Provision of tertiary control reserve with large offshore wind farms

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Summary
First results on the development of a modular wind farm controller within the research project “OWP Control” will be presented. The focus was on meeting the requirements of the transmission system operators for the provision of tertiary control reserve while using existing interfaces in industrial wind farm controller. Different control strategies have been analyzed and several options for the improvement as well as further research with potential benefits for wind farm operators were identified.

1. Introduction

With the growing share of renewable energy the contribution to system safety and grid stability of these systems is becoming increasingly important. This importance is emphasized by the transmission system operators (TSO) with publication of a directive on prequalification of wind turbine generators (WTG) to provide tertiary control reserve (TCR). Particular challenges are the estimation of the possible production, wake effects and changes in wind farm topology. The development of a modular wind farm controller (WFC) for the provision of TCR is one goal of the project “OWP Control” initial results will be presented.

2. Development, modelling and simulation of control strategies

To ensure a modular characteristic of the WFC, the active power set point specification of each WTG was used as the data interface. The following equation forms the basis for calculating the set point specification:

$$P_{\mathrm{Set,OWF}} = \left(\sum_{n=1}^{m} P_{\mathrm{pP},n}\right) - P_{\mathrm{CR,Set}}, \qquad (1)$$

with the active power set point $P_{\mathrm{Set,OWF}}$ for the entire offshore wind farm (OWF) with a total number m of WTGs, the estimated possible power per wind turbine $P_{\mathrm{pP},n}$ and the control power request $P_{\mathrm{CR,Set}}$ of the TSO.

$P_{\mathrm{pP},n}$ is estimated using a static wake model designed by ForWind Oldenburg according to [1]-[4]. The calculation of the active power set point $P_{\mathrm{Set},n}$ for each WTG is based on $P_{\mathrm{Set,OWF}}$. A total of four different control strategies were devised and analyzed.

For the analysis of those control strategies a simulation model was developed, which calculates the OWF’s dynamic performance based on Newtonian’s equation of motion.

3. Results

The simulation model and the control strategies were validated, amongst others, by simulating the "Doppelhöckerkurve", c.f. Fig. 1, which shows that all control strategies fulfill the TSO requirements regarding settling time and control error.

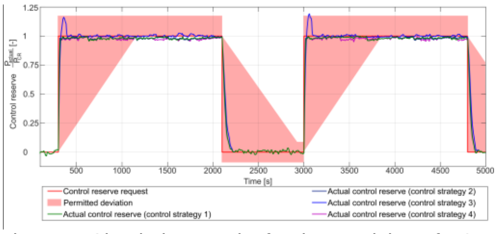

Figure 1: Simulation results for the provision of TCR

Based on operationally relevant scenarios and assessment criteria of interest to operators, one control strategy proved to be optimal which especially minimizes the impact of additional pitch activities during the provision of TCR by putting some WTG into idling operation.

4. Outlook

The first results show that the provision of TCR with OWF is possible. In order to further optimize OWF operation and also during the provision of TCR, it is planned to enhance the WFC through optimization techniques, e.g. load or yield optimization, in "OWP Control".

5. References

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