ACER
European Union Agency for the Cooperation of Energy Regulators

ACER Decision on the Amendment of the Methodology for Coordinating Operational Security Analysis: Annex I

Amendment of the Methodology for Coordinating Operational Security Analysis

in accordance with Article 75 of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation

14 June 2021

Contents

Whereas

(1) This document amends the methodology for coordinating operational security analysis (CSAM) in accordance with Article 75 of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation ('SO Regulation') of 19 June 2019 (approved by Decision No 07/2019 of the Agency for the Cooperation of Energy Regulators of 19 June 2019 on the all TSOs' proposal for the Methodology for coordinating operational security analysis). This document is hereafter referred to as the 'Amendment to the CSAM'.

Article 1

Amendment to the CSAM

1. The methodology for coordinating operational security analysis (CSAM) in accordance with Article 75 of the SO Regulation of 19 June 2019 (approved by Decision No 07/2019 of the Agency for the Cooperation of Energy Regulators of 19 June 2019 on the all TSOs' proposal for the Methodology for coordinating operational security analysis) is amended as follows:

i. A recital, numbered (x) is added to the CSAM recitals and shall read as follows:

"(x) In accordance with Article 35(2) of Regulation 2019/943 of the European Parliament and of the Council on the internal market for electricity (hereafter referred to as "Electricity Regulation"), the regional coordination centres ('RCCs') shall replace the RSCs established pursuant to the SO Regulation and shall enter into operation by 1 July 2022."

ii. In Article 2 of the CSAM, the following definitions and abbreviations shall be added:

a. 'native CCR' means a CCR to which an XNE is attributed within the ROSC process
b. 'non-native CCR' means a CCR to which an XNE is not attributed within the ROSC process
c. the abbreviation 'RAIF' is added, for remedial action influence factor,
d. the abbreviation 'CROSA' is added, for coordinated regional operational security assessment.
e. 'Setpoint' means a state or target value of an individual network element or set of network elements to impact active power flows and/or control voltage and/or manage reactive power, such as but not limited to a Phase-Shifting Transformer (PST), a HVDC system or a Flexible Alternating Current Transmission System (FACTS).

iii. Article 21 of the CSAM shall be amended as follows:

“**Article 21**
Remedial actions inclusion in individual grid models

1. When preparing individual grid models (IGM) pursuant to Article 70 of the SO Regulation, each TSO shall include all remedial actions already agreed as a result of previous coordinated operational security analyses in accordance with Article 17(1) and Article 18(4) or previous coordinated regional operational security assessments (CROSA) in accordance with Regional Operational Security (ROSC) methodologies pursuant to the Article 76 of the SO Regulation.
2. When preparing individual grid models pursuant to Article 70 of the SO Regulation, each TSO shall have the right to perform a local preliminary assessment.
3. When preparing individual grid models pursuant to Article 70 of the SO Regulation, in addition to the remedial actions referred to in paragraph (1) and taking into account where applicable the results of the local preliminary assessment referred to in paragraph (2), each TSO may include in the individual grid model any XRA in accordance with paragraph (5) or any non-XRA in accordance with Article 21(1)(a) of the SO Regulation.
4. Remedial actions included pursuant to paragraphs (1) and (3) shall be clearly distinguishable from the injections and withdrawals established in accordance with Article 40(4) of the SO Regulation and the network topology without remedial actions applied. The injections and withdrawals shall by default be determined by each TSO based on the latest market schedules and forecasts of load and intermittent generation in accordance with Articles 38 and 37, respectively. Any deviation from these default assumptions shall be considered as a remedial action.
5. In the day-ahead timeframe, when preparing the IGMs referred to in Article 33(1)(a), for the topology or setpoint of any network element, injections and withdrawals, each TSO shall include the best-forecast of the operational situation or schedules from the integrated scheduling process, in accordance with Articles 67(1) and 70(1) of the SO Regulation and in accordance with the paragraphs (1), (2), (3) and (4).
6. In addition to paragraph (5), any topology and setpoint of any network element included in the day-ahead IGMs referred to in Article 33(1)(a) shall be considered as forecast topology or setpoint and no remedial actions on topology or setpoints shall be determined at this stage.
7. All subsequent IGMs, which include IGMs updated in the day-ahead timeframe and IGMs in intraday timeframe, shall modify or include new XRAs, compared to the previous IGMs, on topology, setpoints, injections or withdrawals, only if:
   a) these XRAs are agreed in the latest ROSC according to the methodology pursuant to Article 76 of the SO Regulation; or
   b) the change is related to the XRAs which are no longer technically available.
8. If required by at least one TSO from the concerned CCRs, TSOs of a concerned CCR shall agree on detailed rules on how to meet the best-forecast approach of the topology or set-point of any network element pursuant to paragraph (6).
9. RSCs shall monitor topology and setpoints included in the IGMs as a solution for the improvement of forecasts and to prevent unfair behaviour of TSOs that could impact the operational security and economic efficiency.

iv. Article 27 of the CSAM shall be amended as follows:

“Article 27
Overlapping zones, XNEs and XRAs

1. Where a network element has been defined as an XNE and where the physical flows on this XNE are significantly impacted by activation of XRAs in two or more CCRs as referred in paragraph (4), this XNE shall be defined as overlapping XNE. Such overlapping XNEs shall be grouped into overlapping zones and the concerned CCRs shall be considered as impacting CCRs for these overlapping zones.
2. The operational security violations on an overlapping XNE, as defined in paragraph (4), shall be addressed at a regional level first, in its native CCR, together with other XNEs of this CCR:
    a) In case an overlapping XNE is a cross-zonal network element, the native CCR is the CCR to which the concerned bidding zone border is attributed;
    b) In case an overlapping XNE is an internal CNE used in capacity calculation in only one CCR, this CCR shall be the native CCR;
    c) In case an overlapping XNE is an internal XNE not covered by point (b), the XNE connecting TSO shall perform an analysis to identify a native CCR such that the operational security violations on such XNE can be addressed the most effectively and economically efficient.

    In case of a reasoned objection and request from any TSO of the concerned CCRs on the analysis or appointment of the XNE pursuant to (c), the XNE connecting TSO shall demonstrate that the operational security violations on the concerned XNE can be addressed the most effectively and economically efficient within the originally appointed native CCR. If this cannot be demonstrated, RSCs and TSOs of concerned CCRs shall cooperate and agree on the native CCR of such an XNE.
3. The XRA connecting TSO(s) shall appoint each individual XRA to a single impacting CCR. When doing so, TSO(s) shall take into account the assumptions on remedial actions considered in the capacity calculation methodologies established pursuant to Articles 20 and 21 of the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (CACM Regulation).
4. Overlapping XNEs shall be assessed through a quantitative approach by TSOs with support from RSCs, according to the following process:
    a) Individual remedial action influence factor shall be computed for each XRA appointed to a given CCR (a non-native CCR) against all XNECs which are appointed to a different CCR (their native CCR) according to paragraph (2);
    b) XRAs consisting of a combination of multiple devices operated simultaneously in a common way (e.g. parallel PSTs operated with same tap position) shall be considered as an individual XRA and are therefore associated to an individual remedial action influence factor, in accordance with Article 14 of CSAM. Such XRAs consisting of a combination of multiple devices shall be defined by the XRA connecting TSO;
    c) All XRAs that have an individual remedial action influence factor (at maximum range) below 1% shall be discarded. The remaining XRAs shall be grouped per CCR in accordance to paragraph (3);

d) The maximum potential impact of XRAs from a non-native CCR, upon the XNECs appointed to their native CCR according to sub-paragraph (c), is computed as a sum of the absolute values of the remedial action influence factors of the group of XRAs of the considered non-native CCR;

e) If the maximum potential impact of XRAs from a non-native CCR on at least one XNEC with contingencies (appointed to a different, its native CCR) is higher than or equal to 5%, this XNE is labelled as overlapping XNE and its native CCR is labelled as impacted by the considered non-native CCR; and

f) The XRAs from point e) used to identify overlapping XNEs are defined as overlapping XRAs.

5. Overlapping XNEs are assessed on a yearly basis using the CGMs built for the year ahead scenarios established according to article 65 of SO Regulation and on TSO request in case of significant changes occurred in the grid (e.g. commissioning/decommissioning of relevant network elements, forced outages, etc.), using updated year-ahead common grid models in accordance with Article 68 of the SO Regulation. Requesting TSO shall provide a sound justification for such a reassessment. If an XNE is identified as overlapping XNE during the assessment of at least one of the models, this XNE becomes an overlapping XNE as long as there is no new yearly assessment and it participates in further steps of the cross-regional coordination process. Methodology for the appointment of overlapping XNEs and overlapping XRAs shall be re-evaluated and if needed amended on a biennial basis.

6. For the day-ahead timeframe, the residual operational security violations, remaining after each CROSA is finalised, shall be addressed with a common cross-regional coordination process involving TSOs and RSCs of all impacting CCRs. In the period after the implementation of regional ROSCs and before the implementation of cross-regional process, the currently applied processes of managing the residual congestions shall be kept. In case of severe grid violations on overlapping XNEs or repeated issues of residual congestions related to excessive redispatching costs at overlapping XNEs, a concerned connecting TSO may trigger the application of the conservative approach pursuant to paragraph (8) as a last resort measure, previously demonstrating that there are no other viable alternatives.

7. For intraday timeframe, the default approach is to perform a cross-regional coordination process to address residual operational security violations, in accordance with Article 30, after any intraday coordinated regional operational security assessment. The TSOs from a CCR shall communicate to relevant RSCs, at least on a yearly basis, if intraday CROSA is not followed by a cross-regional coordination process due to time constraints or according to an agreement between concerned CCRs. In this case, a conservative approach shall be implemented for intraday CROSA, pursuant to paragraph (8).

8. Under the conservative approach the related regional CROSA process shall ensure that the loading of each overlapping XNEC is not increased more than a maximum percentage of the remaining margin obtained in the CGM to reach its current limit. When the overlapping XNEC is not overloaded, the remaining margin of an overlapping XNE is the absolute value of the difference between the thermal limit (in Amperes and assumed positive) and the absolute value of the active current flow (in Amperes) on this overlapping XNE in the last intraday CGM before the next intraday CROSA is performed. The remaining margin shall be set to zero in case the overlapping XNE is already overloaded.

   The maximum percentage appointed to a non-native CCR shall by default be 10% of the remaining margin. This maximum percentage of the remaining margin can be reassessed during the implementation or also at a later stage upon agreement of all TSOs. ENTSO-E shall publish the final value.

9. When residual overloads are identified during the common cross-regional coordination process:

   a) If violations are located on overlapping XNEs as referred to in paragraph (4)(e), the effective XRAs (i.e. overlapping XRAs) of the impacting CCRs shall be used to solve these violations;

   b) RSCs may propose additional remedial actions in accordance with Article 31.

10. To ensure consistent interaction between CROSAs and coordinated cross-regional operational security assessment, residual violations shall be identified by RSCs with application of the contingency list from each CCR and the inclusion of all XRAs agreed within each CROSA. All XRAs agreed during each CROSA can be re-evaluated during the coordinated cross-regional operational security assessment.

11. RSCs of the concerned CCRs shall identify and propose solutions to manage residual violations with at least the available input data and RSCs' supporting tools, and with respect to the time constraints of day-ahead and intraday processes. The identification of technically and economically efficient remedial actions to address residual operational security violations at cross-regional level shall be done with the aim to solve residual overloads while:

   a) not generating new overloads on any XNE;

   b) minimizing the costs of remedial actions;

   c) respecting the technical, operational, procedural and legal constraints defined by each TSO within the CROSA; and

   d) minimizing changes of agreed XRAs within each CROSA.

   The XRA affected TSOs shall evaluate the resulting recommended XRAs in accordance with Article 17(6) and 17(7).

12. In the implementation of Articles 78, 80 and 81 of the SO Regulation, RSCs and TSOs shall take into account the agreements reached in accordance with paragraphs (1) to (11).

13. The rules for sharing of costs of overlapping XRAs activated to address the residual operational security violations by assigning the shares of costs to individual overlapping XNEs i.e. the mapping process, are provided in the Appendix to this Article. An outcome of the mapping process are the portions of costs of overlapping XRAs appointed to each overlapping XNE.

14. The costs resulting from solving residual violations on overlapping XNEs during the coordinated cross-regional operational security assessment shall be subject to cost-sharing process among CCRs. The costs appointed to each overlapping XNE shall be shared proportionally to the burdening flows created by activation of XRAs in all concerned CCRs (including as well the native CCR) during their CROSAs. The burdening flows induced by a CCR on an overlapping XNE are computed as the maximum between zero and the difference between the absolute value of the flow (in Amperes) calculated in the CGM after CROSA in this CCR and the absolute value of the flow (in Amperes) calculated in the initial CGM before any CROSA has taken place. For the native CCR, the burdening flow is increased by the remaining overload after its CROSA, if any.

$$c_{i,r} = \frac{\Delta f_{i,r}}{\sum_r \Delta f_{i,r}} c_i \quad (2.1)$$

$$\Delta f_{i,r} = \begin{cases} \max(\ 0;\ |f_{i,r}^{afterCROSA}| - |f_i^{beforeCROSA}|) + \Delta f_{i,r}^{remaining}, & \text{if } r \text{ is a native CCR} \\ \max(\ 0;\ |f_{i,r}^{afterCROSA}| - |f_i^{beforeCROSA}|) & \text{if } r \text{ is a non} - \text{native CCR} \end{cases} \quad (2.2)$$

$$\Delta f_{i,r}^{remaining} = \max(\ 0;\ |f_{i,r}^{afterCROSA}| - I_{max,i}) \quad (2.3)$$

c_i	Share of total costs of all XRAs applied at cross-regional process, attributed to overlapping XNEC i [€]
$c_{i,r}$	Share of costs c_i attributed to overlapping XNEC i , further attributed to CCR r [€]
$\Delta f_{i,r}$	Additional burdening flow at overlapping XNEC i induced by CROSA applied in CCR r [A]
$f_{i,r}^{afterCROSA}$	Absolute flow at overlapping XNEC i induced by CROSA applied in CCR r [A]
$f_i^{beforeCROSA}$	Absolute flow at overlapping XNEC i before CROSAs [A]
$\Delta f_{i,r}^{remaining}$	Remaining overload after the CROSA in a native CCR
$I_{max,i}$	Permanent thermal limit (PATL) of an overlapping XNEC i [A], assumed positive

15. The cross-regional process and related cost-sharing process among CCRs described in paragraph (14) shall apply for a given overlapping XNE with all the XRAs agreed at regional level consistently included in the CGM used for the cross-regional process for the concerned CCRs. If this is not the case, the cost resulting from solving the residual operational security violations on the overlapping XNE shall be allocated to the native CCR. The cases of failing in the provision from the first sentence shall be closely monitored by the TSOs and RSCs from the concerned CCRs.

16. Any XRA agreed outside the coordinated cross-regional operational security assessment or any XRA agreed to solve a constraint on an XNE which is not an overlapping XNE cannot impose cost sharing among CCRs.

17. The process described under paragraphs (13) to (16) shall determine the costs allocated to each concerned CCR to solve operational security violations on overlapping XNEs during the cross-regional operational security assessment. As a subsequent step, identification of regional XRAs which caused residual overloads on overlapping XNEs shall be performed, in order to appoint the cross-regional coordination costs to XNEs whose overloads were resolved by these XRAs during the regional CROSAs.

    At each overlapping XNEC with residual overloads, and for each CCR separately, the following steps shall be applied:

    a) The XRAs with linear characteristic shall be taken into account. This includes costly remedial actions, as well as non-costly remedial actions with characteristic close to linear, such as PST and HVDC;

    b) The burdening and relieving flows caused by the XRAs on an overlapping XNEC during regional CROSA shall be calculated, where only the XRAs defined under (a) are taken into account. These flows shall be calculated on the CGM with applied topology changes;

c) The burdening flows by XRAs are normalised with their total sum of burdening flows at each overlapping XNE, as provided in the equation 3.1;

d) The cross-regional costs on XNECs appointed to each CCR pursuant to paragraph (14) are assigned to individual XRAs applied at regional CROSAs, proportionally to their normalised burdening effect from point (c), as provided in the equation 3.2;

e) The costs from point (d) are assigned to the XNECs whose congestions were relieved by the individual XRAs at the regional CROSAs, pursuant to the mapping process applied in each CCR; and

f) Regional cost-sharing methodologies shall then be applied for the costs by the regional CROSAs and the additional costs from the cross-regional optimisation pursuant to paragraph (17).

$$\Delta f_{i,r,x}^{normalised} = \frac{\Delta f_{i,r,x}}{\sum_{r,x} \Delta f_{i,r,x}} \quad (3.1)$$

$$c_x = \sum_i \Delta f_{i,r,x}^{normalised} * c_{i,r} \quad (3.2)$$

$\Delta f_{i,r,x}$	Burdening flow at overlapping XNEC *i* induced by regional XRA *x (only the linearized non-costly XRAs)* applied in CCR *r* [A]
$\Delta f_{i,r,x}^{normalised}$	Normalised burdening flow at overlapping XNEC *i* induced by regional XRA *x* applied in CCR *r* [A]
$c_{i,r}$	Share of total costs of cross-regional process, attributed to overlapping XNEC *i* , further attributed to CCR *r* [€]
c_x	Share of total costs of cross-regional process, attributed to regional XRA *x* [€]

"

18. The cross-regional methodology for the overlapping XNEs each group of CCRs pursuant to paragraph (1) shall be applied not later than 18 months after the last among the concerned CCR apply the implementation of the target solution of ROSC Methodology pursuant to the Article 76 of the SO Regulation. The determination of the mutually impacted CCRs shall be performed during the 1st month of the implementation period."

v. An Annex II shall be added to the CSAM as an appendix to Article 27, and it shall read as follows:

"Appendix to Article 27: Mapping of inter-regional XRA costs

1. All TSOs shall distribute the costs and revenues of cross-border relevant redispatching and countertrading actions eligible for cost sharing, arising during the common cross-regional coordination process, to each hour and each individual XNE eligible for cost sharing associated with a single reference contingency (or N-situation) that represents the worst contingency to be determined and agreed among TSOs. Any reference to XNEC in the remainder of this Appendix

shall be understood as referring to XNE with this single reference contingency (or N-situation) unless otherwise defined in paragraph 5.

2. The costs and revenues of each XRA eligible for costs sharing pursuant to paragraph 1 shall first be split into hourly costs using the following principles:

   (a) The costs and revenues of an XRA, which are attributed clearly to a specific hour (such as activated redispatching energy), shall remain associated only to that hour;

   (b) The costs and revenues of an XRA, which cannot be attributed clearly only to one specific hour, shall be split equally between the multiple hours to which these costs are attributed;

   (c) The costs and revenues of an XRA, which have been attributed to hours in which there was no congestion in the CCR, shall be set to zero; the costs and revenues of such XRA in other hours (considered in the same RAO) in which there was a congestion in the CCR, shall be increased proportionally for the same amount; and

   (d) The incurred costs of curative XRAs shall be considered when the associated contingency materializes, otherwise they shall be equal to zero. Further, curative XRAs shall be considered in paragraph 3 and 4(e)(ii) only when they are associated to the eligible XNECs.

3. Subsequently, the costs and revenues of all XRAs for a specific hour as determined pursuant to paragraph 2 shall be summed up and split between all XNECs eligible for cost sharing in accordance with the following formula (all variables are applicable for the specific hour h):

$$C^{all} = \sum_j C_j \tag{1.1}$$

$$c_i = \frac{r_i}{\sum_i r_i} C^{all} \tag{1.2}$$

$$r_i = r_i^{direct} + r_i^{indirect} \tag{1.3}$$

$$r_i^{direct} = \sum\nolimits_j \alpha_{i,j}^{norm} C_j \tag{1.4}$$

$$\alpha_{i,j}^{norm} = \begin{cases} 0 & \text{if } \sum_i \alpha_{i,j} = 0 \\ \dfrac{\alpha_{i,j}}{\sum_i \alpha_{i,j}} & \text{if } \sum_i \alpha_{i,j} > 0 \end{cases} \tag{1.5}$$

and $\alpha_{i,j}$ is calculated by solving the following optimisation (Equations (1.6) to (1.11)) for all XNECs for which the condition $|F'_{b,i}| > |F_{max,i}|$ is valid:

$$\min_{\alpha,\beta} \left(\sum_j \alpha_{i,j} C_j + \sum_k c_p T_k \beta_{i,k} \right) \tag{1.6}$$

$$0 \leq \alpha_{i,j} \leq 1 \tag{1.7}$$

$$0 \leq \beta_{i,k} \leq 1 \tag{1.8}$$

$$\sum_{j \in RDCT} \alpha_{i,j} V_j = 0 \tag{1.9}$$

$$\sum_j \alpha_{i,j} V_j PTDF_{i,j} + \sum_k \beta_{i,k} T_k PSDF_{i,k} = F_{limit,i} - F'_{b,i} \tag{1.10}$$

$$F_{limit,i} = \begin{cases} F_{max,i} & \text{if} \quad 0 \leq F_{a,i} \leq F_{max,i} \leq F'_{b,i} \\ -F_{max,i} & \text{if} \quad F'_{b,i} \leq -F_{max,i} \leq F_{a,i} < 0 \\ F_{a,i} & \text{if} \quad F_{max,i} \leq |F_{a,i}| \leq |F'_{b,i}| \\ F'_{b,i} & \text{if} \quad F_{max,i} \leq |F'_{b,i}| < |F_{a,i}| \end{cases} \tag{1.11}$$

with

c_i	Share of total costs of all XRAs attributed to XNEC *i* [€]
r_i	Relative weight of XNEC *i* in cost sharing [€]
r_i^{direct}	Relative weight of XNEC *i* in cost sharing, due to direct costs [€]
$r_i^{indirect}$	Relative weight of XNEC *i* in cost sharing, due to indirect costs [€]
C^{all}	Total costs or revenues of all ordered XRAs at a given CROSA [€]
$\alpha_{i,j}$	Optimisation variable representing a fraction of optimal volume V_j of XRA *j* (consisting of redispatching or countertrading) determined by RAO which is needed to solve the congestion on XNEC *i*
$\alpha_{i,j}^{norm}$	Normalised optimisation variable $\alpha_{i,j}$
$\beta_{i,k}$	Optimisation variable representing a fraction of the T_k determined by RAO which is needed to solve the congestion on XNEC *i*
C_j	Total cost or revenue of applied XRA *j* [€]
V_j	The optimal volume of ordered XRA *j* (consisting of redispatching or countertrading) determined by RAO at a given CROSA and for the considered contingency [MW]
T_k	The optimal change of tap of ordered XRA *k* (consisting of PSTs), which is the difference between the tap of this XRA before the RAO and the optimal tap determined by RAO at a given CROSA and for the considered contingency
$PTDF_{i,j}$	Power transfer distribution factor describing the impact of a change of 1 MW of XRA *j* on the physical flow on XNEC *i*
$PSDF_{i,k}$	Phase shifting distribution factor describing the impact of a change of 1 tap position of PST *k* on the physical flow on XNEC *i* [MW]
$F'_{b,i}$	Adjusted total flow on XNEC *i* [MW]
$F_{max,i}$	Maximum flow on XNEC *i* [MW]
$F_{a,i}$	Total flow on XNEC *i* calculated after RAO, which includes the impact of all XRAs [MW]
c_p	Small fictious penalty cost for the activation of a tap of a PST [€]. Such value shall be small enough to not impact the selection of the ordered XRA *j* (consisting of redispatching or countertrading). c_p is proposed to be equal to 0,01 and could be reassessed during Implementation.

It is set $r_i^{direct} = 0$ for all XNECs for which the condition $|F'_{b,i}| \leq |F_{max,i}|$ is valid.

The effects of the PSTs on the XNECs are calculated as follows:

$$\delta_{i,k} = PSDF_{i,k} \cdot T_k \tag{1.12}$$

$$\delta_{i,k}^{burd.} = \begin{cases} 0 & \text{if} \quad \delta_{i,k} \cdot F'_{b,i} \leq 0 \\ \delta_{i,k} & \text{if} \quad \delta_{i,k} \cdot F'_{b,i} > 0 \end{cases} \tag{1.13}$$

$$\delta_{i,k}^{rel.} = \begin{cases} \delta_{i,k} & \text{if} \quad \delta_{i,k} \cdot F_{b,i}^{'} \leq 0 \\ 0 & \text{if} \quad \delta_{i,k} \cdot F_{b,i}^{'} > 0 \end{cases} \tag{1.14}$$

The first step for calculating the indirect relative weights of each XNEC is to calculate the virtual relative weights $r_i^{virtual}$ for the XNECs which are overloaded when considering the PSTs burdening effects, as follows:

$$r_i^{virtual} = \sum_j \alpha_{i,j}^{norm-PST-adj} C_j \tag{1.15}$$

$$\alpha_{i,j}^{norm-PST-adj} = \begin{cases} 0 & \text{if} \quad \sum_i \alpha_{i,j}^{PST-adj} = 0 \\ \dfrac{\alpha_{i,j}^{PST-adj}}{\sum_i \alpha_{i,j}^{PST-adj}} & \text{if} \quad \sum_i \alpha_{i,j}^{PST-adj} > 0 \end{cases} \tag{1.16}$$

and $\alpha_{i,j}^{PST-adj}$ is calculated by solving the following optimisation (Equations (1.17) to (1.23)) for the XNECs for which the condition $|F_{b,i}^{PST-adj}| > |F_{max,i}|$ is valid:

$$\min_{\alpha,\beta} \left(\sum_j \alpha_{i,j}^{PST-adj} C_j + \sum_k c_p.\, T_k.\, \beta_{i,k}^{PST-adj} \right) \tag{1.17}$$

$$0 \leq \alpha_{i,j}^{PST-adj} \leq 1 \tag{1.18}$$

$$0 \leq \beta_{i,k}^{PST-adj} \leq 1 \tag{1.19}$$

$$\sum_{j \in RDCT} \alpha_{i,j}^{PST-adj} V_j = 0 \tag{1.20}$$

$$\sum_j \alpha_{i,j}^{PST-adj} V_j PTDF_{i,j} + \sum_k \beta_{i,k}^{PST-adj} T_k PSDF_{i,k} = F_{limit,i} - F_{b,i}^{PST-adj} \tag{1.21}$$

$$F_{limit,i} = \begin{cases} F_{max,i} & \text{if} \quad 0 \leq F_{a,i} \leq F_{max,i} \leq F_{b,i}^{PST-adj} \\ -F_{max,i} & \text{if} \quad F_{b,i}^{PST-adj} \leq -F_{max,i} \leq F_{a,i} < 0 \\ F_{a,i} & \text{if} \quad F_{max,i} \leq |F_{a,i}| \leq |F_{b,i}^{PST-adj}| \\ F_{b,i}^{PST-adj} & \text{if} \quad F_{max,i} \leq \left|F_{b,i}^{PST-adj}\right| < |F_{a,i}| \end{cases} \tag{1.22}$$

$$F_{b,i}^{PST-adj} = F'_{b,i} + \sum_k \delta_{i,k}^{burd.} \tag{1.23}$$

It is set $r_i^{virtual} = 0$ for all XNECs for which the condition $|F_{b,i}^{PST-adj}| \leq |F_{max,i}|$ is valid.

The PSTs' virtual costs are then calculated as follows:

$$\gamma_{i,k}^{burd} = \begin{cases} 0 & \text{if } \sum_k \delta_{i,k}^{burd.} = 0 \\ \frac{\delta_{i,k}^{burd.}}{\sum_k \delta_{i,k}^{burd.}} & \text{if } \sum_k \delta_{i,k}^{burd.} \neq 0 \end{cases} \quad (1.24)$$

$$C_k^{virtual} = \sum_i \gamma_{i,k}^{burd} \cdot \left(r_i^{virtual} - r_i^{direct}\right) \quad (1.25)$$

The relative weight due to indirect costs is obtained with the distribution of the PSTs' virtual costs to the XNECs according to the following equations:

$$\beta'_{i,k} = \begin{cases} 0 & \text{if } \sum_i \left(\beta_{i,k}.\delta_{i,k}^{rel.}\right) = 0 \\ \frac{\beta_{i,k}.\delta_{i,k}^{rel.}}{\sum_i\left(\beta_{i,k}.\delta_{i,k}^{rel.}\right)} & \text{if } \sum_i \left(\beta_{i,k}.\delta_{i,k}^{rel.}\right) \neq 0 \end{cases} \quad (1.26)$$

$$r_i^{indirect} = \sum_k \beta'_{i,k} C_k^{virtual} \quad (1.27)$$

with

$\alpha_{i,j}^{PST-adj}$	PST-adjusted optimisation variable representing a fraction of optimal volume V_j of XRA *j* (consisting of redispatching or countertrading) determined by RAO which is needed to solve the congestion on XNEC *i*
$\beta_{i,k}^{PST-adj}$	PST-adjusted optimisation variable representing a fraction of the T_k determined by RAO which is needed to solve the congestion on XNEC *i*
$F_{b,i}^{PST-adj.}$	PST-adjusted total flow on XNEC *i* [MW]
$\delta_{i,k}$	Effect of PST *k* on XNEC *i* [MW]
$\delta_{i,k}^{burd.}$	Burdening effect of PST *k* on XNEC *i* [MW]
$\delta_{i,k}^{rel.}$	Relieving effect of PST *k* on XNEC *i* [MW]
$\beta'_{i,k}$	Relative optimisation variable of optimal T_k and XNEC *i*
$r_i^{virtual}$	Virtual relative weight of XNEC *i* due to the burdening effect of PSTs [€]
$\gamma_{i,k}^{burd}$	Relative burdening effect of PST *k* on XNEC *i*
$C_k^{virtual}$	Virtual cost associated to PST *k*

The principles detailed above to take into account burdening effect of PSTs and their associated virtual costs shall be extended to linear non-costly Remedial Actions (such as HVDC for example) with a similar approach to the one described here for PSTs. The adaptation needed to meet this requirement are not described in this annex but shall be developed during implementation phase by sticking to the PST approach.

4. The following additional rules shall apply for the calculation of variables in paragraph 3:

   (a) If C^{all} is positive/negative and less than half of relative weights r_i of XNECs are lower/higher than 0, these weights shall be set to 0 before applying the Equation 1.2;

(b) If C^{all} is positive/negative and half or more of relative weights r_i of XNEC i are lower/higher than 0, the positive/negative value of the lowest/highest negative/positive weight shall be added to all weights of all XNECs before applying the Equation 1.2;

(c) If C^{all} is positive/negative and all relative weights r_i of XNEC i are 0, new weights shall be calculated and shall be equal to the absolute value of the right side of Equation 1.10 or 1.21, depending on the considered step;

(d) In case the absolute value of the right side of the Equation 1.10 or 1.21, depending on the considered step, is higher than the absolute value of the left side of this equation when all $\alpha_{i,j}$ and $\beta_{i,k}$ are set to 1, the right side of this equation shall be set equal to the left side of this equation when all $\alpha_{i,j}$ and $\beta_{i,k}$ are set to 1;

(e) Adjusted total flow on XNEC $F'_{b,i}$ shall be calculated as the one among the two values below with the lowest absolute value:

   i. flow from the input CGM for the common cross-regional coordination process, including all XRAs agreed within each coordinated regional operational security assessment; and

   ii. flow from the input CGM for the common cross-regional coordination process, including all XRAs agreed within each coordinated regional operational security assessment, with included non-costly XRAs agreed during cross-regional coordination except PSTs and costly ANORAs.

The rules (a) to (c) are also explained in the following table:

$\boldsymbol{C^{all}}$	**relative weights $\boldsymbol{r_i}$**	**treatment of relative weights $\boldsymbol{r_i}$**
>0	Less than half are < 0	Set negative weights to zero before applying Equation 1.2
<0	Less than half are > 0	Set positive weights to zero before applying Equation 1.2
>0	Half or more are < 0	Opposite (i.e. positive) value of the lowest negative weight is added to all weights before applying Equation 1.2
<0	Half or more are > 0	Opposite (i.e. negative) value of the highest positive weight is added to all weights before applying Equation 1.2
Any	All are equal to 0	Weights are equal to the absolute value of right side of Equation 1.10 or 1.21, depending on the considered step, i.e.: $r_i = \lvert F_{limit,i} - F'_{b,i} \rvert$ or $r_i = \lvert F_{limit,i} - F_{b,i}^{PST-adj} \rvert$

"

Article 2

Publication of the Amendment to the CSAM

All TSOs shall publish this Amendment to the CSAM without undue delay after the decision has been taken by the European Union Agency for the Cooperation of Energy Regulators in accordance with Article 6(2)(c) and Article 7(4) of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation.