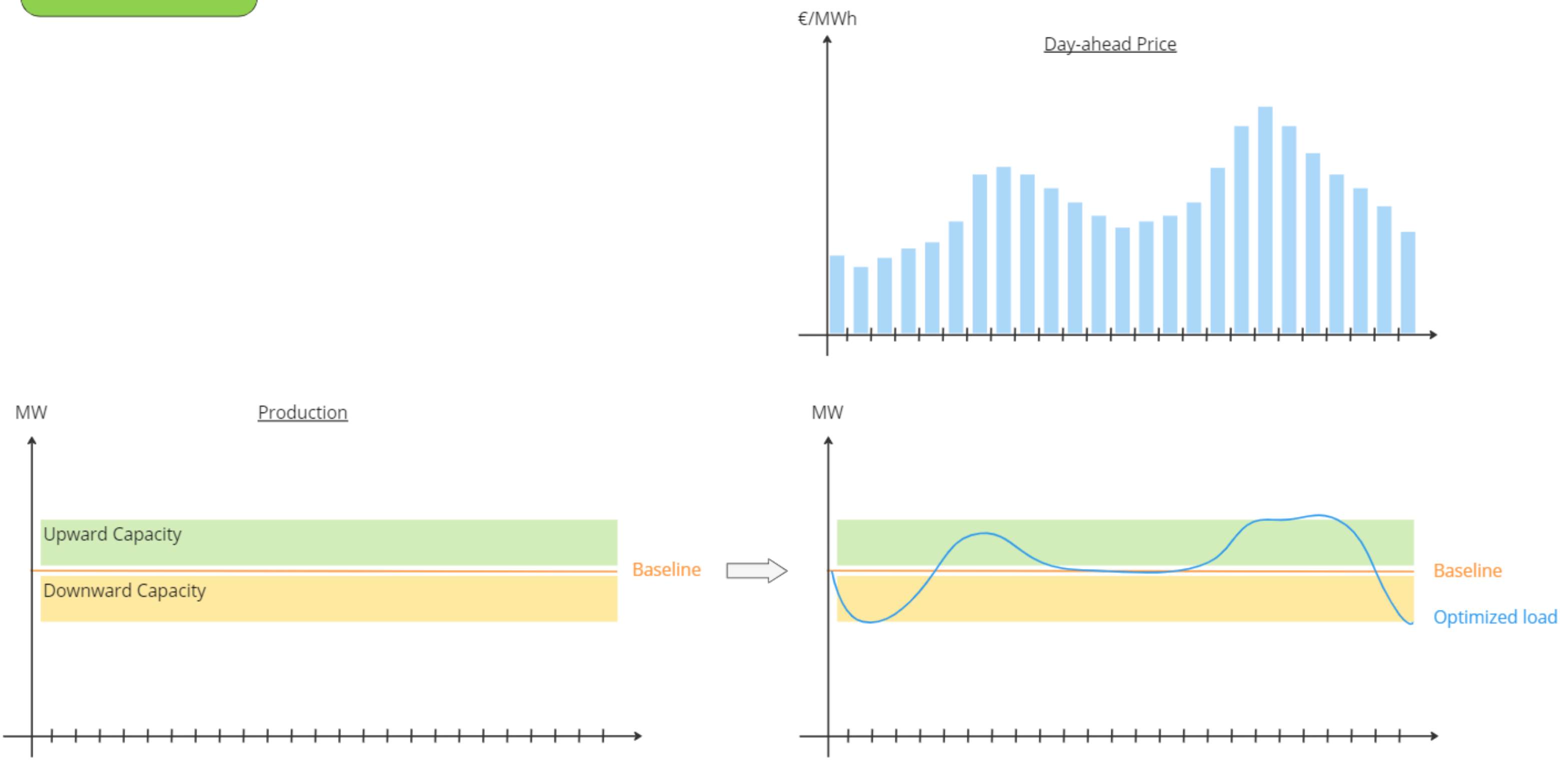
Watts Happening

DA models

Day-Ahead



1 Introduction

The purpose of this document is to explain the functioning of the day-ahead simulation model, used in the Watts.Happening website. Based on the assumptions set out below, the input provided by the user and the data of the hourly day-ahead prices that were applicable in Belgium from **01/05/2023 to 30/04/2024**, the model calculates the yearly potential savings/earnings of an asset's participation in the day-ahead prices. These results are displayed in the "Watts.Happening" simulator.

The simulator takes the constraints of each asset into account and optimizes the load/consumption according to the day-ahead (DA) price. The assets are assumed to be not optimized before the simulation.

Note that the model is limited to one selected asset and one market and does not consider the interaction with other assets nor flexibility products.

2 User input

The user is required to provide information about:

- Asset Type: determines the behaviour of the asset.

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- Average capacity used (Running Set Point): Baseline power, total energy needed per day. Can be used to deduct maximum upward/downward capacity.
- Activation related: duration, frequency, availability ratio
- Asset specific data: minimum power, startup cost, subsidies, etc.

3 Data sources

Hourly day-ahead electricity price: ENTSO-E

- The historic wholesale price of the electricity (EUR/MWh)

Solar and Wind production profile: Elia Opendata

- The historic production of renewables
- Used as baseline (before optimisation) production

Other assets production profile: User input

- The baseline production of the simulated asset is input by the user.

4 Simulated Assets

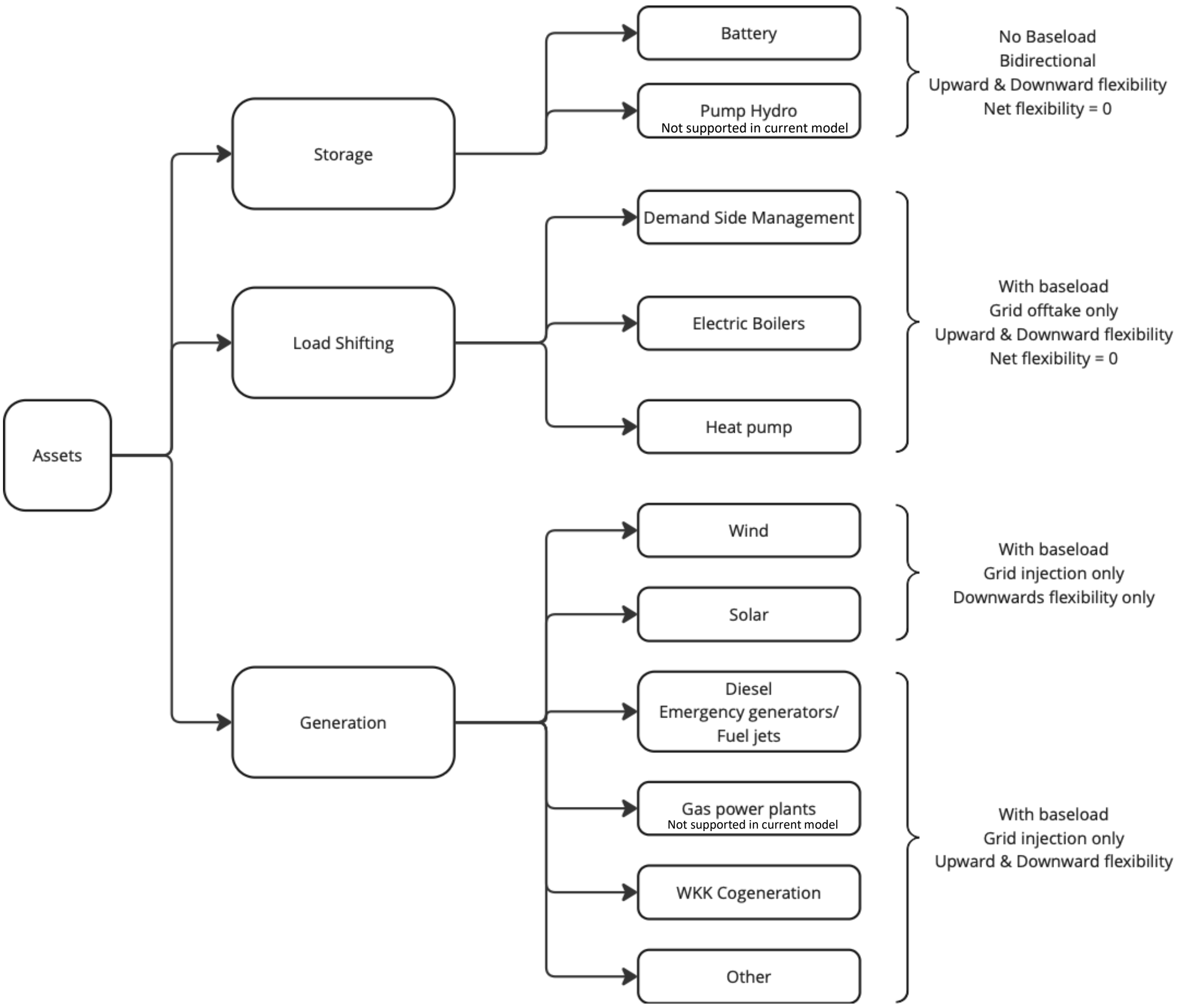
Assets are modelled in 4 categories.

1. The storage assets:
    a. Interacts with the grid in both directions.
    b. They are assumed to have no baseload.
    c. The net flexibility up and down per day is zero, i.e., not charging or discharging the storage with the flexibility service
    d. Includes battery assets.
2. Load (shifting) assets:
    a. Can only offtake from the grid.
    b. Have a consumption baseload.
    c. Have both upward and downward flexibility.
    d. Simulating load shifting mode. Net flexibility of the day is zero, i.e. the total consumption of each day stays the same.
    e. Includes industrial demands, heat pumps, etc.
3. Producer assets (Flexible):
    a. Can only inject to the grid.
    b. Have a generation baseload.
    c. Have both upward and downward flexibility.
    d. Have operation (fuel) cost and start-up costs.
    e. Assumed to be small-scale generator, where the operation schedule is not already optimized, e.g., diesel generator, WKK-Cogen.
4. Producer assets (Renewables):
    a. Can only inject to the grid.
    b. Have a generation baseload.
    c. Only downward flexibility (curtailing)
    d. Have negative operation cost (subsidies)
    e. Assumed to be small-scale renewables, where the bidding is not already optimized.
    f.

5 Assumptions

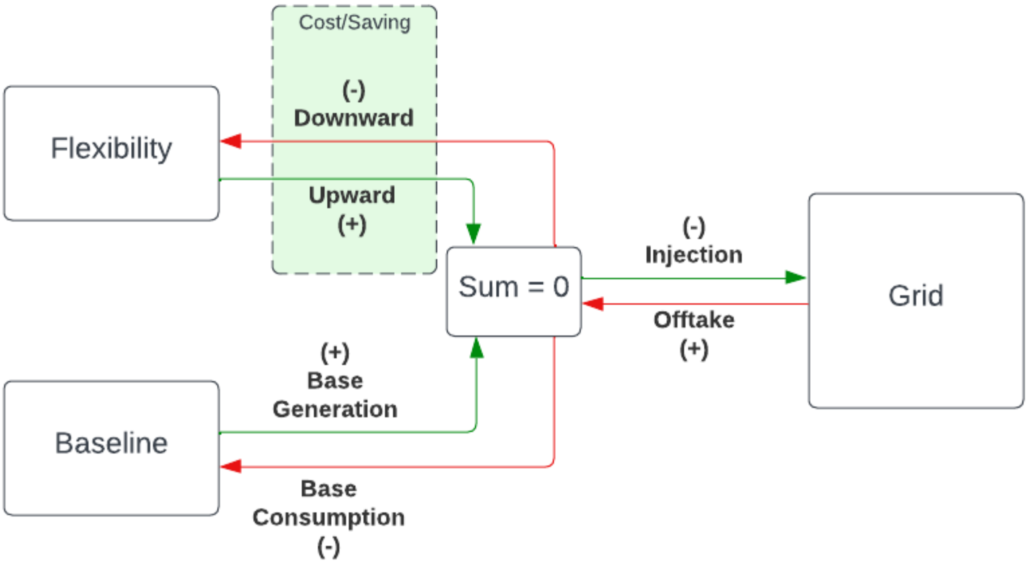
Some assumptions are made in order to keep the model from being too cumbersome while still giving relevant results. The model assumes:

1. The optimization is done each day after the day-ahead price is published.
2. The generation profile for wind, solar, and NG assets is based on the total generation of each fuel type in the grid, instead of individual plants. In other words, it is assuming the production of every single asset is the same.
3. No extra activation cost:
    a. No grid cost, tariffs and taxes
    b. The renewables (with near zero cost or negative cost due to subsidies) don't have curtail threshold originally. they would produce even at negative net gain.
    c. No degradation costs
    d. No efficiency loss
4. For battery assets, an average daily discharge cycle is displayed. The value is calculated as the average daily discharged divided by the available charge capacity, instead of the actual maximum charge capacity



6 Model

Common model



$$\forall\, i = 1 \ldots 24\, h$$

$$Flexibility\_Balance_i + Baseline\_Balance_i + Grid\_Balance_i = 0$$

$$Objective\ Function$$

$$Flexibility\_Balance_i\ \ to\ minimise \sum_{i=1}^{24} Cost_i$$

The model is formulated as a Mixed Integer Linear Programming (MILP) problem.

With the prices for day-ahead, the model optimizes the flexibility for the next day by finding the minimum cost. Constraints on total energy, flexibility, capacity, are added according to different assets and input.

Activation constraints:

The asset has one consecutive available timeframe throughout the day, ranging from 15 minutes to 24 hours, depends on the user's input. The optimisation algorithm finds the most profitable periods to activate within the available timeframe.

For all types of assets, the user inputs the maximum activation day frequency, one day a year, one day a month, one day a week or every day.

Profit calculation:

To reduce simulation time and skip trivial days (e.g. no negative price occurred for renewables), a pre-calculation is done when the "activates every day" option is selected.

1. Battery assets and consumer assets:

   a. These assets profit the most when there is high price spread within one day.
   b. Rank the days according to price spreads. Simulate the days that lie in the 45th to 55th quantile.
   c. The average earning of the qualified days is assumed to be the average earning over the year. (Back testing indicates a <10% error)
2. Renewables producer assets:
   a. These assets only profits when the price falls below the subsidies (assumes to be running cost).
   b. Only simulate the days with negative prices.
   c. The yearly earning is the sum of qualified days.
3. Other producer assets:
   a. These assets profit the most when the price deviates from the running (fuel) cost.
   b. Sort the days according to the sum of price difference from the running cost. Simulate the days that lie in the 45th to 55th quantile.
   c. The average earning of the qualified days is assumed to be the average earning over the year. (Back testing indicates a <10% error)

The pre-calculation for other activation limit is done in a similar method. The days with the highest spread from a week/month/year are picked out for optimization to calculate the profit of activating once a week/month/year.

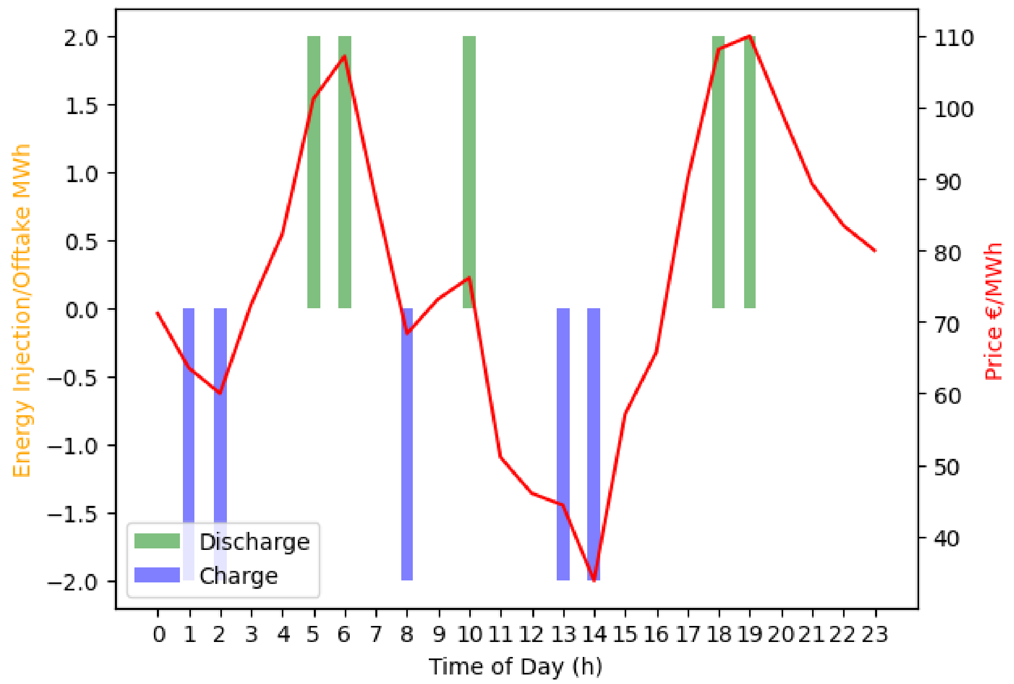
7 Example Optimization Results and Output

This set of parameters is chosen to showcase the charging constraints.

Battery:

Capacity: 4MWh
Power: 2MW
Activation length: unlimited, No charging cycle limit.
Activates every day.

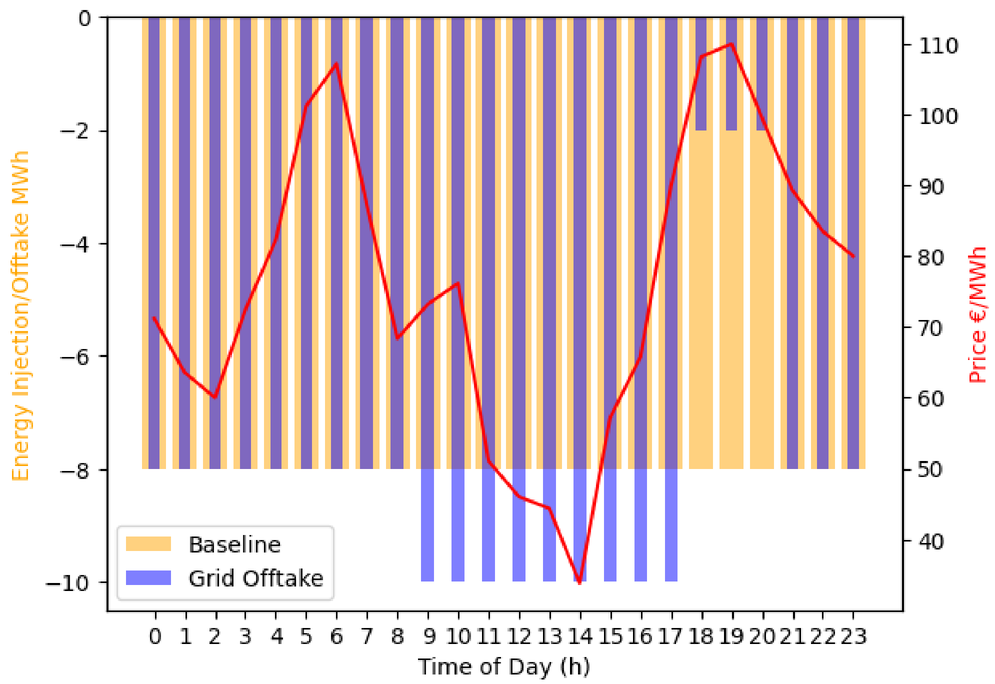
Example results on 2024-04-24
Profit on this day: 465€
Gross Margin: 108168.79€



DSR:

Baseload: 80% of max capacity (Consumption)
Maximum offtake: 10MW
Maximum consecutive availability: 12 hours

Example results on 2024-04-24
Savings on this day: 831€
Gross Margin: 226327€



Renewables:
Solar

Baseload: Real load factor from 2023-05-06 (data from Elia opendata)
Max capacity: 10 MW
Savings on this day: 327€
Total yearly savings: 8663€

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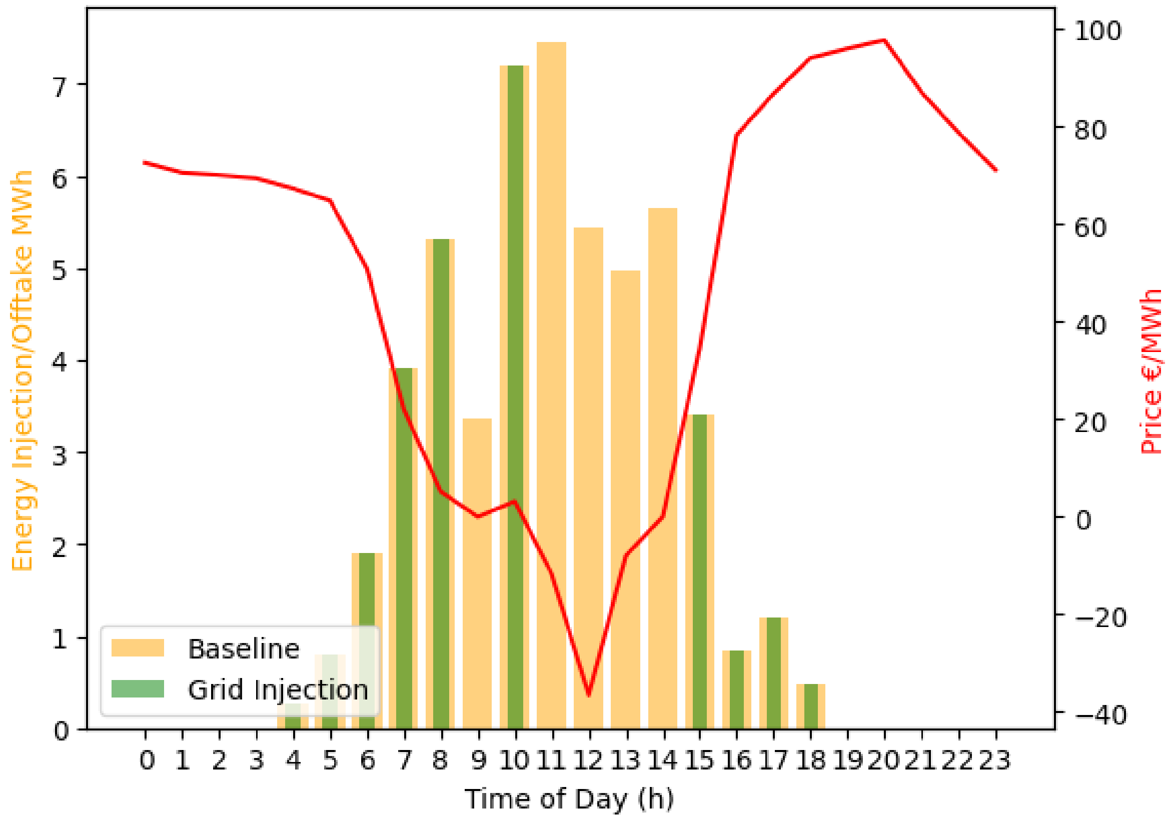
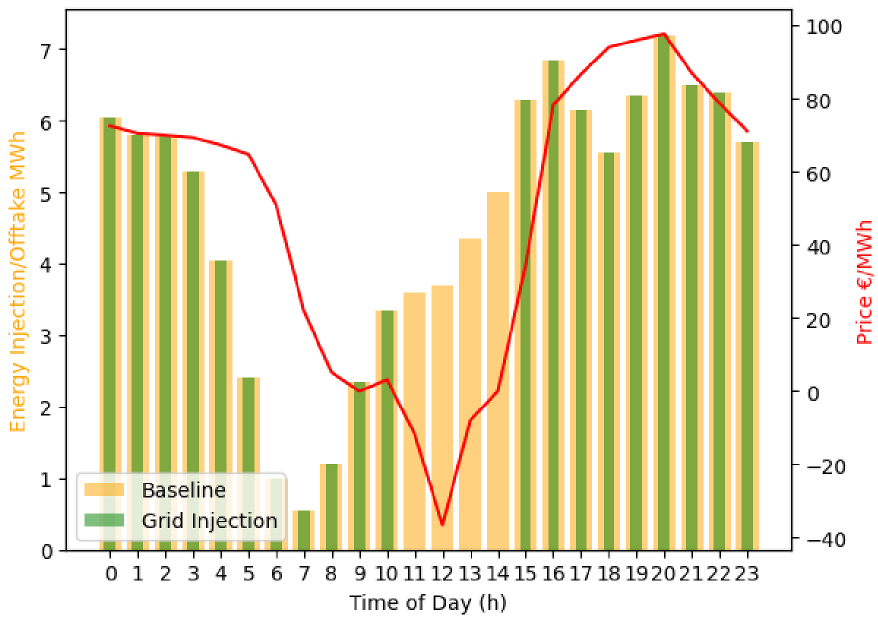


Wind

Baseload: Real load factor from 2023-06-24(data from Elia opendata)
Max capacity: 20MW
Savings on this day: 212€
Total yearly savings: 17373€



Producers:
WKK Cogeneration

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Baseload: 90% of max capacity
Max capacity: 20 MW
LCOE: 80 €/kWh
Savings + profit on 2023-07-05
day: 4695€
Total yearly savings: 1760704.68€