Thoughts on VAWTs

Vertical Axis Wind Generator Perspectives

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A Pinson vertical axis wind turbine (VAWT) in front of a Winpower horizontal axis wind turbine (HAWT). This Pinson turbine is an H-Rotor derivative. It features pitch adjustment for improved performance.

Most people's image of a wind generator is either an old twenty-bladed water pumper on a Midwestern farm or a modern, three-bladed, utility-sized giant. Both of these are HAWTs—horizontal axis wind turbines. Having propeller blades that rotate around a horizontal axis is the common theme for all HAWTs. The VAWT, or vertical axis wind turbine, is an entirely different animal, and appears in a variety of forms.

Currently, no residential vertical axis wind turbines are available in the United States. A few are made in Europe and one is made in New Zealand. I have no information on the quality or reliability of these machines. Some are just prototypes and some are in production. It is often hard to tell what's what from the published information.

Types of VAWTs

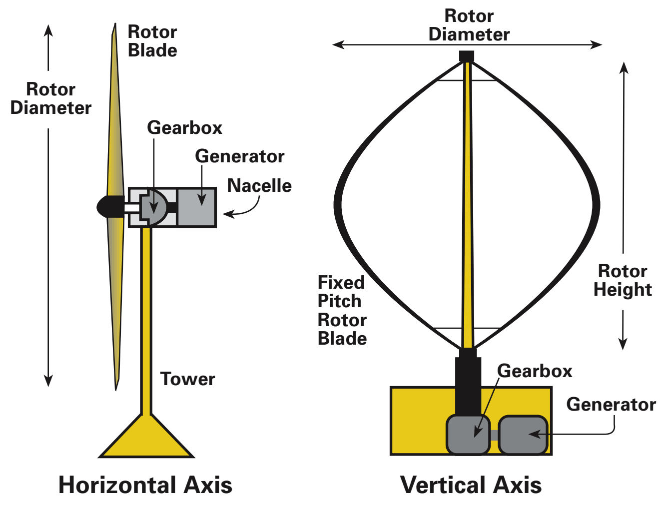
There are three common configurations for a VAWT. The simplest is a Savonius, which can be as crude as a 55-gallon drum cut in half and offset, forming two cupped "blades." They can also be constructed from bent stainless steel. Other designs stack multiple, small Savonius rotors (blade sets) out of sequence with each other for smoother output. Another variation is a spiral Savonius rotor. The first time you see one, you might not even recognize it as a wind generator.

The other common vertical axis wind turbines are H-Rotors and Darrieus turbines. The H-Rotor is two or more straight, vertical blades rotating around a vertical axis. Darrieus turbines (often called eggbeaters) have two or more blades curved in a half hoop.

The Savonius rotor is a drag device. In other words, the wind simply pushes the blades around, and the Savonius only works because there is less resistance when the backs of the blades come around to the wind, because of their shape. A drag device has a lower maximum efficiency. It is limited to a rotational speed at its perimeter of less than the wind speed, and it has to physically occupy all of the area that it sweeps.

The other machines mentioned above are lift devices. A lift device relies on the aerodynamic design of the blade to convert the wind's energy into rotational motion that is 90 degrees to the wind, and much faster than the wind speed. This is similar to the design of an airplane wing, which lifts a plane into the air. An H-Rotor with two or more skinny blades traveling at six times the speed of the wind will generate more than a Savonius sweeping the same area and covering every square inch of it.

Wind Turbine Configurations



The Darrieus pictured here is a small utility-scale machine. Note the extruded aluminum blades and the guy wires, which are typical for a Darrieus.

A drag device's blades travel *with* the wind, and are limited to traveling at the wind speed. A lift device's blades travel *through* the wind, and are driven at much higher speeds. The H-Rotor weighs and costs a fraction of what the Savonius does. The higher costs for the Savonius design are due to the amount of raw materials required and some design issues, which I will describe in further detail below. There is not likely to ever be a cost-effective, commercially produced Savonius variation. The H-Rotor and Darrieus VAWTs are more efficient and more likely to be commercially produced.

Advantages & Disadvantages

Some VAWT enthusiasts make strong claims of superiority for these machines. Many feel that ignoring this type of design is some kind of a conspiracy. Let's examine the specific issues in more detail.

Yawing. VAWT supporters are quick to point out that a VAWT is always pointing into the wind and does not need to reorient (or yaw) like a HAWT when the wind changes direction. This point is valid, but the value of this advantage is often overstated.

It is true that a VAWT does not need a tail and that yawing in turbulent winds does create wear and tear on HAWTs, especially two-bladed ones. But under most conditions, properly sited wind generators do not see lots of rapid wind direction shifts (thirty-plus degrees). Wind direction usually shifts more slowly, and HAWTs will typically follow the changes smoothly. If a site experiences rapid and frequent changes in wind direction, don't place *any* wind generator there! Turbulent winds are very hard on any wind generator—HAWT or VAWT.

Speed Control. Offsetting the VAWT advantage of not needing to yaw is the fact that controlling the output of a VAWT is difficult. You can't have it yaw out of the wind to reduce output, like a side-furling HAWT. This can be a serious problem. A VAWT that makes 2 KW at 20 mph (9 m/s) will want to make 16 KW at 40 mph (18 m/s). You cannot let this happen.

A 2 KW wind generator is not strong enough to handle the forces involved to generate 16 KW. If it were built strongly enough, both the wind generator and the rest of the system components would be much more expensive. Yet most of the time, it would only generate as much as the original 2 KW machine, because output is limited by the wind and swept area, not by alternator capacity. (An alternator converts the mechanical rotation of the blades into electricity.) There are ways to deal with the additional forces of generating at higher wind speeds, but all of them add complexity and cost. This problem is easily handled with a side-furling HAWT.

Fatigue. Another equally serious disadvantage for VAWTs is fatigue. If fatigue is a problem for the HAWT, it is the archenemy of the VAWT. There are two reasons for this. One is that during part of its revolution, a VAWT blade has lift on one side of the blade and then no lift, then lift on the other side, then no lift. This cycle is repeated in every revolution that the machine makes. The other source

This small Savonius rotor was formed from stainless steel. Metal covers the whole swept area.

of fatigue occurs because for part of each rotation, the blade is operating in the turbulence downwind created by the upwind blade(s), and usually a tube or tower in the center.

Does this mean that a VAWT cannot be built to last? No, it only means that designing a VAWT blade and mounting structure is more challenging than designing a HAWT.

Urban Use. Some people say that a VAWT is better suited or safer for use in the city and a HAWT is not suitable or can even be dangerous in the city. The issues for urban siting of wind generators are appearance, noise, performance in turbulence, height, and safety.

Appearance is an aesthetics issue and is highly subjective. I like the appearance of both HAWTs and VAWTs. I have never conducted a poll to determine if there are significant differences in the general public's response to the different wind generator configurations. The challenge of minimizing noise is fairly well understood in HAWTs today and would be a similar challenge for VAWT designs.

The VAWT does have an advantage in dealing with wind direction shifts, but general turbulence will increase fatigue on a VAWT just like a HAWT. Often VAWT proponents point out that a VAWT can be installed on a roof or on the ground, while HAWTS must be on tall, expensive towers. But roofs and the ground are poor sites for *any* type of wind turbine. Turbulence and drag from the ground, trees, and buildings rob much of the energy available in the wind, and turbulent winds are hard on all types of wind generators. Vibration from wind generators on buildings can be an irritant at least, and a structural problem at worst. The standard guideline of installing a wind generator at least 30 feet (9 m) above anything within 500 feet (150 m) holds true for VAWTs, and installing VAWTs on tall towers where they belong has its own set of design problems.

The H-Rotor and Darrieus turbines have at least as much potential for safety issues (such as throwing blades) as a HAWT. All wind generators are by nature rotating machinery. If they fail, they can lose parts. In a residential-size system, this is usually no more dangerous than a tree limb blowing down.

No Magic Bullet

There is an all-too-common belief that a VAWT approach will revolutionize the small wind industry. This seems to be a lot of wishful thinking by people who don't understand physics. It is fed by the seemingly endless string of companies promoting roof-mounted, high-tech variations on the Savonius rotor. Most of these inventions claim to capture more than 100 percent of the energy in the wind at low speeds. The maximum they can actually capture is around 30 percent. If they claim more than that, be very suspicious.

Some of you, especially VAWT enthusiasts, may think that I am opposed to VAWTs. I am not. In fact, I would like to see some models on the U.S. market. I even looked at developing a 500-watt VAWT several years ago. What stopped me was simply limited resources, not the technical problems that come with VAWTs.

There is no magic here. High-quality, detailed engineering, design, and manufacture can produce a good wind generator—HAWT or VAWT. Some special problems must be overcome in designing a VAWT. We need a good solution for power control in high winds and better design for fatigue than is used in the best HAWTs.

If you want to have a wind generator installed or install one yourself, it will be a HAWT. That is what is available on the market today. If you want to build one yourself, there is more information on building HAWTs, and it is a less risky option. If you are a brave experimenter and have a suitable place to put it, you can try a VAWT.

So far, no VAWTs are produced commercially in the United States for several reasons. The most important is that there is no easy way to provide power control in high winds compared to the ease of side-furling a HAWT. VAWTs are also less efficient and tend to be more expensive. The high fatigue cycles inherent in a VAWT make successful design more difficult. The advantage for the VAWT of having no tail or yawing system does not seem to be enough to counter the disadvantages.

Access

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