

Pumping Water with the Wind

MODERN HISTORIC TECHNOLOGY

by Kevin Moore

Illustrations courtesy
of Tom Conlon

It never fails. Whenever I install a new windmill, I can almost guarantee that it will be referred to as an old windmill. When I assure people that it is newly manufactured, the doubt is apparent. “Surely it has been modified to be more efficient,” is a standard comment. “Not really,” is my answer.

There’s no need to reinvent the water-pumping windmill. It’s a workhorse that has been mostly unchanged since before World War II. About one million windmills are pumping water in the world today. The most common application is to install a windmill directly over a drilled or dug well. Pumping water from an aboveground source is also an easy task for a windmill. If you need to pump water on your property and the site has access to reliable winds, a water-pumping windmill may be a good option.

A water-pumping windmill supplies water for cattle that graze under large wind turbines in northern California

The author lifts the sheet-metal covering to expose the pumper’s gearbox.



Courtesy Kevin Moore



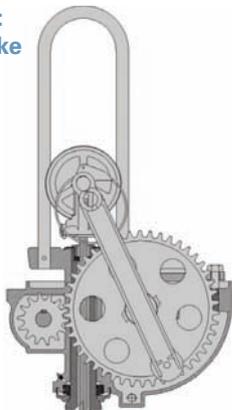
Courtesy Rick Gurriss

How It Works

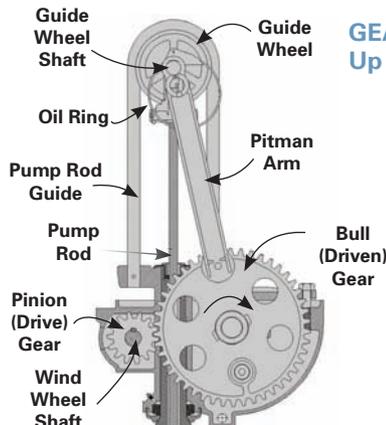
Water-pumping windmills are simple devices. I always enjoy pulling the sheet-metal cover off the gearbox and letting folks see just how a windmill works. I encourage them to spin the hub and watch the internal parts interact. I’ve heard the action of a windmill motor described as “using a big wheel for leverage, like the steering wheel on a big pirate ship.” People also liken it to “a big jack that lifts water.”

No matter how you describe it, the water-pumping windmill is a simple machine that uses mechanical advantage in multiple ways. It’s a direct-drive device that transfers energy via gears, rods, simple valves, and a piston in a cylinder—and uses high torque to move water. In contrast, wind-electric turbines use electrical generators coupled to high-tech airfoils that require high speed to do their job.

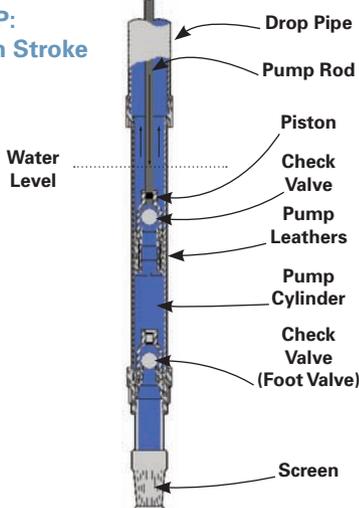
**GEAR BOX:
Down Stroke**



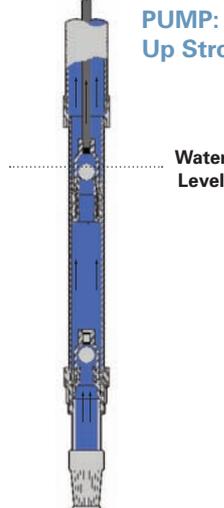
**GEAR BOX:
Up Stroke**



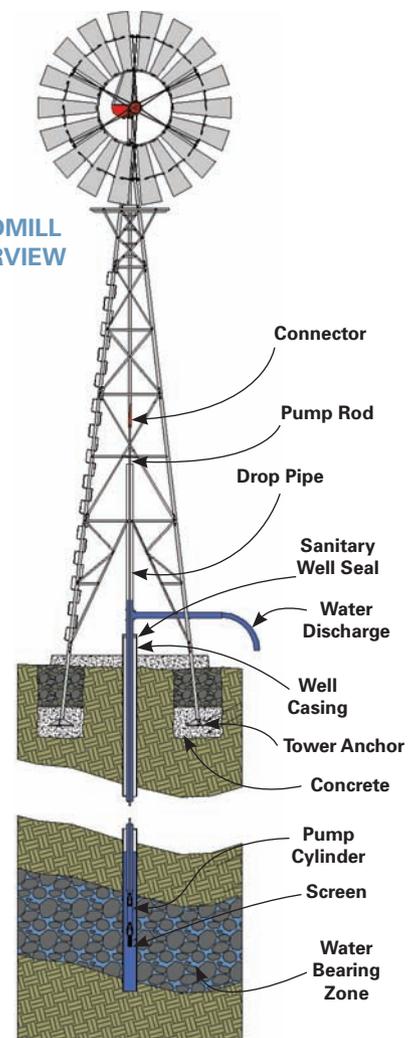
**PUMP:
Down Stroke**



**PUMP:
Up Stroke**



**WINDMILL
OVERVIEW**



Illustrations courtesy of Iron Man Windmill Co. Ltd. ©1977 Iron Man Windmill Co. Ltd.

This difference becomes evident when you compare the eighteen or so large blades on windmills to the two or three sleek blades on wind-electric turbines. The wide blades on the water-pumper are designed for low start-up wind speeds and slow-speed operation, as opposed to the electrical generator's thin blades, which are designed to run at higher rpm.

The blades of the windmill wheel catch the wind—just like the sails on a sailboat—which turns the wheel (rotor). The wheel is attached to a shaft by long arms. The shaft has small pinion gears at the other end, inside a gearbox. The pinion gears drive larger bull gears, which move pitman arms. The pitman arms push a sliding yoke up and down, above the bull gears (much like a crankshaft, connecting rod, and piston in a standard vehicle engine). The moving yoke lifts and drops the pump rod to do the work down below.

The pump rod goes down the tower through a watertight seal at the top of the well's drop pipe, and to the pump cylinder, the part that moves the water. The cylinder is attached to the bottom of the drop pipe below the water level, and has a simple piston and two check valves.

As the piston rises, water moves up the pipe above it. At the same time, water is sucked through a screen and the

lower check valve below the piston, into the lower section of the pump cylinder. When the pump rod reverses and begins to descend, the lower check valve closes and the piston check valve opens. This allows water in the cylinder to pass through, and the water that is trapped above the piston to be pushed up out of the cylinder and ultimately to its final delivery height. One might think of the pump as a cup with a trap door in the bottom that opens when the cup falls and shuts when the cup rises. This cycle is constantly repeated as the wind wheel turns to move the pump rod up and down.

If the wind wheel is moving, the pump piston is moving. As the wind speed increases, the speed and frequency of the piston stroke increases, so more water is pumped. But the windmill's efficiency drops because the airfoil is not optimized for higher wind speeds—it doesn't make as much use of the cubic effect of wind power as a wind generator does. (The power available in the wind is proportional to the cube of the wind speed.) But then, water needs do not increase in proportion to the wind speed either, so this is not a major impediment. In fact, water pumpers do the job they are designed for efficiently and well.

Siting Your Windmill

To avoid turbulence caused by surrounding objects, the blades of water-pumping windmills should be at least 30 feet above any obstructions such as trees or buildings in a 300-foot radius. Access to “clean wind” helps the windmill operate smoothly, ensures a more effective operation, and extends its life. This often means installing a tall tower, so you can get well above nearby buildings, trees, and land features.

Although you can select and site a windmill without using local wind-speed data, correctly sizing the windmill and pump cylinder (see *How Much Will it Pump?*) using real data will remove much of the guesswork about how much the ‘mill will pump. A well-selected and well-sited windmill should start pumping water at wind speeds between 6 and 8 mph. Most windmill manufacturers rate a windmill’s pumping capacity for winds in the 10 to 20 mph range. You should be practical—don’t size the windmill at its peak pumping capacity, or as if it’s only going to experience high winds.



Courtesy Tom Marvin

The author inspects a new gearbox.



Sizing Considerations

Before you choose your windmill, you must know the water level in your well. It doesn’t matter how deep the well is—it’s the static level of the water and the vertical distance the windmill needs to lift the water that is important. You also need to know if the water level changes seasonally, or if the water level “draws down” or falls below the static level when water is pumped.

Unless you know how to make the wind blow on demand, you also will need storage for the water that is pumped. For water storage, I’ve used everything from plastic barrels to ponds. The best method, if you have enough height to create sufficient pressure (about 70 feet of vertical drop will give 30 psi, which is suitable household pressure), is to locate a storage tank above the point of use, and gravity-feed the water from there.

Once you’ve determined the vertical distance your ‘mill needs to lift water within the well and the additional vertical lift to the storage tank, you can investigate your windmill options based on the amount of water you need and your budget. Here’s an example: If the lowest water level in the well is 60 feet below ground and you need to lift water to a tank that is 20 feet above the well, the total lift is 80 feet. Using the Pumping Capacities table, you can find what size windmill to use, as well as correctly determine the cylinder diameter to use.

How Much Will It Pump?

The amount of water your windmill can pump is regulated by the size of the pump cylinder, the elevation to which the water needs to be raised, the size of the wind wheel, and how much wind you have at your site.

A typical windmill with an 8-foot-diameter wheel can lift water 185 feet and pump about 150 gallons an hour in

Protection from High Winds

When you are working with Mother Nature, you soon realize that she will try to destroy anything you dare to use to harness her wind. From large wind-electric turbines to farm windmills, wind machines must be robust and have a means to protect themselves from high winds.

The typical water-pumping windmill uses an off-center mast pipe and an oversize tail vane to turn the blades out of the wind (furl) at high wind speeds. An adjustable spring is used to select the speed control point to furl the windmill out of the wind and to return the windmill into the wind as the wind speed decreases. Windmills are also equipped with a lever at the tower base to manually turn the windmill out of the wind and set a friction brake.

Windmill shown "furlled," or turned out of the wind (blades are parallel to the tail).



Courtesy Kevin Moore

Pumping Capacities*

Cylinder Diam. (In.)	Capacity (Gal. / Hr.) at All Wheel Diameters	Pumping Elevation/Lift (Ft.) @ Wheel Diameter				
		8 Ft.	10 Ft.	12 Ft.	14 Ft.	16 Ft.
1.75	150	185	280	420	600	1,000
1.88	180	175	260	390	560	920
2.00	190	140	215	320	460	750
2.25	260	112	170	250	360	590
2.50	325	94	140	210	300	490
2.75	385	80	120	180	260	425
3.00	470	68	100	155	220	360
3.25	550	58	88	130	185	305
3.50	640	50	76	115	160	265
3.75	730	44	65	98	143	230
4.00	830	39	58	86	125	200
4.25	940	34	51	76	110	180
4.50	1,050	30	46	68	98	160
4.75	1,170	–	41	61	88	140
5.00	1,300	25	37	55	80	130
5.75	1,700	–	–	40	60	100
6.00	1,875	17	25	38	55	85
7.00	2,550	–	19	28	41	65

*At 15 to 20 mph wind speeds; Based on long stroke. For short stroke, reduce capacity by 25% and increase elevations by 33%.
©2007 Rock Ridge Windmills

15 to 20 mph winds when using a 1 3/4-inch pump cylinder. The size of the wind wheel and pump cylinder impact the maximum lift that's possible and the volume of water that can be pumped, respectively. A bigger wind wheel can lift water higher than a smaller one, and a larger cylinder pump can deliver a greater volume of water. If we increase the size of the pump cylinder to 3 inches while still using the same 8-foot-diameter wheel, the volume delivered increases to 470 gallons per hour, but the maximum lift decreases to 68 feet. If we stay with that 3-inch cylinder, but increase the windmill to a 16-foot diameter wheel, we will be able to deliver the same 470 gallons a total of 360 feet.

The above examples use a windmill configured in the standard (long-stroke) mode at wind speeds between 15 and 20 mph. Most windmills have the ability to change the length of the stroke of the pitman arms. At the same wind speeds, but in the short-stroke mode, the windmill will pump at lower wind speeds, but will pump less water.

Windmills are made with wheel diameters ranging from 6 to 20 feet, although the most common size wheel is 8 feet in diameter. Add a 33-foot steel tower to it and the cost is about \$4,000 (windmill: \$2,100; tower: \$1,900). A 20-foot-diameter wheel windmill with a 50-foot-tower will cost close to \$25,000. If you're still unsure how to choose the right windmill for your site, don't worry—most windmill suppliers will be happy to help size the windmill and pump cylinder correctly.

Installation

With sharp edges on 18 sheet-metal blades and a sizable heft (a complete 8-foot windmill weighs about 350 pounds), installing a windmill can be very awkward at best, and outright deadly without proper training and equipment.

Rescuing Used Windmills: Buyer Beware



Courtesy Bryon Rykard

In many parts of the world, old windmills can be found resting idle in the fields. A once-proud but now lonely windmill standing on a tower can be a temptation for many of us. As the wind blows, the motionless windmill seems to call out to you with a squeak or even a painful whimper, just as the Tin Man called to Dorothy in the *Wizard of Oz*. Oil, you think, just a little oil and that windmill will run again.

But in the world of used pumpers, a fine line exists between the “do-it-yourselfers” and the “do-it-to-yourselfers.” Compare that old windmill to an old car. Would you buy a 1940s-era car that’s been weathering the elements for decades and expect to drive it every day? More than likely, that windmill has been standing on top of its tower, exposed to the weather, every day of its life—for decades. Do you think that its owner diligently changed the gearbox oil every year since 1940?

Professional installers can be found in almost every region of the United States, or a windmill and tower can be assembled and erected by most do-it-yourselfers who take a one-day class (see Access). Some people choose to erect the windmill and tower without the benefit of a boom truck or lift, though this is not recommended.

For well installations, it is important to center the windmill directly over the well. Any bending or flexing of the pump rod will lead to excess friction and early failure of the moving parts. Also make sure that the top of the tower is level when the installation is complete. All windmills are designed to rotate on the tower axis to face into the wind. If your tower is not level, your windmill will turn downhill when the wind is calm and will not return to face the wind as easily.

Servicing the Windmill

The one major improvement in the 150 years that American windmills have been made was the introduction of the self-oiling windmill in the 1930s. Before that, a windmill’s parts had to be lubricated weekly by climbing the tower to grease the moving parts. But even with this advancement, windmills still require regular maintenance to keep them working well.

The instructions that a windmill manufacturer would have offered 75 years ago still apply today:

The author installing a 10-foot-diameter windmill.

Most abandoned windmills have been damaged beyond repair during years of disuse. Common points of failure or damage in an old windmill include the soft metal (babbitt) bearings, which need to be poured in place, not simply replaced with a kit. Every shaft hole is mostly likely out-of-round, and moving parts have worn due to lack of oil. Structural failure could be one broken bolt away. Windmill gearboxes are typically cast iron, and are balanced by the even distribution of weight. Once one part fails, other parts are unequally loaded and stressed by the failure.

Even if you find a well-preserved and well-maintained ‘mill, you still need to remove and transport it. Putting up a windmill can be very dangerous—taking down an old windmill is *always* dangerous, and is not work for the uninitiated. It requires skill and experience in climbing, rigging, and dealing with large, heavy objects, and a sixth sense about the condition of the used tower and mill.

So if you’re thinking about salvaging an old windmill that’s been sitting in your neighbor’s field for decades—just stop. Many folks have tried before you, and the relic usually ends up joining the other tired windmills tucked away in the garage corner after someone finally figures out that they’ll be money ahead investing in a new one.

- Always keep an eye and an ear toward your windmill. Peculiar sounds or visible abnormalities should be investigated at once.
- Once a year, change the oil.
- Twice a year, check the nuts and bolts. Tighten any loose fasteners, and replace any that are rusted or damaged.
- Water-pump seals should last five years or more, unless your water contains lots of sand or grit, which will shorten seal life. A good filter on the bottom of the pump will help alleviate this problem.



Courtesy David Martin

Gearbox Care

Many good windmills have been destroyed by using the wrong oil. Each windmill company will specify the correct oil for their gearbox. Most use a 10-weight or very light nondetergent-type oil. The thin oil travels easily to the many moving parts. Nondetergent oil allows any contaminants to fall to the bottom of the gear case. Adding detergent oils will cause build-up and contaminants to block small oil ports. Once the ports become blocked, the lack of oil to the bearings will lead to major failures.

Repair any damage you spot during your semiannual maintenance check to help ensure that your windmill will keep pumping water for decades.

Windmills: Yesterday & Tomorrow

At one time, water-pumping windmills were a common sight on the American landscape. It wasn't until the 1936 Rural Electrification Act, which provided cheap electricity to almost every home, that windmills were replaced by electric pumps. But water-pumping windmills haven't died—and as people search for simple, reliable, and renewable solutions in our complicated world, these pumpers are experiencing a renaissance.

So if you need to pump water and you have a suitable wind site, think about using this modern historic technology. But be prepared for people to ask you, "Is that an old windmill you just put up?"

Access

Kevin Moore (www.rockridgewindmills.com) is a water-pumping windmill enthusiast and owner of Rock Ridge Windmills in northern California. He has worked on windmill projects from rural China to the American Midwest, and teaches water-pumping windmill classes at the Solar Living Institute in Hopland, California.

Tom Conlon (www.ironmanwindmill.com) was in the windmill business in California for many years. Today, he manages a windmill factory in central China where he functions as an unofficial American ambassador of goodwill, while working to introduce American agricultural technology to help improve living conditions in poor rural farming villages.

Water-Pumping Windmill Manufacturers:

Aermotor Windmill Inc. (Texas) • 325-651-4951 • www.aermotorwindmill.com

Dempster Windmills (Nebraska) • 402-223-4026 • www.dempsterinc.com

Iron Man Windmills (China) • 86-27-8349-6716 • www.ironmanwindmill.com

Southern Cross Windmills (Australia) • 61-07-131-786 • www.southcross.com.au/windmills

Water-Pumping Windmill Classes:

Solar Living Institute • 707-744-2017 • www.solarliving.org

University of New Mexico, Carlos Rosencrans • 505-646-4511 • crosencr@nmsu.edu • www.nmsu.edu

