GIVEN PS: (in black) CLARIFICATION: (in <mark>red</mark>)

Preamble to the Problem:

Liberalization of sale of electricity has led to competitive electricity markets. Generators and consumers can trade electricity at prices agreeable to both by bidding in the market, which is facilitated by market operators. Market operators ensure fair trade, reliable exchange of electricity and money, and determine the market prices based on bids submitted.

There are various types of trading markets which exist but 'Day Ahead Market' (DAM) is of our interest in this problem. In DAM, bidding happens a day ahead to the delivery of electricity. The day of delivery is divided into multiple blocks of equal duration <mark>(24 hours-24 Blocks)</mark> and for each of the blocks, bidding happens separately and market prices are determined independently. A 'bid' includes a price as well as a quantity (energy in of KWh). Eg. A consumer bids 100 units at Rs.5 per unit which means that he is willing to buy 100 units of electricity at a cost less than or equal to five rupees. If the market price turns out to be less than Rs.5, the consumer wins the bid, otherwise he loses. The winning consumer is delivered the energy he bids, during particular block duration.

The market prices are determined by an algorithm which finds market prices based on equilibrium in the bid quantities and bid prices submitted by the generators and consumers. It also ensures that the there is no congestion in the lines for supply of electricity. Once the market prices are determined, the bidders are informed whether they won the bid or not and what the unit price is. **For each block, the market price is same for all the members (non-discriminatory) who win the bid, in a given region. The bid winning consumers have to pay for complete bid quantity at the market price irrespective of consumption and this cost gets added to his bill. The losing consumers get no electricity from the market**<mark>(If price we pay is x and market clearing price is y; then if our bid x >=y we get our demanded i.e. bid quantity electricity at Market clearing price y; if our bid price x<y we do not get electricity).</mark>

<mark>Determination of Market clearing price, as explained by Vinayak :</mark>
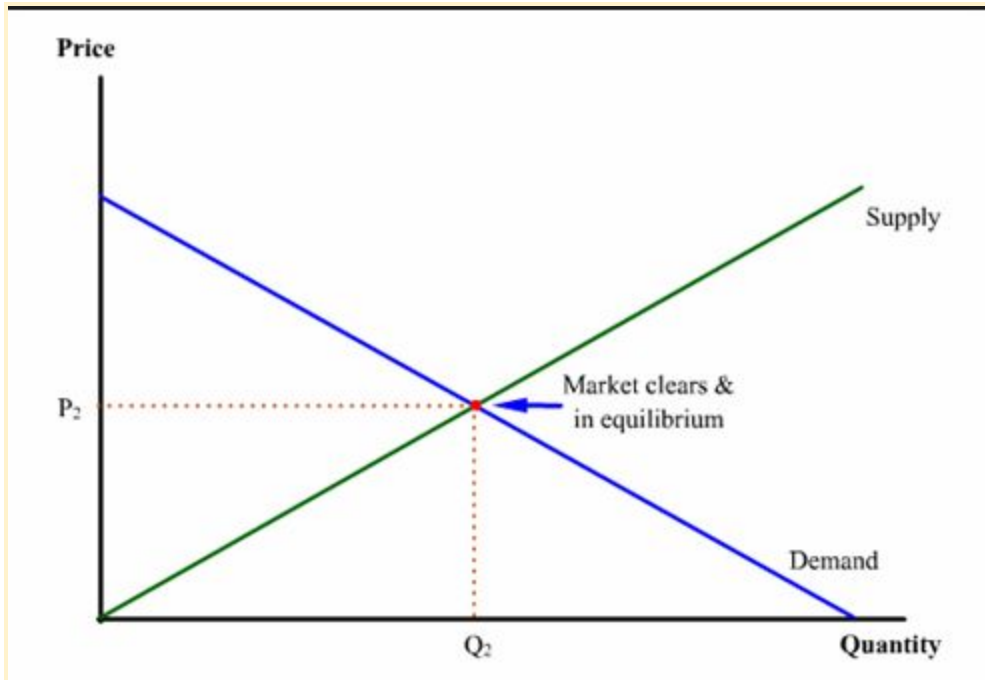
Problem Statement:

Consider a scenario of a gated community with many buildings requiring electricity and a solar panel plant installed along with a battery(we do not know the location, cannot use external data based on location). The community decides to participate in the electricity bidding market in their region. The community also has the option of drawing from a distribution company (DISCOM) at a fixed per unit (KWh) cost. **So there are four sources from which the demand can be fulfilled viz. solar plant, battery, electricity market and DISCOM.**

For the above defined scenario, formulate and develop an algorithm to solve the optimization problem with an objective to minimize the daily electricity bill of the community as a whole. The bid quantities and bid prices for each of the blocks are the decision variables of the optimization problem.(We have to develop algorithm to minimize the difference in the actual train set and the predicted train set, both are forecasted datasets)

Since bidding happens a day ahead, the actual electricity demand of the community and the actual output of the solar plant are not known exactly. So a forecast of these quantities for each

of the blocks is given by an oracle at the time of bidding. A forecast of the most probable market price for each of the blocks is given by the oracle at the time of bidding.

The problem formulation and solution should satisfy the constraints and make assumptions as given in the following sections.

Problem Constraints:

1. The actual demand of all the consumers should be fulfilled at any cost from one of the four sources
2. Precedence of sources to fulfil demand: Solar plant > Electricity from market > Battery > DISCOM
3. Battery has certain efficiency, a limited charging and discharging capacity (specified in the data sheet)
4. Bid quantities should be only integers while bid price can take any value

Problem Assumptions:

1. Battery can charge to its full capacity and discharge to zero state of charge
2. (Battery is charged from solar panel and every day's energy is stored and carried the next day which is stored in battery)
3. **Battery can either charge or discharge in a given block but cannot do both and everything is represented in terms of KWh for convenience**
4. **In a block, battery charges automatically when the supply from solar plant and electricity market combined exceeds the demand** (When the supply from solar and bid market is more, the remaining solar every will be stored in battery by inverter which has 100% efficiency)
5. **In a block, battery discharges automatically when the demand exceeds the supply from solar plant and electricity market combined** (the discharged battery energy here is assumed to being used as supply when solar and bid market fall short of demand)
6. The efficiency of the battery and inverter do not decrease with time
7. The capital costs and maintenance costs associated with solar plant, battery and inverter are ignored. Hence the unit cost of electricity from solar plant is taken as zero
8. There are no upper and lower limits on the bid quantity
9. The market is large enough such that the effect of the bid made by the community, on the market prices is negligible (we are not influencing market clearing price in any way)
10. The daily bill is calculated only based on energy purchased in units and per unit cost. All other charges involved are ignored (Price of solar and battery : 0 rs)

Expected Outputs:

Training and test sets are given separately for the problem. Training set includes predictions and actual values of demand, solar output and market prices while the test set only has the predictions. The teams have to develop an algorithm or an agent which outputs the optimal bid

quantity and price for each of the blocks in the day. The training set can be used by the teams in any manner they deem necessary to develop and validate their algorithms. The final evaluation will be based only on the output of the algorithm to the test set.

Judging Criteria:

Test set includes data for 50 days. The teams have to submit two csv files: 1) bid quantities (in KWh) for each of the blocks in a day, for 50 days 2) bid prices (in Rs./KWh) for each of the blocks in a day, for 50 days. Based on the actual values of demand, solar output and market prices, the daily bill is calculated for each of the 50 days. One point is awarded to each of the top 5 teams with least bill on a given day. So a team can accumulate up to 50 points by being in the top 5 for 50 days. Fifty points are awarded to each of the top 5 teams with least cumulative bill for 50 days. So all teams are evaluated on a scale of 0-100 for every dataset.

Final Score = 10+0.9*(0.2*Public-LeaderBoard-Set-Score + 0.8*Private-Test-Set-Score).

The 10 marks is given for presentation quality during Inter-IIT Tech Meet.

Days refer to the days in the dataset and not days of submission.

Data Sheet:

Parameters to be used in the problem:

1. No of blocks in a day for bidding – 24 blocks each of duration one hour
2. Battery capacity – 25 KWh
3. Battery charging and discharging capacity – 5 KWh i,e,. battery can charge or discharge in energy upto 5 KWh in an hour
4. Battery efficiency – 80% i,e,. if 10 KWh is stored in the battery, it can supply only 8 KWh
5. Inverter efficiency – 100%
6. Price of electricity offered by DISCOM – Rs.7/KWh

Training Set: **Linked Here**

1. Oracle predictions of the community's hourly energy demand (in KWh) for 900 days are available at
2. Oracle predictions of the hourly solar plant output (in KWh) for 900 days are available at
3. Oracle predictions regional market prices (in Rs./KWh) for 900 days are available at
4. Actual values of the community's hourly energy demand (in KWh) for 900 days are available at
5. Actual values of the hourly solar plant output (in KWh) for 900 days are available at
6. Actual values regional market prices (in Rs./KWh) for 900 days are available at

Private Test Set:

1. Oracle predictions of the community's hourly energy demand (in KWh) for 100 days are available at
2. Oracle predictions of the hourly solar plant output (in KWh) for 100 days are available at
3. Oracle predictions regional market prices (in Rs./KWh) for 100 days are available at

Public Leaderboard Set:

1. Oracle predictions of the community's hourly energy demand (in KWh) for 50 days are available at .
2. Oracle predictions of the hourly solar plant output (in KWh) for 50 days are available at .
3. Oracle predictions regional market prices (in Rs./KWh) for 50 days are available at .