Capacity calculation methodology for the day-ahead and intraday market timeframe for Montenegro-Italy CCR 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

1. Scope of the TTC calculation process

The RCC of ITME CCR (hereinafter referred to as "RCC") shall determine the Total Transfer Capacity (TTC) available on each border and direction of ITME 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:

- Base Case – Individual Grid Models (hereinafter referred to as "BC-IGM") prepared by each TSO of ITME CCR (hereinafter referred to as "TSO");
- 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.

The BC-IGMs prepared by the TSOs will then be merged into Common Grid Models according to Article 28(5) of the CACM Regulation. The resulting Common Grid Models will be adopted in the capacity calculation process.

Pending the finalization of the European Common Grid Model for the day-ahead and intraday capacity calculation timeframes in accordance with Article 17 of the CACM Regulation, TSOs shall provide relevant grid models to be used in the capacity calculation process of the ITME CCR in order to ensure an accurate representation of the network. These grid models shall include at least a detailed representation of the 380kV-220kV grid and, where considered relevant by the concerned TSO, the 150/132/110kV grid.

Each TSO shall provide the relevant input data to the RCC:

- By 19:00 of D-2 for the Day-ahead capacity calculation timeframe (DA CCC process);
- By 15:00 of D-1 for the Intraday capacity calculation timeframe performed in D-1(ID CCC process 1);
- By 20:30 of D-1 for the Intraday capacity calculation timeframe performed in D (ID CCC process 2).

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

In accordance with Article 27(4) of the CACM Regulation each TSO shall regularly and at least once a year review and update the key input and output parameters listed in Article 27(4)(a) to (d) of the CACM Regulation.

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 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 RCC 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.

2.1.1 Merit order list for the Italian control area

This kind of shift methodology can be considered for the Italian control area.

The merit order approach for GLSK in the Italian control area is adopted for the CCC for the other CCR where Italy is involved. This approach shall be maintained since GLSK, IGM and CGM are the same for the CCC process.

In fact, the Italian grid has a high level of RES generation installed in general and close to the ITME Border in particular. Those generators as well as the conventional generation are geographically located in different areas, then different generation profiles result in different power flows in the grid elements and consequently different stress areas in the systems with potential impact in the NTC calculations.

2.1.2 Merit order list for the Montenegrin control area

This kind of shift methodology can be considered for the Montenegrin control area.

In fact, the Montenegrin grid as well has a high level of RES generation installed in general. Different generation profiles result in different power flows in the grid elements and consequently different stress areas in the systems with potential impact in the NTC calculations.

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

2.2 List of Critical Network Elements and Contingencies (CNEC)

Each TSO shall provide the RCC with the list of relevant critical network elements and contingencies to be considered in capacity calculation process, jointly defined between the TSOs belonging to ITME CCR.

The monitored elements can be branches for critical flows and nodes for critical voltages.

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 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 in order to fulfill operational security limits in N and N-1 state of the system.

Each TSO shall provide to the RCC the list of available RAs to be considered in the TTC calculation process applied on the concerned border and direction of the ITME 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 CACM Regulation. 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 RCC with 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 TSO at least once a year.

2.4 Operational Security Limits (OSL)

Each TSO shall provide to the RCC with 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.

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.

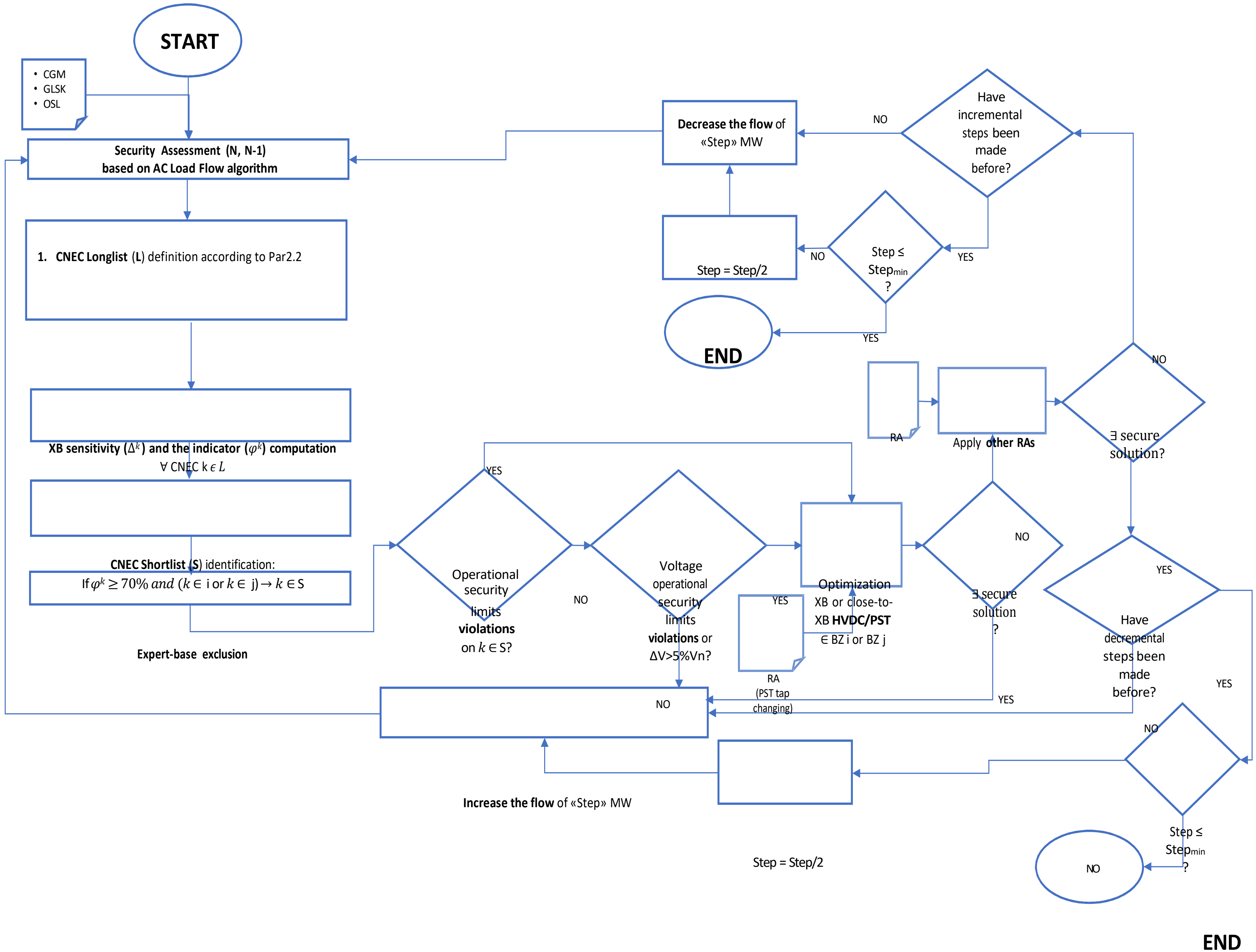
3. TTC calculation process

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 grid model used for TTC calculation process at each border of ITME CCR and direction is the merged CGM defined according Article 28(5) of the CACM Regulation. Pending the finalization of the European Common Grid Model for the day-ahead and intraday capacity calculation timeframe in accordance with Article 17 of the CACM Regulation, dedicated ITME CCR grid model provided by the TSOs shall be used in the calculation process.

For each relevant timestamp, the TTC calculation process for computing TTC on the ITME CCR border and for each direction is performed independently from other borders belonging to other adjacent CCRs.

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


START
CGM
GLSK
OSL
Security Assessment (N, N-1)
based on AC Load Flow algorithm
1. CNEC Longlist (L) definition according to Par2.2
XB sensitivity (Δk) and the indicator (φk) computation
∀ CNEC k ϵ L
CNEC Shortlist (S) identification:
If φk ≥ 70% and (k ∈ i or k ∈ j) → k ∈ S
Expert-base exclusion
Operational security limits violations on k ∈ S?
YES
NO
Voltage operational security limits violations or ΔV>5%Vn?
YES
RA (PST tap changing)
Optimization XB or close-to-XB HVDC/PST ∈ BZ i or BZ j
∃ secure solution ?
NO
YES
RA
Apply other RAs
∃ secure solution?
NO
Have incremental steps been made before?
NO
Decrease the flow of «Step» MW
YES
Step ≤ Stepmin ?
NO
Step = Step/2
YES
END
Have decremental steps been made before?
YES
NO
Step ≤ Stepmin ?
NO
Step = Step/2
Increase the flow of «Step» MW
END

YES

Figure 1. TTC calculation process

1) A Longlist (L) of Critical Network Element and Contingencies (CNECs) is identified such as described in Par 2.2.
2) The sensitivity Δ^k of each CNEC (k) belonging to the Longlist (L) to the flow of the border is computed. The indicator φ^k of each CNEC (k) belonging to the Longlist (L) is computed as:

$$\varphi^k = \Delta^k \cdot \frac{\boldsymbol{XBflow_{IJ}}}{\boldsymbol{PATL^k}}$$

3) A Shortlist (S) of CNECs is defined considering only the CNECs included in the Longlist (L) having a φ^k higher than 70%.
4) 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 2 can be overestimated).
5) A security analysis is performed.
6) If violation of OSLs on CNECs belonging to the Shortlist (S) are detected, remedial actions are applied in order to check if a secure solution can be found.

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

   The set of relevant remedial actions shall be defined considering only actions that could have a beneficial effect in terms of cross-zonal capacity of the border under assessment. In particular, the non-costly remedial actions are explicitly optimized as required in the TTC calculation process, while the costly remedial actions are implicitly applied when it is needed to fulfill the 70% requirements.
7) 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 on the border is increased by "Step" MW and the procedure go back to step 2.
   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 on the border is decreased by "Step" MW and the procedure go back to step 2.

   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 upward/downward power injection is performed on resources defined in GLSK in the exporting side of the border; and
   - a downward/upward power injection shift is performed on resources defined in GLSK in the importing side of the border.

The TTC calculation process shall be repeated considering φ^kthreshold equal to 0% in step 3. The difference between the TTC value computed using φ^k threshold equal to 70% and the one computed using φ^k threshold equal to 0% will provide an estimation of the volumes of the costly remedial actions necessary to fulfill the 70% requirements and, at the same time, ensure real-time fulfillment of operational security limits.

The availability of the required amount of costly remedial actions on each border and for each market time unit shall be confirmed to the RCC by the relevant TSO(s).

.

The final TTC value 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 ITME CCR TSOs according to Article 7(6) of the ITME CCM to take into account the result of the dynamic assessment. For sake of clarity, TSOs shall perform the dynamic assessment by the mean of proper tools developed by the TSO itself on the basis of the wide academic bibliography on the dynamic of the electricity systems: a reference text for further investigation is Electric power systems vol.3 Dynamic behaviour, stability and emergency controls by Roberto Marconato.