

Technological Advantages

Aerospace Technology and Science Combine to Increase Power Output.

The Vindicator™ Laser Wind Sensor — The Case for 10% More Power

The Vindicator™ forward-looking laser wind sensor system enables wind turbine generators to increase power output by 10%. It's a strong claim, but it can be supported scientifically.

First let's examine one major factor affecting wind turbine power output efficiency — yaw, or rotor misalignment with the wind. Page 96 of the "Wind Energy Handbook," 2001, John Wiley & Sons, Ltd., describes the changing nature of the wind environments in which wind turbines normally operate:

"The rotor axis of a wind turbine rotor is usually not aligned with the wind because the wind is continuously changing direction; the rotor is not capable of following this variability and so spends most of its time in a yawed condition. The yawed rotor is less efficient than the non-yawed rotor and so it is vital to assess the efficiency for purposes of energy production estimation."

The Vindicator™ wind sensor effectively and significantly decreases yaw error — and the result can be quantified. There are two important sources that support Catch the Wind, Inc.'s claim that a Vindicator™ wind sensor can provide a 10% improvement in performance for wind turbines that have modern control systems. A modern control system is one that can translate real-time, accurately predicted wind data into yaw and blade pitch control, allowing a turbine to more effectively "catch the wind." This capability will reduce the amount of time that a wind turbine generator spends misaligned with the wind.

FIRST SOURCE: An Important Laser Wind Sensor Study

In January 2006 the National Renewable Energy Laboratory (NREL) published a study on Light Detection And Ranging (LIDAR) For Turbine Control (Technical Report NREL / TP-500-39154). This study examined LIDAR's potential for remotely sensing wind speed and direction. NREL reported that using LIDAR for the measurement of changes in the wind flow approaching wind turbine generators offered the advantages of "increased turbine energy output and reduced turbine fatigue damage." (Page iii – Executive Summary)

SECOND SOURCE: Quantifying the Benefit to Turbine Efficiency

While the NREL study clearly touted the benefits of LIDAR sensor technology to the efficiency of wind turbine generators, it did not attempt to quantify the improvement. In order to better understand and quantify the turbine power output efficiency improvement that could be expected from using laser sensor technology, Catch the Wind, Inc. utilized the expertise of Dr. J. Gordon Leishman, the Minta Martin Chair of Engineering and Professor of Aerospace Engineering at the University of Maryland.



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In his book, "The Principles of Helicopter Aerodynamics," Dr. Leishman dedicates an entire chapter to the "Aerodynamics of Wind Turbines." Dr. Leishman goes into exhaustive analytical detail about the power loss effects of wind turbine generators that are "yawed" or misaligned with the wind. The resultant effect of yaw on power output is reflected on page 727:

"...the power output drops by $\cos^3(\text{yaw angle})$ and so the importance of accurately controlling the orientation of the turbine relative to the wind direction becomes immediately clear. This must be done by design or by some sort of mechanical control device that senses wind direction and automatically points the turbine accurately into the wind."

Dr. Leishman provided Catch the Wind, Inc. with an estimate quantifying how much power loss could be expected because of annual average yaw effects. He summarized by noting that the effect of yaw on wind turbine generators is significant, then went on to consider three cases: unyawed operations, 15 degrees yaw operations and 30 degrees yaw operations. This data was calculated for an 18-meter wind turbine at mean sea level with average annual wind speed from zero to 8 meters per second. A large wind turbine with a rotor diameter of 100 meters would exhibit similar yaw effect characteristics. According to Dr. Leishman, the effects are scalable to large wind turbines.

Dr. Leishman's data shows that the effect of yaw at a moderate wind speed of 6 meters per second results in a power loss of approximately 13 percent for an average annual yaw misalignment of 15 degrees.

By reducing the average annual yaw angle from 15 degrees to 5 degrees, the power output loss can be reduced from 13 percent to 3 percent. Thus a 10 percent improvement in efficiency can be gained if the annual average yaw effect for a large wind turbine is reduced by 10 degrees.

The Vindicator™ laser wind sensor enables turbine control systems to reduce yaw by at least this amount.

The Choice Is Clear

The Vindicator™ laser wind sensor system is destined to quickly become the technology of choice for wind power generation. As with all successful new technologies, the initial promise is based in science. As more Vindicator™ systems are put into service, practical field data will confirm Catch the Wind's claim of 10% greater output power. Catch the Wind, Inc. has been careful and conservative in its estimates. The claim is well supported.

For more information about the Vindicator™ laser wind sensor system and additional laser sensor products, please call:

Catch the Wind, Inc.

10781 James Payne Court, Manassas, VA 20110
703-393-0754 • www.catchthewindinc.com

