Proposal for a common set of requirements for the DA price coupling algorithm

3 November 2016

1. Background

(1) This document is a common proposal developed by all Transmission System Operators (hereafter referred to as "TSOs") and Nominated Electricity Market Operators (hereafter referred to as "NEMOs") for a common set of requirements for the price coupling algorithm (hereinafter referred to as "DA Algorithm Requirements") in accordance with article 37 of Commission Regulation (EU) 2015/1222 establishing a guideline on capacity allocation and congestion management (hereafter referred to as the "CACM Regulation").

(2) For the purpose of this proposal, terms used in this document have the meaning of the definitions included in Article 2 of the CACM Regulation and Regulation 543/2013.

(3) According to Article 37: "*1. By eight months after the entry into force of this Regulation: (a) all TSOs shall jointly provide all NEMOs with a proposal for a common set of requirements for efficient capacity allocation to enable the development of the price coupling algorithm and of the continuous trading matching algorithm. These requirements shall specify functionalities and performance, including deadlines for the delivery of single day-ahead and intraday coupling results and details of the cross-zonal capacity and allocation constraints to be respected;"*

(4) In addition to the above common proposal for the TSOs Algorithm Requirements, article 37 of the CACM Regulation requires that *"all NEMOs shall jointly propose a common set of requirements for efficient matching to enable the development of the price coupling algorithm and of the continuous trading matching algorithm"* (hereinafter referred to as "NEMOs Algorithm Requirements") within the same deadline.

(5) When both proposals are prepared and after the deadline of eight months, all Nominated Electricity Market Operator (hereafter referred to as "NEMO") and all TSOs will cooperate to finalise the sets of the TSOs and NEMOs Algorithm Requirements. Based on the above two sets of requirements, TSOs and NEMOs Algorithm Requirements, *"all NEMOs shall develop a proposal for the algorithm in accordance with these requirements. This proposal shall indicate the time limit for the submission of received orders by NEMOs required to perform the MCO functions in accordance with Article 7(1)(b)."* This NEMOs proposal for the algorithm shall be prepared no later than three months after the submission of the TSOs and NEMOs Algorithm Requirements.

(6) In accordance with Article 37(3) of the CACM Regulation the NEMOs proposal for the algorithm *"shall be submitted to all TSOs. If additional time is required to prepare this proposal, all NEMOs shall work together supported by all TSOs for a period of not more than two months to ensure that the proposal complies with paragraphs 1 and 2.*

(7) According to paragraph 4 of Article 37 "*The proposals referred to in paragraphs 1 and 2 shall be subject to consultation in accordance with Article 12*". The consultation on all proposals, i.e. TSOs and NEMOs algorithm requirements and the NEMOs proposal for the algorithms will be prepared in cooperation between all TSOs and all NEMOs and be consulted upon together to ensure efficient assessment of their content by market participants.

(8) The all NEMOs proposal for the algorithm developed based on the TSOs and NEMOs algorithm requirements and taking into account the comments from the consultation will be submitted to the regulatory authorities for approval no later than 18 months after the entry into force of the CACM Regulation, i.e.14 February 2017.

2. Terminology

1. 'NEMO Trading hub' shall be defined as 'the set of orders submitted by the market participants to a specific NEMO within a Bidding Zone.
2. Cross Zonal Flows are Scheduled flows between adjacent Bidding Zones.

3. Approach

The table below sets out the DA Algorithm Requirements. Each requirement has been classified according to the following criteria:

1. **State**:
   a. Initial Requirement: a requirement that must be complied with at the point the SDAC first commences operation. Such requirements are normally already incorporated into the PCR solution.
   b. Future Requirement: a requirement that must be complied with at a point after the SDAC first commences operation. Such requirements shall need to be properly specified and implemented via a Change Request (which shall include technical feasibility and performance impact assessment). Some Future Requirements may already be under development within PCR.

2. **Owner:** owner of the requirement (TSOs, NEMOs, or joint TSOs and NEMOs) with meaning as defined in the Algorithm Proposal

3. **Nature**:
   a. MCO Function: a requirement that relates to the joint responsibility of NEMOs to carry out MCO functions in accordance with Article 7(2).
   b. Scheduled Exchange Calculation ("SEC") Function: a requirement that relates to the joint responsibility of TSOs to calculate and publish scheduled exchanges on borders between bidding zones in accordance with Article 8(2)(g), where such requirement shall be supported by the DA Algorithm. In many cases these requirements are not yet specified ("Future") and it may be that the calculations will be performed outside the DA Algorithm – e.g., as a separate post-matching process, or a local/regional process. The solution shall be agreed between the relevant NEMOs and TSOs.

In some cases it has not been possible yet to reach agreement between NEMOs and TSOs regarding the common set of requirements. This is indicated by comments in italics in the text.

4. Price coupling algorithm requirements

Title 1: Requirements on functionalities and performance

1. General requirements
   a. For each bidding zone the algorithm shall be able to:
      i. facilitate orders for several Market Time Units (hereafter referred as "MTUs"), such as 15 minutes, 30 minutes and hourly, including cross-matching between MTUs;
      ii. the algorithm shall support the products as approved in-accordance with Article 40 of the CACM regulation;
      iii. facilitate different MTUs which shall be configurable in each bidding zone;
      iv. facilitate configurations with more than one NEMO for a given bidding zone, meaning several day-ahead trading hubs within a bidding zone;
      v. support multiple scheduling areas within a bidding zone as requested by TSOs;
      vi. allocate cross-zonal capacities on a bidding zone border with one or multiple TSOs on one or both sides of the concerned bidding zone border.
   b. The objective of the price coupling algorithm is to maximize economic surplus (this means that the sum of the consumer surplus, the supplier surplus and the congestion income) for single day-ahead coupling for the next trading day, consistent with time limitations, conditions and requirements established by NEMOs and TSOs.
   c. The algorithm shall be able to deal with multiple bidding zones by country and shall be scalable to cover all Europe.
   d. The algorithm shall apply deterministic rules in case of solutions with equivalent social welfare in order to define prices and net positions for each bidding zone.
   e. The algorithm shall find a solution within the allowed time limit, including the potential to extend the processing time in case allowed calculation time is exceeded.
   f. The algorithm shall be able for each MTU to provide the net position per NEMO trading hub and the input for the calculation of the adjacent cross-zonal flows between bidding zones.

Requirement	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
1.a.i		X	X	X	X	
1.a.ii	X			X	X	
1.a.iii		X	X	X	X	
1.a.iv	X		X	X	X	
1.a.v		X	X			X
1.a.vi	X		X		X	
1.b	X		X	X	X	
1.c	X		X	X	X	
1.d	X		X	X	X	
1.e	X		X	X	X	
1.f	X		X	X	X	

	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
g. The algorithm shall be able to calculate the cross zonal flows per bidding zone.	X		X			X
h. For each bidding zone the result from application of the algorithm shall be one price and one net position for each MTU and, where applicable, each NEMO trading hub for bidding zones with several NEMOs in a bidding zone. If required by relevant TSOs in accordance with the fall back procedure there shall be one price and one net position for each MTU for each bidding zone. In case of partial decoupling, net positions and prices shall be determined by implicit auctions on non-decoupled bidding zone borders.	X		X	X	X	
i. For each bidding zone the result from application of the algorithm shall be one price and one net position for each MTU and, where applicable, net positions for each scheduling area. *[Comment: new functionality that is not currently supported nor subject to a current change request]*		X	X			X
j. To secure robustness of the functioning of the algorithm, the complexity of the problems that are to be solved may need to be bounded. This can be managed by imposing limits to the number/usage of different products or/and other requirements that the algorithm can manage. The process to manage this limitation will be described in the algorithm methodology.	X		X	X	X	
2. Qualitative requirements with precision and price ranges						
a. The algorithm shall apply to all market participants providing non-discriminatory access to cross zonal capacity in accordance with Article 3 of CACM.	X		X	X	X	
b. It must be possible to reproduce the same results upon request. In particular, in case of tie rules (between two or more orders), deterministic rules must be implemented, and for branching decisions (if any), such choices need to be logged, to allow for a one-to-one re-creation of the events resulting in the final result.		X	X	X	X	
c. The algorithm shall allow for partial decoupling, including per bidding zone that belong to a predefined set of bidding zones.	X		X	X	X	
d. The algorithm shall be able to deal automatically and easily with leap years, i.e. 366 days in in a year.	X		X	X	X	
e. The algorithm shall be able to deal automatically and easily with day-light savings related to winter and summer time	X		X	X	X	

	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function

changes, i.e. algorithm shall support 23, 24 or 25 hours for a trading day.

f. The calculation process of the algorithm, including prices and allocated capacities resulting from this calculation process, has to be transparent, auditable, and explainable. This requirement applies also to all deterministic rules and applied algorithm heuristics and occurrence rate of these rules and heuristics.

g. The algorithm source code shall be well structured and well documented

h. A description of the algorithm should be made publicly available, and should be kept up to date.

i. The algorithm shall be able to deal with negative prices for each bidding zone as well as with different non-harmonized price boundaries, i.e. maximum price and minimum price, between different bidding zone

j. The algorithm shall be able to round calculated prices and volumes according to bidding zone specific ticks and rounding rules.

3. Performance

a. The algorithm shall be robust and reliable and it shall be resilient to pretested data configurations such as but not limited to non-crossing of bids and offer curves, orders' curtailment, maximum and minimum prices, price and volume indeterminacy.

b. The algorithm shall always produce a unique result, i.e. price and volume indeterminacy shall be resolved.

c. The algorithm shall use proven IT technology, e.g. proven third party software.

d. The algorithm shall be available at all times when required and shall perform according to the requirements in all circumstances.

e. The algorithm should scale well when the number of bidding zones increases: the algorithm should cope with new markets that need to be incorporated in the price coupling, either corresponding to geographical extensions, or with additional NEMOs in existing bidding zones.

f. The performance of the algorithm must have good quality and performance in a way that ensure that all results demanded by the TSOs and market participants are received by them by the time they demand.

Requirement	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
changes (23,24,25 hours)						
f. calculation process transparent	X		X	X	X	
g. source code well structured	X			X	X	
h. description publicly available	X		X	X	X	
i. negative prices	X		X	X	X	
j. rounding	X		X	X	X	
3. Performance						
a. robust and reliable	X		X	X	X	
b. unique result	X		X	X	X	
c. proven IT technology	X		X	X	X	
d. available at all times	X		X	X	X	
e. scale well	X		X	X	X	
f. performance good quality	X		X	X	X	

	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function

g. Price taking orders (PTOs) are buy (respectively sell) limit orders submitted at the maximum (respectively minimum) prices. Failure to accept these price taking orders is a situation we refer to as curtailment:

- In case of over-supply not all price taking supply orders can be accepted;
- In case of under-supply not all price taking demand orders can be accepted.

Curtailment can be partially mitigated by exporting excess energy or importing deficit energy. In case more than 1 bidding zones faces a curtailment situation, when we increase the curtailment of one, the curtailment of the other will decrease. Per bidding area, it should be possible to either:

- Prevent sharing of curtailment: the local curtailments remain local: no support will be received from adjacent zones, nor support will be provided to adjacent zone;
- Share curtailment: the difference in relative (percentage) curtailment between the different bidding zones will be minimized.

The latter option of sharing curtailment also applies in a Flow Based setting, where sharing curtailments may be at the cost of the economic surplus.

The algorithm shall provide a mechanism that allows for a sharing of curtailment of demand between bidding zones in a flow-based capacity allocation.

The algorithm shall support curtailment sharing also in the absence of harmonized min/max clearing price limits between bidding zones.

(Row g: Initial Requirement X, TSOs X, NEMOs X, MCO Function X)

h. All TSOs and NEMOs shall develop performance indicators in order to monitor the performance of the algorithm.

(Row h: Initial Requirement X, TSOs X, NEMOs X, SEC Function X)

i. NEMOs will publish statistical indicators that measure the performance of the algorithm. These indicators will include (but need not be limited to):

- Optimality gap indicator(s);
- Time performance indicators.

In addition, other indicators may be published (e.g., PRBs) that describe the behavior of the algorithm including the impact of actual bid characteristics.

(Row i: Initial Requirement X, TSOs X, NEMOs X, SEC Function X)

	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function

Title 2: Requirements related to Cross-zonal capacities

1. The algorithm shall be able for each MTU to:

	State		Owner		Nature	
a. allow setting constant cross-zonal capacity value for each bidding zone border in accordance with CACM Regulation in case coordinated net transmission capacity is applied; this cross-zonal capacity value may also be a very high value;		X	X		X	
b. constrain cross-zonal flows to the respective cross-zonal capacity value for each bidding zone border for each cross-zonal flow direction, in case the coordinated net transmission capacity (CNTC) approach is applied;	X		X		X	
c. where applicable, allow TSOs setting a default value for cross-zonal capacity for each bidding zone border and for each flow direction in case coordinated net transmission capacity approach is applied;	X		X		X	
d. constrain, where appropriate, an aggregated set of cross-zonal interconnectors with one global cross-zonal transmission capacity limit (cumulative ATC), i.e. a general boundary constraint. This constraint shall be applicable also to a predefined set of bidding zone borders in order to limit for example the net position of a bidding zone(s);	X		X		X	
e. allow to define a positive and a negative bound to the net position for each bidding zone.	X		X		X	
f. process flow-based parameters, if provided at the defined MTU, when allocating cross-zonal capacities for each bidding zone border;	X		X		X	
g. allow definition and application of the following flow-based parameters for each network element of a given bidding zone for flow-based approach:						
i. power transfer distribution factor (PTDF) as the contribution of 1 MW of a net position change to the power flow over the network element; and	X		X		X	
ii. remaining available margin (RAM) or the remaining allowable power flow (AMF) on the network element.	X		X		X	
h. ensure that PTDF multiplied by net position is less than RAM for each network element and net positions concerned by the flow-based parameters for flow-based approach;	X		X		X	
i. receive the flow-based parameters as:						

	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
i. "zero balanced" meaning that the remaining available margin of critical branches applies from zero exchanges and that pre-existing exchanges are transmitted aside; or		X	X		X	
ii. "not zero balanced" meaning that the remaining available margin of critical branches applies from pre-existing exchanges;	X		X		X	
j. allow the coexistence of both flow-based and coordinated net transmission capacity approaches within the coupled regions, i.e. hybrid coupling;	X		X		X	
k. facilitate the following hybrid couplings:						
i. Standard hybrid coupling, where cross-zonal capacity values and flow-based parameters coexist implying that TSOs shall reserve margins ex-ante; and	X		X		X	
ii. Advanced hybrid coupling, where realized cross-zonal capacity transactions are taken into account in the margin of the flow-based critical branches (using virtual bidding areas).		X	X		X	
2. Multiple flow based approaches, i.e. plain, intuitive, bilaterally intuitive, may be used for different capacity calculation regions.	X		X		X	

Title 3: Requirements related to allocation constraints

	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
1. The algorithm shall be able to:						
a. for direct current ("DC") interconnectors constrain increase/decrease of flows over one interconnector and/or a combination of interconnectors from a MTU to the following MTU or between the last MTU from the day before and the first MTU of the following day. The constraint shall take into account the nominations of long term capacity allocations, i.e. physical transmission rights, where applicable. The constraint shall be handled on a single DC interconnector and multiple DC interconnectors in combination;		X	X		X	
b. constrain increase/decrease of net positions of a single bidding zone from a MTU to the following MTU within a day or between the last MTU from the day before and the first MTU of the following day; and	X		X		X	

c. incorporate losses functionality on interconnector(s) between bidding zones during capacity allocation, and activate this functionality during allocation, if requested by relevant owner of the interconnector after approval by relevant NRAs.

2. For the DC interconnectors the flow shall not be below the minimum stable flow ("MSF"), other than at zero. The MSF shall be given for each DC interconnector and activated during allocation, if requested by the owner(s) of the interconnectors after approval by relevant NRAs. The allocation shall take into account the nominations of long term cross-zonal capacity and day ahead cross-zonal capacity, where applicable. The constraints shall be handled on a DC interconnector-by-DC interconnector, multiple DC interconnectors and on a net position (regional) basis.

3. The algorithm shall allow to set a minimum price difference between adjacent bidding zones when DC interconnector is used for power exchange. For this requirement, the algorithm shall model the costs incurred for each MWh passing through a DC interconnector as a "flow tariff". This "flow tariff" shall be treated as a threshold for the price between the bidding zones connected by the DC interconnector. If the price difference between the relevant bidding zones is less than the "flow tariff" the flow shall be set to zero. If there is a flow, the price difference shall equal the "flow tariff", unless there is congestion. Once the price difference exceeds the "flow tariff" the congestion income becomes positive. This functionality shall be incorporated in the algorithm and activated during allocation if requested by the owner(s) of the interconnector after approval by relevant NRAs.

4. The algorithm shall allow for adverse flows, i.e. flows from higher price bidding zone to lower price bidding zone, to materialize if this leads to an increase in overall economic surplus. The algorithm shall enforce intuitive flow in flow based areas, i.e. flow from lower price bidding zone to higher price bidding zone, where requested by relevant TSOs for a bidding zone border.

Item	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
c	X		X		X	
2		X	X		X	
3	X		X		X	
4	X		X		X	

Title 4: Requirements related to balance constraints

1. For overall balance of a defined area, the algorithm shall ensure that the unrounded net positions and transmission losses, where applicable, over all bidding zones within a defined area shall be zero for each MTU.

2. For overall balance of all bidding zones, the algorithm shall ensure that the sum of unrounded net positions and transmission losses, where applicable, of all bidding zones shall be zero for each MTU.

3. For overall balance of a bidding zone, the algorithm shall ensure for each bidding zone the sum of unrounded net position and transmission losses, where applicable, shall be equal to the sum of import and export of this bidding zone resulting from the day ahead capacity allocation for each MTU.

Title 5: Requirements on algorithm output and deadlines for the delivery of single day-ahead coupling results

1. Regarding the prices for each MTU the output of the algorithm shall be:
   a. rounded and unrounded price in Euros for each bidding zone;
   b. shadow prices of critical branches as needed for Flow-Based (FB) capacity allocation; and
   c. regional reference prices, in a network in which the cross-zonal capacity constraints are relaxed - e.g., Nordic region.

2. Regarding the quantities for each relevant MTU the output of the algorithm shall be:
   a. rounded and unrounded net position for each bidding zone, which is defined as the difference between matched supply and demand orders within a bidding zone, where rounding shall follow the rounding rules defined for each bidding zone.

   b. Where there are multiple NEMOs within a bidding zone, the rounded and unrounded net position for each NEMO trading hub in a bidding zone.

Requirement	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
Title 4.1	X		X		X	
Title 4.2	X		X		X	
Title 4.3	X		X		X	
Title 5.1.a	X		X	X	X	
Title 5.1.b	X		X		X	
Title 5.1.c	X		X	X	X	
Title 5.2.a	X		X	X	X	
Title 5.2.b	X		X	X	X	

Description	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
c. number and volume of matched block orders for each bidding zone and paradoxically rejected orders, if any;	X			X	X	
d. allocated capacities, in the form of allocated flows into and out of individual Relevant DC Network Elements (difference in flows in/out reflecting losses where applicable);	X		X			X
e. allocated capacities, in the form of allocated flows on Relevant Bidding Zone borders (flows in/out reflecting losses where applicable);	X		X			X
f. allocated capacities, in the form of allocated flows on Relevant Scheduling Area borders (flows in/out reflecting losses where applicable); *[Comment: new functionality that is not currently supported nor subject to a current change request]*		X	X			X
g. remaining available margin (RAM) or the remaining allowable power flow (AMF) on the network element under FB capacity allocation;		X	X		X	
3. Regarding the quantities for each relevant MTU, with the output of the algorithm, an ex-post process which shall not interfere with the market coupling results calculation, shall provide scheduled exchanges, resulting from day ahead market coupling, in the form of: a. Bilateral and Multilateral Scheduled Exchanges between Scheduling Areas b. Bilateral and Multilateral Scheduled Exchanges between Bidding Zones c. Bilateral and Multilateral Scheduled Exchanges between NEMO trading hubs and pursuant to the Methodology for calculation of scheduled exchanges resulting from market coupling. *[Comment: new functionality that is not currently supported nor subject to a current change request]*		X	X			X
4. Regarding the calculation results the output of the algorithm shall be: a. overall economic surplus and economic surplus for each bidding zone; and	X		X	X	X	
b. output necessary for monitoring in accordance with Article 82(2) and (4) of CACM Regulation.	X		X	X	X	

Requirement	State		Owner		Nature	
	Initial Requirement	Future Requirement	TSOs	NEMOs	MCO Function	SEC Function
5. The algorithm shall provide NEMOS and TSOs with information necessary to comply with monitoring of REMIT regulation where the algorithm is the only feasible source.		X	X	X	X	
6. The algorithm shall be able to implement a change of bidding zone configurations no later than 4 weeks after a TSO notifies a change, subject to the change request procedure. [*Comment: need to develop an appropriate process that ensures basic requirements of a change request are met, including assessing any impact on performance*]	X		X		X	
7. The algorithm shall be capable of finding results normally within 10 minutes.	X		X	X	X	
[Comment: TSOs have proposed to add "the algorithm shall be able to deliver the volume of matched orders and not-matched orders of each NEMO for the bidding zones of the control area if requested by TSOs". This is, however, a requirement TSOs may establish under local arrangements with relevant NEMOs, but it is not an algorithm functionality]						
Title 6: Currency						
1. The algorithm shall for Single Day Ahead Coupling only accept matching in Euro, i.e. all input and output currency data shall be in Euros. This should not prevent local currency orders and settlements.	X		X	X	X	