Stochastic Multi-Market Dispatch for Batteries

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This work develops a stochastic multi-market dispatch framework for Batteries. Probabilistic forecasts are combined with Gaussian copula to generate temporally coherent scenarios. These enter a stochastic MILP with CVaR for day-ahead allocation, refined by intraday re-optimization and validated in a second-by-second simulation.

Motivation

Renewable energy growth needs storage capacity

→ **Batteries** (e.g. 10MW/20MWh)

BESS must participate in multiple markets (DA, ID, FCR, aFRR) to be economically viable

→ **Multi-Market Dispatch**

Dispatch decisions made with imperfect market forecasts

→ **Stochastic Market Scenarios**

Methodology

Market Forecasting:

- Methods: LEAR, DNN, LSTM, NBEATSx
- Naive backcast as benchmark
- Historic data + Generation/Load forecasts

→ Quantil forecasts for next 24h

Gaussian Copula:

- Using quantile forecasts as marginals
- Correlation matrix from historic data
- Monte Carlo sampling

→ 100 temporally coherent market scenarios

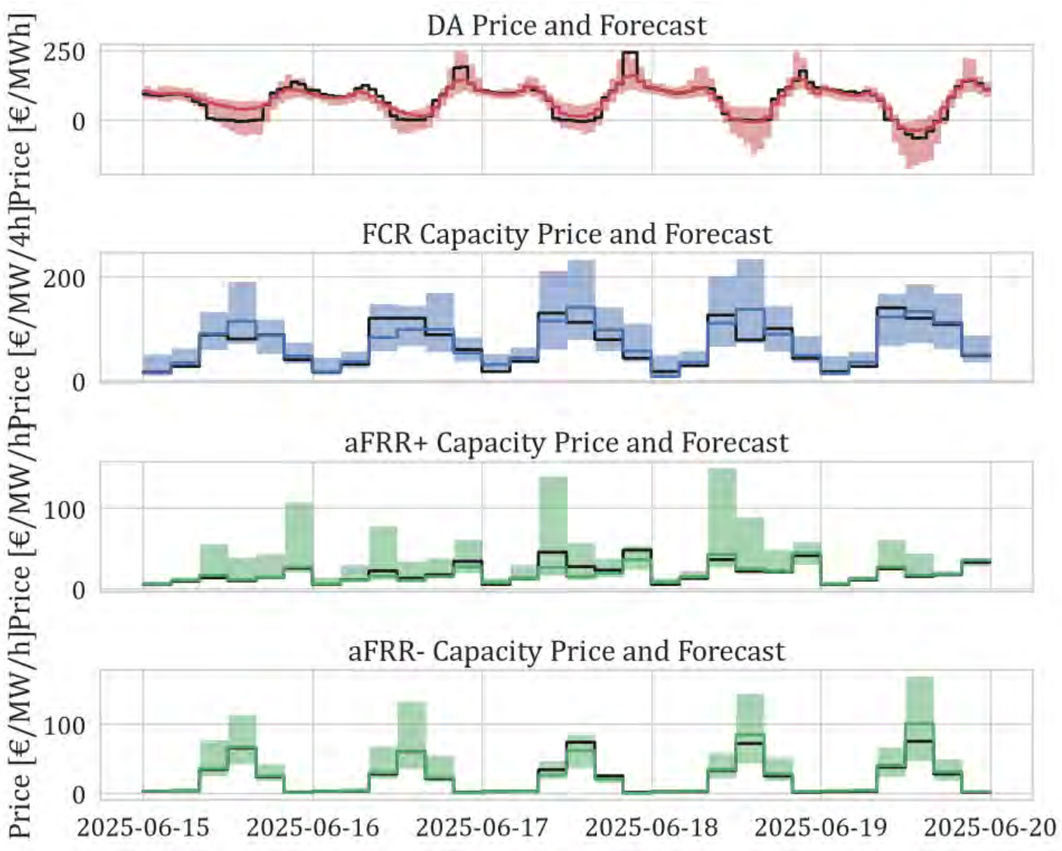


Figure 1: *Generated point forecasts (colored line) and forecast scenarios (shaded area) vs actual value (black line) for market prices.*

Dispatch Optimization

- Stochastic Mixed-Integer Linear Program
- Expected revenue + CVaR in objective function
- Intraday re-optimization
- Second-by-second dispatch simulation

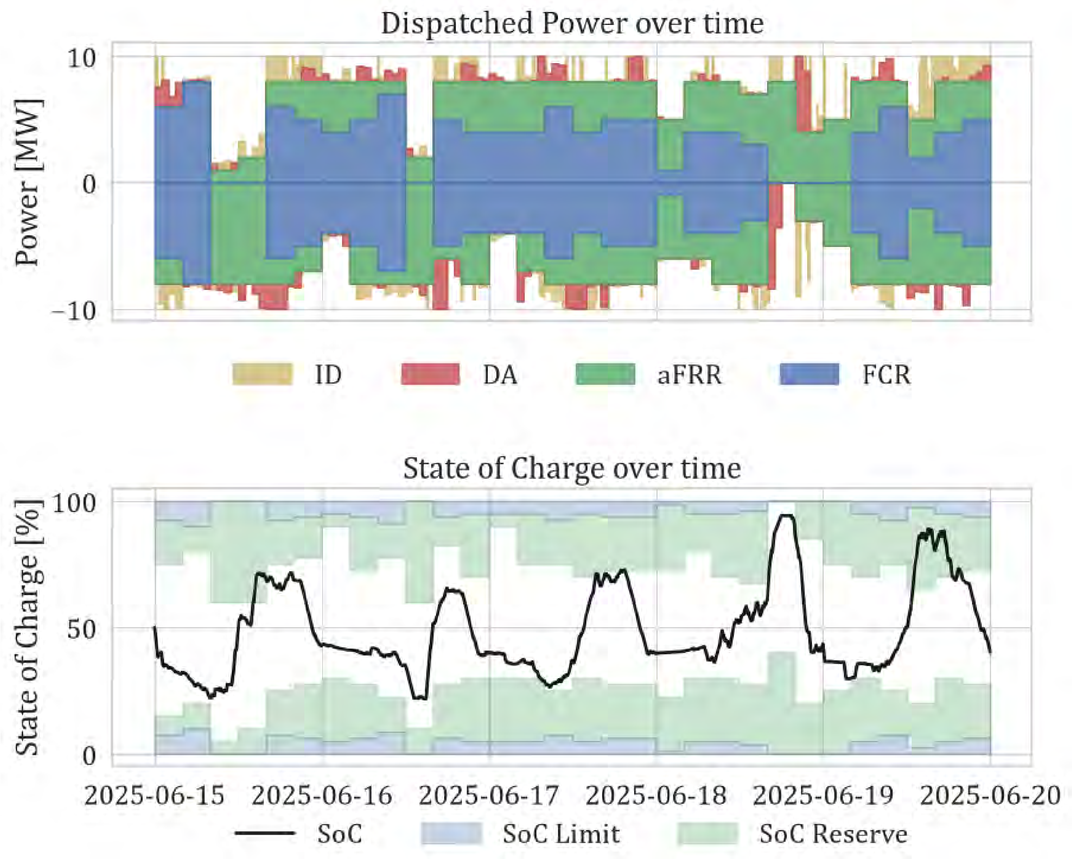


Figure 2: *Resulting dispatch of the battery using LEAR (top) and simulated SoC of the battery (bottom) for an example period.*

Results

- All forecasting methods outperform the backcast
- LEAR methods results in hightest revenue of 2.039 M€
- Battery degradation costs with ~ 0.5 M€ are signifi-cantly lower then revenue

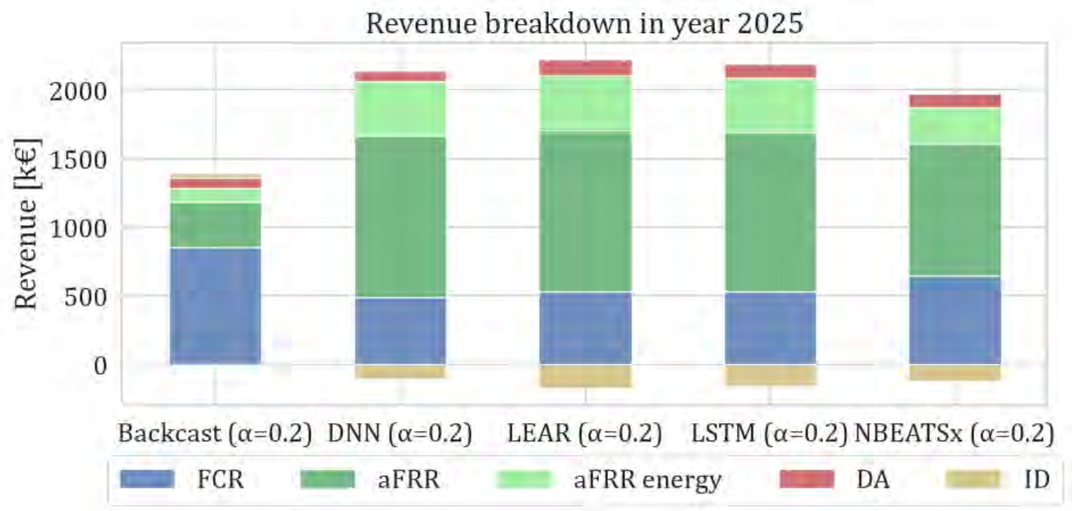


Figure 3: *Simulated revenue of the battery in the year 2025 utilizing different forecasting methods.*

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