INCREASED POWER PRODUCTION FROM UTILITY SCALE WIND TURBINES WITH LASER WIND SENSOR CONTROL

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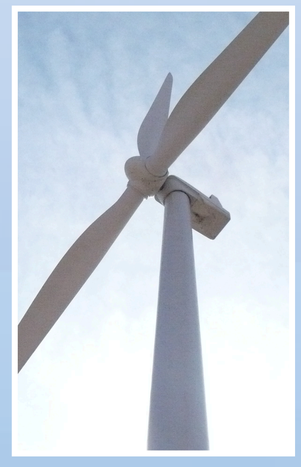
Introduction

Efficient power production from a wind turbine relies on accurate wind speed and direction information ahead of the turbine. In the past, yaw and pitch control of wind turbines has relied on delayed wind information measured by mechanical anemometry at the back of the nacelle. The accuracy of the measured wind data has further been limited by the disturbed nature of the flow field at the back of the nacelle. Turbine control has therefore been REACTIVE.

The recent acceptance of remote sensing techniques such as laser wind sensors (LWS) for wind measurement has opened new opportunities for PROACTIVE turbine control. By accurately measuring the undisturbed wind ahead of the turbine, these sensors are capable of providing inputs to intelligent feed-forward controls. The resulting increase in power production along with reduction in stress loads on the turbine has been recorded over the past year. This poster presents updates to the preliminary results presented at CanWEA 2009.



Proactive Turbine Control Requires

BETTER DATA
A way to measure the undisturbed flow incident on the turbine

MORE TIMELY DATA
A way to measure the undisturbed flow before it gets to the turbine

BETTER USE OF THE DATA
Smarter algorithms to account for arriving inflow disturbances and changes

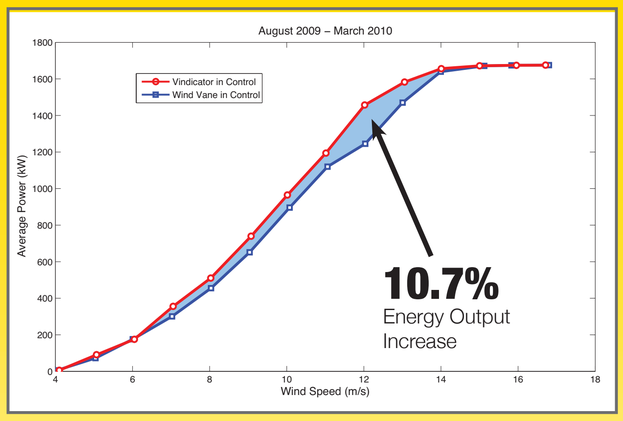
Hypothesis

- Forward Looking LIDAR enables improved pointing accuracy
- Improved Pointing Accuracy Leads To:
  - *Improved Aerodynamic Efficiency*
  - *Reduced Asymmetrical Loading on Turbine Components*
  - *More Power Production*

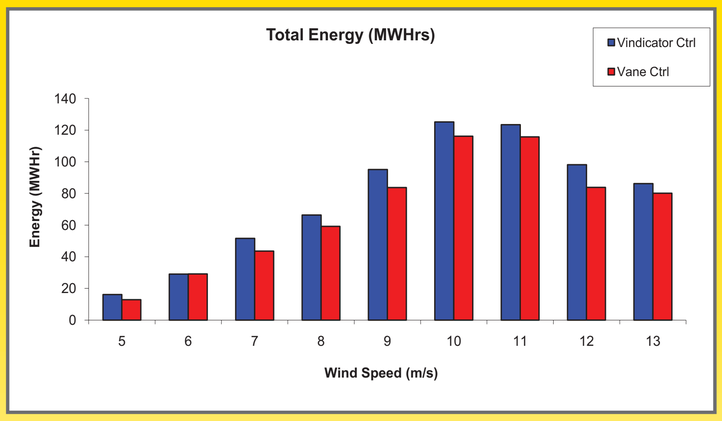
Test Equipment and Test Site

- LIDAR Used: Vindicator® Laser Wind Sensor
- Mounting Configuration
  - *BLU Inside Turbine Nacelle*
  - *RLU Mounted on Top of the Turbine Nacelle*
  - *Forward Looking - Measures at 100 m, 150m, 200m in Front of the Turbine*
- Data Interfaced with Turbine Yaw Motors Through New PLC
- Existing Anemometer and Wind Vanes Remained Functional on the Turbine
- NPPD Vestas V-82 Turbine, #T22
- Ainsworth, NE Wind Farm

Energy Output Increase *Laser Wind Sensor Control vs. Wind Vane Control*

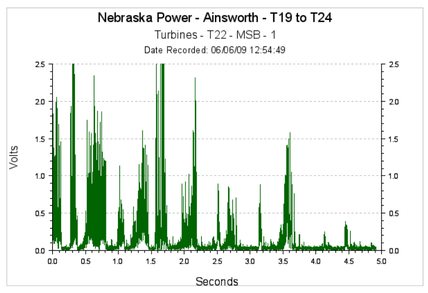


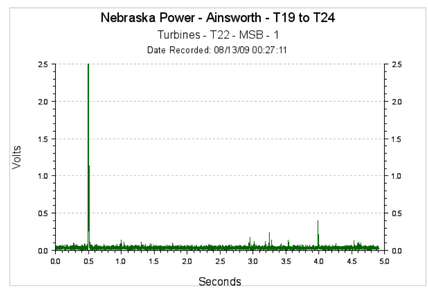
Region 2 Power Output Comparison

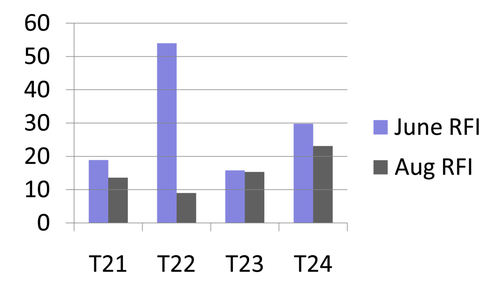


Normalized Total Power Output Comparison

Reduced Stress on Critical Turbine Components



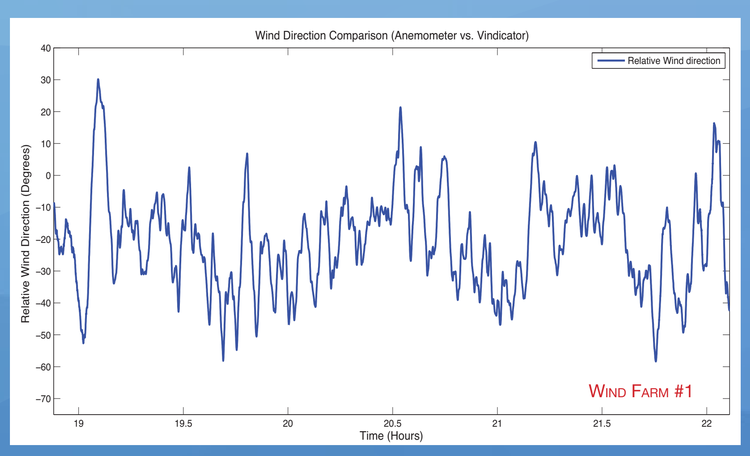




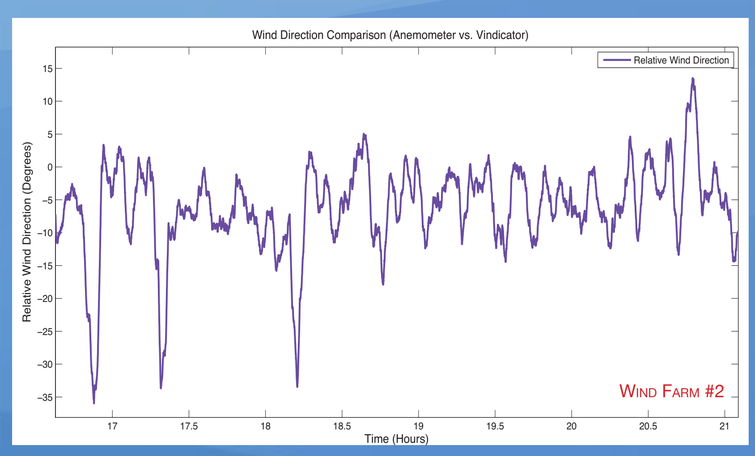
SWANTech 2009 - Third Party Stress Analysis Report

Difference in Measured Wind Direction

Comparison of wind direction data taken by a laser wind sensor to data measured by the wind turbine's sonic anemometer. Difference in measurements shown in degrees.



Laser Wind Sensor vs. Sonic Anemometer



Laser Wind Sensor vs. Sonic Anemometer

Turbine Control Logic

- Must not increase yaw frequency
- Can vary averaging and yaw tolerance
- Utilizes standard “feedback” control logic and averaging techniques
- Utilizes the turbine anemometer for cut in and cut out

Conclusions and Future Work

- LIDAR provides very accurate wind speed and direction from undisturbed airflow ahead of a wind turbine.
- **Proactive yaw control using LIDAR inputs has shown a 10.7% increase in power production on a Vestas V-82 turbine, over a period of 8 months. This improvement has been observed between cut-in and rated power.**
- Reduction in stress loads on the turbine has been observed when turbine was in LIDAR yaw control.
- Additional improvement in power performance and reduction in stress loads is expected with optimized yaw control.

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