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Optimal control of energy extraction in LES of large wind farms[1]

JOHAN MEYERS, JAY GOIT, WIM MUNTERS, KU Leuven. Mechanical Engineering, Celestijnenlaan 300A, B3001 Leuven, Belgium — We investigate the use of optimal control combined with Large-Eddy Simulations (LES) of wind-farm boundary layer interaction for the increase of total energy extraction in very large "infinite" wind farms and in finite farms. We consider the individual wind turbines as flow actuators, whose energy extraction can be dynamically regulated in time so as to optimally influence the turbulent flow field, maximizing the wind farm power. For the simulation of wind-farm boundary layers we use large-eddy simulations in combination with an actuator-disk representation of wind turbines. Simulations are performed in our in-house pseudo-spectral code SP-Wind. For the optimal control study, we consider the dynamic control of turbine-thrust coefficients in the actuator-disk model. They represent the effect of turbine blades that can actively pitch in time, changing the lift- and drag coefficients of the turbine blades. In a first infinite wind-farm case, we find that farm power is increases by approximately 16% over one hour of operation. This comes at the cost of a deceleration of the outer layer of the boundary layer. A detailed analysis of energy balances is presented, and a comparison is made between infinite and finite farm cases, for which boundary layer entrainment plays an import role.

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