European Network of
Transmission System Operators
for Electricity

Explanatory document to the Energinet, Fingrid, Statnett and Svenska kraftnät proposal for the establishment of common and harmonised rules and processes for the exchange and procurement of balancing capacity and for the application of a market-based allocation process in accordance with Article 33(1) and Article 38(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

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1. Introduction

This document gives background information and the rationale for Energinet, Fingrid, Statnett and Svenska kraftnät's proposal for the establishment of common and harmonized rules and processes for the exchange and procurement of aFRR balancing capacity in accordance with Article 33(1) and Article 38(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 the "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 the availability of aFRR reserves in accordance with the LFC block dimensioning rules and thereby ensure operational security.

The purpose of the establishment of a common Nordic market for aFRR capacity is to increase socioeconomic welfare on a Nordic level and to increase operational security in the most efficient way. This is done by enabling cross-zonal procurement of aFRR capacity for use 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 European balancing market coupling via the establishment of European balancing market platforms (developed under the European 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 a 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 includes a methodology for the allocation of CZC. The initial choice of methodology is a market-based allocation process as described in Article 41 of the EB GL. This methodology was also tested in a pilot project – the "Hasle pilot"[1]. The methodology for the allocation of CZC is included in separate proposal.

Regarding the introduction of the mFRR capacity market, the current working assumption is that the same principles shall also be used 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 will be consulted on separately at a later date.

[1] A description of the pilot, the results and conclusions can be found in two published documents: "The Hasle pilot project" published on 17/3/2015, and "Memo: Hasle pilot experiences" published on 21/12/2015.

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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 the 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 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 the 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 the 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 the latest two years after the EB GL entered into force, which is translated to the 18th of December 2019.

1.4. Definitions

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

(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;

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(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 an LFC block;

(10) ‘full activation time’ means the period between the activation request by the connecting TSO in the TSO-TSO model or by the contracting TSO in the 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) ‘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;

(14) ‘standard product’ means a harmonised balancing product defined by all TSOs for the exchange of balancing services;

(15) ‘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 has also prequalified the BSP. There shall only be contractual arrangements between the TSOs and, separately, 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 being developed in all the Nordic countries. The BSP agreement is regulated by Article 18 of the 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 to the aFRR capacity market. Each of the Nordic TSOs are responsible for the pre-qualification process and for monitoring delivery from the BSPs in their own control area.

The Nordic TSOs intend to make the pre-qualification requirements and process as similar as possible in order to facilitate a well-functioning Nordic aFRR capacity market. The end goal is to have fully harmonised rules and contracts in a standard format, but some national differences will exist initially since the general framework for Nordic and European balancing processes has not yet been fully developed.

In particular, the prequalification rules for full activation time (FAT) will differ by country for a transition period after the aFRR capacity market has started. These differences reflect existing differences in the prequalification requirements that prevail today, in which BSPs in Norway and Sweden are prequalified according to a FAT of two minutes while BSPs in Denmark and Finland are prequalified to deliver according to a FAT of five minutes. The Nordic TSOs are working towards a harmonized FAT equal to five minutes in the future. This change will be covered by the future development of the technical specifications of the aFRR product in accordance with the SO GL Regulation as these product definitions do not constitute a part of this proposal.

The foreseen development of the use aFRR in the Nordics is further described in section 3 Outlook. The box immediately below discusses the implications of temporarily using different FATs during the start-up period of the common aFRR market.

The implications of using different FATs within the common Nordic market

The proposed market design does not distinguish between aFRR with different FATs. As aFRR capacity with a longer FAT will, other things being equal, be less helpful in balancing the system, there is a theoretical risk that, for the period during which multiple FATs are used, the procurement process could acquire lower quality balancing resources and result in lower quality balancing. However, given the characteristics of the system, this theoretical outcome will not occur in practice.

The simulation analysis of the market, detailed in the explanatory document accompanying the Nordic proposal on the allocation of cross-zonal capacity for the exchange of balancing capacity, shows that the

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market is likely to result, if anything, in more aFRR capacity being procured from the fast-FAT areas, where aFRR is also comparatively cheap. Since aFRR activation will, in the near term, be based on the pro-rata activation of all providers, as is the case presently, this fact-acting capacity will definitely be activated when aFRR is called upon and thereby contribute to system balancing. We do not therefore envisage that there will be any degradation in the quality of resources procured and, if anything, may actually expect an improvement in response times.

Harmonising the FAT to allow for a longer FAT would have the potential to reduce responsiveness and negatively impact balancing. However, this decision will be taken separately as part of the future development of the technical specifications of the aFRR product in accordance with the SO GL Regulation and will be analysed separately in that context.

2.2.2.Bid formats

From the start of aFRR capacity market, capacity bids will conform to the following requirements:

- The relevant FAT shall be set by each TSO in accordance with the methodologies pursuant to article 157 and 159 of the SO GL Regulation.
- The minimum bid quantity shall be 1 MW and bid granularity shall be in 1 MW steps.
- A 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.
- Single bids can be marked as indivisible. This means that either the bid must be accepted as a whole or rejected. Indivisible bids give BSPs greater flexibility when pricing bids and this flexibility can support higher bid volumes and help lower bid prices. On the other hand, indivisible bids make it harder for the optimisation function to find an efficient solution. A maximum bid size of 50 MW applies to indivisible bids to reduce the probability of potentially problems and will help disincentivise strategic bidding that might result in a loss of efficiency.
- Bids may be linked as coupled upward- with downward capacity bids as well as across time (“block bids”). Bids may also be presented as a bid curve, where only one of the bids comprising the curve can be accepted (See the detailed description below).
- Bid curves cannot be combined with the linking of upward- and downward capacity bids.

A 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 one hour.

A detailed explanation of how bids can be linked follows below.

<u>Block bids</u>

Block bids are bids that link 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 a divisible or indivisible bid. 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.

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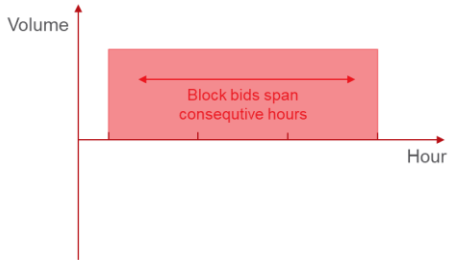

Figure 1. Illustration of an upward block bid

Linked upward- and downward bids

It will be possible to link an upward bid with a downward bid in 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.

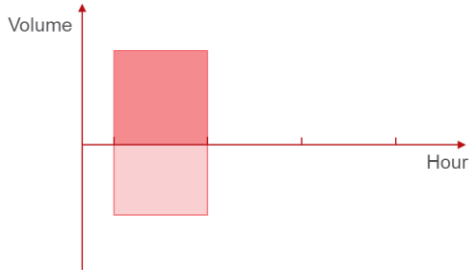

Figure 2. Illustration of linked upward- and downward bid

Linked upward- and downward bids can be combined with a block bid. This format can be used if, for example, BSP costs are largely determined by the decision to run, but when running, both directions can be delivered.

Mutually exclusive bids – bid curve

An alternative way to link bids is to submit a bid curve, in which only one bid of the group of bids constituting the bid curve can be selected. This gives BSPs significant flexibility in presenting their actual cost structures when bidding. All kinds of links between different units of a portfolio can be converted into a bid curve for a certain MTU. However, if a bid curve is submitted, the BSP foregoes the opportunity to use block bids. An example of a bid curve is shown in Figure 3 for upward bids.

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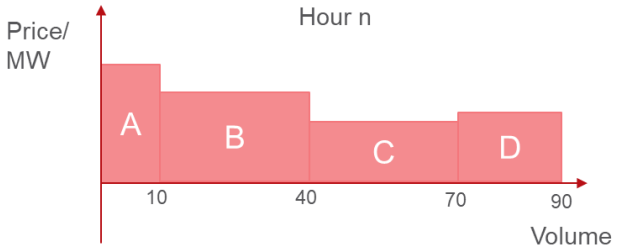

Bid	Price/ MW	Volume	Min volume	Divisible?
A	50	10		No
B	40	40	10	Yes
C	30	70	40	Yes
D	35	90	70	Yes

Figure 3. Example of bid curve for upward bids

Exclusive bids can be combined with linked upward- and downward bids, such that 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 depicting 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

An overview of the allowed combinations of bid formats can be found in Annex 2, in addition to some examples of combinations that are invalid.

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 the following bidding zones: DK2, NO1, NO2, NO3 NO4, NO5, SE1, SE2, SE3,SE4 and FI.

While being a part of the Nordic Balancing Model, Kraftnät Åland does not employ aFRR resources and does not take active part in the Nordic aFRR capacity market.

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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. Dimensioning rules for FRR in the Nordic LFC –block

The dimensioning rules for the Nordic LFC block are under development and out of scope of article 33 in the EB GL. The dimensioning rules will take into account both mFRR and aFRR and the rules will set a volume for the whole LFC-block and an obligation per TSO within the LFC-block. The volume for the LFC-block represents the FRR (both aFRR and mFRR) volume needed to secure system operations in real time balancing. The dimensioning volume may differ from the procured volume in the FRR capacity markets if TSO responsible for an LFC area assess that there will be enough voluntary FRR bids within the energy activation markets to secure the TSO obligations and real time balancing needs.

2.3.2. The procurement volume of aFRR capacity

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

2.4. The procurement rules

2.4.1. The market process

The exact time for gate opening will be determined during the implementation phase and will be at least D-7. The Nordic TSOs do not foresee the need for a restrictive gate opening time and will set the gate opening time taking into account the technical practicalities involved.

The gate closure time will fall on D-1, as specified in the legal proposal. Article 6(9) of Regulation (EU) 2019/943 on the internal market for electricity (recast), which applies from the 1st of January 2020, stipulates that “Contracts for balancing capacity shall not be concluded more than one day before the provision of the balancing capacity”. Setting the gate closure time to fall on D-1 will comply with this requirement.

We have chosen not to specify the exact timing of gate closure in the legal proposal because the feasible timings will likely be affected by decisions taken with respect to other balancing markets (notably mFRR) and the implementation of flow-based coupling, which is expected to change the nature and timing of TSOs CZC capacity reporting requirements. As part of the implementation process, and in line with the TSOs' duty to inform BSPs as set out in the legal proposal, the TSOs will propose a coordinated set of market gate closure times for all markets that is feasible both from a stakeholder perspective as well as from an operational TSO perspective. The proposed timings will be set so as to allow the TSOs to meet their CZC capacity reporting requirements and ensure the aFRR market's resilience to insufficient bids or potential failures in the bid selection process.

Between the gate closure time and a deadline for the TSO approval of the bids, the TSOs will be able to review the bids of their control area. Given the limited time available, this 'review' may need to be largely or completely automated. The aFRR capacity market will then be cleared in the morning of D-1, providing both the optimal selection of bids and the implied allocation of CZC. An overview of the timeline for the market process is shown in Figure 5.

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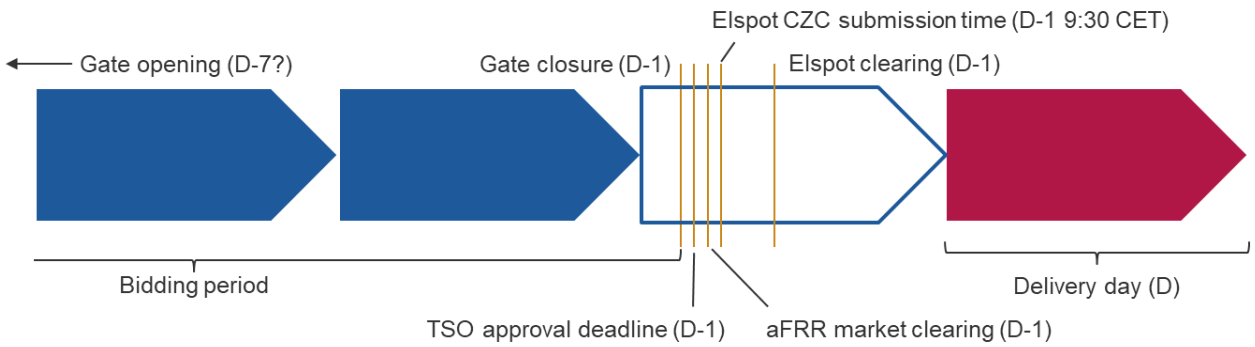

Figure 5. Overview of the market timeline

The detailed process for determining allocated CZC as part of the flow-based capacity calculation method will need to be determined at a later stage, alongside development of the flow-based capacity calculation processes. This is explained in the explanatory document for the proposal pursuant to article 41 in the EBGL.

2.4.2. The overall process of bid submission and bid selection

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

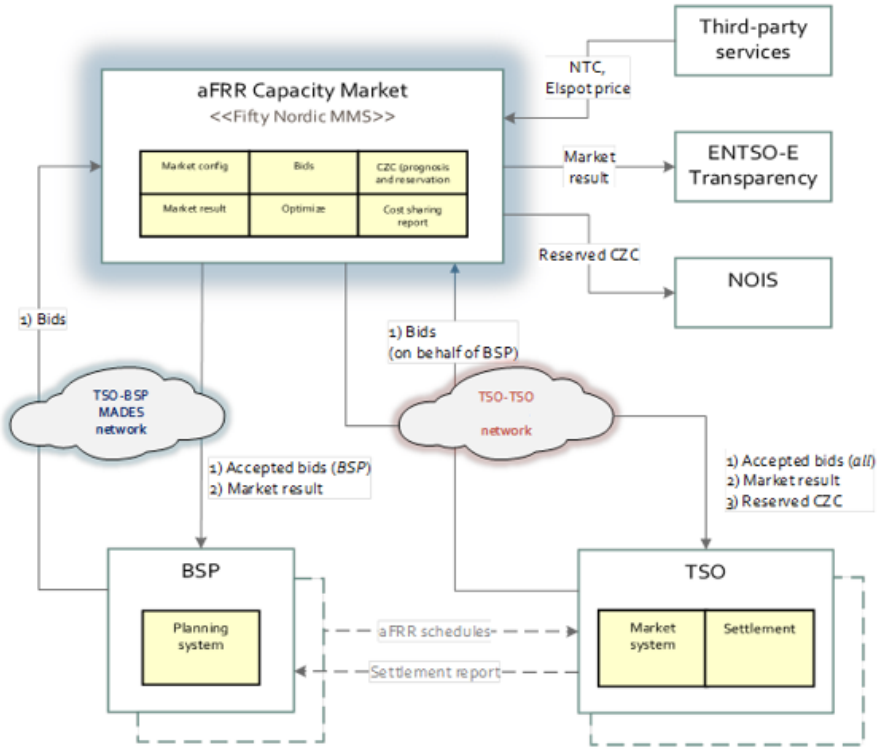

Figure 6. Bid submission, optimisation and bid selection in the Nordic aFRR capacity market

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 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.

2.4.3. The procurement optimisation function

Objective function

The goal of the procurement optimisation function is to minimise the sum of the accepted bid costs and the opportunity costs of reserved CZC based on the value of the CZC to the energy market (estimated based on forecasted values). As explained in Annex 3, this is consistent with the requirements of the EB GL. For each hour in the day, direction (up-/down-regulation) and bidding zone, we minimise the sum of:

- $\boldsymbol{bid\_cost_i \cdot x_i}$

- $\boldsymbol{czc\_cost_{from,to,hour} \cdot czc\_res_{from,to,hour}}$

Where x is the accepted volume the algorithm sets for each bid i. Bid_cost is the cost in MW associated with each bid given as input from BSP bids.

For CZC, the cost associated with each connection and hour is given by as an input as czc_cost. This equals the reservation costs of CZC as described in the legal proposal. czc_res is an endogenous variable representing the volume of CZC allocated to exchange of balancing capacity. For a specific connection and direction it will equal the maximum of exchanged up- and down- regulation .

The constraints of the optimisation

- All demand in each bidding zone, hour and direction must be met either by local or imported balancing capacity bids.
- Between all bidding zones there is defined a maximum CZC which represents the maximum volume of balancing capacity that can be transferred between the bidding zones. By default the maximum CZC will equal 10 percent of the expected NTC, but it can be set lower for operational security reasons in accordance with article 165(g) of the SOGL.
- Divisible bids can only be selected in 1 MW steps.
- A bidding zone or a predefined set of adjacent bidding zones may have a pre-determined restriction on minimum volume and/or maximum volume that must be procured in the respective bidding zone or set of bidding zones.
- The restrictions entailed in bids, including links to other bids, minimum volume, maximum volume and price must be respected.

The constraints can either be 'hard' (must be met) or 'soft' (should be met). If constraints are hard, they can cause the problem to be infeasible (unable to find a solution), and the algorithm cannot return a solution. If the constraints are soft, it will be able to find a solution, but some of the rules above are 'relaxed' in order to find a solution.

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Among the constraints listed above the following are soft constraints:

- Demand
- Minimum procurement volume of a bidding zone or a set of bidding zones

Technically, soft constraints are handled in the optimisation process by applying a cost to the relaxation of the constraint. An example might be that the demand in a bidding zone is greater than the volumes available locally and from neighbouring bidding zones. With a soft constraint, the algorithm is allowed to accept some 'missing' volume at a very high cost, and thus still give a solution.

- *Sum(bids) + imports – exports >= demand – "penalty"*

The penalty cost needs to be set high enough to make it the last option to use. The penalty cost should higher than the highest bid cost plus the CZC cost according to the maximum number of bidding zone borders for the bid to cover all regions.

If a problem is infeasible, but it is possible to find a solution given the penalty variables, the output of the algorithm will give information about this.

Maximum CZCs and bids characteristics (links, indivisibility etc) are examples of hard constraints. The maximum CZCs available for allocation is by default set to 10% of expected NTC, and this is a constraint in the optimisation that must always be met.

Maximum and minimum procurement volumes for a bidding zone or for a set of bidding zones
The maximum procurement volume can be applied as a constraint to prevent too large a share of the overall balancing capacity volume being located in a small part of the Nordic synchronous area and thereby reducing operational security in accordance with Article 165(g) of SOGL. This restriction will only be used if it is considered necessary based on experience with how the procured bids are distributed in the Nordic region.

The minimum procurement volume can be used if the dimensioning process according to Article 157(3)(g) requires such limitations in order to ensure that dimensioning requirements are fulfilled.

Minimum and maximum constraints for procurement volumes can be applied to specific bidding zones or a set of bidding zones. The constraints must be made public before they are applied in the algorithm.

Mathematical formulation
Below is the description of the most important variables, parameters and constraints, as well as the objective function.

Variables:
x_i: sales bid variable (integer), $i \in BIDS$
x_bin_i: binary bid variable (0 if not selected, 1 if selected), $i \in BIDS$
f_agg_{mnt}: flow variable (in MW) from region *m* to region *n* in hour *t*
f_{mndt}: flow variable (in MW) from region *m* to region *n* in hour *t*, in direction *d*
p_dem_{mdt}: penalty variable (in MW) for demand constraint, for region *m*, in hour *t*, in direction *d*
p_minreg_{mdt}: penalty variable (in MW) for minimum procurement volume constraint, for region *m*, in hour *t*, in direction *d*
p_minmac_{zdt}: penalty variable (in MW) for minimum procurement volume constraint, for macro region *z*, in hour *t*, in direction *d*

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Parameters:
Dem_{mdt}: demand for aFRR for region *m*, direction *d*, hour *t*
bid_cost_i: cost of selecting 1MW of bid *i*
$minvolume_i$: minimum volume to be selected for each bid *i*
$maxvolume_i$: maximum volume to be selected for each bid *i*
$hourFrom_i$: the first hour bid *i* is valid from
$hourTo_i$: the first hour after hourFrom bid *i* is not valid (i.e. if a bid has hourFrom = 4 and hourTo = 6, the bid is valid in hour 4 and 5)
$flow\_cost_{mnt}$: cost of allocating 1MW of the CZC from region *m* to region *n*
CZC_{mnt}: maximum allocation capacity for CZC from region *m* to region *n*
$minReg_{mdt}$: minimum aFRR selected for region *m*, direction *d*, hour *t*
$maxReg_{mdt}$: maximum aFRR selected for region *m*, direction *d*, hour *t*
$minMac_{zdt}$: minimum aFRR selected for set of bidding zones *z*, direction *d*, hour *t*
$maxMac_{zdt}$: maximum aFRR selected for set of bidding zones *z*, direction *d*, hour *t*
$pencost\_dem_{mdt}$: penalty cost per MW for demand for region *m*, direction *d*, hour *t*
$pencost\_minreg_{mdt}$: penalty cost per MW for minimum procurement volume for region *m*, direction *d*, hour *t*
$pencost\_minmac_{zdt}$: penalty cost per MW for minimum procurement for set of bidding zones *z*, direction *d*, hour *t*

Constants:
$iQuant$: a constant that defines the bid step size used. As default set to 5

Objective function:
Minimize total bid costs for all bids *i*, all penalty costs for region *m*, direction *d* and hour *t*, and all CZC reservation costs from region *m* to region *n* for hour *t*.

$$min \sum_i x_i \cdot iQuant \cdot bid_{cost_i} \cdot (hourTo_i - hourFrom_i) + \sum_m \sum_d \sum_t p_{dem_{mdt}} \cdot pencost_{dem_{mdt}} + \sum_m \sum_d \sum_t p_{minreg_{mdt}} \cdot pencost_{minreg_{mdt}} + \sum_z \sum_d \sum_t p_{minmac_{zdt}} \cdot pencost_{minmac_{zdt}} + \sum_m \sum_n \sum_t f\_agg_{mnt} \cdot flow\_cost_{mnt}$$

Constraints:
Demand constraint for region *k*, direction *d*, and hour *t*:

$$\sum_{\substack{i \\ if\ i_{region}=k \\ i_{hour}=t \\ i_{direction}=d}} x_i \cdot iQuant + \sum_m f_{mkdt} - \sum_n f_{kndt} \geq Dem_{kdt} - p\_dem_{kdt}, \qquad \forall k, d, t$$

CZC constraint from region *m* to region *n* in hour *t*:
$f\_agg_{mnt} \leq CZC_{mnt} \qquad \forall\, m, n, t$

CZC constraints for aggregate flow variables from region *m* to region *n* in hour *t*:
$f\_agg_{mnt} \geq f_{m,n,UP,t} \qquad \forall\, m, n, t$
$f\_agg_{mnt} \geq f_{n,m,DOWN,t} \qquad \forall\, m, n, t$

Min and max reservation constraints per region *m*, direction *d* and hour *t*:

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$$\sum_{\substack{i \\ if\ i_{region}=m \\ i_{hour}=t \\ i_{direction}=d}} x_i \cdot iQuant \geq minReg_{mdt} - p\_minreg_{mdt}, \qquad \forall m, d, t$$

$$\sum_{\substack{i \\ if\ i_{region}=m \\ i_{hour}=t \\ i_{direction}=d}} x_i \cdot iQuant \leq maxReg_{mdt}, \qquad \forall m, d, t$$

Min and max reservation constraints per set of regions *z*, direction *d* and hour *t*:

$$\sum_{\substack{i \\ if\ i_{macro}=z \\ i_{hour}=t \\ i_{direction}=d}} x_i \cdot iQuant \geq minMac_{zdt} - p\_minmac_{zdt}, \qquad \forall z, d, t$$

$$\sum_{\substack{i \\ if\ i_{macro}=z \\ i_{hour}=t \\ i_{direction}=d}} x_i \cdot iQuant \leq maxMac_{zdt}, \qquad \forall z, d, t$$

Minimum and maximum bid volume for each bid *i*:

$$x_i \cdot iQuant \geq x_{bin_i} \cdot minvolume_i, \qquad \forall\, i$$

$$x_i \cdot iQuant \leq x_{bin_i} \cdot maxvolume_i, \qquad \forall\, i$$

Bid linking constraints for all bids in linked list *J*:

$$x\_bin_{j1} = x\_bin_{j2}, \qquad \forall\, j\ in\ linked\ list\ J$$

Exclusive group constraints for all bids in exclusive group *k_group*:

$$\sum_{\substack{k \in k\_groups \\ if\ k\ \ in\ k_{gropus} is\ a\ linked\ bid}} x\_bin_k \cdot 0.5 + \sum_{\substack{k \in k\_groups \\ if\ k\ in\ k_{groups} is\ not\ a\ linked\ bid}} x\_bin_k \leq 1 \qquad \forall\, k\_groups\ in\ exclusive\ group\ list\ K$$

Demand constraint to add cuts to the problem for direction *d* and hour *t*:

$$\sum_{\substack{i \\ i_{hour}=t \\ i_{direction}=d}} x_i \cdot iQuant \geq \sum_m Dem_{mdt} - p\_dem_{mdt}, \qquad \forall d, t$$

Comments to the optimisation problem:

- As bids can be indivisible, the bid selection problem is what is called a combinatorial optimisation problem or an Integer Program (MILP). Bids may also be linked across time and with other bids, as well as be included in exclusive groups. The linking and non-divisibility of bids is a critical and fundamental characteristic of the bid selection problem that makes a traditional selection method of sorting the bids by price incapable of guaranteeing the most socioeconomic solution. Given the size of the problem, the algorithm will not always be able to find the optimal solution with the time limit set by the user. To be able to control the solver and get solutions that are close to optimal, the algorithm is designed with a set of control parameters.

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- In MILP problems, a set of inputs can have more than one optimal solution, i.e. two different bid selections and CZC reservations can give the exact same total cost. In these cases, by default the system will return the same solution if the user runs the same problem several times. In order to control this behaviour and to make sure that selecting among two equally good solutions is a random process, the algorithm is designed with a random seed value that controls this.

2.4.4. Settlement of contracted capacity

Accepted aFFR bids will be settled at the clearing price prevailing in the relevant bidding zone, for the relevant aFRR direction and MTU. The rules used to determine the clearing price are set out in Paragraphs 2 and 3 of Article 9 of the Proposal. Essentially, these rules amount to the following.

- The clearing price equals the greater of:
  - The highest accepted bid in zone, and
  - Where capacity is imported, the highest combined clearing price of any zone from which capacity is imported including the implied cost of the CZC reserved to enable the transfer (calculated as the previous day-ahead price spread)
- Notwithstanding the above, where, for a given cross-zonal border, the estimated day-ahead price spread is zero AND the absolute limit on the volume of aFRR capacity that can be transferred is not binding, the connected zones across the relevant border must have the same price. In these cases, the zone with the highest price, as determined by the rules above, sets the price in all the relevant zones.

Some examples of how these rules function are shown in the figures below, with each coloured rectangle representing a bidding zone and containing information on the demand and locally accepted bids in that zone. The orange arrows show the export of aFRR from one zone to another. The clearing price in each zone is shown to the right of the zone.

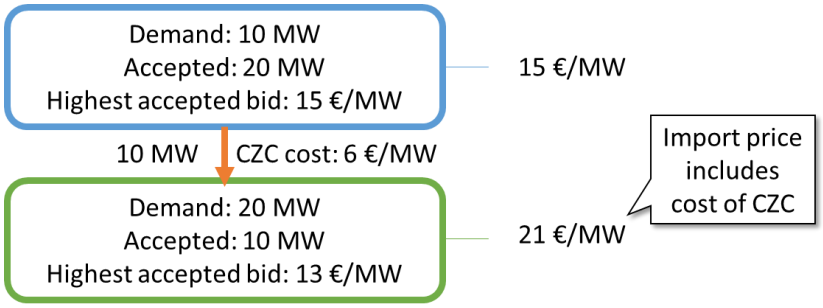

Figure 7. Example of the clearing price being set by the cost of imports

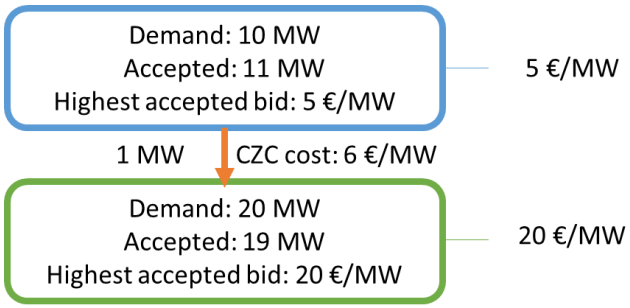

Figure 8. Example of the clearing price being set by the cost of a locally accepted bid

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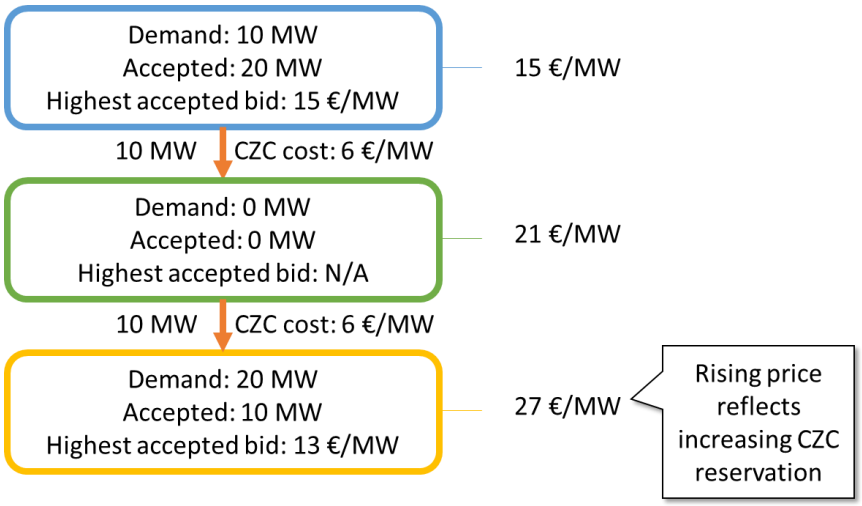

Figure 9. Example of the clearing price in a zone with no local demand or accepted bids

The chosen pricing rule is designed to provide a clear and efficient price (and investment) signal to potential BSP providers. Specifically, if the clearing price were lower than the highest locally accepted bid, it would not signal to a potential investor with a lower supply cost, the potential ability to efficiently displace the high cost bid. Similarly, if the clearing price were lower that the cost of imported capacity including the cost of CZC, it would not signal the potential ability to free up valuable CZC by investing locally. Such investment would reduce the need to procure both aFRR in the neighbouring zone and to reserve CZC for the exchange of aFRR and, as such, the value of both is reflected in the price.
The rule covering the need to have the same price across uncongested bidding zones is intended to ensure that, where there is a group of uncongested bidding zones, the price in each zone reflects the potential value of investment in additional aFRR in each zone as a means of meeting the demand of the other zones in the group. Without this rule, one might get price splitting within the uncongested group of bidding zone due to local variations in accepted bid prices that doesn't really reflect the potential value of new investment in the group of uncongested bidding zones.

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 will settled using the regulation power price.

The Nordic TSOs plan to introduce an energy activation market for aFRR at a later stage. This is described in section 3.

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 capacity bids. These data will be published as soon as the market results of the tender are completed and at the same time as BSPs are notified about the acceptance of their aFRR capacity bids. If justified by market abuse concerns, we may seek to aggregate the data, subject to approval pursuant to Article 18 of the EB Regulation.
- The CZC allocated for the exchange of aFRR capacity. This will be published after the market clearing results are available.

- The use of allocated CZC for the exchange of aFRR capacity, including the 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 activation market, the efficiency of realised energy activation will not be estimated. The estimated costs and benefits will be published as values per day for the entire market region within one week after the delivery day.

2.7. Allocation of cross-zonal capacity

Pursuant to Article 33(4)(b) of the EB GL, the Nordic TSOs exchanging balancing capacity shall ensure both the availability of CZC and that the operational requirements established in European regulation are met through the use of the market-based allocation process for CZC described in the TSOs' proposal pursuant to Article 41 of the EB GL.

2.8. TSO-TSO settlement

As described in Article 13 of the Proposal, TSOs shall pay for the volume of aFRR capacity required by their bidding zones.

As this volume requirement can be met by aFRR procured in other bidding zones, including zones with the control area of a different TSO, there is a need to settle transfers of aFRR capacity. Where capacity is traded across a bidding zone border the separates two TSO control areas, the TSO importing aFRR capacity will pay the TSO exporting aFRR capacity an amount equal to the volume of aFRR capacity transferred multiplied by the average clearing price for the relevant aFRR capacity product in the two bidding zones.

As clearing prices account for CZC reservations costs, this arrangement entails that the importing TSO pays the implied congestion rent and this rent is split 50/50 between the TSOs on the relevant border.

An example showing how settlement apportions cash flows between various parties is shown in Figure 10 below.

The allocation of volume requirements will be as described in section 2.3.2 above.

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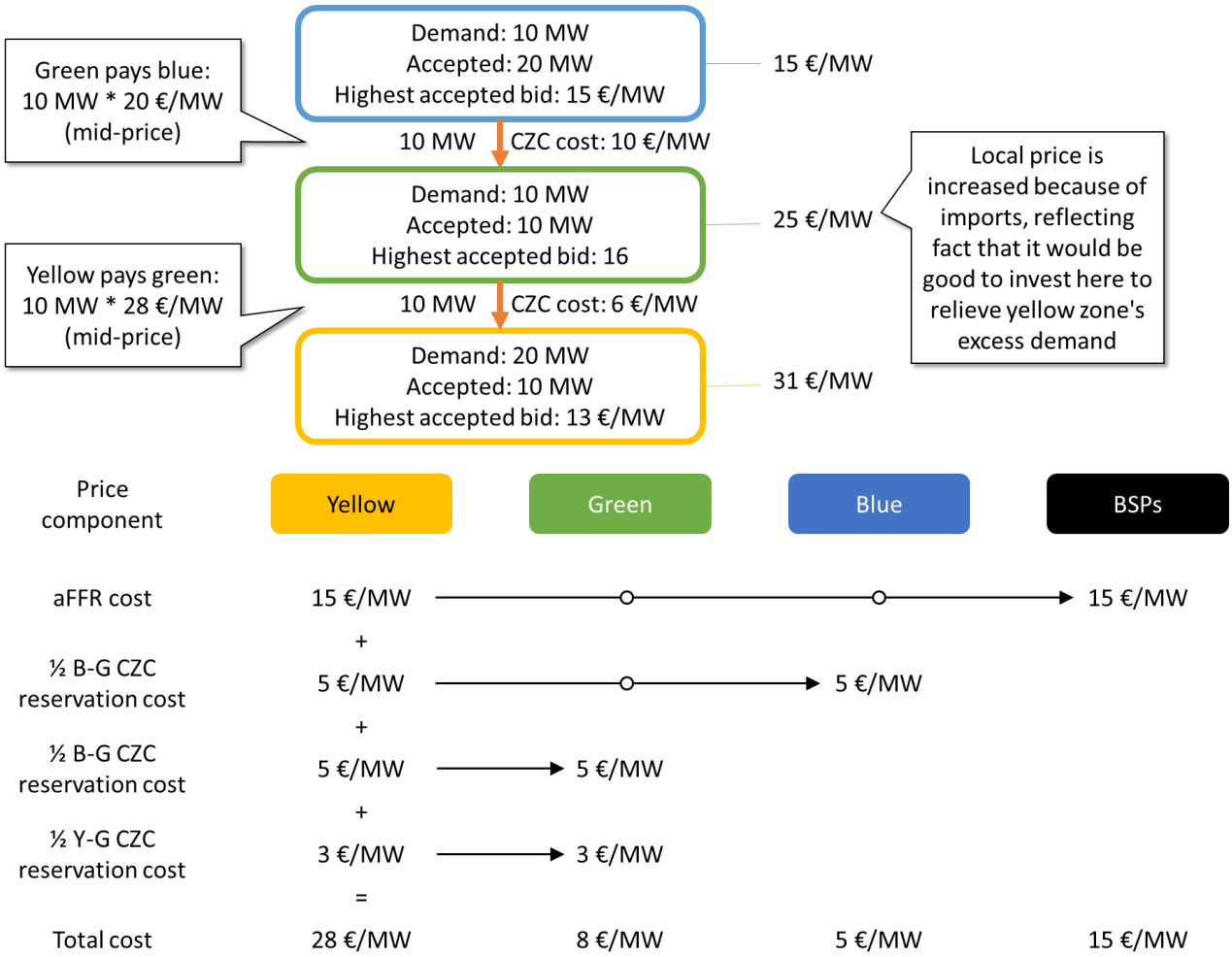

Figure 10. Example of cash flows implied by TSO settlement arrangements

3. Outlook

As a part of the Nordic balancing model, the Nordic TSOs aim to introduce an aFRR energy activation market after balancing in Nordic LFC Block is based on Area Control Errors (ACE-based balancing). BSPs whose balancing resources are procured by the Nordic TSOs 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. The activation of bids will then be according to a Common Merit Order List across the Nordic market region.

Prior to the introduction of a Nordic aFRR energy activation market, only procured aFRR capacity can be activated. Activation will be done pro rata and activated aFRR energy will be settled using the balancing energy price on Nordic regulating power market.

The Nordic TSOs expect that future challenges in system operation will require more automated balancing. The Nordic TSOs therefore plan to increase the number of aFRR contracting hours from a starting level of 35 hours per week to cover all hours of the week. The aFRR volume will gradually be increased from a starting level of 300 MW to a tentative target volume of 600MW. When the dimensioning rules for FRR are developed and implemented, the volumes to be procured will follow the dimensioning rules.

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As part of the market's development, the Nordic TSOs intend to further harmonise the prequalification rules and in particular the length of FAT across the region. The FAT 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 are employed. The expected increase in the number of hours covered and in the volume of aFRR procured will enable a re-evaluation of the activation process as a whole, alongside a consideration of the right FAT. A FAT of five minutes will most probably be used in the Energy standard product across Europe and therefore is expected to form the basis of the harmonised Nordic FAT

The MTU for the capacity market will be the same as that for the day-ahead market and this implies that when the Nordic day-ahead market shift to a shorter MTU, this change will also be applied in the aFRR capacity market.

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Annex 1. Answers to stakeholder consultation

Subject matter and scope, definitions and interpretations and general remarks to the overall method

SFE Produksjon:
We are very positive to the Nordic TSOs initiative to establish a common Nordic aFRR capacity market with allocation of CZC where this gives an increased socio-economic welfare. We find the proposal good enough for a start-up phase […]

Swedenergy:
Swedenergy strongly supports the further integration of the balancing markets in the Nordics and the EU. However, a prerequisite for a fair competition are common and harmonized rules and processes which is not the case in the proposal.

Finnish Energy:
Finnish Energy supports the establishment of a regional balancing capacity market for aFRR. The market should be based common and harmonized rules and process for the exchange and procurement of aFRR balancing capacity as laid out in this proposal. In general, we find the proposal balanced, though consider the proposal of using pay-as-bid pricing unacceptable and the reasoning for applying it scandalous. This and other remarks are explained more in detail below.

Danish Energy:
Danish Energy supports the establishment of a regional balancing capacity market for aFRR. The market should be based common and harmonized rules and process for the exchange and procurement of aFRR balancing capacity as laid out in this proposal.

Energy Norway:
This proposal from the Nordic TSOs on common and harmonized rules and processes for the exchange and procurement of aFRR balancing capacity is a part of the new Nordic Balancing Concept (NBC). Although many elements of NBC are still unknown, Energy Norway supports the objective of the NBC – maintaining a high frequency quality through a more effective balancing market design.

Agder Energi:
Agder Energi is pleased to welcome the establishment of a common Nordic market for aFRR. We have been actively involved in both planning and development of the Norwegian aFRR market since 2009 and have also prequalified several of our power plants. We are now looking forward to participating in a bigger Nordic market.
We agree with the TSOs that an aFRR market contributes to a safer, a more cost-effective and reliable operation of the power system, and therefore look forward to a development with increased use of aFRR in the Nordic synchronous area. With the increasing complexity of the operation of the power system we think it is important to include automatic solutions, both for the system operators as well as for the market actors and considers the aFRR market as a key instrument for maintaining good quality in the Nordic region in the future.
[…]Although the conditions for the market players are not completely equal in the beginning, we think the proposal is a good starting point.

TSOs:
We appreciate the positive reception of the proposal to launch a common Nordic aFRR capacity market since we as TSOs se this Nordic market as one of the building blocks to maintain a safe and reliable operation of the Nordic power system and also a way to increase efficiency and an increase in socio economic welfare. We also do acknowledge that some of the stakeholders are questioning the lack of harmonisation of rules and processes. As noted in section 2.2.1, we intend to harmonise elements of the pre-qualification process and requirements, although this the market may go live before this harmonisation process has been completed.

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Prequalification of aFRR capacity

SFE Produksjon:
[…]but some improvements should be implemented as early as possible [i.e.:] The prequalification process should be described clearer and be harmonized among the Nordic countries.

Swedenergy:
It is important that the prequalification process is clearly described, and that this information is made available to market participants. The prequalification process should be harmonized between countries in the Nordic synchronous area as prerequisite for a non-distorted market is that all participants face the same conditions.

Energy Norway:
It is important that the prequalification process is clearly described, and that this information is made available to market participants. The prequalification process should be harmonized between countries in the Nordic synchronous area.

TSOs:
Prequalification requirements are clearly described in detail for each involved TSO, and are available on their respective homepages. There are reasons for maintaining national prequalification requirements other than FATs, such as the setup of measuring equipment. Of course, rules in this respect could be completely harmonised, but compared to the effort it would demand of BSPs, the gain in terms of equal access to the market would be very limited.

High level design of the aFRR capacity market

Finnish Energy:
It is proposed that GCT shall be 20:00 CET two days prior to the day bids are valid. This leads to the question of capacity reservations. We call for consideration, could the aFRR capacity market be arranged simultaneously with day-ahead market? Hence let the market decide whether to reserve capacity for aFRR or to allocate it for day-ahead trades?
Furthermore, a GCT at D-2 at 20.00 CET does not align with the current FCR-N D-2 market GCT at D-2 15.00 CET with a notification of the clearing result at 16.00. When bidding flexibility into the aFRR market it is important to know the result from the FCR-N D-2 market, hence the bidding would need to be performed between 16.00 – 20.00 which is not optimal since it is out of normal operating hours. An alternative solution would be to place the aFRR GCT at ~8.30 D-1 or at 12:00 which is also the GCT for day-ahead markets.

Swedenergy:
It is proposed that GCT shall be 20:00 CET two days prior to the day bids are valid. This leads to the question of capacity reservations. TSOs should consider the aFRR capacity market could be arranged simultaneously with the day-ahead market. In this way, the market decides whether to reserve capacity for aFRR or to allocate it for day-ahead trades.
The bidding periods and GCT between different balancing markets should be harmonized in order not to lead to unnecessary complexity for the bidders. Further, GCT should preferably be within normal operation hours.
For instance, GCT at D-2 at 20.00 CET does not align with the current FCR-N D-2 market GCT at D-2 15.00 CET with a notification of the clearing result at 16.00. When bidding flexibility into the aFRR market it is important to know the result from the FCR-N D-2 market, hence the bidding must be performed between 16.00 – 20.00 which is not optimal since it is out of normal operating hours. An alternative solution could be to place the aFRR GCT at ~8.30 D-1.

Danish Energy:
It is proposed that GCT shall be 20:00 CET two days prior to the day bids are valid. This leads to the question of capacity reservations. TSOs should consider the aFRR capacity market could be arranged simultaneously with day-ahead market. In this way, the market decides whether to reserve capacity for aFRR or to allocate it for day-ahead trades.
Furthermore, a GCT at D-2 at 20.00 CET does not align with the current FCR-N D-2 market GCT at D-2 15.00 CET with a notification of the clearing result at 16.00. When bidding flexibility into the aFRR market it is important to know the result from the FCR-N D-2 market, hence the bidding must be performed between 16.00 – 20.00 which is not optimal since it is out of normal operating hours. An alternative solution would be to place the aFRR GCT at ~8.30 D-1.

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Energy Norway:
The bidding periods and GCT between different balancing markets should be harmonized in order not to lead to unnecessary complexity for the bidders. Further, GCT should preferably be within normal operation hours.
For instance, GCT at D-2 at 20.00 CET does not align with the current FCR-N D-2 market GCT at D-2 15.00 CET with a notification of the clearing result at 16.00. When bidding flexibility into the aFRR market it can be important to know the result from the FCR-N D-2 market. In this case, the bidding must be performed between 16.00 – 20.00 which is not optimal since it is out of normal operating hours. An alternative solution could be to suggest the aFRR GCT at ~8.30 D-1.

TSOs:
The simultaneous allocation of CZC for the day-ahead and balancing markets is described as the co-optimisation method for allocating CZC in EB GL. As described in the Explanatory Document, this is a complex and demanding methodology and would require development of the Day-ahead algorithm Euphemia and this is not currently feasible.

The gate closure time of the market has been moved closer to real-time (D-1) than in the initial proposal. However, the TSOs must still allow sufficient time after gate closure to ensure that the market optimisation can run and that it is enough time between the market optimisation and NTC calculations to allow for failure and backup routines.

Nord Pool:
Article 4(1): While some justification for the likely exclusion of Bidding Zone (BZ) DK1 is provided in section 2.3 of the explanatory document, it is at the outset from a market and pricing efficiency perspective hard to see why that exclusion should apply since it reduces the chance for procurement/activation of the most relevant production and consumption assets in the Nordic aFRR balancing arrangement. Furthermore, the time gap between implementation of these aFRR arrangements in the Nordic region and implementation of Nordic ACE-based balancing is assumingly rather short and that is another argument why the initial exclusion of DK1 can be put to question.

TSOs:
First of all, DK1 is covered by long-term contracts until early 2020. Secondly, the aFRR-demand in DK1 differs significantly from what will be supplied in the initial phase of the Nordic aFRR capacity market. DK1 needs a 15 minutes FAT product 24 hours a day. The Nordic market supply a 2 or 5 minutes FAT product 5 hours a day.
The inclusion of DK1 is linked to the introduction of ACE-based balancing in the Nordic synchronous area. There is a number of issues to address before including DK1. Energinet will need dedicated communication lines to all other TSO's SCADA systems to enable activation specifically for DK1, and special reservation arrangements must be in place for the HVDC connection between DK1 and the Nordic synchronous area.

Nord Pool:
Article 4(2): While we in general agree to the notion that the aFRR capacity market shall apply the same market time unit resolution as the day-ahead market, we note in related proposals and explanatory documents from Nordic TSOs that the Imbalance Settlement Period, including the Balancing Arrangements and Intraday trading, is to be shifted to 15-minute (MTU) in 2020/2021, but at the same time the Nordic TSOs have stated that the (Nordic) day-ahead market MTU resolution, including Cross Zonal capacity allocation, until further notice shall keep hourly MTU. Due to that fact we recommend that some clarification on this matter is made in the proposal and background material.

TSOs:
During an interim period, the day-ahead and intraday markets will have different MTUs and we see it as more appropriate to relate the aFRR capacity market to the MTU of the day-ahead market since the procurement of aFRR capacity is done before the day-ahead market and thus is of more importance for market participant than the ID- and balancing market.

Nord Pool:
Article 4(3) [9]: In supportive documents, and as stated by TSOs in a webinar on 20th of SEP, it has been clarified that the predefined total Nordic volume of aFRR/hour (MTU) will initially be 300 MW and some year(s) later it may be increased up to 600 MW. However, it is not stated explicitly in the proposal, and accordingly we find that it should be considered for inclusion in the proposal and/or in the related explanatory document.

TSOs:
The market size is related to the FRR dimensioning process and is therefore out of scope for this Proposal. Both the initial market size and an outlook for the market size is stated in the Explanatory Document.

Nord Pool:
Article 4(5): It is positive that change to predefined volumes will be announced to the market participants, because such changes impact the availability in competitive open markets, e.g. SDAC and SIDC, thus such reporting is likely part of the obligations under EC Transparency Regulation. However, it is not clear in the proposal if such a change could be of a temporary nature, or rather refer to what is referenced by us in the comment to Article 4.3 above. Therefore, we recommend that such a clarification is included in the proposal and explanatory document, and if the application may be of temporary nature then it should also be detailed which circumstances could justify such a temporary (from day to day) change in the procurable aFRR volume.
In addition, for the sake of clarity, the term "market participants" should be clarified to mean "the market in general", thus not only the market participants whom are active in the aFRR market since that leads to them being given inside information of price sensitive nature that is not known to the rest of the market.

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TSOs:
Thank you for your comments. We have changed the proposal in order to clarify on this matter. As mentioned previously, the market sizing is related to the FRR dimensioning process, and the procurement rules that must be followed are detailed in Article 32 of EB GL.

Nord Pool:
Article 4(8): Since the procurement of aFRR has an impact on the availability in, and the price formation of, competitive open markets, e.g. SDAC and SIDC, then a notification of the results without undue delay is not sufficient if provided merely to the bidders, but at the same time (or before) the overall results should be published to the market at large for identical reasons as referred to in the response to Article 4.5 above.

TSOs:
We understand your comment and we have clarified or proposal on when to publish market result information. We will publish results at the same time as bidders are notified, without undue delay, once procurement results are known. We aim to provide this information at the same time but there may be cause for an unintentional delay. It should nonetheless be noted that Article 12(f) of EB GL allows for up to one hour between notification of procurement results to the bidders and publishing these results to the market.

Product and bid characteristics

Danish Energy:
Under Item 1, the full activation time, the minimum and maximum bid quantity and finally the bid granularity is not quantified at their values of 5 minutes, 5 MW, “50 “ MW 5 MW respectively.

Nuvve:
While we understand the need for a higher threshold capacity (5 MW) than is common for primary markets, we feel that the requirement for incremental bids of 5 MW decrease the chances that incrementally going distributed resource aggregations would be likely to enter this market.

Hydro Energi:
On bid granularity: A bid granularity of 5 MW would have a negative effect on the offered volumes compared to a smaller bid granularity. This effect would be greater for smaller market parties/smaller power units. We urge the TSOs to reconsider if the bid granularity can be made smaller, perhaps for only some bid types in order to restrict an increase in complexity of the bid acceptance process (assuming this is the reason for the 5 MW granularity). We also urge the TSOs to conduct periodic reviews of the granularity.

Swedenergy:
The justification of values such as 5 MW and 50 MW could also be further explained.

TSOs:
Nordic TSO has reconsidered the bid size and has changed the minimum bid size to 1 MW. Bids less than 50 MW can be marked as indivisible and the reason for not allowing bids larger than 50 MW to be indivisible is due to the risk of market power, operational security and security of supply reasons. If too much aFRR volume is enclosed in one or a few bids the operational security is set at risk. For the Nordic TSOs due to the risk of congestions in the grid it is important that the procured volume is distributed among all areas in the Nordic countries. Also the diversification of risks such as failing of communication and tripping of generators are better if procurement is done with more and smaller bids rather than fewer and larger bids.

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SFE Produksjon:
[…]but some improvements should be implemented as early as possible [i.e.:] A harmonization of Full Activation Time (FAT).

Finnish Energy:
A prerequisite for a non-distorted market is that all participants face the same conditions. However, the proposal suggests different requirements for pre-qualifications in the different countries, e.g. regarding the aFRR full activation time (FAT). This should be motivated otherwise the implicit understanding is that "it is simpler to us (the TSOs) to keep it so". The potential future shortening of the FAT is also discussed. We discourage unreasonably short FAT values. Longer FAT values allow for greatest number of bids in the market, best possible competition, and lower prices for aFRR. A Nordic harmonization of FAT should not pre-empt the European harmonization currently foreseen in 2025.

Swedenergy:
A prerequisite for a non-distorted market is that all participants face the same conditions. However, the proposal does not comply to this. The proposal for different requirements on Full Activation Time (FAT) between control areas, is not acceptable and not in line with the EU process of harmonization. The proposal or FAT should be changes to 5 min for all areas from day 1.

Vattenfall:
Furthermore, the proposal does not propose equal conditions for all market participants. The proposal for different requirements on Full Activation Time (FAT) between control areas, is not acceptable and not in line with the EU process of harmonization. The proposal or FAT should be changes to 5 min for all areas.

Agder Energi:
Even if it is already described in the proposal we want to repeat that the final solution for the aFRR market must include a harmonization of the prequalification process and the Full Activation Time (FAT) and the use of marginal pricing.

Danish Energy:
A prerequisite for a non-distorted market is that all participants face the same conditions. However, the proposal suggests different requirements for pre-qualifications in the different countries, e.g. regarding the aFRR full activation time (FAT). This should be motivated otherwise the implicit understanding is that "it is simpler to us (the TSOs) to keep it so". The potential future shortening of the FAT is also discussed. Dansk Energi discourage unreasonably short FAT values. Longer FAT values allow for greatest number of bids in the market, best possible competition, and lower prices for aFRR. A Nordic harmonization of FAT should not pre-empt the European harmonization currently foreseen in 2025.

Energy Norway:
A prerequisite for a non-distorted market is that all participants face the same conditions. However, the proposal suggests different requirements for pre-qualifications in the different countries, e.g. regarding the aFRR full activation time (FAT). The FAT should be harmonized within LFC-block as early as possible, preferably from day 1. The justification of values such as 5 MW and 50 MW could be further explained.

TSOs:
We understand your comments and concerns. Our long-term aim is indeed to harmonise FAT. Our intention for the initial phase of the market, however, is to keep our current suggestion of FAT. We will perform an analysis of the impact that the differences of FAT has on the Nordic synchronous system and also how large volume the system need depending on the choice of FAT. To link the Nordic work with the European harmonization, a FAT up to 7.5 min will be allowed until 2025, thereafter FAT shall be 5 min for all resources participating on the European energy platform for aFRR.

SFE Produksjon:
We find the possibilities of linking to be sufficient to cover our requirements.

Swedenergy:
The linking of bids seems sufficient.

Agder Energi:
We find the bid formats and the possibility to link bids to be sufficient, and also the length and the timing of the proposed bidding period.

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Danish Energy:
The suggested linking facilities seems to be appropriate for bidding in aFRR capacity effectively.

Energy norway:
The linking of bids seens sufficient.

TSO:
[…no answer required…]

aFRR capacity bid submission

TSO:
There have been no comments to this article.

Settlement of product aFRR capacity

SFE Produksjon:
[…]but some improvements should be implemented as early as possible [i.e.:] Pay as cleared/marginal pricing should be considered implemented from day 1.

Swedenergy:
We strongly oppose the proposal that BSP settlement of procured balancing capacity would be based on pay-as-bid for the first two years. We do not see a technical challenge in moving directly towards marginal pricing for the aFRR capacity, as is in any case the future method foreseen by TSOs.
We are disappointed that TSOs still approach balancing from a national perspective and focus on individual needs rather than Nordic balancing needs as a whole. Even though the needed amount is determined per area, the pricing must be regional and later European. Swedenergy is concerned that individual TSOs' may reserve the cheapest resources for themselves and allocate only to rest for Nordic good and uses this as reasoning for applying pay as bid pricing. The proposed pay as bid regime should be replaced or complemented with a firm deadline for when full marginal pricing should be implemented.

Finnish Energy:
We shocked by the proposal that BSP settlement of procured balancing capacity would be based on pay-as-bid for the first two years, with rationale that it enables individual TSOs to use cheapest resources located within their control area by themselves and only enable others to purchase more expensive resources. This is not in line with having a common market. No, the pricing must be marginal pricing and when possible, subject to transmission capacities, the price same for the whole Nordic region. We do not see a technical challenge in moving directly towards marginal pricing for the aFRR capacity, as is in any case the future method foreseen by TSOs.

Danish Energy:
We strongly oppose the proposal that BSP settlement of procured balancing capacity would be based on pay-as-bid for the first two years. We do not see a technical challenge in moving directly towards marginal pricing for the aFRR capacity, as is in any case the future method fore-seen by TSOs.
Dansk Energi is concerned that, as a result of the pay-as-bid scheme, individual TSOs are incentivized to keep the cheapest resources for themselves and allocate only to rest for the Nordic market. We urge TSOs to elaborate on the different pricing options and justify the choice of pay-as-bid.

Energy Norway:
We strongly oppose the proposal that BSP settlement of procured balancing capacity would be based on pay-as-bid for the first two years. We do not see a technical challenge in moving directly towards marginal pricing for the aFRR capacity, as is in any case the future method foreseen by TSOs. Marginal pricing must be implemented as soon as possible, preferably from day 1.

Vattenfall:
Vattenfall regrets that the proposal is not ambitious enough what regards the timeline for the step towards full marginal pricing. The proposed pay as bid regime should be replaced, or complemented with a firm deadline for when full marginal pricing should be implemented.

Lyse Produksjon:
We are generally positive to the Nordic TSOs' proposal for a common Nordic aFFR capacity marked. However, we believe that the Nordic TSOs should strive to implement marginal pricing (pay-as-cleared) as soon as possible. With pay-as-bid the BSP is incentivized to bid as close to the price level as possible to avoid "losing" to much money compared to other BSPs. This will complicate the bidding process and could also result in an inefficient market.

Hydro Energi:
On pay-as-bid VS marginal pricing: We urge the TSOs to introduce marginal pricing as soon as possible, as pay-as-bid makes the bidding process unnecessarily complex and introduces a strategy element to this process that may obscure the true marginal prices of the market parties. The latter effekt would cast doubt on whether the bid acceptance process can truly provide the optimal socio-economic distribution of aFRR capacity in the

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Nordics and lead to a suboptimal use of CZC for exchange of aFRR capacity (as the process would compare the bids of an pay-as-bid market against the results of a marginal pricing market).

Nord Pool:
The proposal to base availability payments of individual orders on pay-as-bid and not marginal pricing is in our view problematic. To begin with it introduces a different principle then that applied for active up/down regulation since over 20 years in the Nordic region. Furthermore, it will likely distort the evaluation of projected value of cross zonal capacity in the day-ahead market versus in aFRR, because marginal pricing is used in day-ahead market and accordingly market participants take that in consideration in their orders, and likewise they would if pay-as-bid principle is applied in aFRR take that in to consideration for that process. Put more concretely, the pricing of a given set of orders (e.g. single units) would be higher in a pay-as-bid regime than in a marginal-price regime and therefore when making projections of the "welfare" value of cross zonal capacity for usage in aFRR versus in day-ahead it would appear like the value would be higher in aFRR while it might only be due to the different pricing models applied.

TSOs:
We have altered the proposal to incorporate pay-as-clear pricing from the outset.

Methododlogy for allocating cross-zonal capacity for aFRR capacity market, The procurment volume of aFRR capacity, aFRR capacity procrument optimisation and bid selection

TSOs:
There have been no comments to these three articles, except that the Nord Pool comment to Article 4(3) partly refers to Article 9.

TSO-TSO settlement in the aFRR capacity market

Nord Pool:
While some explanations are given for the concept of "…average of marginal bid values in importing and exporting areas…" in section 2.8.2 of the explanatory document it is in our current understanding neither (1) explicitly explained what effect that would have on imbalance settlement prices per Bidding Zone, nor (2) given any solid justification of why an "averaging pricing principle" shall be applied. We think that "averaging" as a principle for price formation is prone to suboptimal economic results, and furthermore we find it is an important principle that "exporting of extremes" should not become part of the (imbalance) settlement price of Bidding Zones where such "extremes" were not observed, which we are concerned with that the described "averaging principle" can lead to. Due to these concerns, we find it important that more clarity is given in the proposal and in the explanatory document regarding the proposed "averaging pricing principle", and in the event it becomes clear that our concerns are valid then we recommend that an alternative model is applied based on alignment on this matter with market stakeholders.

TSOs:
A pricing mechanism has been completely revised and a new description is now included in both the legal proposal and the updated explanatory document.

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Publication of information, Final provision, Publication and implementation of the Proposal, Language and other issues

Swedenergy:
13(1) A general comment is that we would like to point out that the planned go live date in the middle of the summer is unfortunate from an operational perspective, and we recommend the TSOs to change the timeline accordingly.

Vattenfall:
Finally we would like to point out that the planned go live date in the middle of the summer is unfortunate from an operational perspective and we recommend the TSOs to change the timeline accordingly.

TSOs:
Thank you for these comments, we understand your concerns and have changed the go-live date to after summer.

Hydro Energi:
On publishing of anonymized bids: In bidding areas with few market parties and/or one dominant party it may be possible (with high probability) to identify the market party responsible for each of the bids. This would be especially true for the dominant market party. We urge the TSOs to consider this effect when deciding what information to make public.

TSOs:
Publication of the anonymized bids is required in article 12(3) of EB GL. However, if justified by market abuse concerns, we may seek to aggregate the data, subject to approval pursuant to Article 18 of the EB Regulation.

Nord Pool:
Article 12(3): While it is positive that the estimated reduction in procurement costs for aFRR based on allocation of CZC versus no such (up-front) allocation will be regularly published within a week of the given delivery day it is still not clear what such estimates would be based on. More clarity on that would be beneficial in the proposal and especially in the explanatory document, not least to be able to assess the relevance of the aspects considered in such an estimate.

TSOs:
Estimation is based on the knowledge TSOs will have on the offered bids. The result is relevant when assessing how well the CZC allocation method works.

Swedenergy:
In the longer term, it is important that the proposal facilitates an easy move from a Nordic aFRR balancing capacity market to a full aFRR balancing energy activation market that is ultimately integrated into the European PICASSO platform. While the latter are not within the scope of the current proposal, we urge TSOs to ensure compatibility between the Nordic and European platforms.

Agder Energi:
We look forward to the further development of the aFRR energy activation market into a true common European marked (PICASSO) and hope that the Nordic experience can be useful.

Danish Energy:
In the longer term, it is important that the proposal facilitates an easy move from a Nordic aFRR balancing capacity market to a full aFRR balancing energy activation market that is ultimately integrated into the European PICASSO platform. While the latter are not within the scope of the current proposal, we urge TSOs to ensure compatibility between the Nordic and European platforms.

Energy Norway:
One positive aspect of the NBC is that it provides experience before the integration of European balancing markets. To gain benefits from this it is important that the proposal facilitates a seamless transition from, in this case, a Nordic aFRR balancing capacity market to a full aFRR balancing energy market that is ultimately integrated into the European PICASSO platform. While the latter is not within the scope of the current proposal, we urge TSOs to ensure compatibility between the Nordic and European platforms.

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Finnish Energy:
In the longer term, it is important that the proposal facilitates an easy move from a Nordic aFRR balancing capacity market to a full aFRR balancing energy activation market that is ultimately integrated into the European PICASSO platform. While the latter are not within the scope of the current proposal, we urge TSOs to ensure compatibility between the Nordic and European platforms.

TSOs:
We are indeed aware of PICASSO and keep the focus from the future integration opportunities. That being said, it is also necessary to remember that PICASSO is still under development and practical implementations for such features cannot be guaranteed.

Einar Fjellman:
FRR balancing must not be a matter only for experts. Whenever FRR balancing capacity is required, it is a consequence of an inadequate transmission network or/and inadequate electricity production resources. The cost of maintaining balance may be substantial and will eventually fall upon the subscriber. It is therefore important that the agreement contains a description of the factors that make necessary balancing operations and the nature of balancing. Such a description, easy to understand both by ordinary people, media and politicians, will encourage development towards a more secure and reliable electricity system.

TSOs:
We agree that it is important to communicate as simply and as clearly as possible. We also agree that non-experts should be able to understand the markets and that it is an advantage also to experts and TSOs if there is a good understanding outside of expert-circles.
We believe that the Explanatory Document is relatively easy to understand, and we are always willing to help if media and politicians search understanding of the market.

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Annex 2. Bid Types

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

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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Annex 3. Nordic TSOs' assessment of EB GL, Article 58.3

In selecting the optimisation function for the procurement of balancing capacity bids and the allocation of CZC, the TSOs have had regard to the requirements of the EB GL, where articles 58(3) and 3 of the EB GL are of particular relevance.

Article 58(3) is reproduced below for reference.

Article 58
Balancing algorithms

3. 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.

The optimisation function constraints explicitly include limits reflecting the availability of CZC and a reservation cost for the provision of CZC is incorporated into the optimisation function. The requirements set forth in A58 (b) above are therefore clearly met.

To implement A 58 (a), the Nordic TSOs needed to " minimise the overall procurement costs of all jointly procured balancing capacity". The Nordic TSOs have opted to use a mathematical interpretation where we take the sum of all accepted bids costs, valued at the relevant bid prices. An alternative interpretation could have been to value the relevant bids using the associated clearing price. Note that here we refer exclusively to the choice as regards the optimisation function for the procurement of balancing capacity bids and the allocation of CZC, not the price actually paid to BSPs.

The TSOs concluded that both approaches could legitimately be argued to comply with A 58(a). In the case of the selected approach, the costs reflect the overall social costs of procurement. Taking into account the objectives of EBGL as set forth in Article 3, the Nordic TSOs believe the selected approach is the most efficient.

Specifically, when assessing the theoretical implications of the two alternative implementations (using either bid costs or clearing prices), the TSOs observed that using clearing prices would lead to less efficient market outcomes (i.e. higher social costs of procurement) and, equivalently, higher total costs for all parties involved for the provision of aFRR. This implication is described in detail in the section below.

Given this, the chosen implementation, in which "overall procurement costs" are assessed using bid prices, was deemed to best comply with the requirements and objectives of the EB GL.

Efficiency implications of the two potential implementations

The optimisation process involves minimising a cost function and the choice of how to define this cost function has important implications for which bids are accepted, as demonstrated by the example below. If we use bid prices to evaluate procurement costs, we are effectively taking the social costs of procurement – these bids reflect the value of the resources used up in the supply of aFRR. Conversely, if we use clearing prices, we are taking the financial costs to the TSOs, since this is what must be paid by the TSOs when procuring aFRR. What the example below demonstrates is that using bid prices minimises social costs and

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therefore maximises efficiency. Using clearing prices, minimises TSOs' procurement costs, but may harm efficiency.

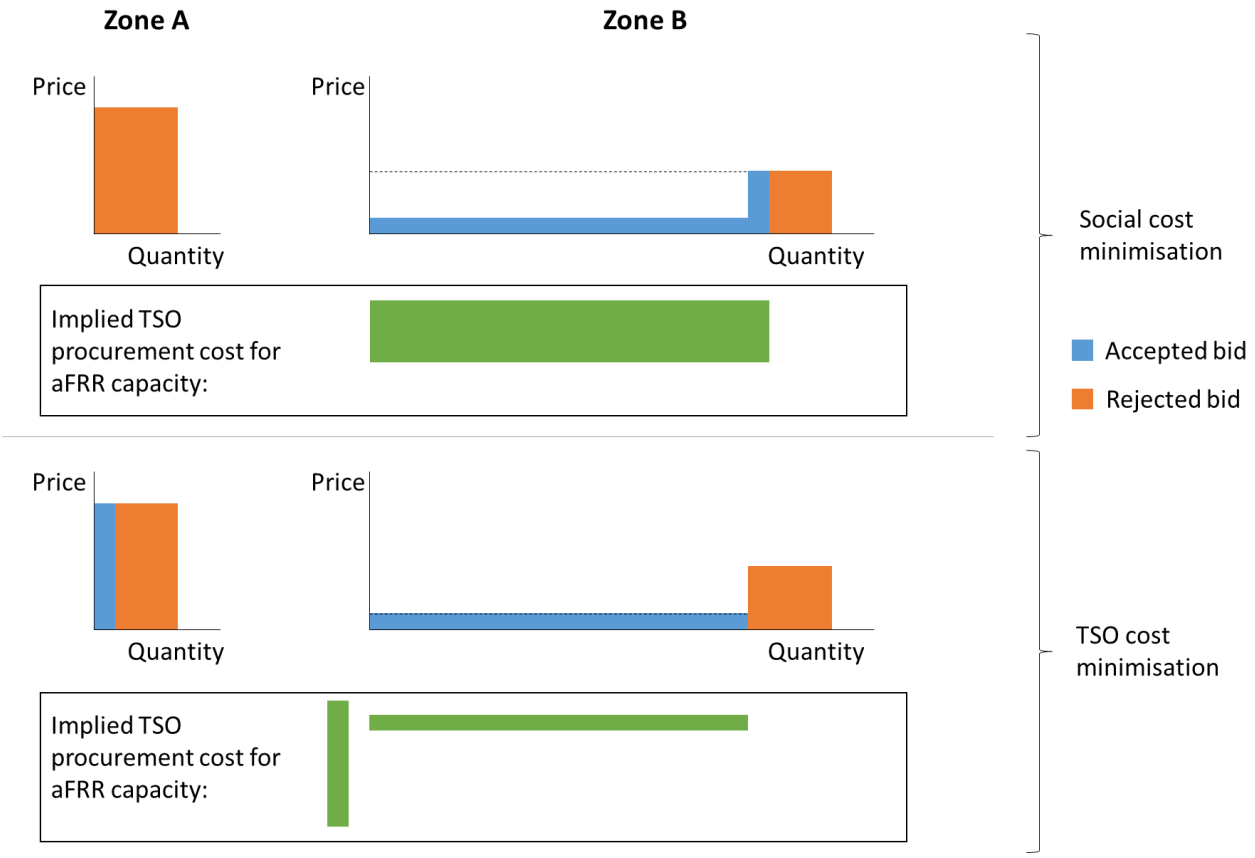

Figure 11. Example of different bid selection approaches

The example above considers the case of two zones and divisible bids. The effective supply curve in the two zones is as shown. Accepted bids are in blue; rejected bids are in orange. The costs of reserving CZC are assumed to be zero to keep things simple but the same outcome can be achieved with a positive CZC reservation price.

The top case shows the solution if we seek to minimise social costs by using bid prices (and maximise efficiency); the bottom case shows the solution if we seek to minimise TSO procurement costs by using clearing prices. The size of TSO costs is shown again in green in both cases so you can see what is going on.

In this example, zone B has cheaper aFRR and it is therefore efficient to procure everything there and reserve some CZC capacity. Procuring everything in zone B means accepting a high clearing price in zone B. In this example, we could reduce TSO costs by procuring less in zone B, and thereby reducing the price paid to a large volume of capacity, and instead procuring a small amount of expensive capacity in zone A.

As can be seen in the example, selecting an interpretation that uses bid prices gives a social efficient outcome. Conversely, selecting an interpretation that uses clearing prices can result in efficiency being sacrificed to lower TSO costs specifically.

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