Greece-Italy TSOs proposal of common capacity calculation methodology for the day-ahead and intraday market timeframe in accordance with Article 21 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management

ANNEX 1 – TTC Calculation process

May 2018

1. Scope of the TTC calculation process

The Coordinated Capacity Calculator shall determine the Total Transfer Capacity (TTC) available on each border and direction of the GRIT CCR for each relevant market time unit of the day-ahead and intraday market timeframe according to the TTC calculation process described in this Annex.

2. Relevant inputs

Relevant inputs for the TTC calculation process are:

- Merged CGM file, created according to Article 28(5) of CACM Regulation;
- Generation Load Shift Key (GLSK) files;
- List of relevant Contingencies (C);
- List of available Remedial Actions (RA);
- Operational Security Limits to be considered for each grid element.

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 on the basis of the forecast information about the generating units and loads.

Each TSO of the GRIT CCR 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) of the GRIT CCR 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.

2.2 List of relevant Contingencies (C)

Each TSO of the GRIT region 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.

2.3 List of relevant Remedial Actions (RA)

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

Each TSO of the GRIT CCR 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 have to be considered as activated only on relevant N-1 scenarios. They shall respect the following requisites:
  - a) If manually implemented in real time, they have to 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 article 25 of Regulation (EU) 2015/1222 (CACM). 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) of the GRIT CCR 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 in order 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 GRIT TSO at least once a year.

2.4 Operational Security Limits (OSL)

Each TSO of the GRIT CCR 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 drop between N and N-1 state.

3. TTC calculation process

The TTC calculation process is based on an iterative approach described in hereafter and on the application of Alternate Current (AC) Load Flow algorithm.

The grid model used for TTC calculation process at each border of GRIT CCR and direction is the merged CGM defined according Article 28(5) of the CACM Regulation.

For each relevant timestamp, the TTC calculation process to be applied for computing TTC from Bidding Zone I to Bidding Zone J is described in figure 1:

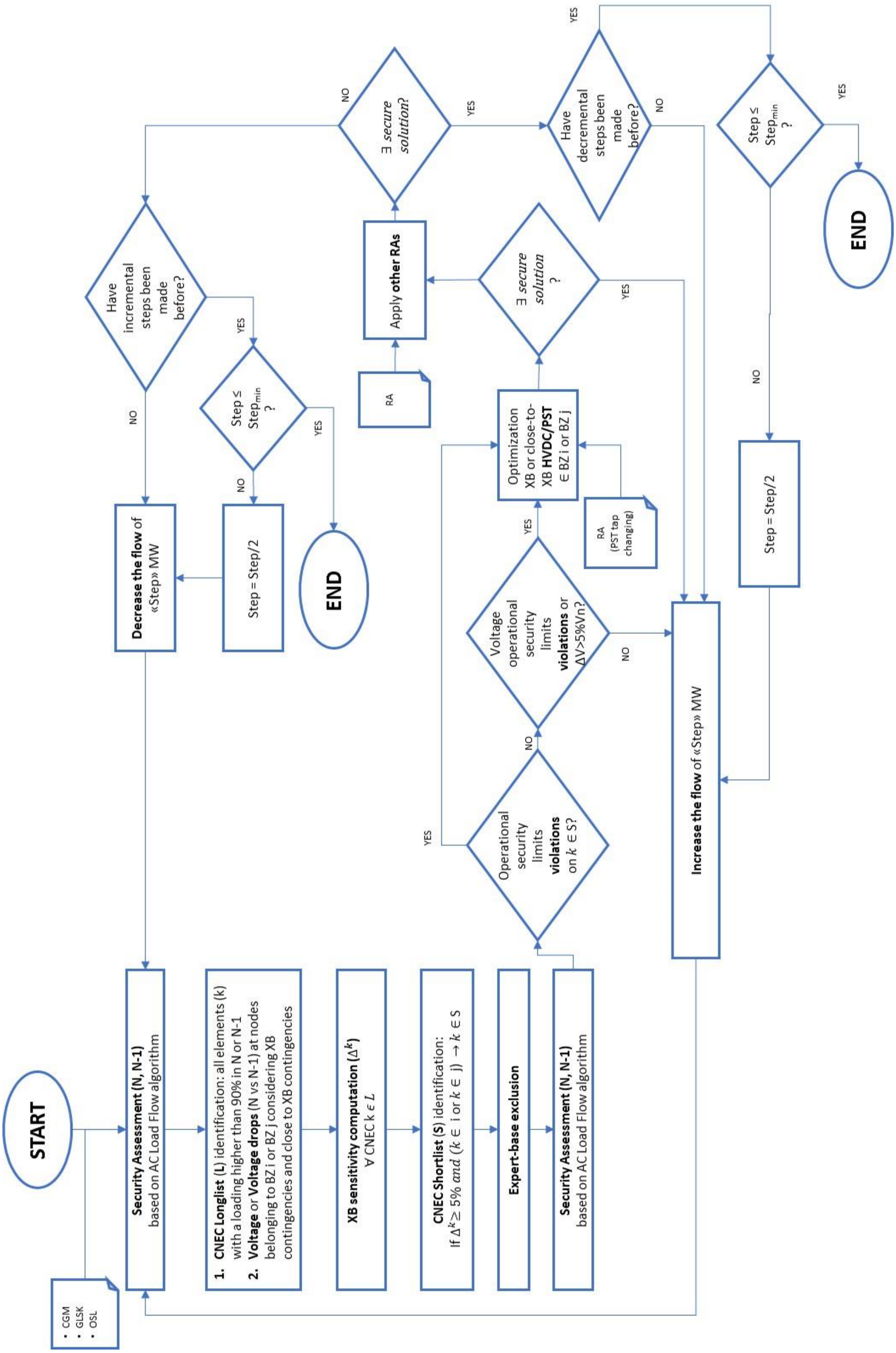

Figure 1. TTC calculation process

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;
2) Based on the results of the 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 of the Critical Network Element 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 is computed.
4) A Shortlist (S) of CNECs s defined considering only the CNECs included in the Longlist (L) having a $\Delta^{\boldsymbol{k}}$ higher than 5%.
5) TSOs of the GRIT CCR 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) A security assessment of the grid (AC load flow) is performed in order to check:
    a. Loading level of CNECs part of the Shortlist (S);
    b. Voltage and voltage drop between N and N-1 considering only cross-border contingencies and close to cross border contingencies;
7) If violations are detected in step 7, 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 $\mathrm{PST}_{\mathrm{tap}}^{\mathrm{p}}$

$\mathrm{MAXloading}_{\mathrm{l}}$ 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.

8) If the value of the objective function of step 8 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 8.

   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.

9) The following decision tree is applied:

   Has been a secure status found after step?

   a. If yes: 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

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

Bidding Zone J is increased by "Step" MW and the procedure go back to step 1.

b. If no: 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;

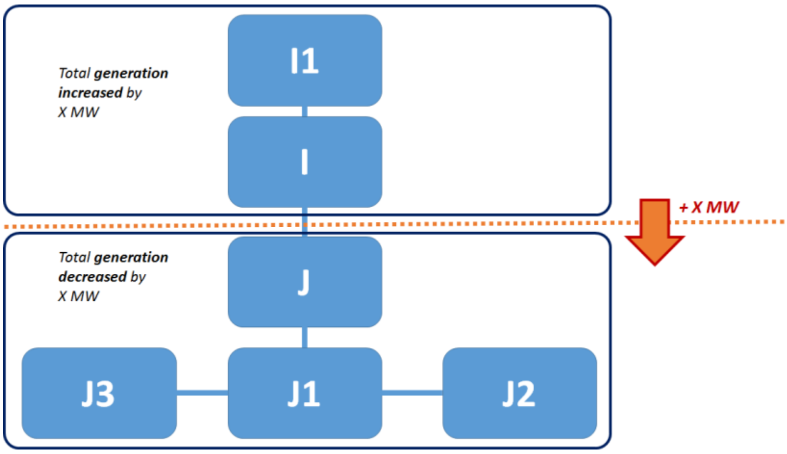

Figure 2. Stepwise flow increase from I to J

The final value for the GRIT border is computed according to the above mentioned procedure, since dynamic assessment in either the Greek grid or the Italian grid has no consequences at the DC flow on the GRIT cable.

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 7.5 of the "Greece-Italy TSOs proposal of common capacity calculation methodology for the day-ahead and intraday market timeframe in accordance with Article 21 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management".