**Abstract**

# Wind sensing: a new technology to estimate the inflow at the rotor disk for smart wind turbine and wind farm control

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The current standard equipment mounted on board wind turbines for the measurement of the wind inflow is composed of one or more anemometers and wind vanes, which provide measurements of wind speed and direction at hub height (Fig. 1). Even when properly calibrated, all such devices suffer from one inherent unavoidable limitation: they provide measurements at the single point in space where they are located. As such, they are necessarily blind to all wind characteristics that imply wind variations across the rotor disk. This means that wind turbine and wind farm controller operate based only on very limited information about the actual flow conditions at the rotor. For example, from a single point measurement one cannot detect the impingement of the wake shed by an upstream wind turbine. Similarly, one cannot measure the vertical wind shear, which, on the other hand, has a strong effect on wake behavior. This *limited awareness* of the actual flow conditions at the rotor disk hinders the development of advanced wind turbine and wind farm control laws.

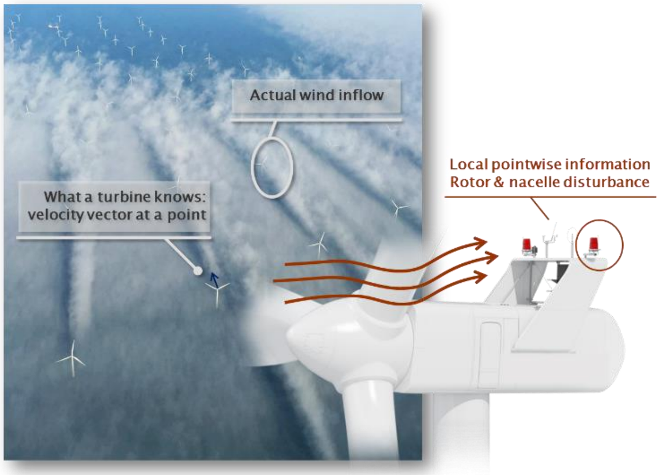


Figure 1. The limited knowledge of wind conditions available to a wind turbine today, compared to the actual complexity of the inflow.

*Wind sensing* is a new technology that addresses the limitation of current on-board wind measurement equipment. Wind sensing is based on the idea of using *the whole wind turbine rotor as a large sensor*. In fact, any change in wind conditions –speed, direction, vertical shear, veer, the interaction with a wake, etc. – leaves its unique trace on the response of the machine. By measuring the rotor response, for example in terms of loads and/or accelerations, one may "invert" the rotor response and estimate the wind conditions at the rotor disk.

This new approach has several interesting and unique characteristics. First, it provides a rich description of the wind inflow directly at the rotor disk in real-time during the operation of the machine. This improved situation awareness enables advanced features of wind turbine and wind farm controllers, which are out of reach when using the current wind measurement devices. Furthermore, differently from remote sensing devices as LiDARs, wind sensing can be implemented using the cheap and readily available load sensors that are already often installed on modern large machines to enable load-mitigating active control laws. In these cases, wind sensing can amount to a simple software upgrade.

This presentation will review the current state of development of the wind sensing technology, showing results from simulations, wind tunnel experiments and field testing. The presentation will also address the use of wind sensing for implementing smart control laws, showing some preliminary results on wake-steering wind farm control.

## References

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