Irrigation with Wind Power

by R. Nolan Clark

Irrigating with wind power. Windmills have been used for centuries to grind grain and pump water. Many are still used today for pumping livestock and domestic water supplies. These units normally produce a maximum power of 1 kW and pump less than 3 m³/hr. However, new wind machines are being developed that produce 10–200 kW. These new machines are capable of powering large pumps used for irrigation pumping.

In the United States about 27% of agricultural products grown today, on about 12% of the cropped lands, are irrigated. However, irrigation requires large amounts of energy to pump adequate water. An estimated 87×10^9 kWh of energy were used during 1978 for pumping irrigation water, or enough energy for 4,000,000 homes. Only energy used for manufacturing fertilizer and for tractor and truck fuel exceeds that used in irrigation, making irrigation the largest on-farm, nonvehicular use of energy in agriculture.

Most irrigation pumping is done with electricity, natural gas, or diesel fuel. All of these energy supplies are rapidly increasing in price and are decreasing in supply, thus creating interest in new or alternate energy sources for irrigation pumping.

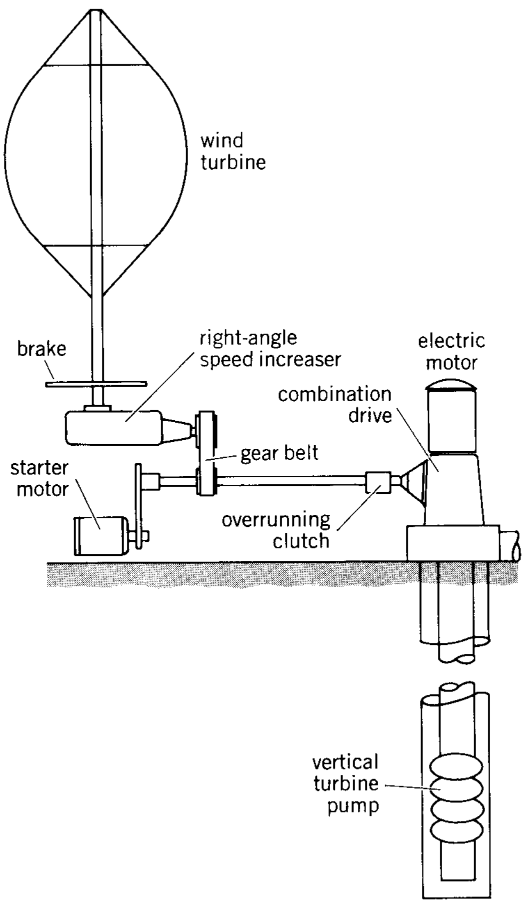

Fig. 1. Schematic of the wind-assisted irrigation pumping system.

Wind is being studied as an alternate power source because most irrigated areas are in windy regions.

Irrigation requires large amounts of water, often supplied by deep wells. Flow rates usually range between 100 and 500 m³/hr, and water is often pumped from wells ranging from 20 to 200 m deep. These wells require power units between 20 and 200 kW to lift the water to the surface and distribute it to the land.

Experimental pumping system. The USDA Science and Education Administration, in cooperation with the U.S. Department of Energy, has been testing an experimental wind-powered irrigation system since early 1977. This pumping system (called a wind-assist system) uses both a wind turbine and an electric motor to power a conventional vertical-turbine irrigation pump (Fig. 1). The electric motor is large enough to operate the pump by itself and runs continuously. The wind turbine is coupled to the pumping system through an overrunning clutch so it will furnish power to the pump only when the wind speed exceeds 6 m/s. When the wind turbine operates, the electric motor is not being replaced, but the electric load is being reduced. This power arrangement allows water to be pumped at the desired flow rate, regardless of the wind power level, and a conventional irrigation well and vertical-turbine pump can be used without modification.

The wind turbine is a Darrieus, or vertical-axis, type that was designed to produce 40 kW in a 15-m/s wind (Fig. 2). The rotor height is 17 m, and the maximum rotor diameter is 11.3 m. The rotor is set on top of a 9-m steel tower and is supported at the top by four 22.2-mm steel cables. When the turbine is producing power, the rotor turns at a steady speed of 90 rpm. A speed increaser and right-angle-gear drive increase the shaft speed from 90 to 1780 rpm (Fig. 1). An overrunning clutch in the wind turbine drive shaft transmits power to the pump without transferring power from the electric motor back to the wind turbine at low wind speeds. Between the electric motor and the pump discharge head is a combination gear drive that permits power to be supplied to the pump from two independent power sources (Fig. 1). A 750-mm-diameter disk brake, with three double-action calipers, is used to stop the rotor in normal or emergency shutdown.

The entire pumping system was assembled from commercially available equipment, and much of the system was installed in an existing irrigation well. The 200-mm vertical-turbine pump was installed in 1964 and is a type commonly used in irrigation pumping. The well supplies 104 m³/hr of water and has a 105-m total dynamic head. Neither the pump nor the well was modified for use here.

Performance. The vertical-axis wind turbine begins to produce power at 6 m/s wind speed, and the power output continually increases until the system is stopped at 20 m/s wind speed. In the Texas Panhandle, where the experimental turbine is located, 90% of the available wind power is within this wind speed range. The power harvested by a wind turbine increases proportionally to the cube of the wind speed. Thus, as wind speed increases, the wind power produced increases rapidly (Fig. 3). With the wind-assist pumping system, as wind turbine power increases, the electric power con-

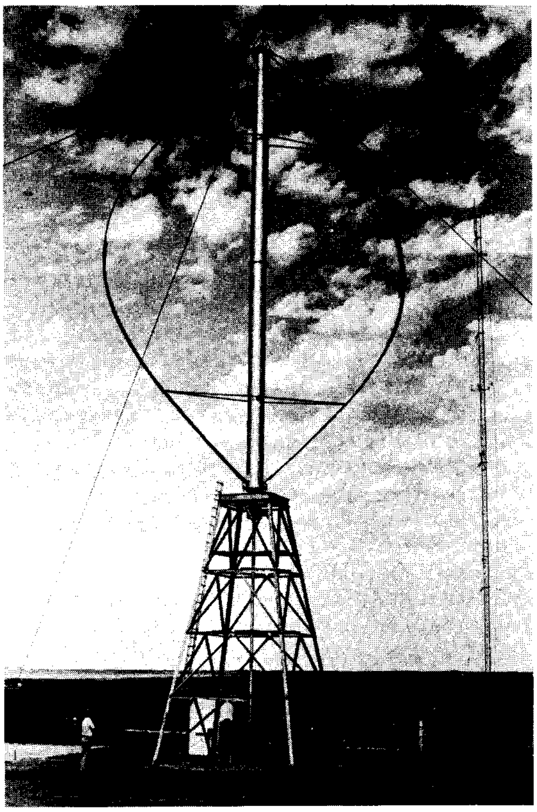

Fig. 2. A 40-kW vertical-axis wind turbine with rotor height of 17 m and maximum diameter of 11.3 m, installed at USDA Southwestern Great Plains Research Center, Bushland, TX.

sumed decreases, until the electric motor is almost completely unloaded. The sum of the wind power and electric power represents the steady power needed to operate present irrigation pumps. For the experimental system shown in Fig. 3, the pump requires a constant 51 kW to lift the water to the surface. At low wind speeds water is pumped primarily with electricity, whereas at high wind speeds water is pumped primarily by wind power.

A normal irrigation season usually requires about 2000 hr of pumping during the spring and summer months. In the Southern Great Plains, between March 1 and October 1, wind speed exceeds 6 m/s at least 3000 hr—time that could be used for irrigation pumping with wind energy. During this period, the experimental turbine could supply 40,000 kWh of power, or about 40% of that required by the irrigation pump. Presently, all the water needed for irrigation cannot be supplied with wind energy, simply because the wind does not blow all of the time during peak crop water-use periods. However, temporary storage of water in surface reservoirs can increase the percentage of irrigation water supplied by wind power.

The wind-assist pumping system has potential for providing an alternate energy source for irrigated agriculture in areas with average wind speeds exceeding 7 m/s. New wind turbines which are being developed should be economically priced and should provide farmers with a good power unit for their pumps. [R. NOLAN CLARK]

Trickle-drip irrigation. The use of trickling or dripping as a method of irrigating large fields has

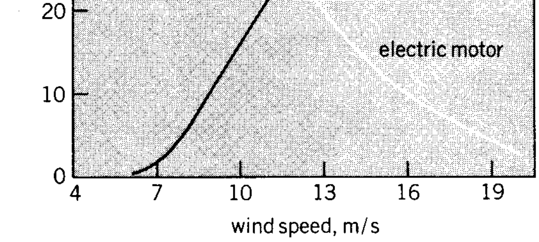

Fig. 3. Wind turbine power, electric motor power, and total pumping load versus wind speed for the experimental wind turbine.