ME C231A / EE C220B Project Plan: MPC for ERCOT BESS Bidding Strategy

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1. Introduction & Motivation

As renewable penetration increases, volatility in electricity prices creates both a challenge for grid stability and an opportunity for arbitrage using Battery Energy Storage Systems (BESS). **Project Goal**: We aim to design a 2 stage control strategy using MPC to maximize revenue by participating in Day-Ahead (DA) and Real-Time (RT) Energy and Ancillary Service (AS) markets, serving as a benchmark against ongoing research in the eCAL lab with Prof. Scott Moura. We will focus our analysis on the ERCOT market (Texas).

2. Overview Project Scope

We will develop a two-stage optimization controller. Both stages are designed as **convex optimization problems**.

- **Stage 1 - Day-Ahead (DA) Scheduler:** Runs at 10 am of Day-1 for hours 0 to 23 of Day 0 (the target day).
    - Determines bids/commitment for DA Energy, Regulation Up, and Regulation Down capacity (other AS ignored at this stage for simplicity), as well first estimate of the RT energy bids
- **Stage 2 - Real-Time (RT) MPC Controller:** Manage state-of-charge (SoC) and real-time energy bids while enforcing DA commitments.

If time allows, we would additionally want to consider:

- Integration of the 3 remaining DA Ancillary Services: Responsive Reserve Service (RRS), Non-Spinning Reserve (NSRS), and ERCOT Contingency Reserve Service (ECRS).
- Implementation of a basic forecasting model (e.g., LSTM or XGBoost) to replace the Persistence forecast.

3. Goals & Analysis Metrics

Our primary objective is **Revenue Maximization**. We will evaluate the controller's performance through three specific lenses:

1. **Value of information:** Quantify the "optimality gap" (= performance) between the Persistence Forecast controller and the Perfect Information controller to understand the theoretical upper bound of revenue.
2. **Horizon sensitivity:** Analyze how horizon handling affects performance and end-of-day SoC by comparing:
    - *Shrinking Horizon:* Horizon that reduces as the day progresses.
    - *Receding Horizon:* Fixed window of 24h, 48h, and 72h.
3. **(Optional) Robustness to anomalies:** Evaluate performance on "out-of-distribution" days (e.g., grid failures, extreme weather events) to see if the MPC effectively capitalizes on critical price spikes.

5. Team Task Breakdown

To ensure all members gain experience with MPC implementation, we will work together on the formulation and implementation of the MPC. Collaboration will be done through GitHub (repo here). Data on prices of the different markets can easily be found on ERCOT's portal.

Member	Primary Responsibility	Learning Goal Focus
Thibaud, Lazlo	**Forecaster:** Module taking as inputs a control strategy (perfect, persistence, LSTM, etc…), a current time of the day, a horizon and returning a forecast between the current time and the end of the horizon	Machine Learning and Data processing
Lazlo	**DA stage solver:** Module solving the DA stage, and providing bids for the DA markets, as well as a first estimate of the RT bids and the RT SoC	Convex optimization & Solver interfacing
Max, Agustin	**RT stage solver:** Module solving the RT MPC given a horizon	MPC
All	**Combine the DA and the RT stages:** Evaluate performance	MPC
Thibaud	**Horizon sensitivity analysis:** Analyze how horizon handling affects performance and end-of-day SoC	MPC
?	**(Optional) Robustness to anomalies:** Evaluate performance on "out-of-distribution" days	MPC