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Energy research Centre of the Netherlands

The ECN Scale Wind Farm Facility

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The ECN Scale Wind Farm Facility

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Abstract In order to further advance the knowledge on wind fields in and around wind farms, including the understanding of wakes and turbine-turbine interaction, ECN has made available the scale wind farm. The high quality data are used for the development and validation of wind farm aerodynamic models and wind farm control strategies.

Key words Wind Energy, Measurements, Wakes

1. Introduction

Wind energy is the only option for renewable energies that can produce large amounts of energy without emissions at relative low costs. The next years, the amount of wind power installed worldwide will increase significantly. This also implies that the wind farms will be even larger, especially offshore. In order to reduce the cost of wind energy even further, the energy production of large wind farms should be increased by means of understanding the flow within wind farms so that optimised wind farm control strategies can be developed. At the moment, the large uncertainties connected to the wind field in the wind farm leads to financial risks when investing in these large wind farms.

The understanding of unsteady wind fields within and around wind farms could be greatly increased when more detailed models or measurements of the wind field in a wind farm would be available. The same applies to understanding the response of many turbines within a wind farm on the mutual wakes. One reason for this is that adequate measurements are lacking and the models are not (yet) accurate enough. In full-scale wind farms meteorological masts are very expensive and the number of masts is thus limited. Therefore a lot of research is based solely on the base of the measurements at the turbines – power measurements and nacelle anemometers. However, while this allows for some insights in the internal wind farm flow at the turbines locations it gives no information on the flow between the turbines. This has hindered research on wind farm aerodynamics and wind farm control.

The availability of high quality measurement data within wind farms would greatly help the development and the validation of new models. However, where the value of wind tunnel data is limited due to scaling effects and the use of full-scale field data is limited due to the high costs, ECN has overcome this problem by building the scale wind farm facility. The scale wind farm consists of relatively small wind turbines together with many measurement masts that measure the wind conditions in the wind farm and above. The scale of this wind farm is not too small to alleviate the dominant scaling effects and the scale is not too large to permit the building of sufficient meteorological masts.

The ECN scale farm consists of ten permanent magnet, direct drive, pitch controlled wind turbines. The turbines have 10kW rated power, a rotor diameter of 7.6m and a hub height of 7.5m. It is essential that the researchers have full access to the hardware and software of the wind turbines. The scale farm has been designed in a way that allows ECN performing experiments without any risks for the environment as well as the turbines themselves. As a result, ECN will be able to adapt the controllers as well as the turbines for the dedicated experiments.

Inside and around the wind farm a network of fourteen measurement masts has been installed, which measure the wind velocity field from 3.6m to 19m height. This covers the rotor area and upto one rotor diameter above the rotor. The scales are indicated in Figure 1. The large number of meteorological masts within the wind farm permits to measure at the same time single, double, triple and quadruple wakes while simultaneously measuring the external conditions with three nearby 108m meteorological masts. The unusually densely spaced wind measurements gives the unique possibility to capture the complete wind field, which gives valuable additional information compared to the usual measurement of the wind speed at a single location. Fur-

thermore, most of the wind measurements will be performed using 3D sonic anemometers thus capturing the three wind velocity vectors of the wind field.

The scale farm is located in ECN's large wind turbine test field in Wieringermeer in between the prototype turbines. The measurements are directly coupled to the existing measurement network. As a result, also the measurements of the three 108m high masts are coupled to the measurements. The scale wind farm and its surroundings are characterized by flat terrain, consisting of mainly agricultural area, with single farmhouses and rows of trees. The lake IJsselmeer is located at a distance of 1 km East of the scale wind farm. Great care has been taken to ensure undisturbed inflow of the wind in the scale wind farm.

This worldwide unique research facility shall give further insights in the field of wind farm aerodynamics, wake interaction and wind farm control. The high quality data are used for the development and validation of wind farm aerodynamic models and wind farm control strategies. This will allow operating a wind farm at maximum efficiency while guaranteeing at the same time a maximum in reliability and a minimum in mechanical and electrical loads. A secondary goal is to use the same infrastructure to measure data on rotor aerodynamics and advanced wind turbine control strategies. The research will be performed under collaborations with national and international partners, coming from research institutes, universities and wind turbine manufactures.

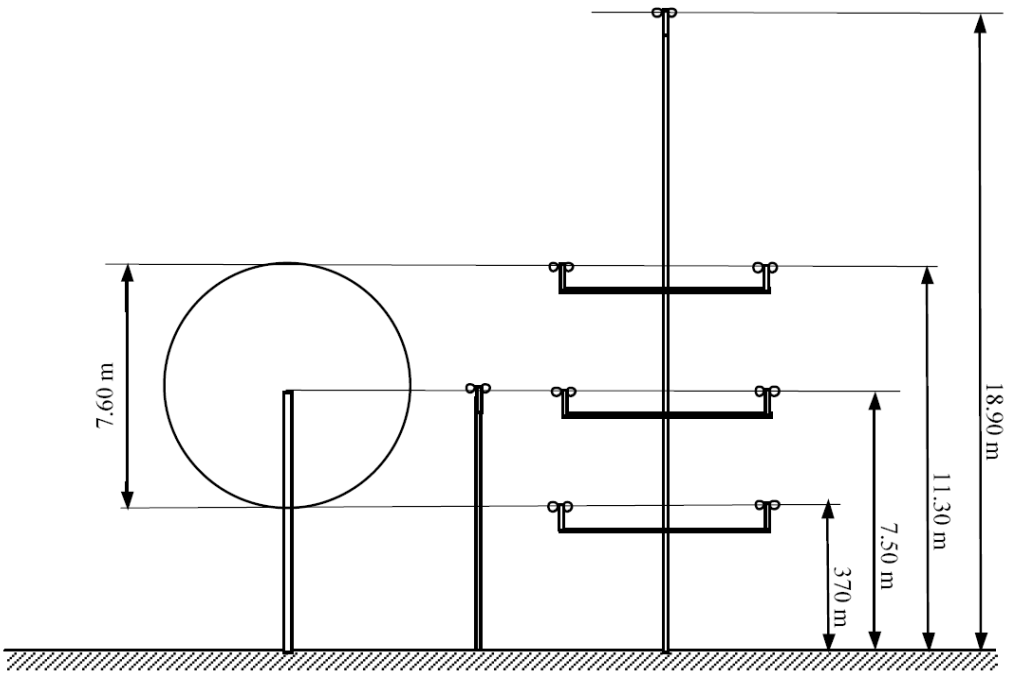

Figure 1. Scales in the ECN scale wind farm.

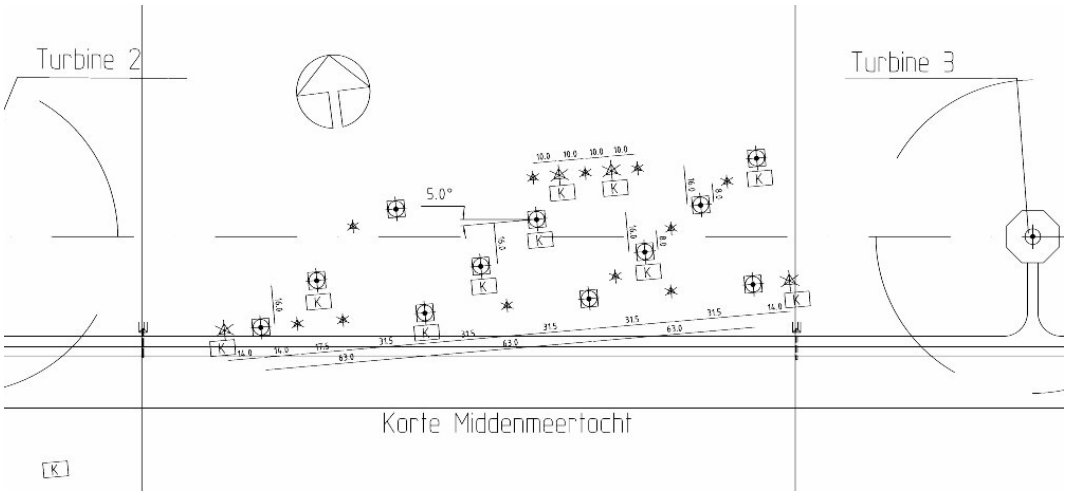

Figure 2. Lay-out of the ECN scale wind farm

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ECN Scale Wind Farm
Experiments for wind farm aerodynamics

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What is the ECN Scale Wind Farm

The scale wind farm has been built to obtain high quality measurement data within and around wind farms which would greatly help the development and the validation of wind farm flow models.
However, where the value of wind tunnel data is limited due to scaling effects and the use of full-scale field data is limited due to the high costs, ECN has overcome this problem by building the scale wind farm facility.
The scale wind farm consists of relatively small wind turbines together with many measurement masts that measure the wind conditions in the wind farm and above.
This worldwide unique research facility gives further insights in the field of wind farm aerodynamics, wake interaction and wind farm control. The high quality data are used for the development and validation of wind farm aerodynamic models and wind farm control strategies.

Specifications

Wind turbines

Number	10
Type	AIRCON P10
Rotor diameter	7,6 m
Hub height	7,5 m
Rated power	9,8 kW
Erected in	March 2008

Meteo masts

Number of small masts	14
Measurement height	3,7 m; 7,5 m; 11,3 m and 18,9 m
Wind speed and direction	12 cups and 12 vanes 26 sonics (3D)

Power measurements on all turbines
Measurement of turbine parameters (Pitch, yaw, etc.)

ECN is accredited according ISO 17025 and MEASNET

power performance measurements
Noise measurements
Mechanical Load measurements