Baltic FRR dimensioning methodology

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Contents

1 Abbreviations and Definition

ACE - Area control error
ACEol – Open loop area control error
aFRR - Automatically activated Frequency Restoration Reserve
BC - Balancing Capacity
BSP – Balance Service Provider
FRR - Frequency Restoration Reserve
FRCE – Frequency Restoration Control Error
LFC - Load Frequency Control
mFRR - Manually activated Frequency Restoration Reserve
SAFA - Synchronous Area Framework Agreement
SOGL - COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation
TSO - Transmission System Operator

2 Introduction

The main purpose of frequency restoration process according to SOGL Article 143 is to regulate the FRCE towards zero within the time to restore frequency in the Baltic LFC block and consequently replace activated FCR by activating FRR capacities. FRR shall be sufficiently available to maintain the FRCE quality target levels and to be within operational security limits.

FCR and FRR capacities are provided by BSPs, who shall activate FCR according to the frequency deviation and FRR as instructed by connected TSO. Baltic TSOs shall operate activation of two types of FRR products – manual FRR (mFRR) and automatic FRR (aFRR). FCR capacity is dimensioned for Baltic LFC areas on the synchronous area level. FRR capacity dimensioning is the obligation of Baltic LFC block according to SOGL Article 157.

aFRR activations are automatically generated as aFRR setpoint signals in the frequency restoration controller and forwarded to the BSPs control system that manages the reserve providing units. The goal of the aFRR activations is to replace activated FCR and to restore the FRCE towards zero in shorter time periods.

mFRR activations are done with human operator involvement and sent as activation instruction messages. The goal of these activations is to replace activated aFRR, to pro-actively prevent expected FRCE deviations and to keep the grid within operational security limits.

The TSOs of Baltic LFC block shall submit the FRR dimensioning methodology for approval to the regulatory authorities following SOGL 119(2).

3 Methodology

Purpose of FRR dimensioning methodology is to ensure sufficient FRR volumes to be procured by Baltic TSOs to regulate Baltic LFC block FRCE towards zero and to ensure operational security. Baltic FRR dimensioning methodology is based on the combination of probabilistic and deterministic methods. Probabilistic approach estimates necessary FRR capacities based on the historical data. The deterministic approach defines must-have FRR capacity to at least cover the reference incident of Baltic LFC block. The principles are developed considering requirements of SOGL and SAFA.

3.1 FRR dimensioning data

Baltic LFC block shall use data for FRR dimensioning with minimum resolution of 1 min average of instantaneous values (up to 10 s data). It is considered that the following data shall be used in for FRR dimensioning process:

1. ACEol (open loop ACE) equals to area control error (ACE) value without the effect of balancing services of aFRR, mFRR or RR.

$$ACEol = ACE - mFRR - aFRR \quad \text{Eq 1}$$

2. Maintenance and limitations of HVDC links and power generating modules and demand units.
3. Outage density data of disconnections of large power plants (rated higher than 50 > MW), and HVDC links based on the estimated forced outage rates. Baltic LFC block is defining the default forced outage ratio as 2% for all HVDC links, power generating modules and demand units. The Baltic LFC block shall review the forced outage rates periodically and

reserve the right to change the forced outage ratio with prior notification to the market, but without changes in the methodology.

4. Long-term RES forecasted capacities and possible imbalances in the Baltic power systems are used for the long-term FRR dimensioning.
5. HVDC flow direction and volume. The Baltic LFC block reserve the right to update the HVDC flow estimation methodology in the FRR dimensioning algorithm with prior notification to the market, but without changes in the methodology.

3.2 FRR dimensioning

FRR dimensioning for Baltic LFC block shall consider both probabilistic imbalance values and deterministic imbalance values. The principle shall ensure that FRCE target levels and operational security is ensured according to SOGL and SAFA. Largest value of the two processes shall determine the final FRR capacity for appropriate direction.

3.3 Probabilistic FRR dimensioning

The probabilistic FRR dimensioning is developed to represent possible imbalances of defined imbalance sources in Baltic LFC block as a large set of randomised samples which shall represent different imbalance scenarios. The combination of imbalance scenarios will reflect the most probable range of imbalances in the Baltic LFC block. The principle of combining different imbalance sources together is illustrated on Figure 1. Baltic LFC block considers the FRR dimensioning methodology to be sufficient to follow SOGL Article 157(2) (h) and (j).

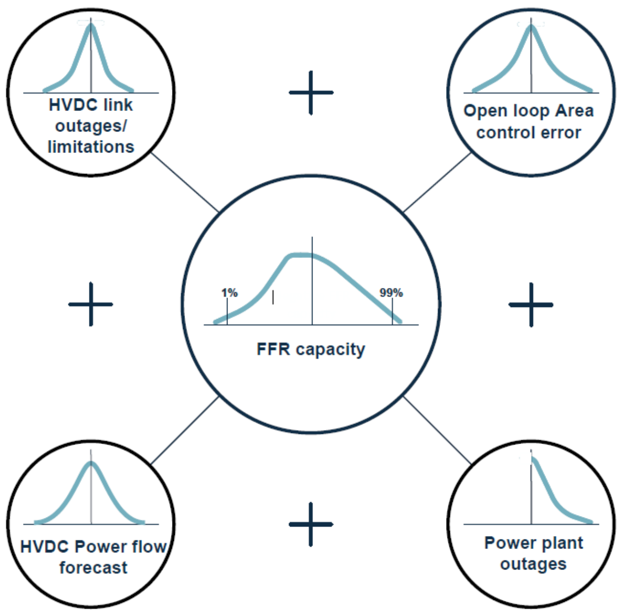

Figure 11 FRR dimensioning principle

The different imbalance scenarios are simulated by applying Monte-Carlo method, which samples imbalance sources and creates 100 years of 1 minute imbalance data scenarios. Following the law of large numbers principle, the average values of all the simulated yearly imbalance data percentiles shall reflect the most likely need for FRR in appropriate direction. Below are represented the simplified equations of FRR dimensioning for both directions.

$$FRR_{down} = \frac{\sum_{i=1}^{n}(MC_n(ACEol_{MC} + Outage_{MC}))_{1th}}{n} \qquad \text{Eq 21}$$

$$FRR_{up} = \frac{\sum_{i=1}^{n}(MC_n(ACEol_{MC} + Outage_{MC}))_{99th}}{n} \qquad \text{Eq 32}$$

Where:

n – number of years simulated

$ACEol_{MC}$ - random samples of ACEol of the Baltic LFC block values from the density functions

$Outage_{MC}$ - random samples of HVDC and larger power plant outage values from the density functions in the Baltic LFC block

MC – function that collects and simulates 1-minute values of a year via Monte Carlo method and provides FRR value estimations for a simulated year.

3.3.1 Deterministic FRR dimensioning

In addition to probabilistic imbalances in the system. Baltic LFC block shall also need to follow SOGL Article 157(2)(e) and (f), which requires that FRR reserve capacity shall be not less than dimensioning incident of the LFC block. Baltic LFC block shall use the deterministic method of FRR dimensioning whenever probabilistic method identifies less reserves than the dimensioning incident. In such instance, FRR demand will be defined as equal to the reference incident. The dimensioning incident will be defined by each LFC area accordingly. In the event of deterministic dimensioning only the mFRR values shall be affected.

3.4 aFRR dimensioning

The aFRR capacity is dimensioned to balance the power changes due to load variation, inadvertent non-observance of schedules by producers, and prediction errors of RES production. The aFRR capacity will be calculated based on the recommendation of SAFA Policy on Load-Frequency Control and Reserves.

The amount of aFRR is the range of adjustment within which the load-frequency controller can operate automatically, in both directions (positive and negative). The amount of the aFRR that is needed typically depends on the size of load variations schedule changes and generating units, in this respect, the recommended minimum amount of aFRR has to ensure:

that the positive aFRR (necessary downward regulation) is larger than the 1st percentile of the difference of the 1-minute average ACEol and the 15 minute average ACEol of the LFC Block of the corresponding quarter of hour, and

$$aFRR_{down} = (ACEol_{1min} - ACEol_{15min})_{1th} \qquad \text{Eq 43}$$

that the negative aFRR (necessary upward regulation) is larger than the 99th percentile of the difference of the 1-minute average ACEol and the 15 minute average ACEol of the LFC Block of the corresponding quarter of hour

$$aFRR_{up} = (ACEol_{1min} - ACEol_{15min})_{99th} \qquad \text{Eq 45}$$

aFRR capacity need is highly dependent on short-term changes of generation and consumption of power system. Most of aFRR is needed for time-period where consumption and generation are changing rapidly e.g. morning load ramping. Due to the different need of aFRR through-out the day, the daily aFRR needs are dimensioned for 4-hour cycles. The 4-hour cycle values are calculated by separating the imbalance data for each cycle and applying the defined principle for the subset of the data.

Baltic LFC block will periodically review the aFRR calculation cycle length to dimension aFRR needs. Baltic LFC block will provide prior information to market participants, if changes in aFRR calculation cycle are applied.

3.5 mFRR dimensioning

To fulfil the total Baltic LFC block FRR demand, mFRR shall be considered as the remaining part of FRR which is not covered by aFRR. mFRR capacities are defined by using the Eq 5Eq 56 and Eq 6Eq 7.

$$mFRR_{down} = FRR_{down} - aFRR_{down} \quad \text{Eq 56}$$

$$mFRR_{up} = FRR_{up} - aFRR_{up} \quad \text{Eq 76}$$

3.6 LFC area reserve requirement

LFC area reserve requirement defines the FRR amount needs of an LFC area. LFC area reserve requirement is defined using principles underlined in Chapter 3. All the input data shall be related only to the specific LFC area, for which the LFC area reserve requirement of FRR, aFRR and mFRR is calculated. As a result of LFC area reserve requirement calculations, the LFC area demand of aFRR and mFRR are identified which will be used in the sharing key calculations.

4 FRR dimensioning operation principle

Baltic TSOs foresee to implement FRR dimensioning as long- and short-term process. Long-term process shall provide FRR capacity estimations for the following year and short-term process shall provide FRR capacities for the day-ahead FRR capacity procurement process.

4.1 Long-term process

The long-term process is considered as an indication to the market participants of FRR reserve capacities. Baltic LFC block shall publish the FRR capacities for at least the following year by 15th of August of the current year. Information will be provided to ENTSO for Electricity for publication by the LFC block monitor and published by the Baltic LFC block TSOs in the websites.

As an input data the probabilistic process will use the latest 12 months ACEol values and HVDC links / conventional generation outage density data and foreseen changes in the imbalance sources, such as an increase in RES or new large demand/generation units that is compared with deterministic values to determine final long-term FRR, aFRR and mFRR estimations.

4.2 Daily process

Daily process is used to dimension the FRR needs for the day-ahead FRR capacity procurement process. Based on the findings of the calculations, the BC shall be procured in the balancing capacity market.

As an input data this process will use latest 12 months ACEol values, HVDC links / conventional generation outage density data and equipment unavailability/limitations data which willbe compared with deterministic values. It is foreseen to run the daily dimensioning in the D-2 (two days in advance) timeframe to publish the FRR capacity needs for the market participants before the FRR capacity procurement process. Timeline for daily FRR dimensioning process is provided as following:

1. Baltic TSOs collect input data for FRR dimensioning process by D-2 15:00 EET.
2. FRR dimensioning process of probabilistic and deterministic analysis is performed by D-2 15:45 EET.
3. Baltic TSOs and Baltic LFC block monitor publish the dimensioned FRR, aFRR and mFRR demands for upward and downward direction by 16:00 EET.

5 Final provisions

The Baltic LFC block FRR dimensioning methodology will be set in force after approval of Baltic LFC block operational agreement and approval of this methodology by the Baltic NRAs.