LES Bidding Task Definition

# Summary

For LES day-ahead markets, there are two primary steps. The first step is the day-ahead bidding, which involves coming up with committed net energy consumption for each timestep of the next day. The second step is the actual consumption of energy. Deviations from the committed energy consumption result in imbalance fees, meaning that it is always preferable to plan energy consumption accurately in the day-ahead phase rather than pay extra in imbalance fees later. A battery, or other flexible resources, can then be used to try and match the committed power as much as possible in order to compensate for the forecasting inaccuracy. This can be done by charging and discharging the battery such that the imbalance costs are reduced.

Currently the day-ahead bid is determined simply by taking the forecast of the grid balance of the next day, ignoring the operation of the battery or any other flexible resources. **The purpose of this task is to explore how the day-ahead market bid could be improved by considering forecasting errors and the operation of the battery** (to compensate for the errors). It is important to consider that the errors of day-ahead energy demand forecasts can be expected to have a mean of zero during a 24-hour period which means that the battery power used to help follow the day-ahead market commitment can also be expected to have a mean of zero; however, due to the inefficiency of the battery, the average battery power on the AC side will need to be slightly positive to compensate for losses if the state of charge is going to be maintained.

# System

Consider the following test system, which comprises simply of a grid connection, an uncontrollable electrical load, and a battery.

A picture containing diagram

Description automatically generated

# Assumptions

* For the day-ahead bidding stage, the forecast of the next-day consumption is not perfect. Assume that the probability distribution function describing the error of this forecast is the same for every timestep (i.e it does not increase with time)
* The flex bidding stage can be ignored
* For the battery operation stage, assume that a perfect forecast of the system load is available
* To ensure that the bidding/operation strategy is sustainable, aim for the net change in state of charge per day to be zero. This could be achieved by applying a stricter condition such as requiring that the battery state of charge is 60% every night at midnight.
* Assume the battery charging efficiency and discharging efficiency are both 95%

# Market information

Energy purchased the day before is purchased at the day-ahead market price.

Any deviation from the day-ahead committed energy consumption at a given timestep must be bought or sold at the imbalance price, which is equal to the day-ahead market price for that timestep + 0.02€/kWh (if buying deficit) or – 0.02€/kWh (if selling excess).

# Data

CSV time-series data will be provided to describe:

* the true energy demand
* the cleared energy buy and sell prices

# Research questions

1. Assuming that a day-ahead forecast of energy demand is made and the probability distribution function of the forecasting errors is known, what is the optimal bidding strategy on the day-ahead market to reduce energy costs (day ahead + imbalance)? Note that to fairly measure the accrued costs of a given 24-hour period, the battery state of charge at the end of the day should be the same as at the start of the day.
2. Now consider how the bidding strategy would change if we consider:

* Battery power limit, or
* Battery energy capacity limit, or
* Grid power limit