Research tools can ensure optimal financial returns from wind farms

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But how does it actually affect wind turbines, if you arrange them closely together, and overall, how do you get the most benefits in terms of financial outcome from a wind farm? TOPFARM, a large-scale EU project led by Risø DTU, has been looking into these matters during the last 3 years. The result: a simulation platform that can optimize the total economic benefitsA recently completed EU project, TOPFARM, has focused on how a wide range of factors affect the economically optimum location of each wind turbine within the wind farms – in technical terms this is called the topology of a wind farm. And contrary to common practice, productions as well as costs associated with the establishment and operation of each wind turbine are included in the model of calculation.

These costs generally cover expenses which depend on the topology of the farm. They could be costs associated with operation and maintenance; costs related to the fatigue load of the main components of a wind turbine and startup expenses related to foundations, grid, roads etc.

"A selected case analysis of Middelgrunden Windfarm has shown, that exactly the expenses to establish, for example, an electricity network mean a lot to the total benefit. The analysis furthermore shows that the load caused by turbulent wakes behind each wind turbine could have an impact on the optimum wind farm topology and thus on the economy of a wind farm - this aspect would naturally not be considered by an optimization model exclusively relying on the final product, namely

power generation, " explains Gunner Chr. Larsen, senior scientist at Risø DTU who has been the project coordinator for TOPFARM.

TOPFARM has 9 national and international partners from industry as well as research.

Tool box

The core of the optimization tool consists of 5 calculation modules. The first module consists of models (of varying complexity) that describe the wind inside a wind farm. The second module is a detailed model of how the wind affects each wind turbine in a wind farm. The input to this module is the wind field from the first module and the result is production data and load data from the individual turbines.

The third module comprises models of the control system at both wind farm level and wind turbine level, while the fourth module contains cost models, which make it possible to formulate the optimization problem in economic terms.

The fifth and the last module is a package of optimization algorithms that, with the input from the other four modules, generates the optimum layout of a given wind farm. This is the module that gave rise in the case story to the new location of turbines at Middelgrunden wind farm, as seen on the picture.

"From the direct economic output of the wind farm – power generation -, costs with regard to the wearing down caused by load, for example, must be deducted because of the consequent repair and reduced service life of key wind turbine components. But also startup expenses, which are directly affected by the location, can be crucial to the economy – e. g. at sea where foundation costs typically depend on the depth of water. Should the turbines be arranged differently so that they 'provide less

shade' from each other? Or is it necessary to build a road or some other infrastructure in connection with a particular location of wind turbines inside a wind farm? If so, it is important to include these considerations in your calculations," explains Gunner Chr. Larsen.

The simplified models used today to set up wind farms, primarily looks at how much power is generated from the farm. But the TOPFARM project clearly shows that there is a need for a more complex model that can incorporate far more and more complex factors.

Next step: a user-friendly program

When one takes the optimal location of each turbine as one's starting point, there will be millions of location options for the wind turbines. This means that even a supercomputer will get a demanding job, if you do not ensure that the calculations at each level of the optimization platform are carried out as efficiently as at all possible.

Consequently, it has been a big challenge for TOPFARM to develop fast models without jeopardizing the essential physics of the individual sub-modules. In addition, the amount of calculations in the optimization procedure can be further reduced using so-called structured grid, where the location options of the individual wind turbines are limited in advance, for example by only allowing locations on selected curves.

The TOPFARM optimization platform is currently a research tool, but the vision of the scientists at Risø DTU is to pursue opportunities with the purpose of creating a more user-friendly programme that can be used by wind farm developers in their daily work. The basic sub-models have already been developed in the TOPFARM project, and efforts will therefore primarily concentrate on a more streamlined implementation of software and on developing a suitable user interface.

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