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Experimental study of the kinetic energy budget of a wind turbine stream-tube[1] JOSE LEBRON, Rensselaer Polytechnic Institute, LUCIANO CASTILLO, Texas Tech University, CHARLES MENEVEAU, Mechanical Engineering and CEAFM, Johns Hopkins University — We consider the kinetic energy budget of a wind turbine stream-tube. Unlike the traditional Betz analysis, which neglects turbulence, we include the effects of turbulent kinetic energy fluxes at the stream-tube boundaries as well as dissipation of kinetic energy inside the stream-tube. The analysis is applied to a previously acquired PIV data set described in Cal et al. (2010, JRSE 2, 013106). Since the wind turbines in that experiment were lightly loaded, we observe that the stream-tube diameter changes by only 7% and the mean velocity by 12% between front and back of the wind turbine. Deviations from axisymmetry of the stream-tube are observed downstream of the wind turbine, mainly due to tower effects. Besides the importance of mean kinetic energy flux, we find that the radial Reynolds stress component acting on the stream-tube surface is a dominant contributor to the overall kinetic energy balance, and is responsible for the wake recovery. We also attempt to evaluate the turbulent dissipation rate by integrating the Reynolds stress times the mean velocity gradients inside the stream tube.

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