EPEX ID&DA Energy Market Data Analysis –

Profit Calculation

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Introduction

This code represents an analysis and simulation of electricity market trading based on the data provided by EPEX Spot, a subsidiary of the European Energy Exchange (EEX). EEX is the largest energy exchange and clearing house in Europe. EPEX Spot operates Day-Ahead markets through a blind auction mechanism, where electricity for the next day is traded.

In a Day-Ahead blind auction, participants submit their buy and sell bids without any knowledge of the other bids. The auction occurs once a day, every day of the year, and it involves 24 hourly contracts corresponding to each delivery hour of the following day. EPEX Spot aggregates these bids to create supply and demand curves, which are then used to determine the market clearing prices (equilibrium prices) for each hourly contract.

This project involves working with the raw data of the auction results, which includes equilibrium prices for the 24-hour energy supply contracts for each day in a given year. Additionally, it includes historical prices from the EPEX continuous market for August 2022, where energy is traded live, similar to stocks on the stock market.

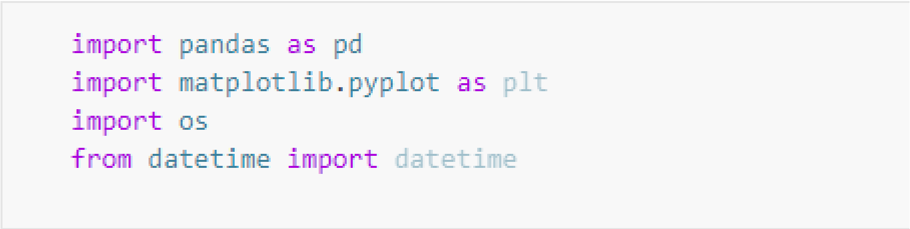
For the purpose of this analysis, we assume the existence of a hypothetical wind park that consistently produces 100MWh of energy every hour. To make the simulation more realistic, we can optionally include a production cost of 0.25 Euro per MWh of energy produced.

The main objectives of this code are:

1. To analyze the equilibrium prices from the Day-Ahead auction to understand the pricing trends and market behaviour over the given year.
2. To compare the Day-Ahead market prices with the continuous market prices for August 2022.
3. To simulate the revenue generation for the hypothetical wind park by calculating the income from selling the produced energy in both markets.
4. Optionally, to incorporate the production cost into the simulation to estimate the net revenue.

By achieving these objectives is look to gain insights into the dynamics of the energy markets operated by EPEX Spot and the potential financial performance of a renewable energy producer in these markets.

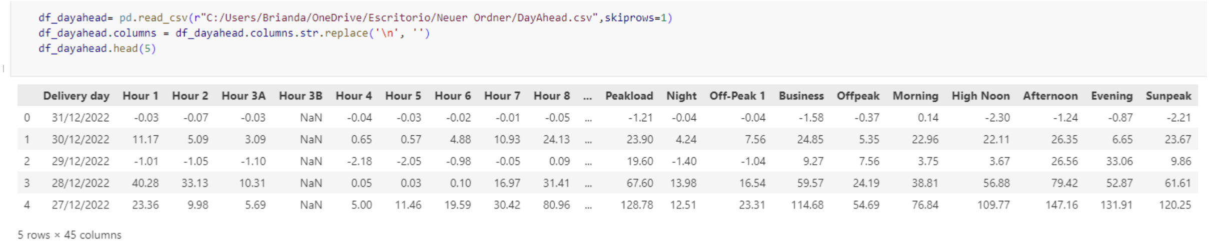
1.1. Import all the Python packages



```
import pandas as pd
import matplotlib.pyplot as plt
import os
from datetime import datetime
```

1.2. Importing the Data

➔ Reading the CSV file and skipping the first row



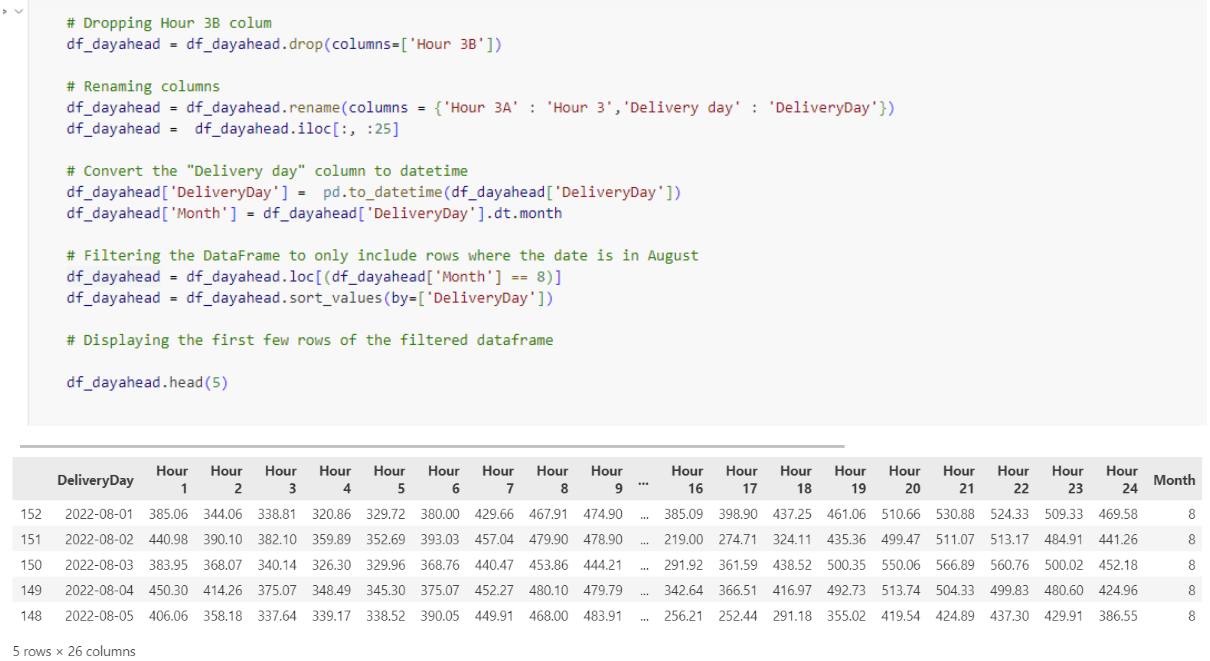
```
df_dayahead= pd.read_csv(r"C:/Users/Brianda/OneDrive/Escritorio/Neuer Ordner/DayAhead.csv",skiprows=1)
df_dayahead.columns = df_dayahead.columns.str.replace('\n', '')
df_dayahead.head(5)
```

	Delivery day	Hour 1	Hour 2	Hour 3A	Hour 3B	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	...	Peakload	Night	Off-Peak 1	Business	Offpeak	Morning	High Noon	Afternoon	Evening	Sunpeak
0	31/12/2022	-0.03	-0.07	-0.03	NaN	-0.04	-0.03	-0.02	-0.01	-0.05	...	-1.21	-0.04	-0.04	-1.58	-0.37	0.14	-2.30	-1.24	-0.87	-2.21
1	30/12/2022	11.17	5.09	3.09	NaN	0.65	0.57	4.88	10.93	24.13	...	23.90	4.24	7.56	24.85	5.35	22.96	22.11	26.35	6.65	23.67
2	29/12/2022	-1.01	-1.05	-1.10	NaN	-2.18	-2.05	-0.98	-0.05	0.09	...	19.60	-1.40	-1.04	9.27	7.56	3.75	3.67	26.56	33.06	9.86
3	28/12/2022	40.28	33.13	10.31	NaN	0.05	0.03	0.10	16.97	31.41	...	67.60	13.98	16.54	59.57	24.19	38.81	56.88	79.42	52.87	61.61
4	27/12/2022	23.36	9.98	5.69	NaN	5.00	11.46	19.59	30.42	80.96	...	128.78	12.51	23.31	114.68	54.69	76.84	109.77	147.16	131.91	120.25

5 rows × 45 columns

1.2. Filtering the Data

- ➔ Dropping Hour 3B column
- ➔ Renaming columns
- ➔ Convert the "Delivery Day" column to Date Time
- ➔ Filtering the Data Frame only to include rows where the date is in August
- ➔ printing the first few rows of the filtered data frame



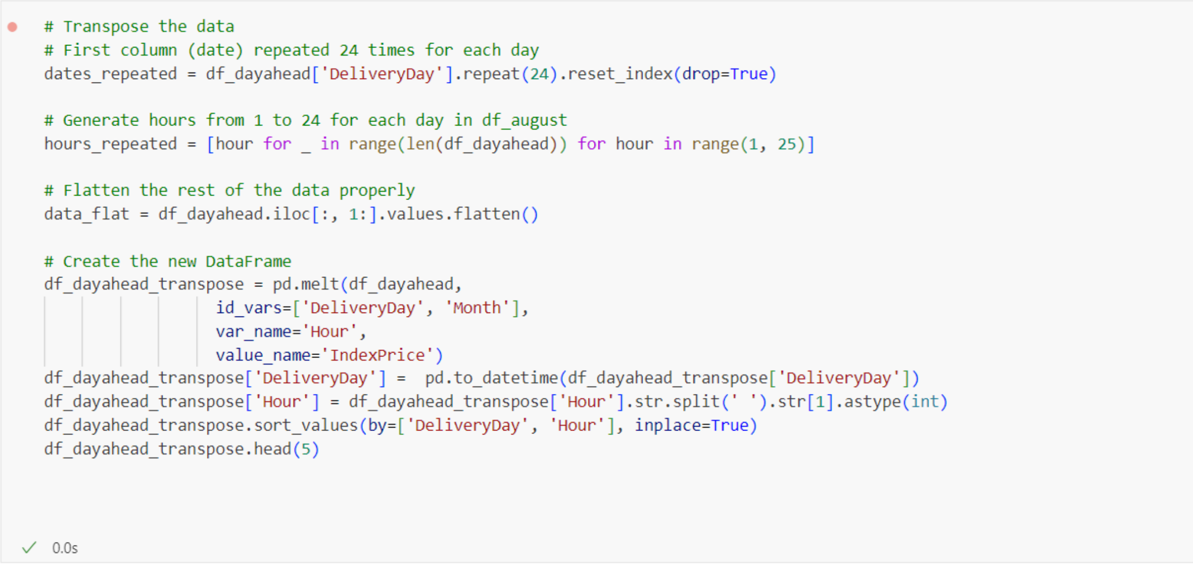
```
# Dropping Hour 3B colum
df_dayahead = df_dayahead.drop(columns=['Hour 3B'])

# Renaming columns
df_dayahead = df_dayahead.rename(columns = {'Hour 3A' : 'Hour 3','Delivery day' : 'DeliveryDay'})
df_dayahead =  df_dayahead.iloc[:, :25]

# Convert the "Delivery day" column to datetime
df_dayahead['DeliveryDay'] =  pd.to_datetime(df_dayahead['DeliveryDay'])
df_dayahead['Month'] = df_dayahead['DeliveryDay'].dt.month

# Filtering the DataFrame to only include rows where the date is in August
df_dayahead = df_dayahead.loc[(df_dayahead['Month'] == 8)]
df_dayahead = df_dayahead.sort_values(by=['DeliveryDay'])

# Displaying the first few rows of the filtered dataframe

df_dayahead.head(5)
```

	DeliveryDay	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	...	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22	Hour 23	Hour 24	Month
152	2022-08-01	385.06	344.06	338.81	320.86	329.72	380.00	429.66	467.91	474.90	...	385.09	398.90	437.25	461.06	510.66	530.88	524.33	509.33	469.58	8
151	2022-08-02	440.98	390.10	382.10	359.89	352.69	393.03	457.04	479.90	478.90	...	219.00	274.71	324.11	435.36	499.47	511.07	513.17	484.91	441.26	8
150	2022-08-03	383.95	368.07	340.14	326.30	329.96	368.76	440.47	453.86	444.21	...	291.92	361.59	438.52	500.35	550.06	566.89	560.76	500.02	452.18	8
149	2022-08-04	450.30	414.26	375.07	348.49	345.30	375.07	452.27	480.10	479.79	...	342.64	366.51	416.97	492.73	513.74	504.33	499.83	480.60	424.96	8
148	2022-08-05	406.06	358.18	337.64	339.17	338.52	390.05	449.91	468.00	483.91	...	256.21	252.44	291.18	355.02	419.54	424.89	437.30	429.91	386.55	8

5 rows × 26 columns

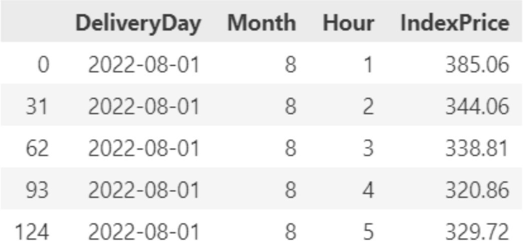
1.3. Data Transformation

- ➔ Transpose the data
- ➔ Generate hours from 1 to 24 for each day in the data frame
- ➔ Flatten the rest of the data properly
- ➔ Ensure lengths are aligned correctly
- ➔ Create the new Data Frame



```
# Transpose the data
# First column (date) repeated 24 times for each day
dates_repeated = df_dayahead['DeliveryDay'].repeat(24).reset_index(drop=True)

# Generate hours from 1 to 24 for each day in df_august
hours_repeated = [hour for _ in range(len(df_dayahead)) for hour in range(1, 25)]

# Flatten the rest of the data properly
data_flat = df_dayahead.iloc[:, 1:].values.flatten()

# Create the new DataFrame
df_dayahead_transpose = pd.melt(df_dayahead,
                    id_vars=['DeliveryDay', 'Month'],
                    var_name='Hour',
                    value_name='IndexPrice')
df_dayahead_transpose['DeliveryDay'] =  pd.to_datetime(df_dayahead_transpose['DeliveryDay'])
df_dayahead_transpose['Hour'] = df_dayahead_transpose['Hour'].str.split(' ').str[1].astype(int)
df_dayahead_transpose.sort_values(by=['DeliveryDay', 'Hour'], inplace=True)
df_dayahead_transpose.head(5)
```

✓ 0.0s



	DeliveryDay	Month	Hour	IndexPrice
0	2022-08-01	8	1	385.06
31	2022-08-01	8	2	344.06
62	2022-08-01	8	3	338.81
93	2022-08-01	8	4	320.86
124	2022-08-01	8	5	329.72

1.4. Hourly Profit Calculation

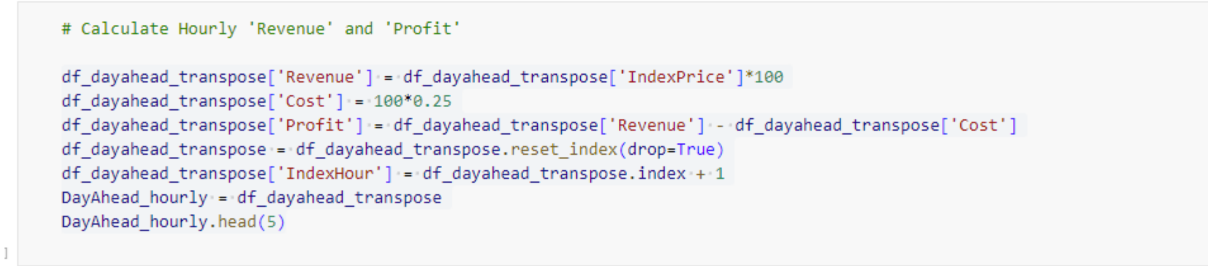
➔ Add new columns named “Revenue”, “Cost” and “Profit” respectively and calculate

➔ Hourly revenue by multiplying by 100

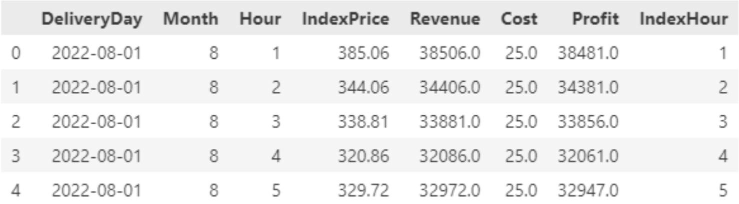
➔ Cost by multiplying revenue times 0,25

➔ Profit by subtracting revenue - cost

➔ Add a new column named “Index Hour” to define hours in order from the 1st August to 31 August, based on the original index of the data frame plus 1

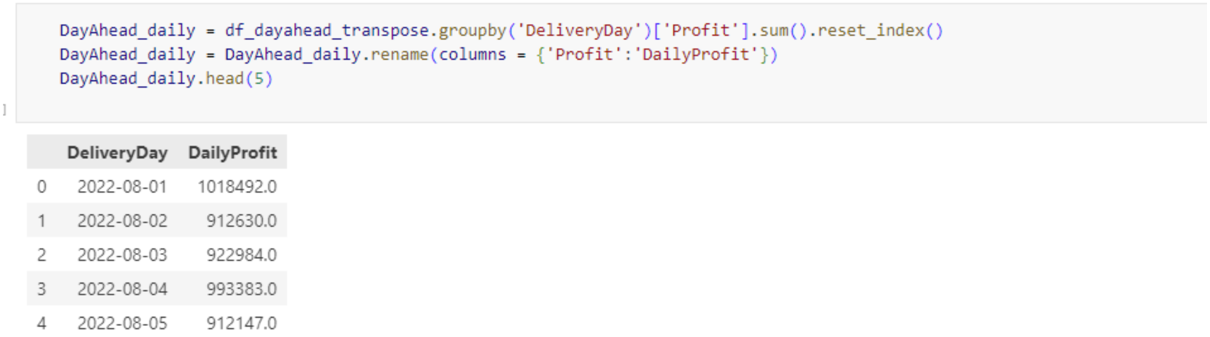


```
# Calculate Hourly 'Revenue' and 'Profit'

df_dayahead_transpose['Revenue'] = df_dayahead_transpose['IndexPrice']*100
df_dayahead_transpose['Cost'] = 100*0.25
df_dayahead_transpose['Profit'] = df_dayahead_transpose['Revenue'] - df_dayahead_transpose['Cost']
df_dayahead_transpose = df_dayahead_transpose.reset_index(drop=True)
df_dayahead_transpose['IndexHour'] = df_dayahead_transpose.index + 1
DayAhead_hourly = df_dayahead_transpose
DayAhead_hourly.head(5)
```



	DeliveryDay	Month	Hour	IndexPrice	Revenue	Cost	Profit	IndexHour
0	2022-08-01	8	1	385.06	38506.0	25.0	38481.0	1
1	2022-08-01	8	2	344.06	34406.0	25.0	34381.0	2
2	2022-08-01	8	3	338.81	33881.0	25.0	33856.0	3
3	2022-08-01	8	4	320.86	32086.0	25.0	32061.0	4
4	2022-08-01	8	5	329.72	32972.0	25.0	32947.0	5

1.5. Daily Profit calculation



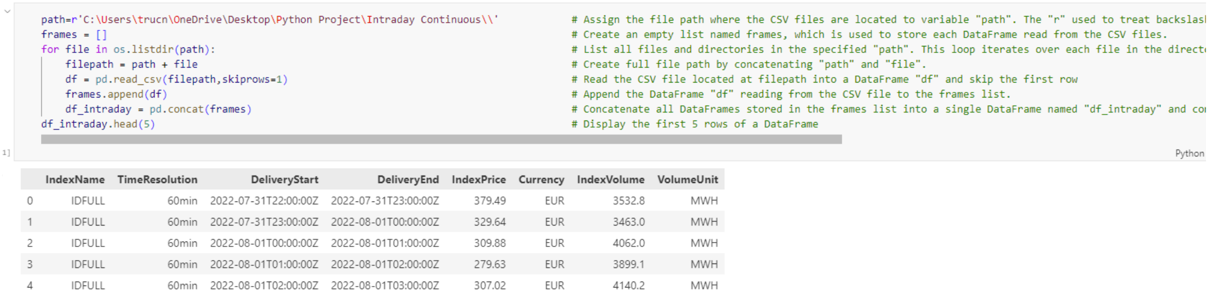
```
DayAhead_daily = df_dayahead_transpose.groupby('DeliveryDay')['Profit'].sum().reset_index()
DayAhead_daily = DayAhead_daily.rename(columns = {'Profit':'DailyProfit'})
DayAhead_daily.head(5)
```

	DeliveryDay	DailyProfit
0	2022-08-01	1018492.0
1	2022-08-02	912630.0
2	2022-08-03	922984.0
3	2022-08-04	993383.0
4	2022-08-05	912147.0

2. Intraday (ID) Continuous

2.1. Import Data from a Local Folder

- ➔ Create a "path" variable to assign file path where the CSV files are located
- ➔ Create an empty list to store each data frame read from CSV files
- ➔ Create a loop to read all CSV files and concatenate all data frames in the list into one file

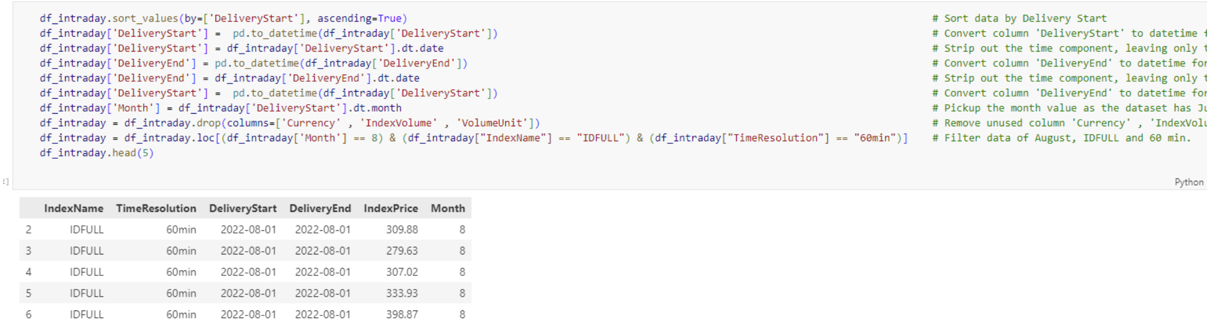


```
path=r'C:\Users\trucn\OneDrive\Desktop\Python Project\Intraday Continuous\\'      # Assign the file path where the CSV files are located to variable "path". The "r" used to treat backslasl
frames = []                                                                       # Create an empty list named frames, which is used to store each DataFrame read from the CSV files.
for file in os.listdir(path):                                                     # List all files and directories in the specified "path". This loop iterates over each file in the directo
    filepath = path + file                                                        # Create full file path by concatenating "path" and "file".
    df = pd.read_csv(filepath,skiprows=1)                                         # Read the CSV file located at filepath into a DataFrame "df" and skip the first row
    frames.append(df)                                                             # Append the DataFrame "df" reading from the CSV file to the frames list.
    df_intraday = pd.concat(frames)                                               # Concatenate all DataFrames stored in the frames list into a single DataFrame named "df_intraday" and co
df_intraday.head(5)                                                               # Display the first 5 rows of a DataFrame
```

	IndexName	TimeResolution	DeliveryStart	DeliveryEnd	IndexPrice	Currency	IndexVolume	VolumeUnit
0	IDFULL	60min	2022-07-31T22:00:00Z	2022-07-31T23:00:00Z	379.49	EUR	3532.8	MWH
1	IDFULL	60min	2022-07-31T23:00:00Z	2022-08-01T00:00:00Z	329.64	EUR	3463.0	MWH
2	IDFULL	60min	2022-08-01T00:00:00Z	2022-08-01T01:00:00Z	309.88	EUR	4062.0	MWH
3	IDFULL	60min	2022-08-01T01:00:00Z	2022-08-01T02:00:00Z	279.63	EUR	3899.1	MWH
4	IDFULL	60min	2022-08-01T02:00:00Z	2022-08-01T03:00:00Z	307.02	EUR	4140.2	MWH

2.2. Processing Data

- ➔ After all data of 31 days were combined, start to sort data by "Delivery Start"
- ➔ Convert "Delivery Start" and "Delivery End" into date time format, then strip out the time to pick up the date only.
- ➔ Remove unused columns including "Currency", "Index Volume", "Volume Unit"
- ➔ Filter to select values Month = August, Index name = IDFULL and time resolution = 60min



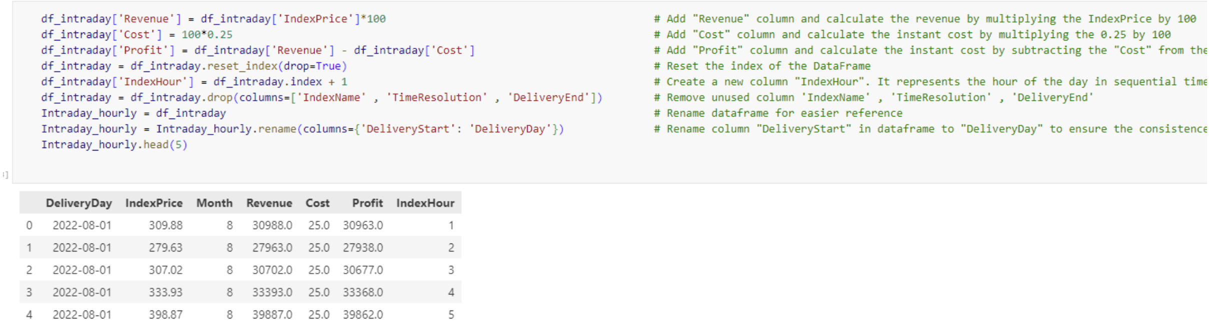
```
df_intraday.sort_values(by=['DeliveryStart'], ascending=True)                                                                                    # Sort data by Delivery Start
df_intraday['DeliveryStart'] =  pd.to_datetime(df_intraday['DeliveryStart'])                                                                   # Convert column 'DeliveryStart' to datetime f
df_intraday['DeliveryStart'] = df_intraday['DeliveryStart'].dt.date                                                                             # Strip out the time component, leaving only t
df_intraday['DeliveryEnd'] = pd.to_datetime(df_intraday['DeliveryEnd'])                                                                         # Convert column 'DeliveryEnd' to datetime for
df_intraday['DeliveryEnd'] = df_intraday['DeliveryEnd'].dt.date                                                                                 # Strip out the time component, leaving only t
df_intraday['DeliveryStart'] =  pd.to_datetime(df_intraday['DeliveryStart'])                                                                   # Convert column 'DeliveryEnd' to datetime for
df_intraday['Month'] = df_intraday['DeliveryStart'].dt.month                                                                                    # Pickup the month value as the dataset has Ju
df_intraday = df_intraday.drop(columns=['Currency' , 'IndexVolume' , 'VolumeUnit'])                                                             # Remove unused column 'Currency' , 'IndexVolu
df_intraday = df_intraday.loc[(df_intraday['Month'] == 8) & (df_intraday["IndexName"] == "IDFULL") & (df_intraday["TimeResolution"] == "60min")]   # Filter data of August, IDFULL and 60 min.
df_intraday.head(5)
```

Python

	IndexName	TimeResolution	DeliveryStart	DeliveryEnd	IndexPrice	Month
2	IDFULL	60min	2022-08-01	2022-08-01	309.88	8
3	IDFULL	60min	2022-08-01	2022-08-01	279.63	8
4	IDFULL	60min	2022-08-01	2022-08-01	307.02	8
5	IDFULL	60min	2022-08-01	2022-08-01	333.93	8
6	IDFULL	60min	2022-08-01	2022-08-01	398.87	8

2.3. Profit Calculation – Hourly

- ➔ Add new columns named “Revenue”, “Cost” and “Profit” respectively and calculate
  - ◆ Revenue = Index Price * 100
  - ◆ Cost = 0.25 *100
  - ◆ Profit = Revenue - Cost
- ➔ Add a new column named “Index Hour” to define hours in order from the 1st August to 31 August, based on the original index of the data frame plus 1
- ➔ Remove columns named “Index Name”, “Time Resolution” and “Delivery End” for a clear view

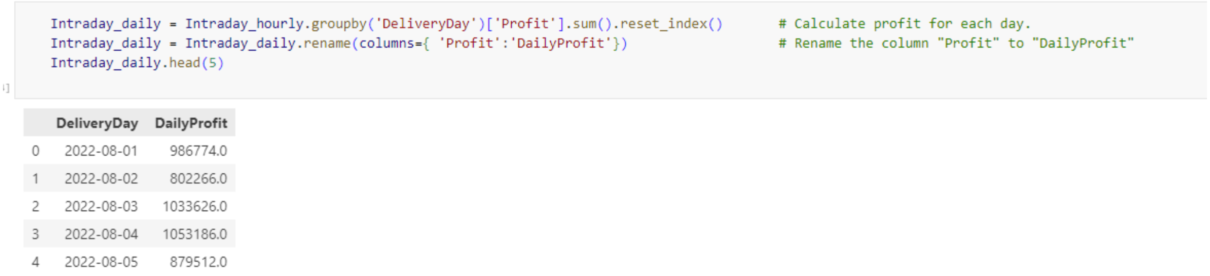


```
df_intraday['Revenue'] = df_intraday['IndexPrice']*100                                        # Add "Revenue" column and calculate the revenue by multiplying the IndexPrice by 100
df_intraday['Cost'] = 100*0.25                                                                # Add "Cost" column and calculate the instant cost by multiplying the 0.25 by 100
df_intraday['Profit'] = df_intraday['Revenue'] - df_intraday['Cost']                          # Add "Profit" column and calculate the instant cost by subtracting the "Cost" from the
df_intraday = df_intraday.reset_index(drop=True)                                              # Reset the index of the DataFrame
df_intraday['IndexHour'] = df_intraday.index + 1                                              # Create a new column "IndexHour". It represents the hour of the day in sequential time
df_intraday = df_intraday.drop(columns=['IndexName' , 'TimeResolution' , 'DeliveryEnd'])      # Remove unused column 'IndexName' , 'TimeResolution' , 'DeliveryEnd'
Intraday_hourly = df_intraday                                                                 # Rename dataframe for easier reference
Intraday_hourly = Intraday_hourly.rename(columns={'DeliveryStart': 'DeliveryDay'})           # Rename column "DeliveryStart" in dataframe to "DeliveryDay" to ensure the consistence
Intraday_hourly.head(5)
```

	DeliveryDay	IndexPrice	Month	Revenue	Cost	Profit	IndexHour
0	2022-08-01	309.88	8	30988.0	25.0	30963.0	1
1	2022-08-01	279.63	8	27963.0	25.0	27938.0	2
2	2022-08-01	307.02	8	30702.0	25.0	30677.0	3
3	2022-08-01	333.93	8	33393.0	25.0	33368.0	4
4	2022-08-01	398.87	8	39887.0	25.0	39862.0	5

2.4. Profit Calculation – Daily

- ➔ From the hourly data frame, calculate the daily profit by grouping the profit by date
- ➔ Rename for column “Profit” to “Daily Profit” for easier reference

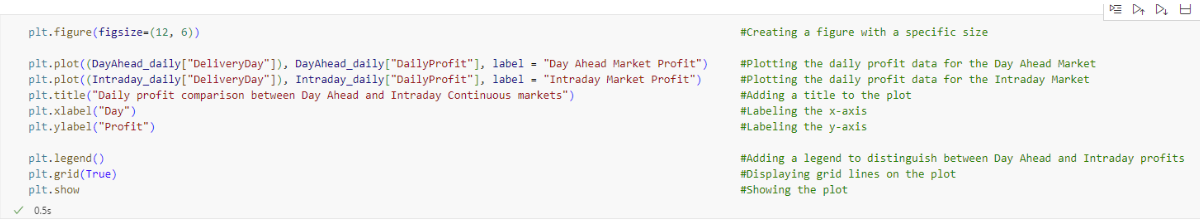


```
Intraday_daily = Intraday_hourly.groupby('DeliveryDay')['Profit'].sum().reset_index()      # Calculate profit for each day.
Intraday_daily = Intraday_daily.rename(columns={ 'Profit':'DailyProfit'})                  # Rename the column "Profit" to "DailyProfit"
Intraday_daily.head(5)
```

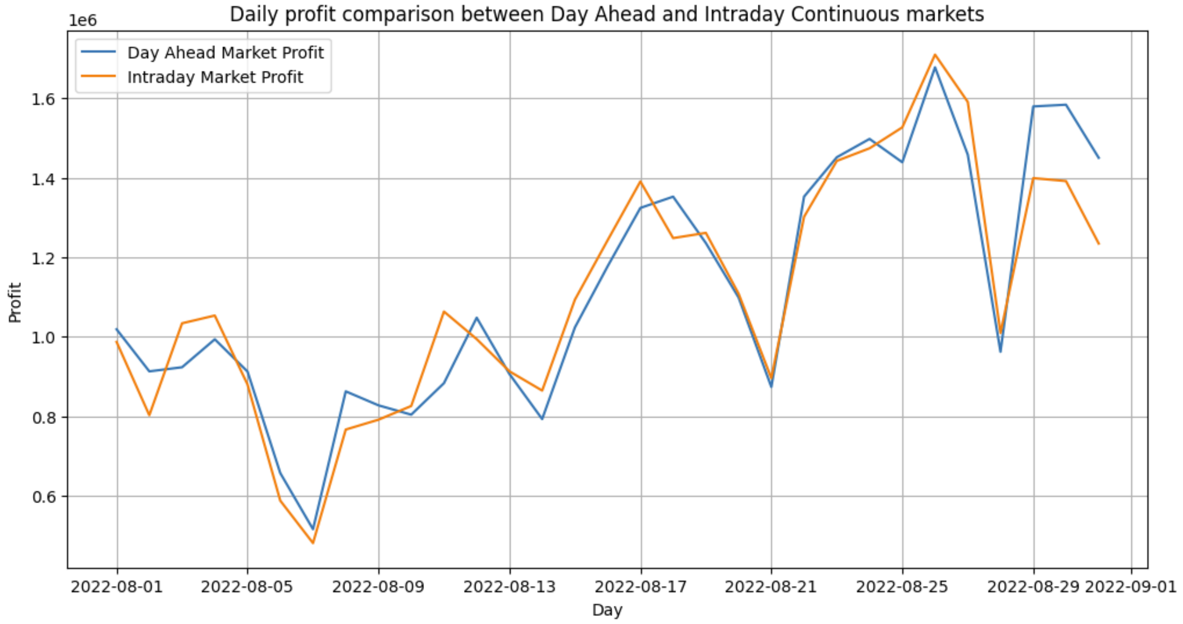
	DeliveryDay	DailyProfit
0	2022-08-01	986774.0
1	2022-08-02	802266.0
2	2022-08-03	1033626.0
3	2022-08-04	1053186.0
4	2022-08-05	879512.0

3. Reporting

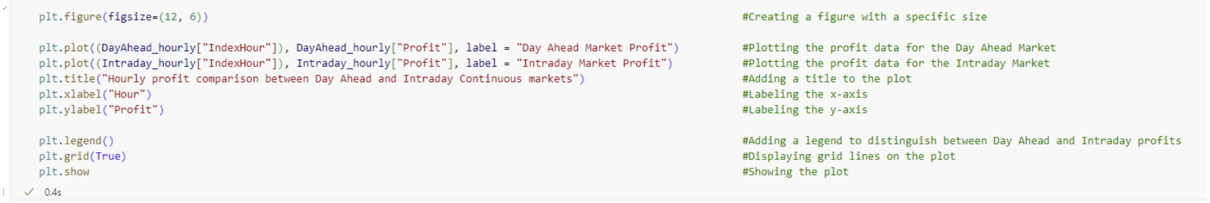
3.1. Daily Reporting



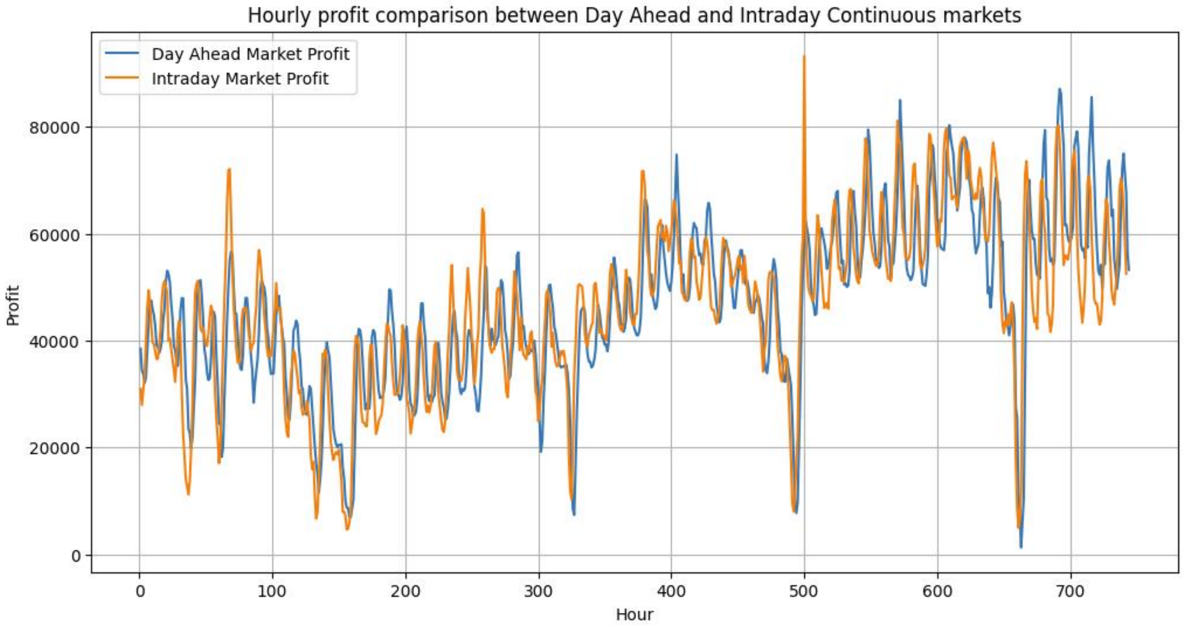
```
plt.figure(figsize=(12, 6))                                                                                    #Creating a figure with a specific size

plt.plot((DayAhead_daily["DeliveryDay"]), DayAhead_daily["DailyProfit"], label = "Day Ahead Market Profit")    #Plotting the daily profit data for the Day Ahead Market
plt.plot((Intraday_daily["DeliveryDay"]), Intraday_daily["DailyProfit"], label = "Intraday Market Profit")     #Plotting the daily profit data for the Intraday Market
plt.title("Daily profit comparison between Day Ahead and Intraday Continuous markets")                         #Adding a title to the plot
plt.xlabel("Day")                                                                                              #Labeling the x-axis
plt.ylabel("Profit")                                                                                           #Labeling the y-axis

plt.legend()                                                                                                   #Adding a legend to distinguish between Day Ahead and Intraday profits
plt.grid(True)                                                                                                 #Displaying grid lines on the plot
plt.show                                                                                                       #Showing the plot
✓ 0.5s
```



3.2. Hourly Reporting

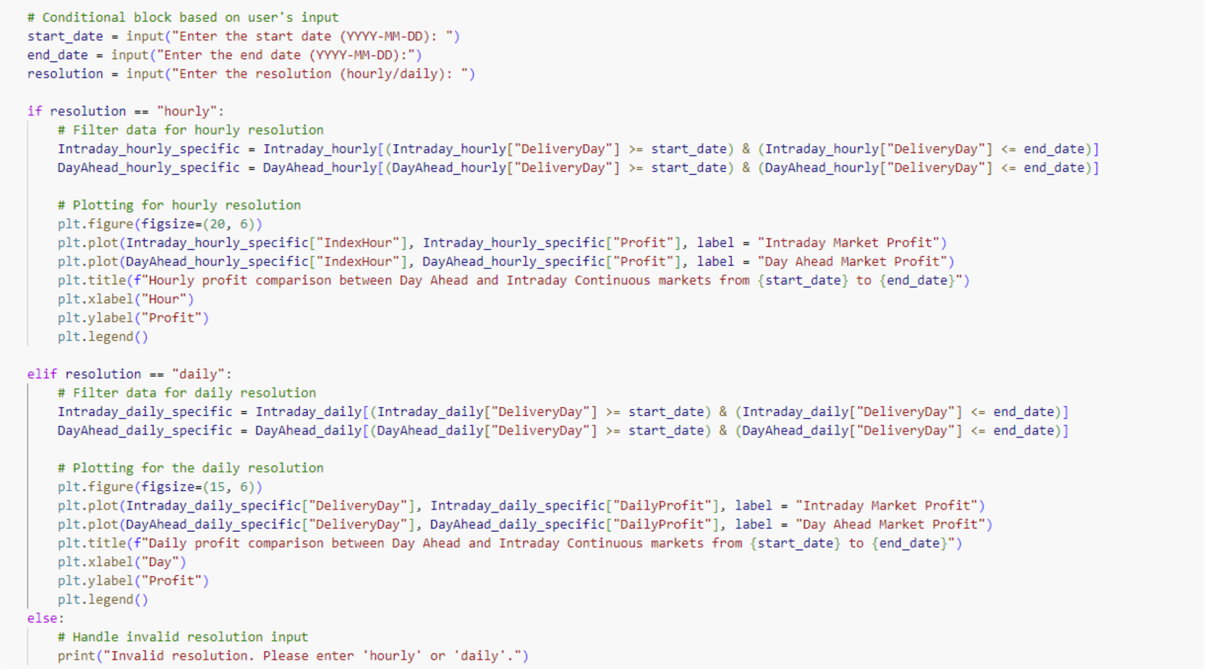


```
plt.figure(figsize=(12, 6))                                                                                 #Creating a figure with a specific size

plt.plot((DayAhead_hourly["IndexHour"]), DayAhead_hourly["Profit"], label = "Day Ahead Market Profit")      #Plotting the profit data for the Day Ahead Market
plt.plot((Intraday_hourly["IndexHour"]), Intraday_hourly["Profit"], label = "Intraday Market Profit")       #Plotting the profit data for the Intraday Market
plt.title("Hourly profit comparison between Day Ahead and Intraday Continuous markets")                     #Adding a title to the plot
plt.xlabel("Hour")                                                                                          #Labeling the x-axis
plt.ylabel("Profit")                                                                                        #Labeling the y-axis

plt.legend()                                                                                                #Adding a legend to distinguish between Day Ahead and Intraday profits
plt.grid(True)                                                                                              #Displaying grid lines on the plot
plt.show                                                                                                    #Showing the plot
✓ 0.4s
```

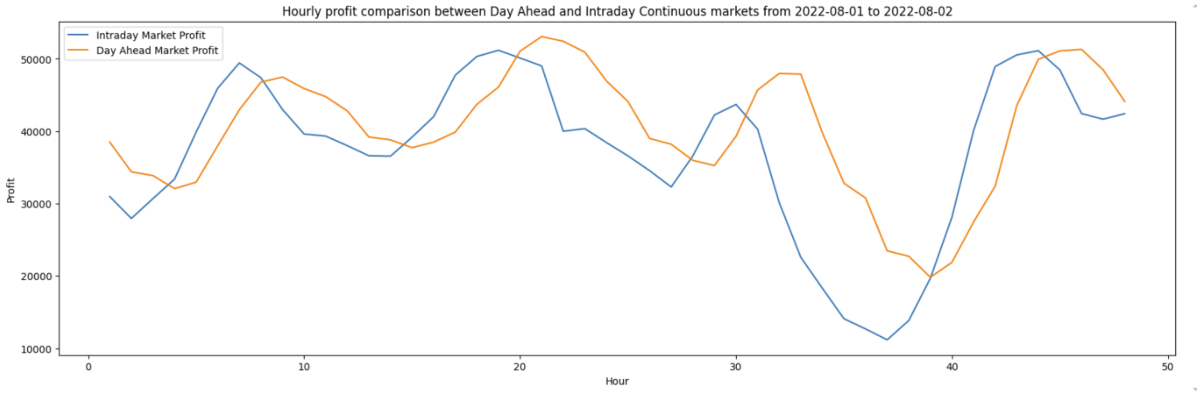


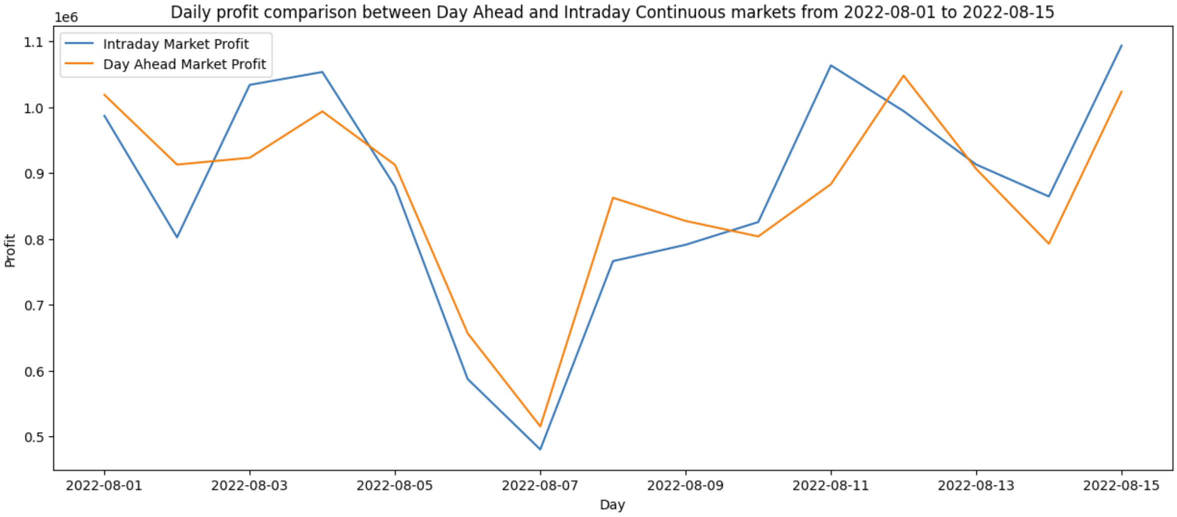
3.3. Reporting Based on Users' Needs

- ➔ Collect user input for the start date, end date, and desired resolution (hourly or daily)
- ➔ Filter the data accordingly
- ➔ Generate a report based on the filtered data



```
# Conditional block based on user's input
start_date = input("Enter the start date (YYYY-MM-DD): ")
end_date = input("Enter the end date (YYYY-MM-DD):")
resolution = input("Enter the resolution (hourly/daily): ")

if resolution == "hourly":
    # Filter data for hourly resolution
    Intraday_hourly_specific = Intraday_hourly[(Intraday_hourly["DeliveryDay"] >= start_date) & (Intraday_hourly["DeliveryDay"] <= end_date)]
    DayAhead_hourly_specific = DayAhead_hourly[(DayAhead_hourly["DeliveryDay"] >= start_date) & (DayAhead_hourly["DeliveryDay"] <= end_date)]

    # Plotting for hourly resolution
    plt.figure(figsize=(20, 6))
    plt.plot(Intraday_hourly_specific["IndexHour"], Intraday_hourly_specific["Profit"], label = "Intraday Market Profit")
    plt.plot(DayAhead_hourly_specific["IndexHour"], DayAhead_hourly_specific["Profit"], label = "Day Ahead Market Profit")
    plt.title(f"Hourly profit comparison between Day Ahead and Intraday Continuous markets from {start_date} to {end_date}")
    plt.xlabel("Hour")
    plt.ylabel("Profit")
    plt.legend()

elif resolution == "daily":
    # Filter data for daily resolution
    Intraday_daily_specific = Intraday_daily[(Intraday_daily["DeliveryDay"] >= start_date) & (Intraday_daily["DeliveryDay"] <= end_date)]
    DayAhead_daily_specific = DayAhead_daily[(DayAhead_daily["DeliveryDay"] >= start_date) & (DayAhead_daily["DeliveryDay"] <= end_date)]

    # Plotting for the daily resolution
    plt.figure(figsize=(15, 6))
    plt.plot(Intraday_daily_specific["DeliveryDay"], Intraday_daily_specific["DailyProfit"], label = "Intraday Market Profit")
    plt.plot(DayAhead_daily_specific["DeliveryDay"], DayAhead_daily_specific["DailyProfit"], label = "Day Ahead Market Profit")
    plt.title(f"Daily profit comparison between Day Ahead and Intraday Continuous markets from {start_date} to {end_date}")
    plt.xlabel("Day")
    plt.ylabel("Profit")
    plt.legend()
else:
    # Handle invalid resolution input
    print("Invalid resolution. Please enter 'hourly' or 'daily'.")
```





Summary

I successfully navigated challenges by applying knowledge acquired in our lectures and through ongoing research using resources such as GitHub Copilot, Python forums, and AI prompt engineer. Recognizing the importance of incorporating comments in the code for future reference, not just for ourselves but also for other programmers, was a pivotal realization. Jupyter played a crucial role in facilitating my progress throughout this journey, as did the valuable guidance and support provided by our lecturer in clarifying tasks and guiding us through the process.