

1 The wind farm layout optimization problem

The goal of this section is to give the reader an understanding of the wind farm layout optimization problem, and explain the key factors that makes the problem so complex.

1.1 Definition of the wind farm layout optimization problem

An overview of the wind farm layout optimization problem is presented by Samorani [Samorani, 2013]. Grouping of wind turbines in a wind farm decreases installation and maintenance cost. However, positioning of wind turbines in a farm also introduces new challenges. The power produced by wind turbines is largely dependent on wind speed, therefore it is important that the wind speed that hits a wind turbine is as large as possible. The main challenge for wind farms is that a wind turbine positioned in front of another wind turbine will cause a wake of turbulence, meaning that the wind speed that hits the second wind turbine will be decreased. This effect is called "wake effect", and will be explained later. Since the goal is to produce as much power as possible it is very important to position the wind turbines so that the wake effect is minimal. Samorani states the wind farm layout optimization problem like this "The wind farm layout optimization problem consists of finding the turbine positioning (wind farm layout) that maximizes the expected power production". However, in this thesis, the problem formulation will be extended to include cost constraints and also the problem of deciding the number of wind turbines, not just their positions. A formal definition is given below

"The wind farm layout optimization problem consists of finding the number of turbines and turbine positioning (wind farm) that maximizes the expected power production within a given budget."

1.2 Challenges of wind farm construction

Samorani gives an overview of the main challenges of wind farm construction. First, a suitable site has to be found, meaning a site with good wind conditions. Sites are classified in 7 different wind power classes, where sites with power class 4 or higher are suitable for hosting a wind farm with today's turbine technology. But, even though the wind farm has the required wind conditions, it might not be suitable for hosting a wind farm after all, because it might be far from the electronic grid, so that connecting it to it would be too costly, or it could require costly road work because current roads cannot handle the transportation trucks.

Second, land owner has to be contacted and convinced that hosting a wind farm on their land is a good idea. Land owners usually get a percentage of the wind farm profit. This phase of contract negotiation usually takes a few months. At the same time, wind distribution needs to be measured as accurately as possible. This step is extremely important, since the layout of the farm is optimized based on the measured wind distribution. Getting enough data to capture the wind distribution can take a few months if wind conditions are similar all year long, but if the wind conditions vary extensively over the year this step can take a few years.

An even more important step is to decide on which turbines to buy for the wind farm. Larger turbines usually generate more power, but they are also more expensive than smaller ones. There is therefore a trade off between the cost and power production. In [Samorani, 2013] the number of

wind turbines are also decided in this step, but in this project, deciding the number of turbines is included in the wind farm layout optimization problem and will therefore be part of the next step.