European Network of
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Explanatory note for the calculation of Frequency Restoration Control Error Target Parameter for LFC blocks of synchronous area Continental Europe

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Explanatory Note

The SO GL according to Article 118 requires the TSOs of CE to specify in their Synchronous Area Operational Agreement the Frequency Restoration Control Error Target Parameters (hereafter referred to as FRCE target parameters) of the individual LFC block of synchronous area CE. If a LFC block consist of more than one LFC area, all TSOs of the LFC block shall specify in their LFC block Operational Agreement the FRCE target parameters of the individual LFC areas.

These target parameters shall allow a regular check of the control performance of the individual areas, by themselves. The calculation of level 1 and level 2 will provide concrete values, which are the limit values for the ACE. The ACE shall not exceed these values for more than:

- level 1: 30 % of the time intervals of the year respectively
- level 2: 5 % of the time intervals of the year.

Furthermore, according to Article 8 the FRCE target parameters per LFC block need to be published on internet.

The following table will give an impression of these values per LFC block:

LFC-Block	belonging LFC-Areas	Level 1	Level 2
OST	OST	25,285	47,817
APG	APG	78,234	147,954
SHB	NOS BiH, HOPS, ELES	64,015	121,062
Elia	Elia	87,887	166,208
ESO	ESO	62,775	118,717
SG	SG	76,883	145,398
CEPS	CEPS	86,080	162,790
TNG+TTG+AMP+50HZT+EN+CREOS	TNG+TTG+AMP+50HZT+EN+CREOS	247,631	468,311
REE	REE	187,236	354,093
RTE	RTE	225,851	427,120
IPTO	IPTO	63,851	120,752
MAVIR	MAVIR	52,000	98,340
TERNA	TERNA	158,993	300,682
SMM	CGES, MEPSO, EMS	69,358	131,167
TTB	TTB	102,579	193,993
PSE	PSE, Western WPS	124,964	236,326
REN	REN	73,253	138,533
TEL	TEL	76,336	144,363
SEPS	SEPS	49,310	93,253
TEIAS	TEIAS	161,771	305,934

Table 1: FRCE target parameters for each LFC block of Synchronous Area Continental Europe

The calculation is performed based on the following description and formulas. The yearly process will be performed by Subgroup Systemfrequency (SG SF), in the same time as the calculation of FCR (C_i, P_{pi} and K_{ri}), as the K-Factors will act as basis for the calculation of level 1 and level 2.

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The methodology is based on the following simplifying assumptions:

(1) The frequency behaviour can be considered as a sum of two uncorrelated components, the quarter-hourly frequency average (fqh) and the deviation from this average, the frequency noise (Δfnoise).
(2) Both signals, fqh and Δfnoise, can be approximately modelled as normal distributions with mean value equal to zero.
(3) The sum of ACE values of the Synchronous Area is equal to the frequency deviation multiplied with the total K-Factor of the Synchronous Area.
(4) The ACE behaviour of the LFC Blocks is not correlated.
(5) The ACE of a LFC Block can be approximately modelled as a normal distribution with mean value equal to zero.

The main steps for the calculation of level 1 and level 2 ACE targets for the individual LFC Blocks are the following:

- Calculate the distribution of frequency noise;
- Calculate the distribution of quarter-hourly frequency average values which after convolution with the frequency noise distribution will fulfil the frequency quality target parameter (15000 minutes outside ±50 mHz).
- Calculate the frequency deviations for the probabilities defined by level 1 and level 2.
- Calculate the shares of each LFC Block proportional to the square root of the respective K-Factor.

The determination of ACE target parameters is based on frequency data for at least one year with a measurement period equal to or shorter than one second (Instantaneous Frequency Data according to SO GL).
In the first step, the average frequency fqh for each quarter of an hour[1] is calculated from the Instantaneous Frequency Data.
In order to obtain the frequency deviation noise Δfnoise, fqh is subtracted from the frequency f, which is based on the Instantaneous Frequency Data, i.e.

$$\Delta f_{noise} = f - f_{qh} \qquad (7)$$

SO GL Article 127(3) and Article 127(4) require that the range of ±50 mHz must not be exceeded for more than 15000 minutes per year. Therefore, in the second step, the range of ±rnoise, which must not be exceeded for more than 15000 minutes a year, is estimated based on the assumption of a normal distribution.

The probability p_m of exceeding the 15000 minutes per year is calculated based on the following equation:

$$p = 1 - \left(\frac{\text{time intervals per year outside the range}}{\text{total time intervals per year}}\right) \qquad (8)$$

$$p_m = 1 - \left(\frac{7500}{525600}\right) = 0{,}9857 \qquad (9)$$

In order to calculate r_{noise}, the standard deviation of Δfnoise (σnoise) is estimated from the data and multiplied with the inverse cumulative probability value of p_m. (see Table 2).

$$r_{noise} = \sigma_{noise} \cdot 2.1898 \qquad (10)$$

[1]To be calculated between minutes 0:00-14:59, 15:00-29:59, 30:00-44:59, 45:00-59:59 of each hour of the day.

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SO GL parameters	minutes per year	Probability p_m	inverse cumulative probability value as c σ
minutes outside standard frequency range (for deviations in one of the directions)	75002	0.9857	2.1898 σ

Table 2: Minutes per year with the corresponding probability and the inverse cumulative probability as a function of standard deviation.

In the third step, the value rqh, which represents the same range for an allowed normal distribution of the quarter-hourly average frequency deviation, is calculated based on the assumption that the two signals are not correlated:

$$r_{qh}[\text{Hz}] = \sqrt{(0.05)^2 - r_{noise}^2} \quad (11)$$

In the fourth step, the ranges which correspond to the probabilities required by SO GL Article 128(3) are calculated taking rqh as basis. The probabilities are calculated as follows:

$$p_{qh,\text{Level 1}} = 1 - \left(\frac{5256}{35040}\right) = 0{,}85 \quad (12)$$

$$p_{qh,\text{Level 2}} = 1 - \left(\frac{876}{35040}\right) = 0{,}975 \quad (13)$$

For the calculation of the ranges, the inverse cumulative probabilities of $p_{qh,\text{Level 1}}$ and $p_{qh,\text{Level 2}}$ will be used.

SO GL Parameters	qh per year	Probability p_{qh}	inverse cumulative probability value as c σ
qh outside level 1 ACE range	5256	0.85	1.0364 σ
qh outside level 2 ACE range	876	0.975	1.96 σ

Table 3: Values outside the ranges.

$$r_1[\text{Hz}] = r_{qh}\frac{1{,}0364}{2{,}1898} \text{ and } r_2[\text{Hz}] = r_{qh}\frac{1{,}96}{2{,}1898} \quad (14)$$

In the last step, the level 1 and level 2 ranges (L1 and L2) are calculated for each LFC Block. With KSA as K-Factor of the Synchronous Area expressed in MW/Hz, K_{FCR} as the total FCR of the Synchronous Area and KFCR,i as initial FCR obligation of LFC block i, the targets are given by:

$$L_1[\text{MW}] = K_{SA} \cdot r_1 \cdot \sqrt{\frac{K_{FCR,i}}{K_{FCR}}} \quad (15)$$

[2] It is half of the 15000 minutes defined in SO GL as it only refers to the Standard Frequency Range of 50 mHz.

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$$L_2[MW] = K_{SA} \cdot r_2 \cdot \sqrt{\frac{K_{FCR,i}}{K_{FCR}}} \quad (16)$$

Consideration of imbalance netting and Cross-Border Activation of Reserves

In case of a cross-border activation of reserves, the TSOs of the participating LFC Blocks can agree to take the effect of the cross-border activation into account for their level 1 and level 2 target values according to the B-1.

The definition of level 1 and level 2 target values derived above relies on the assumption that the disturbances of a LFC Block increase with the size of its generation and consumption. This assumption may not be valid for LFC Blocks with altered FRR or RR activation requests due to the implementation of Exchange of Reserves, Sharing of Reserves or Cross-Border Activation of Reserves. In this case, the participating LFC Blocks may agree to take the effect of the Cross-Border Activation of Reserves or Imbalance Netting into account for the calculation of FRCE target parameters for the evaluation of the ACE quality.

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Explanatory note

To determine the limits on sharing and exchanging FCR between synchronous areas it is required to distinct 4 different scenarios:

- Exchange of FCR where CE is the providing synchronous area (FCR units or groups are physically connected to CE)
- Exchange of FCR where CE is the receiving synchronous area (FCR units or groups are physically connected in other synchronous areas than CE)
- Sharing of FCR where CE is the providing synchronous area (FCR units or groups are physically connected to CE)
- Sharing of FCR where CE is the receiving synchronous area (FCR units or groups are physically connected in other synchronous areas than CE)

CE providing

For the scenarios (exchange and sharing) of FCR where CE is the providing synchronous area, the limit is determined by means of a maximum frequency deviation of 10 mHz, which is caused by a simultaneous activation of FCR units or groups subject to exchange and sharing. It is equivalent to a limit on a maximum amount of FCR power under the consideration of the total K-Factor of CE, calculated by Sub-Group System Frequency for each year. The determination of the total K-Factor takes into account the total amount of FCR in CE, the self-regulation of loads as well as the surplus-control of generating units. In 2017 for instance these three components led to a total K-Factor of 27000 MW/Hz for the synchronous area of CE.

Hence, the exemplarily limits of FCR subject to an exchange or sharing for 2017 can be calculated by the following formula:

$$FCR_{exchange,2017} = K_{total,CE} * f_{disturb} = 27000 \frac{MW}{Hz} * 10\,mHz = 270\,MW$$

$$FCR_{sharing,2017} = K_{total,CE} * f_{disturb} = 27000 \frac{MW}{Hz} * 10\,mHz = 270\,MW$$

For the avoidance of doubt, it should be emphazised that the total K-Factor is recalculated every year and does therefore influence the limit of FCR exchange and FCR sharing between synchronous areas.

CE receiving

On the other hand, if CE is the receiving synchronous area, following security limits have been established:

For the exchange of FCR, the Reserve Receiving TSOs of a LFC Block have to ensure that at least 30% of their total combined initial FCR obligations are physically connected within their LFC block. This requirement is derived from the conditions for exchange of FCR within a synchronous area according to Article 163(2) SO GL. Moreover, the FCR exchange is limited to a maximum of 5 % of the FCR dimensioning amount (according to Article 156(6) of the SO GL) of the receiving synchronous area for each Reserve Transfer HVDC Link.

Sharing of FCR while synchronous area of CE taking the role of the receiving synchronous area is not allowed, justified by the fact that the priority access for the activation of FCR providing units or groups subject to the sharing process is held by the providing synchronous area.

Legal Background Information

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It should be noted that similar requirements regarding the exchange and sharing of FRR and RR according to Article 118(1)(z) and 118(1)(aa) of SO GL are subject to NRA approval according to Article 6(3)(d) of SO GL, but the limitations set in this Article for the exchange and sharing of FCR are not.

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