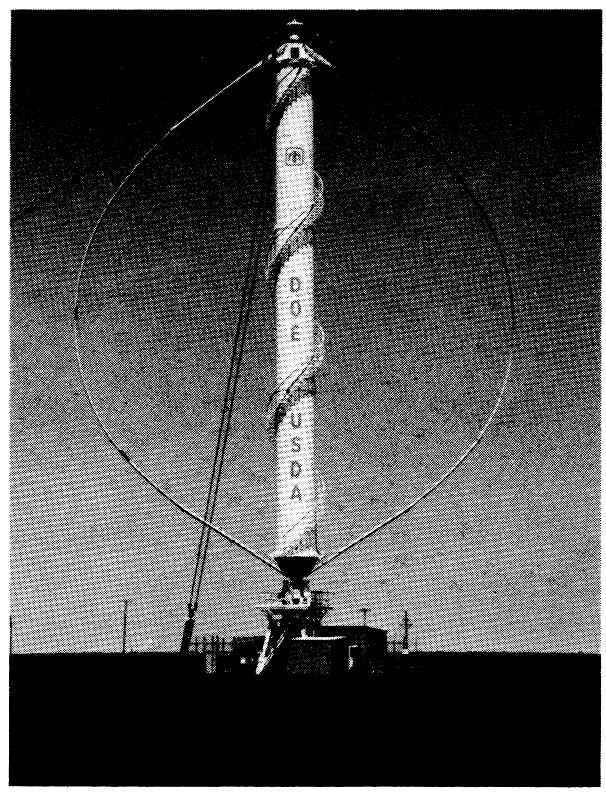
Newer wind machines are based on the principle of "lift"; that is, the blades--or the sails of sailing craft--use wind-flow across them to soar. Once moving, the wind actually pulls them along. Because of the way in which the lift devices are designed--they are actually airfoils--they are much more efficient at using the wind's energy than drag machines.

For most traditional windmills, the axis upon which the blades are mounted is horizontal to the earth; thus, they are called horizontal-axis wind turbines, or HAWTs. The blades are set essentially perpendicular to the wind and are continually shifted to retain this orientation as the wind changes. Blades can also be mounted on an axis that is perpendicular to the earth, as they were in ancient Persia. Those with this configuration are called vertical-axis wind turbines, or VAWTs. These machjnes are always perpendicular to the prevailing wind, although their blades experience an ever-changing wind direction as they rotate from up - to downwind. Experimental wind machines have been built using either lift or drag, with either horizontal or vertical axes, in an effort to find the most efficient way to harness the wind's power.

In the 1920s , a French scientist named Georges Darrieus conceived the idea of mounting slender, airfoil-type blades on a vertical axis and using the principle of lift to create a new VAWT. Its advantages include a high efficiency in using the power of the wind and not having to track the wind's direction, as is the case for all HAWTs. In addition, all its equipment is on or near the ground where it is easy to reach, not high up, as in the case of most HAWTs. The VAWT Test Bed is a Darrieus-type VAWT that has a diameter of 34 meters.

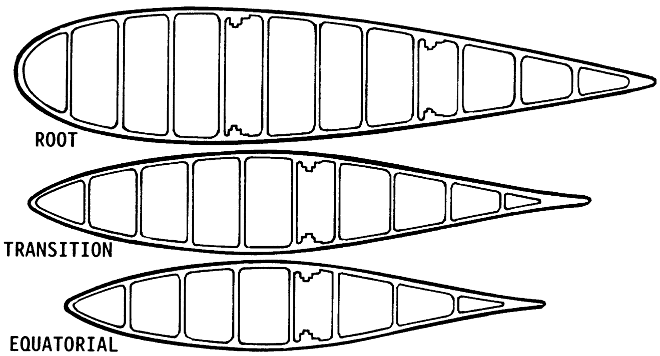
Wind-powered machines of all kinds are still used as a source of power in many parts of the world. Although they were once prevalent in the United States for water pumping and generating dc electricity, they nearly disappeared with the advent of utility-supplied electricity in rural as well as in urban areas. In a farsighted program to explore sources of energy for the nation's future requirements, the Department of Energy supports research in using the inexhaustible wind and sun to supplement depletable energy sources. Studies have shown that the wind could provide significant amounts of electrical power for the nation's needs.

The futuristic-looking VAWT Test Bed, designed by engineers at Sandia National Laboratories in Albuquerque, N.M., is a research wind turbine outfitted with a multitude of monitoring devices to provide essential information about its performance as it produces electricity.



HOW DOES IT WORK?

The wind turbine's vertical axis is a 165 ft. tall, rotating aluminum column that measures 10 ft. in diameter. Two large, bowed aluminum blades, each spanning 183 ft., swing out from the column's axis, and at their widest point, they are 110 ft. (34 meters) apart. Each blade is made of sections of specially designed airfoils that are bolted together; three different dimensions are used to build them to increase the blades' efficiency. The blades clear the ground by 23 ft. so the area underneath the wind turbine could be used for other purposes, such as farming or grazing cattle.



Although most horizontal-axis wind machines are self-starting, the Darrieus-type VAWT needs a boost from its electrical power system acting as a motor to start the blades turning. The blades slowly begin to move and catch the wind--the wind then increases their speed of revolution up to the turbine's operational value. For the Test Bed the electrical system switches from operating as a motor and begins to generate electricity at about 25 rpm in an 8.5 mph wind (called the cut-in wind speed). Because of their design and the fact that they are lift-type devices, the blades can rotate up to 12 times the actual speed of the wind.

A special feature of the VAWT Test Bed is that it is designed to run over a continuously variable range of rotor speeds, from 25 to 40 rpm. Most wind turbines generating electricity today turn at a constant rotor speed.

The maximum wind speed at which the VAWT Test Bed is allowed to operate is 45 mph, because above this, the machine would be subjected to severe stresses. It is also possible for the blades to rotate at excessive speeds, which would endanger the entire structure. Therefore, the wind turbine is equipped with two kinds of brakes. Mechanical brakes, mounted in the base of the central axis, involve four spring-applied, hydraulically released calipers that act on a disc 80 inches in diameter. The pads on the calipers are pushed against the disc, just like disc brakes operate on a car. In an emergency, these brakes can stop the turbine in 10 seconds. For routine braking, the variable-speed electrical generating system is used to slow the wind turbine to just a few revolutions per minute; then the mechanical brakes bring it to a final stop.

WHAT DOES IT DO?

The VAWT Test Bed is a research tool, providing information for Sandia's engineers, and, as an added benefit, it provides electricity to the local utility. In a cooperative arrangement between DOE and the U.S. Department of Agriculture (USDA), the turbine will be tested at the USDA's Agricultural Research Service at Bushland, Texas, near Amarillo.

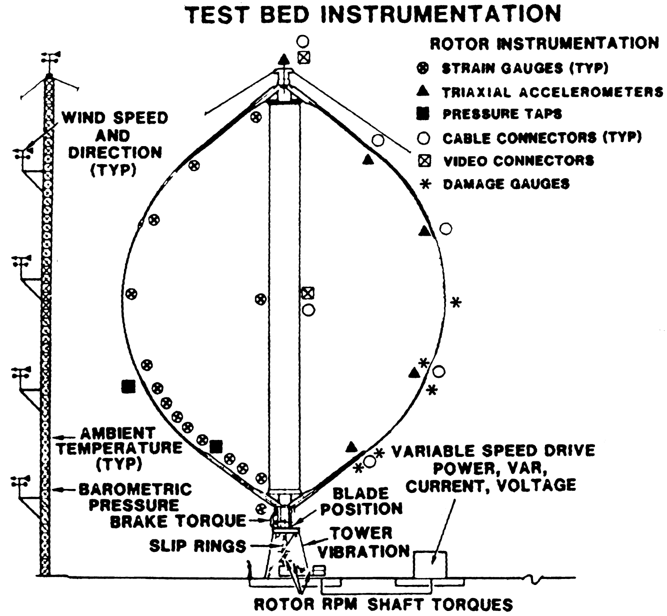
The wind turbine's blades rotate about a central axis, which is a shaft connected to a speed-increasing transmission. The transmission's output shaft, in turn, drives a variable-speed motor/generator that--operating as a generator--converts the power in the shaft to electricity. This occurs at the base of the vertical column. The electricity produced is transmitted from the site to the local electric utility first through underground cables near the wind turbine and then on conventional above-ground lines.

The VAWT Test Bed is rated to produce 500 kilowatts of power while rotating at 37.5 rpm in a 28 mph wind. With Bushland's annual average windspeed of 14 mph, the test bed could supply more than 100 households with their yearly electrical needs.

Instruments are located at every essential position on the turbine and its associated components to measure significant aspects of the turbine, especially stress on the blades. A system of computerized data acquisition software and hardware operates continuously at the test bed. The instrumentation is illustrated below.

Planning for the VAWT Test Bed began in 1984; its major goal is to advance the performance and capabilities of VAWT technologies for future commercial applications. It is the latest experimental project in Sandia's 15-year involvement with wind energy and is part of DOE and Sandia's long-term commitment to energy research and to technology transfer to private industry .

TEST BED INSTRUMENTATION



Agricultural Research Service | United States Department of Agriculture | Sandia National Laboratories