Market Handbook

Nordic FRR capacity markets

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2 Introduction

The Nordic TSOs have been collaborating in the development of capacity markets for aFRR and mFRR. This is considered advantageous as critical limitations of transmission grid are reflected in the energy prices and yields a more optimal utilization of both available transmission capacity and resources. However, with small bidding zones and unevenly distributed balancing resources the exchange of balancing capacity with allocation of cross zonal capacity is necessary to ensure operational security in all areas.

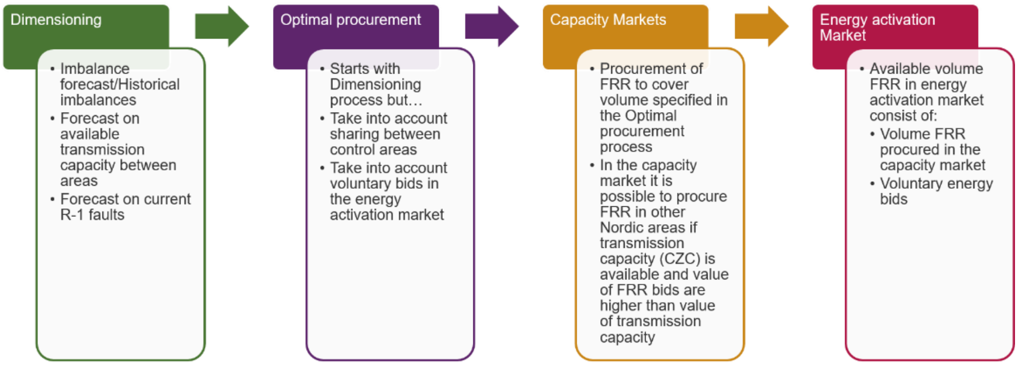
Both aFRR and mFRR resources are today unevenly distributed across the Nordics. Reserving cross-zonal capacity (CZC) for FRR makes it possible to procure FRR capacity across bidding zones and by that fulfilling the demand of FRR per LFC area that is needed according to the FRR dimensioning process. The FRR dimensioning process is developed in accordance with the System Operational Guideline (SO GL) Article 157 and will stipulate an FRR demand per Load Frequency Control (LFC) area (equal to a bidding zone). This initial LFC area reserve requirement can then be procured in another LFC area provided that there is available CZC that can accommodate the exchange.

The Nordic TSOs have in collaboration built a Nordic Market Management System (NMMS) for capacity procurement of aFRR and mFRR.

The platform handles the procurement of aFRR capacity reserves in a common market for all Nordic TSOs consisting of all bidding zones in Norway, Sweden and Finland, and the DK2 bidding zone of Denmark.

Similarly, the platform handles the procurement of mFRR capacity reserves. At first in national markets, but later as a common Nordic market. The national markets mean, that procurement for the Danish bidding zones is done as a common market between DK1 and DK2, procurement for the Norwegian bidding zones as a common market between NO1, NO2, NO3 and NO4, and procurement for the Swedish bidding zones as a common market between SE1, SE2, SE3 and SE4. Finland will not utilize the Nordic platform, Nordic MMS, for national purposes and will join the platform and procurement process, when a common Nordic mFRR capacity market is implemented – expectedly in Q2 2024.

The Nordic FRR capacity markets will be followed by mFRR and aFRR energy activation markets via the establishment of a new Nordic energy activation market (mFRR EAM) and later the European balancing market platforms, MARI (mFRR) and PICASSO (aFRR).



Picture 1: FRR dimensioning SOGL art 157 --> Analysis of optimal provision EBGL art 32.1 --> Capacity markets EB GL title III --> Energy activation Market (Picasso) EB GL Chapter 2

3 Legal basis

The EB Regulation provides that when several TSOs exchange balancing capacity they have to develop a proposal for the establishment of common and harmonised rules and processes for the exchange and procurement of balancing capacity. These TSOs have also to develop a proposal for the principles for balancing algorithms for the procurement of balancing capacity bids[1]. The proposal shall be submitted to the concerned regulatory authorities for their approval.

The TSOs exchanging balancing capacity shall develop algorithms to be operated by the capacity procurement optimization functions for the procurement of balancing capacity bids. This algorithm shall minimize the overall procurement costs of all jointly procured balancing capacity and if applicable, take into account the availability

[1] Articles 33 and 58 of the EB Regulation

of cross-zonal capacity including possible costs for its provision[2]. The algorithms developed shall:

- respect operational security constraints;
- take into account technical and network constraints; and
- if applicable, take into account the available cross-zonal capacity.

The exchange of balancing capacity between TSOs shall be performed based on a TSO-TSO model taking into account the available cross-zonal capacity and the operational limits[3]. The TSOs shall submit all balancing capacity bids from standard products to the capacity procurement optimisation function. The TSOs shall allow balancing service providers to transfer their obligations to provide balancing capacity within the geographical area in which the procurement of balancing capacity has taken place. The transfer of balancing capacity bids shall be allowed at least until one hour before the start of the delivery day. The TSOs shall set conditions to be fulfilled when transfer of balancing capacity shall be allowed. If TSO(s) does not allow the transfer of balancing capacity, the concerned TSO(s) shall explain the reason for the rejection to the balancing service providers involved and request exemption from the concerned regulatory authorities[4].

The TSOs exchanging balancing capacity shall ensure availability cross-zonal capacity fulfilling the operational security requirement either by:

- the methodology for calculating the probability of available cross-zonal capacity after intraday cross-zonal gate closure time, or
- the methodologies for allocating cross-zonal capacity to the balancing timeframe applying co-optimised allocation process,

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[2] Article 58 of the EB Regulation

[3] Article 33 of the EB Regulation; operational limits are defined in Chapters 1 and 2 of Part IV Title VIII of the SO Regulation

[4] Article 34 of the EB Regulation

market-based allocation process or allocation process based on economic efficiency analysis.

The Nordic TSOs have chosen market-based allocation process of cross-zonal capacity for exchange balancing capacity[5]. The methodology for market-based allocation shall be developed on a capacity calculation region (CCR) level and submitted for the concerned regulatory authorities for approval. This methodology shall apply for the exchange of balancing capacity 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.

The requirements for such a methodology shall include:

- the notification process for the use of the market-based allocation process;
- 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 the exchange of energy, and if applicable the actual 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;
- 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; and
- the process to define the maximum volume of allocated cross-zonal capacity for the exchange of balancing capacity or sharing of reserves.

The cross-zonal capacity allocated on a market-based process shall be limited to 10 % of the available capacity for the exchange of energy of

5 Article 41 of the EB Regulation

the previous relevant calendar year between the respective bidding zones. The volume limitation of 10% may not apply where the contracting is done not more than two days in advance of the provision of the balancing capacity[6].

The methodology for market-based allocation is based on a comparison of the actual market value of cross-zonal capacity for the exchange of balancing capacity and the forecasted market value of cross-zonal capacity for the exchange of energy, or on a comparison of the forecasted market value of cross-zonal capacity for the exchange of balancing capacity, and the actual market value of cross-zonal capacity for the exchange of energy[7].

The actual market value of cross-zonal capacity for the exchange of balancing capacity used in a market-based allocation process shall be calculated based on balancing capacity bids submitted to the capacity procurement optimisation function[8]. The actual market value of cross-zonal capacity shall be calculated based on the avoided costs of procuring balancing capacity. Furthermore, the forecasted market value of cross-zonal capacity shall be based on one of the following alternative principles[9]:

- the use of transparent market indicators that disclose the market value of cross-zonal capacity; or
- the use of a forecasting methodology enabling the accurate and reliable assessment of the market value of cross-zonal capacity.

The Nordic TSOs will use a forecasting methodology to forecast market value of cross-zonal capacity[10].

The concerned regulatory authorities have approved the Nordic TSOs methodology for the market-based allocation process. The methodology includes the bidding zone borders, the market

[6] Article 41(2) of the EB Regulation
[7] Article 41(3) of the EB Regulation
[8] Article 39 and Article 33 of the EB Regulation
[9] Article 39(5) of the EB Regulation
[10] ACER decision No 22/2020

timeframe, the duration of application and the cross-zonal allocation methodology.

The TSOs may only allocate cross-zonal capacity for the exchange of balancing capacity if cross-zonal capacity is calculated in accordance with the capacity calculation methodologies developed pursuant to Regulations (EU) 2015/1222 and (EU) 2016/171911. The TSOs shall include cross-zonal capacity allocated for the exchange of balancing capacity as already allocated cross-zonal capacity in the calculations of cross-zonal capacity12.

The legal requirements set in the EB Regulation has been included in ACER decisions No 19 – 22/2020[13].

4 Handling of bids

BSPs participating in one or both of the markets send their bids to NMMS where market clearing is performed. A detailed description of how to connect to the platform can be found in the Implementation guide published on www.nordicbalancingmodel.net.

4.1 Single bids

A single bid is submitted for one specific Market Time Unit (MTU) and one direction. The bid includes information about the bidding zone it belongs to. The bid quantity must respect 1 MW as a minimum quantity and 1 MW granularity.

Single bids can be marked as divisible or indivisible. If a bid is indivisible the bid must be accepted as a whole or rejected. Indivisible bids give Balancing Responsible Party (BSP) more flexibility for pricing of the bids and this can both increase the bid volume and decrease bid prices. On the other hand, indivisible bids can potentially have a negative effect for the procurement optimization function to find an efficient solution. A maximum bid size of 50 MW applies to

[11] Article 38(5) of the EB Regulation

[12] Article 38(6) of the EB Regulation

[13] Microsoft Word - ACER Decision xx-2020 on the Nordic aBCM A41 (europa.eu)

indivisible bids as this will reduce the probability for such adverse effects and also disincentivizes strategic bidding that can result in loss of efficiency.

4.2 Block bids

Block bids give an opportunity to link bids together in time. A block bid consists of a set of single bids, where each bid belongs to different MTUs, but otherwise have the same quantity, price and direction. A block bid can only be constructed for consecutive MTUs.

A block bid can be submitted as divisible or indivisible. For a divisible block bid that is accepted, the same share of the bid's volume is selected for all MTUs for which the block bid is valid.

4.3 Duration and resting time

BSPs may specify for the bid the technical limitations – required maximum duration of the accepted bid and required minimum resting time, i. e. the minimum required duration between the end of acceptance and the following acceptance of the same bid.

BSP may also link together multiple bids with the same maximum duration and minimum resting time. In that case, these technical restrictions are respected for the whole group of the bids.

The option to specify maximum duration and minimum resting time is available for mFRR bids only and it is not allowed to set such restrictions for block bids.

4.4 Bid curve

A bid curve represents a set of single bids for a specific MTU and direction, where only one of the bids included in the bid curve, can be accepted. This gives BSPs great flexibility in presenting their actual cost structure in their bidding. However, if the option of bid curve is used, the BSP foregoes the opportunity to use block bids.

The bids for aFRR and mFRR services may be combined into a single bid curve. This option would be used typically for the cases when the BSP wants to offer the same resource capacity to both aFRR and mFRR market. Combining these two bids into the same bid curve ensures that only one of these two bids will be accepted.

4.5 Location information

The more precise location of the bid within bidding zone may be required by some Nordic TSOs. Such requirement may be specified in the agreement/contract between TSO and BSP. In that case, BSP must specify the location from which the offered reserve would be provided if the bid would be accepted. The locational information, if specified in the bid, is used by TSOs to evaluate and mitigate the potential congestion on bottlenecks within the given bidding zone. The mitigation of the potential congestion may include the forced acceptance or rejection of the bid in question to relieve the congestion.

This potential requirement is relevant for mFRR bids only.

5 Gate opening (GOT) and Gate closure (GCT)

ACER decision set requirements to FRR capacity market gate closure time but there are no provisions for FRR capacity market gate opening time.

The TSOs have agreed that gate opening time for FRR capacity markets will be 00:00 (D-7), i.e., one week before delivery day.

Balancing capacity market timeframe shall be between 07:00 CET (D-1) and 10:00 (D-1). The balancing capacity gate closure time shall be within this balancing capacity market timeframe.

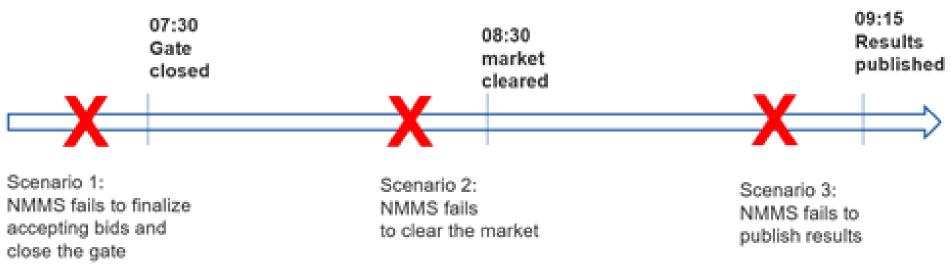
Gate closure time is 7:30 CET (D-1) in order to respect the deadline of publishing cross-zonal capacities to the market participants and sending cross-zonal capacities to the NEMOs. Having gate closure time after 7:30 CET would create a risk that the results of FRR capacity markets are not available at the latest at 9:10 CET in case mitigation measures has to be activated. These mitigation measures include extended gate closure and reopening of FRR capacity markets. Capacity gate closure time is the same for both aFRR and mFRR bids. aFRR will be cleared before mFRR, meaning also that all aFRR processes will be finalized before mFRR processes will be initiated.

5.1 Reopening of Gate closure time

Reopening of the gate, hence asking for more bids, is a last resort before going to fallback procedure. Before reopening CZC will be increased from 10 % to up to 20 % to get a potential market result/be able to clear the market.

6 Fallback

Nordic TSOs have identified two possible fallback scenarios where full optimization and market clearing will not be possible (Scenario 1 and 2) and one scenario where full optimization will be performed but results cannot be provided to BSPs (Scenario 3). Svenska kraftnät, Energinet and Statnett will have common fallback procedures according to description below. Fingrid will have their own national fallback for scenario 1 and 2.



6.1 Scenario 1: Before GCT

If Scenario 1 occurs BSPs will not be able to submit bids to the platform/the platform will not be able to receive bids at GCT 07:30.

Fallback will be national without the possibility to optimize cross zonal capacity and bids across bidding zones.

Each TSO will contact its national BSPs and ask them to submit bids via fallback system/confirm bids already sent to NMMS.

When TSOs have received bids from BSPs a national clearing per bidding zone will be performed by each TSO. If available bids within a bidding zone are not enough to satisfy the FRR demand for the that bidding zone or combination of bidding zones, bids from adjacent bidding zones can be used and cross zonal capacity will be reserved manually. It is up to the single TSOs to decide whether or not to reserve CZC manually. No TSO is obliged to in fallback, since time can be very short. When TSOs have performed national clearing BSPs will be informed about the result.

6.2 Scenario 2: After GCT but before market clearing

If scenario 2 occurs bids from BSP have been received by NMMS but NMMS is not able to clear the market and fallback will as in scenario 1 be performed national without the possibility to optimize cross zonal capacity and bids across bidding zones.

TSO will use national bids received from NMMS and clear the market per bidding zone or combination of bidding zones in the same way as in scenario 1.

6.3 Scenario 3: After market clearing

In scenario 3, market clearing via NMMS is possible, but the NMMS is not able to publish the market results via the platform. Each TSO will receive the market result from NMMS and inform its BSPs about the result.

7 Market clearing rules

The following section describes the overall market clearing rules. A description on how the optimization is performed in relation to allocation of cross-zonal capacity (CZC) and in relation to bid selection. Furthermore, pricing rules and definitions affecting this are described in the following sections.

A detailed description of the algorithm can be found aFRR algorithm documentation (nordicbalancingmodel.net).

7.1 Optimization rules

The FRR market clearing algorithms are daily auction optimizations that allocate CZC and select bids that meet the requirements for FRR at the lowest socio-economic cost.

The coverage of the requirements by the available bids is performed independently for aFRR and mFRR service whereas the common CZCs are shared by both clearings. This means that the 10 percent of CZC, that can be utilized for the exchange of reserve capacity must cover the sum of aFRR and mFRR.

The algorithm is identical for aFRR and mFRR, but clearings for aFRR and mFRR are performed sequential. The procurement of aFRR capacity will be first, which means that aFRR capacity has priority access to CZC. The procurement of mFRR capacity will thus only be able to utilize CZC that has not been reserved already for the exchange of aFRR.

aFRR has priority access to CZC since it is expected to create the highest socio-economic benefit. However, if that changes over time, the clearing order of aFRR and mFRR will be amended.

The algorithm is split in several steps, but the same general rules apply for all steps:

- **Meet FRR requirements:** the total volume selected + imports – exports give the demand for each bidding zone, direction and hour
- **Import/export:** for each hour and between bidding zones up to a defined limit (CZC capacity)

- **Bids can be complex:** block bids, bid curves, duration and resting restrictions (for mFRR only)
- **Linked CZC constraints:** possibility to limit the allocated CZC for aggregated lines

Due to the complex bid types, the optimization algorithms used in the CZC allocation and bid selection are defined as mixed integer linear programs (MILP), which by nature are hard to solve. Because of this the FRR market clearing algorithm has a maximum time limit (user defined) which will, for some auctions, give a clearing result, which is not proven to be the optimal results if this maximum time limit is reached.

The optimizations cover one day, both directions (up/down regulation) and all bidding zones. Because of CZC between bidding zones and the fact that BSPs can submit complex bids, the results can be suboptimal for individual hours (block bids), bidding zones (CZC's) and directions, but optimal for the daily market auction as a whole. An example could be bids that are skipped even though they are 'in the money', because a block bid is chosen, since it optimizes the total economy.

The CZC allocation (Step 1) and bid selection (Step 2) in the FRR market clearing algorithm are two separate optimization processes performed in sequence. First, the CZC allocation step finds the most socio economically optimal allocation of CZC resources in the market based on complete bid information, regional specifications and requirements and CZC limits and CZC cost.

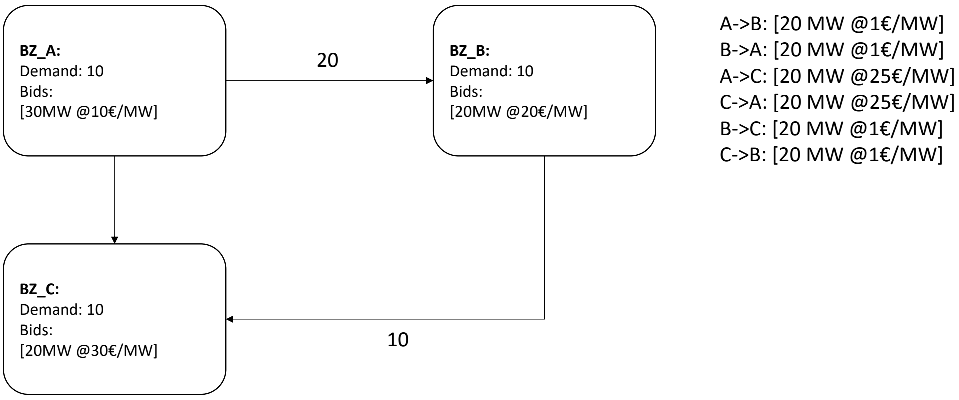
The CZC cost is defined as the market spread in the day-ahead market for the previous day added a mark-up, which is dynamic between 1 and 5 EUR/MW depending on the size of the forecast error for the previous (rolling) 30 days.

Up to 10 % of the transmission capacity on a border can be reserved for balancing capacity. In case of scarcity, reserved capacity can be increased until demand is satisfied, but to a maximum of 20 %. Recall that transmission capacity is shared by both aFRR and mFRR. It could therefore happen that the CZC on some border(s) would be predominantly or even fully utilized by aFRR clearing. The objective function includes both bid costs and CZC costs and the algorithm will minimize the sum of these two.

The bid selection step then uses the allocated CZC to find the most socio economically optimal selection of bids, i.e., minimizing the total bid costs of the selected bids that meet the FRR requirements. Both steps use the same type of information and market rules, but the bid selection step does not use CZC costs in the objective function and the CZC is fixed using the CZC allocation results from Step 1.

7.2 Step 1 – CZC allocation

The CZC allocation step finds the most socio economically way of allocating CZC given the FRR requirements by minimizing the total bid costs and CZC costs. The example below illustrates the procedure:



The result is to select the bid in BZ_A and send 20 MW from A to B and 10 MW from B to C. The cost of using line A-C is high and the optimal solution is therefore to send the FRR from A to C via B.

The CZC allocation step also includes a fallback mechanism if one or more bidding zones cannot meet its reserve requirements either locally or from imports. Then the algorithm moves into a Step 1b which increases CZC limits until demand is satisfied or up to a maximum of 20 percent of NTC compared to 10 percent as a starting point and allocates CZC based on this new limit. Any CZC allocated above the original CZC limit will be penalized such that capacity from the closest neighbor is prioritized.

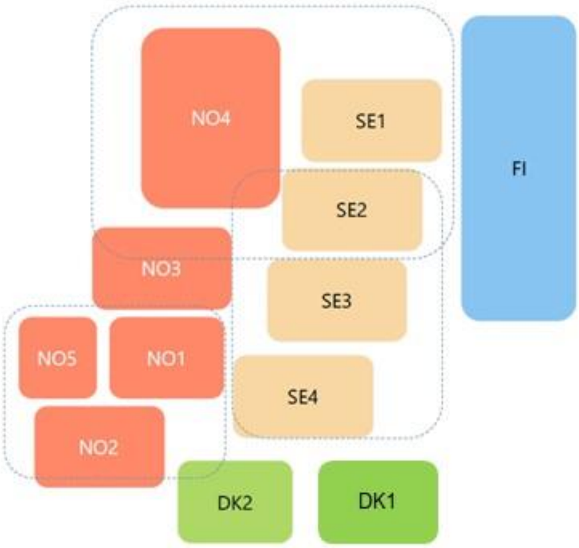
7.3 Step 2 – bid selection

The bid selection step is like the CZC allocation step, but without:

- CZC cost in the objective function
- CZC variables (i. e. they are fixed values)
- macro area and bidding zones constraints (minimum and maximum reservation constraints)

7.4 Macro area

Bids are specified on an Elspot area level (NO1, NO2..., SE1, SE2), referred to as bidding zones. Macro areas are combinations of bidding zones. Each macro area can have one or more bidding zones, and a bidding zone can be part of one or several macro areas as shown below.



CZC limits between bidding zones within the macro area are not removed, but the macro areas functionality gives the user the possibility to control how bids are selected by using minimum and maximum reservation constraints.

As shown in the table below, demand, bids, and cross-border-capacity (CZC) are specified on a bidding zone level, as well as minimum and maximum activated reserves constraints. Macro areas can have constraints for minimum and maximum activated reserves within the area.

Input types	Bidding Zones	Macro Areas
Bids	X	
Demand	X	
CZC	X	
Minimum reservation	X	X
Maximum reservation	X	X

The difference between demand and minimum reservation is that the demand constraint allows for import and export to be used to meet the demand requirements, whilst the minimum reservation only uses selected bids. For national markets for example, the minimum reservation can be applied on macro areas to set a total demand for the country.

An additional feature of macro areas is the possibility to force the pricing algorithm to set the price equal for all bidding zones within a macro area. The macro area is then referred to as a virtual price area.

8 Pricing and definitions of congestions

Market players are paid based on a marginal pricing methodology, i.e., the same price for each bidding zone, hour and direction (up/down). The methodology aims at sending a price signal to the market players. The price can be interpreted as ‘the maximum bid cost that would be selected’. As the general rule, the price for each bidding zone, hour and direction is based on the most expensive selected bid for that bidding zone, hour and direction such that all selected bids are profitable/in-the-money. What complicates the price setting is complex bid types and exchange between bidding zones.

For block bids, the pricing methodology only focuses on the profitability of the block bids over all hours in the block. That means that e.g., a block bid is not necessarily profitable for all hours in the block, but profitable for all hours in total.

Exchange (or the lack of exchange) of FRR between bidding zones will result in a line (from/to bidding zones) being either congested or uncongested for each hour. If a line is congested, it means that a higher CZC limit would have resulted in more CZC allocated on the line and a better overall socio-economic solution for the auction. If a line is uncongested, it means that an increase in CZC limit for a line and hour will not change the original solution. If a line is congested, the importing bidding zone will have a price which is the maximum of the cost of the most expensive selected bid and the price in the exporting bidding zone. For uncongested bidding zones prices will be equal.

The example below shows a situation without exchange between bidding zones. Prices are set to the highest bidding cost of the selected bids for each bidding zone, i.e., 15 for A and B, and 5 for bidding zone C.

INPUT

DEMAND:

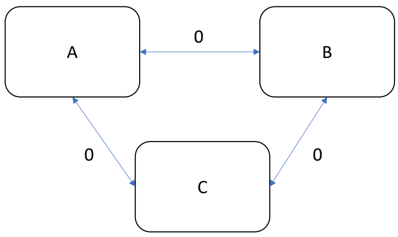
A: 20
B: 20
C: 20

BIDS:
[vol,cost]:

A:
[10,10]
[10,15]
B:
[10,10]
[10,15]
C:
[10,1]
[10,5]

CZC:

[vol,cost]
A->B: [0,1]
B->A: [0,1]
A->C: [0,1]
C->A: [0,1]
B->C: [0,1]
C->B: [0,1]



OUTPUT

BIDS:

A:
[10,10]
[10,15]

B:
[10,10]
[10,15]

C:
[10,1]
[10,5]

The same example, but with different bid costs and volume and CZC limits shows how prices are affected by exchange.

DEMAND:

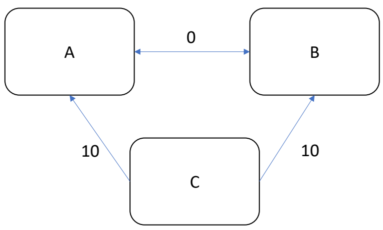
A: 20
B: 20
C: 20

BIDS:
[vol,cost]:

A:
[10,10]
[10,15]
B:
[10,11]
[10,12]
C:
[10,1]
[60,5]

CZC:

[vol,cost]
A->B: [10,1]
B->A: [10,1]
A->C: [10,1]
C->A: [10,1]
B->C: [10,1]
C->B: [10,1]



OUTPUT

BIDS:

A:
[10,10]
[10,15]

B:
[10,11]
[10,12]

C:
[10,1]
[60,5]

Both bids in C are selected and 10 MW is sent to both A and B. If the CZC limit was higher, C would send even more which means that the lines between A-C and B-C are congested. The line between A and B is uncongested. As a result of this, A and B will have the same price which is the maximum of the highest selected bid cost and the price from C. C will have a price based on the highest accepted bid in C. As a result, the price in A and B will be 11 €/MW and the price in C will be 5 €/MW.

9 Transfer of obligation

According to article 34, transfer of obligation is allowed within bidding zones. An exemption has been given to the Nordic LFC Block meaning that transfer cannot happen across bidding zones. BSPs should contact the national TSO to clarify how to transfer obligation is done on a national level.

10 Transparency and reporting

Market data from the aFRR CM are published on the ENTSO-E Transparency platform (https://transparency.entsoe.eu/) according to the Transparency Regulation (Reg EU 543/2013[14], article 17) and the EB GL (Guideline on electricity balancing, Reg EU 2017/2195[15], article 12):

- Prices of procured balancing reserves
- Amount of balancing reserves under contract
- Information on offered volumes as well as offered prices of procured balancing capacity
- Information on the allocation of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves
    - i. date and time when the decision on allocation was made
    - ii. period of the allocation
    - iii. volumes allocated
    - iv. market values used as a basis for the allocation process
- Information on the use of allocated cross-zonal capacity for the exchange of balancing capacity or sharing of reserves:
    - i. volume of allocated and used cross-zonal capacity per market time unit
    - ii. volume of released cross-zonal capacity for subsequent timeframes per market time unit
    - iii. estimated realized costs and benefits of the allocation process

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[14] Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the European Parliament and of the CouncilText with EEA relevance (europa.eu)

[15] COMMISSION REGULATION (EU) 2017/ 2195 - of 23 November 2017 - establishing a guideline on electricity balancing (europa.eu)

The data listed above are also published on the NUCS platform (https://www.nucs.net/). Additionally, NUCS publishes the following data:

- Maximum transmission capacity available for the exchange of FRR balancing capacity
- The actual reservation percentage limit applied
- Updated mark-ups

11 How to become an FRR provider

BSPs need to contact the national TSO to clarify how to become an FRR provider.

TSO	Contact
Svenska kraftnät	afrr@svk.se mFRR@svk.se
Energinet	electricitymarket@energinet.dk
Statnett	BSP@statnett.no
Fingrid	Reservit@fingrid.fi