Explanatory document to all TSOs' proposal for a harmonised methodology for the allocation process of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves per timeframe in accordance with Article 38(3) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

[For Consultation]

29 June – 29 August 2022

DISCLAIMER
This document is released on behalf of the all transmission system operators ("TSOs") only for the purposes of the public consultation on the proposal for methodology for a harmonised allocation process of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves per timeframe (hereafter referred to as "methodology for a harmonised allocation process per timeframe") in accordance with Article 38(3) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing ("EB Regulation"). This version of the Explanatory document for the methodology for a harmonised allocation process per timeframe does not, in any case, represent a firm, binding or definitive TSOs' position on the content.

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Definitions and Abbreviations

Definitions	Description
Application of a timeframe of CZCA	one or more TSOs applying one or more cross-zonal allocation processes of this methodology for a harmonised allocation process per timeframe on one or more bidding zone borders. The application shall have an approved methodology of Article 38(1) of EB Regulation in place.
Balancing capacity validity period	the period for which the single standard product for balancing capacity bid (i.e. each submitted capacity volume has one single bid price) is offered and for which the accepted standard product for balancing capacity bid could be activated as standard balancing energy bid where all the characteristics of the standard balancing energy product are respected. The balancing capacity validity period is defined by a start time and an end time.
Contracting period	the period for which balancing capacity is procured by the capacity procurement optimisation function and which may extend over multiple balancing capacity validity periods.
Co-optimisation method	Methodology to allocate CZC for the exchange of balancing capacity or sharing of reserves that is based on a comparison of the actual market value of CZC for the exchange of balancing capacity or sharing of reserves and the actual market value of CZC for the exchange of energy.
Cross-zonal capacity allocation Optimisation function	the functionality that determines the allocation of cross-zonal capacity for the exchange of energy and for the exchange of balancing capacity or sharing of reserves and determines the marginal clearing prices and volumes of balancing capacity for each application and per participating TSO.
Data aggregating interface	a tool which collects all standard balancing capacity bids, TSO's balancing capacity demand, day-ahead market bids (for market-based allocation the adjusted bids of the applied reference day per bidding zone), available cross-zonal capacities, and if relevant limitations for the exchange of balancing capacity and sharing of reserves. For the co-optimised allocation process the data aggregating interface shall connect the SPBC bids and the day-ahead market bids in case of cross-product linking. All data shall be aggregated by the data aggregating interface and it shall forward the relevant information to the cross-zonal capacity allocation optimisation function. There shall be one single data aggregating interface for the market-based allocation process and there shall be another single data aggregating interface for the co-optimised allocation process and the inverted market-based allocation process.
Data disaggregating interface	a tool that collects all relevant outputs from the cross-zonal capacity allocation optimisation function and communicates the relevant outputs to each TSO or application, and for the market-based allocation to the day-ahead capacity calculation process per CCR. There shall be one single data disaggregating interface for the market-based allocation process and there shall be another single data disaggregating interface for the co-

	optimised allocation process and the inverted market-based allocation process.
Day-ahead Market timeframe	the timeframe of the electricity market until the day-ahead market gate closure time, where, for each market time unit, products are traded the day prior to delivery.
Duration of application	the period for which balancing capacity cooperation applies one of the methodologies over one or more bidding zone borders to allocate CZC for the exchange of balancing capacity or sharing of reserves according to Article 38(2) of the EB Regulation.
Economic surplus from the exchange of balancing capacity or sharing of reserves	the sum for the relevant time period of (i) the TSOs' surplus for the exchange of balancing capacity or sharing of reserves, (ii) the balancing service providers' surplus for the exchange of balancing capacity or sharing of reserves, and (iii) the congestion income. Surplus for balancing service providers being the difference between the price of the accepted bids and the clearing price per capacity unit multiplied by the accepted capacity volume of the bid. Surplus for TSOs for the exchange of balancing capacity being the difference between the maximum possible clearing price and the actual clearing price per capacity unit multiplied by the volume of balancing capacity demand. Surplus for TSOs for sharing of reserves being the sum of multiplying the quantities and prices of all balancing capacity bids rejected due to sharing of reserves if pay-as-bid pricing is applied and being the highest price of the balancing capacity bid multiplied with the capacity volume of the bids that are not cleared any more due to the sharing of reserves if marginal pricing is applied. Surplus for congestion income being the price of cross-zonal capacity as determined by Article 21 of this methodology multiplied with the allocated volume of cross-zonal capacity.
Exchange of balancing capacity	As defined in Article 2(30) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing.
Forecast adjustment	correction of the order books of the applied reference day per bidding zone in order to improve the accuracy of the forecasted market value of cross-zonal capacity for the exchange of energy.
Intraday market timeframe	as defined in Article 2(37) of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.
Market coupling operator	as defined in Article 2(30) of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.
Market Operator	as defined in Article 2(7) of Commission Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast).
Market time unit	the time unit for the aFRR, the mFRR, and RR balancing capacity bids or the day-ahead market time unit (i.e. the period for which the balancing capacity bid price or the market price is established).

Market value of cross-zonal capacity	The economic surplus of CZC allocation, which is the sum of the producer surplus, consumer surplus and congestion income from the exchange of energy (1) for the purpose of exchange of Day-ahead market energy or (2) for the purpose of the exchange of balancing capacity or sharing of reserves.
Positive forecast error	an underestimation in percent per day-ahead market time unit of the applied forecasted market value of cross-zonal capacity for the exchange of energy.
Procurement of balancing capacity	a range of processes during a certain time period and ranges from creating a balancing capacity auction until the selection of balancing capacity bids at the gate closure time (the Contracting of balancing capacity) and informing the balancing service providers about their selected bids.
Reference day	the day which is used to define the forecasted market value of cross-zonal capacity for the exchange of energy or sharing of reserves for the timeframe market-based allocation or to define the forecasted market value of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves for the timeframe inverted market-based allocation.
Release of cross-zonal capacity	CZC allocated for the exchange of balancing capacity or sharing of reserves that are no longer needed and is released as soon as possible and returned in the subsequent capacity allocation timeframes.
Sharing of reserves	a mechanism in which more than one TSO takes the same balancing capacity, being, FRR or RR, into account to fulfil their respective reserve requirements resulting from their reserve dimensioning processes.
Single day-ahead coupling	as defined in Article 2(27) of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.
Single intraday coupling	as defined in Article 2(27) of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.
TSO BC demand	the balancing capacity volume to be procured for own purposes resulting from the TSO's dimensioning process within the scope of the methodology pursuant to Article 33(1) of the EB Regulation and defined per scheduling area and bidding zone in accordance with Article 32(1) of the EB Regulation.
TSO BC sensitive demand	a part of the TSO BC demand defined by the respective TSO to be volume sensitive for the purpose of reserve sharing, bid indivisibility, and substitution of reserves for cost minimisation and volume shortage.
TSO procurement volume	the balancing capacity volume to be procured by the respective TSO in its own area determined by the cross-zonal capacity allocation optimisation function.
Use of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves'	the physical use of CZC with an actual transfer of balancing energy.

Abbreviations

The list of abbreviations used in this document:

AC	Alternating current
ACER	Agency for the Cooperation of Energy Regulators
aFRR	Frequency restoration reserves with automatic activation
ATC	Available Transfer Capacity
BC	Balancing capacity
BCM	Balancing capacity market
BEC	Bilateral Exchange Computation
BSP	Balancing service provider
CA	Control area
CACM	Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management
CB	Critical branch
CCR	Capacity Coordination Region
CZC	Cross-zonal capacity
CZCA	Cross-zonal capacity allocation
CZCAOF	Cross-zonal capacity allocation optimisation function
D	Day of realisation
D2CF	Two-days ahead congestion forecast
DACC	Day-ahead capacity calculation
DAM	Day-ahead market
DC	Direct current
EB Regulation	Commission Regulation (EU) 2017/2195 of 23 November 2017 a establishing a guideline on electricity balancing
ECC	European Commodity Clearing
ENTSO-E	European Network of Transmission System Operators for Electricity
EU	European Union
FB	Flow-based
FCR	Frequency containment reserves
FRR	Frequency restoration reserves
GCT	Gate closure time

GSK	Generation shift key
H	Hour
JAO	Joint Allocation Office
LFC	Load-frequency control
LFCR	Load-frequency control and reserves
LT	Long-term
LTTR	Long-term transmission right
mFRR	Frequency restoration reserves with manual activation
MC	Market coupling
MP	Market party
MW	Megawatt
NEMO	Nominated electricity market operator
NRA	National regulatory authority
NTC	Net Transfer Capacity
RCC	Regional coordination centre
RR	Replacement reserve
SA	Synchronous area
SDAC	Single day-ahead coupling
SIDC	Single intraday coupling
SO Regulation	Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity transmission system operation
TSO	Transmission system operator

1 Introduction

The Commission Regulation (EU) 2017/2015 establishing a guideline on electricity balancing (EB Regulation) proposes the application of cross-zonal capacity allocation (CZCA) for the balancing process to improve competition and increase welfare by means of cross-zonal balancing exchanges. This implies that TSOs may allocate cross-zonal capacity (CZC) available for the single day-ahead coupling (SDAC) to the same timeframe in which the balancing capacity (BC) procurement is organised. To yield the largest benefit through CZCA in a market-based environment, the EB Regulation introduces four CZCA processes:

- Article 40 to develop a methodology based on the co-optimised allocation process;
- Article 41 to develop a methodology based on the market-based allocation process and/or the inverted market-based allocation process;
- Article 42 to develop a methodology based on economic efficiency analysis.

This document gives background information and rationale for the All TSOs' proposal for a harmonised methodology for the allocation process of CZC (harmonised methodology) for the exchange of balancing capacity or sharing of reserves as required by EB Regulation Article 38(3).

The harmonised methodology shall include three timeframes which all focus on day-ahead procurement according to the Clean Energy Package, consequently excluding the timeframe of economic efficiency analysis.

For higher legibility, the document is structured as follows:

- **Chapter 1** and **2** give a general presentation of the EB Regulation requirement and the co-optimised allocation process, the inverted market-based allocation process and the market-based allocation process;
- **Chapter 3** provides background information regarding balancing capacity markets and cross-border exchange of balancing capacity;
- **Chapter 4** covers the assessment of the market value of CZC for day-ahead market purposes and for balancing capacity market purposes. The principles of the required CZCA optimisation (cost-benefit analysis) are provided;
- **Chapter 5** introduces a comprehensive description of the harmonised allocation process, where all three cross-zonal allocation processes as explained in chapters 1 and 2 are described. This also includes forecast validation and forecasting processes for the market-based and the inverted market-based approach.
- **Chapter 6** is dedicated to specific topics in this harmonised methodology.

1.1 EB Regulation and the scope of the CZCA harmonised Proposal

The EB Regulation established an EU-wide set of technical, operational and market rules to govern the functioning of electricity balancing markets.

The main purpose of this guideline is the integration of balancing markets to enhance the efficiency of the European balancing processes. The integration should be done in a way that avoids undue market distortion. This requires a harmonisation in both technical requirements and market rules. To provide this level of harmonisation, the EB Regulation sets out requirements for the development of harmonised methodologies for CZCA for balancing purposes.

1.2 Cross-zonal capacity for balancing capacity purpose

TSOs procure ahead of real-time BC for automatic and manual frequency restoration reserves (FRR) and/or replacement reserves (RR).

The cross-border cooperation for the BC procurement could be implemented by two different schemes:

- **Exchange of balancing capacity** refers to the BC provision to a TSO in a different scheduling area than the one in which the offering balancing service provider (BSP) is connected. Exchange of balancing capacity between balancing areas may lead to a deviating geographical BC procurement location than the dimensioning results for each area to increase efficiency, competition and cost savings. The total BC procured in all scheduling areas is equal to the total dimensioned volumes.
- **Sharing of reserves** refers to a mechanism in which more than one TSO take the same reserve capacity into account to fulfil the respective reserve requirements as required from the reserve dimensioning processes. This is possible between two or more TSOs which from experience do not need the same procured BC unit at the same time. TSOs can therefore share their reserves and reduce the procurement of the total BC still meeting their individual system security requirements and save procurement costs.

Article 38(1) of the EB Regulation allows two or more TSOs to allocate a part of the CZC for the cross-border exchange of balancing capacity or sharing of reserves. Such an allocation may:

- enable TSOs to procure and use BC in an efficient, economic and market-based manner;
- improve competition for BC markets;
- improve competition between different markets;
- facilitate regional BC procurement.

1.3 Competition on cross-zonal capacity between day-ahead and balancing capacity markets

The CZC between two bidding zones is limited. Therefore, this limitation requires the implementation of a mechanism to allocate the scarce CZC in an economically efficient way. The CZC allocated to the SDAC decreases the available CZC for BC purposes and vice versa. In other words, CZC allocation to one market increases its economic surplus but decreases the economic surplus of another and vice versa. The DA and BC markets therefore directly compete for the available CZC of the day-ahead timeframe. By establishing a CZCA methodology, the equal treatment of both markets shall be ensured.

The allocation process implies CZCA for the BC market at D-1 for the 24 hours of the next day together with and at the same market time unit (MTU) as the CZCA to the SDAC.

For the co-optimised allocation process, firm energy supply and demand bids, together with firm balancing capacity bids therefore compete for the available CZC for each MTU of the next day, as calculated and published by the TSOs before the GCT of the SDAC.

The classical economic concept to optimally allocate CZC to different purposes (also called the optimal capacity split problem) is to express the marginal economic surplus for an increment of CZC used for each purpose, and then find the capacity split where the marginal value for each purpose is equal (or the difference in marginal value is minimal if the lines do not cross). This principle is shown in **Figure 1** below.

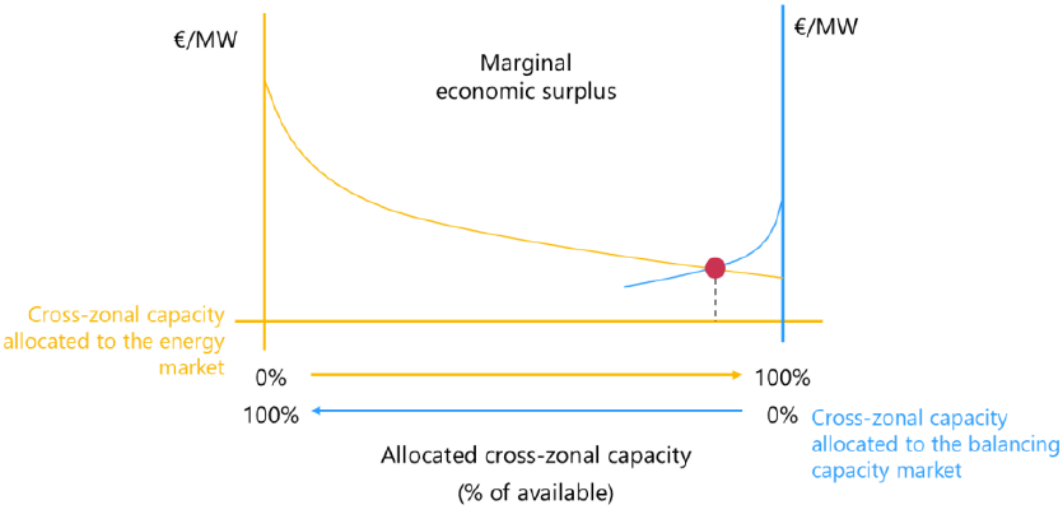

FIGURE 1: PRINCIPLE OF OPTIMAL CAPACITY ALLOCATION TO DIFFERENT PURPOSES

CZC allocation across all borders, all MTUs and all allocation purposes give maximum market welfare if and only if it is not possible (i.e., without violating constraints) to reduce the difference in marginal economic surplus between allocation purposes for any hour on any border any further, while the summed effect of resulting increases of the difference in marginal economic surplus on any other border, hour and allocation purpose is lower. This is called a Pareto optimum.

The objective of the co-optimisation function is to maximise the sum of the economic surplus of the balancing capacity market and the SDAC while minimising BC procurement costs.

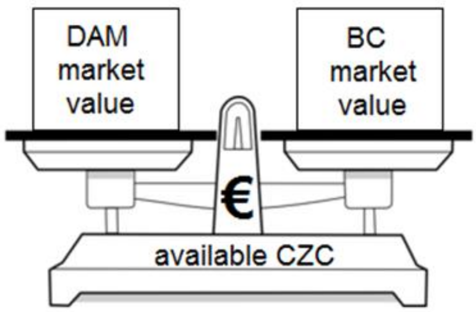

FIGURE 2: HOW TO ALLOCATE AVAILABLE CROSS-ZONAL CAPACITY

As a result, one unit of CZC may be allocated for the exchange of balancing capacity or sharing of reserves if the corresponding CZC market value is higher than the market value for the same CZC unit allocated to SDAC.

2 EB Regulation requirements for the harmonised methodology for the allocation process of cross-zonal capacity

Article 38(3) of the EB Regulation requires all TSOs to develop a proposal for a harmonised methodology for the CZCA processes for the exchange of balancing capacity or sharing of reserves according to Articles 40 and 41. This section provides a summary of the EB Regulation requirements for the aforementioned allocation processes.

2.1 Co-optimised allocation process: Article 40 of the EB Regulation

Article 40(1) of the EB Regulation states the requirement to develop "*a proposal for a methodology for a co-optimised allocation process of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves*."

Besides the obligation to develop a proposal, Article 40 defines boundary conditions and specific requirements for this methodology.

In the words of the EB Regulation, such a methodology shall:

> *a) apply for the exchange of balancing capacity or sharing of reserves with a contracting period of not more than one day and where the contracting is done not more than one day in advance of the provision of the balancing capacity;*

This means that the entire process of the co-optimised CZCA methodology takes place after D-1 BC market gate closure time (GCT) and DAM GCT, i.e. when all bids are firm. This means that according to the EB Regulation, co-optimisation allocation is done during the SDAC auction.

> *(b) include the notification process for the use of the co-optimised allocation process;*

> *(c) include a detailed description of how cross-zonal capacity shall be allocated to bids for the exchange of energy and bids for the exchange of balancing capacity or sharing of reserves in a single optimisation process performed for both implicit and explicit auctions;*

In the CZCA processes, there is direct competition between (at least) two different products for the same CZC: bids for energy and bids for balancing capacity. The inputs of the single optimisation process are both balancing capacity bids and energy bids, submitted per scheduling area and per bidding zone, respectively. The result is an optimal allocation of the CZC to both products.

> *(d) include a detailed description of the pricing method, the firmness regime and the sharing of congestion income for the cross-zonal capacity that has been allocated to bids for the exchange of balancing capacity or sharing of reserves via the co-optimised allocation process;*

Pricing methods are, for example, pay-as-bid and pay-as-cleared. The objective function of the co-optimised allocation process is completely independent of the method for the TSO-BSP pricing, which is applied *ex-post* to the selected balancing capacity bids (see Section 4.2).

Nonetheless it is required to describe the allowed pricing methods for the cross-zonal capacity allocation processes in order to calculate and determine exactly the allocation of CZC to the exchange of balancing capacity or sharing of reserves based on the objective of welfare maximisation.

It is also required to describe in detail when the CZC is considered to be firmly allocated to the matched bids for the exchange of balancing capacity or sharing of reserves.

The congestion income is part of the total economic welfare. It can appear whenever there is a price difference between bidding zones. The congestion income on a border, if any, must be shared between the network owners who share that border: it is required that the harmonised methodology contains the principles for sharing the congestion income for all timeframes.

Article 40(3) of the EB Regulation requires that the definitions of the pricing method of CZC, the firmness regime of CZC, and the sharing of congestion income from CZC for which the co-optimised allocation process is applied to ensure equal treatment between balancing capacity bids and energy bids.

> *(e) include the process to define the maximum volume of allocated cross-zonal capacity for the exchange of balancing capacity or sharing of reserves;*

Article 40 poses no a priori limitation for the co-optimised allocation of CZC for exchange of balancing capacity or sharing of reserves, but limits can arise from technical or economic reasons.

> *(f) be based on a comparison of the actual market value of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves and the actual market value of cross-zonal capacity for the exchange of energy;*

Actual bids, which represent the actual market value, are used for all products. This means that:

- the GCT is the same for balancing capacity and energy markets;
- TSOs (balancing) and NEMOs (trading energy) have the same timeslot to send data to the market coupling operator.

It is stated in Article 40(4) of the EB Regulation that CZC allocated for the exchange of balancing capacity or sharing of reserves via the co-optimised allocation process shall be used only for the exchange of balancing capacity or sharing of reserves and the associated exchange of balancing energy.

2.2 Market-based proposal: article 41 of the EB Regulation

Article 41(1) of the EB Regulation states the requirements to develop "*a methodology for a market-based allocation process of cross zonal capacity for the exchange of balancing capacity or sharing of reserves.*"

Besides the obligation to develop a proposal, article 41 of the EB Regulation defines boundary conditions and specific requirements for this methodology.

In the words of the EB Regulation, such a methodology shall:

> a) *apply for the exchange of balancing capacity or sharing of reserves with a contracting period of not more than one day and where the contracting is done not more than one week in advance of the provision of the balancing capacity;*
>
> b) *include the notification process for the use of the market-based allocation process;*
>
> c) *include a detailed description of how to determine the actual market value of cross zonal capacity for the exchange of balancing capacity or sharing of reserves, and the forecasted market value of cross zonal capacity for exchanges of energy and the forecasted market value of cross zonal capacity for the exchange of balancing capacity or sharing of reserves;*

d) *include a detailed description of the pricing method, the firmness regime and the sharing of congestion income for the cross zonal capacity that has been allocated to bids for the exchange of balancing capacity or sharing of reserves via the market-based allocation process;*

Pricing methods are, for example, pay-as-bid and pay-as-cleared. It is required to describe in detail when the CZC is considered to be firmly allocated to the matched bids for the exchange of balancing capacity or sharing of reserves, in other words, to identify the time interval during which this CZC is not available for any other allocation processes.

In general, the congestion income is part of the total economic welfare and its value can change due to allocation of CZC for the exchange of balancing capacity or sharing of reserves. It appears whenever there is a price difference between bidding zones and it can also take into account the cost of using CZC (in case a third party owns transmission rights). The congestion income on a border, if any, must be shared between the TSOs who share that border: it is required that the MB CZCA Proposal contains the principles for sharing the congestion income.

Article 41(4) of the EB Regulation requires that the definitions of the pricing method of CZC, the firmness regime of CZC, and the sharing of congestion income from CZC for which the MB CZCA Proposal is applied ensure equal treatment between balancing capacity bids and energy bids.

(e) include the process to define the maximum volume of allocated cross zonal capacity for the exchange of balancing capacity or sharing of reserves pursuant to paragraph 2;

Article 41 poses no a priori limitation for the market-based allocation of CZC for exchange of balancing capacity or sharing of reserves, but limits can arise from technical or economic reasons.

(f) be based on a comparison of the actual market value of cross zonal capacity for the exchange of balancing capacity or sharing of reserves and the forecasted market value of cross zonal capacity for the exchange of energy;

Moreover, it is stated in article 41(5) of the EB Regulation that CZC allocated for the exchange of balancing capacity or sharing of reserves via the market-based allocation process shall be used exclusively for the exchange of balancing capacity or sharing of reserves and the associated exchange of balancing energy, otherwise it shall be released.

2.3 Principles from Articles 38 and 39 of the EB Regulation

Article 38 of the EB Regulation – General requirements

The co-optimised CZCA methodology is based on general requirements set out in Article 38 of the EB Regulation:

Article 38(1) of the EB Regulation states that two or more TSOs are allowed to allocate parts of CZC for the use of balancing, based on three different allocation methodologies, co-optimised allocation being one of them.[1]

Article 38(2) of the EB Regulation lists the information that any CZCA proposal needs to specify regarding its scope of application: bidding zone borders, market timeframe, duration, and methodology.

[1] Any contract between two or more TSOs for CZCA for the exchange of balancing capacity or sharing of reserves already in place before the EB Regulation entered into force may remain valid until the contract expires.

Article 38(3) of the EB Regulation stipulates that, where relevant, all TSOs shall develop a proposal to harmonise the different proposals for each of the three allocation methodologies by 5 years after the EB Regulation entered into force. This is implemented with the All TSOs' proposal for a harmonised methodology for the allocation process of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves per timeframe.

Article 38(4) of the EB Regulation mentions that CZC which is allocated to the exchange of balancing capacity or sharing of reserves can only be used for the standard products of mFRR, aFRR and RR for both AC and DC interconnections. On DC interconnectors, CZC may also be allocated for operating and exchanging FCR. The reliability margin of AC interconnectors shall be used for operating and exchanging FCR and shall not be used for the exchange of balancing capacity or sharing of reserves.

Article 38(5) of the EB Regulation forbids the CZCA for balancing purposes when the capacity calculation is not performed according to capacity calculation methodologies developed pursuant to Commission Regulation (EU) 2015/1222 and pursuant to Commission Regulation (EU) 2016/1719. However, the TSOs believe this requirement shall not prevent TSOs to establish an early market based integrated balancing capacity markets and applying allocation of cross-zonal capacity.

Article 38(8) of the EB Regulation requires that:

- on a regular basis it is assessed whether the allocated CZC is needed for the purpose of balancing;
- when CZC is no longer needed for balancing, it shall be released as soon as possible and returned in the subsequent capacity allocation timeframes, where it shall no longer appear as already allocated CZC in the calculations of CZC.

According to Article 38(9) of the EB Regulation, allocated CZC shall be released when it has not been used for the associated exchange of balancing energy, meaning that the RR, mFRR and aFRR quantities affecting CZC have not been activated in their relevant timeframes. Releasing CZC means that it becomes available for the exchange of balancing energy with shorter activation times (e.g. allocated CZC for aFRR, when released, is available for imbalance netting).

Article 39 of the EB Regulation – Calculation of the market value of cross-zonal capacity

Article 39 of the EB Regulation defines the principles for the calculation of the market value of CZC.

Article 39(1) of the EB Regulation states that for the co-optimised CZCA methodology, the market value of CZC is determined based on actual market values of CZC.

Article 39(2) of the EB Regulation says that the actual market value of CZC for the exchange of energy is calculated based on actual bids from the SDAC and its calculation should take into account, where relevant and possible, expected bids from SIDC.

Article 39(3) of the EB Regulation says that the actual market value of CZC for the exchange of balancing capacity shall be calculated based on balancing capacity bids submitted to the capacity procurement optimisation function.

Article 39(4) of the EB Regulation says that the actual market value of CZC for sharing of reserves shall be calculated based on the avoided costs of procuring balancing capacity. This is implicitly taken into account in the co-optimised CZCA methodology because sharing of reserves means that the total demand for balancing capacity of the TSOs in the sharing agreement is lower; therefore the benefit of allocating CZC is the avoided cost of procurement.

2.4 Other relevant information from the EB Regulation

Article 33 of the EB Regulation – Exchange of balancing capacity

According to Article 33(2) of the EB Regulation, *"except in cases where the TSO-BSP model is applied pursuant to Article 35, the exchange of balancing capacity shall always be performed based on a TSO-TSO model whereby two or more TSOs establish a method for the common procurement of balancing capacity taking into account the available cross-zonal capacity and the operational limits defined in Chapters 1 and 2 of Part IV Title VIII of Regulation (EU) 2017/1485."*

Article 33(3) of the EB Regulation states that, apart from the exceptions in Articles 26 and 27 of the EB Regulation, *"all TSOs exchanging balancing capacity shall submit all balancing capacity bids from standard products to the capacity procurement optimisation function"*, without modifying or withholding any balancing capacity bids which shall be included in the procurement process.

Article 33(4) of the EB Regulation requires that all TSOs exchanging balancing capacity ensure the (secure) availability of CZC, either by a probabilistic approach (described in Article 33(6) of the EB Regulation) or by the CZCA methodologies pursuant to Articles 38 to 42 of the EB Regulation.

Article 36 of the EB Regulation – Use of cross-zonal capacity

According to Article 36(2) of the EB Regulation, *"two or more TSOs exchanging balancing capacity may use cross-zonal capacity for the exchange of balancing energy when cross-zonal capacity is:*

a) available pursuant to Article 33(6); i.e. it is calculated with the probabilistic approach,

b) released pursuant to paragraphs 8 and 9 of Article 38; meaning that CZC was allocated according to one of the methodologies in Articles 40, 41 and 42 of the EB Regulation and then either not used for the associated exchange of balancing energy or deemed too high in a re-evaluation,

c) allocated pursuant to Articles 40, 41 and 42. meaning that CZC was allocated according to one of the processes according to Articles 40 and 41 of the EB Regulation and can, therefore, be used for the associated exchange of balancing energy.

Article 58 of the EB Regulation – Balancing algorithms

Following Article 58(3) of the EB Regulation, in the proposal pursuant to Article 33, two or more TSOs exchanging balancing capacity shall develop algorithms to be operated by the capacity procurement optimisation functions for the procurement of balancing capacity bids. Those algorithms shall:

(a) minimise the overall procurement costs of all jointly procured balancing capacity;

(b) if applicable, take into account the availability of cross-zonal capacity including possible costs for its provision.

According to Article 58(3)(a), the price formation of balancing capacity markets have to comply to the cost minimisation principle, taking into account all TSO BC demand of all standard balancing capacity products that are exchanged or shared, of all TSO members of an application. The cost minimisation entails that in terms of price formation, is based on the BSP bids exactly.

Article 56 and 57 of the EB Regulation – Settlement rules for the procurement

According to Article 56 and 57, applications shall establish harmonised rules for all standard balancing capacity bids, the TSO BC demand and congestion income of any application. The requirements shall be respected in the development of the capacity procurement optimisation function according to Article 58(3) and integrated in the cross-zonal capacity allocation optimisation function of each timeframe of the cross-zonal capacity allocation optimisation function.

3 Background information

3.1 Balancing capacity market

According to Article 32 of the EB Regulation, all TSOs of an LFC Block shall regularly and at least once in a year review and define the reserve capacity requirements for the LFC Block or scheduling areas of the LFC Block pursuant to the dimensioning rules as required in the SO Regulation. Reserve capacity can be provided by:

a) procurement of balancing capacity within the control area (CA) and exchange of balancing capacity with neighbouring TSOs;

b) sharing of reserves;

c) the volume of non-contracted balancing energy bids which are expected to be available both within their control area and within the European platforms taking into account the available CZC.

3.1.1 Balancing capacity auctioning

Each TSO procuring balancing capacity shall define the rules for the procurement of balancing capacity. These rules shall comply with the following principles, according to Article 32(2) of the EB Regulation:

a) the procurement method shall be market-based for at least the frequency restoration reserves and the replacement reserves;

b) the procurement process shall be performed on a short-term basis to the extent possible and where economically efficient;

c) the contracted volume of balancing capacity may be divided into several contracting periods.

d) the procurement of upward and downward balancing capacity for at least the frequency restoration reserves and the replacement reserves shall be carried out separately.

Co-optimisation and the market-based approach require a BC auction at D-1. However, each balancing capacity application consisting of one or more TSOs can choose if the auction at D-1 has a contracting period of 24 hours, is smaller or even consists of multiple contracting periods, within 24 hours, as long as harmonised within the application.

The validity period of the SPBCs and the TSO BC demand are equal in each application and according to the options as part of the SPBC methodology.

3.1.2 Exchange of balancing capacity

The exchange of reserves allows TSOs to organise and to ensure the availability of reserve capacity resulting from the dimensioning by relying on BSPs that are connected to an area operated by a different contracting TSO within a synchronous area or between two synchronous areas.

Two or more TSOs exchanging or mutually willing to exchange balancing capacity shall develop a proposal for the establishment of common and harmonised rules and processes for the exchange and procurement of balancing capacity while respecting the requirements set by EB Regulation for procurement for balancing capacity.

Except in cases where the TSO-BSP model is applied, the exchange of balancing capacity shall always be performed based on a TSO-TSO model whereby two or more TSOs establish a method for the common procurement of balancing capacity taking into account the available CZC and the operational limits defined by SO Regulation.

All TSOs participating in the same exchange of FCR, FRR or RR shall specify an exchange agreement as defined by SO Regulation.

Exchange of reserves between two areas may lead to a different geographical location of the balancing capacity from the dimensioning results for each area; however, the total amount of balancing capacity within the two areas is still equivalent to the total amount without the exchange of reserves.

Figure 3 illustrates the exchange of 200 MW of balancing capacity from Area B to Area A.

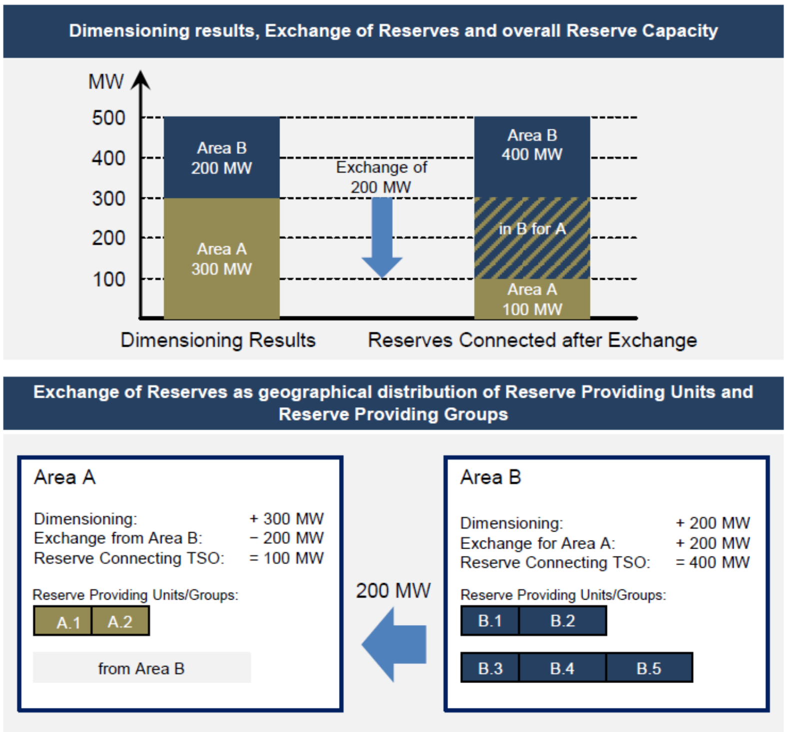

FIGURE 3: EXCHANGE OF RESERVES – ILLUSTRATIVE EXAMPLE. SOURCE: LFCR SUPPORTING DOCUMENT 2013

Suppose that the dimensioning rules result in the need of 300 MW for Area A and 200 MW for Area B. Without the exchange of reserves the respective reserve capacity has to be provided by reserve providing units or reserve providing groups connected to the Area which means that 300 MW have to be connected in Area A and 200 MW in Area B.

As a result of the exchange of reserves of 200 MW from Area B to Area A, 200 MW of reserve capacity needed for Area A is now located within Area B, whereas Area A still ensures, besides, the availability of the full amount of its reserve capacity.

Although the geographical location of the reserve capacity is different from the dimensioning results for each area, the total amount of reserve capacity within Area A and B is still 500 MW which is equivalent to the total amount without the exchange.

3.1.3 Sharing of reserves

The sharing of reserves agreement allows two or more TSOs to organise and to ensure the availability of balancing capacity that is required by dimensioning rules by relying on the same reserves inside a synchronous area and between two synchronous areas.

The roles and responsibilities of the reserve connecting TSO, the reserve receiving TSO and the affected TSO for the exchange of reserves between synchronous areas, shall be described in the synchronous area operational agreement and a sharing agreement as defined by SO Regulation.

In contrast to the exchange of reserves, sharing of reserves changes the total amount of procured balancing capacity by the connecting TSOs, with an impact on the geographical distribution as an additional implicit effect. The sharing of reserves agreement defines priority rights to the shared reserves in the situation where either two or more TSOs have a simultaneous need.

Figure 4 illustrates the sharing of 100 MW balancing capacity between two areas with a possible relocation of 100 MW of reserves from Area A to Area B.

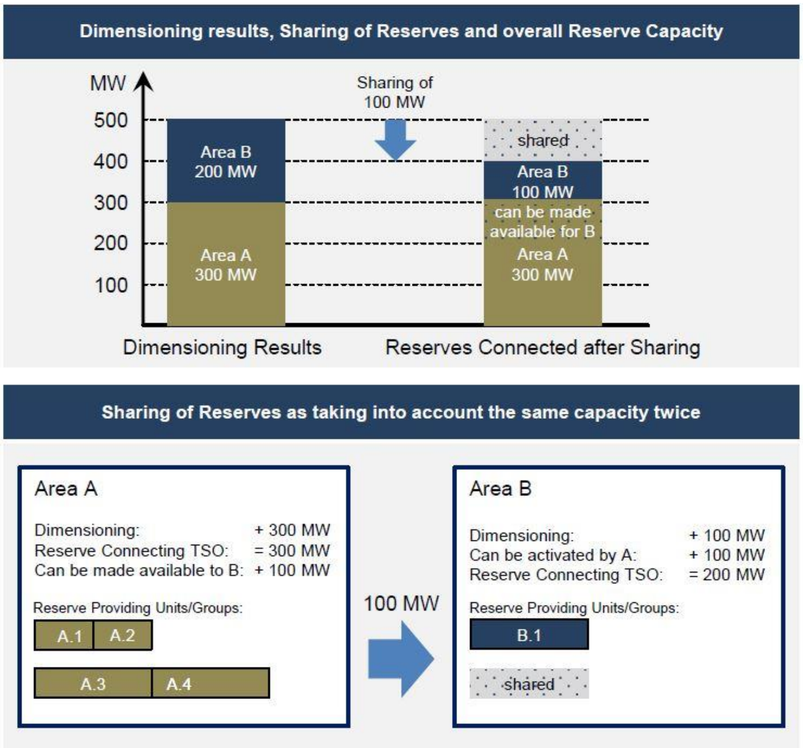

FIGURE 4: SHARING OF RESERVES – SIMPLE EXAMPLE. SOURCE: LFCR SUPPORTING DOCUMENT 2013

Suppose that the dimensioning rules for area A and area B result in need of 300 MW for area A and 200 MW for area B. Without the sharing of reserves, the TSOs of area A and area B have to ensure the availability of respectively 300 MW and 200 MW.

However, assuming that in some cases it might be very unlikely that both TSOs need to activate the full amount reserve capacity at the same time, the TSOs of area A and area B can 'share' part of their reserve capacity. In practice, this means that the TSOs of area B can make use of, e.g. 100 MW of the reserve capacity of the TSOs in area A.

As a result, the TSOs of area A and area B now need to ensure the availability of 300 MW and 100 MW. The TSOs of area A now make 100 MW of their reserve capacity also available to the TSOs of area B. The total amount of the reserve capacity within the system is now 400 MW, whereas it was 500 MW without the sharing agreement (leading in this example to a reduction of 100 MW of reserve capacity in the total system).

3.1.4 Limitations to the CZC allocated to the balancing capacity market

Due to its criticality for system adequacy, and its possible interference with the SDAC processes, allocation of CZC to the balancing capacity market may be subject to additional limitations, beyond the capacity calculation processes that are in place for the allocation of CZC to the energy market.

Relevant NRAs and TSOs within a balancing capacity cooperation may decide to limit CZC allocation to the balancing capacity market

a) in case it is necessary to comply with the SO Regulation limits for local procurement (Articles 167 and 169 and Annexes),

b) as a way to avoid market distortions and to safeguard the effective execution of the SDAC,

c) as a measure for market power mitigation, or

d) in case of an already reduced CZC due to planned or unplanned outages, wherein the allocation to the balancing capacity market would excessively constrain the execution of the SDAC.

Such additional limits would then be entered as an input to the CZCAOF and be enforced as an additional constraint to the optimisation itself.

4 Market value of cross-zonal capacity

The decision to optimally allocate CZC for DAM purposes or for BC exchange or sharing of reserves shall be based on a comparison of the corresponding CZC market value for the exchange of energy following actual or forecasted day-ahead energy bids and the CZC market value for the exchange of balancing capacity or sharing of reserves following actual TSO balancing capacity demand and actual or forecasted BSP SPBC bids. Depending on the allocation method, underlying information for CZC market value calculation differs:

- Co-optimisation: EB Regulation Article 40(2) requires the comparison of actual CZC market values based on firm day-ahead energy bids and firm BC bids and TSO BC demand.
- Market-Based Approach: EB Regulation Article 41(3) requires the comparison of forecasted CZC market values for day-ahead energy exchange purposes but actual CZC market values as based on firm BC bids and TSO BC demand.
- Inverted Market-Based Approach: EB Regulation Article 41(3) requires the comparison of actual CZC market values based on firm day-ahead energy bids but forecasted CZC market values and actual TSO BC demand for BC exchange or sharing of reserves purposes.

EB Regulation Articles 39(2) to 39(4) specify how the actual market value shall be derived: with regard to the exchange of energy the bids of market participants in the DAM shall be used, also taking into account bids in the intraday market where relevant and possible; and balancing capacity bids submitted to the capacity procurement function pursuant to EB Regulation Article 33(3) of the EB Regulation shall be used with regard to the BC exchange. When CZC is used for sharing of reserves, the market value shall be based on the avoided costs of procuring balancing capacity to calculate the consumer surplus for the balancing capacity market. The actual market value of CZC for the exchange of energy between bidding zones and for the BC exchange are calculated per day-ahead market time unit.

EB Regulation Article 39 (5-6) further specifies how the forecasted market value shall be derived.

The economic concept to optimally allocate CZC to different purposes (also called the optimal capacity split problem) is to express the marginal market value for an increment of CZC used for each purpose and then find the capacity split where the marginal values are equal (or the difference in marginal values is minimal if the lines do not cross).

The maximisation of the economic surplus is achieved by allocating CZC on all borders, all hours and for all allocation purposes such that the Pareto optimum is reached. I.e.

(a) it is not possible (without violating constraints) to reduce the difference in marginal market values on any border for any hour of the day

(b) without increasing marginal market value difference more of one other border or a sum of other borders during the same day. .

However, this concept assumes that the economic surplus optimisation problem must be convex. This assumption may not hold for BCMs, and the consequences of applying this method are further described in chapter 4.2.4.

4.1 Actual Market Value of cross-zonal capacity for the Exchange of Energy

4.1.1 The market value of cross-zonal capacity

In the co-optimised allocation process as well as in this Explanatory Document, the market value of CZC for the exchange of energy between all bidding zones of the SDAC is defined as the economic surplus (change/incremental) of the SDAC resulting from the additional CZC allocated for the energy market. It is calculated based on the sum of producer surplus, consumer surplus and congestion income, and it is defined per day-ahead market time unit.

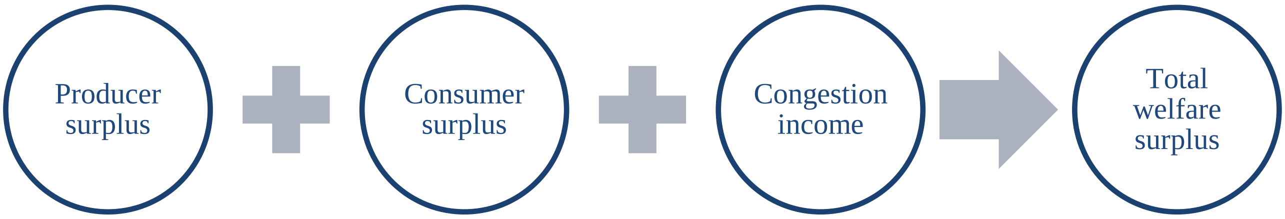

FIGURE 5: MARKET VALUE OF CZC IS DEFINED AS THE TOTAL ECONOMIC SURPLUS

Note that:

- the important measure for the market value is the economic surplus of allocating one additional MW of CZC for either purpose, not the absolute values of this economic surplus.
- only the implicit allocation of CZC (Flow-Based or ATC-based) is relevant for the calculation since the final allocation of CZC is based on co-optimisation; any explicit allocation of CZC which may take place, e.g. monthly or yearly only affects and determines the upper limit of CZC that may be allocated via co-optimisation.

In the following, the principles of cross-border exchange of energy are explained.

4.1.2 Isolated energy markets cleared independently

Figure 6 shows the base case of isolated energy markets which are cleared independently, i.e. no CZC is allocated or used for the exchange of energy and the market-clearing prices (will) differ. In this example, the market-clearing price in zone C is lower than in zone B. The consumer and producer surpluses are highlighted in blue and red, respectively, and the total sum of the areas represents the total economic surplus.

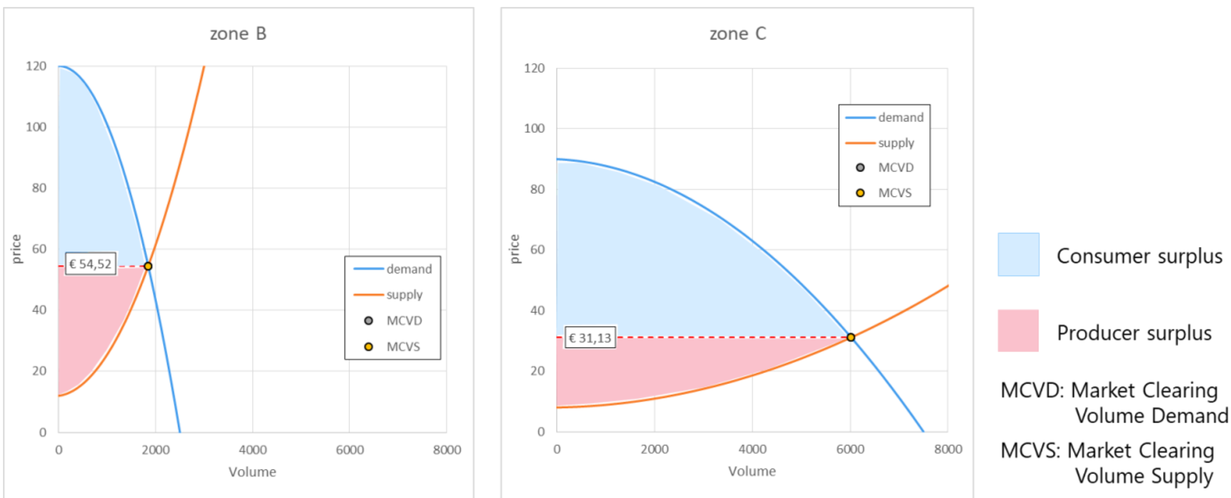

FIGURE 6: ECONOMIC SURPLUS IN TWO ENERGY MARKETS CLEARED IN ISOLATION

4.1.3 Coupled energy markets with congestion

When CZC is allocated and may be used for the exchange of energy, market participants may trade across the border. If the amount of available CZC is large enough, this may even lead to full price convergence between the two bidding zones. Once prices have converged, any additional CZC would then have a value of 0.

Figure 7 depicts a situation where the allocated CZC only allows for a partial price convergence: the market-clearing price in zone C remains lower than in zone B. In addition to buyer and seller surpluses, the remaining price difference creates a positive congestion rent which is also part of total economic surplus (the green area between the red dotted lines in the zone B). With full price convergence, the congestion rent distributions would cancel out and disappear.

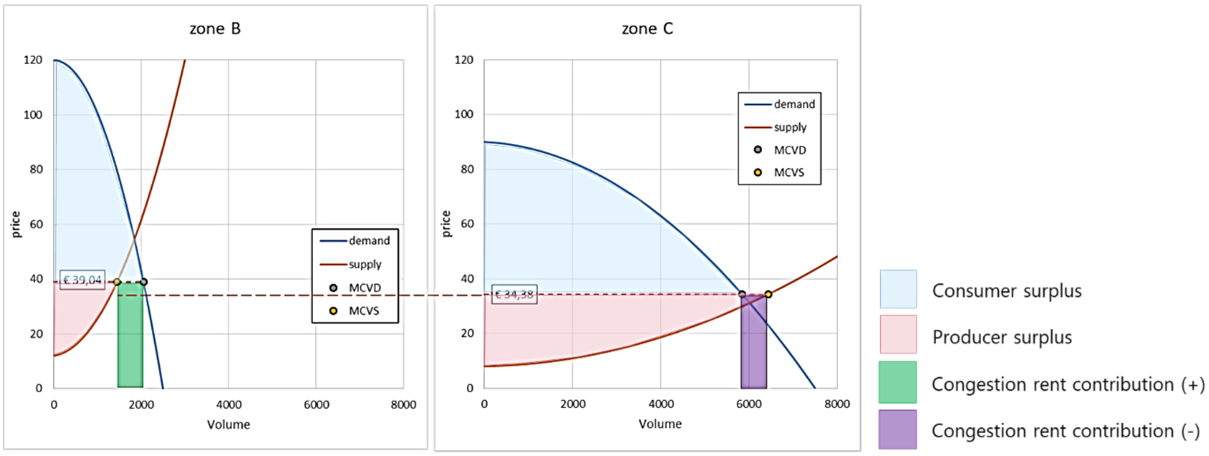

FIGURE 7: ECONOMIC SURPLUS IN COUPLED ENERGY MARKETS WITH CONGESTION

The same logic may be applied to multiple markets and bidding zones; it is thus possible to calculate the value of CZC for each border for which co-optimisation applies. The general calculation of economic surplus is shown in the equation below and consists of the sum of consumer buyer/surplus, producer/seller surplus and congestion rent over all markets. The congestion rent for a market or bidding zone is calculated based on the market-clearing price and the market net position, where the market net position equals the sum of exchanges in both directions (positive for export, negative for import) on all borders with other markets. The market net position also equals the difference in supply and demand volumes cleared.

$$\sum_{all\ markets} \{Consumer/buyer\ surplus + Producer/seller\ surplus - Market\ Net\ Position * Market\ Clearing\ Price\}$$

EQUATION: CALCULATION OF THE ECONOMIC SURPLUS WHEN SUPPLY AND DEMAND ARE MATCHED TO AN EQUILIBRIUM CLEARING POINT

The absolute market value of CZC may now be calculated as the difference between total economic surplus when CZC is allocated for the exchange of energy and the situation of isolated markets. The marginal market value of CZC at a specific border is equal to the price difference at the border.

4.2 Actual Market Value of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves

The market value of CZC for the exchange of balancing capacity or sharing of reserves is defined as the additional total economic surplus in the balancing market resulting from the additional CZC allocated for the balancing capacity market. It is calculated based on consumer surplus (TSO) and on producer surplus (BSP) as well as on congestion income (transmission capacity owner) from BC exchange and sharing of reserves.[2]

The underlying data are upward and downward balancing capacity bids which have been submitted and accepted by the capacity procurement optimisation function pursuant to Article 33(3) of the EB Regulation. This function is part of the co-optimisation method and is described in more details in chapter **Error! Reference source not found.**.

Following Article 32(3) of the EB Regulation, the procurement of upward and downward balancing capacity for at least the frequency restoration reserves and the replacement reserves shall be carried out separately.

Sharing of reserves means a reduction of TSO BC demand. The additional market value of sharing of reserves is therefore based on the avoided costs of procuring according to Article 39(4) of the EB Regulation and assigned as the consumer surplus.

4.2.1 The market value is independent of the pricing method for balancing capacity

The calculation of the market value is based on the maximisation of economic surplus. Hence it is independent of the pricing method for balancing capacity, i.e. pay-as-bid or marginal pricing. While the principle of economic surplus determination is in general the same, the allocation of CZC may differ if one applies pay-as-bid or marginal pricing but this is also subject to the prices and volumes of the bids. Subject to the chosen pricing method, market parties will prepare prices and volumes of the bids accordingly.

4.2.2 Isolated markets for balancing capacity with pay-as-bid pricing

Figure 8 depicts the base case of two isolated markets for balancing capacity with pay-as-bid pricing. In this example, it is assumed that the supply curves for balancing capacity are monotonously non-decreasing in both markets, and the demand for balancing capacity in both areas is fixed and perfectly inelastic.[3] In case the local TSO BC demand exceeds the available amount of locally submitted BC bids, the CZC market value for the exchange of balancing capacity or sharing of reserves is calculated for the unsatisfied bids based on the local balancing capacity bid price cap.

In this example, the price for the last accepted bid for TSO A is higher than the respective price for TSO B. The red arrow indicates available CZC for the exchange of balancing capacity or sharing of reserves if the markets were coupled.

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[2] Producer surplus equals 0 if pay as bid is applied.

[3] It should be noted that this is a simplification, as the balancing capacity market includes non-convexities as start-up and shut-down costs along with minimum output requirements (which states that if a plant is running, it must produce at least a certain amount). This is further elaborated in 4.2.4.

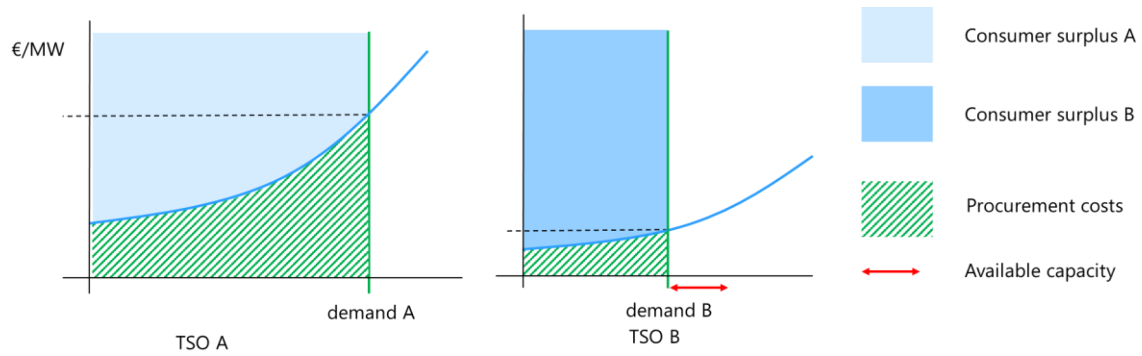

FIGURE 8: ECONOMIC SURPLUS IN ISOLATED MARKETS WITH PAY-AS-BID PRICING

4.2.3 Coupled balancing capacity markets with pay-as-bid pricing

When the two markets are coupled, and CZC is allocated, TSO A will be able to procure part of its balancing capacity in the area of TSO B. As a result, the marginal price in market A will decrease, and that in market B will increase. Figure 9 shows the situation where available CZC is not enough to reach full price convergence; consumer surplus for TSO A will decrease, whereas consumer surplus for TSO B will increase. A part of the procurement costs of TSO A in the isolated situation is now used to procure cheaper balancing capacity in market B. As is shown on the left hand side of Figure 9, the difference in economic surplus is the area (yellow) below the supply curve of area A, above the shifted supply curve of area B (dashed blue line) and between the supply clearing volume in the coupled situation and the original demand A. This is the market value of the allocated CZC in this particular situation. To derive the marginal market value, these results must be compared to incremental changes of CZC, i.e. for each additional MW of CZC allocated to the balancing capacity market.

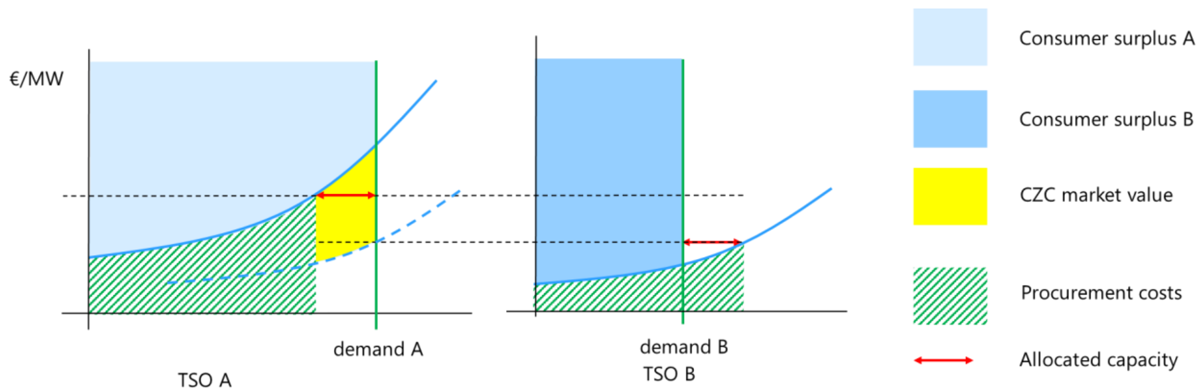

FIGURE 9: ECONOMIC SURPLUS IN COUPLED BALANCING MARKETS WITH PAY-AS-BID PRICING

4.2.4 Non-convexities in balancing capacity markets

The balancing capacity market is directly linked to the energy market, i.e. the BSPs' expectation of the market-clearing in the energy market will be reflected in their bidding behaviour for balancing capacity. The alternative costs for the provision of reserves instead of energy are lowest for the market participants that are almost indifferent to deliver energy, i.e. their marginal costs are near the spot price. For reserves to be offered, some market participants can lower their energy output, and others can start energy production at a moderate economic loss. The former has a variable cost, and the latter has a fixed cost.

This dependency between the two markets makes it difficult to apply to the market coupling principles presented in section **Error! Reference source not found.**. For this to be true, there must be no externalities, and no transaction costs and perfect information. Additionally, the economic surplus optimisation problem must be convex. This includes the absence of discrete variables. Discrete variables mean combinatorial problems that are hard to solve. Balancing capacity bids that reflect fundamental costs cannot be organised as a monotonously increasing "merit order list".

Non-convexities include start-up and shut-down costs along with minimum output requirements (which states that if a plant is running, it must produce at least a certain amount). Due to this combinatorial problem, there does not exist a "market-clearing price" in spinning reserve markets that clear a balancing capacity market efficiently, nor a "marginal price". The market price conveys little or no information on which reserve offers were accepted.

The non-convex effects in the balancing capacity market can be tackled through discrete variables (block bids and combinatorial constraints), and by maximising the economic surplus integer programming. The efficiency of the allocation would be the highest if the energy and balancing capacity market were integrated into one single auction, where the economic surplus is maximised over all matched energy market bids and balancing capacity market bids subject to system constraints.

The combinatorial difficulties can be overcome by restricting reserve bids to a simple format (price, volume). This would render a "merit order" of bids, but the bids would not reflect underlying costs, and the auction would not deliver economic surplus optimisation. This will, on the other hand, reduce the efficiency of the CZCA and increase the procurement cost of balancing capacity, since BSPs must include a higher risk in their price determination or abstain from participating in the market, which will reduce liquidity.

5 Methods for the calculation of market value of cross-zonal capacity

As already elaborated in chapter 2, the three allocation approaches differ in the availability of firm information and, consequently, the requirement of forecasting the market value of CZC.

While an allocation process based on economic efficiency analysis is not foreseen as a relevant allocation approach by TSOs, the three other allocation approaches will be further elaborated in this chapter.

The following graph provides a generic overview of the six main steps of the CZC allocation process and how they interfere:

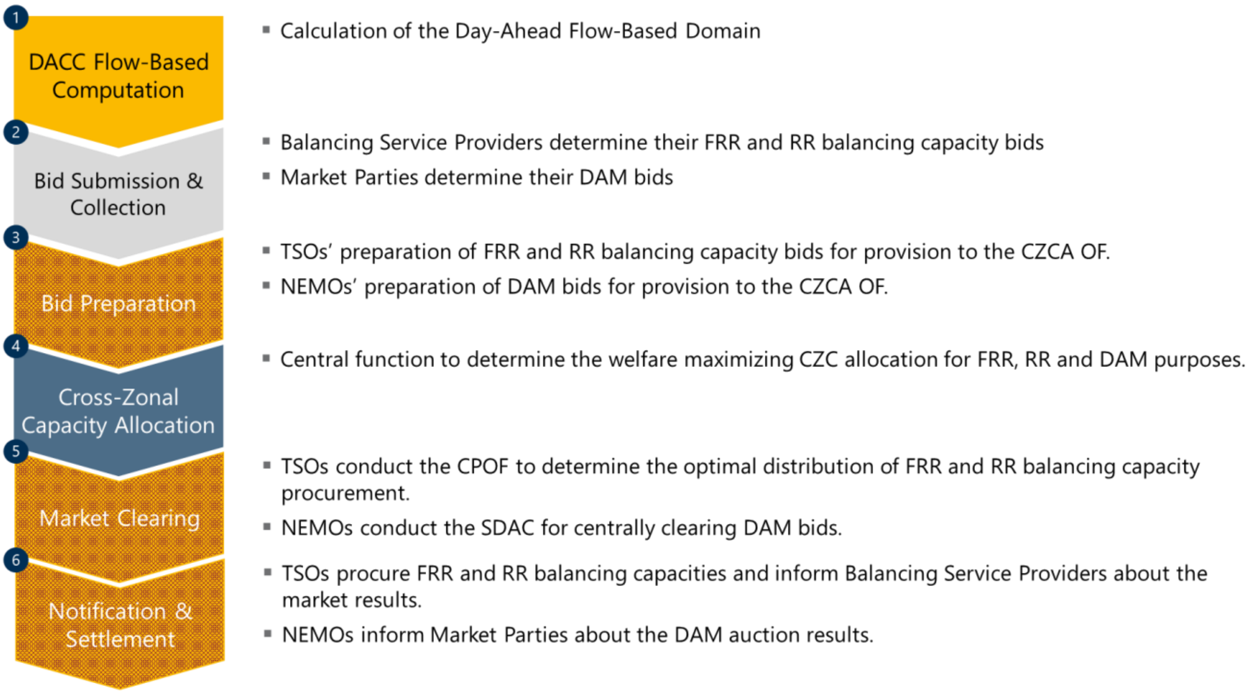

FIGURE 10: THE SIX MAIN PROCESS STEPS OF CZC ALLOCATION

1. In the Day-Ahead Capacity Calculation (DACC), the CZC for the DAMs and the BCMs are determined.
2. In the Bid Collection process, BSPs determine their BC bids as do MPs for DA. Bids are then provided to TSOs and NEMOs.
3. TSOs and NEMOs prepare the bids for providing them to the CZCAOF. They pseudonymise the bids and build the individual merit orders, if applicable, taking into account links in the bid preparation process.
4. The central process of co-optimisation is the CZCAOF. The CZCAOF determines the total welfare maximising allocation of CZC for DAM purposes and for BCM purposes.
5. Based on the CZCAOF outcome, the DAMs can be cleared and BCM bids are provided to the capacity procurement optimisation function (CPOF), for determining the bids to be procured from BSPs.
6. In the notification and settlement process, MPs are informed about their matched bids and results are published. TSOs inform their BSPs and settle the procured BC offers. NEMOs inform MPs about cleared bids.

These six steps are individual sub-processes of the allocation process and will be further elaborated in the following:

5.1 Process Steps of CZC allocation

5.1.1 Flow-Based Computation[4]

The DACC is implemented per capacity calculation region (CCR). The following process graph summarises inputs, processing and outputs.

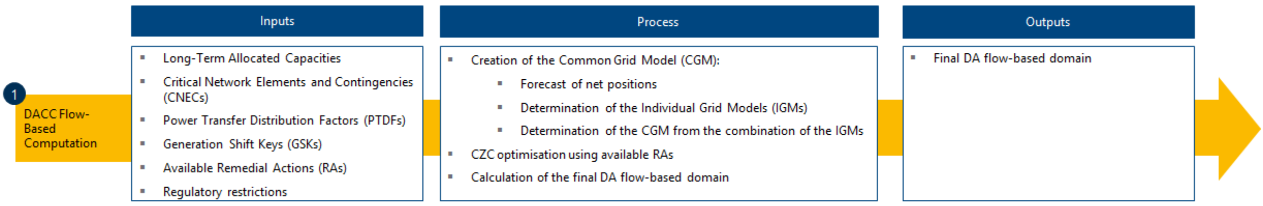

FIGURE 11: PROCESS GRAPH OF THE DACC FLOW-BASED COMPUTATION

The flow-based computation determines the flow-based domain, both, for the DAMs and the BCMs on D-1 for the next day. This requires the long-term allocated CZCs, the information about critical network elements and contingencies (CNECs) as well as Power Transfer Distribution Factors (PTDFs), Generation Shift Keys (GSKs) and available remedial actions (RAs). Beyond, regulatory restrictions need to be taken into account.

From this information the final DA flow-based domain is determined. This is done in a multistep process. First, the net positions are forecasted together with the DC flows in the Common Grid Model Alignment and provided to each CCR. TSOs develop scenarios for each Market Time Unit (MTU) and determine their Individual Grid Models (IGMs). The IGMs are merged to obtain the Common Grid Model (CGM) for each

[4] The flow-based computation is explained e.g. in the Explanatory Note DA FB CC methodology for Core CCR.

MTU. Subsequently, CZCs are optimised taking into account RAs and the final DA flow-based domain is calculated.

5.1.2 Bid Submission & Collection

BSPs and MPs optimise their portfolios based on the available market and system information. Therefore, they split their production capacities into offers to the DAM and the BCMs. The according bid preparation and provision is shown in the following graph.

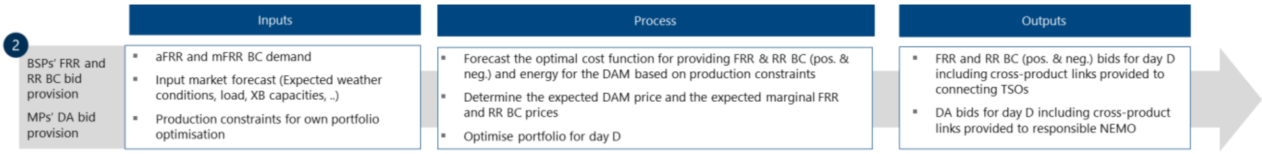

FIGURE 12: PROCESS GRAPH OF THE BID PREPARATION AND PROVISION OF BC AND DAM BIDS

When BSPs determine their offers to the BCM and MPs their provisions to the DAM, they know the total demand from their TSO as well as external market, system and weather conditions and their own production constraints.
With these inputs, BSPs and MPs forecast their optimal production function and cost function for providing BC and energy bids. In combination with the external conditions, BSPs determine their expectations for the DAM price and the marginal BCM prices. By bringing price expectations and cost functions together, BSPs and MPs optimise their portfolio for day D and their offers to the DAM and the BCMs.
The output of the individual portfolio optimisation are the bids to the DAM and the BCMs. These bids are provided to NEMOs and TSOs.

5.1.3 Bids Preparation

In the bid preparation process, NEMOs and TSOs separately prepare the bids provided by MPs and BSPs for further processing in the CZCAOF, EUPHEMIA and the CPOF. This is shown in the following graph.

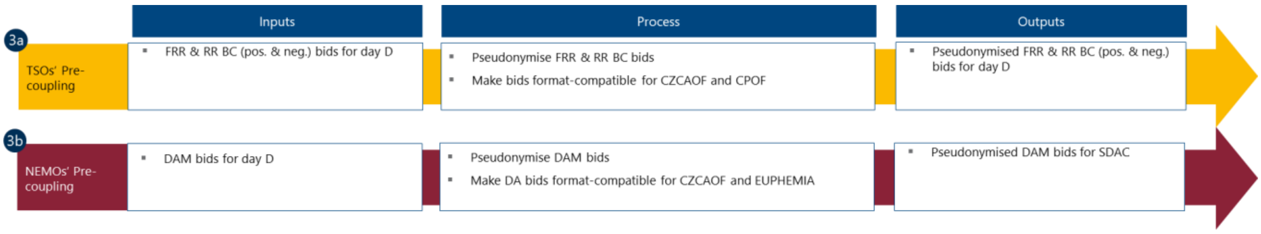

FIGURE 13: PROCESS GRAPH OF THE BID PREPARATION BY TSOS AND NEMOS

TSOs pseudonymise bids and make them format-compatible for the CZCAOF and the CPOF.
Pseudonymised bids for each BCM are combined in BCM bids order books.
BC demand per product and direction has been determined in the TSOs' (individual) dimensioning process including possible reserve sharing potential and an indication of substitution of reserves. TSOs provide this demand information including tolerance bands for sharing of reserves, substitution of reserves and bid indivisibility to the CPOF.
NEMOs take the DAM bids from MPs and make them formatcompatible for the CZCAOF.
Pseudonymised DAM bids are then provided as DA order books to the CZCAOF and EUPHEMIA.

5.1.4 Cross-Zonal Capacity Allocation

Depending on the CZC allocation approach, the CZC allocation is determined from

- the provided DA order books and TSOs' BCM bids order books and demand and tolerance bands for sharing and substitution of reserves and bid indivisibility (co-optimised allocation approach).

- the adjusted DA order books from the applied Reference Day, TSOs' BCM bids order books and demand and tolerance bands for sharing and substitution of reserves and bid indivisibility and CZCA limitations for BC use (market-based approach).
- the provided DA order books and adjusted SPBC offers from the applied Reference (inverted market-based approach).

Total available CZC is provided from the flow-based computation. The CZCAOF also takes into account CZC allocation constraints per border or per product and minimum local reserve requirements. CZC allocation applies a Europe-wide total economic surplus maximising algorithm. CZC is allocated to DAM if DA market value from the next Megawatt (MW) of CZC allocated to the DAM is equal or higher than the market value from the next MW of CZC allocated to any BCMs. The high-level CZCAOF process is shown in the following graph.

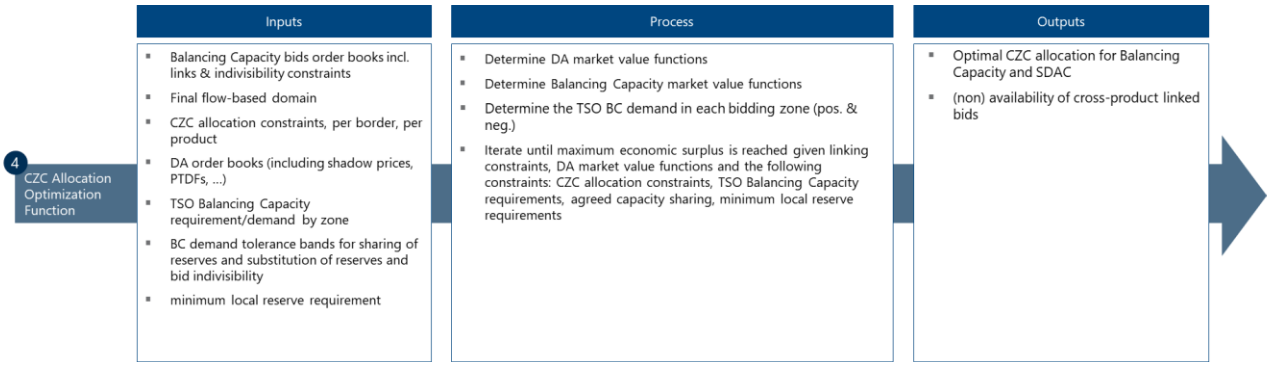

FIGURE 14: PROCESS GRAPH OF THE CZCAOF

In an optimisation process the CZCAOF determines the optimal CZC allocation for BCMs and for the SDAC, taking into account cross-product linking between the different markets, if applicable.

5.1.5 Market Clearing

After or together with CZC allocation, depending on the implementation option[5], the DAMs and the BCMs are separately cleared. The market clearing processes for DAMs and BCMs are displayed in the following figure and explained thereafter.

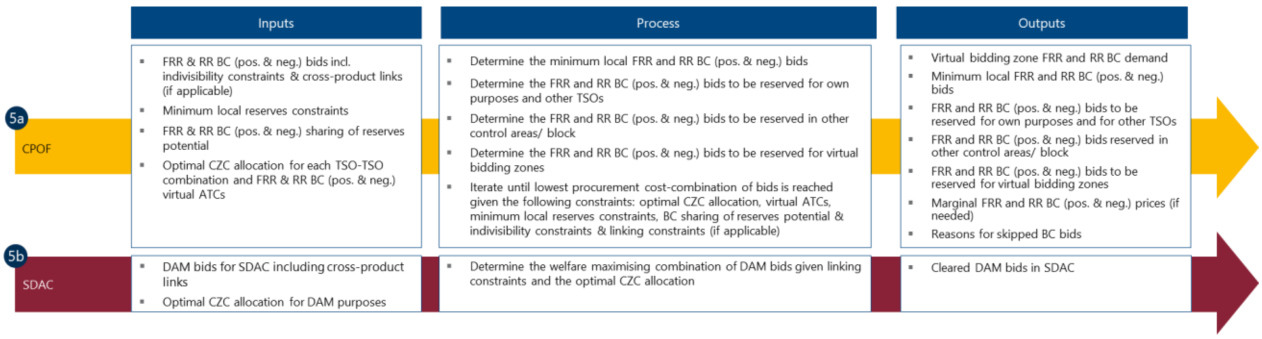

FIGURE 15: PROCESS GRAPH OF THE MARKET CLEARINGS OF THE DAMS AND BCMS

[5] See chapters 8 and 9 of the Co-optimised CZC allocation process Implementation Impact Assessment report.

5.1.5.1 Balancing Capacity Market Clearing

The clearing of the BCMs, also named the procurement of BC, is conducted by the CPOFs. Therefore, the outcomes of the CZCAOF relevant for BC products is provided directly to each CPOF. Beyond, outputs from prior functions and technical or regulatory requirements are inputs to the CPOF. From these inputs, each CPOF determines the most beneficial distribution of BC procurement for control areas considered in the CPOF given the actual CZC allocation. Thus, the CPOF determines the minimum local BCM bids per control area and the bids to be reserved for own purposes, for other TSOs and also for each virtual bidding zone in one TSO's control area. In line with this, it also determines for each TSO of the application the BC to be reserved abroad.
Consequently, a CPOF provides the optimal procurement pattern including volumes, marginal prices and cross-product links for each TSO within the application. It also provides the reasons why bids have been skipped.

5.1.5.2 Day-Ahead-Market Clearing

Similar to the BCM clearings in CPOFs, NEMOs have already installed an algorithm to clear the DAM (EUPHEMIA). For the SDAC, EUPHEMIA requires the allocated CZC for DAM purposes and the DAM bids including cross-product links. It also determines the Europe-wide welfare maximising matching of bids, taking into account cross-product links and finally provides the cleared DAM bids.

5.1.6 Notification and Settlement

The notification and settlement process informs MPs and BSPs about matched bids, exact volume and prices. The process is organised as shown in the graph.

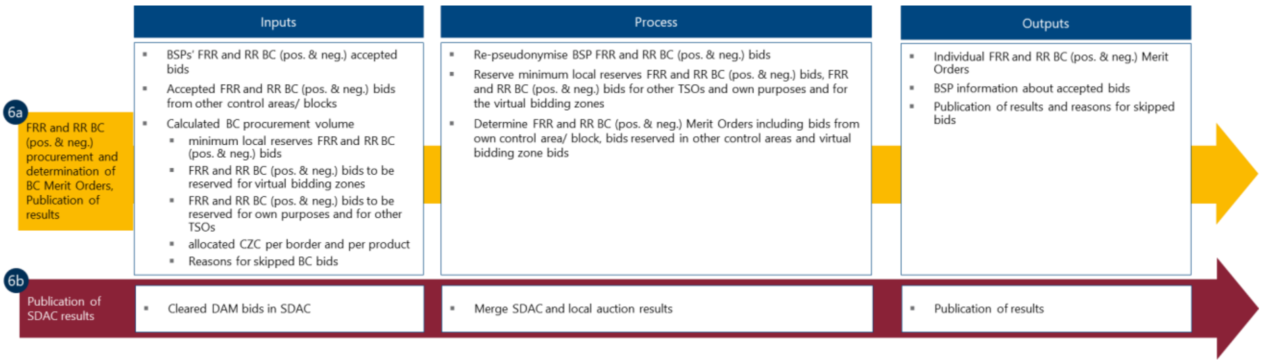

FIGURE 16: PROCESS GRAPH OF THE NOTIFICATION AND SETTLEMENT PROCESS

Notification and settlement are done separately by individual TSOs and NEMOs for BSPs and MPs in their control areas or their bidding areas. Therefore, the outputs of the CPOF and of the SDAC process enter the notification and settlement process.
TSOs re-pseudonymise the settled bids and calculate the surplus for each of their BSPs, network owners and themselves. Subsequently, they inform BSPs about accepted bids and publish results and reasons for skipped bids. As further outcomes, TSOs determine the congestion revenues and the inter-TSO compensation. Finally, TSOs settle the accepted BC bids with BSPs and inter TSO-TSO settlement.
NEMOs re-pseudonymise cleared DAM bids, publish the results and settle the matched DAM bids.

In the remainder of this chapter, this generic CZC allocation process will be adapted to the specific context of each of the three allocation approaches. The key differences arise from the point in time when either DAM bids or BC bids are firm. When determining the CZC allocation for BC purposes and for energy purposes,

- in the co-optimised allocation approach, DAM bids and BC bids are firm.
- in the market-based approach, BC bids are firm but DAM bids are not firm.
- in the inverted market-based approach, DAM bids are firm but BC bids are not firm.

Consequently, actual DAM bids need to be forecasted in the market-based approach and BC bids need to be forecasted in the inverted market-based approach before step 4.

5.2 Co-optimised CZC allocation approach

Co-optimised CZC allocation performance the CZC allocation based on joint optimisation of the BCMs and the DAMs. The CZC split can be determined from the CZC market values for BCMs and for DAMs based on firm bids. This CZC allocation approach provides the most efficient solution for CZC allocation for balancing capacity and for energy purposes. On the other hand, it requires BSPs and MPs to optimise their portfolio without having any information on acceptance of their bids and, consequently, on production requirements. As BSPs and MPs are exposed to a high level of market uncertainty, they would add risk mark-ups to their bid-prices resulting in inefficiently higher prices. To mitigate this inefficiency, cross-product linking allows BSPs/ MPs to connect bids from different markets in the co-optimised allocation approach in the sense that if a bid is accepted for one market, it cannot be accepted in another.

The ENTSO-E project team Co-optimisation Implementation Impact Assessment has elaborated requirements for a feasible implementation of a co-optimised allocation approach pursuant to EB Regulation Article 40.

5.2.1 One-step/ two-step implementation

Two alternative implementation options are currently discussed which are a one-step implementation and a two-step implementation. The one-step implementation defines co-optimisation as an integral process in which the CZCAOF, the DAM clearing and the virtual clearing of the BCMs are integrated as much as possible. This integration enables a joint optimisation of the SDAC, the BCMs and the CZC allocation providing the most efficient and welfare maximising outcome.

On the other hand, the integrated optimisation process requires the iterative solution of a complex mathematical problem. Time issues for solving this mathematical problem might run the overall problem intractable. With the two-step implementation, only BCMs are cleared jointly with the CZCAOF. DAMs shall use the remaining CZC and clear after the CZCAOF sub-process. Therefore, the CPOF is conducted with the CZCAOF in step 1 and DAM clearing is implemented by EUPHEMIA using the outcome of the first step in step 2. The CZC split requires an exact market result. This is guaranteed only by the joint optimisation of the CZCAOF with the CPOF for the BCMs as balancing capacity must be available to fulfil TSOs' demand if possible. A joint optimisation of CZCAOF together with the SDAC in the first step and CPOF as step 2 might result in too little balancing capacity.

The two implementation options are explained in more details in the following.

5.2.1.1 One-step co-optimised allocation process

Figure 17 provides a process overview of the one-step co-optimised allocation approach.

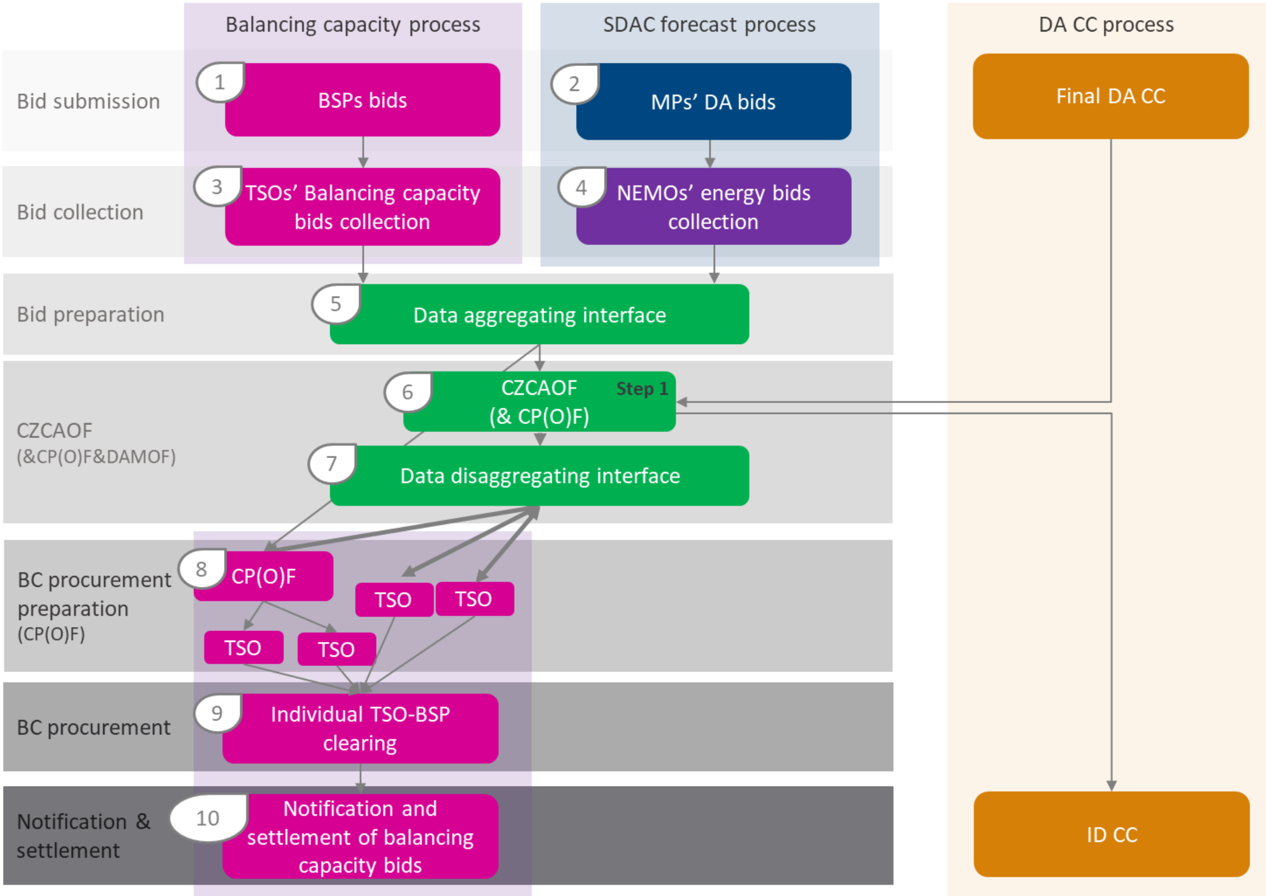

Figure 17: Process Overview One-Step Co-optimised Allocation

In 1 and 2, BSPs and MPs submit bids (including a linking code[6]) to TSOs and NEMOs respectively. In 3 and 4, TSOs and NEMOs collect BC and DAM bids, respectively. In 3, TSOs define their demands and in 4, NEMOs perform validations and conversions of bids provided by MPs. TSOs/ NEMOs send the pseudonymised set of BC/ DA bids to the data aggregating interface. In 5, the data aggregating interface prepares all bids for the CZCAOF. In 6, the CZCAOF together with EUPHEMIA provides a first-best solution for CZC allocation and DAM clearing. This, implicitly also results in the allocation of CZC for BCMs and, therefore, the determination of BC volumes to be procured in each BCM. In 7, the data from the CZCAOF is provided to relevant TSOs and applications in charge by the data disaggregating interface. In step 8, decentral CPOFs or individual TSOs prepare the BC procurement using the information of allocated CZC (per product and direction). Each TSO re-pseudonymises the BC bids. In 9, each TSO separately procures the BC volumes based on the accepted BC bids. Finally, in 10, TSOs publish the procurement results.

[6] The linking code is the unique identifier which marks two cross-product linked bids as connected.

5.2.1.2 *Two-step co-optimised allocation process*

Figure 18 shows the differences which come along with the two-step co-optimised allocation approach.

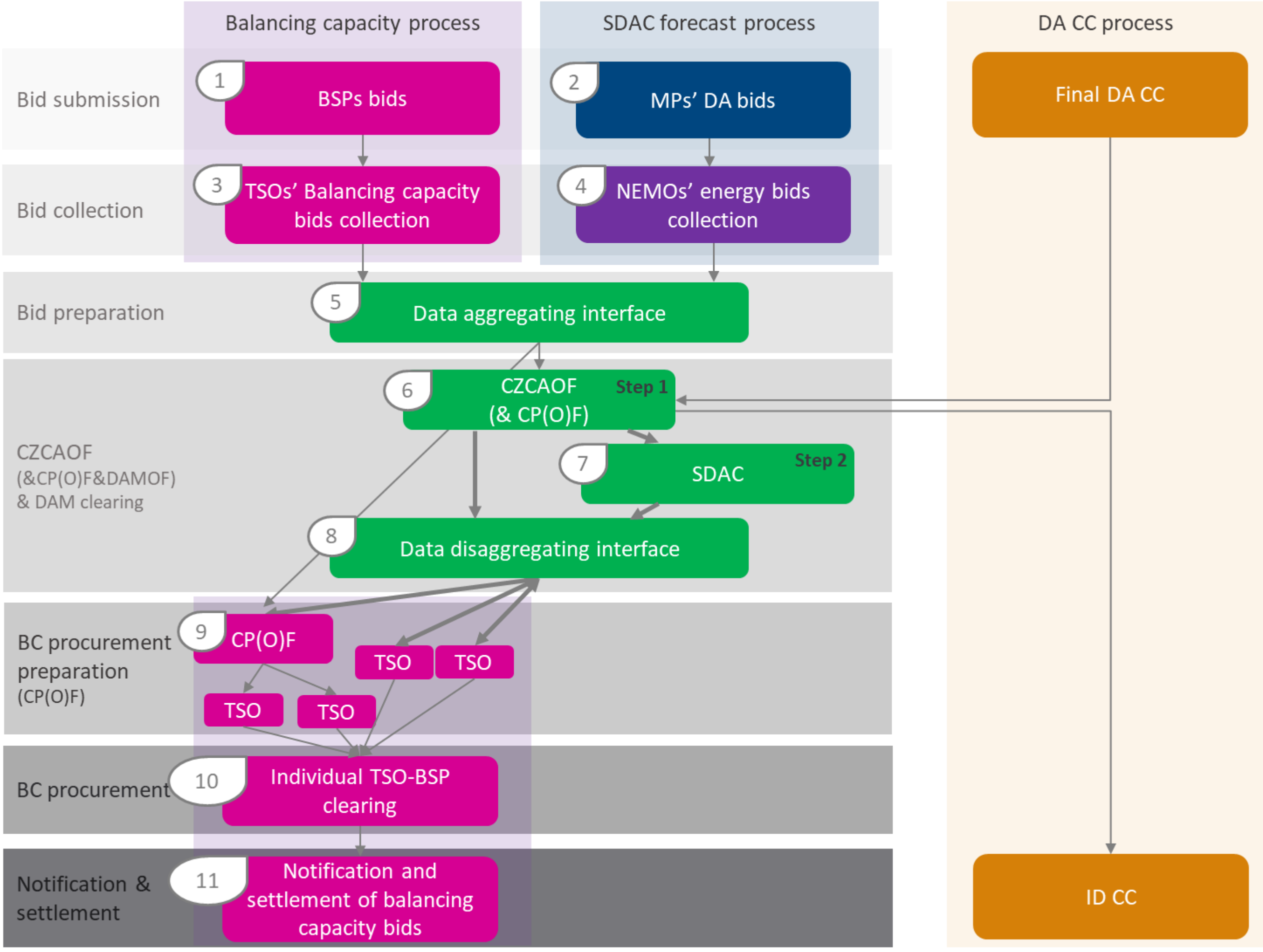

FIGURE 18: PROCESS OVERVIEW TWO-STEP CO-OPTIMISED ALLOCATION

The individual sub-processes of the two-step implementation are almost identical to the sub-processes of the one-step implementation. The difference between the two implementation options is the coordination between the CZCAOF and EUPHEMIA for the matching of DAM bids in the SDAC. In 6, the CZCAOF is optimised together with the CPOFs (and DAMOF) providing accepted BCM bids and revised PTDFs/ATCs/BC order books. This is step 1 of the two-step approach. The CZCAOF provides the revised PTDFs/ATCs to EUPHEMIA. In 7, EUPHEMIA performs the SDAC of the DAM bids based on the provided revised PTDFs/ATCs resulting in the matched DAM bids as outcome of step 2. After provision of the outcomes by the data disaggregating interface, individual TSOs and CPOFs prepare the procurement in step 9.

In contrast to the one-step implementation there is only a one-directional exchange from the CZCAOF to EUPHEMIA but not in the opposite direction.

5.2.2 *Cross-product linking of bids*

Cross-product linking is a linking-of-bids type by which bids of different products are connected. E.g., a positive aFRR BC order is linked with a DAM supply bid order. Since one GCT for all products disables submission of bids of unsettled generation capacities, liquidity is decreased in less attractive markets. The aim of cross-product linking in a co-optimised allocation approach is to prevent the choice to be made by

BSPs or MPs to engage in one single market. Cross-product linking allows BSPs/ MPs to combine bids to different markets in the sense that the same generation capacity can be used either in one market or the other but not in both within the same MTU.
This type of cross-product linking between different BC products or between BC products and the DAM is called exclusive bid linking.
Cross-product linking can be applied to the following conditions:

- Bids with exclusive acceptance of one bid among a set of bids. Exclusive group bids link offers from which only one can be accepted.
  The acceptance of one offer of the exclusive group has *ex ante* the same economic value for the BSP/ MP as the acceptance of any other offer within the exclusive group. Disclaimer: the actual surplus for the MP shall be determined by the clearing price of the market where the bid is accepted.

- Bids which link products of the same or of different quality for the same MTU.
  If one offer of the linked bids is accepted, the other offer cannot be accepted or must be accepted. This is relevant for BSPs which offer one and the same share of a generation capacity e.g., as negative aFRR BC and as a DAM supply bid in the same MTU. If the bid is not accepted in the DAM, the production unit cannot be used in the same MTU for negative aFRR provision. This is an example for so-called linking families.
  The CPOF will then select the offer or combination of offers whose acceptance provides highest economic welfare.

Cross-product linking can be implemented in two different ways:

- unilateral cross-product linking of bids; and
- multilateral cross-product linking of bids.

The linked bids can vary between the markets both in price and volume.

The following implementation could be implemented in the two-step co-optimised allocation: BCM bids (like aFRR, mFRR and RR bids) are linked multilaterally while unselected bids are transferred unilaterally to the DAM. This is illustrated in Figure 19.

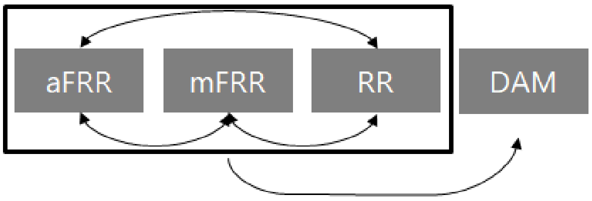

FIGURE 19: OUTLINE OF CROSS-PRODUCT LINKING OF BIDS USING THE MULTILATERAL APPROACH WITHIN THE BCM AND THE UNILATERAL APPROACH BETWEEN THE BCM AND THE DAM

By doing so, BCMs as a whole are prioritised above the DAM in regard to the bid usage. This corresponds to sequential markets as currently organised in Austria, Germany, the Netherlands and Nordic systems. It minimises the risk of unsatisfied demand since liquidity is first offered and used for BC before left overs are offered to DAM clearing.
Within the BCMs, prioritisation can be made, like performing the auction of the higher quality product aFRR before the lower quality mFRR BC auction and the lower quality RR BC auction, such that MPs can re-optimise the bids of the second auction based on the results of the first auction. The DA market clearing is performed with pure DAM bids and the linked bids that were not in the money in the BCMs.

5.3 Market-based Allocation

The market-based allocation approach differs from the co-optimised allocation approach in the sense that BCM bids are firm whereas DAM bids are not. In preparation of the CZC allocation the market value of CZC allocated for DAM purposes must be forecasted. The forecasting process and the forecast validation process will be elaborated in more details after the description of the general market-based allocation process overview.

5.3.1 Market-based allocation process

The following Figure 20 shows the sub-processes of the market-based allocation approach.

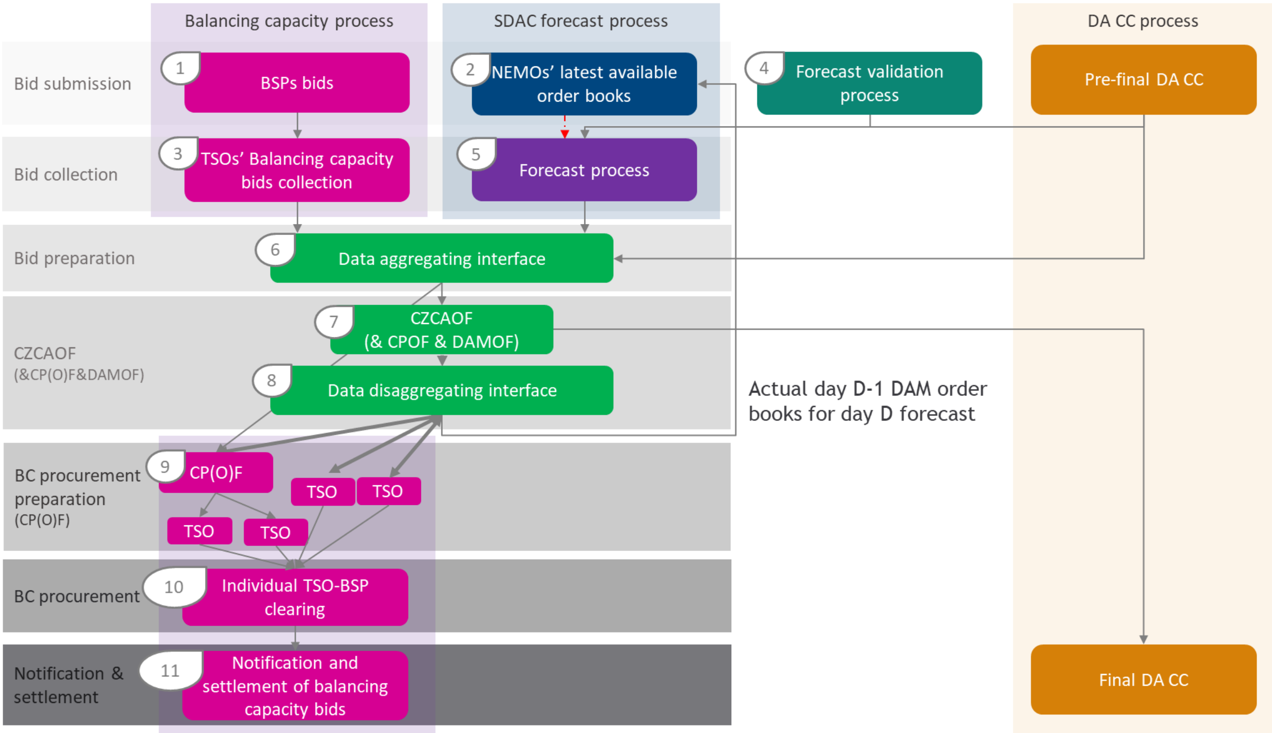

FIGURE 20: PROCESS OVERVIEW MARKET-BASED ALLOCATION

In step 1, BSPs submit bids to TSOs. As MPs' bids for the DAM are not yet firm, they are forecasted by applying information from the past. As described in more details in subsection 5.3.2, the major input is the latest available DAM order books which are submitted in line with step 2. They can be taken from the day-before process. In step 3, TSOs define their demands and collect and prepare the bids from BSPs. The forecasting of the market value comprises two main process steps: In step 4, TSOs/ forecasting entities conduct a forecast validation. This forecast validation provides a recommendation on aspects to be considered during the actual forecasting performed in step 5. The forecasting is run in step 5. Together with resulting adjusted DAM order books actual balancing capacity bids and the balancing capacity demand is provided to the data aggregating interface. In 6, the data aggregating interface prepares all bids and adjusted DAM order books for the CZCAOF. The CZCAOF employs the BCM bids and demand and the adjusted DAM order books to determine the CZC split. This is done under consideration of the actual market values of CZC for BCM purposes and the forecasted market values of CZC for DAM purposes. NTCs/ PTDFs are provided to EUPHEMIA for running the SDAC. NTCs/ PTDFs are also provided to CPOFs. In 8, the data from the CZCAOF is provided to relevant TSOs and applications in charge by the data disaggregating interface. In step 9, decentral CPOFs or individual TSOs prepare the BC procurement using the information of allocated CZC (per product and direction). Each TSO re-pseudonymises the BC bids. In 10, each TSO separately procures the BC volumes based on the accepted BC bids. Finally, in 11, TSOs publish the procurement results.

5.3.2 Forecasting of the market value of CZC for DAM purposes

This subsection explains the forecasting of the market value of CZC for DAM purposes, which consists of a static process step (process step 0), the forecast validation process (process step 1) and the forecasting process (process steps 2, 3 and 4). Although forecast validation and forecasting are strongly related to each other, they are understood as two separate parts. The following process descriptions demonstrate how the processes interact.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
0 Selection of the relevant bidding zones per application	▪ All existing combinations of bidding zones per application	▪ Select the relevant bidding zones per application ▪ Review the selected bidding zones per application either on a regular basis or triggered by specific events	▪ Relevant bidding zones within and beyond the considered application	▪ TSOs per application	▪ no	▪ per CZCAOF	▪ none

The static process step 0 determines the relevant bidding zones to be considered during the subsequent forecast process steps. TSOs per application evaluate which bidding zones affect the available CZC of their bidding zones. This could be BC exchanges or sharing of reserves or SDAC outcomes in general from directly involved bidding zones or from bidding zones outside the application which affect CZCs of the application. TSOs review the set of relevant bidding zones either on a regular basis or triggered by specific events.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
1 Forecast validation	▪ Adjusted Reference Day order books of forecasting period ▪ Forecasted market value calculation output from DAMOF of forecasting period ▪ Actual order books per bidding zone per forecasting period ▪ PTDFs of forecasted days ▪ Forecast library	▪ Determine the market values from the actual bids by applying the DAMOF of the last forecasting period ▪ Compare the market values calculated from the adjusted order books of the Reference Day with the market values from the actual bids to determine forecast error 3 (the positive forecast error) of the forecasted days of the considered period.	▪ Forecast error 3 (being in the allowed 5 percent deviation of the positive forecast error) as input to step 3 ▪ Reference day D-1 for the Reference Day library	▪ Regional Coordination Centers	▪ Not requi-red	▪ per CZCAOF	▪ CZCAOF (incl. DAMOF and CPOF)

In the forecast validation, Regional Coordination Centres review former forecasting processes in preparation of the upcoming forecast of day D. Therefore, they compare the market values calculated from adjusted order books of applied Reference Days in the past with the actual market values as outcome from SDAC. This so-called forecast error 3 provides indications of (1) the forecasting precision and (2) if forecasts in the past were based on a systematic bias. The forecast validation process could be run on a day-by-day basis or weekly or (at most) monthly.

The forecast error 3 is required to evaluate the allowed maximum 5-percent positive forecast deviation. This criterion states the following: The average of the underestimation of the market value of the DAMs during the last 30 days may not exceed 5 percent. If a continuous positive forecast error over 5 percent is identified, the forecasting entity needs to undertake measure to reduce the underestimation of the market value of the DAMs such that the 5-percent criterion is met again. The outcomes of the forecast validation enter the actual forecasting reference determination as a recommendation.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
2 Reference Day Selection Use of respective order books	▪ Relevant bidding zones per application ▪ External conditions: Weather data, grid information for day D, availability information ▪ Reference day library ▪ Forecast error 1 (if defined)	▪ If a default reference day is defined, check if an alternative to the default reference day from the reference day library better meets expectations based on selection criteria regarding weather conditions, grid situation data, availability information for each MTU of day D for each bidding zone ▪ Determine deviations in external factors between applied Reference Day and day D per bidding zone	▪ Applied Reference Day per bidding zone ▪ order books of day-ahead bids of the applied Reference Day ▪ Determined per-MTU deviations between the applied Reference Day and day D per bidding zone	▪ Forecasting Entity or ▪ TSOs per application	▪ yes	▪ at least per bidding zone	▪ none

The determination of forecasted market values is based on the situation of a reference day in the past. This reference day should meet best the situation of day D. If an application uses this approach, by default, this default reference day could be day D-1. If the Forecasting Entity or the TSOs per application expect another reference day from the Reference Day Library to meet better the situation of day D, they can apply this reference day. Therefore, they consider external conditions such as weather data, grid information and other available information about the situation of the individual MTUs of day D. Beyond, also information about the deviation of the applied and the default Reference Day, the so-called forecast error 1, is considered. The Reference Day Selection and, consequently, the respective order books could be selected decentrally day-by-day.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
3 Order book adjustment	▪ Applied Reference Day order books ▪ Determined per-MTU deviations between the Reference Day and day D per bidding zone ▪ Forecast errors 2 and 3	▪ Translate determined MTU deviations into synthetic bids (at minimum price per MWh) ▪ Adjust the Reference Day order books by adding/ reducing the synthetic bids to/ from the existing supply bids	▪ Adjusted Reference Day order books per bidding zone per MTU for day D	▪ Forecasting Entity or ▪ TSOs per application	▪ yes	▪ at least per bidding zone	▪ DAMOF

While the applied Reference Day should already meet the expected situation of MTUs of day D most appropriately in total, order books of individual MTUs might require specific readjustment. This is done after determining the expected deviation of individual MTUs of day D from the MTUs of the applied Reference Day. In addition, the order books may be adjusted due to day-dependent uncertainties regarding external factors. Experience from evaluating prior deviations of adjusted and unadjusted order books of applied Reference Days will be considered as forecast error 2 together with the forecast error 3. For the calculation of the market value, the forecasting entity or the TSOs per application need to apply the DAM optimisation function. This is a reduced version of the actual EUPHEMIA.
The resulting adjusted order books will be provided to the CZCAOF for determining the CZC allocation.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
4 Ex-post validation	▪ Adjusted Reference Day order books of last forecasting period ▪ Forecasted market value calculation output from DAMOF of last forecasting period ▪ order books of default reference day of last forecasting period ▪ PTDFs of previous day ▪ Forecast library	▪ Determine the day D default reference day market values of the last forecasting period. ▪ Compare the market values calculated from the order books of the applied Reference Day with the market values from the order books of the default Reference Day to determine forecast error 1 of the last forecasting period (if a default Reference Day is defined). ▪ Compare the market values calculated from the adjusted order books with the market values from the order books of the applied Reference Day to determine forecast error 2 of the last forecasting period.	▪ Forecast error 1 as input to steps 2 (if defined) ▪ Forecast error 2 as input to steps 3	▪ Forecasting Entity or ▪ TSOs per application	▪ yes	▪ at least per bidding zone	▪ DAMOF

After the run of the forecast reference determination the Forecasting Entity/ the TSOs per application, compare the outcome of the applied Reference Day order books with the default Reference Day order books (if they use a default reference day) and the adjusted and the unadjusted order books of the applied Reference Day to determine forecast errors 1 (if defined) and 2. Forecast errors 1 and 2 will be used in the forecasting process of day D+1.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
Determination of CZCA limitation for BC use	▪ Adjusted Reference Day order books per bidding zone for day D ▪ grid information for day D BC bids ▪ Forecast error 3	▪ Determine the additional CZCA limitation for BC use to protect DAM when applying the CZCAOF	▪ CZCA limitation for allocating BC between the bidding zones per application (to be provided to the joint CZCAOF)	▪ TSOs/ NRAs individually or ▪ TSOs/ NRAs per application jointly	▪ Not necessa-rily	▪ per bidding zone border	▪ CZCAOF (if requested)

Besides the actual forecasting process individual TSOs or TSOs per application jointly can provide so-called CZCA limitations to the CZCAOF. This CZCA limitation shall protect the CZC allocated for DAM purposes. If TSOs expect that the forecasting process results in a too high share of CZC allocated for BCM purposes, they can provide such a restriction to be considered in the CZCAOF. These limitations shall overrule the outcomes of the forecasting process. The CZCA limitation can be adjusted in a day-by-day process or irregularly.

5.4 Inverted Market-based allocation process

The process for the inverted market-based allocation is represented in the following graph, where:

- The allocation of CZC is performed using the same functions (steps 5 & 6) as the co-optimised allocation of CZC, with the difference that forecasted SBCP offers are used instead of actual SBCP offers;
- TSOs applying the inverted market-based approach forecast the SBCP offers to be used for allocating CZC;
- Actual SBCP offers by BSPs are used during a separate procurement phase (steps 9 to 11), that takes place after the CZCA.

5.4.1 Inverted Market-based allocation process

The following Figure 21 shows the sub-processes of the inverted market-based allocation approach.

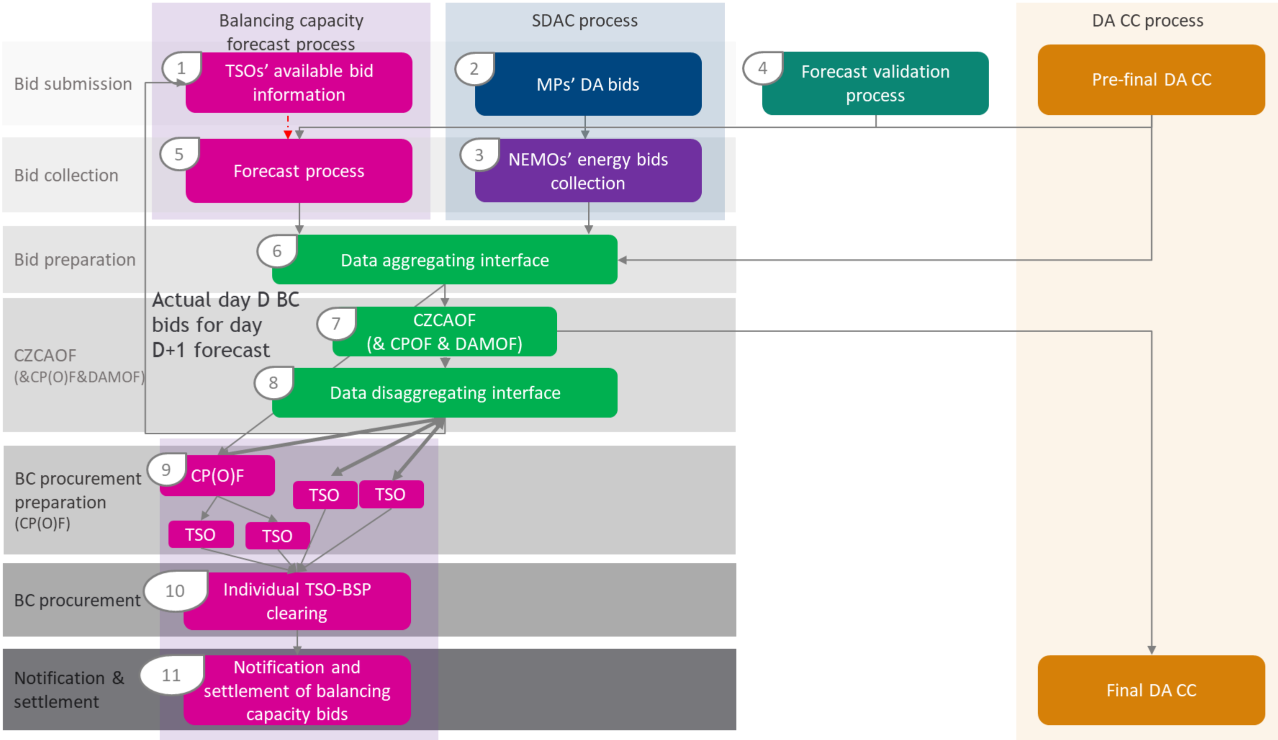

FIGURE 21: PROCESS OVERVIEW INVERTED MARKET-BASED ALLOCATION

As BSPs' offers of SBCP are not yet firm in step 1, they are forecasted by applying information from the past. Following subsection 5.3.2, the major input are the historical SBCP offers which are submitted in line with step 1. In step 2, MPs submit bids to NEMOs. In step 3, NEMOs collect and prepare the bids from MPs. The forecasting of the market value of CZC for SBCP purposes comprises two main process steps: In step 4, TSOs/ forecasting entities conduct a forecast validation. This forecast validation provides a recommendation on aspects to be considered during the actual forecasting performed in step 5. The forecasting is run in step 5. Together with resulting adjusted SBCP offers actual DAM bids and the balancing capacity demand is provided to the data aggregating interface. In 6, the data aggregating interface prepares all bids and adjusted SBCP offers for the CZCAOF. The CZCAOF employs the DAM bids, the adjusted SBCPs and the BC demand to determine the CZC split. This is done under consideration of the actual market values of CZC for DAM purposes and the forecasted market values of CZC for BCM purposes. NTCs/ PTDFs are provided to EUPHEMIA for running the SDAC. NTCs/ PTDFs are also provided to CPOFs. In 8, the output data from the CZCAOF is provided to relevant TSOs and applications in charge by the data disaggregating interface. In step 9, decentral CPOFs or individual TSOs prepare the BC procurement using the information of allocated CZC (per product and direction) and actual SBCP bids. In 10, each TSO separately procures the SBCP volumes based on the accepted SBCP bids. Finally, in 11, TSOs publish the procurement results.

5.4.2 *Forecasting of the market value of CZC for SBCP purposes*

This subsection explains the forecasting of the market value of CZC for BCM purposes, which consists of a static process step (process step 0), the forecast validation process (process step 1) and the forecasting process (process steps 2, 3 and 4). Although forecast validation and forecasting are strongly related to each other, they are understood as two separate parts. The following process descriptions demonstrate how the processes interact.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
0 Selection of the relevant scheduling areas per application	▪ All existing combinations of scheduling areas per application which are relevant for the inv. MBA approach	▪ Select the relevant scheduling areas per application applying the inv. MBA approach ▪ Review the selected scheduling areas per application either on a regular basis or triggered by specific events	▪ Relevant bidding zones within and beyond the considered application	▪ TSOs per application	▪ no	▪ per CZCAOF	▪ none

The static process step 0 determines the relevant scheduling areas to be considered during the subsequent forecast process steps. TSOs per application evaluate which scheduling areas affect the available CZC of their scheduling areas. This could be BC exchanges or sharing of reserves from directly involved scheduling areas or from scheduling areas outside the application which affect CZCs of the application. TSOs review the set of relevant scheduling areas either on a regular basis or triggered by specific events.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
1 Forecast validation	▪ Adjusted Reference Day SBCP offers per scheduling area per MTU for day D of forecasting period ▪ Forecasted market value calculation outputs from CZCAOF of forecasting period ▪ Actual SBCP offers per scheduling area per forecasting period ▪ PTDFs of forecasted days ▪ Forecast library	▪ Determine the market values from the actual bids by applying the CZCAOF of the last forecasting period ▪ Compare the market values calculated from the adjusted SBCP offers of the Reference Day with the market values from the actual SBCPs to determine forecast error 3 (the negative forecast error) of the forecasted days of the considered period.	▪ Forecast error 3 (being in the allowed 5 percent deviation of the negative forecast error) as input to step 3 ▪ Reference day D-1 for the Reference Day library	▪ Regional Coordination Centers or TSOs of an application	▪ Not requi-red	▪ per CZCAOF	▪ CZCAOF (incl. DAMOF and CPOF)

In the forecast validation, Regional Coordination Centres or TSOs review former forecasting processes in preparation of the upcoming forecast of day D. Therefore, they compare the market values calculated from adjusted SBCP offers of applied Reference Days in the past with the actual market values as outcome from SBCP procurement. This so-called forecast error 3 provides indications of (1) the forecasting precision and (2) if forecasts in the past were based on a systematic bias. The forecast validation process could be run on a day-by-day basis or weekly or (at most) monthly.

The forecast error 3 is required to evaluate the allowed maximum 5-percent negative forecast deviation. This criterion states the following: The average of the overestimation of the market value of the BCMs during the last 30 days may not exceed 5 percent. If a continuous negative forecast error over 5 percent is identified, the forecasting entity needs to undertake measure to reduce the overestimation of the market value of the BCMs such that the 5-percent criterion is met again. The outcomes of the forecast validation enter the actual forecasting reference determination as a recommendation.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
2 Reference Day Selection Use of respective SBCP offers	▪ Relevant scheduling areas per application ▪ External conditions: Weather data, grid information for day D, availability information ▪ Reference day library ▪ Forecast error 1 (if defined)	▪ If a default reference day is defined, check if an alternative to the default reference day from the reference day library better meets expectations based on selection criteria regarding weather conditions, grid situation data, availability information for each MTU of day D for each scheduling area ▪ Determine deviations in external factors between applied Reference Day and day D per scheduling area	▪ Applied Reference Day per scheduling area ▪ SBCP offers of the applied Reference Day ▪ Determined per-MTU deviations between the applied Reference Day and day D per scheduling area	▪ Individual TSO	▪ yes	▪ Schedulin g area	▪ none

The determination of forecasted market values is based on the situation of a reference day in the past. This reference day should meet best the situation of day D. If an application uses this approach, by default, this reference day could be day D-1. If the Forecasting Entity or the TSOs per application expect another reference day from the Reference Day Library to meet better the situation of day D, they can apply this reference day. Therefore, they consider external conditions such as weather data, grid information and other available information about the situation of the individual MTUs of day D. Beyond, also information about the deviation of the applied and the default Reference Day, the so-called forecast error 1, is considered. The Reference Day Selection and, consequently, the respective SBCP offers could be selected decentrally day-by-day.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
3 SBCP offers adjustment	▪ Applied Reference Day SBCP offers ▪ Determined per-MTU deviations between the Reference Day and day D per scheduling area ▪ Forecast errors 2 and 3	▪ Translate determined MTU deviations into price correlations of SBCP offers ▪ Adjust the Reference Day SBCP offers by adding/ reducing the price estimates from the price correlation analysis	▪ Adjusted Reference Day SBCP offers per scheduling area per MTU for day D	▪ TSOs per application	▪ yes	▪ decentral	▪ CPOF

While the applied Reference Day should already meet the expected situation of MTUs of day D most appropriately in total, SBCP offers of individual MTUs might require specific readjustment. This is done after determining the expected deviation of individual MTUs of day D from the MTUs of the applied Reference Day. In addition, the SBCP offers may be adjusted due to day-dependent uncertainties regarding external factors. Experience from evaluating prior deviations of adjusted and unadjusted SBCP offers of applied Reference Days will be considered as forecast error 2 together with the forecast error 3. For the calculation of the market value, the forecasting entity or the TSO pairs per connected scheduling areas need to apply the CPOF.

The resulting adjusted SBCP offers will be provided to the CZCAOF for determining the CZC allocation.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
4 Ex-post validation	▪ Adjusted Reference Day SBCP offers of last forecasting period ▪ Forecasted market value calculation output from CPOF of last forecasting period ▪ D-1 SBCP offers ▪ PTDFs of day D ▪ Forecast library	▪ Determine the day D default reference day market values of the last forecasting period. ▪ Compare the market values calculated from the SBCP offers of the applied Reference Day with the market values from the SBCP offers of the default Reference Day to determine forecast error 1 of the last forecasting period (if a default Reference Day is defined). ▪ Compare the market values calculated from the adjusted SBCP offers with the market values from the SBCP offers of the applied Reference Day to determine forecast error 2 of the last forecasting period.	▪ Forecast error 1 as input to steps 2 (if defined) ▪ Forecast error 2 as input to steps 3	▪ Forecasting Entity or ▪ TSOs per application	▪ yes	▪ decentral	▪ CZCAOF

After the run of the forecast reference determination the Forecasting Entity/ the TSOs per application, compare the outcome of the applied Reference Day SBCP offers with the default Reference Day SBCP offers (if they use a default reference day) and the adjusted and the unadjusted SBCP offers of the applied Reference Day to determine forecast errors 1 (if defined) and 2. Forecast errors 1 and 2 will be used in the forecasting process of day D+1.

	Inputs	Process	Outputs	Possible Owner	daily	Level of operation	Required function
Determination of CZCA limitation for BC use	▪ Adjusted Reference Day SBCP offers per scheduling area for day D ▪ grid information for day D BC bids ▪ Forecast error 3	▪ Determine the additional CZCA limitation for SBCP use to protect DAM when applying the CZCAOF	▪ CZCA limitation for allocating SBCP between the scheduling areas per application (to be provided to the joint CZCAOF)	▪ TSOs/ NRAs individually or ▪ TSOs/ NRAs per application jointly	▪ Not necessa-rily	▪ per bidding zone border	▪ CZCAOF (if requested)

Besides the actual forecasting process individual TSOs or TSOs per application jointly can provide so-called CZCA limitations to the CZCAOF. This CZCA limitation shall protect the CZC allocated for DAM purposes. If TSOs expect that the forecasting process results in a too high share of CZC allocated for BCM purposes, they can provide such a restriction to be considered in the CZCAOF. These limitations shall overrule the outcomes of the forecasting process. The CZCA limitation can be adjusted in a day-by-day process or irregularly.

5.5 Firmness regime for the allocation of cross-zonal capacity

Allocated CZC for the exchange of balancing capacity or sharing of reserves after the co-optimisation process is firm after the selection of upward balancing capacity bids or downward balancing capacity bids by the capacity procurement optimisation function pursuant to Article 33(3) of the EB Regulation.

According to Article 38(9) of the EB Regulation, when CZC allocated for the exchange of balancing capacity or sharing of reserves has not been used for the associated exchange of balancing energy, it shall be released for the exchange of balancing energy with shorter activation times or for operating the imbalance netting process.

The costs of ensuring firmness or in the case of curtailment of firm CZC in the event of force majeure or emergency situations are borne by the relevant TSOs sharing the CZC. These costs include the additional costs from the procurement of balancing capacity due to the non-availability of the balancing capacity given the curtailment of CZC.

Additional costs of the procurement of balancing capacity relate to additional (local) procurement of balancing capacity by means of a second auction, in order to respect reserve compliancy, based on the dimensioning process.

6 Provisions referring to specific topics in the harmonised methodology document

This chapter provides background information to specific topics in the document "Methodology for a harmonised allocation process of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves per timeframe".

In **Article 3**: Principles on the processes of allocating cross-zonal capacity for the exchange of balancing capacity or sharing of reserves, **number 3**, it reads

"The maximum price of each bid of SBCP in both directions shall be equal to the maximum day-ahead market bid price for SDAC, both following Article 41(1) of Commission Regulation (EU) 2015/1222 of 24 July 2015."

The reason for this limitation is due to the fact that reserving a generation unit fully or partly for balancing purposes withholds this part of the generation unit from providing energy to a DAM. The maximum price per MWh for DAM bids is 3000 EUR. As the SBCP price compensates the opportunity costs of not providing energy from a generation unit to another energy market, the maximum SBCP price should be the same as the maximum DAM energy price.

In **Article 3**: Principles on the processes of allocating cross-zonal capacity for the exchange of balancing capacity or sharing of reserves, **number 12**, it reads

"For each Application of a timeframe of CZCA where the TSO BC demand for a SBCP exceeds the available amount of bids in all bidding zones of the application for the relevant SBCP, while taking into account the maximum volume of allocated cross-zonal capacity for the exchange of balancing capacity or sharing of reserves, a national fallback procedure shall apply."

A fallback is required after CZC is allocated. The CZCAOF is run and the DACC is, at least, started. This means that there is no additional possibility to re-allocated CZC to facilitate TSOs' BC demand. Consequently, additional balancing capacity can only be reserved within the borders of a TSO's individual scheduling area(s) or the balancing block. This is why the fallback procedure for such a situation should be target by a national solution.

In **Article 5**: The market timeframe of the co-optimised allocation process, **number 2, lit. d, ix**, it reads:

"the TSO's maximum volume of balancing capacity to be exchanged with each participating TSO within the Application of the co-optimised allocation timeframe"

Each TSO may decide from/ to which TSO he wants to import or export within the application making use of transits or not.

In **Article 8**: Determination of the actual market value of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves in the co-optimised allocation process, **number 1, lit. d**, it reads:

"The actual market value of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves between all bidding zones where the co-optimised allocation process is applied shall be calculated as one combined market value for balancing capacity in case the sharing of reserves is applied in combination with the exchange of balancing capacity;"

Sharing of reserves is a decision taken before the process of CZC allocation. If two TSOs decide to share BC reserves, this reduces their demand. Therefore, the change in surplus is the difference of BSP surplus without sharing of reserves and with sharing of reserves due to reduced TSO demand.

In contrast, the surplus from exchange of balancing capacity is the outcome of cross-border balancing procurement. It stems from the replacement of a higher-cost BSP bid by a lower-cost BSP bid from another market.

While sharing of reserves changes the demand (moves the demand curve to the left), exchange of balancing capacity neither changes supply nor demand.