Technical University
of Denmark

46750 - Optimization in Modern Power Systems

Assignment 2: From Board Game to Real-World Decision-Making Challanges

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Group 14

1 Project Proposal For group 14

1.1 Preliminary Consulting Project Proposal: Wind Farm Capacity Optimization

The client is a wind farm developer looking to determine the capacity (MW) that maximizes profit over the project lifetime. Investment is limited by a budget and defined by a cost-per-MW parameter. The main challenge is uncertainty in wind production and electricity market prices, especially the difference between day-ahead forecasts and balancing-market realizations.

Without optimization, it is difficult to: (i) balance investment cost (CAPEX) against uncertain operating revenues, (ii) quantify imbalance risk between day-ahead and balancing markets, and (iii) understand how capacity choices respond to changing prices, production, and budget limits.

We propose a three-step roadmap with models of growing realism, from a simple baseline with perfect foresight to a risk-aware version that accounts for uncertainty.

1.2 Proposed Modeling Roadmap

Model 1 – Deterministic Baseline Find the best capacity assuming full knowledge of average wind production and prices.

- **Decision Variables:** Installed capacity (MW), wind turbine size.
- **Inputs and Data:** Average forecasted wind production, average day-ahead and balancing prices, CAPEX (cost per MW), OPEX, budget, and project lifetime.
- **Key Assumptions:** Prices and production are perfectly known. The producer bids predicted power and sells all generation.
- **Model Boundaries:** No time variation, no uncertainty, no grid limits (constraints).
- **Expected Outcome:** Estimate of total and break-even capacity under perfect information, serving as a benchmark for later models.
- **Trade-off and Insights:** Simple benchmark that gives clear profitability results but ignores market variability and uncertainty.

Model 2 – Multi-period Model Extend the baseline to several years by separating the day-ahead and balancing markets. Include both forecasted and realized wind production to evaluate how balancing revebues affect optimal capacity.

- **Decision Variables:** Installed Capacity(MW).
- **Inputs and Data:** Forecasted day-ahead production, realized production for the balancing market, day-ahead and balancing prices, CAPEX and OPEX and budget.
- **Key Assumptions:** The producer is a price taker and always sells what is generated.
- **Model Boundaries:** No grid limits; assumes perfect market access and fixed market rules for the day-ahead and balancing settlements.
- **Expected Outcome:** Capacity that maximizes total profit from both markets and shows the influence of forecast errors on revenue.
- **Trade-off and Insights:** Adds realism by linking profits to both markets. Helps evaluate how imbalance penalties or bonuses change optimal dispatch. Requires more data but offer clearer operational insight.

Model 3 – Stochastic (Uncertainty-Aware) Model Include several possible scenarios for future wind and market prices to measure expected profit and risk. This model will show how uncertainty changes the best capacity.

- **Decision Variables:** Installed Capacity (MW)
- **Inputs and Data:** Scenario sets for forecasted and realized wind generation, day-ahead and balancing prices, CAPEX, OPEX, and budget.
- **Key Assumptions:** Scenario set represents uncertainty well;the producer remains a price taker.
- **Model Boundaries:** No grid limits (constraints).
- **Expected Outcome:** Identification of a robust capacity that balances expected profit and risk exposure under multiple uncertain scenarios.
- **Trade-off and Insights:** Most realistic and risk-aware. Quantifies how uncertainty affects profit and identifies a robust capacity choice. Harder to interpret and more data heavy, but gives the clearest picture of profit-risk balance.