

Synchronous Area Framework
Agreement (SAFA)
for
Regional Group Continental Europe

Annex 1: Policy on Load-Frequency Control and Reserves

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INTRODUCTION

This document is part of the Synchronous Area Operational Agreement for the Synchronous Area CE as defined in Article 118 of the guideline on electricity system operation (SO GL) (Part IV LFC&R).

Electricity generation and consumption need to be controlled and monitored for the secure and high-quality operation. Frequency control, Active Power Reserves and the corresponding control performance are essential for TSOs to perform their professional business.

Within the Synchronous Area, the control actions and the reserves are organised in a hierarchical structure with Scheduling Areas, Monitoring Areas, LFC Areas, LFC Blocks and the Synchronous Area with two Coordination Centres.

Control actions are performed by different complementary processes, each relying on reserves with different characteristics and qualities:

- a. Frequency Containment Reserves (FCR) as defined in the Article 3 SO GL correspond to Primary Control Reserves used in the Policy 1 of the MLA OH prior to 2009;
- b. Automatic Frequency Restoration Reserves (aFRR) as defined in the Article 3 SO GL correspond to Secondary Control Reserves used in the Policy 1 of the MLA OH prior to 2009;
- c. Manual Frequency Restoration Reserves (mFRR) as defined in the SO GL Article 3 correspond to Tertiary Control Reserves with an activation time (independent of the time of activation) of at most 15 minutes used in the Policy 1 of the MLA OH prior to 2009;
- d. Replacement Reserves (RR) as defined in the Article 3 SO GL refer to Tertiary Control Reserves which correspond to various types of reserves, e.g. schedule-based tertiary reserves used in the Policy 1 of the MLA OH prior to 2009.

The ENTSO-E Sub Group Coordinated System Operation (SG CSO) and the Sub Group System Frequency (the sub-group or Working-group for Reporting) serve as the common body in the RG CE for agreeing on all operational and organisational matters in the framework of this Load-Frequency Control and Reserves Policy.

A METHODOLOGIES, CONDITIONS AND VALUES SUBJECT TO ALL REGULATORY AUTHORITIES APPROVAL

The following section includes all methodologies, conditions and values jointly developed by all TSOs from the Synchronous Area CE according to Article 118 and which are subject to approval by all regulatory authorities according to Article 6(3) SO GL.

A-1 FCR DIMENSIONING ACCORDING TO ARTICLE 118(1)(A) SO GL (MANDATORY & NRA APPROVAL)

The SAFA-Parties acknowledge that the document “All CE TSOs proposal for the dimensioning rules for FCR in accordance with Article 153(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation” that has been approved according to Article 5 SO GL on 7 September 2018 and submitted for approval to the competent regulatory authorities in accordance with Article 6(2) SO GL is accepted by all Parties subject to approval of the competent regulatory authorities. The Parties agree to apply this methodology as it is approved by the TSOs regardless of the fact that it has not been approved by the NRAs, while taking into account that it may be subject to a Request for Amendment. Amendment Proposals that will be developed by Parties on the basis of a Request for Amendment by the competent regulatory authorities according to Article 7 of SO GL will be processed by applying the regular amendment rules according to Article 14 of the SAFA.

A-2 ADDITIONAL PROPERTIES OF FREQUENCY CONTAINMENT RESERVES ACCORDING TO ARTICLE 118(1)(B) SO GL (OPTIONAL & NRA APPROVAL)

[TO BE INCLUDED]

A-3 FREQUENCY QUALITY PARAMETERS ACCORDING TO ARTICLE 118(1)(C) SO GL (OPTIONAL & NRA APPROVAL)

[NO CONTENT]

A-4 IF APPLICABLE, FOR SYNCHRONOUS AREAS OTHER THAN CE, LIMITS FOR THE EXCHANGE OF FCR BETWEEN THE TSOs ACCORDING TO ARTICLE 118(1)(T) SO GL (OPTIONAL & NRA APPROVAL)

[NO CONTENT]

A-5 LIMITS ON THE AMOUNT OF EXCHANGE AND SHARING OF FRR BETWEEN SYNCHRONOUS AREAS ACCORDING TO ARTICLE 118(1)(Z) SO GL (MANDATORY & NRA APPROVAL)

The SAFA-Parties acknowledge that the document “All CE TSOs proposal for the limits on the amount of exchange and sharing of FRR between synchronous areas in accordance with Article 176(1) and Article 177(1) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation” that has been approved according to Article 5 SO GL on 7 September 2018 and submitted for approval to

the competent regulatory authorities in accordance with Article 6(2) SO GL is accepted by all Parties subject to approval of the competent regulatory authorities, while taking into account that it may be subject to a Request for Amendment. Amendment Proposals that will be developed by Parties on the basis of a Request for Amendment by the competent regulatory authorities according to Article 7 of SO GL will be processed by applying the regular amendment rules according to Article 14 of the SAFA.

A-6 LIMITS ON THE AMOUNT OF EXCHANGE AND SHARING OF RR BETWEEN SYNCHRONOUS AREAS ACCORDING TO ARTICLE 118(1)(AA) SO GL (MANDATORY & NRA APPROVAL)

The SAFA-Parties acknowledge that the document “All CE TSOs proposal for the limits on the amount of exchange and sharing of RR between synchronous areas in accordance with Article 178(1) and Article 179(1) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation” that has been approved according to Article 5 SO GL on 7 September 2018 and submitted for approval to the competent regulatory authorities in accordance with Article 6(2) SO GL is accepted by all Parties subject to approval of the competent regulatory authorities, while taking into account that it may be subject to a Request for Amendment. Amendment Proposals that will be developed by Parties on the basis of a Request for Amendment by the competent regulatory authorities according to Article 7 of SO GL will be processed by applying the regular amendment rules according to Article 14 of the SAFA.

A-7 COMMON PROPOSAL PER SYNCHRONOUS AREA FOR THE DETERMINATION OF LFC BLOCKS IN ACCORDANCE WITH ARTICLE 141(2) (MANDATORY & NRA APPROVAL)

The SAFA-Parties agree that the document “All TSOs proposal for the determination of LFC blocks for the Synchronous Area Continental Europe in accordance with Article 141(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation” that has been approved by the competent regulatory authorities in accordance with Article 6 (2) SO GL shall be applied by all SAFA-Parties.

B METHODOLOGIES, CONDITIONS AND VALUES SUBJECT TO APPROVAL BY ALL TSOs

The following section includes all methodologies, conditions and values which were jointly developed by all CE TSOs according to Article 118 of the SO GL and have been approved according to Article 5 of the SO GL on 7 September 2018, but are not subject to approval by the regulatory authorities.

B-1 FREQUENCY RESTORATION CONTROL ERROR TARGET PARAMETERS ACCORDING TO ARTICLE 118(1)(D) (MANDATORY)

The mandatory assessment of the load-frequency control performance of the LFC blocks shall be based on the ACE target parameters and frequency quality evaluation criteria according to the Article 128 and 131 of the SO GL.

The objective behind the level 1 and level 2 parameters is to provide quality targets for the individual ACE quality of each LFC block. Since it is the responsibility of each TSO in its LFC block to keep ACE as low as possible, the level 1 and level 2 parameters must not be exploited in order to reduce reserves or reserves activation. These parameters should rather be interpreted as an absolute warning limit that shows that quality of ACE is below the required standard and that respective countermeasures have been reported and will be implemented urgently.

The level 1 and level 2 Frequency Restoration Control Error Target Parameters for the LFC blocks within CE are provided in Table 1. The values will be calculated annually. The methodology to calculate these target parameters is described in the explanatory note.

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 CE

B-2 METHODOLOGY TO ASSESS RISK AND EVOLUTION OF THE RISK EXHAUSTION OF FCR ACCORDING TO ARTICLE 118(1)(E) SO GL (MANDATORY)

The methodology to assess the risk of exhaustion of FCR is based on a probabilistic approach and takes into account the probability of FCR deployment due to the following operational situations:

- forced instantaneous outages of generation modules, HVDC interconnectors between two synchronous areas and substations/bus bars which connect two generation units/blocks: modelled by a probability density function, calculated by using a one-minute sequential Monte Carlo simulation.
- Imbalances due to changes in demand, renewable generation, long lasting Frequency Deviation events or the market-induced Imbalances: modelled by a probability density function calculated using the worst 15-seconds average Frequency Deviation data (15-seconds is equal half time of Full Activation Time [FAT] for FCR) for every minute of the last year.

The probability density function of the total amount of FCR needed is the convolution of the previous probability density functions. Therefore, the risk of exhaustion of FCR will be the number of events in 20 years (10.512.000 minutes) in which the FCR need is larger than the FCR dimensioned.

This methodology is described in the following paragraphs.

STEP 1. Calculation of the probability density function of FCR required due to generation tripping

This calculation shall be carried out using a probabilistic assessment with the aim of determining which is the largest expected FCR spent due to generation/in-feed loss for a certain number of years.

Starting from a generation scenario and the trip probability of each unit, a Monte Carlo simulation shall be performed for every minute in the period considered in order to calculate the amount of FCR required due to generation trips. This simulation is time sequential, since it is essential to model that the FCR used in one minute to counteract an Imbalance in the previous minute will not be instantly recovered, and there is a probability for another unit to trip before the FCR has been replaced by the Frequency Restoration Reserves (FRR).

The following assumptions shall be taken into account:

- a peak hour generation scenario modelled, considering exclusively units larger than 600 MW, operating at full capacity. Consequently, a generation trip is equivalent to the full loss of the generation capacity of one single unit;
- the generation trips occur independently from each other, except for generating units located in the same plant or that are connected to the network on the same node;
- the reconnection time of the units that have tripped is assumed to be at least larger than 30 minutes. This is based on the consideration that the unit that tripped will not be reconnected and partially compensate the Imbalance it has caused within the time of deployment of FRR;
- the trip probability of each generation unit is constant in time and is assumed to follow this Poisson distribution:

$$p(\lambda) = 1 - e^{\frac{-\lambda}{525600}}$$

Where p is the probability of tripping of the unit in a certain minute and λ is the number of trips per year of the unit. The number of trips per year must be divided by the number of minutes in a year (525.600 for a non-leap year) as the probability to be calculated is the probability in each minute;

- the used probability of failure of generating units will be based on historical data provided by each LFC block, and yearly updated. Also, the expected rate of relevant simultaneous outages (i.e. simultaneous tripping of large units due to cooling issues, bus-bar or substation trips affecting several units, etc.) is provided according to historical values;
- the FRR deployment is approximated to a first order linear system with a FAT based on historical values. The deployment of FRR replaces, for each minute, the correspondent part of the deployed FCR in the previous minute;
- the time-sequential Monte Carlo simulation shall be performed considering at least 10^8 minutes (≈ 190 years) with a granularity of 1 minute.

STEP 2. Calculation of the probability density function of FCR required due to other causes than generation tripping

The expected FCR in use when the generation trip occurs due to fast demand changes, RES or – mainly – deterministic Frequency Deviations shall be modelled, and taken into account in order to calculate the total risk of exhaustion of FCR.

The following assumptions will be taken into account:

- The deployment of FCR shall be proportional to the Frequency Deviation in quasi-steady state after the dynamic effects of the Imbalance have disappeared. Since the minimum available FCR at all times is 3000 MW and the quasi-steady state Frequency Deviation is 0.2 Hz, then the proportional constant between the FCR used and Frequency Deviations is 15000 MW/Hz;

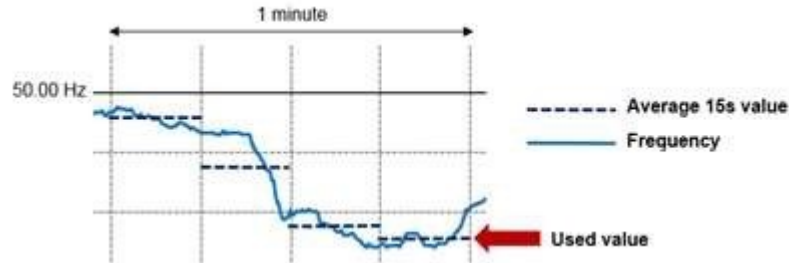


Figure 1: Worst 15-seconds average Frequency Deviation

- The data used to calculate this expected use of FCR shall consider the worst 15-seconds average Frequency Deviations for each minute of the last year. In order to avoid taking into account deviations due to large generation trips twice, the 15 minutes after a generation loss recorded according to observation of outages shall be discarded

STEP 3. Calculation of the total required FCR

The probability density function of the total FCR required shall be calculated as the convolution of the probability distribution of FCR demand due to generation tripping, and the probability distribution of FCR in use due to previous Imbalances.

Therefore, the number of events in which the FCR demand is larger than the FCR dimensioned (i.e. the risk of FCR exhaustion) is given by the following expression:

$$\text{risk of FCR exhaustion} = F_{FCR}(x) \cdot 10.512.000$$

Where $F_{FCR}(x)$ is the cumulative distribution function of the previous convoluted function where the FCR demand is larger than the FCR dimensioned, i.e.

$$F_{FCR}(x) = \int_x^{\infty} f$$

f being the probability distribution of the total FCR needed.

Values larger than 1 means a risk of FCR exhaustion higher than once in twenty years.

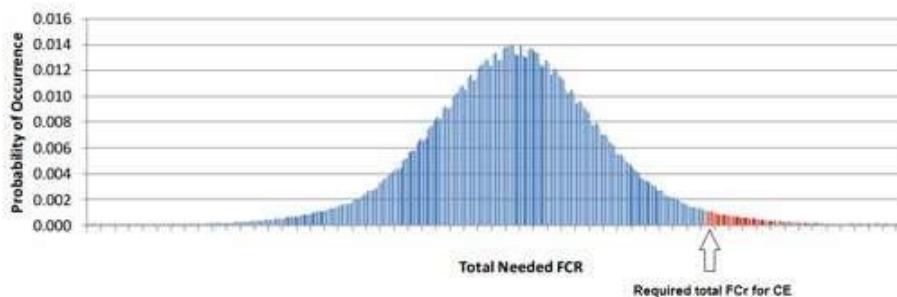


Figure 2: Probability distribution of the total FCR

B-3 NOMINATION OF THE SYNCHRONOUS AREA MONITOR ACCORDING TO ARTICLE 118(1)(F) SO GL (MANDATORY)

The Coordination Centres shall fulfil the obligations of the synchronous area monitor according to Article 133 of the SO GL by assigning specific tasks to the SG SF. Such tasks shall be jointly specified between the Synchronous Area Monitor and SG SF.

B-4 CALCULATION OF THE CONTROL PROGRAM ACCORDING TO ARTICLE 118(1)(G) SO GL (MANDATORY)

In accordance with Article 136 of SO GL, the ramping period for ACE calculation in synchronous area CE is defined as follows:

- the starting point of the ramping period of the control program is 5 minutes before the control program changes;
- the ending point of the ramping period of the control program is 5 minutes after the control program changes;
- the length of the ramping period is 10 minutes, the ramping is linear.

The control program (e.g. for power exchanges and frequency set-points) must be entered into the LFC input and ACE calculation as time-dependant set-point values of the netted area AC position of the LFC area. An example for an hourly exchange schedule is given in Figure 3.

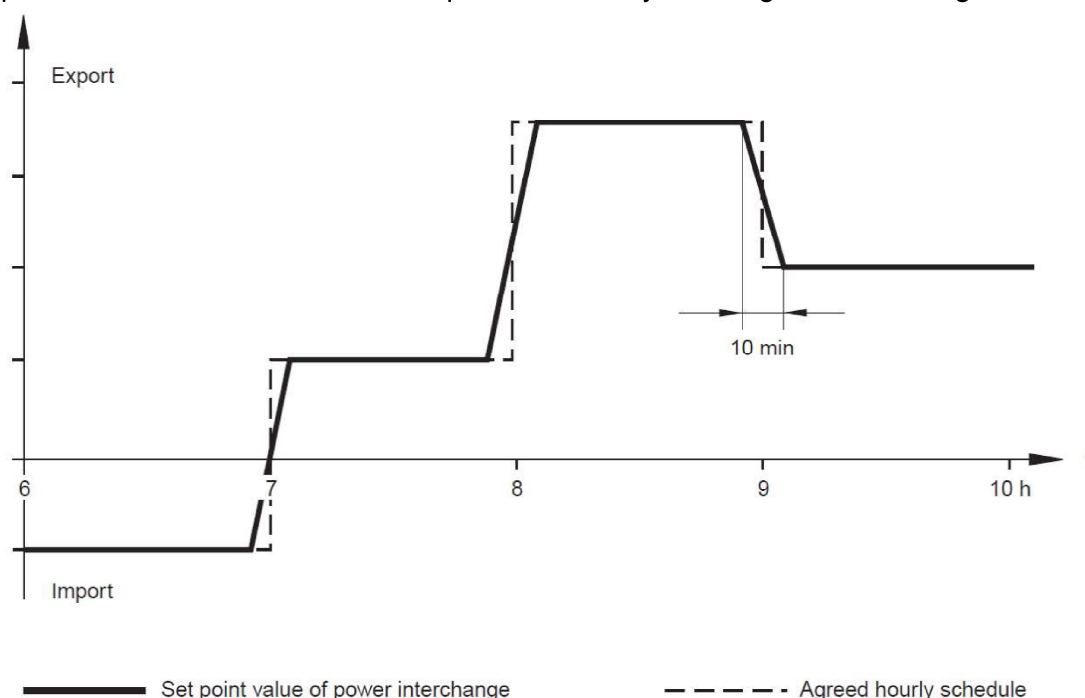


Figure 3: Example for an hourly control program

For avoidance of doubt, the ramping period shall apply to any change of control program: market, countertrading, cross-border redispatch, balancing program interchange, offset in case of application of the Extraordinary Procedure.

In order to prevent unintentional Frequency Deviations and major control actions under undisturbed conditions, TSOs are required to maintain careful compliance with times for program changes, particularly where changes in the exchange programs of several hundred

MW are involved. In particular, care must be taken to ensure that generating capacity is brought on line or disconnected on a staggered basis.

Ramping should be considered by each TSO of a LFC area in order to minimize the activation of active power reserves, the magnitude of the ACE and the corresponding Frequency Deviation. This could be reflected, for example, with financial incentives or operational requirements provided by TSO to generating units to follow the defined ramping requirements.

B-5 RESTRICTIONS FOR THE ACTIVE POWER OUTPUT OF HVDC INTERCONNECTORS ACCORDING TO ARTICLE 118(1)(H) SO GL (OPTIONAL)

[NO CONTENT]

B-6 LOAD-FREQUENCY-CONTROL STRUCTURE ACCORDING TO ARTICLE 118(1)(I) SO GL (MANDATORY)

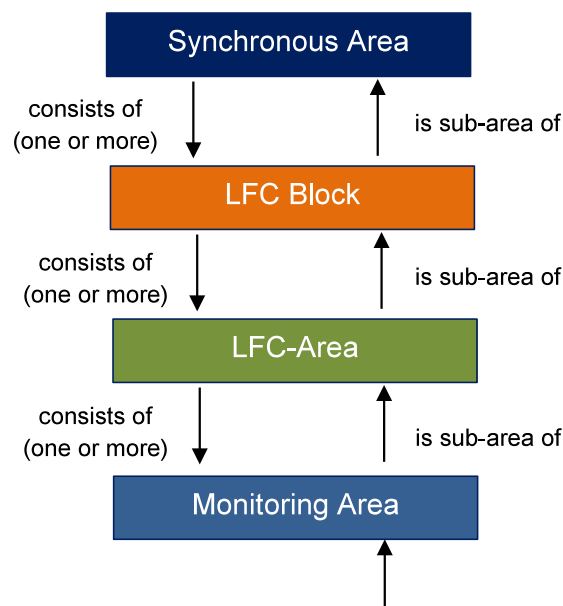
In accordance with Article 139 of the SO GL, the SAFA Parties hereby define for the Synchronous Area CE:

- the Process Responsibility Structure; and
- the Process Activation Structure.

B-6-1 PROCESS RESPONSIBILITY STRUCTURE

B-6-1-1 LIST OF MONITORING AREAS, LFC AREAS AND LFC BLOCKS

The current Process Responsibility Structure according to Article 141 of the SO GL is defined in Article A-7 *LFC Block Determination*.



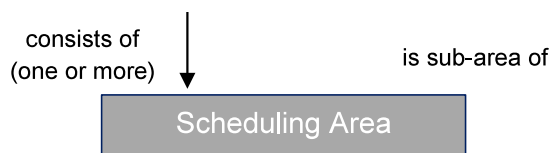


Figure 4: Hierarchy of operational areas

The operation of Load-Frequency Control processes is based on operational areas, where every area has its own responsibilities in the LFC structure. The overall body is the Synchronous Area in which frequency and phase are the same for the whole area. The Synchronous Area CE consists of several LFC Blocks, each LFC Block consists of one or more LFC Areas. An LFC Area itself consists of one or more Monitoring Areas, which also consist of one or more Scheduling Areas.

The above described hierarchy is illustrated in Figure 4: Hierarchy of operational areas. Each of these operational areas have its own obligations. A Scheduling Area is responsible for the scheduling process in that area. A Monitoring Area has in addition to the scheduling the obligation to calculate and measure the active power interchange in real-time in that area. An LFC Area has the additional obligation to fulfil the Frequency Restoration Control Error Target Parameters by using the Frequency Restoration Process (FRP).

A LFC Block is additionally responsible for the dimensioning of FRR and RR. The Synchronous Area has the obligation to fulfil the Frequency Restoration Control Error Target Parameters by using the Frequency Containment Process (FCP).

B-6-1-2 DEMARCATION OF SCHEDULING AREAS, MONITORING AREAS, LFC AREAS AND LFC BLOCKS

Each TSO operating a Monitoring Area, a LFC Area or a LFC Block shall cooperate with TSOs of neighbouring Monitoring Areas, LFC Areas and LFC Blocks

- to demarcate its areas by the position of physical points of measurement of the interchanged power over Tie-Lines and Virtual Tie-Lines;
- the TSOs operating a Tie-Line shall agree on one physical measurement point which serves as the common point of control for both TSOs;
- the TSOs operating a Tie-Line shall agree on a fall-back physical measurement point;
- to declare the list of Tie-Lines and Virtual Tie-Lines of each Monitoring Area, LFC Area and LFC Block in operation (including transmission lines and transformers of the different voltage levels between the areas) to the SG CSO and
- to maintain and update the list of Tie-Lines and Virtual Tie-Lines.

B-6-1-3 CONNECTION OF POWER GENERATING MODULES AND DEMAND FACILITIES VIA VIRTUAL TIE-LINES

Two or more TSOs of more than one LFC Areas are allowed to agree on cross-border operation of Power Generating Modules or Demand Facilities through Virtual Tie-Lines. In this case, a share of the respective Active Power output shall be transferred through the Virtual Tie-Line.

B-6-2 PROCESS ACTIVATION STRUCTURE

The Process Activation Structure of the synchronous area CE according to Article 140 of the SO GL includes mandatory processes:

- the Frequency Containment Process (FCP);
- the Frequency Restoration Process (FRP) and
- the Time Control Process.

Furthermore, there are optional processes:

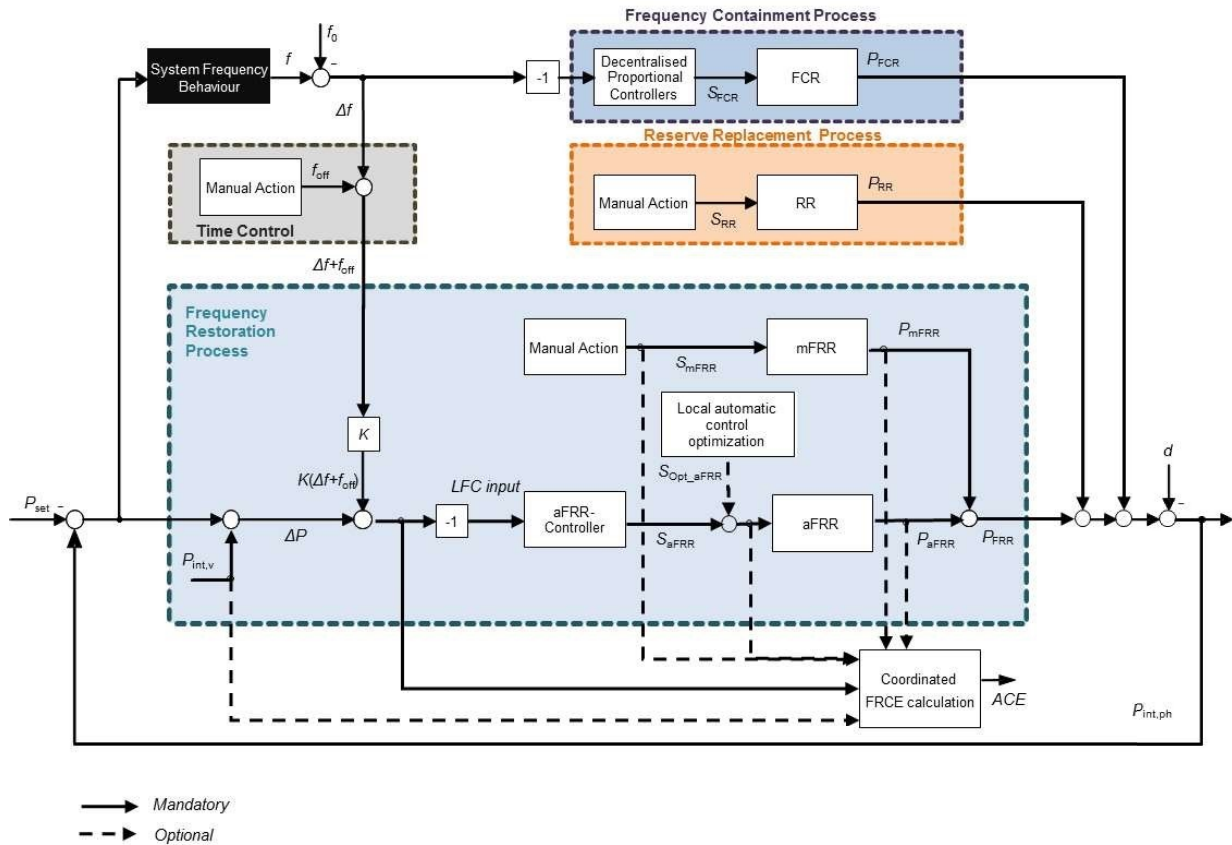
- the Reserve Replacement Process (RRP);
- the Imbalance Netting Process;
- the cross-border FRR Activation Processes and
- the cross-border RR Activation Process.

In case of applying a cross-border FRR activation process, the FRCE might be recalculated in a coordinated manner in order to correspond to the remaining imbalance the LFC area is responsible for. The recalculation of FRCE may optionally use the following inputs: the Virtual Tie-Line(s) involved in the cross-border exchange process, the set-points of FRR activation and the effective FRR activation.

At any time, the calculation of FRCE is mandatory for an LFC Area. When there is no coordinated calculation of FRCE, the ACE for an LFC Area is directly determined as equal to the opposite of the LFC input according to Figure 5.

The Process Activation Structure of the Synchronous Area CE is implemented in each LFC Area according to the control process in

- the control error, i.e. input, of the FCP is the Frequency Deviation;
- the control error, i.e. input, of aFRP is the LFC input of an LFC Area;
- the mFRP and RRP are manually triggered by the TSO in order to release or to supplement aFRP based on observed or expected imbalances;
- optionally, optimization of local aFRP may be introduced leading to additional aFRR activation (e.g. predictive aFRR activation).


 Figure 5: Control Process¹

Variable	Short Description and Sign Conventions
<i>ACE</i>	The ACE represents the individual remaining imbalance the LFC area is responsible for. In case of coordinated FRR activation the ACE may differ to the LFC Input and be recalculated in coordinated manner. Without coordinated FRCE calculation, the ACE corresponds to the opposite of the LFC Input.
<i>FRCE</i>	equals the ACE (only for RG CE).
<i>d</i>	disturbance.
<i>f₀</i>	Nominal System Frequency of the Synchronous Area. The Nominal System Frequency is equal to 50 Hz.
<i>f</i>	System Frequency of the Synchronous Area measured in Hertz (Hz).
$\Delta f = f - f_0$	Frequency Deviation.
<i>f_{off}</i>	Frequency Offset used for Time Control. Positive if the Synchronous Time is behind UTC.
$f_{\text{set}} = f_0 + f_{\text{off}}$	Reference frequency setpoint of the Synchronous Area in Hz equal to the sum of Nominal Frequency of the Synchronous Area and the Frequency Offset used for Time Control.

¹ The mandatory ACE arrow leading to the box of this coordinated calculation is only mandatory when there is no coordinated FRCE calculation.

K	the K-Factor defined in MW/Hz is an estimation for the change of Active Power output of a LFC Area resulting from a Frequency Deviation, i.e. including FCR, self-regulation, etc.
$K(\Delta f + f_{\text{off}})$	the Frequency Control Error is the estimation for the actual amount of Active Power which is adjusted in the LFC Area in response to the System Frequency to $f_{\text{set}} = f_0 + f_{\text{off}}$.
$LFC \text{ Input} = -(\Delta P + K(\Delta f + f_{\text{off}}))$	the LFC Input is the opposite of the sum of the Power Control Error and the Frequency Control Error. The LFC Input is the input of the aFRR controller.
P_{set}	set-point power interchange of a LFC Area calculated from the ramped Control Program, positive in case of export.
$P_{\text{int,ph}}$	sum of the active power flows over physical Tie-Lines (P_{T_ph}) of the LFC Area (positive in case of export).
$P_{\text{int,v}}$	sum of the active power flows over Virtual Tie-Lines of the LFC Area (positive in case of export) including correction signals from common optimization platforms for Imbalance Netting and aFRR energy exchange.
$\Delta P = (P_{\text{int,ph}} + P_{\text{int,v}}) - P_{\text{set}}$	the Power Control Error is the deviation between the set-point power interchange of the LFC Area and the sum of the Active Power flows over Tie-Lines (physical and virtual).
S_{FCR}	set-point for activation of FCR
S_{RR}	set-point for activation of RR sent to the RR provider.
S_{mFRR}	set-point for activation of mFRR sent to the mFRR provider.
S_{aFRR}	set-point for activation of aFRR sent to the aFRR provider.
$S_{\text{Opt_aFRR}}$	set-point for local optimization of aFRR activation.
P_{FCR}	activated FCR.
P_{RR}	activated RR.
P_{FRR}	activated FRR.
P_{aFRR}	activated aFRR.
P_{mFRR}	activated mFRR.

Table 2: Short Descriptions and Sign Conventions

B-6-2-1 FREQUENCY CONTAINMENT PROCESS

B-6-2-1-1 IMPLEMENTATION OF THE CONTROL FUNCTION

Each TSO of each LFC Area shall implement the FCP and organise the availability of the corresponding reserves, according to Article 142 of the SO GL.

B-6-2-2 IMPLEMENTATION OF THE FREQUENCY RESTORATION PROCESS (FRP)

B-6-2-2-1 IMPLEMENTATION OF THE CONTROL FUNCTION

Each TSO of each LFC Area shall implement the FRP with a respective load-frequency controller and organise the availability of the respective reserves.

The FRR shall be used for the FRP, according to Article 143 of the SO GL, in order to regulate the ACE to zero, other purposes, for example, the minimisation of unintentional energy exchange, are not allowed.

B-6-2-2-1-1 LOAD-FREQUENCY CONTROLLER

The load-frequency controller shall have proportional-integral behaviour. The controller parameter shall reflect the dynamic properties of the aFRR. The typical values for the load-frequency controller parameters are:

- 0 % to 50 % for the proportional term;
- 50 s to 200 s for the integral term; and
- 1 s to 5 s for the controller cycle time.

All TSOs shall provide the load-frequency controller parameters to the Synchronous Area Monitor on a yearly basis or if the parameters significantly change.

B-6-2-2-1-2 ACCURACY OF MEASUREMENTS

To ensure consistent calculations of the ACE:

- the accuracy and sensitivity of frequency measurement shall be at least 1 mHz;
- the accuracy of the active power measurements on each Tie-Line must be better than 1.5 % of its highest rated value (the complete measurement range, including discretisation);
- the controller cycle, i.e. refresh rate, shall not exceed 5 s;
- it is recommended that the transmission latency from measurement equipment of the tie-lines to the SCADA system does not exceed 1 s.

B-6-2-2-1-3 LOAD-FREQUENCY CONTROLLER CLOCK:

Each TSO shall implement a synchronisation of the load-frequency controller clock to a reference time.

B-6-2-2-1-4 OPERATION MODES OF THE LOAD-FREQUENCY CONTROLLER:

The load-frequency controller shall include the following operation modes:

1. Normal Operation Mode: In Normal Operation Mode the LFC input of the LFC Area "i" is calculated as the sum of the Power Control Error and the Frequency Control Error.

$$LFC\ input_i = - \left(\sum_{j \in \Omega_i} (P_{Tph,i}^j) - P_{set} + K_i(f - f_{set}) \right) \quad (1)$$

where Ω_i corresponds to the set of the tie lines of the LFC area i

2. Frequency Control Mode: In Frequency Control Mode the LFC input of the LFC Area "i" is equal to the Frequency Control Error (the Power Control Error is omitted).

$$LFC\ input_i = - K_i(f - f_{set}) \quad (2)$$

4. Frozen Control Mode: In Frozen Control Mode the output of the load-frequency controller of the LFC Area "i", and thus the set-point for the activation of aFRR, remains constant (ACE is not controlled).

$$S_{aFRR,i} = const. \quad (4)$$

5. Manual Control Mode: In Manual Control Mode one or more Tie-Line measurements, Power Control Error, Frequency Control Error and/or the output of the load-frequency controller of the LFC Area "i" is overwritten by a manually defined value.

The controller is deactivated meaning that there is a fixed set-point for activation of aFRR. This fixed set point and the actual value of this set point should be able to ramp up or down to another value. A possible value can be zero.

$$LFC\ input_i(t) = - \left(\Delta P_i^{manual}(t) + \Delta f^{manual}(t) \right) \quad (6)$$

Additional recommendations:

It is recommended that the load-frequency controller includes the following operation mode

3. Tie-Line Control Mode: In Tie-Line Control Mode the LFC input of the LFC Area i is equal to the Power Control Error (the Frequency Control Error is omitted).

$$LFC\ input_i = -\left(\sum_{j \in \Omega_i} \left(P_{T_{ph,i}}^j\right) - P_{set}\right) \quad (3)$$

B-6-2-2-1-5 AFRR MINIMUM AMOUNT RECOMMENDATION:

Additional recommendations:

The amount of aFRR is the range of adjustment within which the load-frequency controller can operate automatically, in both directions (positive and negative) at the time concerned, from the working point of the FRR.

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 is larger than the 1st percentile of the difference² of the 1-minute average ACEol³ and the 15 minute average ACEol of the LFC Block of the corresponding quarter of hour⁴, and
- that the negative aFRR 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.

This recommended statistical approach is based on historical data.

An alternative approach based on empiric noise management (recommended in the former UCTE) may also be taken into account leading to recommended minimum amount of aFRR given in the following

² Difference to be calculated on 1-minute resolution

³ **ACEol** means remaining ACE open loop without contribution of mFRR and RR activations.

⁴ 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.

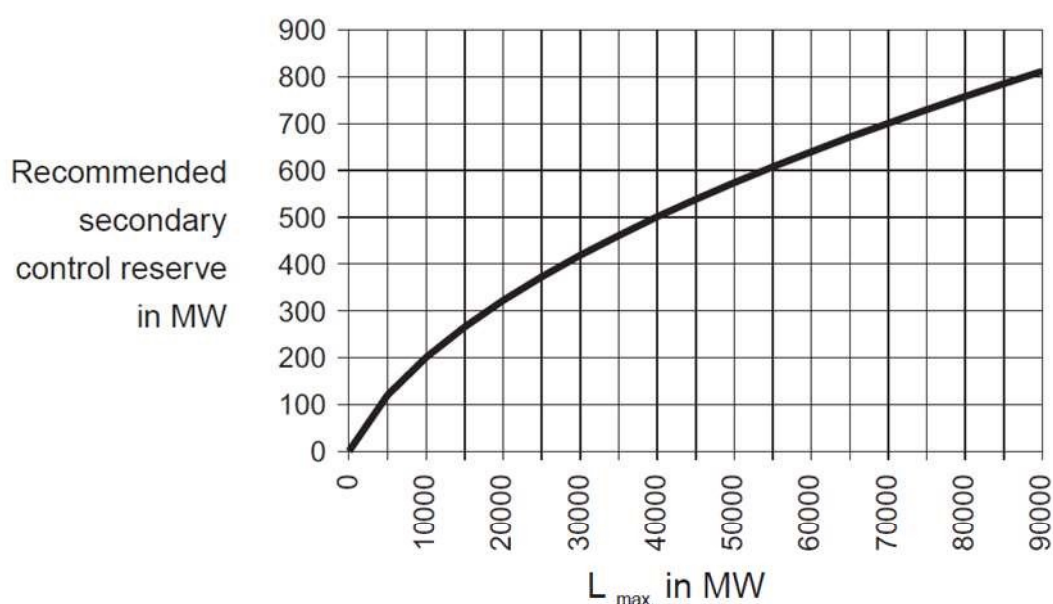


Figure 6: Recommended minimum aFRR reserve in the former UCTE

with L_{max} being the maximum anticipated consumer load for an LFC Area over the period considered.

A comparison between the new and the legacy recommendation for data between 2010 and 2014 resulted in comparable amounts per LFC Block; however, the new recommendation is considered more future-proof as it implicitly considers not only peak load, but all Imbalances. Both approaches may also be combined.

B-7 METHODOLOGY TO REDUCE THE ELECTRICAL TIME DEVIATION ACCORDING TO ARTICLE 118(1)(J) SO GL (MANDATORY)

At the synchronous area level, the electrical system operation is based on Active Power control with the aim of maintaining continuously the equilibrium between consumption and generation. In this process, the global parameter controlled is the system frequency meaning the number of times that the repeated event (voltage wave cycle) occurs per unit time (1 second). Whichever is the adopted control process structure for the repeated phenomena (frequency or time of voltage wave cycle) the performance for a long term period is the deviation of the electrical time from a time reference. In this sense, the final evaluation and control refers at the same values: time as integration of period of voltage wave and time etalon as Universal Time Control (UTC). The integration of frequency / voltage time period is considered the electrical time or the Synchronous Time (the electrical time of the Synchronous Area). If the Nominal Frequency is 50 Hz, the voltage time period represents 1/50 Hz-1 or 20 ms.

The responsibilities of the Synchronous Area Monitor according to Article 181(3) of the SO GL are fulfilled by the Time Monitor that shall act as a service provider for the Synchronous Area Monitor.

A long term integration of Nominal Frequency is absolute interval of astronomical time, while that same time integration of real voltage time period (frequency) has a different value. This difference serves in the majorities of the Synchronous Area as a performance indicator for the real time operating of the structure of control and maintaining the system power equilibrium.

During the normal operation, the average System Frequency usually deviates from its nominal value. These deviations can be the consequences of different events which occur in system operation and typically controlled by the Frequency Restoration Process (FRP). Even in normal operation due to the fact that the Frequency Deviation cannot be controlled exactly to zero, especially in presence of Imbalances pointing in one direction. Thus, electrical time deviations cannot be avoided and have to be controlled. This task shall be carried out by the Time Monitor, which has the obligation to monitor the electrical time deviation and based on that to calculate the new frequency set point for the Synchronous Area.

Moreover, significant electrical time deviations are proportional to the energy amount delivered due to FCR activation.

B-7-1 IMPLEMENTATION OF TIME CONTROL

B-7-1-1 FREQUENCY SET-POINT

The actual frequency set-point value for time control shall be used in the frequency restoration controller for the calculation of the Frequency Deviation in order to limit the deviation between Synchronous Time and UTC. The frequency set-point value shall be calculated by the Time Monitor, which is a TSO that continuously monitors the deviation between Synchronous Time and Universal Coordinated Time (UTC).

B-7-1-1-1 FREQUENCY SET-POINT VALUE

The frequency set-point value has to be calculated by the Time Monitor out of the sum of the nominal frequency 50 Hz and the time correction Frequency Offset and is valid for all hours of the next day, starting at 00:00 or as agreed otherwise by the Synchronous Area Monitor. All TSOs have to apply the transmitted frequency set-point value in their frequency restoration controller for the full next day.

B-7-1-2 MEAN FREQUENCY VALUE

The Time Monitor measures the Electrical Time Deviation, defined as the time discrepancy between Synchronous Time and UTC. The Time Monitor establishes and distributes accordingly the frequency set-point to all LFC blocks of the Synchronous Area. In case of an exceptional range of discrepancy as described below, the Time Monitor should trigger the applicable escalation process.

B-7-1-3 RANGE OF DISCREPANCY

B-7-1-3-1 TOLERATED RANGE OF DISCREPANCY

A discrepancy between Synchronous Time and UTC is tolerated within the range of ± 20 s (without need for time control actions).

B-7-1-3-2 CORRECTION RANGE OF DISCREPANCY

The discrepancy between Synchronous Time and UTC is within the range of ± 20 s and ± 60 s for which time control actions have to be applied.

B-7-1-3-3 EXCEPTIONAL RANGE OF DISCREPANCY

Under exceptional conditions the discrepancy between Synchronous Time and UTC is beyond the range of ± 60 s and exceptional time correction frequency offsets may be applied as described below.

B-7-1-4 TIME DEVIATION CALCULATION

The Time Deviation between Synchronous Time and UTC has to be calculated for 10 a.m. each day by the Time Monitor. The relevant time zone is the Central European Time (CET = GMT+1), applying daylight saving.

B-7-1-5 TIME CORRECTION FREQUENCY OFFSET

The Frequency Offset determined by the Time Monitor with respect to the ranges of discrepancy is as follows:

- if the Electrical Time Deviation is within the Tolerated Range of Discrepancy, the Frequency Offset for time correction has to be set to zero;
- if the Electrical Time Deviation is outside of the Tolerated Range of Discrepancy and Synchronous Time is behind UTC, the Frequency Offset has to be set to +10 mHz;
- if the Electrical Time Deviation is out of the Tolerated Range of Discrepancy and Synchronous Time is ahead of UTC, the Frequency Offset has to be set to –10 mHz.

B-7-1-5-1 EXCEPTIONAL TIME CORRECTION FREQUENCY OFFSETS

Only under exceptional conditions outside the Exceptional Range of Discrepancy may Frequency Offsets larger than 10 mHz for the time correction of the Synchronous Time be applied. These Frequency Offsets are set by the Time Monitor.

In this case, The Time Monitor may investigate the cause of the discrepancy and provide a report to the respective governance body for further actions.

B-7-1-6 TIME CORRECTION NOTICE

The information for the time correction that has to be applied shall be forwarded by the Time monitor to all LFC Blocks of the Synchronous Area every day by 10:15 a.m. UCT or as agreed otherwise by the Synchronous Area Monitor. The LFC Blocks forward this information to their underlying LFC Areas without delay.

B-7-1-6-1 CONTENT OF THE TIME CORRECTION NOTICE

Each notice has to contain the time deviation, the time correction Frequency Offset, and the date and duration for the time correction.

B-7-1-6-2 NOTICE TRANSMISSION

The Time Correction Notice shall be transmitted by using secure and reliable electronic communication that allows a half-automated procedure.

B-7-1-6-3 OUTSTANDING TIME CORRECTION NOTICE

In case the Time Deviation information or Time Correction Notice is missing, TSOs shall apply the nominal frequency of 50 Hz as frequency set-point value for aFRP until they receive the outstanding notice. In parallel, TSOs shall take action to receive the correct information from the Time Monitor.

B-8 ALLOCATION OF RESPONSIBILITIES BETWEEN THE TSOs ACCORDING TO ARTICLE 118(1)(K) SO GL (MANDATORY)

The responsibilities for the achievement of the objectives of the SO GL, are allocated as follows:

- each TSO shall be responsible for the operation of the FCP for its Initial FCR obligation according to Article 153(2)(d) of the SO GL;
- each TSO shall be responsible for the activation and availability of its Initial FCR Obligation according to Article 153(2)(d) of the SO GL;
- each TSO shall endeavour to fulfil the frequency quality target parameters in accordance with Article 127 of the SO GL.

B-9 OPERATIONAL PROCEDURES TO REDUCE FREQUENCY DEVIATION ACCORDING TO ARTICLE 118(1)(N) SO GL (MANDATORY)

B-9-1 EXTRAORDINARY PROCEDURE IN CASE OF ALERT STATE DUE TO A VIOLATION OF SYSTEM FREQUENCY LIMITS

B-9-1-1 GOAL OF THE PROCEDURE

According to Article 118(1)(n) of the SO GL, the procedure for long-lasting deviations from nominal frequency (as defined in Article *B-6 Load-Frequency Control Structure*) regarded as Alert State⁵ due to a violation of System Frequency limits shall guarantee

- The mandatory sharing of relevant operational information between the TSOs in case of significant steady-state Frequency Deviations which are considered to be a risk for Operational Security because of imminent potential cascading effects like load shedding or generation disconnection, and
- The reduction of respective Frequency Deviations with predefined/pre-prepared and coordinated countermeasures.

B-9-1-2 REMEDIAL ACTIONS IN THE SCOPE OF THIS PROCEDURE

Any Remedial Action to significantly reduce the ACE, i.e. Frequency Deviation, in order to return to Normal State shall encompass measures compliant with security rules according to the SO GL Part II Operational Security.

B-9-1-3 DECLARATION OF ALERT STATE

The Coordination Centres shall monitor the System Frequency and determine the Stages according to the limits defined in Figure 1 which are based on the System States defined in Article 152 of the SO GL.

B-9-1-3-1 DETERMINED STAGES

The following stages both correspond to Alert State according to Article 18(2) of the SO GL:

- Stage 1: a continuous Frequency Deviation of more than 100 mHz over a time period of more than 5 minutes or a continuous Frequency Deviation of more than 50 mHz over a time period of more than 15 minutes.
- Stage 2: a continuing Frequency Deviation of more than 100 mHz over a time period of more than 10 minutes or a continuous Frequency Deviation of more than 50 mHz either over a time period of 20 minutes or manually triggered after Stage 1 took place. Each LFC

⁵ This procedure does not directly refer to the local Alert State of a TSO with respect to Article 18 of the SO GL. Nevertheless, it can be derived from this requirement that a respective local Alert State of at least one Impacting TSO correlates with the synchronous area wide Alert State considered in the SO GL Part IV LFC&R and in this procedure.

area can ask for this manual trigger by contacting the responsible Coordination Centre. In case there are contradicting requests from TSOs, the Coordination Centre shall decide on appropriate actions and trigger of Stage 2.

In case of a long lasting remarkable imbalance of a TSO which does not (yet) trigger Stage 1 or Stage 2, but is not expected to be compensated in the foreseeable future or in case of detection of an expected risky imbalance situation, the TSO with long lasting remarkable imbalance or any TSO affected that has serious concerns regarding its own system by this long lasting imbalance has the right to ask for a manual trigger at any time by contacting the responsible Coordination Centre. The Coordination Centre shall decide on appropriate actions and trigger of Stage 1 or Stage 2.

GL SO: Alert State and Emergency State Extraordinary Procedure: Stage 1 and 2

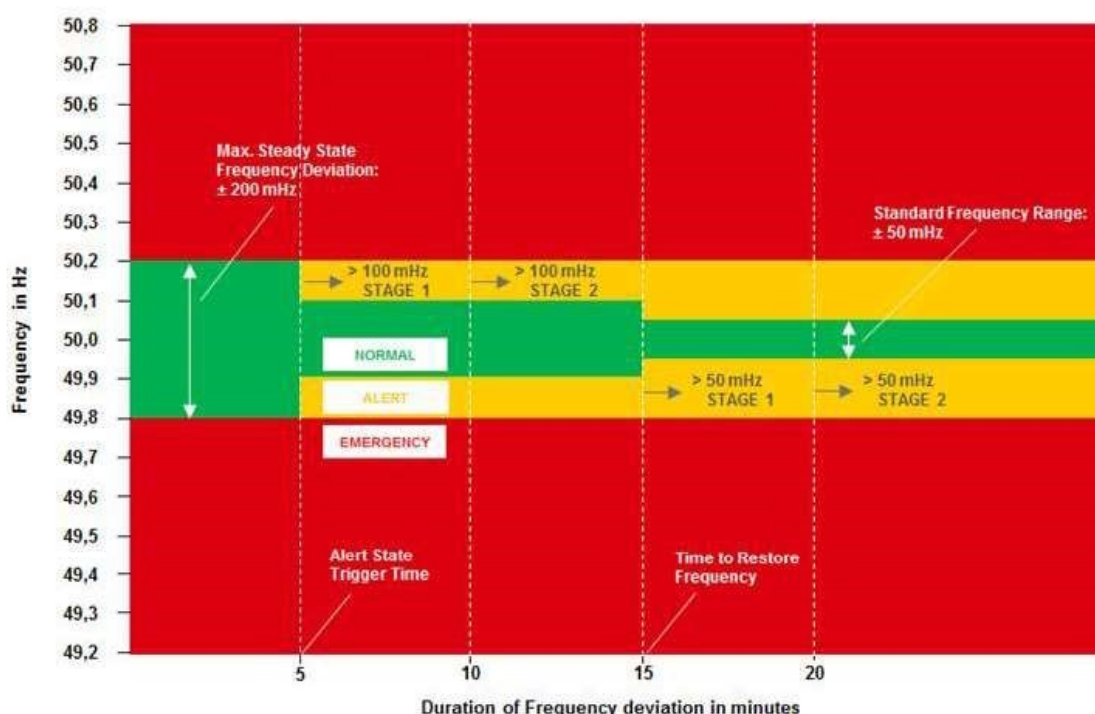


Figure 7: Illustration of Stage 1 and Stage 2 based on the System States of the SO GL.

B-9-1-4 ACTIONS TO BE TAKEN IN STAGE 1

In case a frequency deviation of more than 200 mHz occurs, the Emergency State is reached. Any corresponding actions and procedures are described in the Policy on Emergency and Restoration.

In case of Stage 1 the Coordination Centres shall identify the Impacting TSOs based on the ACE and contact immediately their control rooms by phone or teleconference.

The responsibility for launching the teleconferences through the Coordination Centres changes according to a monthly rotation.

B-9-1-4-1 IDENTIFICATION OF IMPACTING TSOs

An Impacting TSO means a TSO that is predominantly responsible for a Frequency Deviation that triggers Stage 1 or Stage 2 of the Extraordinary Procedure in case of Alert State according to the determined criteria.

A TSO shall be identified as Impacting TSO in case the following conditions are fulfilled in ENTSO-E Awareness System (EAS):

- the TSOs with an ACE exceeding the threshold of 375 MW⁶ and
- the TSO has declared Alert State.

In case the threshold is exceeded by a TSO that has not declared Alert State the Coordination Centre shall contact the TSO asking for respective confirmation.

Alternatively, a TSO may declare to be an Impacting TSO by proactively contacting a Coordination Centre.

In case the EAS is not available, the Coordination Centre shall identify the Impacting TSOs based on the online observation data or any other available information.

B-9-1-4-2 INFORMATION PROVIDED BY THE IMPACTING TSOs

The Impacting TSOs shall inform the Coordination Centre about:

- The estimated reason for the imbalance
- The Remedial Actions that have already been taken;
- The time period when these actions are expected to become effective;
- If these actions are expected to be sufficient to solve the frequency deviation and
- Which further actions are planned.

This first contact aims at clarifying from each Impacting TSO if some actions have been already set up, the delay for these actions and if these actions are expected to be sufficient in order to solve the frequency deviation. The Impacting TSOs are expected to set up all the measures that are possible regarding their own rules (market and security) in order to avoid the second step of this procedure as much as possible.

B-9-1-4-3 TAKING NOTE OF INFORMATION IN STAGE 1

The Coordination Centre shall take note of the information as described in the chapter on *Identification of Impacting TSOs and Information provided by the Impacting TSOs* above and send a respective e-mail to the Impacting TSO, to TSOs that activate remedial actions as part of the Extraordinary Procedure in case of Alert State (the Supporting TSOs) and to the other Coordination Centre as soon as possible.

B-9-1-4-4 MANUAL TRIGGERING OF STAGE 2

In case the Impacting TSO(s) expect(s) its/their taken and planned Remedial Actions will not be sufficient and an improvement of the System Frequency cannot be observed by the Coordination Centre, the Coordination Centre shall start the measures corresponding to Stage 2 without delay. Alternatively, the Impacting TSOs may ask the Coordination Centre for the immediate initiation of Stage 2.

⁶ Threshold calculated as 1/8 of the reference incident of the synchronous area for more than 30 consecutive minutes

B-9-1-5 ACTIONS TO BE TAKEN IN STAGE 2

B-9-1-5-1 PHONE CONFERENCE

In case of Stage 2 the Coordination Centre shall immediately start a phone conference with all relevant Supporting TSOs. If necessary, the Impacting TSOs may join the conference.

The phone conference shall be possible without prior scheduling or prior connection request.

B-9-1-5-2 FURTHER REMEDIAL ACTIONS

As a result of the phone conference, one or more further Remedial Actions to return to Normal State shall be agreed by the participating TSOs. Possible Remedial Actions are e.g.:

- activation of additional⁷ aFRR by means of enforcing the frequency restoration controller to activate additional reserves, i.e. manually overwriting / adjusting the exchange program while – for example – using virtual tie-lines or cross-border schedules;
- activation of additional mFRR or RR;
- mutual emergency assistance services

For the evaluation of the appropriate Remedial Actions the following aspects shall be taken into account:

- the Imbalance and expected duration of the Imbalance;
- the amount of available Active Power Reserves in the different LFC Blocks;
- the expected activation time;
- impacts on the load flows based on simulations within the related observability areas or the last available merged snapshots (every 15 minutes) and on the expected location of generation units or loads which are planned to be used to compensate the Imbalance;
- specific boundary conditions, e.g. risk of entering into Emergency State due to tripping of solar power generation, etc.

B-9-1-5-3 DOCUMENTATION OF STAGE 2

The Coordination Centre shall document the agreed Remedial Actions and send as soon as possible a respective e-mail to the Impacting TSO, the Supporting TSOs, the other Coordination Centre as well as to further TSOs for information.

B-9-1-5-4 EX POST ANALYSIS

The Coordination Centre shall distribute a report in case of Stage 2 events latest one week after the events. Furthermore, the Synchronous Area Monitor performs a detailed analysis in the internal Quarterly Reports.

B-9-1-5-5 DATA PROVISION

All TSOs shall provide the following data:

- real-time input of LFC;
- available remaining aFRR and mFRR;
- available RR (amount and activation time).

⁷ Additional means in addition to the Active Power Reserves activation used for the compensation of the LFC Blocks of the Supporting TSOs.

B-10 ROLES AND RESPONSIBILITIES OF THE TSOs IMPLEMENTING AN IMBALANCE NETTING PROCESS, A CROSS-BORDER FRR ACTIVATION PROCESS OR A CROSS-BORDER RR ACTIVATION PROCESS ACCORDING TO ARTICLE 118(1)(o) SO GL (MANDATORY)

B-10-1 ROLES RELATED TO IMBALANCE NETTING, CROSS-BORDER ACTIVATION OF RESERVES, EXCHANGE OF RESERVES AND SHARING OF RESERVES

In accordance with Article 118(1)(o), (u), (v) and (w) of the SO GL, the Parties hereby define the roles of TSOs implementing or affected by an Imbalance Netting Process, a Cross-Border FRR Activation Process, a Cross-Border RR Activation Process, an exchange of Reserves or sharing of Reserves.

B-10-1-1 IMPLEMENTING TSOs

TSOs implementing an Imbalance Netting Process, a cross-border aFRR Activation or mFRR Activation Process, a cross-border RR Activation Process, exchange of Reserves or sharing of Reserves which shall commonly develop the platforms for these processes and sign an operational procedure agreement per process, are defined as Implementing TSOs. According to Article 118(1)(u), the Reserve Receiving TSO and the Reserve Connecting TSO, as well as according to Article 118(1)(v) and (w) the Control Capability Receiving TSO and the Control Capability Providing TSO, is also defined as Implementing TSO.

Any TSO of the Synchronous Area CE shall have the right to join the existing Imbalance Netting Process, a cross-border aFRR or mFRR Activation Process, a cross-border RR Activation Process, exchange of Reserves or sharing of Reserves when this TSO:

- fulfils requirements of the relevant process platform
- signs the relevant operational procedure agreement per process and
- notifies the process according to the *Notification Process* described below

B-10-1-2 AFFECTED TSOs

A TSO may declare itself as affected (Affected TSO) when this is based on an Operational Security Analysis and within one month after notification to the SG CSO in accordance with Article 150(2) of SO GL.

B-10-2 RESPONSIBILITIES RELATED TO IMBALANCE NETTING, CROSS-BORDER ACTIVATION OF RESERVES, EXCHANGE OF RESERVES AND SHARING OF RESERVES

In accordance with Article 118(1)(o), (u), (v) and (w) of the SO GL, all TSOs of the Synchronous Area CE hereby define the responsibilities of TSOs implementing or affected by an Imbalance Netting Process, a cross-border FRR Activation Process, a cross-border RR Activation Process, an exchange of Reserves or sharing of Reserves.

B-10-2-1 NOTIFICATION PROCESS

B-10-2-1-1 NOTIFICATION

TSOs of Synchronous Area CE that are willing to implement an Imbalance Netting Process, a cross-border aFRR or mFRR Activation, a cross-border RR Activation Process, an exchange of Reserves or sharing of Reserves shall send a notification to the SG CSO at least three months before exercising their right to implement, in accordance with Article 150(1) of the SO GL.

B-10-2-1-2 NOTIFICATION OF ADDITIONAL PROCESSES

TSOs of Synchronous Area CE that are willing to implement an Additional Process (different from processes in accordance with Article 118(1)(o), (u), (v) and (w)) according to with cross-border implications which is in line with the SO GL shall:

- perform a study to investigate the impacts of the new process on the Operational Security of the synchronous area CE.
- in order to request a trial phase for the new process, send the study report and the additional restrictions (see chapter on *Trial Phase* below) to SG CSO and RG CE, at least three months in advance of the implementation; the RG CE shall decide on initiating the trial phase and apply the additional restrictions.

B-10-2-2 IMPLEMENTATION OF OPERATIONAL PROCEDURES FOR LIMITATION OF IMBALANCE NETTING AND CROSS-BORDER ACTIVATION OF RESERVES

B-10-2-2-1 AGREEMENT ON OPERATIONAL PROCEDURES

In accordance with Article 150(3) of the SO GL, upon the request of the Affected TSO the TSOs implementing Imbalance Netting or cross-border activation of reserves and the Affected TSO shall agree on Operational Procedures enabling the Affected TSO:

- to perform Operational Security Analysis in real-time, and
- to limit Imbalance Netting power interchange, Frequency Restoration power interchange and Replacement Power interchange.

The agreed Operational Procedures shall include the rules for possible limitations and reasons for the limitations which shall be provided by the Affected TSO.

The TSOs implementing Imbalance Netting or cross-border activation of reserves and the Affected TSOs shall notify the SG CSO about their operational procedure agreement and possible adaptations to the originally notified process.

B-10-2-3 LIMITS FOR EXCHANGE AND SHARING OF RESERVES

Each Affected TSO has the right to request tighter limits because of:

- exchange of FCR within or between the Synchronous Area;
- exchange of aFRR, mFRR or RR within or between the Synchronous Area;
- sharing of aFRR, mFRR or RR within or between the Synchronous Area.

In this case the TSO shall notify the Synchronous Area Monitor about these limits.

B-10-3 TRIAL PHASE

A Trial Phase is only required for processes that have potential impact on system security. In case one or more TSOs submit a new process proposal every proposing TSO is obliged to perform an assessment on potential impact on system security. In case where system security impact is detrimental, RG CE or SOC (in case of inter-Synchronous Area impacts) shall decide whether a Trial Phase shall be performed.

B-10-3-1 TRIAL PHASE FOR IMBALANCE NETTING, CROSS-BORDER ACTIVATION OF RESERVES, EXCHANGE OF RESERVES AND SHARING OF RESERVES PROCESSES

The relevant TSO involved in an Imbalance Netting Process, a cross-border aFRR Activation or mFRR Activation Process, a cross-border RR Activation Process, an exchange or sharing of Reserves between LFC Blocks within or between Synchronous Areas shall foresee a trial phase of at least one year.

The Trial Phase shall include a regular reporting. The regular report shall be delivered each 6 months (or as otherwise agreed by SG CSO) and provided to the SG CSO with at least the statistical evaluation of ACE, cross-border power interchange, possible impact on the Frequency Quality as well as evaluation of operational procedures.

The SG CSO shall decide about the successful completion of the Trial Phase based on the evaluations provided by the regular report.

B-10-3-2 TRIAL PHASE FOR ADDITIONAL PROCESSES

In case a Trial Phase for an Additional Process has been approved by the RG CE according to the *Notification of Additional Processes*, the SG CSO shall:

- report every three months to the RG CE
- evaluate the impact of the process on Operational Security at the end of the trial phase
- inform the RG CE about the final results and recommend a final decision to the RG CE.

The RG CE shall decide on the implementation of the process.

B-11 REQUIREMENTS CONCERNING THE AVAILABILITY, RELIABILITY AND REDUNDANCY OF THE TECHNICAL INFRASTRUCTURE ACCORDING TO ARTICLE 118(1)(P) SO GL (MANDATORY)

B-11-1 RELIABILITY

The frequency restoration controller of aFRR shall be operated on-line and shall have a very high reliability. The tools for activation of mFRR and RR shall be operated on-line and shall have a very high reliability as well. A hot-stand-by-backup system must be available to take over the control function in case of an outage or fault of the main system. This requirement applies as well for all European platforms performing cross-border Imbalance Netting or a cross-border FRR and RR activation process.

B-11-1-1 RELIABILITY OF MEASUREMENTS

Measurements must be transmitted in a reliable manner, i.e. redundant/parallel data links, to the frequency restoration controller. The used communication protocols must allow detecting invalid values and missing or invalid measurement values shall cause an alarm.

For each LFC Area of Synchronous Area CE, the related TSO shall have frequency measurements from at least two different geographical locations available within this LFC Area.

B-11-2 REDUNDANCY

B-11-2-1 TSO CONTROL ROOMS REDUNDANCY

The control room functions shall be backed up to face any damage to the main installations. This shall be activated within less than three hours and tested at least once a year.

B-11-2-2 MANUAL CONTROL CAPABILITY

In case of deficiency of the automatic frequency restoration controller, manual control of reserves must be possible.

B-11-2-3 METERING AND MEASUREMENT TRANSMISSION TO OPPOSITE SIDE

The operating TSOs of a tie-line shall agree on a common primary measurement, whose measured value shall be used in the load frequency controller of the concerned TSOs. A secondary measurement shall be used as backup and shall be available in parallel to the primary measurement in case the active power-flow can exceed 50 MW. Accuracy and cycle times for the secondary measurements must fulfil the same characteristics as the primary measurements.

B-11-3 AVAILABILITY

B-11-3-1 DATA RECORDING

Each TSO of Synchronous Area CE shall perform continuous recordings with a measurement period equal to or shorter than 10 s of all values needed for monitoring of the input and response of the frequency restoration controller and for analysis of normal operation and incidents in the Synchronous Area. These values include:

- the frequency measurement,
- the total active power flow measurement and
- the power exchange set-point value.

B-11-3-2 SHARING OF INFORMATION

The TSO shall inform in real-time all TSOs within the Synchronous Area CE about its Wide Area State of the system. In case of not being in Normal State, the constrained TSO shall provide more details on critical operational conditions and at minimum to the interconnected TSOs, expected time to come back to Normal State and shall call for help if needed (refer to bi-multilateral TSOs agreements). The constrained TSO shall communicate the information via the following ways:

- EAS,
- preformatted messages (Fax, e-mail, web-based, etc.),
- phone calls to complement messages.

B-11-3-3 INTER-TSO CONTACT LISTS FOR SYSTEM OPERATION

Inter-TSO agreements shall include a list of functional positions directly involved in the system operation to be contacted at any time with phone numbers, fax numbers and e-mail addresses that shall be provided by all TSOs of the Synchronous Area CE and regularly updated. This list includes desks of control rooms and the relevant staff. All critical information about real-time operation shall be sent to these TSO counterparts.

B-12 COMMON RULES FOR THE OPERATION IN NORMAL STATE AND ALERT STATE ACCORDING TO ARTICLE 118(1)(q) SO GL (MANDATORY)

As all common rules for the operation in Normal State and Alert State, the target of load-frequency-control is to reduce Frequency Deviations. Those rules refer to the rules for operational procedures to reduce Frequency Deviation according to *B-9 Operational Procedures to Reduce Frequency Deviation*.

Additionally, and to prevent entering Emergency State, the TSO shall endeavour to conclude Mutual Emergency Service Agreements. These agreements should not be limited to TSO agreements within the Synchronous Area but also between Synchronous Areas.

In case of a long lasting remarkable Imbalance of a TSO which does not (yet) trigger Stage 1 or Stage 2, but is not expected to be compensated in the foreseeable future or in case of detection of an expected risky Imbalance situation, the TSO with long lasting remarkable Imbalance or any TSO affected by this long lasting Imbalance, has the right to ask for a manual trigger at any time by contacting the responsible Coordination Centre. The Coordination Centre shall decide on appropriate actions and trigger of Stage 1 or Stage 2.

In case a Frequency Deviation of more than 200 mHz occurs, Emergency State is reached. Any corresponding actions and procedures are described in the Policy on Emergency and Restoration.

B-13 ROLES AND RESPONSIBILITIES OF THE RESERVE CONNECTING TSO, THE RESERVE RECEIVING TSO AND THE AFFECTED TSO AS REGARDS THE EXCHANGE OF FRR AND RR ACCORDING TO ARTICLE 118(1)(u) SO GL (MANDATORY)

In accordance with Article 165(1) of the SO GL all TSOs of the Synchronous Area CE hereby define the roles and responsibilities of the Reserve Connecting TSO, the Reserve Receiving TSO and the Affected TSO for the exchange of FRR and/or RR. The roles and responsibilities as well as the notification processes and operational procedures are described in *B-10 Roles and Responsibilities of the TSOs implementing an Imbalance Netting Process, a cross-border FRR Activation Process or a cross-border RR Activation Process*.

B-14 ROLES AND RESPONSIBILITIES OF THE CONTROL CAPABILITY PROVIDING TSO, THE CONTROL CAPABILITY RECEIVING TSO AND THE AFFECTED TSO FOR THE SHARING OF FRR AND RR ACCORDING TO ARTICLE 118(1)(v) SO GL (MANDATORY)

In accordance with Article 166(1) of SO GL, all TSOs of the Synchronous Area CE hereby define the roles and responsibilities of the Control Capability Providing TSO, the Control Capability Receiving TSO and the Affected TSO for sharing FRR/RR. The roles and responsibilities as well as the notification processes and operational procedures are described in *B-10 Roles and Responsibilities of the TSOs implementing an Imbalance Netting Process, a cross-border FRR Activation Process or a cross-border RR Activation Process*.

B-15 ROLES AND RESPONSIBILITIES OF THE RESERVE CONNECTING TSO, THE RESERVE RECEIVING TSO AND THE AFFECTED TSO FOR THE EXCHANGE OF RESERVES BETWEEN SYNCHRONOUS AREAS, AND OF THE CONTROL CAPABILITY PROVIDING TSO, THE CONTROL CAPABILITY RECEIVING TSO AND THE AFFECTED TSO FOR THE SHARING OF RESERVES ACCORDING TO ARTICLE 118(1)(w) SO GL (MANDATORY)

In accordance with Article 171(2) of SO GL all TSOs of the RG CE hereby define the roles and responsibilities of the Reserve Connecting TSO, the Reserve Receiving TSO and the Affected

TSO for the exchange of Reserves between Synchronous Areas and of the Control Capability Providing TSO, the Control Capability Receiving TSO and the Affected TSO for the sharing of Reserves. The roles and responsibilities as well as the notification processes and operational procedures are described in *B-10 Roles and Responsibilities of the TSOs implementing an Imbalance Netting Process, a cross-border FRR Activation Process or a cross-border RR Activation Process*.

B-16 TECHNICAL DESIGN OF THE FREQUENCY COUPLING PROCESS ACCORDING TO ARTICLE 172(2) SO GL (MANDATORY)

All TSOs of each Synchronous Area jointly define three classes of frequency services, namely FCR Exchange, Frequency Netting and Frequency Optimisation.

B-16-1 FCR Exchange

FCR Exchange is a process agreed between two Synchronous Areas where one Synchronous Area delivers FCR to the other. In such a case it shall be fulfilled that:

- the providing Synchronous Area shall provide the FCR subject to FCR Exchange in addition to its own initial FCR dimensioning obligation according to SO GL Article 173(3) and
- the receiving Synchronous Area (via the TSO or via the sourced BSPs) shall have a back-up process in case the service fails.

B-16-2 Frequency Netting

Frequency Netting is a process agreed between two or more Synchronous Areas that reduces counter-activations of FCR only when the Synchronous Areas have Frequency Deviations which have an opposite sign. Frequency Netting hence always improves the instantaneous frequency quality of all participating Synchronous Areas in case there are Frequency Deviations with opposite signs.

B-16-3 Frequency Optimisation

Frequency Optimisation is a process agreed between two or more Synchronous Areas that improves overall frequency quality by mutual FCR support between Synchronous Areas. This is arranged such that the frequency in all Synchronous Areas are used and optimised to ensure that the sum of the absolute Frequency Deviations is minimised. The objective function of Frequency optimisation applies different weights to the Synchronous Areas, with no Synchronous Areas having a zero weight and the weightings being agreed by all Synchronous Areas. Frequency Optimisation hence improves the average frequency quality of those Synchronous Areas involved.

All Synchronous Areas willing to implement any of those services with RG CE shall send a notification to the SG CSO three months in advance in accordance with Article 150(1) of the SO GL.

B-17 METHODOLOGY TO DETERMINE LIMITS ON THE AMOUNT OF EXCHANGE AND SHARING OF FCR BETWEEN SYNCHRONOUS AREAS ACCORDING TO ARTICLE 173(4) AND ARTICLE 118(1)(X) SO GL (MANDATORY)

B-17-1-1 EXCHANGE OF FCR BETWEEN SYNCHRONOUS AREAS

In accordance with Article 173(4) of the SO GL all TSOs of the Synchronous Area CE hereby establish the limits on the amount of Exchange of FCR between Synchronous Areas.

B-17-1-1-1 EXCHANGE OF FCR BETWEEN SYNCHRONOUS AREAS WHERE THE SYNCHRONOUS AREA CONTINENTAL EUROPE IS THE RESERVE CONNECTING SYNCHRONOUS AREA

The maximum total exchanged FCR amount between Synchronous Area CE and the other Synchronous Areas shall not exceed the following security limits for Synchronous Area CE:

- Aggregated FCR activation of all FCR units or groups subject to the exchange with adjacent Synchronous Areas induces a disturbing Frequency Deviation that is limited to a maximum of 10 mHz, which corresponds to a limit in power according to the K-Factor of the Synchronous Area CE. The SG SF shall calculate this limit on a yearly basis.

B-17-1-1-2 EXCHANGE OF FCR BETWEEN SYNCHRONOUS AREAS WHERE THE SYNCHRONOUS AREA CE IS THE RESERVE RECEIVING SYNCHRONOUS AREA

The exchange of FCR between Synchronous Areas where the Synchronous Area CE serves as the Reserve Receiving Synchronous Area shall consider the following constraints:

- All Reserve Receiving TSOs of a LFC Block involved in an exchange of FCR between Synchronous Areas shall ensure that at least 30 % of their total combined Initial FCR Obligations are physically provided inside their LFC Block.
- 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 Reserve Receiving Synchronous Area for each reserve transfer HVDC link.

B-17-1-2 SHARING OF FCR BETWEEN SYNCHRONOUS AREAS

In accordance with Article 118(1)(x) of the SO GL all TSOs of the Synchronous Area CE hereby establish the limits on the amount of sharing of FCR between synchronous areas.

B-17-1-2-1 SHARING OF FCR BETWEEN SYNCHRONOUS AREAS WHERE THE SYNCHRONOUS AREA CONTINENTAL EUROPE IS THE RESERVE CONNECTING SYNCHRONOUS AREA

The maximum total shared FCR amount between Synchronous Area CE and the other Synchronous Areas shall not exceed the following security limits for Synchronous Area CE:

- Total activated shared FCR with an adjacent Synchronous Area induces a disturbing Frequency Deviation that is limited to a maximum of 10 mHz, which corresponds to a limit in power according to the K-Factor of the Synchronous Area CE. The SG SF shall calculate this limit on a yearly basis.

B-17-1-2-2 SHARING OF FCR BETWEEN SYNCHRONOUS AREAS WHERE THE SYNCHRONOUS AREA CE IS THE RESERVE RECEIVING SYNCHRONOUS AREA

Sharing of FCR Capacity where Synchronous Area CE is the Reserve Receiving Synchronous Area shall not be allowed.