

Aerodynamic Wind Farm Design



EWIS

Being one of the leading institutes on wind energy research, ECN established the EWIS (ECN Wind Industrial Support) group in 2009 to better bring the R&D results to the market. During the last three decades, ECN has developed expertise on aerodynamics, structural analyses, turbine control, offshore operation and maintenance, and grid connection. With the growing wind industry, ECN received more requests for assistance and EWIS has become the vehicle to support the wind energy industry in their product developments.

EWIS's focus is on the high end of the market which means that we will make use of tools and knowledge that have been developed in-house and include the latest R&D results!

The EWIS team is a mixture of young professionals and experienced researchers which ensures a fast response and high quality.

More information

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Description of service

The Service

In large wind farms with a large number of turbines, especially offshore, there is a mutual influence of wind turbines on each other due to aerodynamic wake effects: the flow at the downstream turbines is affected by the wind turbine(s) which are placed upwind. This has the following effect on the downstream turbine:

- the energy yield decreases due to the lower mean wind speed in the wake;
- the mechanical loads increase due to the added turbulence in the wake and the large changes in wind speed over the rotor area.

Moreover, the rate of the wake recovery is dependent on the turbulent kinetic energy.

The aerodynamic wind farm design service comprises the determination of wake effects in offshore wind farms. With the tool FarmFlow (see also SP-360) the wake losses and added turbulence at the turbine locations are calculated for 72 wind directions and 20 wind speed bins and taking into account the distance between the turbines. The service to calculate wind farm wake effects should be used for projects concerning:

- calculation of energy losses due to the wakes in wind farms;
- calculation of added turbulence due to the wakes in wind farms.

The results can be used to determine the annual energy production of a wind farm, the decreased energy yield and its influence on the economics, and to determine the increased mechanical loads.

The software FarmFlow that is used for this service is optimised for offshore conditions and flat terrain. For complex terrain calculations, the software WASP is used. The service can be complemented with the addition of determining the wind resource. For the North Sea the wind resource is based on the offshore wind atlas available at ECN. Time series for specific periods, or long-term wind climate can be obtained and used in conjunction with the FarmFlow results for farm losses.

The Approach

To optimise the layout of the wind farm and determine the wake losses, ECN with the customer determine a baseline layout and perform FarmFlow calculations. The input for the calculations are amongst others:

- turbine data: power coefficients and thrust coefficients for all wind speeds (the FarmFlow software already contains a database with data of turbines which are presently commercially available);
- average turbulence level for each wind direction and every wind speed;
- long-term wind climate to calculate the Annual Energy Production (AEP) or alternatively the long-term wind speed data.

Next, the results of the baseline will be reported and discussed with the customer and if necessary alternative layouts can be evaluated.

The results are reported in a confidential ECN report that includes a description of the method, the results and an uncertainty assessment. The results include annual energy production and losses of all turbines and of the entire wind farm. The analysis may include the influence of nearby wind farms.

The Experience

The wind farm optimisation service is being used on a regular basis since 2005, especially for offshore wind farms. The ECN program FarmFlow has been developed in ECN research projects. It is a dedicated wind farm design tool to model the wake losses and added turbulence due to the wakes in offshore wind farms. The software is based on a compromise between engineering models and Navier-Stokes solvers. FarmFlow uses a parabolised Navier-Stokes solver with a $k-\epsilon$ turbulence model, in combination with a free vortex wake model to calculate the pressure gradients in the near wake. This approach delivers state-of-the-art accuracy with reasonable calculation time.

Optional additional activities

Optionally, the grid losses of the electrical infrastructure in the wind farm can be assessed and quantified. This is done with the tool EE-Farm (see SP-350), also developed by ECN Wind Energy. More information can be found on the EWIS website.

Ask EWIS for a competitive offer for the aerodynamic design of your offshore wind farms.

Experienced researchers will provide the results using the state-of-the-art design tool FarmFlow developed at ECN Wind Energy.

For more information about this service,
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