European Network of
Transmission System Operators
for Electricity

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Explanatory document to Energinet, Fingrid, Statnett and Svenska kraftnät proposal for establishment of common and harmonized rules and processes for the exchange and procurement of aFRR balancing capacity in accordance with Article 33(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

Date of the approval

DISCLAIMER
This document is released on behalf of Energinet, Fingrid, Statnett and Svenska kraftnät only for the purpose of the public consultation on proposal for establishment of common and harmonized rules and processes for the exchange and procurement of aFRR balancing capacity in accordance with Article 33 (1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. This version of the proposal for establishment of common and harmonized rules and processes for the exchange and procurement of aFRR balancing capacity does not in any case represent a firm, binding or definitive TSOs' position on the content.

Contents

1. Introduction 3
1.1. Purpose 3
1.2. Background 3
1.3. Legal basis 4
1.4. Definitions 4
2. The proposal 6
2.1. Application of the TSO-TSO model 6
2.2. Product definition and bid characteristics 6
2.3. Geographical scope 9
2.4. The procurement rules 11
2.5. Activation of balancing energy bids 13
2.6. Publication of market information 13
2.7. Allocation of cross-zonal capacity 14
2.8. TSO-TSO settlement 14
3. Outlook 16
Appendix 1 17

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1. Introduction

This document gives background information and rationale for Energinet, Fingrid, Statnett and Svenska kraftnät proposal for establishment of common and harmonized rules and processes for the exchange and procurement of aFRR balancing capacity in accordance with Article 33(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (hereinafter referred to as "EB GL"). This proposal is hereinafter referred to as "Proposal", and Energinet, Fingrid, Statnett and Svenska kraftnät are hereinafter collectively referred to as the "Nordic TSOs".

1.1. Purpose

The purpose of the aFRR capacity market is to ensure availability of aFRR reserves in accordance with the LFC block dimensioning rules and thereby ensure the operational security.

The purpose of the establishment of a common Nordic market for aFRR balancing capacity is to increase socioeconomic welfare on a Nordic level. This is done by enabling cross-zonal procurement of aFRR balancing capacity available for balancing the Nordic Synchronous Area, whilst taking into account network constraints.

1.2. Background

The Nordic TSOs intend to establish regional balancing capacity markets for aFRR and mFRR balancing capacity.

The Nordic aFRR capacity market shall be followed by a Nordic aFRR energy activation market which, in line with EB GL, shall later integrate with the European balancing market coupling via the establishment of the European balancing market platforms (developed under the project PICASSO).

The regional balancing capacity market is based on the FRR dimensioning process, which will result in FRR volumes per LFC area (equal to bidding zone). This initial LFC area reserve requirement can then be procured in another LFC area provided that there are available cross-zonal capacities (hereinafter "CZC") that can accommodate the exchange.

The Nordic TSOs therefore propose that the capacity procurement optimisation function for the common aFRR capacity market shall include a methodology for the allocation of CZC. The initial choice of methodology is the market-based allocation process as described in Article 41 of EB GL. This methodology was also tested in a pilot project denoted the "Hasle pilot"[1]. The methodology for the allocation of CZC is consulted separately.

Regarding the introduction of the mFRR capacity market, the current working assumption is that the same principles shall be used also in this market and that the allocation of CZC for the two markets shall be carried out in a coordinated manner. The mFRR capacity market design is consulted separately.

[1] Description of the pilot, the results and conclusions can be found in two published documents: "The Hasle pilot project" published on 2015-03-17, and "Memo: Hasle pilot experiences" published on 2015-12-21.

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1.3. Legal basis

Regional capacity markets are not mandatory under European legislation, but they are regulated. Title III Chapter 2 of EB GL and Article 33 in particular are relevant for the Nordic aFRR capacity market. Furthermore, the Nordic TSOs have agreed to allocate CZC for the exchange of aFRR balancing capacity; consequently Title IV Chapter 1 of EB GL and, in particular, Articles 38 and 41 are of relevance.

According to Article 5(3) of EB GL:

"The proposals for the following terms and conditions or methodologies shall be subject to approval by all regulatory authorities of the concerned region:

(b) for the geographical area concerning two or more TSOs exchanging or mutually willing to exchange balancing capacity, the establishment of common and harmonized rules and process for the exchange and procurement of balancing capacity pursuant to Article 33(1);

(g) in a geographical area comprising two or more TSOs, the application of the allocation process of cross-zonal capacity for the exchange of balancing capacity or sharing of reserves pursuant to Article 38(1);

(h) for each capacity calculation region, the methodology for a market-based allocation process of cross-zonal capacity pursuant to Article 41(1);

From the perspective of EB GL, it should be stated that since the Nordic aFRR capacity market is based on a voluntary agreement between the Nordic TSOs, the Proposal is consequently not legally bound by a stipulated timeline. The proposal for the market-based allocation methodology according to Article 41(1), however, shall be submitted to relevant regulatory authorities for approval at latest two years after EB GL entered into force, which is translated to the 18th of December 2019.

The timeline described in the Proposal and this document is necessary from a market implementation perspective rather than being required by EB GL. The go-live summer 2019 for the Nordic balancing capacity markets are already decided and require that the two proposals concerning the aFRR capacity market are put forward during 2018 and approved by NRAs.

1.4. Definitions

Generally, the definition of terms found in EB GL, SO GL and CACM shall apply in the proposal and explanatory document. In order to ease reading of this document, here follows the definition of the main terms used.

(1) 'area control error' or 'ACE' means the sum of the power control error ('ΔP'), that is the real-time difference between the measured actual real time power interchange value ('P') and the control program ('P0') of a specific LFC area or LFC block and the frequency control error ('K*Δf'), that is the product of the K-factor and the frequency deviation of that specific LFC area or LFC block, where the area control error equals ΔP+K*Δf;

(2) 'balancing service provider' means a market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs;

(3) 'capacity calculation region' means the geographic area in which coordinated capacity calculation is applied;

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(4) 'capacity procurement optimisation function' means the function of operating the algorithm applied for the optimisation of the procurement of balancing capacity for TSOs exchanging balancing capacity;

(5) 'common merit order list' means a list of balancing energy bids sorted in order of their bid prices, used for the activation of those bids;

(6) 'connecting TSO' means the TSO that operates the scheduling area in which balancing service providers and balance responsible parties shall be compliant with the terms and conditions related to balancing;

(7) 'divisibility' means the possibility for a TSO to use only part of the balancing energy bids or balancing capacity bids offered by the balancing service provider, either in terms of power activation or time duration;

(8) 'exchange of balancing capacity' means the provision of balancing capacity to a TSO in a different scheduling area than the one in which the procured balancing service provider is connected;

(9) 'FRR dimensioning rules' means the specifications of the FRR dimensioning process of a LFC block;

(10) 'full activation time' means the period between the activation request by the connecting TSO in case of TSO-TSO model or by the contracting TSO in case of TSO-BSP model and the corresponding full delivery of the concerned product;

(11) 'load-frequency control area' or 'LFC area' means a part of a synchronous area or an entire synchronous area, physically demarcated by points of measurement at interconnectors to other LFC areas, operated by one or more TSOs fulfilling the obligations of load-frequency control;

(12) 'load-frequency control block' or 'LFC block' means a part of a synchronous area or an entire synchronous area, physically demarcated by points of measurement at interconnectors to other LFC blocks, consisting of one or more LFC areas, operated by one or more TSOs fulfilling the obligations of load-frequency control;

(13) 'market area' means an area made up of several market balance areas interconnected through AC or DC links. Trade is allowed between different market balance areas with common market rules for trading across the interconnection;

(14) 'operational security limits' means the acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits;

(15) 'standard product' means a harmonised balancing product defined by all TSOs for the exchange of balancing services;

(16) 'TSO-TSO model' means a model for the exchange of balancing services where the balancing service provider provides balancing services to its connecting TSO, which then provides these balancing services to the requesting TSO;

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2. The proposal

2.1. Application of the TSO-TSO model

The Nordic TSOs will exchange aFRR capacity based on a TSO-TSO model. This implies that each balancing service provider (hereinafter "BSP") provides balancing capacity to its connecting TSO which also has prequalified the BSP. There shall only be contractual arrangements between the TSOs and between BSPs and their connecting TSO.

The Nordic TSOs shall strive to establish national requirements (BSP agreements) that are as similar as possible to those of their Nordic counterparts in order to ensure a level playing field for BSPs and to facilitate the functioning of the Nordic aFRR capacity market. Revised BSP agreements are currently developed and proposed in all Nordic countries. The BSP agreement is regulated by Article 18 of EB GL.

2.2. Product definition and bid characteristics

2.2.1. Pre-qualification of aFRR capacity

Only a BSP with prequalified aFRR resources can submit bids in the aFRR capacity market. Each of the Nordic TSOs are responsible for the pre-qualification process and monitoring of the delivery from the BSPs in their control area.

The Nordic TSOs have the intention to make the requirements and process of the pre-qualification as similar as possible in order to facilitate a well-functioning Nordic aFRR capacity market. The end goal is to have fully harmonized rules and contracts regarding a standard format, but some national differences will be necessary in the first phases since the general framework for Nordic and European balancing processes is not yet fully developed.

In particular the prequalification rules for the full activation time will be different in the Nordics for a transition period after the aFRR capacity market has started. This is in accordance with the prequalification requirements that prevails today, where BSPs in Norway and Sweden is prequalified according to a full activation time equal two minutes and BSPs in Denmark and Finland have been prequalified to deliver according to a full activation time of five minutes. The Nordic TSOs are, however, working towards having a harmonized full activation time equal to five minutes in the future. The foreseen development is further described in section 3 Outlook.

2.2.2. Bid formats

The aFRR capacity product characteristics shall be consistent with the prevailing terms and conditions for balancing service providers related to aFRR energy activation in the Nordic LFC block. From the start of aFRR capacity market the bids shall be in accordance with the following formats:

- Full activation time shall be in accordance with prequalification (see section 2.2.1)
- Minimum bid quantity shall be 5 MW and bid granularity shall be 5 MW steps.
- The bid shall include the bidding zone it belongs to, and no other locational information will be required. This implies that portfolio bids for units within a bidding zone are allowed.

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- Single bids less than 50 MW can be marked as indivisible. This means that either the bid must be accepted as a whole or rejected.
- Bids may be linked: upward- with downward capacity and in time ("block bids"). Bids may also be presented as a bidding curve, where only one of the bids constituting the curve can be accepted.
- Bidding curves cannot be combined with linking of upward- and downward capacity bids.

The predefined volume of aFRR capacity will be procured daily for a predetermined set of market time units (hereinafter "MTU"). When the aFRR capacity market goes live, the MTU will be hours.

The linking of bids can be done in different ways. In order to clarify the possibilities, below follows an explanation of the bid linking that is allowed.

Block bids

Block bids refer to linking in time and are bids that are valid for a number of consecutive MTUs. A block bid shall have the same volume, direction and price in all 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 bid is valid. Figure 1 illustrates an upward block bid.

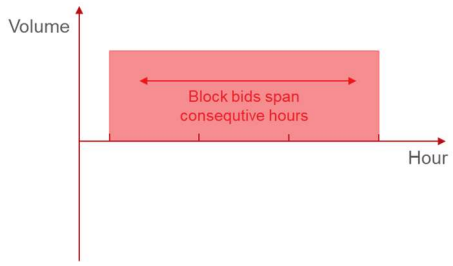

Figure 1. Illustration of an upward block bid

Linked upward- and downward bids

It will be allowed to link an upward bid with downward bid of the same MTU, meaning that both bids must either be accepted or rejected. The two linked bids can have different volumes and prices. It will be possible to submit the linked bids as divisible and a minimum quantity can be set, but divisibility is then expected only to be relevant in one direction. The linking of an upward- and downward bid is shown in Figure 2.

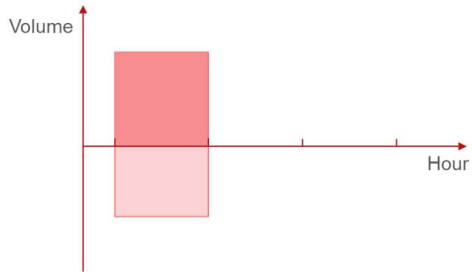

Figure 2. Illustration of linked upward- and downward bid

Linked upward- and downward bids can be combined with a block bid. This can be used if for example the main cost for the BSP is running the machine, but when running, both directions can be delivered.

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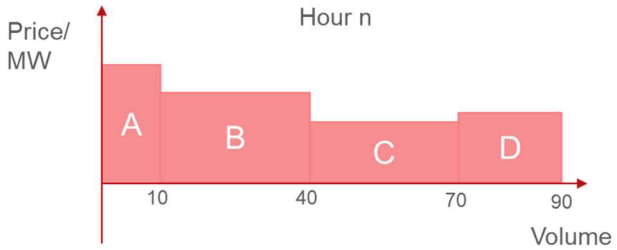
Mutually exclusive bids – bid curve

An alternative way to submit single bids with the possibility to use links as described above, is to submit a bid curve where only one bid of the group of bids constituting the bid curve can be selected. This give BSPs great flexibility in presenting their actual cost structure in their bidding. All kinds of links between different units of a portfolio can be converted into a bid curve for a certain MTU. However, if the option of bid curve is used, the BSP foregoes the opportunity to use block bids. An example of a bid curve is shown in Figure 3 for upward bids.



Bid	Price/ MW	Volume	Min volume	Divisible?
A	50	10		No
B	40	40	10	Yes
C	30	70	40	Yes
D	35	90	70	Yes

Figure 3. Example of bid curve for upward bids

Exclusive bids can be combined with linked upward- and downward bids, where only *one pair* of bids can be selected in the group of bid pairs. An example of this is shown in Figure 4.

Up / Down	0	5	10	15	20	25
0		U:20	U:12	U:8	U:6	U:5
5	D:40	D:40 U:2	D:40 U:2	D:40 U:4	D:40 U:4	D:40 U:4
10	D:30	D:30 U:2	D:30 U:2	D:30 U:3	D:30 U:3	
15	D:25	D:25 U:2	D:25 U:3	D:25 U:3		
20	D:25	D:25 U:3	D:25 U:3			
25	D:22	D:22 U:3				

Figure 4. Example of a matrix depicted a number of linked upward- and downward bids, with volume (MW) on the axes and prices (price/MW) within the matrix. Here most of the cost of reserving capacity is related to downward capacity and the maximum total quantity is 30 MW

In Appendix 1, an overview of allowed combinations of bid formats can be found, in addition to some examples of combinations that are invalid.

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2.2.3. Transfer of bids

The Nordic TSOs currently do not foresee to allow a BSP to transfer the obligations from an accepted aFRR capacity bid to another BSP. The contract period for the aFRR capacity market will only be two days, and this is expected to reduce the need for such flexibility for the BSPs. According to Article 34(1) of EB GL, TSOs can request exemption from allowing BSPs to transfer balancing capacity bids, when the contracting period is strictly less than one week.

2.3. Geographical scope

The geographical scope of the aFRR capacity market is limited to all bidding zones in the Nordic synchronous area. According to the current bidding zone configuration this includes: DK2, NO1-5, SE1-4 and FI.

The possible inclusion of DK1 (Fyn/Jylland) will be considered at a later stage in connection with the introduction of ACE-based balancing, since DK1 is part of the continental synchronous area where ACE-based balancing currently is applied.

2.3.1. The procurement volume of aFRR capacity

The procurement volume and how its distributed between the bidding zones shall follow the prevailing rules for dimensioning in the Nordic LFC block.

In the first phase of the Nordic aFRR exchange, an initial geographic distribution is defined as the total amount of aFRR balancing capacity to be procured and allocated among the bidding zones so as to minimise the risk of cross-zonal congestion when aFRR balancing resources are fully activated.

The calculation of the initial geographical distribution considers a situation in which the short-term imbalance in each individual bidding zone is assumed to be equal to the historical average short-term imbalance of the bidding zone. The short-term imbalance is the imbalance that is mitigated by aFRR (currently between 5-30 minutes).

If aFRR is distributed among bidding zones proportionally to the historical average short-term imbalance values, aFRR is then only used to mitigate short-term imbalances in the bidding zone where it is allocated.

Minimum and maximum values will be defined separately for positive and negative imbalances:

- the bidding zone's share in the sum of the positive absolute short-term imbalance will be the value for the downward aFRR;
- the bidding zone's share in the sum of the negative absolute short-term imbalance will be the value for the upward aFRR.

The inputs to this methodology are:

- $Imbi(t)$: One minute values of imbalance per bidding zone i
    - The imbalance data shall be collected for the historic periods (hours, weekday, month) corresponding to when aFRR capacity is procured. If no decision is made for when aFRR capacity shall be procured, the contracting hours from last year shall be used.
- One minute values are based on several inputs, including:
    - Flow after intraday day

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- Measured flow on AC tie lines[2] out of an area
- Frequency bias factor
- aFRR activation signals
- mFRR activation
- Quarterly movements

The short-term imbalance for each bidding zone *i*; this is calculated by:

$$Imb_{short,\,i}(t) = \frac{1}{t_s}\int_{t-t_s/2}^{t+t_s/2} Imb_i(\tau).d\tau - \frac{1}{t_l}\int_{t-t_l/2}^{t+t_l/2} Imb_i(\tau).d\tau$$

in which, t_s is 4 minutes and t_l is 30 minutes

Since upward aFRR and downward aFRR are considered separately, negative short-term imbalance (driver for upward aFRR) will need to be considered separately from positive short-term imbalance (driver for downward aFRR). Therefore $Imb_{short,\,i}(t)$ in $Pos\_Imb_{short,\,i}(t)$ and $Neg\_Imb_{short,\,i}(t)$ is split according to:

$$Pos\_Imb_{short,\,i}(t) \quad \begin{cases} Imb_{short,\,i}(t) \text{ if } Imb_{short,\,i}(t) > 0 \\ \text{'no value'} \text{ if } Imb_{short,\,i}(t) \leq 0 \end{cases}$$

$$Neg\_Imb_{short,\,i}(t) \quad \begin{cases} Imb_{short,\,i}(t) \text{ if } Imb_{short,\,i}(t) < 0 \\ \text{'no value'} \text{ if } Imb_{short,\,i}(t) \geq 0 \end{cases}$$

The averages are calculated over time of the existing values of $Pos\_Imb_{short,\,i}(t)$ and $Neg\_Imb_{short,\,i}(t)$:

$\overline{Pos\_Imb_{short,\,i}}$: Average of short-term imbalance for bidding zone *i* for times that short-term imbalance is positive;

$\overline{Neg\_Imb_{short,\,i}}$: Average of short-term imbalance for bidding zone *i* for times that short-term imbalance is negative;

The total amount of Nordic aFRR, c_{aFRR} , shall be distributed among the bidding zones in proportion to the imbalance.

For each bidding zones i, this will result in an allocation of downward aFRR, $aFRR_{Downward,\,i}$, and an allocation of upward aFRR, $aFRR_{Upward,\,i}$, as follows:

$$aFRR_{Down\quad,\,i} = \frac{\overline{Pos\_Imb_{short,\,i}}}{\sum_{i=Elspot\ areas}\overline{Pos\_Imb_{short,\,i}}} \cdot Nordic\_aFRR$$

$$aFRR_{Upward,\,i} = \frac{\overline{Neg\_Imb_{short,\,i}}}{\sum_{i=Elspot\ areas}\overline{Neg\_Imb_{short,\,i}}} \cdot Nordic\_aFRR$$

[2] Fennoskan DC cable is also included in the calculation of the short-term imbalance, thus treated as an AC tie line.

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The sets of $aFRR_{Downward,\,i}$ and $aFRR_{Upward,\,i}$ are the initial geographic distribution and consequently the output of the methodology.

The calculations for initial geographic distribution will be published by the Nordic TSOs. The updating of the initial geographic distribution is expected to be done annually.

The dimensioning rules of the Nordic LFC block will be developed further and this is described in the outlook in section 3.

2.4. The procurement rules

2.4.1. The market process

The gate closure time for BSPs to submit aFRR balancing capacity bids shall be two days prior to the day of delivery (D-2), with a gate closure at 20:00 CET. This timing allows for rectifying possible issues or failure in the optimisation for bid selection before information is then provided to the NTC calculations on the morning of D-1. When CZC is allocated for the exchange of aFRR capacity, this reduces the available day-ahead transmission capacity.

The Nordic TSOs do not foresee restricting the gate opening time for the BSPs more than necessary, taking into account technical reasons. The exact time for gate opening will be determined during the implementation phase but it will be at least D-7.

Between the gate closure time and a deadline for approval, the TSOs can review the bids of their control area and, if necessary, reject bids. The optimisation of bids and allocation of CZC will then lead to clearing of the aFRR capacity market later in the evening of D-2. An overview of the timeline for the market process is shown in Figure 5.

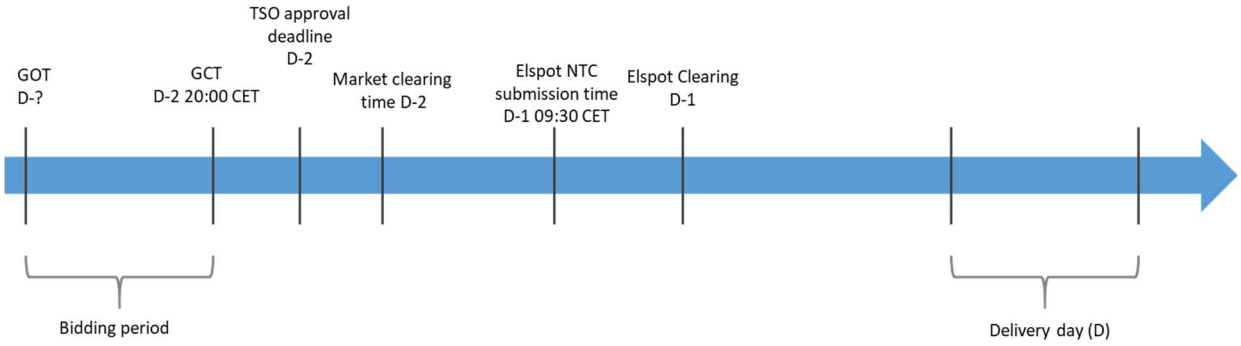

Figure 5. Overview of the market timeline

2.4.2. Bid selection and procurement optimization function

A schematic illustration of the bid submission, optimisation and selection process is shown in Figure 6.

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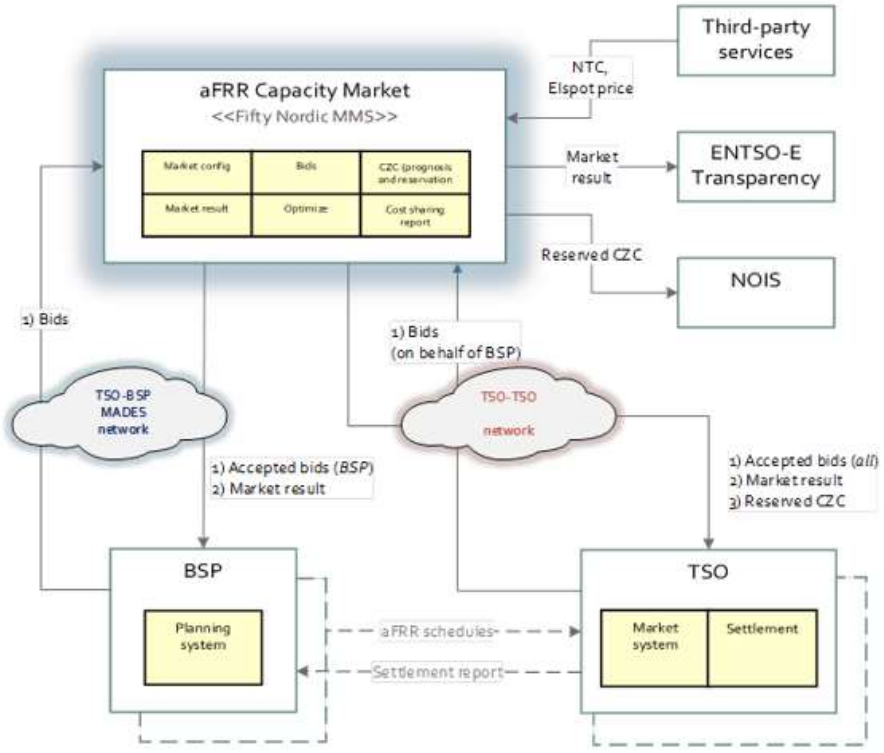

Figure 6. Bid submission, optimisation and bid selection in the Nordic aFRR capacity market

The bid format will be based on ENTSO-E Reserve Resource Process (EERP), a standardised bidding format for the procurement of Reserve Capacity.

BSPs will initially at least have two different options to send in their aFRR balancing capacity bids:

- Directly to the host. ENTSO-E's Market Data Exchange Standard (MADES) communication protocol will be used for the exchange of data.
- Via a web interface,

Connecting TSOs will have full access to all bidding data, also when bidding data is sent directly to the host.

In an iterative process, bids are selected and CZC is allocated until an acceptable solution is found. CZC will only be allocated to the exchange of aFRR capacity if the aforementioned calculations show that this increases socioeconomic welfare. Consequently, transmission capacity will only be allocated for exchange of aFRR capacity if the price difference between the relevant bidding areas is larger in the aFRR capacity market than in the day-ahead market.

The optimisation will be done taking into account the following restrictions:

- Predetermined procurement volume
- bids from BSPs,
- the forecasted value of day-ahead market transmission capacity.

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The outputs from the optimisation tool are:

- the selected bids,
- allocated CZC (MW) for exchange of aFRR capacity per bidding zone border; the day-ahead market transmission (trading) capacities communicated to the power market on the day before delivery will be decreased by this amount.

If the optimisation fails, there will be back-up routines that will aim to minimise the market impact.

2.4.3. Settlement of contracted capacity

Initially the settlement of procured balancing capacity shall be based on pay-as-bid towards the BSPs. BSPs will receive an availability payment, for each MTU where the aFRR capacity bid is accepted, equal to the bid price multiplied with bid volume ("pay-as-bid"). The Euro (EUR) will be the currency of the aFRR capacity market.

The Nordic TSOs foresee to introduce marginal pricing at a later stage. This is described in Section 3 Outlook.

2.5. Activation of balancing energy bids

For the first phase of the aFRR capacity market, balancing energy bids will be activated pro-rata and activated aFRR energy is settled with regulation power price.

The Nordic TSOs foresee to introduce an energy activation market at a later stage. This is described in Section 3 Outlook.

2.6. Publication of market information

The market results will be sent for publication to the ENTSO-E transparency platform in accordance with Article 12(3) of EB GL. The data will include:

- Anonymised prices and volumes of the procured aFRR balancing capacity bids. These data will be published as soon as the market results of the tender are completed and BSPs have been notified about the acceptance of their aFRR capacity bids.
- The CZC allocated for the exchange of aFRR balancing capacity. This will be published after the NTCs have been submitted to the day-ahead market.
- The use of allocated CZC for the exchange of aFRR balancing capacity, including realised costs and benefits of the allocation process. The Nordic TSOs will monitor the efficiency of the CZC allocation process and, based on the aFRR capacity bid data, will calculate the reduction in procurement costs compared to fulfilling the initial distribution of capacity without allocating CZC for exchange. As long as energy activation is done through pro-rata activation without an energy acitvation market, the efficiency of realised energy actiavtion is not estimated. The estimated costs and benefits will be published within a week after the delivery day.

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2.7. Allocation of cross-zonal capacity

Pursuant to Article 33(4)(b) of EB GL, the Nordic TSOs exchanging balancing capacity shall ensure both the availability of CZC and that operational requirements are met by one of the methodologies for allocating CZC to the balancing timeframe which are presented in Chapter 2 of Title IV of EB GL. Of these methodologies, the Nordic TSOs intend to use a market-based allocation process of CZC in order to secure the exchange of aFRR. Pursuant to Article 38(1) of EB GL, the proposal for a methodology for this process is found in the separate proposal document also submitted to the national regulatory authorities, entitled "Energinet, Fingrid, Statnett and Svenska kraftnät proposal for the methodology for a market-based allocation process of cross-zonal capacity for the exchange of aFRR balancing capacity in accordance with Article 38 (1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing".

2.8. TSO-TSO settlement

For the first phase of the aFRR capacity market will apply a cost sharing model based on the polluter-pay-principle. With the introduction of the marginal pricing at a later stage, the Nordic TSOs also look to change the settlement between TSOs, explicitly sharing the congestion rent, which is implicitly shared in the model for the first phase.

2.8.1. Cost-sharing key

The financial obligation for the procurement of aFRR capacity will be shared between the TSOs according to a pollution-based sharing key, which is based on the polluter-pays principle per control area.

The indicator for the 'pollution' shall correlate with the need for aFRR energy, i.e. if the total pollution as indicated by this indicator decreases, the need for aFRR shall decrease as well. Consequently, when costs are allocated to each of the Nordic TSOs based on this indicator, this shall provide an incentive to each TSO to reduce their 'pollution'.

The indicator for pollution is the imbalance minus the rolling average of the previous MTU. The "90th percentile" is used as the 'pollution' indicator for aFRR capacity. It is a good proxy for the maximum use of contracted capacity and consequently for the need for contracting that amount of capacity. It is not sensitive to special conditions (including disturbances) and outliers that are caused by data errors.

The inputs to this methodology are:

- $Imbi(t)$: One minute values of imbalance per Control Area i
    - The imbalance data shall be collected for the historic periods (hours, weekday, month) corresponding to when aFRR balancing capacity is procured. If no decision is made for when aFRR balancing capacity shall be procured, the contracting hours from last year shall be used.
- One minute values are based on several inputs, including:
    - Flow after intraday day
    - Measured flow on AC tie lines out of an area
    - Frequency bias factor
    - aFRR activation signals
    - mFRR activation

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- Quarterly movements

The short-term imbalance for each Control Area i; this is calculated by:

$$Imb_{aFRR,\,i}(t) = \frac{1}{t_s}\int_{t-t_s/2}^{t+t_s/2} Imb_i(\tau).d\tau - \frac{1}{t_l}\int_{t-t_l/2}^{t+t_l/2} Imb_i(\tau).d\tau$$

in which, t_s is 5 minutes and t_l is 60 minutes

The calculation is made by each control area and will be published. The Nordic TSOs shall have access to the methodology for imbalance calculations, and shall have access to all background data upon request. The Nordic TSOs are jointly responsible for the data quality and the calculation methodology.

With the introduction of the marginal pricing at a later stage, the Nordic TSOs also look to change the settlement between TSOs, explicitly sharing the congestion rent, which is implicitly shared in the model for the first phase.

2.8.2. Cost-sharing model

Bidding zones with more procured aFRR capacity than their aFRR obligation are termed exporting bidding zones. Bidding zones with procured aFRR capacity below their aFRR obligation are termed importing bidding zones.

Balancing capacity offers from BSPs will be settled pay-as-bid. The methodology to share the costs arising from this settlement will be based on the principle that exporting control areas first fulfil their own aFRR capacity obligation with the cheapest available balancing capacity bids from the bottom of the bid curve, after which the remaining bids are "exported" to importing control areas. Importing control areas pay the average cost of the capacity imported across all Nordic control areas.

In more detail, the above methodology entails the following:

1. The choice of cost sharing methodology will not affect the optimisation process. The common Nordic procurement of aFRR balancing capacity will be made optimally on a Nordic level. This means that FRR balancing capacity will be procured where it is cheapest, taking into account the initial geographical distribution and cross-zonal restrictions.
2. An obligation per control area is defined by the chosen sharing key, see 2.8.1.
3. In control areas where the amount of procured balancing capacity exceeds the local aFRR obligation, the local aFRR obligation will be met by the cheapest bids in that control area.
   - If the amount of procured balancing capacity in a control area exceeds the aFRR obligation, the excess bids (more expensive) will be paid for by the remaining control areas' TSOs.
   - If the amount of procured balancing capacity in a control area does not meet the area's obligation, the residual aFRR obligation is met by "import" from control areas with excess capacity.
4. Importing control areas pay the average price of the "imported" capacity. In other words, the total cost of the excess capacity is divided among importing control areas in relation to how much they "import".

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3. Outlook

As a part of the Nordic balancing model, the Nordic TSOs aim to introduce a Nordic aFRR energy activation when balancing in Nordic LFC Block is based on Area Control Error (ACE-based balancing). BSPs whose balancing resources are procured in advance in the aFRR capacity market will then have an obligation to bid into the aFRR energy activation market, whereas other BSPs may do so on a voluntary basis. Activation of bids will then occur according to a Common Merit Order List across the market region.

In the time period before introducing the Nordic aFRR energy activation market, only procured aFRR capacity can be activated. Activation is done pro rata and activated aFRR energy is settled with balancing energy price on regulating power market.

The Nordic TSOs expect that future challenges will require more automated balancing. The Nordic TSOs will increase the number of aFRR contracting hours from 35 hours/week today to all hours. After that, the aFRR volume will gradually be increased from today's level of 300 MW to a tentative target volume of 600MW. From that point in time a new dimensioning method for aFRR will have to be implemented.

As part of this development, the Nordic TSOs aim to further harmonize the prequalification rules and in particular the length of full activation time. The length of full activation time has a direct impact on the frequency quality in the synchronous area and the stability of the system, especially when relatively small volumes of aFRR is employed. The successively increase of of the number of hours and the volume of aFRR will enable a re-eavaluation of the activation process as a whole. A full activation time of five minutes is most probably the full activation time that will be used in the Energy standard product across Europe and therefore what the Nordic TSOs expect to apply as the harmonized full activation time. In the Nordics.

The overall long term aim for the pricing principles of the aFRR capacity market is for settlement of the procured balancing capacity to be based on marginal pricing. Until this change occurs, capacity will be procured using the pay-as-bid methodology.

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Appendix 1

Bid Type Combinations – Allowed Combinations

Case	Divisible	Block	Joint linked up-and-down	Exclusive	Description
0	No	No	No	No	(single bid) Indivisible non-block bid can span one or more hours (discontinuous interval is allowed). Each our is cleared sparately, i. e. the bid can be accepted or rejected separately hour by hour. The accepted quantity must be either equal to offered quantity or zero. The result can be different in each hour of the bid.
D	Yes	No	No	No	(single bid - varying quantity) Divisible non-block bid has the same rules as described in case 0 with the difference that it can be accepted in the range between minimum and offered quantity. The divisibility is expressed by the presence of the minimum quantity. The result can be different for each hour of the bid.
B	No	Yes	No	No	Indivisible block bid spans multiple consecutive hours (discontinuous interval is not allowed) with the same or different quantities per hour. In all hours, the bid must be either fully accepted or rejected.
DB	Yes	Yes	No	No	Divisible block (between minimum and offered quantity) bid spans multiple consecutive hours (discontinuous interval is not allowed) with the same or different quantities per hour. In all hours, the bid must be either accepted (between minimum and offered quantity) or rejected. I. e. it is not possible to accept the bid in one hour and reject it in another hour.
L	No	No	Yes	No	Joint linked up-and-down bids consist of two linked bids for different directions and the same price and hour(s). Both linked bids must have the same price and both must be either accepted or rejected; the offered quantity can be, however, different hour by hour. There are no links in time. The partial acceptance of the bid is not allowed.
DL	Yes	No	Yes	No	The same as case L with the exception that, for each hour, the bid can be accepted also partially (between minimum and offered quantity). Please note that it is possible to link together one divisible and one indivisible bid.
BL	No	Yes	Yes	No	The same as case L with the exception that both bids must be either fully accepted in all hours or fully rejected in all hours. It is not allowed to link one block and one non-block bid.
DBL	Yes	Yes	Yes	No	Combination of cases DL and BL: both bids must be either accepted in all hours or rejected in all hours but the accepted quantity can be between minimum and offered quantity.
E	No	No	No	Yes	Exclusive bids in the same group (they have the same exclusive group ID) are mutually exclusive for the same hour (block bids cannot be part of the exclusive bid group). The bid can be accepted in the given hour only if all other bids in the group are rejected.
DE	Yes	No	No	Yes	The same case as E with the difference that the bid can be accepted also partially (between minimum and offered quantity). Please note that the exclusive group can contain both divisible and indivisible bids.
LE	No	No	Yes	Yes	If joint linked up-and-down bid is part of the exclusive group (see case E), both coresponding linked bids must be part of the exclusive group and they both must be either accepted or rejected together, i. e. they are not considered as mutually exclusive. Both linked bids must have the same price.
DLE	Yes	No	Yes	Yes	This is the combination of the cases DE and LE: if the bid is accepted, the second linked bid must be also accepted and all other bids in the exclusive group must be rejected. In contrast to the case LE, the bid can be accepted also partially (between minimum and offered quantity).

Bid Type Combinations – Invalid Combinations

Case	Divisible	Block	Joint linked up-and-down	Exclusive	Description
BE	No	Yes	No	Yes	Block bid cannot be part of the exclusive group.
DBE	Yes	Yes	No	Yes	Block bid cannot be part of the exclusive group.
BLE	No	Yes	Yes	Yes	Block bid cannot be part of the exclusive group.
DBLE	Yes	Yes	Yes	Yes	Block bid cannot be part of the exclusive group

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Bid Type Combinations – Invalid Combinations

Case	Divisible	Block	Joint linked up-and-down	Exclusive	Description
BE	No	Yes	No	Yes	Block bid cannot be part of the exclusive group.
DBE	Yes	Yes	No	Yes	Block bid cannot be part of the exclusive group.
BLE	No	Yes	Yes	Yes	Block bid cannot be part of the exclusive group.
DBLE	Yes	Yes	Yes	Yes	Block bid cannot be part of the exclusive group

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