Electrical grid

UpWind

SIXTH FRAMEWORK PROGRAMME

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THE CHALLENGE

As the penetration of wind energy in power systems increases, requirements on power quality and controllability will become more demanding. The rate of wind power development in Spain, Denmark and Northern Germany has been so rapid that it is impacting upon the reliability of the power system. Measures to maintain system security are already being implemented. Improvements incorporated in the wind turbines and wind farms are needed to allow a significant level of penetration.

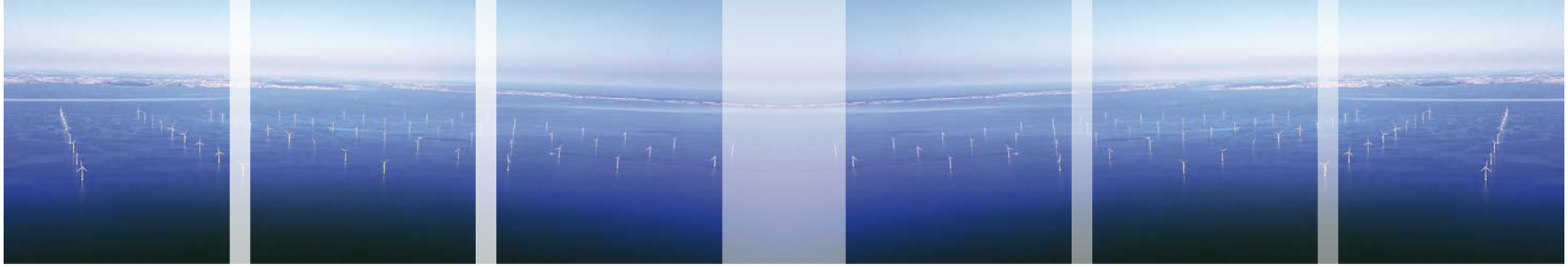
By planning and improving the controllability of wind power output, satisfactory system reliability can be achieved without excessive investment in transmission or distribution system reinforcement.

The aim of this work package (WP) is to investigate the design requirements of wind turbines which result from the need for reliability of wind farms in power systems, and to study possible solutions that can improve the reliability. Reliability is an important issue as failure of future very large wind farms may have a significant impact on the power balance in the power system. As offshore wind farms are normally more difficult to access than onshore wind farms, failures are likely to cause a significant lower availability than similar failures on land.

The WP investigates operational as well as statistical aspects of wind farm reliability. Operational aspects include grid code requirements, extreme wind conditions and specific wind farm control options. The statistical aspects will be covered by the development of a database and by statistical modelling.

UpWind considers future large wind turbines 5-10-20 MW in very large offshore wind farms of hundreds of MW. Technical and economical barriers in relation to grid connection of these installations are being investigated. Significant up scaling will have an impact on electrical design and may have significant influence on reliability and availability. New methods of risk assessments and standardisation are likely to be needed.

UpWind



THE RESEARCH ACTIVITIES, RESULTS AND EXPECTATIONS

The reliability of wind farms as power producing units may be considered in two respects: the availability of the individual wind farm itself, and its impact on the reliability of the overall electrical power system.

The initial task to be performed is to provide adequate general models and accurate data for the reliability and risk assessments of wind turbines and wind farms. Such models are essential to enable comparison of different electrical design and grid connection options. The reliability model and data has to take into account the intermittent nature of the energy source, the grid events, and the dependability on electrical components.

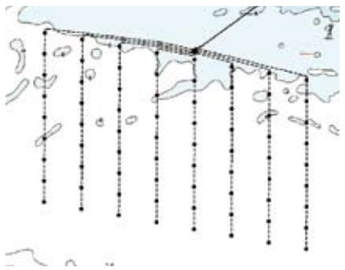
The overall power system requirements are reflected in the grid codes. In this context it is important to predict what the future requirements of the transmission system operators might be in order to integrate increased amounts of wind power in the system. Additionally, future networks with higher levels of wind penetration requires analysis.

Equally important and with reference to electrical transmission systems, is the requirement to establish new design criteria for future wind turbines. In this respect, it may be necessary to predict the power quality performance standards as offered by wind turbine manufacturers and how these standards may address the requirements of grid codes.

Extreme wind conditions influence reliability and are particularly important when several large wind farms are geographically adjacent. A critical issue constitutes an increase of the wind speed exceeding the cut-out wind speed of wind turbines.

Many wind turbines have a cut-out wind speed of 25 m/s or below. It is important to quantify the impact of these events and to develop new solutions.

The impact of various electrical and control concepts of wind farms on the reliability are investigated. The considered electrical designs need to comply with relevant European grid codes and should maximize reliability observing reasonable cost constraints. Different designs of electrical systems for wind farms with respect to their susceptibility to grid deviations. Requirements can then be established and issued in the new design criteria in accordance with grid code requirements. Different designs of electrical systems for wind farms will be evaluated with respect to their ability to participate in power control.



Finally the consequences of up scaling of wind turbines and wind farms for the cost model and reliability are being investigated.

The research activities of WP9 are purely analytical and focus mainly on reliability modelling, on design criteria of future large wind turbines, and on improved grid integration.

Initially, a survey on reliability of existing large offshore wind farms was based on available operational statistics in order to enable comparison of different options and identify factors that influence reliability, taking into account grid events, electrical construction and protection systems.

A database with data on the reliability of electrical components in wind farms will be set up. This database will serve as the basis for a subsequent evaluation of the reliability of different electrical system options.

Subsequently, reliability software tools for wind turbines and wind farms will be developed. One model will be developed and incorporated into a general commercial reliability software package. Another model is developed for ECN simulation programmes Vision and EeFarm. These models will focus on the effect of electrical design on the reliability of large offshore wind farms. The reliability model will be enhanced during the project. Limitations and various detail levels of models will be investigated as well.

The requirements and design criteria with reference to electrical networks (transmission and distribution grids) are established in two steps. First a state-of-the-art survey is made on existing European grid codes and corresponding performance of existing wind turbines. Secondly, the future grid code requirements for higher wind penetration will be analyzed and new design criteria for future wind turbines with respect to electrical networks will be established for single wind turbines or wind farms.

Different designs of electrical systems for wind farms are being evaluated with respect to their impact on system security. Based on representative turbine and electrical system parameters, the different electrical concepts will be ranked with respect to their compliance with new design criteria and grid code requirements. Similarly, different designs of electrical systems for wind farms will be evaluated in relation to their ability to participate in power control, including automatic frequency and voltage control.

Isolated island grids with high penetration of wind results in specific requirements on the reliability. The need for security of operation results into frequent wind power curtailments. Island grids depend more on the reliability of the wind than large interconnected systems like the UCTE. Hence, specific requirements to fully exploit the high wind potential, will be specified for wind turbines operating in such systems.

The investigation of how extreme wind conditions influence the reliabilities will quantify the probability of these events, in connection with the amount of lost generation and also study the influence of control system modifications, aiming at less abrupt cut-out of large-scale wind power generation.

Finally, the research activities will focus on up scaling of the electric system of wind turbines and assess possible technical and economical barriers. Cost functions will be derived for grid connection of wind turbines of 5, 10, 20 MW and offshore wind farms of 500 to 1000 MW.