# Stochastic Optimal Bidding

Master's Thesis Proposal, Department of Mathematics

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## 1 Introduction

Energy markets are central to ensuring reliable electricity supply while balancing economic efficiency and environmental sustainability. Market participants (e.g., generators, retailers, aggregators) must decide how to bid strategically under uncertainty and competition. Bidding strategies directly influence market prices, dispatch outcomes, and overall system efficiency.

The increasing penetration of renewable energy sources (RES) has introduced significant variability and uncertainty in electricity production, challenging traditional bidding models. Moreover, the ongoing liberalization of electricity markets, coupled with the coexistence of multiple trading stages, requires more sophisticated optimization approaches. These challenges make the design of optimal bidding strategies both mathematically rich and practically relevant.

## 2 Goals of the Thesis

The main goal of this thesis is to develop and test an optimization model for market bidding of a generator company that produces energy from RES, tailored for the Italian electricity market. This market consists of:

- a Day-Ahead (DA) market,
- four Intra-Day (ID) markets, three of which are pay-as-cleared and one pay-as-bid,
- Balancing Markets (BM).

The objective is to construct a bidding strategy that accounts for renewable production uncertainty, price fluctuations, and market design, possibly with particular emphasis on risk management through Conditional Value-at-Risk (CVaR).

## 3 Starting points

Suggested lectures:

- a seminal work can be found in [1], which introduces a tractable formulation for CVaR optimization. CVaR has become central in energy bidding models to account for rare but costly price fluctuations or imbalance penalties. By definition with respect to a specified probability level $\beta$, the $\beta$-VaR of a portfolio

is the lowest amount $\alpha$ such that, with probability $\beta$, the loss will not exceed $\alpha$, whereas the $\beta$-CVaR is the conditional expectation of losses above that amount $\alpha$. Note that portfolios with low CVaR necessarily have low VaR as well;

- the study by Silva et al. [2] presents a comprehensive multistage stochastic optimization model tailored for a Virtual Power Plant (VPP) that aggregates wind, solar photovoltaic, and battery storage systems. This linear programming model considers participation in DA, ID, and balancing markets, allowing the VPP to refine its bids as forecast uncertainties are progressively resolved. A comparative analysis shows that adding intraday market participation yields substantial operational and economic improvements over traditional DA and BM-only strategies;

- notes on the Italian electricity market.

# References


[1] Rockafellar, R. T., & Uryasev, S. (2000). Optimization of conditional value-at-risk. *Journal of risk*, 2, 21-42.

[2] Silva, A. R., Pousinho, H. M. I., & Estanqueiro, A. (2022). A multistage stochastic approach for the optimal bidding of variable renewable energy in the day-ahead, intraday and balancing markets. *Energy*, 258, 124856.