

Gust Prediction Using Lidar Observations  
**Elliot I. Simon, Michael S. Courtney, Guillaume Léa**  
DTU Wind Energy (Risø), Roskilde, Denmark  
ellsim@dtu.dk

### Abstract

**Keywords:** *nowcasting, scanning lidar, gusts, wind ramps, balancing markets*

In established, ambitious markets such as Denmark, wind energy production accounts for over 40% of annual electricity consumption<sup>[1]</sup>, with goals to reach 100% of primary energy from renewables by 2050<sup>[2]</sup>. Phase and scale errors in wind power forecast models can lead to costly system imbalances, particularly on very short time scales (i.e. up to 15 minutes). As the share of wind fueled generation increases, and energy markets reform towards shortened bidding horizons, new approaches will be useful in providing very short term forecasts which outperform the persistence method. Events such as gusts and wind ramps are particularly worthwhile of attention, since they can lead to substantial instantaneous deviations in power and energy.

Pulsed Doppler lidars can provide detailed measurements of the incoming wind at large distances upstream of a wind farm. Derived radial velocities and other backscatter signals can be used to determine characteristics of the inflow, such as the presence of incoming gusts. A campaign to determine the best practices for measuring and processing data for this purpose was conducted over a 3 week period in Denmark.

In the WAFFLE experiment, a long range scanning lidar (Windcube 400S) running DTU's WindScanner software was deployed at Risø on the coast of Roskilde Fjord. PPI (plan position indicator) scans were conducted up to 10km upstream of the predominant wind direction, in order to provide a preview of the incoming wind. Time series and image based processing of the lidar observations is performed to relate the distant wind measurements to local sonic met-mast measurements and active power signals from a Vestas V52 turbine. This method is demonstrated to provide early notice of gusts to the operator. Not only can this system be useful for nowcasting applications of energy production, but is also practical for utilization in extreme load avoidance and turbine/windfarm level control.

### References:

1. Danish Wind Energy Association, 2017: The Danish Market  
[http://www.windpower.org/en/knowledge/statistics/the\\_danish\\_market.html](http://www.windpower.org/en/knowledge/statistics/the_danish_market.html)
2. Ministry of Foreign Affairs of Denmark, 2017: Independent from Fossil Fuels by 2050  
<http://denmark.dk/en/green-living/strategies-and-policies/independent-from-fossil-fuels-by-2050>