

Offshore energy storage sizing

Influence of technical limitations and operation strategy

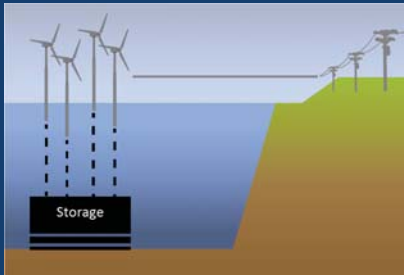
Challenge

Investigation on the sizing of an offshore energy storage unit operated in conjunction with an offshore wind farm. The main interest is the sizing of the storage unit for capacity firming purposes within a market bid period. The storage unit is evaluated with technical limitations to reveal the sizing parameter sensitivities.

Results

Results show that there are several important parameters regarding storage sizing.

- Storage sizing is shown to be very dependent on the production forecast error and market bid length.
- Power reversal dead time constraint can be countered by choosing an appropriate control strategy.
- Storage unit ramp limitation gives minor influence on storage performance.
- No control strategy gives significant more reduction in grid energy imbalance than the constant, fixed mode control strategy. The same reduction can however be obtained, with somewhat less energy routed through the storage by applying an alternative control strategy.

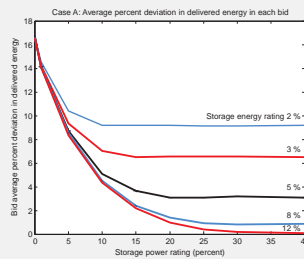


Simulation system

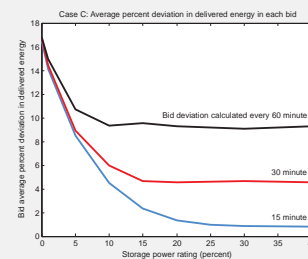
The wind farm production data was created using the Dogger Bank reference wind farm in combination with an offshore wind measurement series. The two units share a grid connection with similar rating to the wind farm.

Simulation Cases

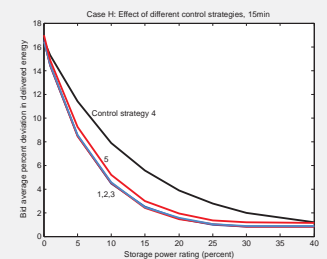
Each case focuses on a specific parameter of the storage unit.



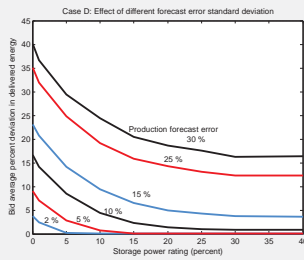
Storage energy rating sensitivity.



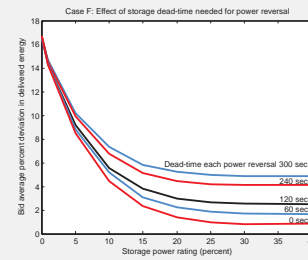
Bid interval length sensitivity.



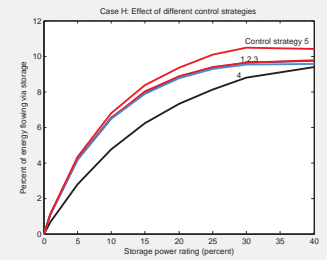
Control strategies sensitivity.



Production forecast error sensitivity.



Power flow reversal dead time sensitivity.



Control strategies sensitivity.

Acknowledgements:

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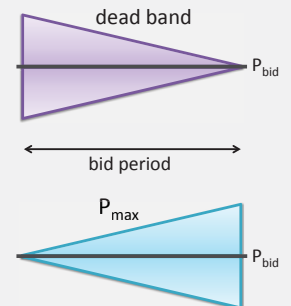


Methods

The simulation was run in time domain over the course of one year. An important prerequisite was that the combined wind power plant and the storage unit operated in a market where the imbalance between bid and delivered energy is measured and penalized. The storage unit goal was to firm the wind power capacity within each bid period.

Different constraints have been introduced to show parameter sensitivity of the storage unit. Technical constraints included ramping limitations of the storage unit and dead time when performing power flow reversals. Furthermore, five different control strategies were implemented:

1. Constant and fixed set-point for grid power in each bid period.
2. Constant set-point for grid power with recalculation of set-point during bid.
3. Strategy 2 with linearly increasing storage max-power limitation.
4. Strategy 2 with a linearly decreasing dead-band for storage power command.
5. Min-max operation aiming at unidirectional storage power-flow within each bid period.



Control strategy 3 and 4 recalculates the storage set point throughout the bid period with either a start-up dead band or limitations in maximum power output. The limitations are set on top of the wind farm bid output.

Details are found in the full paper Spro et al., "Influence of technical limitations and operation on sizing of an offshore energy storage connected to an offshore wind farm", [submitted for publication].