European Network of
Transmission System Operators
for Electricity

All Continental Europe TSOs' proposal for assumptionsAssumptions and methodology for a FCR probabilistic FCR dimensioning in the Continental Europe synchronous area 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

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All Continental Europe TSOs, taking into account the following,

Whereas

This document is a proposal jointly developed by all Transmission System Operators of the Continental Europe synchronous area (hereafter referred to as the "TSOs") regarding the determination of assumptions and a probabilistic dimensioning approach for FCR (hereafter referred to as "probabilistic FCR Dimensioning") to be conducted, in order to assess the required FCR capacity in accordance with Article 153(2) of

(1) Article 153(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereafter referred to as "System Operation Guideline Regulation"). This proposal is " or "SO GL") contains criteria that the Transmission System Operators (hereafter referred to as "Probabilistic methodology for FCRTSOs") of each synchronous area shall follow when specifying the dimensioning". rules for Frequency Containment Reserve (hereafter referred to as "FCR").

(2) According to Article 6(3)(d)(ii) of the SO GL, the dimensioning rules for FCR are subject to approval by all regulatory authorities of the concerned region. Once approved these rules are included in the synchronous area operational agreement. For the Continental Europe synchronous area this agreement is part of the wider Synchronous Area Framework Agreement (hereinafter referred to as "SAFA") stipulated by the TSOs.

(3) The Article 153(2)(c) of the System Operation Guideline Regulation requires the TSOs of the Continental Europe synchronous areaTSOs of the Continental Europe synchronous area have historically adopted a deterministic criterion for the dimensioning of FCR. Such criterion considersconsider that the FCR shall be able to contain a frequency deviation due to the worst expected outages combination in the system, reflected by the 'reference incident' being equal to 3000 MW in both positive and negative direction, pursuant to Article 153(2)(b) of the System Operation Guideline.

(2)(4) For the Continental Europe synchronous area, Article 153(2)(c) of the SO GL states that the TSOs of the Continental Europe synchronous area have the right to define a probabilistic dimensioning approach for FCR, taking into account the pattern of load, generation and inertia, including synthetic inertia as well as the available means to deploy minimum inertia in real-time in accordance with the methodology referred to in Article 39 of the System Operation Guideline RegulationSO GL, with the aim of reducing the probability of insufficient FCR to below or equal to once in 20 years.

(3) TSOs have historicall adopted a deterministic criterion for the FCR dimensioning of FCR in the Continental Europe synchronous area. Such criterion consider that the FCR shall be able to contain the frequency deviation due to the worst expected outages combination on the system. The value hystorically adopted is 3000 MW

(4)(5) The proposed probabilistic FCR Dimensioningdimensioning generally contributes to the achievement of the objectives of Article 4(1) of the System Operation Guideline Regulation.SO GL. Specifically, the proposed probabilistic FCR Dimensioningdimensioning provides the TSOs of the CEContinental Europe synchronous areasarea with a methodology to evaluate the needs of FCR considering all the relevant factors contributing factors. Such methodology contributes to the

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determination of common operational security requirements and principles as set in ~~the~~ Article 4 (1~~)~~ ~~()~~(a) of ~~System Operation Guideline Regulation~~the SO GL. It furthermore contributes to ensuring the conditions for maintaining operational security throughout the Union as set in Article 4(1~~) ()~~(d) of ~~System Operation Guideline Regulation~~the SO GL. Finally it contributes to ensuring the conditions for maintaining a frequency quality level of all synchronous areas throughout the Union as set in Article 4 (1~~) ()~~(e) of ~~System Operation Guideline Regulation.~~the SO GL. The ~~proposed~~ probabilistic FCR ~~Dimensioning~~dimensioning does not impact on the other objectives listed in Article 4(1) of the ~~System Operation Guideline Regulation~~SO GL.

~~(5)~~(6) The probabilistic methodology for FCR dimensioning contributes to ~~pursue~~pursuing the general objectives of the ~~System Operation Guideline Regulation~~SO GL of safeguarding operational security by defining the proper FCR dimensioning needs.

~~SUBMIT THE FOLLOWING PROPOSAL TO ALL REGULATORY AUTHORITIES OF THE CONTINENTAL EUROPE SYNCHRONOUS AREA:~~

Article 1
Subject matter and scope

1. ~~This is a proposal developed in accordance with the Article 4 (2) (c) of System Operation Guideline Regulation.~~ The assumptions and methodology for the probabilistic FCR ~~Dimensioning shall be considered as a common proposal of all~~dimensioning represent the dimensioning rules for FCR for Continental Europe ~~TSOs~~synchronous area in accordance with Article 153(2) of the ~~System Operation Guideline Regulation~~SO GL.

Article 2
Definitions and interpretation

~~1.~~2. For the purposes of ~~this~~the probabilistic ~~methodology for~~ FCR dimensioning, terms used in this document shall have the meaning of the definitions included in Article 3 of the ~~System Operation Guideline Regulation~~SO GL.

~~2.~~3. Further, in ~~this probabilistic methodology for~~theprobabilistic FCR dimensioning, unless the context requires otherwise, the following ~~additional~~ definitions shall ~~also~~ apply:

a) Critical Condition' is a serie of minutes meeting one or more of the citeria for not acceptable minute and spaced each other not more than a parametrical number of minute.
b) 'Deterministic frequency deviation' or 'DFD' means regular deviations of the grid frequency that occur around the hourly or sub-hourly intervals.
c) 'Equivalent reservoir energy capacity' means the energy requirement for LER associated to the Time Period and shall amount to twice the energy provided by the full activation of LER for the Time Period.
d) 'FAT' means 'automatic FRR Full Activation Time' as defined in Article 3 (101) of SO GL.
e) 'frequency nadir' is the minimum instantaneous frequency reached during an underfrequency transient.
f) 'frequency zenith' is the maximum instantaneous frequency reached during an overfrequency transient.
g) 'Initial RoCoF', is the RoCoF calculated at the time in which a disturbance happens.

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a) 'LER' means 'FCR providing units or groups with limited energy reservoirs':
h) FCR providing units or FCR providing groups are deemed as with limited energy reservoirs in case a full continuous activation for a period of 2 hours in either positive or negative direction might, without consideration of the effect of an active energy reservoir management, lead to a limitation of its capability to provide the full FCR activation.
b)i) 'LER Share' means the amount of LER in MW;.
c)a) 'Market induced imbalances' means the 'generation-load imbalance caused by the change in generation set points according to the results of the market scheduling'.
d) 'System droop' means 'the ratio between frequency deviation and steady state power response provided by FCP';
e) 'Time Period', according to Article 156 (9) of System Operation Guideline Regulation, means 'the time for which each FCR provider shall ensure that its FCR providing units or groups with limited energy reservoirs are able to fully activate FCR continuously, as of triggering the alert state and during the alert state';
f)j) 'Long lasting frequency deviation' or 'LLFD' means an 'event with an average steady state frequency deviation larger than the long-lasting frequency threshold over a period longer than the time to restore frequency.
g)k) 'Long-lasting frequency threshold' means a parameter used to identify Long lasting frequency deviation, the default value is 25 mHz..
l) 'Market induced imbalances' means the 'generation-load imbalance caused by the change in generation set points according to the results of the market scheduling'.
h) 'LFC' means 'load frequency control block as defined in Article 3 (18) of System Operation Guideline Regulation.
i) 'FRP' means 'frequency restoration process' as defined in Article 3 (42) of System Operation Guideline Regulation.
j) 'FRP' means 'frequency restoration process' as defined in Article 3 (42) of System Operation Guideline Regulation
k) 'FAT' means 'automatic FRR Full Activation Time' as defined in Article 3 (101) of System Operation Guideline Regulation.
l)a) 'Equivalent reservoir energy capacity' means the energy requirement for LER associated to the Time Period and shall amount to twice the energy provided by the full activation of LER for the Time Period.
m)a) 'frequency nadir' is the minimum instantaneous frequency reached during an underfrequency transient.
n)a) 'frequency zenith' is the maximum instantaneous frequency reached during an overfrequency transient.
o)a) 'RoCoF', means Rate of Change of Frequency, is the derivative of the frequency.
p) 'Initial RoCoF', is the RoCoF calcualated at the time in which a disturbance happens.
q)m) 'Maximum Transient Frequency Deviation' is the difference in absolute value between the frequency at the time in which the disturbance happens and the frequency nadir for under-frequency or the frequency zenith for over-frequency phenomena. It represents the maximum frequency excursion before frequency starts to recover.
r)n) 'Maximum Initial RoCoF' is maximum RoCoF acceptable during a transient.
o) 'RoCoF', means Rate of Change of Frequency, is the derivative of the frequency.
p) 'System droop' means 'the ratio between frequency deviation and steady state power response provided by FCP'.
'Time Period', means 'the time
q) In this probabilistic methodology for which each FCR provider shall ensure that its FCR providing units or groups with limited energy reservoirs are able to fully activate FCR continuously, as of

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triggering the alert state and during the alert state' as determined according to Article 156(9) of the System Operation Guideline.

3.4. In this dimensioningdocument, unless the context requires otherwise:

a) the singular indicates the plural and vice versa;
b) references to an "Article" are, unless otherwise provided, any reference to an Article meansstated, references to an articleArticle of this probabilistic methodology for FCR dimensioning;document;
c) the table of contents and headings are inserted for convenience only and do not affect the interpretation of thisthe probabilistic methodology for FCR dimensioning; and
d) any reference to legislation, regulation, directive, order, instrument, code or any other enactment shall include any modification, extension or re-enactment of it then in force.

Article 3
Outcome of the probabilistic methodology for FCR dimensioning

The outcomeoutcomes of the probabilistic methodology for FCR dimensioning is a symmetrical value in MW for FCR for the entire Continental Europe synchronous area in accordance with Article 153 of the System Operation Guideline Regulation.

1. , computed according to the process described in Article 4 Probabilistic Simulation Model.

Article 4
FCR dimensioning criteria and process

1. The Probabilistic Simulation Model shall be able to calculate asymmetrical value for FCR for the entire Continental Europe synchronous area represents the minimum amount of FCR needed in accordance with Article 153 of the System Operation Guideline RegulationSO GL, taking into account the pattern of load, generation and inertia, including synthetic inertia as well as the available means to deploy minimum inertia in real-time in accordance with the methodology referred to in Article 39 of the System Operation Guideline RegulationSO GL, with the aim of reducing the probability of insufficient FCR to below or equal to once in 20 years.

2. The following sources of frequency disturbance shall be inputssymmetrical value for FCR for the entire Continental Europe synchronous area is computed by the mean of an iterative procedure as follows:
   a) the process starts by setting a FCR value equal to the reference incident;
   2.b)the FCR value is tested by the mean of the Probabilistic Simulation Model: referred to in Article 5;
   a) Deterministic frequency deviation.
      The TSOs shall consider the market induced imbalances, analyse frequency historical trends of the synchronous area over several years, and statistically determine the typical trends and amplitudes of these frequency deviations in order to use them as an input of the Probabilistic Simulation Model.
   b) Long lasting frequency deviation.
      The TSOs shall take into account Long lasting frequency deviations. They shall analyse frequency historical trends in order to characterize the phenomena from a statistical point of view. The analysis shall determine:
      • the number of occurrences of these events;

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Commented [A1]: The detailed model should be in annex (and approved). Or put in the text depending on the complexity of the details. All the relevant parameters shall be excluded in order to avoid a reapproval every change

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- the typical duration;
- a representative frequency deviation trend;
- typical time of occurrence, if highlighted by statistical analysis.

c) Outages of relevant grid elements. if the FCR is deemed sufficient according to the criteria in Article 7, the procedure stops, otherwise the FCR value is increased by 100 MW and a new iteration is run;

d) the process continues until a sufficient FCR value is detected.

Article 5
Probabilistic Simulation Model

1. The Probabilistic Simulation Model simulates the behaviour of the whole Continental Europe synchronous area in terms of frequency trends, testing the efficiency of the value of FCR in ensuring a proper frequency quality according to the frequency acceptance criteria in Article 6. .

c)

The TSOs shall define a list of all the grid elements whose outages lead to relevant power imbalances and indeed to relevant FCR activation.

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3.2. The Probabilistic Simulation Model shall implement a function to calculate the dynamic frequency response consequent to a disturbance. Such function shall consider the variation in power imbalance between two following calculation steps and calculate the key parameters of the frequency transient: frequency Nadir, frequency Zenith and RoCoF. To limit the computational effort, the calculations can be based on an simplified single-busbar dynamic model. Such model implements the following linear transfer functions: equation of motion, which models the response of the power systems in terms of inertia and self regulation of load, droop, which models tha static characteristic of the FCP, and the equivalent dynamic of FCR provision, which models the combined effects of the dynamic responses provided by all FCR providers.(frequency nadir, frequency zenith and RoCoF), along with the steady state frequency deviation considering the system droop. The models parameters are tuned to provide the best equivalent behaviour of the power system.

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4. The Probabilistic Simulation Model shall be used to calculate the requested FCR in the scenario described in Article 6. Therefore, also the following variables represent inputs for the model:

a) Time Period;

b) LER Share;

c) FAT of the synchronous area.

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5. The Probabilistic Simulation Model calculates the required FCR using an iterative method. At every iteration, the Probabilistic Simulation Model uses a Probabilistic Simulation Process in order to verify if the frequency is within frequency acceptance criteria. If the criteria are not fulfilled, the Probabilistic Simulation Model increases gradually the FCR and calculates the next iteration. The iterations stop once the condition is fulfilled.

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6.3. The Probabilistic Simulation Process shall be able to simulate several years of operation conditions of the synchronous area by means of random draws of long lasting frequency deviations, deterministic frequency deviations and outages of relevant grid elements. It has the aim to generate a large number of random combinations of all the possible sources of frequency disturbance. Since the Probabilistic

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Simulation Process works on the time domain, this approach requires to simulate a long system operation period.power imbalances associated to DFDs, LLFDs, and outages of relevant grid elements. For each simulated year a power imbalance trend is determined and the corresponding frequency deviation and relevant parameters are computed according to the function described in paragraph 2.
The operation period to be simulated shall be estimated to generate statistically significant results and to provide the best compromise between the desired level of accuracy and computational time efforts, and not less than; in any case at least 200 years shall be simulated.
The time discretization adopted by the Probabilistic Simulation Process shall be 1- minute. Each variable shall thus be calculated on a 1-minute basis.

4. Input power imbalances deriving from DFDs and LLFDs are computed by the mean of an algebraic relation simulating the steady state behaviour of the system.

5. Power imbalances associated to outages of relevant grid elements are determined simulating the FRP with a single FRP controller without FRR limitations. The single FRP controller shall use a FAT calculated as an average of the FAT of all the LFC areas belonging to the synchronous area weighted by the FRR K-factors, until the FAT will be harmonized.

6. The annual review of FRR K-factors can be neglected as long as the review does not affect signicantly the average FAT as defined in paragraph 5.

7. The Probabilistic Simulation Process can neglect the entire Cross-Border Load-Frequency Control Process.

7.8. The Probabilistic Simulation Process shall be able to simulate the depletion of LER and its effects on the frequency deviation, taking into account the LER Share and the Time Period. If an alert state is detected, as of triggering the alert state and during the alert state, the depletion of the LER is simulated considering that the energy content in the reservoir as of triggering the alert state allow the LER to fully activate FCR continuously for a period equal to the Time Period.

Article 5
Frequency acceptance criteria

9. The dimensioning process is implemented through the iterative increase of More details about the Probabilistic Simulation Model as describedare reported in the Annex.

Article 6
Sources of power imbalances

1. As detailed in the Annex and mentioned in Article 4(5). The condition5(3), the Probabilistic Simulation Model shall take into account:
   a) Outages of relevant grid elements,
   b) Deterministic frequency deviations (DFDs),
   c) Long lasting frequency deviations (LLFDs).

2. For DFDs and LLFDs, the TSOs shall consider the market induced imbalances and analyse frequency historical trends of the synchronous area over a number of years, as defined by the Continental Europe TSOs according to Article 9.

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3. For outages of relevant grid elements the TSOs shall define a list of all the grid elements whose outages lead to relevant power imbalances and indeed to relevant FCR activation.

Article be assessed at7
Frequency acceptance criteria

1. At each iteration, all Critical Conditions occurring in each simulated year are identified by checking whether a serie of minutes, spaced each other not more than a parametrical number of minutes meets one or more of the following criteria:
   a) The Steady State Frequency Deviation exceeds the steady state maximum frequency deviation.
   b) The frequency nadir or frequency zenith during a frequency transient exceeds the admissible thresholds, as defined by the Continental Europe TSOs according to Article 9.
   c) The absolute value of RoCoF exceeds the Maximum Initial RoCoF, as defined by the Continental Europe TSOs according to Article 9.

1.2. The is thatFCR considered is deemed sufficient when the number of identified Critical Conditions is less than or equal to 1/20 of the number of simulated years. Such condition shall be fulfilled by the final dimensioned FCR.

2. A Critical Condition is defined as one of the following conditions:
   a) The Steady State Frequency Deviation as simulated by the Probabilistic Simulation Model exceeds the steady state maximum frequency deviation.
   b) The frequency nadir or frequency zenith during a frequency transient exceeds the Maximum Transient Frequency Deviation.
   c) The absolute value of RoCoF exceeds the Maximum Initial RoCoF.

Article 6
Simulation scenario

The analyses and processes described in Article 4 shall be performedArticle 8
Simulation scenarios

1. The symmetrical value for FCR for the entire Continental Europe synchronous area is determined every two years, considering the best estimations of the input data regarding the evolution of sources of frequency disturbances)(taking into account the frequency management procedures implemented in the meantime by the Continental Europe TSO)s,TSOs), the expected LER shares, their respective Time Period and any other factor impacting the calculation and dimensioning of FCR.

Article 7
Further assumptions

1. The Probabilistic Simulation Model and the Probabilistic Simulation Process described in Article 4 shall be referred to the whole synchronous area.
   2. The Probabilistic Simulation Process shall simulate the FRP with a single FRP controller without FRR limitations. The single FRP controller shall use a FAT calculated as an average of the FAT of all the LFC areas belonging to the synchronous area weighted on FRR K-factor, until the FAT will be harmonized, according to the Implementation Framework for aFRR balancing energy platform.

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3.1. The Probabilistic Simulation Process can neglect the entire Cross-Border Load-Frequency Control Process.

2. In case there are significant changes in the input datasets, the TSOs may, on their own initiative, redetermine the symmetrical value for FCR for the entire Continental Europe synchronous area even before the two years period foreseen in paragraph 1.

3. The national regulatory authorities of the Continental Europe synchronous area have the right to send the TSOs a coordinated request for the redetermination of the The symmetrical value for FCR for the entire Continental Europe synchronous area.

Article 9
Reporting

1. Before each run of the FCR dimensioning process pursuant to Article 4, the TSOs shall provide the national regulatory authorities of the Continental Europe synchronous area with the values, and justifications for each value, of all the relevant thresholds adopted to assess the frequency acceptance criteria of Article 7, and all the parameters described in the Annex.

4. The TSOs shall The Probabilistic Simulation Process shall simulate the FRP deployment dynamic and the system droop.

5. If a continuous exceeding of the standard frequency range includes the triggering of an alert state, the activated energy and the residual energy in the reservoir is calculated from the first exceeding of the standard frequency range limits.

6. At the full availability of the reservoir, send to the energy level will be considered equal to halfnational regulatory authorities of the Equivalent reservoir energy capacity.Continental Europe synchronous area at the end

7.2. The annual review of FRP K-factors (Article 156 (2)each run of System Operation Guideline Regulation) can be neglected as long as the review does not affect signicantly the average FAT as defined inthe FCR dimensioning process pursuant to Article 7(2).4 a report listing:

i. the mitigation measures considered in the LLFDs dataset and how they were taken into account;
ii. the main parameters adopted to assess the frequency acceptance criteria and the reasons behind their choice;
iii. the symmetrical value for FCR;
iv. the reasonings behind the choice to redetermine the symmetrical value for FCR in case such redetermination occurs on initiative of the TSOs according to Article 8(2);

Article 10
Publication and implementation of the probabilistic methodology for FCR dimensioning

1. Each Continental Europe TSO shall publish the probabilistic methodology for FCR dimensioning without undue delay after all NRAsthe national regulatory authorities of the Continental Europe synchronous area have approved the proposed probabilistic methodology for FCR dimensioningdocument, in accordance with Article 8 of the System Operation Guideline RegulationSO GL.

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2. The Continental Europe TSOs shall have implemented the probabilistic methodology for FCR dimensioning within 12 months after the national regulatory authorities of the Continental Europe synchronous area have approved the document.

2.3. Within 1 month from the approval of the FCR dimensioning by 12 months after its approval by allthe national regulatory authorities of the CEContinental Europe synchronous areas. The implementation area, the Continental Europe TSOs shall take place by submitting the resultsorganize a series of the applied probabilistic methodology for FCR dimensioning conducted bymeeting with the TSOs of the CE synchronous areas according to the probabilistic methodology for FCR dimensioning to the concernedabove mentioned regulatory authorities for informationin order to keep discussing how the FCR obligation may be identified in order to allocate more responsibilities to the LFC blocks causing the most significant LLFDs.

3. The Continental Europe TSOs shall have the right to implement the probabilistic methodology for FCR dimensioning every two years following the first implementation defined in Article 8(2).

4. The Continental Europe TSOs shall have the right to implement the probabilistic methodology for FCR dimensioning whenever the input defining the scenario change

Article 11

Article 9
Language

1. The reference language for this methodology shall be English. For the avoidance of doubt, where TSOs need to translate this methodology into their national language(s), in the event of inconsistencies between the English version published by TSOs in accordance with Article 8(1) of the System Operation Guideline RegulationSO GL and any version in another language, the relevant TSOs shall, in accordance with national legislation, provide the relevant national regulatory authorities with an updated translation of the methodology.

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