
# Takehome - Energy Analyst: Supply Curve Analysis

## Background

Powerline provides market intelligence tools and automated bidding software to operate renewable energy and battery storage projects on the electricity grid. Our technology leverages the latest methods in machine learning and artificial intelligence to identify critical patterns in wholesale energy markets and automate the operation of renewable + battery projects on the electricity grid. Our customers are owners and operators of grid-scale energy projects. Our value proposition to these stakeholders is to provide them with in-depth understanding of how their assets operate and actionable ways to improve their performance. Therefore, we at Powerline need to have detailed, accurate, and in-depth view into the operation of these assets, as well as market dynamics. It is critical for our technical, as well as commercial success to ask the right questions, analyze various data sources, look at the right metrics, and derive useful conclusions and even alternative strategies. That would be the core of your role as an Energy Analyst at Powerline. This assignment is designed to evaluate your relevant thought process and skillsets.

- Timing:
    - We anticipate this exercise shouldn't take more than **3 hours**, but we realize folks are busy. We, therefore, ask that you provide a solution within **3 business days** of receiving these instructions. If you think you'll need more time, please let us know ahead of time. Getting a "perfect" solution is likely not possible within this timeframe; it's more important for us to see how you set up the solution and your thought process. We will expand upon your solution during the technical interview.

- Code:
    - Use Python for any code written so our full team can easily review.
    - Add a ReadMe.m for how to run
    - Add a requirements.txt file

- Written Documentation/ Reporting
    - Any file format is fine.

Please feel free to reach out with any questions. We are happy to answer them as they also give us insight into how you work.

## Australian Energy Market (AEMO)

Australia has a wholesale energy market operated by the Australian Energy Market Operator (AEMO). The market clears every 5 minutes in real-time for a variety of products including energy and what is defined as FCAS products (Frequency Contingent Ancillary Service), which includes both regulation services (following an AGC signal sent by AEMO to energy assets) and contingency frequency response. Prices are settled regionally, in 5 separate interconnected regions. Energy prices are often different across regions (depending on interconnectivity), but FCAS products, since they depend on frequency, are often the same price except when regions are completely islanded from each other.

Summary of important points:

- Market clearing is every 5 minutes.
- Note that timestamps in AEMO are reported as interval *ending*. That means 2023-01-01 12:00 means the interval from 11:55 → 12:00 on January 1, 2023.
- The trading day is from 4am → 4am, not midnight. So for example, the trading day for January 1 runs from starting interval 04:00-04:05 on January 1 to ending interval 03:55-04:00 on January 2
- The price cap for energy is $16,600 max, and -$1000 min, so quite volatile.
- There are 5 interconnected regions, with a single market clearing price per region.

# Assignment: Supply Curve Analysis

Attached is data for one day of bids for every generator into AEMO's wholesale ENERGY market to sell energy into each region. Your task is to use this data to generate insights about how different generators bid into the market and their relative competitiveness with each other.

Note each generator has 10 fixed "price bands" that it is allowed to bid into for each product on a given day (generators can update these for the next day, but not within a day). For each interval, the generator will allocate a specific amount of capacity into each price band. The sum of all capacity across price band is always equal to the unit's full registered capacity. If the generator is unavailable, or partially available, it will update its "MAXAVAIL" to the available capacity, but still will have non-zero quantities for MW allocated across price bands.

## ***Task*:**

Develop relevant metrics, graphs, charts, and analyses to address the following questions as comprehensively as possible. While we recognize the dataset's limitations for drawing generalizable conclusions, we are primarily interested in seeing your thought process, the factors you consider, and an analysis of your findings.

- *1. Setup*: For each 5minute interval, reconstruct the ENERGY supply curve for each region (y-axis = price, x-axis = cumulative capacity). Create a function that can plot a chart of the supply curve for one 5min interval. In this chart, also plot the clearing price of that interval to see where the two intersect.

- *Hint*:
    - Each generator is uniquely in one region and can only sell to that region.
    - Consider the availability of the asset in your calculation. For example, if the asset has 0 MW available (MAXAVAIL column in data), then don't consider that particular bid as valid for that interval since it would never be selected.

2. *Price setting*: Who set the price in each interval for each product? Identify which generator set the price per interval. Do this for each region separately.

Is there a dominant player by fuel type or other characteristics who sets prices more / less frequently than others?

- *Hint*:
    - Note that the clearing price may be slightly different from a specific bid price from a generator due to co-optimization across energy and FCAS. Therefore, you

might consider finding the bid with a price closest to the clearing price, or the bid just above, and just below.

3. *Revenue vs. Price setting*: How does the price-setting pattern correlate with asset revenue?

- *Hint*: you will need to calculate revenue per interval for each asset. Note that the data for total cleared capacity is in (MW) and the clearing price is in ($/MWh).

## Bonus

1. *Clearing success rate*: Estimate the clearing success rate of each generator. Are there specific times or conditions that affect the likelihood of getting bids cleared?

- *Hint*: you can assume that if the generator placed capacity into a price band below the forecasted clearing price in the data provided, then it intends to clear.

2. *Price band prices vs. price setting*: Do the values of different price bands correlate to the generator's price-setting patterns?

## Data

Attached is historical data for the day of 2024-06-13. Below is a description of the data fields in this dataset.

Also attached is a spreadsheet with more detail about each specific generator (duid) in NEM Registration and Exemption List.xlsx

**NEM Registration and Exemption List.xlsx**

- details about the specific duid/ generator
    - For example:
        - duid
        - Region
        - Fuel Source
        - Max Capacity
        - …

**raw_bid_data_2024-06-13.xlsx**

- bid data for a specific day

| | |
|---|---|
| settlementdate | The date of the settlement |
| duid | Unique ID of the asset. |
| interval_datetime | The interval datetime (every 5min) |
| product | The name of the market product to participate in. In this case ENERGY |
| PRICEBAND.n. | The asset's bid price in the nth price band of its bid-curve. 10 total |
| BANDAVAIL.n. | The asset's offered/bid volume (MW) in the nth price band of its bid-curve. 10 total |
| MAXAVAIL | Maximum available MW submitted by the duid for a specific interval |
| rrp | clearing price |
| forecasted_rrp | Forecasted clearing prices, available 5min prior to the interval |
| TOTALCLEARED | Total cleared MWs for the asset in a particular interval for a particular product |