[Wind and Battery cooperation to provide frequency regulation in energy markets](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7797224)

* Real-time cooperation scheme for optimal bidding in energy and regulation markets in presence of battery life cycle

Framework assumptions: Wind and battery bids in day-ahead and regulation markets, price-takers

1. Performance -based frequency regulation

Received capability and performance payments based on market clearing prices

1. Wind provides frequency regulation, but wind has forecast error and uncertainty, so battery come in to offset the difference. Battery alone would increase charge cycles. Scheme below. A diagram of a wind error

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2. Define process for SOC
3. Optimal bidding model

A math equations and numbers

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Constraints: (1) Capacity (2) SOC (3) Battery life preserving constriants

Results: Data from 2014 PJM to generate price scenarios A table with numbers and text

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Conclusion:

By combining with battery, improve wind regulation performance in presence of forecasting error while keeping battery life preserved.