Explanatory note for FRR dimensioning methodology calculation

Baltic LFC block TSOs need to maintain LFC block imbalance within FRCE target levels in accordance with SOGL Article 128. FRCE parameters restoration towards zero is ensured while utilizing frequency containment process, by activating FCR capacities, and frequency restoration process, by activating aFRR and mFRR capacities, the principle is defined in Figure 1. In the given Baltic LFC block FRR dimensioning methodology the need for aFRR and mFRR is calculated.

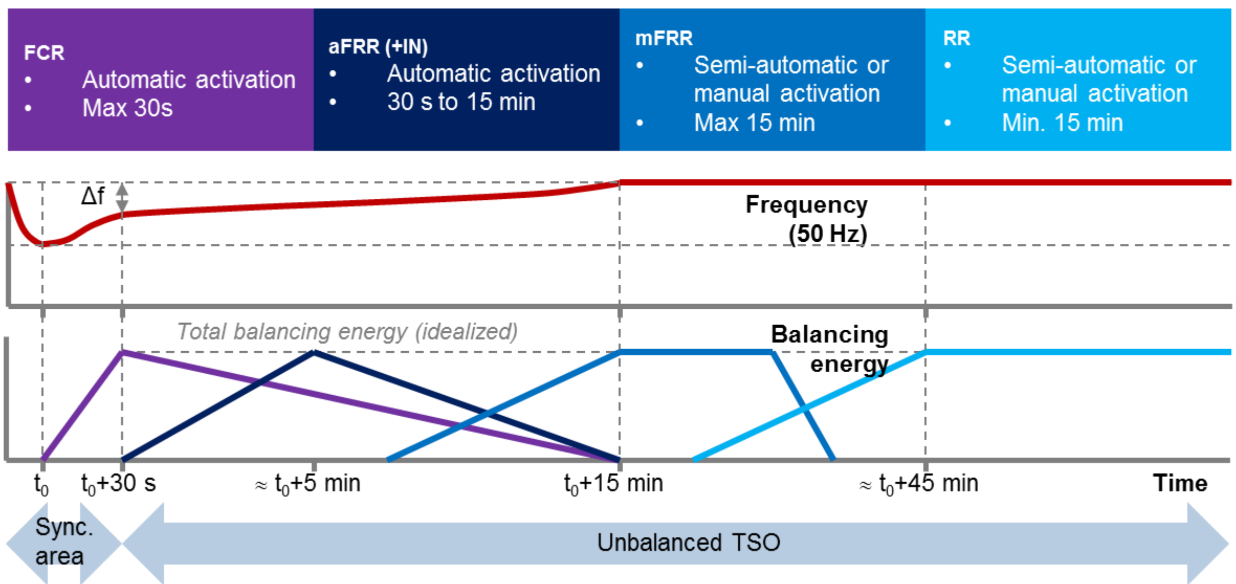

Figure 1 Active power balance control principles

Baltic LFC block system imbalances consists of positive and negative system imbalances, which are the result of mismatches of actual and planned generation and/or consumption, unplanned outages of power plants or large consumers and unplanned outages of importing or exporting HVDC connections. It is impossible for Baltic TSOs to exactly foresee imbalances due to mismatches in the system and possible outages in the grid. To have a realistic representation of possible imbalances in the system Baltic LFC block TSOs propose to use combination of deterministic and probabilistic approach to cover the positive and negative system imbalances for at least 99% of the time in accordance with SOGL Article 157.

The power system imbalance is a normal distribution where most values cluster towards close to zero, while other values are symmetrically tapered off toward both side extremes. An example of Baltic system open loop ACE (imbalance without activation of reserves) value distribution curve for 2022 is provided below.

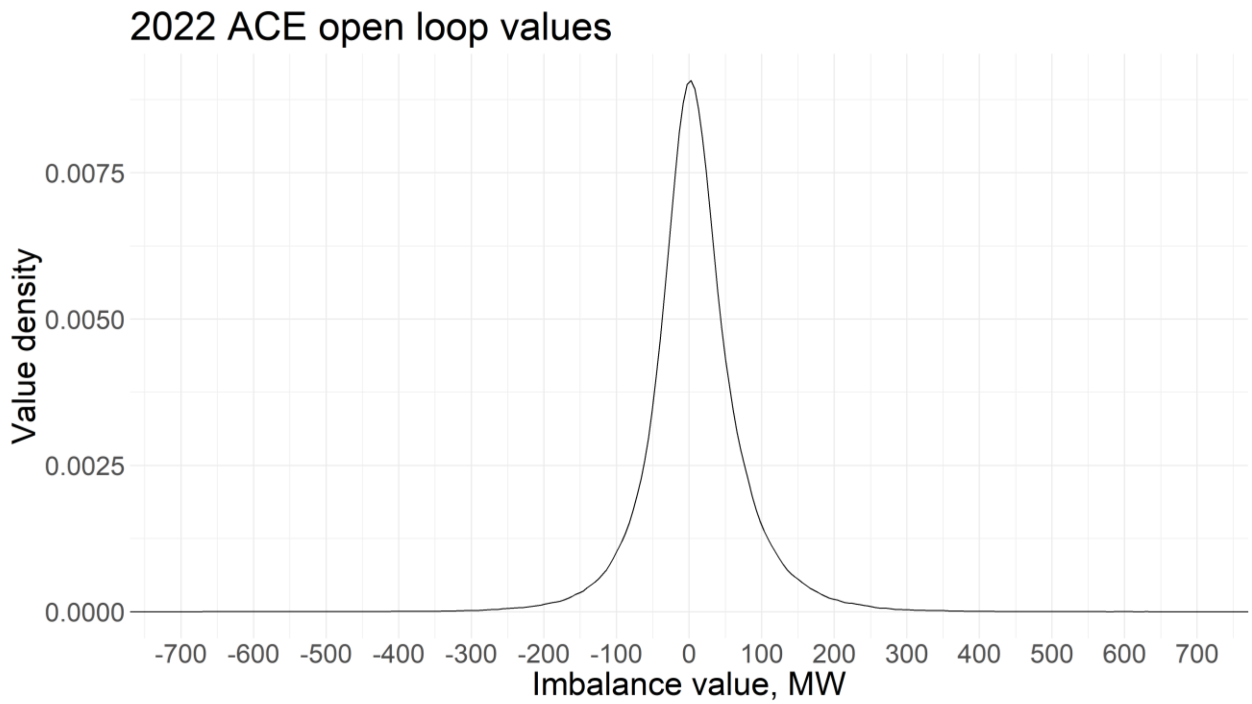

Figure 2. 2022 actual ACE open loop values for Baltics

1 Probabilistic FRR dimensioning

For probabilistic approach the Baltic TSOs gather different imbalance sources and simulate long periods of possible imbalances to estimate the potential need with statistical reliability. For the simulation the Baltic TSOs foresee the usage of statistical approach Monte Carlo method. Monte Carlo method relies on the repeated random sampling of possible scenarios to obtain numerical results. The repeated random sampling of large set of data points tends to average out to the expected value based on the probability theory called the law of large numbers.

For the Baltic LFC block FRR demand the repeated random samples of different imbalances are gathered to result with a total system imbalance probability distribution for each simulation cycle. The current approach simulates yearly 1 minute imbalance data (total of 520 000 imbalance values are calculated) for 100 cycles to simulated most likely imbalances needs for 100 years. From yearly probability distributions the probabilistic values for FRR upward and downward need can be established by calculating the 1st and 99th percentile of the distribution and the average need for 100 year is estimated to reflect the Baltic LFC block FRR demands. A simplified example on how the random samples are taken for short period and summarized to reflect 1 minute imbalance values is shown below. Negative values reflect excessive energy in the system and need downward activation of FRR and positive values reflect missing energy and need upward activation of FRR.

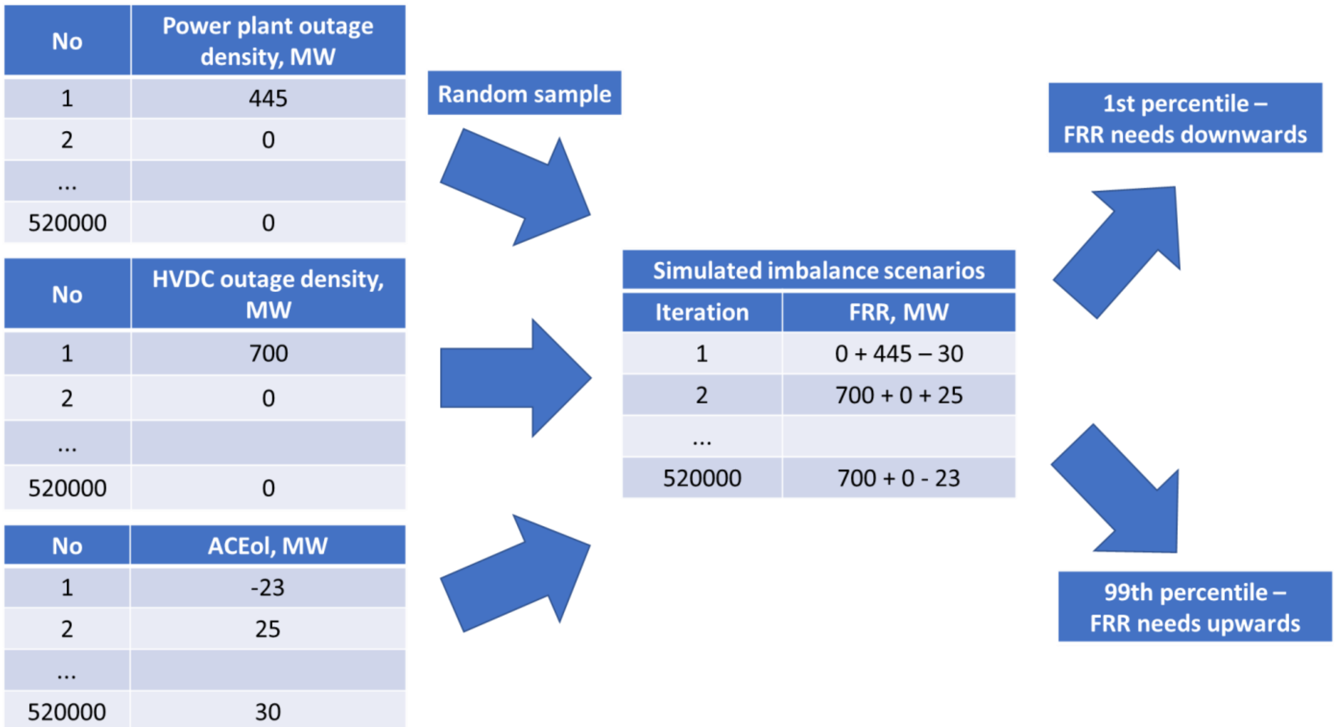

Figure 3 FRR dimensioning simulation example for a year simulation.

An example for a yearly Monte Carlo simulation result is shown for all Baltic imbalance sources on following Figure:

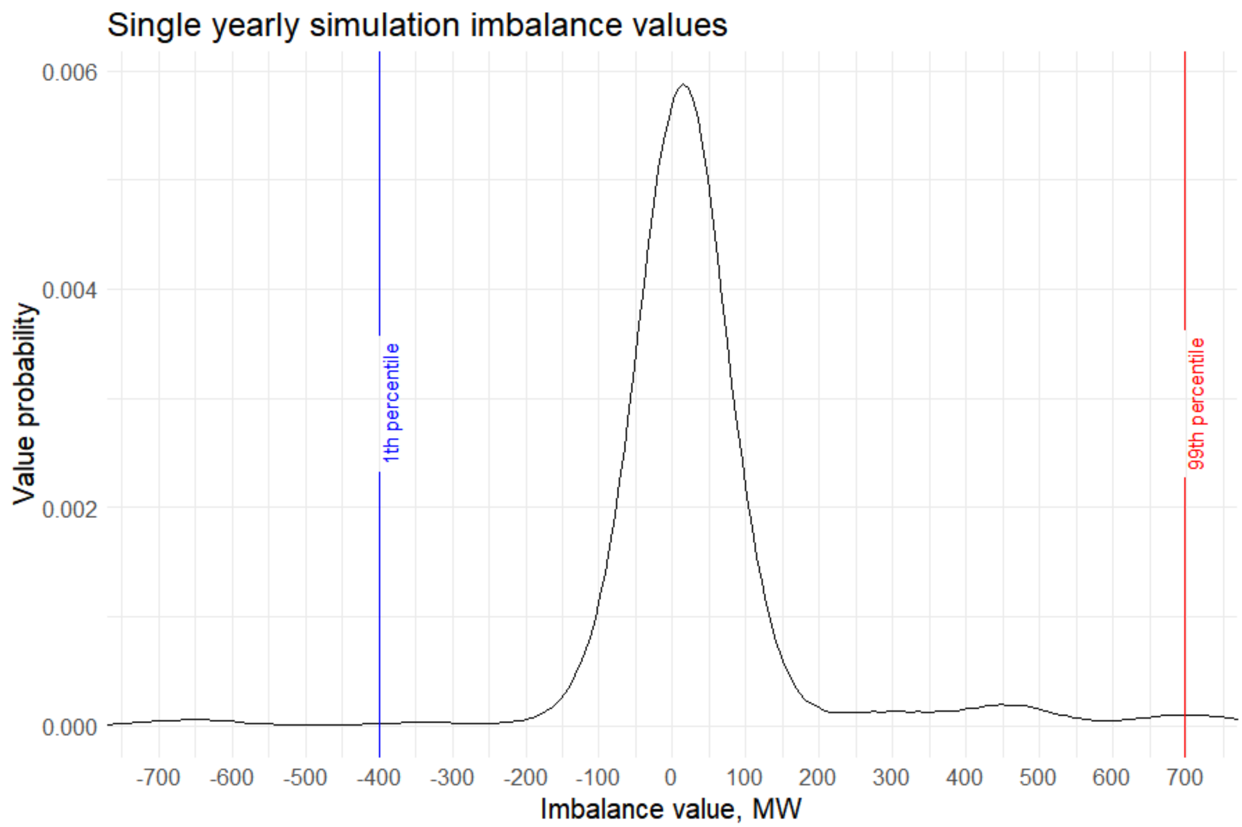

Figure 4. Example output of single year simulation data of different imbalance sources.

A comparison data is provided in the Figure 5, where potential imbalances from a single year simulation and actual data for 2022 are shown. Figure shows that that in the simulation example is in similar range, but larger extremes are potentially foreseen. The probabilistic approach makes sure that Baltic LFC block shall have enough FRR capacity to cover the imbalances in 99%. For actual data, the low probability events may have not happened and are not reflected in the data. Based on the risk assessment, Baltic LFC block TSOs find the probabilistic FRR estimation sufficient to resolve overall risks of imbalance that occur due to unforeseeable generation and demand mismatches and smaller imbalances in the grid. In addition to probabilistic approach in accordance with SOGL Article 158(e) and (f) the Baltic LFC block needs to cover the reference incident values. Deterministic FRR dimensioning is described in next chapter.

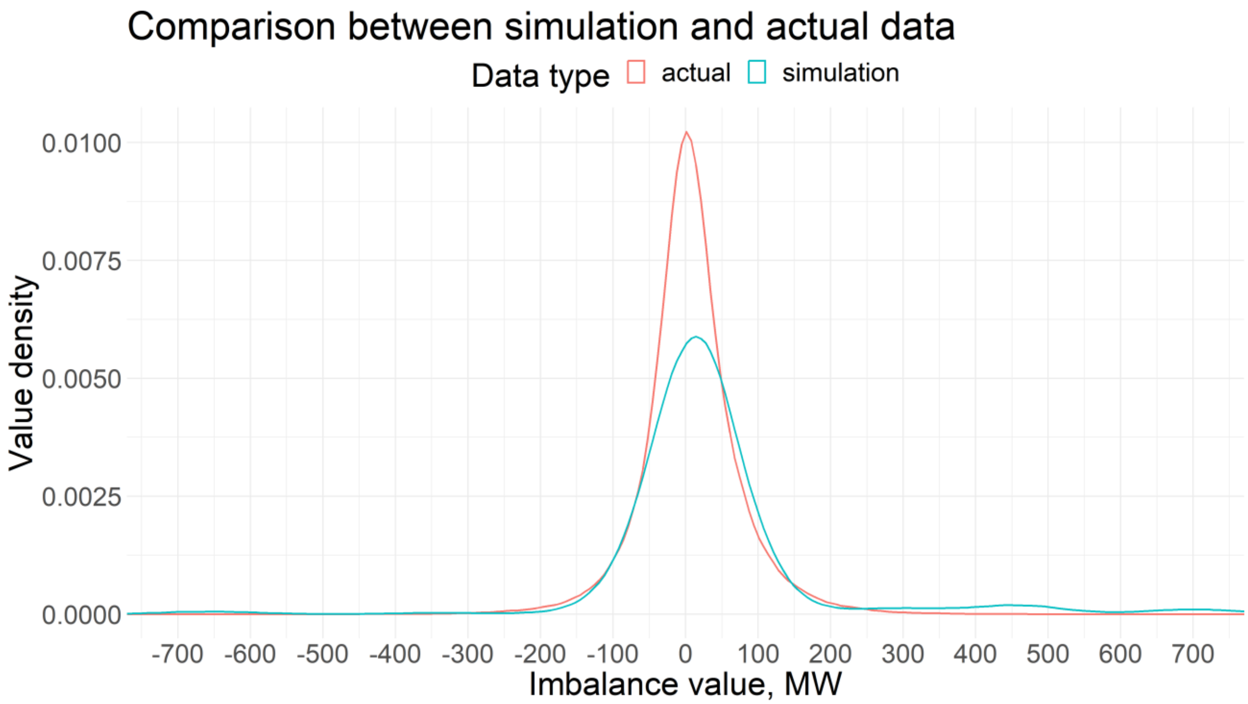

Figure 5. Comparison of actual ACE open loop data and simulated imbalance values.

2 Deterministic FRR dimensioning

Deterministic FRR dimensioning ensures that Baltic LFC block shall have FRR capacities available to cover the positive and negative size of reference incident. Reference incident is largest imbalance of Baltic LFC block that results an instantaneous change of active power of a single power generating module, single demand facility or single HVDC interconnector. For the Baltic LFC block scenario the largest elements are considered HVDC connections – NordBalt and Estlink 2.

For the dimensioning process the LFC areas shall identify the reference incidents for positive and negative directions that shall be considered in the overall dimensioning process by comparing the probabilistic and deterministic FRR values. The larger value shall chosen to be procured in the Baltic capacity market for the Baltic LFC block.