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Relating Inflow Conditions to Power Output at an Altamont Pass, CA Wind Farm

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During the summer of 2012, a WindCube lidar was deployed upwind of several wind turbines at a wind farm in California. The lidar measured vertical profiles of wind speed and direction from 40 to 150 m above ground level with a sampling frequency of 1 Hz. SCADA data were obtained from the wind farm, allowing for comparison among the lidar-derived wind speeds, the wind speeds measured by the nacelle-mounted cup anemometers, and the power produced by the turbines. One of the primary goals of the field campaign was to relate wind and turbulence observations across a turbine rotor disk to the power produced by the turbine.

Since the downwind turbines were located along a ridgeline, the wind was expected to accelerate as it was forced uphill toward the turbines. An initial comparison between the lidar-derived wind speeds at hub height and the wind speeds provided by the nacelle-mounted cup anemometers revealed that the nacelle wind speeds were consistently higher than the corresponding lidar wind speeds. However, the degree of overspeeding appeared to be affected by both upwind terrain and atmospheric stability. These effects are examined by stratifying the lidar and nacelle wind speeds by wind direction and lidar-derived stability parameters. During the summer of 2013, an additional WindCube lidar will be deployed on the ridgeline next to a turbine to examine the overspeeding in greater detail.

In addition to the lidar wind speed at hub height, the nacelle wind speed and turbine power production are compared to the lidar-derived "equivalent" wind speed. The equivalent wind speed is an area-averaged wind speed from the rotor disk area and is a more accurate estimate of the inflow conditions affecting the turbine. The equivalent wind speed, along with wind shear, stability, and turbulence information, is then used to develop a set of dynamic power curves. While typical power curves are presented as a function of mean hub-height wind speed only, dynamic power curves depend on a variety of atmospheric conditions and are more representative of power production at real wind farms.

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