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Wind Energy in Missouri

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Because of the rapidly increasing cost of conventional fuels many farmers are interested in the possibility of using other energy sources on the farm. This guide discusses one energy alternative, wind energy and its potential for Missouri.

Availability

The amount of wind energy depends on **wind speed** and the **size of the collecting machine.** Of the two, wind speed has the greatest effect. If you double the size of the collecting machine, you double the energy collected. However, if wind speed doubles, the energy collected increases by a factor of 8.

To calculate the maximum power theoretically available from a wind machine, use the following equation:

Power = .00502 X Area X (Wind Speed)^3

In this equation, power is measured in watts, .00502 is constant, area is the area swept by the collecting rotor (measured in square feet), and wind speed is measured in miles per hour.

Unfortunately, wind machines are not 100 percent efficient in collecting this maximum amount. Actual efficiency will range from 15-50 percent, depending on the particular type of unit you have.

Most wind machines are not effective when wind speeds are less than 7 mph and must be shut down when they exceed 20-25 mph. For peak operating efficiency wind velocities need to be in the range of 15-20 mph.

The U.S. Department of Commerce regularly measures wind velocity at many locations. They are compiled and averaged to provide data that is useful in estimating potential energy output of wind machines. Table 1 gives Missouri locations.

Table 1. Average Monthly Wind Speeds and Directions for Selected Missouri Locations.

Month	*Columbia*		*Kansas City*		*St. Louis*		*Springfield*	
	Mph	*Direction*	*Mph*	*Direction*	*Mph*	*Direction*	*Mph*	*Direction*
Jan.	10.6	S	10.7	SW	10.4	NW	12.0	SSE
Feb.	11.3	NW	11.6	NW	10.8	NW	12.4	SSE
Mar.	12.1	WNW	12.4	E	11.8	WNW	13.4	SSE
Apr.	11.4	S	12.2	SE	11.4	WNW	12.7	SSE
May	9.0	SSE	10.0	SW	9.4	S	10.8	SSE
June	8.7	SSE	9.7	SE	8.7	S	10.0	SSE
July	8.2	SSE	8.4	NW	7.8	S	8.8	SSE
Aug.	7.9	SSE	9.1	SW	7.5	S	8.9	SSE
Sept.	8.3	SSE	8.5	SE	7.9	S	9.6	SSE
Oct.	9.4	SSE	10.1	S	8.7	S	10.4	SSE
Nov.	10.4	S	11.2	NE	9.9	S	11.5	SSE
Dec.	10.7	S	11.3	N	10.3	WNW	11.8	SSE
Average	9.8	SSW	10.4	NW	9.5	S	11.0	SSE

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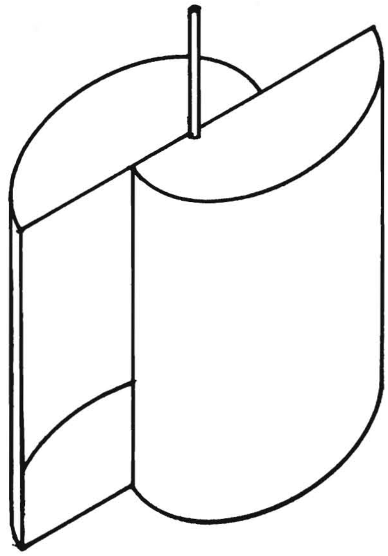

Figure 1. Savonius rotor.

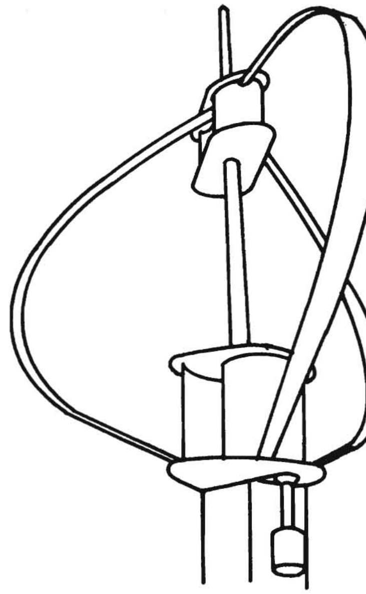

Figure 2. This Darrieus rotor has two small Savonius rotors mounted on the shaft to provide starting motion.

Rotor Types

Wind machines fit into two general classes, based on the orientation of the rotor to the wind. Rotors, with their main axis parallel to the ground, are **horizontal axis machines.** This type of machine must have some mechanism to keep the rotor pointed into the wind. In areas where winds are gusty and variable, these units may not be able to track the wind rapidly enough to achieve maximum efficiency.

Vertical axis machines rotate around a vertical shaft and can accept wind from any direction.

The **Savonius rotor** in Figure 1 has a vertical axis, is slow turning, and is a high-torque wind machine. It is well suited for pumping water and its low speed makes balancing less critical. To make a Savonius rotor machine, cut a 55-gallon drum in half, and weld the two halves into an offset assembly. The maximum efficiency for this machine is 15-18 percent.

The **Darrieus rotor** is also a vertical axis machine (Figure 2). It has either two or three blades, designed with an airfoil cross section. It is the kind of high-speed machine often used to power electrical generators. The Darrieus rotor has an extremely low-starting torque. To start it turning, you need either an electric motor or some other type of vertical axis rotor. Peak efficiency can approach 35-40 percent.

The familiar **farm windmill** is a multi-blade turbine and a horizontal axis machine (Figure 3). It has very high-starting torque, so it is well suited for pumping water. The farm windmill is a low-speed machine, and most units are designed to shut down at high wind velocities. Maximum efficiencies can approach 30 percent.

High-speed, propellor-type machines use airplane-type propellors in a horizontal axis configuration (Figure 4). They are frequently mounted directly onto an electrical generator unit. They have low-starting torque but work well with generators. The maximum efficiency is about 45 percent.

Pumping Water

The earliest use for wind power was for pumping water. The multi-bladed turbine was particularly well adapted to providing the low power required to lift water from deep wells in remote locations. A large water tank insured livestock of a water supply during periods of no wind.

Large windmills can lift water 400-600 feet from a deep well. Maximum pumping capacities range from 100-2000 gallons per hour, depending on windmill diameter and the height of the lift.

Generating Electricity

Small generators powered by high-speed propellors were popular in the rural areas of the United States in the 1930s. These machines produced direct current (D.C.), used primarily for lighting. Direct current can be easily stored in batteries designed for deep discharge cycles. As the use of electric power grew and electrical distribution lines from central generating plants were built, these wind-powered units became inadequate and obsolete by 1940. The typical cost for generating electricity with one of these older units ranges between 15 and 25 cents per kilowatt hour.

Nearly all of the electrically powered equipment manufactured today is designed to operate on alternating current (A.C.) at a frequency of 50-60 H_z. A D.C. generator/battery storage system requires some type of inverter (conversion unit) to change D.C. into A.C. and to boost operating voltage up to that required by the device being powered.

Most electrical generation systems are designed to produce rated power at wind speeds of 20-30 mph. Below this speed, power output drops off dramatically. At higher

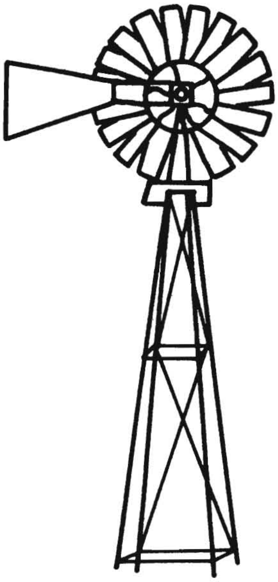

Figure 3. Multi-blade turbine unit.

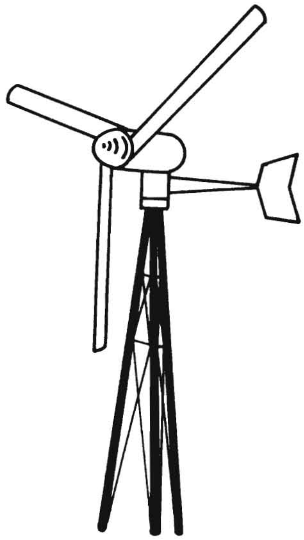

Figure 4. This high-speed propellor unit is equipped with a downstream generator unit.

speeds, safety devices will shut the systems down. Table 1 shows that the 20-30 mph speed is well above the average speed at any Missouri location.

Water Heating

Wind energy can be converted to mechanical energy and used to heat water. This has been done successfully in a research project at Cornell University. A vertical axis turbine was connected to a stirring device which is immersed in an insulated tank of water. The mechanical energy from operating the stirrer converts directly into heat, and the water gets hot.

Hydrogen Production

Direct current produced by wind generators can be directly used in an electrolysis process to break down water into its hydrogen and oxygen components. Hydrogen can then be used as a fuel in a modified internal combustion engine. Remember than hydrogen is a very volatile fuel, you must be extremely careful in collecting and handling it. It also has low energy per unit of volume. This makes storage very difficult.

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