FCR model

1. Introduction

The purpose of this document is to explain the functioning of the FCR (Frequency Containment Reserve) balancing product simulation model, used on the Watts.happening website. Based on the assumptions set out below, the input provided by the user and the historical data of the FCR auctions in Belgium (the reference period is shown at the top of simulation results page and on the documentation page), the model calculates the yearly remuneration potential of an asset's participation in the FCR product. These results are displayed in the "Watts.Happening" simulator.

Note that the model is limited to one selected asset and does not consider the interaction with other assets or flexibility products.

2. User input

The user is required to provide information about:

- The maximum power of its asset as well as operating limits, such as the non-flexible part and the running set-point. This information allows the model to define the Upward and Downward Capacity of the asset.
- The Capacity Bidding Price, if any. This represents the minimum price below which the asset will not participate in a balancing auction. It is expressed in € per MW per hour.
- The availability of the asset. This input considers the availability constraints, due to the asset's schedule, maintenance, or unforeseen events, by means of an Availability factor.

3. Data sources

All data used in the model is publicly available. To build the model the following data have been used:

- FCR Capacity Auction Results: Datacenter FCR/aFRR/mFRR (regelleistung.net)
    - *Local marginal capacity price* (€/MW) – Belgium
    - *Demand* (MW) – Belgium

4. Assumptions

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

- The Capacity Bid is divisible
- No extra activation cost:
    - No grid cost, tariffs and taxes
    - 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.
    - No degradation costs
    - No efficiency loss
- No penalty is considered.
- Unlike the actual FCR algorithm that optimises the bid selection iteratively, this simplified model only simulates one iteration of clearing at regional level and a second iteration in the Belgian market, in the case that import or export limits are breached.

- For storage mean such as Batteries, the asset is considered as having no limitation on the Activation Time. This because FCR is a neutral product in terms of energy. It means that normally by taking into account the "Non-flexible capacity" and with a good EMS provided by the BSP, the energy reservoir of the asset should be enough to sustain the delivery of FCR with no time limitation, no matter the size of the reservoir. Only constraint is the Alert Mode which forced the asset to have a minimum size of reservoir of 25min of full delivery in both direction. Which is why we excluded the 15min activation.
- In 2025, the simulation is done without a complete full year of data. The results are scaled to a full year assuming the missing months has a similar performance to the months calculated.

Some of these assumptions will change as the model evolves.

5. Model

The model works in three steps:

- The **first step** is to simulate a Capacity Bid for all auctions of the calculation period in which the asset can participate based on its availability.
    - As FCR is a symmetrical product, to calculate the volume of Capacity Bid, the model takes the minimum between the Upward and Downward Capacity of this asset.
    - No Capacity Bid will be created for auctions that are part of the unavailability periods mentioned by the user.
- The **second step** is to take account of the asset's activation constraints. There are two of these, Activation Frequency and Activation Time. The constraint on Activation Frequency aims to apply a filter on the day on which the asset will participate in flexibility, while the constraint on Activation Time consists of applying a second filter on the hours of participation of the days selected in the previous filter.
    - For the Activation Frequency, there are 4 possibilities:
        - Every day: in which case no additional constraints are applied. All the days will be taken into account by the model for the next step, except for unavailability periods mentioned by the users in the previous step.
        - Max once a week: for this, the model will select only one day per week and the remuneration will be calculated solely on that day. The model is based on FCR Capacity Auction Results. It selects the day with the highest average *Local marginal capacity price* (€/MW) – Belgium of the week.
        - Max once a month: In this case, the model applies the same logic as for max once a week, but this time takes just one day per month.
        - Max once a year: In this case, the model applies the same logic as for the maximum once a week, but this time it is a single day over the whole year.
    - For the Activation Time, the model considers 3 possible cases.
        - 15min; 1 hour; 2 hours: In the case of the FCR product, the minimum Activation Time to participate in the flexibility product is 4 hours. For an Activation Time under 4 hours, the model considers that the asset does not meet the product's prerequisites and therefore cannot receive any remuneration.
        - 4 hours; 8 hours; 12 hours: the model takes into account respectively one, two or three periods with the *highest local marginal capacity price* of the day. The other periods will not be considered when calculating the remuneration.

        - No limitation: the model does not apply a filter to the days. All periods are taken into account.
- The **third step** is to define for each auction period whether the simulated Capacity Bid is rewarded or not based on whether it clears the regional auction system.
    - First the model defines the Capacity Bidding Price. This price is set by default according to the type of asset selected. However, the user has the possibility to enter a price constraint for the reservation of upward and downward capacity. If this is the case, the model considers the most restrictive price. In other words, the Capacity Bidding Price equals the maximum between the upward and downward price constraint entered by the user.
    - Then, for each auction period, the model updates historical clearing data with the user's Capacity Bids to calculate a new marginal price and a capacity allocation:
        - Regional historical bid data updated with the user's bids are used to compile a merit order - a stack of bids in order of their offered price.
        - User bids clear if their cumulative capacity in this stack is less than or equal to the regional demand (1420 MW).
            - If so, the model considers the Capacity Bid as rewarded.
            - If not, the model considers the Capacity bid as not rewarded. So, the Allocated Capacity equals 0 MW.
        - Allocated Capacity is capped at the national export limit (100MW above the national demand of 86MW).
        - If the bid is in an auction where Belgian cleared volume is between 26MW and 186MW, the Marginal Capacity Price is equal to the highest non-constrained regional clearing bid of each auction.
        - If the user bid is in an auction where Belgium cleared volume is below 26MW or above 186MW, the Marginal Capacity Price is equal to the highest *Belgian local marginal capacity price* of each auction.
- The **fourth step** consists in calculating the Capacity Remuneration of the asset for 2025.
    - For FCR, as it is pay-as-clear market, the model multiplies the Allocated Capacity by the Marginal Capacity Price for each auction period of 2025 to get Capacity Remuneration of the asset.
    - In addition, the model also applies an Availability factor to the Capacity Remuneration to consider unavailability of the asset due to maintenance or unforeseen events. This Availability factor is set by default depending on the type of the asset but can be modified by the user.

6. Output

The model generates two outputs:

- The Capacity Remuneration as described hereabove. It is expressed in € per year.
- The Bid Allocation Percentage:
    - This percentage indicates to what extent the Capacity Bid is considered as Allocated Capacity by the model. If it equals 100%, it means that the asset capacity is rewarded for every auction in which it participates. This figure is directly linked to the Capacity Bidding Price.