Methodology for a coordinated capacity calculation in accordance with Article 37 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing within GRIT CCR

ANNEX 1 – TTC Calculation process

September 2022

1. Scope of the TTC calculation process

The Coordinated Capacity Calculator of GRIT CCR (hereinafter referred to as "Coordinated Capacity Calculator") shall determine the Total Transfer Capacity (TTC) available on each border and direction of GRIT CCR for each relevant market time unit of the Coordinated Capacity Calculation processes referred to in Article 4 of the "Methodology for a balancing timeframe coordinated capacity calculation in accordance with Article 37 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing within GRIT CCR" (BT CCC methodology) according to the TTC calculation process described in this Annex.

2. Relevant inputs

Relevant inputs for the TTC calculation process are:

- Individual Grid Models prepared by the relevant TSOs. These grid models shall include at least a detailed representation of the 380kV-220kV grid and, where considered relevant, the 150kV grid;
- Generation Load Shift Key (GLSK) files prepared by each TSO;
- List of relevant Contingencies (C) prepared by each TSO;
- List of available Remedial Actions (RA) prepared by each TSO;
- Operational Security Limits to be considered for each grid element, provided by each TSO;
- List of additional constraints prepared by each TSO.

Each TSO shall provide the relevant input data to the Coordinated Capacity Calculator:

- By 23:00 of D-1 for the BT CCC process 1;
- By 11:00 of D for the BT CCC process 2;
- 50 minutes before the start of the impacted MTU in case a TTC update process is activated according to Article 13 of the BT CCC methodology.

The Coordinated Capacity Calculator shall use the input data listed above to calculate maximum power exchange on bidding zone borders of the GRIT CCR, which shall equal the maximum calculated exchange between two bidding zones on either side of the bidding zone border respecting operational security limits.

2.1 Generation Load Shift Key (GLSK)

GLSKs are needed to transform any change in the balance of one bidding zone into a change of injections in the nodes of that bidding zone. GLSKs shall be elaborated based on the best forecast information about the generating units and loads.

Each TSO shall define a GLSK file for each:

- Control Area: GSLK is computed for each relevant network node in the same Control Area;
- and time interval: GLSK is dedicated to individual market time unit in order to model differences between different system conditions.

In order to avoid newly formed unrealistic congestions caused by the process of generation shift, TSOs can define both generation shift key (GSK) and load shift key (LSK):

- Generation shift: GSK constitute a list specifying those generators that shall contribute to the shift.
- Load shift: LSK constitute a list specifying those load that shall contribute to the shift in order to take into account the contribution of generators connected to lower voltage levels (implicitly contained in the load figures of the nodes connected to the 220 and 400 kV grid).

If GSK and LSK are defined, a participation factor is also given:

- G(a) Participation factor for generation nodes
- L(a) Participation factor for load nodes

The sum of G(a) and L(a) for each area has to be to 1 (i.e. 100%).

Hence, for a given Control Area and a market time unit, the relevant TSO(s) shall provide to the Coordinated Capacity Calculator a GLSK file containing for each node of the relevant grid:

- Node identification code;
- Available upward margin;
- Available downward margin;
- Merit order rank.

How to distribute the shift among different generators and loads connected to the same node is then defined according to the participation factors.

TSOs shall make at least once a year ex-post analysis of GSKs (including the testing period) and if considered necessary request to change them.

2.1.1 Merit order list for the Italian bidding zones

This kind of shift methodology can be considered for the Italian bidding zones.

The main reason for this choice is since the Italian grid has a high level of RES generation installed in general and close to the GR-IT Border in particular. Those generators as well as the conventional generation are geographically located in different areas, then for different generation profiles we get different power flows in the grid elements and consequently different stress areas in the systems with potential impact in the NTC calculations. Examples:

- If the wind production is high the marginal production could be reduced;

- If the winter is wet the marginal price of hydro power-plants could be lower than the marginal price of thermal power-plants, and vice-versa for dry seasons;
- Depending on the primary sources' prices, the market behavior will be different and affect the location of the production.

2.1.2 Proportional to the remaining capacity available on generation for the Greek bidding zone

This kind of shift methodology can be considered for the Greek bidding zone.

2.2 List of relevant Contingencies (C)

Each TSO shall provide to the Coordinated Capacity Calculator the list of contingencies to be considered in capacity calculation process, according to article 33 of the Commission Regulation (EU) 2017/1485.

The contingency list shall be reviewed at least once a year.

2.3 List of relevant Remedial Actions (RA)

The set of relevant remedial actions shall be defined in accordance with the CSA Methodology, considering only actions that could have a beneficial effect in terms of cross-zonal capacity of the border under assessment.

An available Remedial Action (RA) is a measure that can be applied in due time by a TSO to fulfill operational security limits in N and N-1 state of the system.

Each TSO shall provide to the Coordinated Capacity Calculator the list of available RAs to be considered in the TTC calculation process applied on each border and direction of the GRIT CCR for each relevant market time unit.

These RAs shall be classified in the following two categories:

- Preventive Remedial Actions (PRAs) are those applied in a preventive way since they require time to be implemented and/or because they are necessary in order to avoid unacceptable breaches of the operational security limits after a Contingency (according to the operational security limits defined according to paragraph 2.4 of this Annex). If they are applied, they shall be considered as activated in the N-state as well as in any of the simulated N-1 scenarios.
- Curative Remedial Actions (CRAs) are those needed to cope with and to relieve rapidly constraints with an implementation delay of time for full effectiveness compatible with operational security limits defined according to paragraph 2.4 of this Annex. They are implemented after the occurrence of the relevant Contingency, so they must be considered as activated only on relevant N-1 scenarios. They shall respect the following requisites:
    a) If manually implemented in real time, they must be:
        - Simple (imply a limited number of maneuvers)
        - Fast in implementation (according to the security criteria adopted)
        - 1 to 1 with a contingency i.e. a single set of predefined manual actions can be

applied in real time to solve one contingency effects

  - Consistent with National Control Centers operational practice (i.e., These actions have to be included in the operating instruction of the National Control Centers)

b) If automatically operated, the operators are not involved in implementation in real time. Therefore, the constraints in a) are not applicable.

The possible types of RAs considered in the TTC Calculation process are the following:

- Changing the tap position of a phase shifting transformer (PST);
- Topological measure: opening or closing of one or more line(s), cable(s), transformer(s), bus bar coupler(s)or switching of one or more network element(s) from one bus bar to another;
- Change the flow in a line using a FACTS (flexible alternating current transmission system);
- Change the voltage on a node managing reactance(s), capacitor(s) and/or synchronous compensator(s).

All explicit RAs applied in TTC calculation process shall be coordinated in line with the capacity calculation methodology for the day-ahead and intraday market timeframe for Greece-Italy CCR. Prior to each calculation process, the TSOs of a bidding zone border shall agree on the list of remedial actions that can be shared between both in the capacity calculation. This means that a shared remedial action of one TSO is used to solve the contingency in the grid of another TSO.

These shared remedial actions can only be activated with prior consent of the neighboring TSO since their activation have a significant impact on its control area.

Hence, for a given border and a market time unit, the relevant TSO(s) shall provide to the Coordinated Capacity Calculator a RA file containing for each available remedial action:

- Identification code;
- List of punctual RA considered applicable (a RA in the file can be composed by one or more single compatible RAs) – for quantitative RAs (such as PST tap changing) the TSO shall provide the upper and lower limits to be considered available for the scope of the TTC calculation process;
- Category for each of the RA listed before;
- Rank of the remedial action (defined to give priority to the less complex/risky RA and, only after, to the most complex/risky ones).

The list of available remedial actions shall be reassessed by each TSO at least once a year.

2.4 Operational Security Limits (OSL)

Each TSO shall provide to the Coordinated Capacity Calculator the relevant operational security limits to be considered in the TTC calculation process for each relevant market time unit.

For each grid element, the relevant TSO shall define:

- PATL, Permanent Admissible Transmission Loading (Maximum loading accepted in N state);

and where relevant:

- TATL, Temporary Admissible Transmission Loading (Maximum loading accepted in N-1 state if no automatic curative remedial actions are available);

- FSATL, Fast Solved.

For each node of the network, the relevant TSO shall define:

- Minimum voltage level accepted in N state;

and where relevant:

- Minimum voltage level accepted in N-1 state;
- Maximum voltage level accepted in N state;
- Maximum voltage level accepted in N-1 state;
- Maximum accepted voltage drops between N and N-1 state.

The same limits are used also for operational security analysis pursuant to Commission Regulation (EU) 2017/1485 and shall be reviewed at least once a year.

3. TTC calculation process

The TTC calculation process is based on an iterative approach described in the following. For each iteration an Alternate Current (AC) Load Flow algorithm is used.

The TTC calculation process for the Internal Italian Borders is performed on the Individual Grid Model provided by Terna.

For each relevant timestamp, the TTC calculation process for computing TTC on each bidding zone border and for each direction (e.g., from Bidding Zone I to Bidding Zone J) is performed independently because the grid topology allows to assume that the TTC value on each border is not affected by TTC values on other borders.

For each market time unit, the TTC value on each border and direction is computed according to the process described in figure 1.

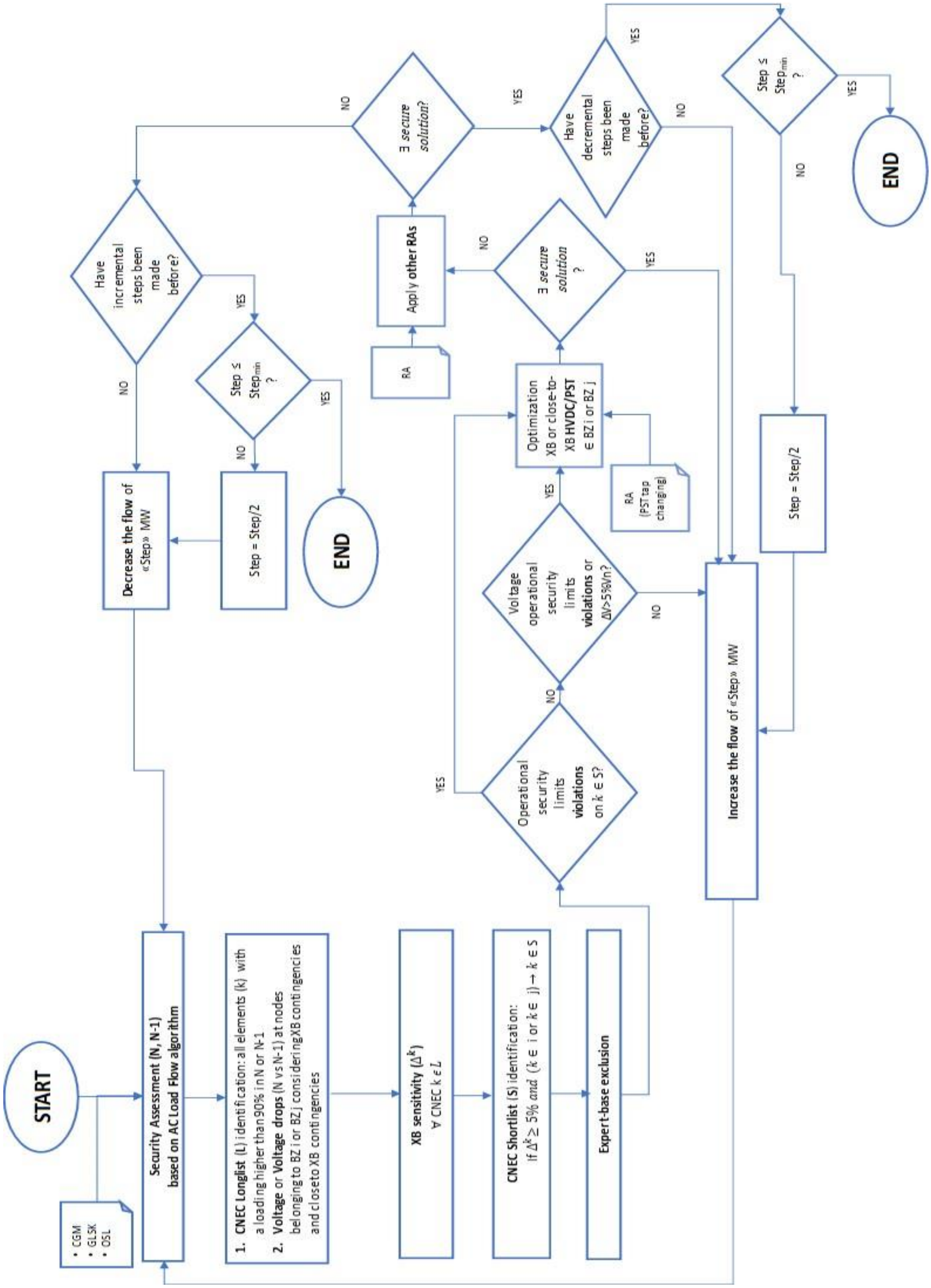

Figure 1. TTC calculation process

1) A full security assessment of the grid (AC load flow in N and N-1) is performed on the base case represented by the CGM or the relevant grid model for the market time unit;

2) Based on the results of the AC load flow:

   a. A Longlist (L) of Critical Network Element and Contingencies (CNECs) is identified as the set of CNECs loaded more than 90% of the PATL in N or N-1;

   b. Voltage and voltage drop between N and N-1 are computed considering only cross-border contingencies and close to cross border contingencies;

3) The sensitivity $\Delta^{\boldsymbol{k}}$ of each CNEC (k) belonging to the Longlist (L) to cross-border flows from Bidding Zone I to Bidding Zone J ($XBflow_{IJ}$) is computed.

4) A Shortlist (S) of CNECs is defined considering only the CNECs included in the Longlist (L) having a $\Delta^{\boldsymbol{k}}$ higher than 5%.

5) TSOs can discard CNECs from the Shortlist (S) in case they consider them not relevant (eg. CGMs do not represent all voltage levels so, in some particular cases, sensitivity computed at step 5 can be overestimated).

6) If violations are detected for any CNEC included in the Shortlist (S), the following PST/HVDC optimization algorithm is run when computing TTC values for borders composed by more than one link:

   Objective function: $minimize[NV]$

   Variables: PST_{tap}^{p}, $HVDC_{flow}^{d}$

   Constraints:

$$if\ loading_l \geq MAXloading_l \rightarrow loading_l \leq 1{,}025 loading_l^0\ \forall\ l$$

$$PST_{min}^{p} \leq PST_{tap}^{p} \leq PST_{max}^{p}\ \forall p$$

$$HVDC_{min}^{d} \leq HVDC_{flow}^{d} \leq HVDC_{max}^{d}\ \forall d$$

   Where:

   NV is the number of violations computed as the sum of:

   - number of overloaded CNECs ∈ S;
   - number of simulated events in the voltage assessment which lead to a voltage violation;

   PST p is a cross-border PST or close-to-close border element (for border I-J);

   $\mathrm{PST}_{\mathrm{min}}^{\mathrm{p}}$ is the minimum tap position of PST p;

   $\mathrm{PST}_{\mathrm{max}}^{\mathrm{p}}$ is the maximum tap position of PST p;

   HVDC is a cross-border HVDC or close-to-close border element (for border I-J);

   $HVDC_{min}^{d}$is the minimum acceptable flow on HVDC d;

   $HVDC_{max}^{d}$is the maximum acceptable flow on HVDC d;

   $\mathrm{loading}_{\mathrm{l}}^{0}$ is the loading of element l in the initial state;

   $\mathrm{loading}_{\mathrm{l}}$ is the loading of element l according to PST tap position $\mathrm{PST}_{\mathrm{tap}}^{\mathrm{p}}$;

$MAXloading_l$ is the relevant operational security limit of element l.

The PSTs/HVDCs setting adopted in the successive steps is the one who minimize the objective function previously mentioned and which is closer to neutral position.

7) If the value of the objective function of step 6 is higher than 0, remedial actions are applied in order to detect if a secure solution can be found.

   In particular, in the first step, Coordinated Capacity Calculator shall check if enough non-costly Curative Remedial Actions are available for solving each of the security issues detected in after step 6.

   If not, Coordinated Capacity Calculator shall apply (one-by-one[1]) the RA provided by the TSOs of the GRIT CCR, following the priority given by the relevant TSO.

   The set of relevant remedial actions shall be defined in accordance to the CSA Methodology, considering only actions that could have a beneficial effect in terms of cross-zonal capacity of the border under assessment.

8) The following decision tree is applied:

   Is there any violation detected on CNECs included in the Shortlist (S) after applying the step?

   a. If no: has been a decreasing step applied before?

      i. If yes: Step = Step/2

      ii. If no: Step = Step

      If Step ≤ 50MW (Step_min) then the procedure stops, else the flow from Bidding Zone I to Bidding Zone J is increased by “Step” MW and the procedure go back to step 1.

   b. If yes: has been an increasing step applied before?

      i. If yes: Step = Step/2

      ii. If no: Step = Step

      If Step ≤ 50MW (Step_min) then the procedure stops, else the flow from Bidding Zone I to Bidding Zone J is decreased by “Step” MW and the procedure go back to step 1.

   For each increasing/decreasing step, the CGM is modified in order to reach the target TTC using the GLSK shift method, described in figure 2:

   - a generation upward shift in all the bidding zones with a positive sensitivity on the flow from I to J and
   - a generation downward shift in all the bidding zones with a negative sensitivity on the flow from I to J;

[1] A combination of several RAs is seen as a single RA if provided by the relevant TSO.

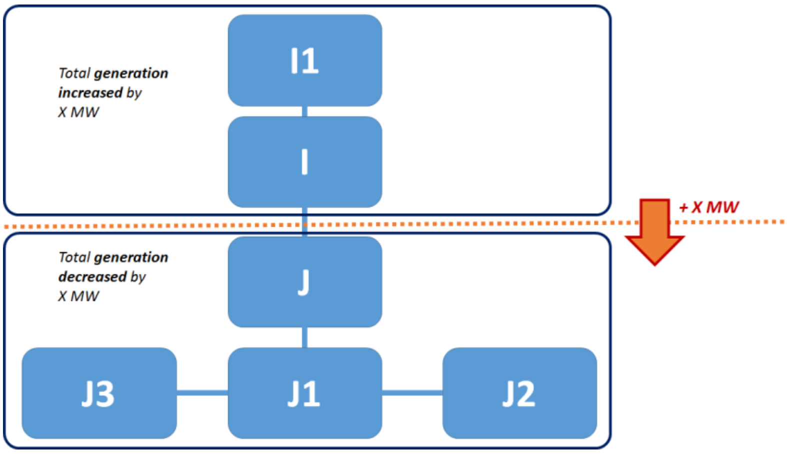

Figure 2. Stepwise flow increase from I to J

The final value for the GR-IT Border is computed according to the above-mentioned procedure, since dynamic assessment in either the Greek grid or the Italian grid has no consequences on the DC cable constituting this border.

The final TTC value for the internal Italian borders is computed as the minimum value between the TTC value defined according to the above-mentioned procedure and the maximum acceptable TTC value defined by the Italian TSO according to Article 7(7) of the GRIT CCM to consider the result of the dynamic assessment. For sake of clarity Italian TSO shall perform the dynamic assessment by the mean of proper tools developed by the TSO itself based on the wide academic bibliography on the dynamic of the electricity systems: a reference text for further investigation is Electric power systems vol.3 Dynamic behavior, stability and emergency controls by Roberto Marconato.