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A wind-tunnel investigation of wind-turbine wakes in different yawed and loading conditions

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Wind-turbine wakes have negative effects on wind-farm performance. They are associated with: (a) the velocity deficit, which reduces the generated power of downwind turbines; and (b) the turbulence level, which increases the fatigue loads on downwind turbines. Controlling the yaw angle of turbines can potentially improve the performance of wind farms by deflecting the wake away from downwind turbines. However, except for few studies, wakes of yawed turbines still suffer from the lack of systematic research. To fill this research gap, we performed wind-tunnel experiments in the recirculating boundary-layer wind tunnel at the WIRE Laboratory of EPFL to better understand the wakes of yawed turbines.

High-resolution stereoscopic particle image-velocimetry (S-PIV) was used to measure three velocity components in a horizontal plane located downwind of a horizontal-axis, three-blade model turbine. A servo-controller was connected to the DC generator of the turbine, which allowed us to apply different loadings. The power and thrust coefficients of the turbine were also measured for each case. These power and thrust measurements together with the highly-resolved flow measurements enabled us to study different wake characteristics such as the energy entrainment from the outer flow into the wake, the wake deflection and the helicoidal tip vortices for yawed turbines.