DOCUMENT RESUME

ED 270 288 SE 046 433

TITLE	Wind Energy Systems.
INSTITUTION	Conservation and Renewable Energy Inquiry and Referral Service (DOE), Silver Spring, MD.
REPORT NO	FS-135
PUB DATE	Jan 82
NOTE	5p.; For other information bulletins in this series, see SE 046 434-441 and SE 046 444.
PUB TYPE	Reports - General (140)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Alternative Energy Sources; *Electricity; *Energy; *Energy Education; *Power Technology; Science Education; *Wind Energy

ABSTRACT

During the 1920s and 1930s, millions of wind energy systems were used on farms and other locations far from utility lines. However, with passage of the Rural Electrification Act in 1939, cheap electricity was brought to rural areas. After that, the use of wind machines dramatically declined. Recently, the rapid rise in fuel prices has led to a resurgence in the use of wind power, especially for producing electricity. This bulletin provides information on: (1) types of wind machines; (2) several applications of the mechanical and electrical power generated by wind machines; (3) storing of electricity produced by wind systems; (4) utility hook-ups; (5) sizing a system; and (6) economic considerations. An annotated list of seven publications dealing with wind energy systems is included, with source and current cost noted. (JN)

INFORMATION

CONSERVATION AND RENEWABLE ENERGY INQUIRY AND REFERRAL SERVICE

WIND ENERGY SYSTEMS

During the twenties and early thirties, millions of wind energy systems were used on farms and other locations far from utility lines. However, with passage of the Rural Electrification Act in 1936, cheap electricity was brought to rural areas. After that, the use of wind machines dramatically declined. Recently, the rapid rise in fuel prices has led to a resurgence in the use of wind power, especially for producing electricity.

Classifying Wind Machines

Tip Speed Ratio

One method of classifying wind machines is by their "Tip Speed Ratio." This is the speed the tip of the rotor blade travels compared to the windspeed. For example, if the tip of the rotor blade is traveling 30 m.p.h. and the windspeed is 15 m.p.h., then the Tip Speed Ratio is 2:1. Wind machines with high Tip Speed Ratios are ideal for generating electricity. Machines with low Tip Speed Ratios are usually used to produce mechanical power for water pumping. The greater the surface area of the rotor blades, the lower the Tip Speed Ratio.

Horizontal Axis

Wind machines are also classified as either horizontal axis or vertical axis. The most common kind of horizontal axis machine is the American Farm windmill (figure 1). This machine has many blades, thus exposing a large surface area to the wind. It has a low Tip Speed Ratio and is commonly used for pumping water. Horizontal axis machines that have only two or three blades are used for producing electricity (see figure 2). They have a small surface area and a high Tip Speed Ratio. To work properly, horizontal axis machines need a tail vane or some other control to orient them into the wind.

Vertical Axis

An example of a vertical axis machine is the Savonius rotor (figure 3). Many do-it-yourselfers are building these from little more than oil drums cut in half. These machines have large surface areas, low Tip Speed Ratios and are used for mechanical tasks. Another kind of vertical axis machine is the Darrieus rotor (figure 4). One Darrieus rotor machine looks like a giant egg-beater. It has three vertical blades that are bowed in the middle. There are also Darrieus machines that have straight blades. All Darrieus rotors have small surface areas, high Tip Speed Ratios, and are used for producing electricity.

Applications

The mechanical and electrical power generated by wind machines can be used for many purposes, and further applications are constantly being discovered. Only a few will be covered here.

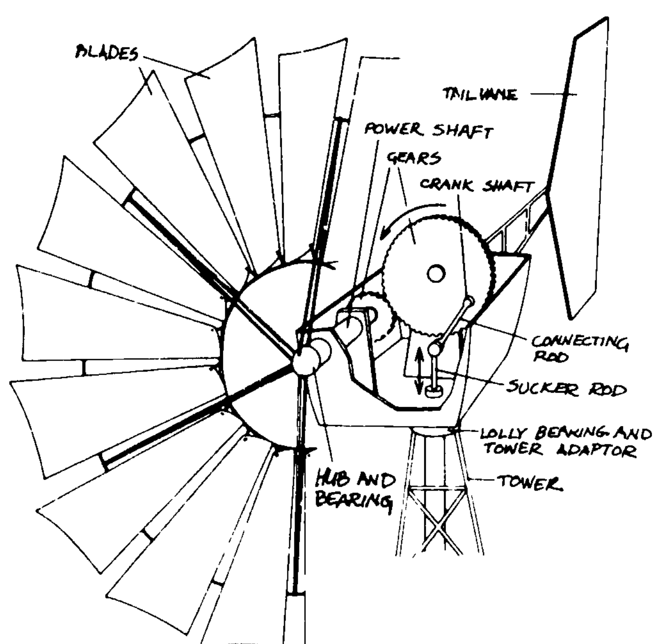

Figure 1. Components of an American Farm windmill

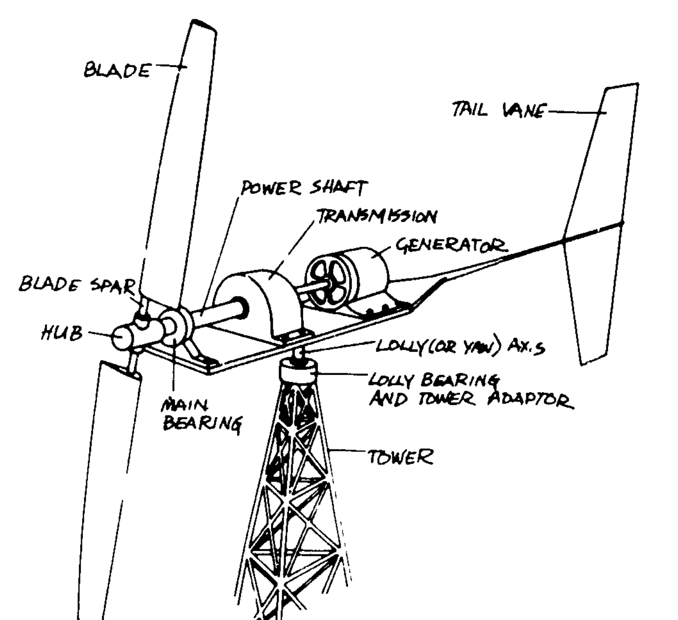

Figure 2. An electricity producing wind generator

All illustrations herein are reprinted from the "Wind Power Book."

FS 135, 1st Edition, y 1982

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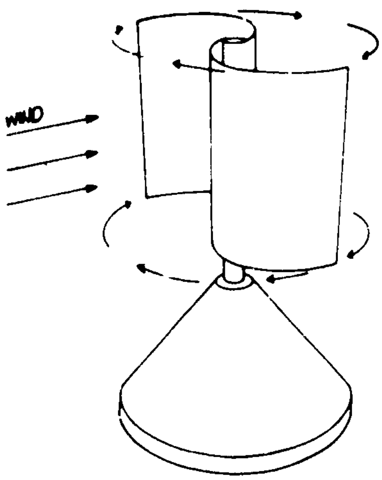

· Figure 3. A simple Savonius rotor wind machine

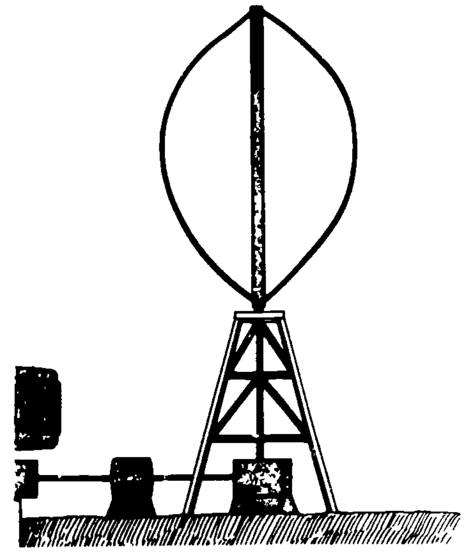

Figure 4. A Darrieus "eggbeater" rotor machine

As mentioned before, mechanical power produced by wind machines is usually used for water pumping. One system uses a wind machine to pump water uphill to a lake. The water from the lake then runs downhill, creating enough force to power a small hydroelectric system. Another type pumps water to a tank where it is stored until needed (see figure 5).

Mechanical power can also be used for irrigation. There are two kinds of wind powered irrigation systems. One kind uses a wind machine to pump water uphill where it is stored. When the fields require irrigation, the water runs downhill through pipes or grates, onto the fields.

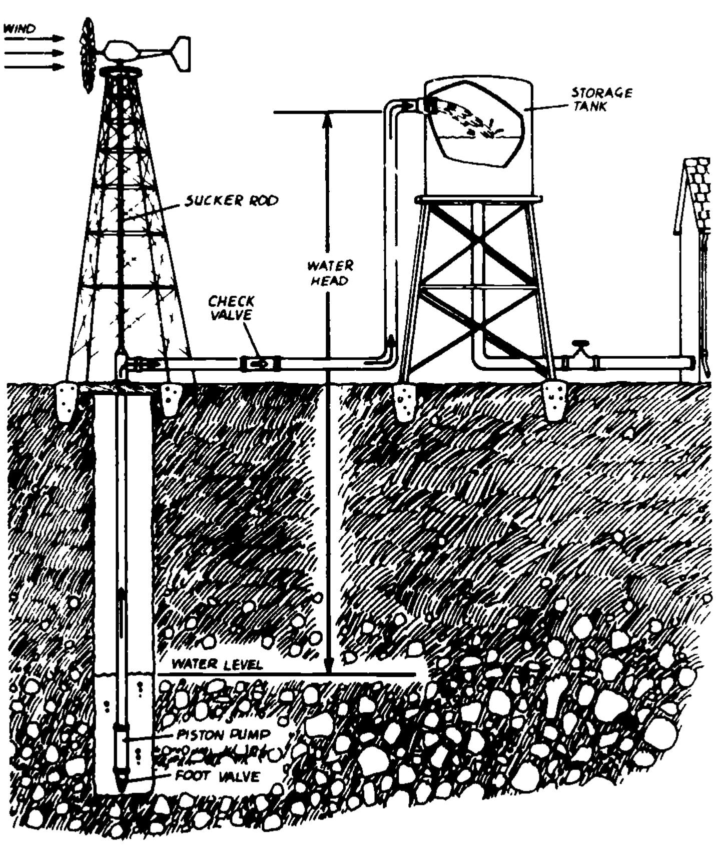

Figure 5. A complete water-pumping system

The other irrigation system uses a wind machine to generate electricity for a pump that brings water into the fields.

Windmills are sometimes used to dry grain. Grain elevators are equipped with large blowers that dry the grain by forcing air through the storage bins. Wind machines can generate the electricity to operate these blowers.

Wind powered heating systems are also possible. Such systems use wind energy to heat water that is stored in a tank. The hot water can be used directly or for space heating. Either mechanical power or electricity is used to heat the water. If mechanical power is used, the windmill drives a paddle or a pump that splashes the water around in the tank, heating the water by friction. Electricity can be used by connecting a heating element to an electricity-generating wind machine. When the heating element is placed in the water tank, the water is heated (see figure 6).

Most people use windmills to generate electricity for household appliances. Because wind generated electricity is more expensive than electricity purchased from a utility, any excess electricity should be stored.

Storing Electricity

Batteries are sometimes used to store excess electricity produced by wind systems. However, choosing the right kind of battery is important when designing a storage system for a wind machine.

Deep-Cycle batteries are one of the most appropriate batteries to use. These are the batteries used in golf carts. They provide a steady amount of electrical current over a long period of time. and can tolerate a large number of charge and discharge cycles.

Automobile batteries do not work well. They provide a large amount of electrical current in a short period of time. Also, automobile batteries cannot tolerate the continuous charging and discharging required of batteries used in wind systems.

Batteries will only store electricity as direct current—DC. Most appliances require alternating current—AC. An electronic, stand-alone inverter will be needed to

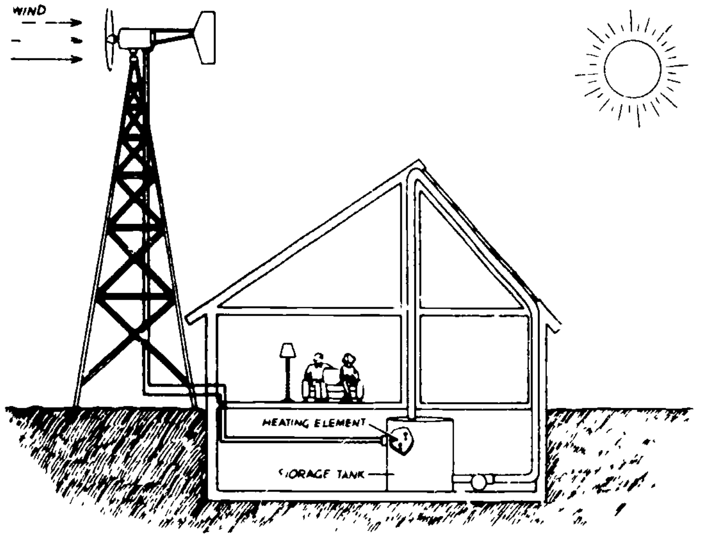

Figure 6. A wind-powered heating system

convert the DC from battery storage to the AC required for appliances.

Battery storage systems are expensive. In most cases, they are only worth the expense if the windmill is in a remote area, far from utilities. Finally, if a battery storage system is used, care must be taken to prevent the batteries from becoming completely discharged during windless periods. If this happens, the life of the battery and the performance of the wind generator will be reduced.

Utility Hook-ups
Instead of storing excess electricity in batteries, you can connect your wind system to the public utility's power lines. You can then draw electricity through your electric meter when the wind isn't blowing hard enough. When you are generating more electricity than you can use, your meter will run backwards. You will then be selling electricity back to the utility. The "Public Utility Regulatory Policies Act" of 1978 requires utilities to sell electricity to "qualified" small power producers and to buy back the electricity at reasonable rates. Before you can hook-up to a utility, however, you must get their permission. You will also need to use a synchronous inverter which is much more expensive than a stand-alone inverter (see figure 7).

By connecting to a utility grid, you can avoid a significant investment in batteries. Also, you would not need the wiring and other additions to the system required to make the electricity suitable for appliances.

Sizing Your System
If you are connected to a public utility you can get an idea of how large a system you'll need. Look at your electric bills for the past year to determine your electricity consumption. Decide what percentage of the entire load you hope to power. Then, select a wind system capable of meeting that goal with the wind energy available to your site.

Economics
A system with a comparatively low pricetag may save you money initially. But it may also produce significant- [illegible] electricity than other systems. Suppose you are considering two systems: system A, costing $4500, and system B, costing $5500. After 20 years, system A produces 23000 kilowatt hours of electricity, and system B produces 55000 kilowatt hours of electricity. After evaluating the economic factors you may well find that system B is producing electricity at 12¢ per kilowatt hour, and system A is producing electricity at 18¢ per kilowatt hour. System B, in this case, is the better bargain.

To learn more about wind energy systems, refer to the following publications.

FUNDAMENTALS OF WIND ENERGY N. Cheremisinoff; Ann Arbor Science Publications, P.O. Box 1425, Ann Arbor, MI 48106, 1978, 170 pp., $6.95. Provides a historical overview of wind systems. Also describes modern applications, performance, design, site selection, energy storage, environmental considerations, and the potential of wind systems.

HANDBOOK OF SOLAR AND WIND ENERGY F. Hickok; Cahners Books, 221 Columbus Ave., Boston, MA 02116, 1975, 125 pp., $5.95. Contains information on small wind systems, home heating and water pumping.

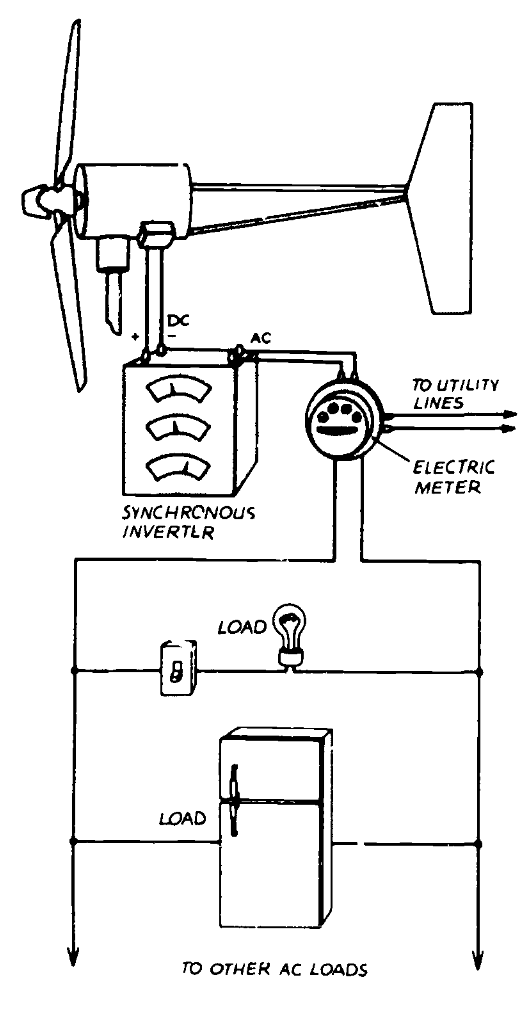

Figure 7. A synchronous inverter couples a DC wind generator to both the utility grid and the house wiring system

HARNESSING THE WIND FOR HOME ENERGY D. McGuigan; Garden Way Publishing Co., Charlotte, VT 05445, 1978, 134 pp., $4.95. How-to book on measuring electrical potential and selecting appropriate systems. Describes working installations.

HOME WIND POWER . United States Department of Energy; Garden Way Publishing Co., Charlotte, VT 05445, 1981, 203 pp., $10.95. Covers everything you need to know about a home wind energy system. Includes information on site evaluation, installation, economics, monitoring, and maintenance.

THE WIND POWER BOOK J. Park; Cheshire Books, Palo Alto, CA 94301, 1981, 253 pp., $11.95 + $1.50 postage. Covers fundamentals, economics, and designs of small wind energy systems. Contains basic and technical information.

WIND POWER FOR THE HOMEOWNER. D. Marier; Rodale Press, Emmaus, PA 18049, 1981, 368 pp., $16.95. A guide to selecting, siting, and installing an electricity-generating wind power system. Aimed towards homeowners installing their own systems.

A SITING HANDBOOK FOR SMALL WIND ENERGY CONVERSION SYSTEMS. H. Wegley, J. Ramsdell, M. Orgill, and R. Drake; Battelle Memorial Institute, 1980, 72 pp., $6.00. Report No. PNL-2521 Rev. 1. A handbook written to serve as a siting guide for individuals wishing to install small wind energy systems. Based on 50 years of siting experience.

The illustrations for this factsheet were drawn by Edward Wong-Ligda for the "Wind Power Book," by Jack Park. Reprinted by permission of Cheshire Books.

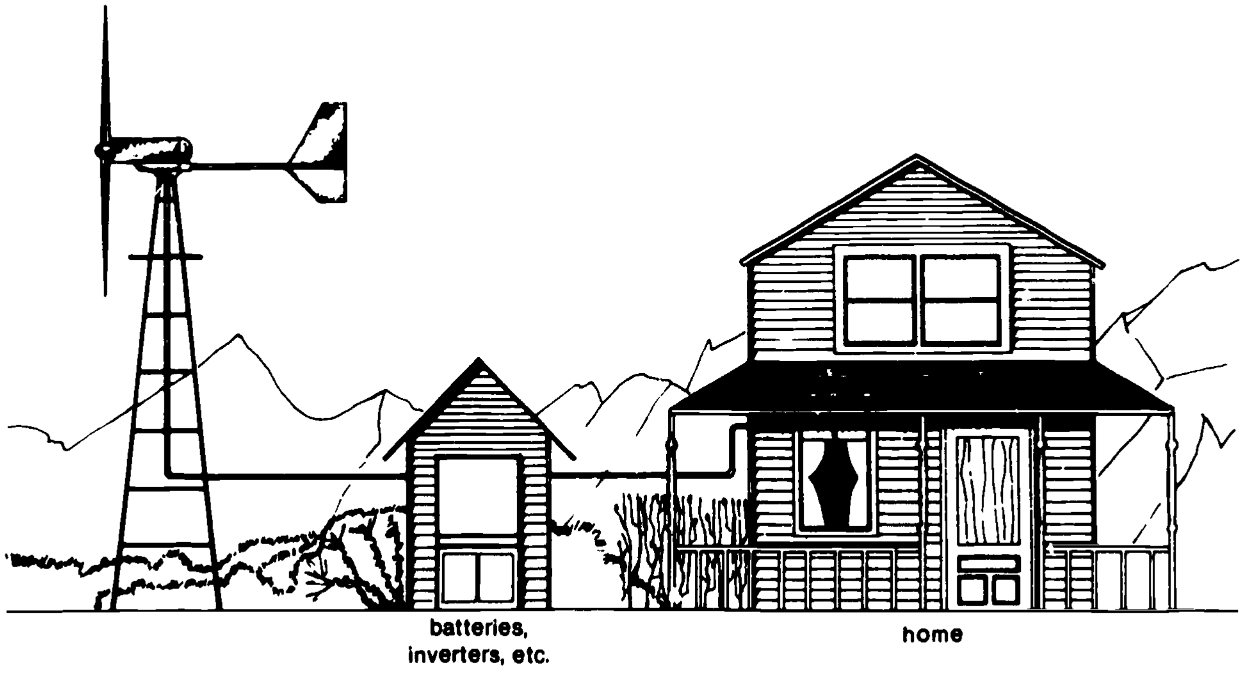

Figure 8. Typical Wind Electric System. Batteries and Inverter are housed in an auxilliary shed to protect them from the weather.

Illustration reprinted from "Wind Power for Farms, Homes and Small Industry" by the United States Department of Energy.