



DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

- Title:** Optimal Power Control in DFIG Turbine based Wind Farm considering Wake Effect and Lifetime
- Location:** Pontoppidanstræde 111, auditorium
- Time:** Tuesday 15 August 2017 at 13.00
- PhD defendand:** Jie Tian
- Supervisor:** Professor Zhe Chen
- Moderator:** Associate Professor Xiongfei Wang
- Opponents:** Associate Professor Filipe Miguel Faria Da Silva, Dept. of Energy Technology, Aalborg University (Chairman)
Professor Wei-Jen Lee, Electrical Engineering Dept. & director of the Energy Systems Research Center at UT Arlington, US
Professor Bikash Chandra Pal, Dept. of Electrical and Electronic Engineering, Imperial College London, UK

All are welcome. The defence will be in English.

**After the defence there will be an informal reception
in Pontoppidanstræde 111 (coffee room).**



Abstract:

In recent years, the large scale wind farm is increasingly integrated into the power grid worldwide and trends to move from onshore to offshore. In a wind farm, due to the wake effect, the upstream wind turbine causes the power loss to its downstream wind turbines. According to a filed survey in large scale offshore wind farm, the power loss due to the wake effect may reach up to approximately 15% of the total power output from the whole wind farm. The widely implemented active power control method in the Doubly Fed Induction Generator (DFIG) wind turbine based wind farm is the Maximum Power Point Tracking (MPPT), by which each individual turbine generates the maximum active power seen from a single wind turbine without the consideration of the wake effect in the wind farm.

The DFIG based wind turbine has two degrees of freedom for active power control, which are the pitch angle and the tip speed ratio. According to the wake models, the power loss of the downstream wind turbine due to the wake effect is also determined by the pitch angle and tip speed ratio of the upstream wind turbine. As the first main contribution of this PhD thesis, considering the wake effect, a Maximum Power Generation (MPG) active power control method is proposed to maximize the total active power of the wind farm, by optimizing the pitch angle and tip speed ratio of all the wind turbines in the wind farm. To implement the optimized pitch angle and tip speed ratio, optimized pitch angle curves and active power curves are generated for each individual wind turbine at various wind directions.

Due to the expensive installation and maintenance in the offshore wind farm, the reliability issues in the wind turbine system became more and more important. According to a filed survey, the electrical parts of the wind turbine system have the maximum failure probability than the other components, which indicates the power converters have shorter lifetime expectancy than other components. The lifetime expectancy of the power converter is highly depending on the operation condition of the wind turbine, which indicates the lifetime expectancy of the power converter is also determined by the pitch angle and tip speed ratio of the wind turbine. In consequence, the lifetime expectancy of the wind turbine is also determined by the pitch angle and tip speed ratio of the wind turbine. Besides, the energy production of the wind farm is determined by both the active power and the operation time. As the secondary main contribution of this PhD thesis, considering the wake effect and the lifetime expectancy, a Maximum Energy Production (MEP) active power control method is proposed to maximize the total energy production of the wind farm, by optimizing the pitch angle and tip speed ratio of all the wind turbines in the wind farm. With the optimized pitch angle and tip speed ratio, optimized pitch angle curves and active power curves are generated for each individual wind turbine at various wind directions.

The DFIG wind turbine has some amount of reactive power capability, which depends on the active power generation of the wind turbine, both from the stator side of the generator and the Grid Side Converter (GSC). In case that the DFIG wind turbine is employed to provide reactive power to support the grid voltage control, the conventional reactive power dispatch method assigns the total reactive power requirement on the wind farm to each wind turbine in positive proportion to their respective reactive power capability. Considering that the reactive power also determines the lifetime expectancy of the wind turbine, as the third main contribution of this PhD thesis, an optimal reactive power dispatch method is proposed to improve the lifetime of the wind turbine, based on the wake effect analysis and the lifetime estimation.