A ten month measurement campaign was carried on in an onshore wind farm located in the North of France to test different wind farm coordinated control scenarios (involving both axial induction and yaw offset control strategies). The performance of the wind turbines during these scenarios is analyzed and compared with the normal functioning mode. Results show that reduction of wake-added turbulence intensity and increase in downstream power production can be achieved thanks to upstream wind turbine curtailment. A loss of power production due to wind turbine misalignment could also be measured. Finally, several practical problems encountered during the campaign underline the challenge to implement these strategies on an actual wind farm because of the difficulty to assess accurately the incoming wind conditions with the sensors currently available on the wind turbines.

**Objectives**

Among new concepts aiming at decreasing wind leveled cost of energy, wind farm coordinated control is a research field that has gained increasing importance over the past years. It aims at increasing the efficiency of a wind farm and decreasing the fatigue loads faced by wind turbines by reducing aerodynamic interactions between them by either curtailing or yawing the upstream wind turbine.

Simulation results found in the literature indicate that an increase in overall power production can be obtained, however they underline the high sensitivity of these gains to incoming wind conditions [1]. It is therefore not known to what extent these gains can be reproduced in a real wind farm where wind conditions are very fluctuating. Only a few full scale field tests have been realized over the past years to investigate these concepts [2, 3].

The French national project SMARTOELE constitutes one of the first attempts of implementing these strategies on a full scale wind farm. A wind farm of 7x2MW wind turbines has been instrumented with an original set-up using one ground based scanning lidar, 2 nacelle-mounted and a ground based lidars and a nacelle-embedded 2-axis inclinometer, strain gauges and a met mast. During this ten months campaign different curtailment and yaw offset scenarios were tested and the performance of the wind turbines analyzed.

**Results and Challenges**

- **Axial induction control**
  - Down-regulation of SMV to up to 20%:
    \[ P_{SMV} = 1600 \text{ kW} \text{ if } 1600 < P_{SMV} < 2000 \text{ kW} \]
  - Change in power production
  - Change in wake-added Turbulence Intensity

- **Yaw offset control**
  - Misalignments of +8° and –12° successively applied to SMV6
  - Loss of power at the upstream WT
  - Wake deflection at the downstream WT

- **Challenges**
  - Unreliability of SCADA wind measurements
  - Wind vane calibration
  - Nacelle anemometer calibration

**Conclusions and Perspectives**

- Increase in power production and decrease in wake-added TI thanks to upstream wind turbine down-regulation was measured at the downstream wind turbine. Unfortunately, augmentation of overall power production could not be achieved.
- Diminution of power production due to wind turbine misalignment could be measured and fitted with a cosine function. The exponent found is consistent with values indicated in the literature (see e.g. [3]). However no wake deflection could be seen at the downstream turbine, the applied yaw angles at the downstream turbine being too small.
- Among the problems encountered during this first measurement campaign, the unreliability of SCADA wind measurements (nacelle wind vane and anemometers) was enlightened. This is a crucial issue for wind farm coordinated control as assessing the exact incoming conditions is critical.
- A second measurement campaign is currently in process in which new scenarios based on the results of this first campaign are being tested.

**References**


[win.europe.org/confex2017]

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