Horizontal and Vertical-Axis Wind Turbines - A Place For Each

Jules Smith

Visit any large utility-scale wind farm and you're likely to see row upon row of turbines that look like airplane propellers, turning on a horizontal axis. Have you ever wondered why vertical-axis turbines are less common? The stock answer is that vertical-axis turbines are not as efficient as horizontal-axis turbines, and since investors want the highest return on their money, they build whatever will provide the biggest payback. But that may be an oversimplification.

A Darrieus wind turbine (left),
and a Savonius wind turbine (right)
Darrieus photo CC BY-SA 3.0 by Guillaume Paumier.
Savonius photo CC 0 by Bernd Wolf.

Raw Efficiency

If we define efficiency as the amount of energy extracted from a given volume of wind, then horizontal-axis turbines do tend to be more efficient than their vertical-axis counterparts. Why? Simply put, with a horizontal-axis wind turbine (HAWT), the full surface of each blade is always perpendicular to the oncoming wind throughout its rotation and therefore always generating lift and always imparting torque to the axle.

With a vertical-axis wind turbine (VAWT), each scoop or blade captures or uses oncoming wind only part of the time. This is obviously true of simple scoop-like Savonius turbines; for half of each rotation the scoop is actually moving against the wind. Even with lift-type Darrieus turbines, each blade provides maximum lift only at the front and back of its rotation cycle.

However, this assumes the the wind is always coming from the same direction. What happens when the wind direction changes? Here, vertical-axis turbines have an advantage over their horizontal counterparts.

A horizontal-axis turbine must have some mechanism to adjust its yaw, to keep it facing the wind. Small turbines may simply have a rudder on the back. Larger devices will typically have some mechanism to turn the turbine into the wind, responding to sensors mounted atop the unit. But these are reactionary; they can only respond to the direction change after it has already occurred. In the time it takes to adjust, they've lost power. More advanced systems are able to anticipate changes in wind direction and adjust the yaw of the turbine first, so the blades are always aligned perpendicular to the oncoming wind. But these systems add to the complexity, cost, and maintenance requirements of the device.

In contrast, vertical-axis turbines capture the wind whatever its direction.

Factors Beyond Efficiency

Vertical-axis turbines tend to be simpler than their horizontal-axis counterparts, without the need for yaw control and often without complex gearing between the main axle of the turbine and the generator. The fewer moving parts there are, the less likelihood there is of mechanical failure and the less maintenance those parts require. This translates into lower production and maintenance costs.

Other factors may not translate directly into a dollar amount, but they do impact the environmental and social cost of wind turbines. Specifically, some VAWT designs, particularly variations on the scoop-like Savonius turbine, tend to be more bird-friendly than HAWTs. Birds see the turbine as a solid object and don't try to fly through it, as they may when approaching the spinning blades of most horizontal-axis turbines.

VAWTs may also be quieter. As mechanical devices, all wind turbines will produce some noise. For HAWTs, noise typically comes from four sources: the movement of the blades through the air, the turbulence between the rotating blades and the stationary tower (often perceived as a low-frequency pulse), the gearing mechanism, and the generator. VAWTs eliminate the turbulence noise and, with simpler designs, much of the gearing and generator noise as well. With fewer gearing requirements, VAWTs often function well in wind speeds below the threshold required for horizontal-axis turbines. They start at lower wind speeds and may even cope better with higher wind speeds.

Of course, there are different types of vertical-axis turbines operating under different principles, with new designs coming onto the market all the time. But given the general difference between most vertical and horizontal-axis designs, does either configuration have a clear advantage over the other? Or is each more suited to a specific environment? Kristyn Bishop, Marketing Manager with Windspire Energy, answers, "VAWTs are designed for suburban residential use and use lower wind streams while fitting zoning and building codes. However, VAWTs can also be used in all the numerous other applications that HAWTs can."

The wind is always blowing somewhere and there are enough wind-rich sites to suit any configuration. The important thing is to capture the wind. Vertical-axis turbines – whether as efficient as horizontal-axis turbines or not – have a role to play.

Jules Smith is the Principal of LightningStrike Studios (https://www.lightningstrikestudios.com/), a professional communications firm providing marketing content, corporate communications, and web site design. He writes across a wide range of topics, specializing in renewable energy and information technology.