Exploring Energy Markets: A Python Challenge in Data Analysis and Energy Storage Insights

Task Overview:

In this test, you will delve into the fascinating world of energy storages and energy markets. You will gain insights into the factors influencing energy trading with energy storage. This test is designed to assess your problem-solving abilities, data analysis skills, and Python proficiency.

Theoretical Background:

- Electricity grids are operated with a certain frequency. This frequency is sustained when supply and demand of electricity are exactly matched. With oversupply the frequency rises, with demand exceeding supply it drops. As long as the frequency is kept in a tolerable range the grid is stable, otherwise it is endangered of power failures. To keep the balance between supply and demand in that tolerable range wholesale electricity markets are structured in a multimarket setting for trading bundles of electricity.
- To cope with the increasing volatility and uncertainty in power production that come with rising shares of renewable energies in the electricity grid, grid-scale energy storage systems can provide additional flexibility. Because of their high efficiency and their ability to store or deliver power almost instantaneously battery energy storage systems are an optimal fit for the short-term nature of the electricity markets. That's why we use and love to trade them!
- **Battery energy storage systems** are very costly, so it is important to make the best use out of them. One important factor is the ageing of the storages, very simplified: the more the storage is used, the faster it degrades.
- **Cycles:** Battery usage is measured in cycles, representing a full charge and discharge. Frequent usage accelerates degradation.
- **Spreads / Energy Markets:** Energy storage systems are commonly used to buy energy during low-price periods and sell it during high-price periods, exploiting price spreads. Depending on the available price spreads of a market during a certain time period it makes sense to drive more cycles with the battery compared to other timespans.
- **Cycle costs:** These costs are associated with one cycle of storage usage and are used to determine the minimum spread required for the storage operation to be economically viable.
- **Nominal Power and Capacity** of an energy storage describe its size. The nominal power refers to the maximum power the storage can charge or discharge during an hour while the Capacity describes the maximum amount of energy a storage can hold. Important for your task is the combination of both. A storage with 1 MW of nominal power and 2 MWh of nominal capacity takes 2 hours to completely charge or discharge all its energy.
- **Efficiency** represents the percentage of energy retained during charging or discharging. Assume equal charge and discharge efficiency. Example: if the efficiency is 90%, only 90% of the charged energy will actually fill the storage, 10% are lost. Vice versa for discharging only 90% of the original charged energy comes out of the battery. That means we need to buy more energy than we can sell, as some energy gets lost.

Task description:

Your task is to develop a simplified algorithm that estimates the cycle costs required to achieve a specific average daily cycle count for an energy storage system while not breaching the maximum daily number of cycles. The inputs for the function should be (with default values you can use):

- Price signals of a single market (see attachment)
- The nominal power of the storage (2 MW)
- The usable capacity of the storage (4 MWh)
- The efficiency of the energy storage (90%)
- The target average cycles per 24-hour time horizon (1.5)
- The maximum number of cycles per 24-hour time horizon (2.5)

Keep these rules in mind:

- Account for the efficiency.
- Consider storage limitations, including capacity and nominal power.
- The target average cycles should drive the cycle costs, the maximum number of cycles for each day should be a capped within the algorithm to ensure they are not violated.
- If your algorithm gets too complex, make some simplifications, and quickly elaborate on them and why they are sufficient for a first version (it is better to have a functioning first version with simplifications and ideas for improvements than not finishing your approach at all)
    - E.g., Ideally your algorithm goes over the price data with a rolling horizon, but the data can also be analyzed per day (from 00:00 to 00:00).
- Use python for your solution.

For this task you receive:

- Aa csv-file ("market_prices.csv") with market prices to search for the best spreads.
- As a benchmark: your estimated cycle costs should be in a range of 20-36 €/MWh.