A Realistic Wind Farm Optimization Framework

Different Turbine Layout Evolutionary Algorithms have been designed and implemented with the goal to optimize the performance of real wind farms in operation in Europe. The flow dynamics framework relies on a wind turbine wake model (EPFL, 2014) that has shown a higher accuracy compared to the traditionally used wake models. Three optimization perspectives have been considered: power output maximization, power density optimization and multi-objective optimization, considering well resolved wind roses and free (non-gridded) turbine positioning.

The EPFL Gaussian model: A more accurate velocity deficit model

A new analytical wake model developed at WIRE (EPFL, 2014) has been used for the first time to a realistic WFLO framework. The model applies a Gaussian profile of the velocity deficit downstream of the turbine, and has shown higher accuracy than the traditionally used wake models.

An Ad-Hoc Wind Farm Genetic Algorithm

Genetic (Evolutionary) Algorithms are metaheuristic tools, designed to optimize high-dimensional problems with lower computational cost compared to numerical simulations. Here a new crossover-ellitist approach especially adapted to the WFLO problem has been introduced (EPFL2, 2018).

Optimized Layout

The obtained layout increases the number of turbines in the perimeter of the wind farm with respect to the baseline. This in turn allows the turbines at the central part of the domain to increase their power output compared to the baseline. The overall performance trade-off is positive due to a higher performance of the inner turbines.

Optimization of the Annual Return according to the Number of Turbines and the Wind Farm Area Size

Preliminary results show that optimized layouts allow higher Annual Returns (AR=5%) than the original layout (4.8%). At the same time they allow for higher number of turbines. The highest AR (8.2%) is obtained for 1.75x the original area.

Area Shape-free Multi-Objective Optimization of the Power Output (PO) and the electricity Cable Length (CL)

A Multi-Optimization of the Power Output and the Cable-Length provides a set of Pareto Solutions (Pareto Front, dark blue in Fig b), that allows the investor to obtain a personalized trade-off between the electricity Cable costs and the Power Output performance. Results provide solutions with a PO improvement up to >2% (CL reduction 14%, Fig c) until a 64% CL reduction (Fig a). Finally, a 23% CL reduction is obtained for a PO as in the baseline.

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