European Network of
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All TSOs' of CCR Nordic proposal for a methodology for a market-based allocation process of cross-zonal capacity for the exchange of balancing capacity in accordance with Article 41(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

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 the methodology for a market-based allocation process of cross-zonal capacity for the exchange of aFRR balancing capacity in accordance with Article 41(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. This version of the explanatory document does not in any case represent a firm, binding or definitive TSOs' position on the content.

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1. Introduction

This document gives background information and rationale for Energinet, Fingrid, Statnett and Svenska kraftnät proposal for the methodology for a market-based allocation process of cross-zonal capacity (hereinafter referred to as "CZC") for the exchange of balancing capacity; this is in accordance with Article 41(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. 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 be replaced by the European balancing market platform (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 bidding zone). This initial LFC area reserve requirement can be procured in another LFC area provided that there is available CZC that can accommodate the exchange.

The Nordic TSOs therefore propose that the capacity procurement optimisation function for the common aFRR 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 project denoted "Hasle pilot" (see section **Fel! Hittar inte referenskälla.**). The proposal for establishment of common and harmonized rules and processes for the exchange and procurement of aFRR capacity is consulted separately. The two proposals are, however, carried out in parallel and may advantageously be read in conjunction.

Regarding the addition of the mFRR capacity market, the current working assumption is that the same principles shall be used also in this market and that the methodologoy of the Proposal also can be applied for this market.

1.2. Legal basis

Regional balancing 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 capacity; consequently Title IV Chapter 1 of EB GL and, in particular, Articles 38, 39 and 41 are of relevance for market-based allocation of CZC.

According to Article 38(1), if CZC is to be allocated for the purpose of exchanging balancing capacity, one of three alternative processes can be chosen: (a) a co-optimised allocation process, (b) a market-based allocation process, (c) an allocation process based on economic efficiency analysis; each is subject to their own article in EB GL.

The option (b) is chosen and the development of that method is subject to Article 41 of EB GL. The choice of option (b) is further elaborated in section **Fel! Hittar inte referenskälla.**.

In accordance with article 38(5) in EB GL, TSOs may allocate cross-zonal capacity for the exchange of balancing capacity or sharing of reserves only if cross-zonal capacity is calculated in accordance with the capacity calculation methodologies developed pursuant to Regulation (EU) 2015/1222 and (EU) 2016/1719. For the Nordics this will be the flow-based approach. Until the flow-based approach is implemented the capacity calculation will be based on the current net transmission capacity approach (NTC). Annex 3 gives a legal assessment of article 38(5) and the basis for an early application of the allocation methodology pursuant to the Proposal.

1.2.1. NRA Approval and Implementation timeline

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:

(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 the Nordic aFRR capacity market is based on a voluntary agreement between the Nordic TSOs and the separate proposal is consequently not legally bound by a stipulated timeline. This Proposal, however, for the market-based allocation methodology according to Article 41(1) 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 and the proposal shall cover the CCR Nordic.

The timeline described in the Proposal and this document is necessary from a Nordic market implementation perspective rather than being required by EB GL. The go-live date for the Nordic aFRR capacity markets is already been agreed by the Nordic TSOs but a requirement to fullfill the capacity market timeplan is to have an NRA approval of the proposals concerning the aFRR capacity market..

1.2.2. Calculating the market value of CZC

The market-based process for the allocation of CZC for the exchange of balancing capacity requires that the market value of CZC for both the exchange of energy and the exchange of balancing capacity are determined. Article 39 of EB GL details various principles that shall be followed in these processes:

(1) The market value of cross-zonal capacity for the exchange of energy and for the exchange of balancing capacity or sharing of reserves used in a co-optimised or market-based allocation process shall be based on the actual or forecasted market values of cross-zonal capacity.

(5) The forecasted market value of cross-zonal capacity shall be based on one of the following alternative principles:

a) the use of transparent market indicators that disclose the market value of cross-zonal capacity; or

b) the use of a forecasting methodology enabling the accurate and reliable assessment of the market value of cross-zonal capacity

The forecasted market value of cross-zonal capacity for the exchange of energy between bidding zones shall be calculated based on the expected differences in market prices of the day-ahead and, where relevant and possible, intraday markets between bidding zones. When calculating the forecasted market value, additional relevant factors influencing demand and generation patterns in the different bidding zones shall be taken duly into account.

(6) The efficiency of the forecasting methodology pursuant to paragraph 5(b), including a comparison of the forecasted and actual market values of the cross-zonal capacity, may be reviewed by the relevant regulatory authorities. Where the contracting is done not more than two days in advance of the provision of the balancing capacity, the relevant regulatory authorities may, following this review, set a limit other than that specified in Article 41(2).

1.3. Exchange of aFRR capacity

The proposal for common rules and processes for exchange of aFRR capacity is separate from the proposal for the market-based allocation of CZC for the aFRR capacity market. That proposal is contained in the document entitled ”Energinet, Fingrid, Statnett and Svenska kraftnät proposal 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” with an accompanying explanatory document.

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

(2) ‘capacity calculation region’ means the geographic area in which coordinated capacity calculation is applied

(3) ‘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.

(4) ‘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;

(5) ‘firmness’ means a guarantee that cross-zonal capacity rights will remain unchanged and that a compensation is paid if they are nevertheless changed;

(6) ‘force majeure’ means any unforeseeable or unusual event or situation beyond the reasonable control of a TSO, and not due to a fault of the TSO, which cannot be avoided or overcome with reasonable foresight and diligence, which cannot be solved by measures which are from a technical, financial or economic point of view reasonably possible for the TSO, which has actually happened and is

objectively verifiable, and which makes it impossible for the TSO to fulfil, temporarily or permanently, its obligations in accordance with this Regulation;

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

(8) '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

(9) '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

(10) '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;

(11) '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.

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2. Assessment of impacts of allocating CZC for exchange of balancing capacity

This section aims to motivate the choice of allocating CZC for exchange of balancing capacity and more specifically the application of the proposed market based allocation method. In section 2.1 a qualitative assessment of the market-based methodology compared to alternative methodologies is presented. The pilot conducted by Svenska Kraftnät and Statnett in 2014/15 with market based allocation of CZC on the border between South-Norway and South-Sweden, is shortly presented in section 2.2. In section 2.3 a theoretical framework is given for general understanding of the socio-economic benefits of allocating CZC for exchange of balancing capacity in addition to explaining how the proposed methodology relates to the theoretical framework. This serves as a basis for the next three sections, section 2.3, 2.4 and 2.5, which includes an analysis of the performance of the reference day method for forecasting the market value of CZC in the day-ahead market, a simulation study of a Nordic aFRR capacity market with allocation of CZC according to the market-based approach and finally a simulation of how the CZC allocation impacts the day-ahead market.

2.1. Comparison of alternative methodologies

The proposed Nordic aFRR capacity market is based on allocation of cross-zonal capacity in accordance with the Market-based allocation process (EBGL, article 41). This section aim to explore the alternatives that exist within objectives and legal boundary conditions of EB GL. The alternatives to the proposed Market-based allocation process is thoroughly analysed in the Hasle pilot project. This section however use EB GL as a baseline while the Hasle pilot was conducted before the EB GL had entered into force. The Hasle pilot project report shall however be read in conjunction to the below assessment.

2.1.1. Objectives of EB GL

Article 3 in EB GL mention a number of objectives which the regulation aims at. The integration of balancing markets and the promotion of exchange of balancing services is an objective relevant for the choice of methodology for allocation of CZC. This is also underlined by ACER1. The market integration is perceived to bring efficiency and reduce the overall cost for balancing services. ACER monitoring report also highlight that the cost for FRR capacity represents a fairly large part of the total costs as shown in the Figure 1 below.

[1] For instance in the ACER/CEER Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017, section 5.3 Balancing market

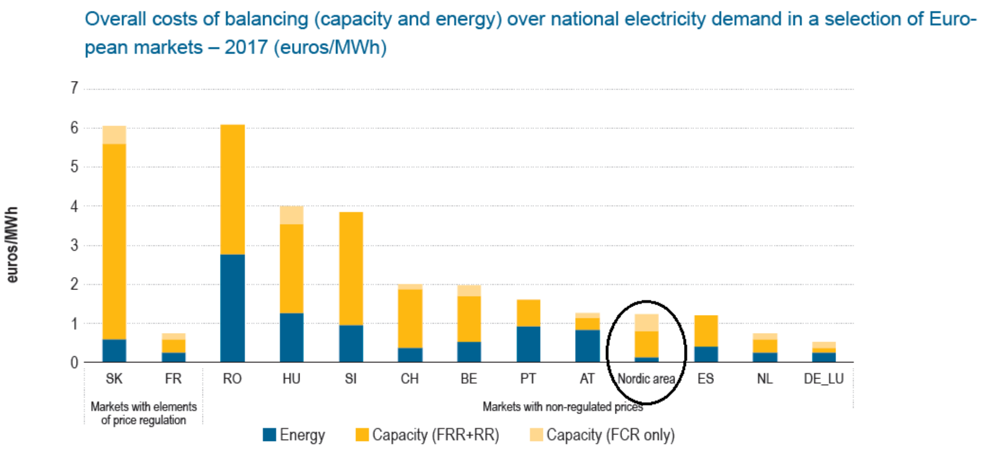

Figure 1: Overall cost for balancing. Source: NRAs and ACER calculations, Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017 (October 2018)

The exchange of balancing services shall contribute to the operational security (EB GL, art. 3(c)). This emphasises the importance of a secure method for allocation of cross-zonal capacity. Resulting real-time energy exchange may otherwise cause violations of voltage and power flow limitations, which in turn will limit the access to reserves for the requesting TSO.

The cross-zonal capacity allocation method shall contribute to long-term development and facilitate consisting functioning of the wholesale and balancing markets (EB GL, art. 3(d)). This accentuates the need to link the markets and allocate scarce transmission capacity for either the exchange of energy or the exchange of reserves across bidding zones.

The Nordic LFC block/synchronous area characteristics in terms of number of bidding zones, structural bottlenecks and distribution of generation in proportion to the demand is quite different compared to the continental Europe and require a rather sophisticated cross-zonal allocation method in order to ensure fairness, objectivity and the prerequisites for market-based balancing capacity procurement (EB GL, art. 3(e)). This implies that the capacity procurement optimisation function needs to optimise the procurement across the areas based on both their specific capacity cost and the cost for transferring this capacity to where it is needed. If efficient valuation of cross-zonal capacity is neglected, the market will generate adverse short- and long term price signals. At the same time, without capacity trade across borders, the market liquidity will be very low in some areas and the possibility for competition will be seriously hampered, which ultimately will add additional costs for the Nordic end consumers.

2.1.2. Alternative methodologies for facilitating CZC for balancing capacity exchange

According to article 33(4) in EB GL, all TSOs the TSOs can either decide to ensure cross-zonal capacity based on a probabilistic approach or in accordance with one of the three alternative methodologies specified in EBGL, article 40 – " Co-optimised", Article 41- "Market based" and article 42 – Economic efficiency.

These methodologies can be separated from each other based on the application of forecasts or expectations.

The probabilistic approach is the only approach where there are no explicit allocation of CZC for exchange of balancing capacity. The exchange of balancing capacity relies on an expectation that sufficient available CZC after energy exchange in day-ahead or intraday time frame is fairly high. This means that TSOs must handle the risk that less CZC is available than expected.

The other three approaches are based on explicit allocation of CZC for exchange of balancing capacity where the value of CZC used for energy exchange in day-ahead and intraday time frame is compared with the value of CZC used for exchange of balancing capacity. The values can either be based on actual values, which require knowledge of the actual bids of the market, or forecasts. The table below summarises the differences between the three methodologies for explicit allocation of CZC for the exchange of balancing capacity.

	The co-optimised approach (EB GL, art 40)	The market-based approach (EB GL, art 41)	The economic efficiency approach (EB GL, art 42)
Value of CZC for energy exchange day-ahead and intraday	Value based on actual bids	Forecasted value	Forecasted value
Value of CZC for balancing capacity exchange	Value based on actual bids	Value based on actual bids	Forecasted value
Descision time for allocation of CZC/ contracting period for balancing capacity	D-1: Part of market coupling algorithm for the day-ahead market	Before sending CZCs to the day-ahead market coupling 10:30 D-1. Maximally one week in advance of provision of balanfing capacity	More than one week in advance of the provision of the balancing capacity

Table 1. Comparison of methodologies for explicit allocation of CZC for balancing capacity

Below follows a more detailed description of the four methodologies:

Co-optimised approach

The co-optimised allocation process refers to a single, unified process for the allocation of cross-zonal capacity between the energy and reserve markets based on actual values. The contracting for the exchange of balancing capacity must be done "not more than one day in advance of the provision of the balancing capacity".45 This implies a change in the market coupling algorithm and functioning in order to allow TSOs to participate and place asks for reserves products while (pre-qualified) market participants may place offers to provide reserves products. The market coupling algorithm would then minimise the cost to procure energy and reserves at the same time and allocate transmission capacity optimally to energy trade and reserves exchange.

The market-based approach

The market-based allocation process refers to the allocation of cross-zonal capacity for the exchange of balancing capacity based on the actual value of reserves and the forecast value of energy. If the forecast value of energy is higher at a pre-agreed point in time (e.g. at D-2), transmission capacity is allocated for the exchange of energy. Alternatively, the market-based allocation process can be based on the comparison of the forecasted value of reserves and the actual value of energy (at D-1), which we refer to as "market-based allocation process with TSO participation" in the energy market. The contracting for the exchange of balancing capacity must be done "not more than one week in advance of the provision of the balancing capacity". If the reservation of transmission capacity is contracted more than two days in advance of the provision of balancing capacity, the maximum transmission capacity allocation that is permitted is 10% of the available capacity of the exchange of energy between bidding zones.

The economic efficiency approach

An allocation process based on economic efficiency analysis is based on the ex-ante forecasts of the benefits of reserving transmission capacity for reserves relative to the benefits of reserving transmission capacity for energy. Similar to the market-based allocation process, the reservation of transmission capacity for the exchange of reserves is made if the benefits expected based on forecasts are higher than for the exchange of energy. The contracting for the exchange of balancing capacity must be done "more than one week in advance of the provision of the balancing capacity".

The probalistic approach

An allocation process based on a probabilistic approach refers to a balancing capacity exchange based on an ex-ante forecast of available cross-zonal capacity after the day-ahead and intraday markets. The forecast will then be used as available transmission capacity by the capacity procurement optimisation function and exchange will be possible in cases where the forecast predict that the wholesale markets will not utilize all available cross-zonal capacity. In cases where the forecast predict a lower wholesale market utilization than the actual outcome and the exchanged balancing capacity is activated, the system operator use remedial actions, primarily countertrade, to alleviate the system and secure operation within the security limitations.

2.1.3. Assessment behind the choice of market-based allocation method

This section will first give an answer to why a methodology based on explicit allocation of CZC is chosen as opposed to the probabilistic approach. Thereafter the reasoning for the choice to base the Proposal on the market-based allocation methodology is elaborated.

Explicit allocation vs probabilistic approach

The main motivations for choosing a methodology based on explicit allocation of CZC for exchange of balancing capacity can be summarised as follows:

- The Nordic LFC block consists of a large number of bidding zones which are relatively small compared to the continent. This is considered advantageous as critical limitations of transmission grid is reflected in the energy prices and yields a more optimal utilisation of both available transmission capacity and resources. However, with small bidding zones and unevenly distributed balancing resources the exchange of balancing capacity with allocated CZC is necessary to ensure operational security in all areas.
- A probabilistic approach will not guarantee that there will be enough CZC corresponding to the exchanged volume of balancing capacity. When there is not sufficient balancing capacity after day-ahead and intraday timeframe the TSOs must rely on countertrade, otherwise the level of operational security is reduced. To which extent is obviously determined by the confidence interval applied in the forecasting methodology. Resources for countertrade must be reserved either in a parallel procurement process, by re-dispatch of production or by presumed availability of balancing bids based on historical availability data.
- The probabilistic approach does not compare values of CZC used for energy and balancing capacity In stead as much CZC as possible are made available for exchange of energy in the day-ahead and intraday timeframe. It is important to be aware that energy market is in general impacted by the

volume of balancing capacity procured, as it affect the bids submitted to the energy makret. A less optimal utilisation of balancing capacity bids between bidding zones together with a larger procurement volume in order to enable countertrade would potentially have a greater negative impact on the energy markets than the reduced availability of CZC would yield.

The Nordic TSOs need to ensure that the necessary volumes of balancing energy bids are accessible in each bidding zone, thereby ensuring operational security. The preconditions in terms of available frequency restoration reserve (FRR) balancing resources is quite different across the Nordic bidding zones. While the Norwegian bidding zones NO2, NO3 and NO5 and Swedish bidding zones SE1 and SE2 have a rather good availability of flexible hydro-based balancing resources, the bidding zones NO1, SE3, SE4 DK2 and FI are deficit areas where currently national capacity procurement schemes are necessary to ensure available resources. As an example, In Sweden, SE3 and SE4 rely on long-term contracts with Gas turbine Balancing Service Providers (BSPs) and an affiliated company of Svenska kraftnät.

In deficit areas it will not always be enough balancing capacity bids compared to the volume necessary to keep operational security within acceptable limits. These bidding zones must then rely on additional capacity procured in other bidding zones. When there are a risk for not having available CZC to these areas after the day-ahead and intraday timeframe, there are no other option than to reduce CZC given to the day-ahead market. This happen both in the Southern bidding zones in Norway and Sweden today, and in Annex 1 a Swedish case study with empirical data is presented.

When TSOs are forced to reduce CZC to ensure access to necessary balancing capacity in neighbouring areas this is an allocation of CZC less transparent and less efficient than will be achieved with a capacity market including an allocation methodology for explicit allocation of CZC for balancing capacity when the actual or forecasted values implies that this is beneficial.

In cases where there are resources for performing countertrade, it should be notices that this yield a less optimal utilisation of resources compared to explicitly allocating CZC for the exchange of balancing capacity. If the bids available for TSOs to perform countertrading were completely consistent with the bids in day-ahead and intraday markets, countertrading could be used instead of allocating CZC to the balancing capacity market to achieve an equally efficient final energy dispatch. However, the bids available for countertrading are highly unlikely to be consistent with the energy bids submitted to the day-ahead market. Not all units have the flexibility to adjust their energy delivery or consumption closer to real time and, for units having this flexibility, the costs of adjustment may be higher than what is incorporated in the bid price they submit to the day-ahead market. When deciding how much balancing capacity to procure in each bidding zone and thereby the exchange of balancing capacity, it will not be easy to assess the costs of countertrading that must be accounted for and TSOs would have to be very careful not to rely on more countertrading resources than will actually be available. After all, the motivation for procuring balancing capacity prior to the day-ahead market is to ensure that there is enough flexibility to handle imbalances and congestions in real time.

The choice of methodology

This section includes the qualitative assessment of the possible allocation methodologies. The Co-optimised and Economic efficiency is excluded from the thorough assessment below, based on the following reasons.

Co-optimised have obvious advantages since it is based on a comparison of the actual market values of cross-zonal capacity for exchange of reserves and for exchange of energy. The implementation requires however that the market coupling algorithm and functioning is adjusted accordingly, which in turn require an all TSO decision. The allocation methodology is also in itself subject for all TSOs to develop and (EBGL Article

40.1) and for all NRAs to approve (EBGL Article 5.2). The technical and market complexity and the need for a pan-European process makes the implementation infeasible during the coming years.

Economic efficiency is on the other hand a simplified allocation process based on an ex-ante economic analysis. This approach is limited to markets applying longer contracting periods and procurement is done more than a week before provision (EBGL, Article 42). The Nordic TSOs have discarded this option based on the economical inefficiencies created by a more fixed cross-zonal allocation and fixed procurement of reserves (days instead of hourly market).

The table below therefore focus on the Market-based and the Probabilistic approach based on the EB GL key objectives addressed in section **Fel! Hittar inte referenskälla.**.

Note that the evaluation is done based on the prevailing circumstances in the Nordic power system.

Table 2: Evaluation table

Method: / **Key objective:**	**Market-based approach**	**Probabilistic approach**
Integration of balancing markets and promote exchange of balancing services	Yes	
Contribute to operational security	Yes, the requesting TSO have adequate transmission capacity available/ensured in order to execute the exchange of energy in real-time	Would require that additional reserves for counter trade can be ensured, which is currently not possible in all areas.
Contribute to efficient long-term operation and development of electricity system and electricity sector	Yes, bottlenecks in the grid are taken into account in the reserve capacity allocation phase which support efficient operation. The bottlenecks are included in the price incentives which promote long term signals of efficient reserve allocation. However, it shall be noted that the methodology is not perfect, inefficiencies will occur (e.g. compare to Co-optimised)	The application of the method in a Nordic context will not support efficient system operation, nor efficient long term development of the sector. Counter trade can and will be used and feasible as a tool during specific operational situations, but not as a tool to base a cross-zonal market on.
Consistent functioning of day-ahead, intraday and balancing markets	Allow consistent function of day-ahead and balancing market. The Intraday market is not included in the proposed methodology	No
Ensure fair, objective, transparent and Market-based procurement of balancing services	Yes, the method is objective and transparent if market indicators are adequately published.	Uncertain long-term investment incentives, depending on the efficiency and volume of countertrading.

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Foster liquidity of balancing markets while preventing undue market distortions	Long-term investment signals are generated (more efficiently during stable market conditions), however less efficient than if Co-optimised methodology is used. Inclusion of intraday market would also be a potential improvement, even though complexity is increased. The methodology is also dependent on the efficiency/robustness of the forecasting tool, which is necessary to monitor/follow-up	Unlikely to provide correct signals as it dampens energy price differential artificially Cross-zonal value in day-ahead is not correctly reflected in the balancing market.
Avoid undue barriers to entry for new entrants	Yes, cross-zonal (Nordic) market integration will support geographical/national market barriers.	

Other evaluation criteria that the Nordic TSOs have considered when the different cross-zonal approaches where assessed.

Table 3: Additional considerations in evaluation

Method: / Key objective:	Market-based approach	Probabilistic approach
Operational efficiency	Promote operational efficiency. Exchange is always performed based on explicitly allocated cross-zonal transmission capacity.	Less efficient from an operational perspective as it will require increased number (and volumes) of counter trade actions in real-time.
Economic efficiency	Will facilitate generation of adequate short- and long term incentives to market participants. If complemented with adequate reporting of market data. However, the methodology is not perfect, and require follow-up (e.g. forecast methodology)	Counter trade is not to be considered as a methodology to send adequate economic signals to market participants. Settlement of counter trade will however reimburse BSPs for activations.
Applicability in the Nordic LFC block	The methodology is feasible in the Nordic LFC block since bottlenecks are efficiently considered both from an operational and a market perspective. The uneven distribution of reserves can be accommodated by the methodology.	Not feasible due to the high number of bidding zones / frequency of bottlenecks. Will not take into account the very limited amount of reserves in parts of the Nordic system.

2.2. Hasle Pilot: a study on the market-based allocation of CZC

The Hasle pilot was a bilateral project between Statnett and Svenska kraftnät. Its purpose was to get practical experience with and evaluate market-based allocation of transmission capacity for the exchange of aFRR capacity on the so-called Hasle border between NO1 and SE3. It consisted of two phases; the first phase was eight weeks in October to December 2014, the second phase was six weeks in May to June 2015.

The main conclusions from the two phases of the Hasle pilot showed the following:

- Coordinated procurement of reserves and allocation of transfer capacity is possible in practice.
- Exchange of reserves based on an assessment of the alternative value of transfer capacity has a positive socioeconomic benefit; therefore, it is efficient use of transfer capacity.
- The conservative allocation of transfer capacity for automatic reserves realized half the potential efficiency gain. A better price forecast and a less conservative allocation of transfer capacity could increase the benefit further.
- The allocated CZC for exchange of aFRR capacity had very little impact on day-ahead market prices in the studied period. However, the impact was bigger when the day-ahead market price difference was bigger.

The pilot involved just a few of the Nordic bidding zones with connections and the simulation study with the whole Nordic market region presented in section 2.3 is important for the overall understanding of how the allocation of CZC for aFRR capacity will work in the Nordic region. However, the Hasle-pilot has given important experiences and learnings which have been taken into account when forming the market rules and methodology for the Nordic aFRR capacity market described in the proposal. There are published reports with more detailed descriptions of the pilot itself, the market results and overall experiences and learnings[2].

2.2.1. Conclusion

There are in theory a number of different possibilities to ensure transmission capacity in order to exchange reserves cross border. However, the EB GL suggest four methodologies. Three of them implies explicit allocation of cross-zonal capacity for exchange of reserves while the fourth is probability based and implies the use of counter trade in case the transmission capacity needed is available when the exchange of capacity is realised as exchange of energy.

The Nordic TSOs discard two of the methodologies for explicit allocation of cross-zonal capacity. The **Co-optimised** approach is very complex and currently not feasible to implement in the Nordic region. However, in case of a future all TSO decision, the Nordic TSOs are very open to reconsider more complex methodologies.

The **Economic efficiency** is on contrary discarded due to the fact that this method is designed for a long-term reservation that is carried out in cases where procurement is performed more than one week ahead of operation. This quite simplified method may result is larger and unnecessary economic inefficiencies.

[2] "The Hasle pilot project" published on 2015-03-17, and "Memo: Hasle pilot experiences" published on 2015-12-21 can be found on the following web site: https://www.statnett.no/for-aktorer-i-kraftbransjen/systemansvaret/kraftmarkedet/reservemarkeder/sekundarreserver/

The **probabilistic approach** is feasible in situations where there is a low probability that no cross-zonal capacity is available and where there are resources available for counter trade in order to ensure the trade in those instances of time when this risk anyway would be realised. This is not the case in the Nordic power system and application of the probabilistic approach would therefore either or both distort efficient price incentives in balancing markets and compromise operational security or necessitate alternative, not market based operational measures.

The Nordic TSOs therefore propose to use the **market-based** approach in accordance with EB GL, article 41. The methodology provides a reasonably efficient and market-based solution that would accommodate the implementation of a Nordic FRR capacity market while taking into account the cost of allocation of transmission capacity.

2.3. Theoretical framework for socio-economic benefit

In order to visualize the socioeconomic benefits of an allocation methodology, it can be useful to use an example with two areas and simple continuous bid curves to illustrate the impacts of changing the CZC. First, when using the term socioeconomic benefit this refers to the producer and consumer surplus in a market. Consumer surplus is the difference between the maximum price a consumer is willing to pay and the actual price paid. Producer surplus is the difference between the price a producer receives for its generation and the marginal cost. It is assumed that the demand curve represents the consumers' true marginal willingness to pay and the supply curve represents the producers' true marginal cost. When consumers pay and producers are paid the equilibrium price, the socioeconomic surplus can be illustrated as in **Fel! Hittar inte referenskälla.** for a market without any congestions and transport costs.

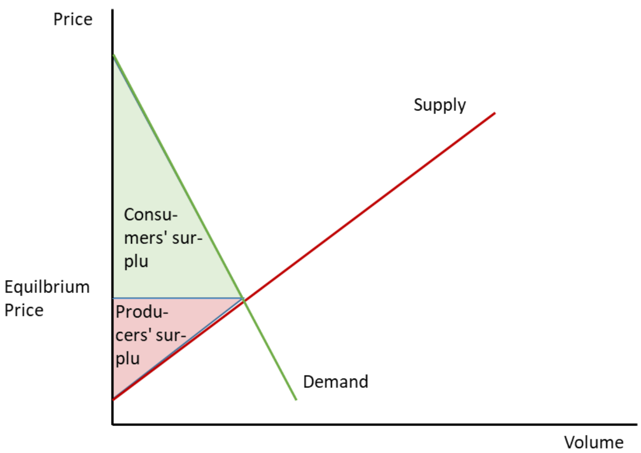

Figure 2. Socioeconomic surplus in market with no congestion and no transport costs

Fel! Hittar inte referenskälla. introduces a high price area A (higher demand and more costly generation) and a low price area B (lower demand and less costly generation). Based on the demand- and supply curves of each area, a net imports curve for area A and a net exports curve for area B can be constructed, as illustrated in Figure 3.

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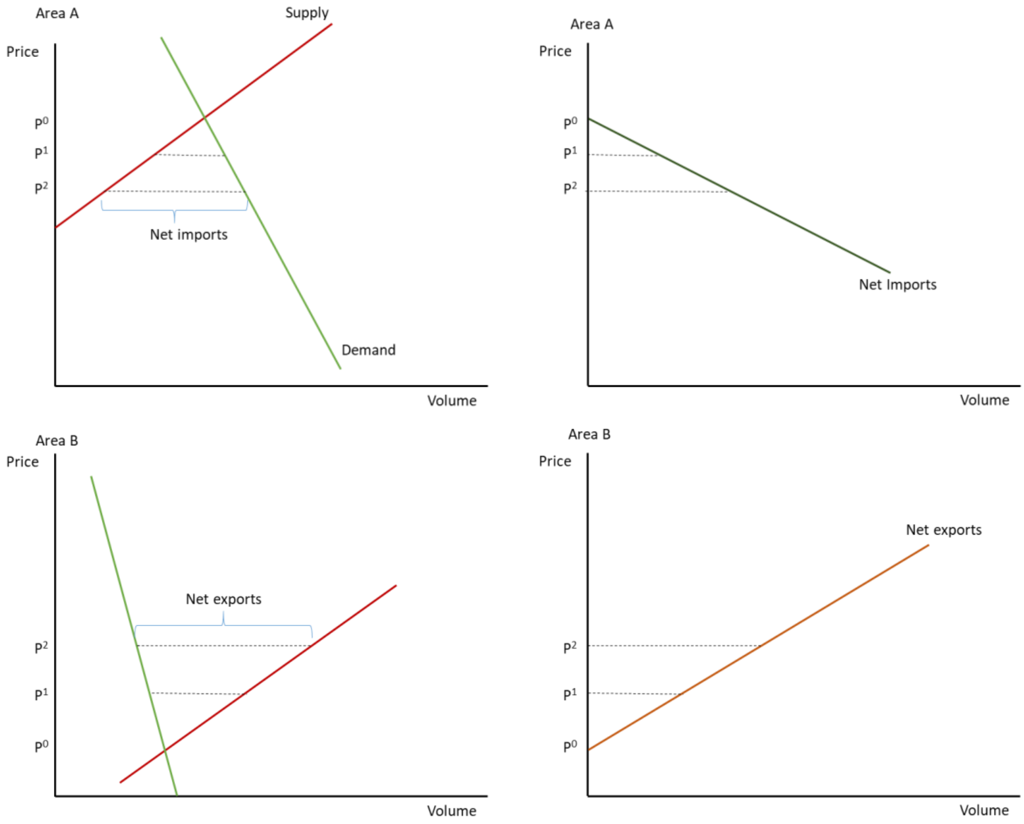

Figure 3. Net import curve for high price area A (above) and net export curve for low price area B (below)

Putting the net exports and net import curves of Figure 3 together in one diagram as done in **Fel! Hittar inte referenskälla.**, allows to find the the optimal volume of net exports from area B to A, which maximizes the total socioeconomic surplus.

If the same price occurs in both markets and if the supply curves and the demand curves of both areas are aggregated into one diagram one would get a figure similar to **Fel! Hittar inte referenskälla.**. In total both areas benefit from the exchange. In area A the socioeconomic surplus increases because the increase in consumer surplus outweigh the decrease in producer surplus due to access to cheaper generation in area B. In area B the socioeconomic surplus increases because the increase in producer surplus outweighs the decrease in consumer surplus due to the higher market price that is realised when more demand from area A get access to the market.

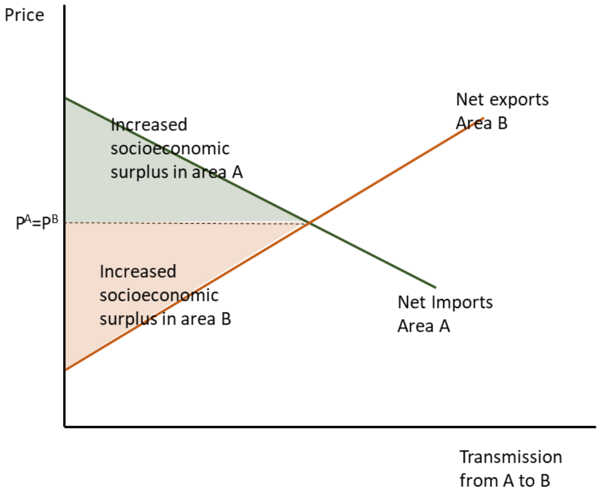

Figure 4. Optimal volume of exports from area B to A in terms of total socioeconomic surplus

In **Fel! Hittar inte referenskälla.** the CZC constraint is introduced and this limits the net exports. The optimal exchange is not reached, and the prices do not converge fully. The reduction in socioeconomic surplus relative to a situation with no limit on transmission capacity yields the cost of the congestion. The price difference that is reached represents the marginal increase in socioeconomic surplus with a marginal increase in CZC from B to A. This is an important insight used in allocation methodology, since the use of CZC between two markets now can be compared. The aim is to allocate CZC to the market where the marginal increase in socioeconomic surplus is the highest.

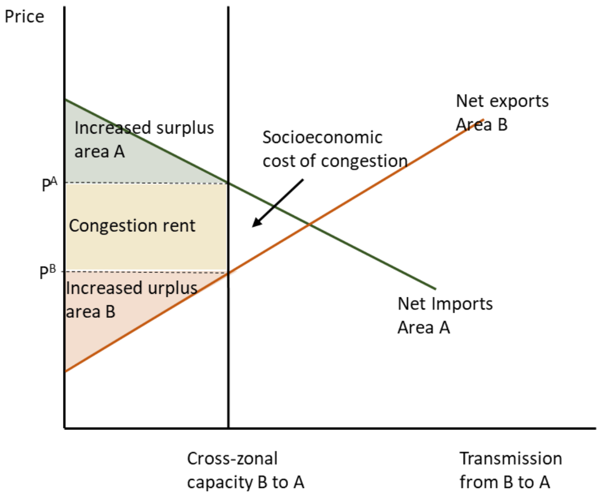

Figure 5. Socioeconomic surplus in market with congestion

This is illustrated in **Fel! Hittar inte referenskälla.** wheretwo markets area A and B are involved. As a starting point all the transmission capacity is used in market 2. The price difference is, however, much larger for market 1 than market 2. To allocate some of the capacity from market 2 to market 1 creates new prices for the markets. It can be shown that the new price difference is still somewhat larger in market 1 than the new price difference in market 2. The increase of the socioeconomic surplus due to increased transmission capacity is clearly higher for market 1 than the decrease in socioeconomic surplus in market 2 due less available transmission capacity. This is a clear beneficial reallocation of the transmission capacity from market 2 to market 1.

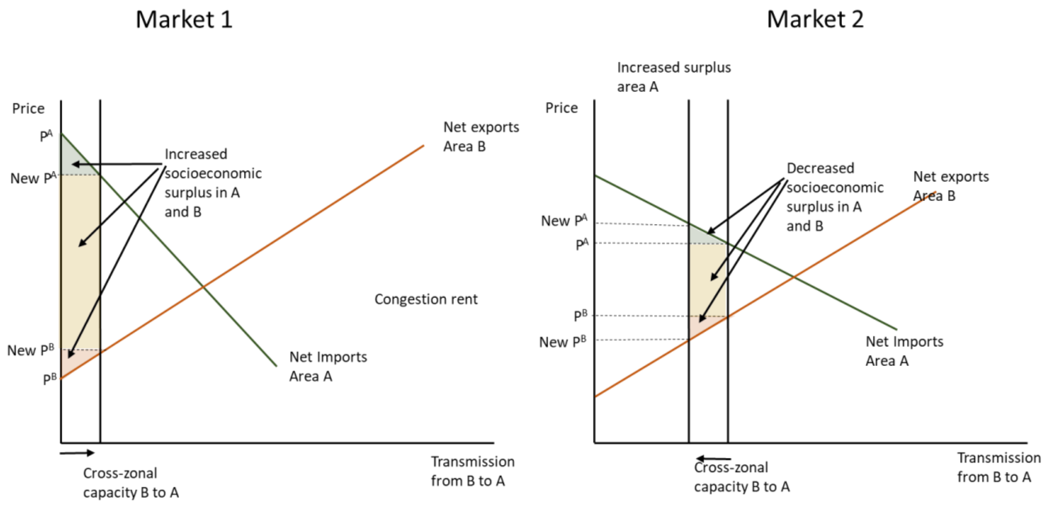

Figure 6. Change in socioeconomic surplus in two interconnected markets

A popular way to illustrate the optimal allocation of capacity between two markets is to use a bathtub diagram as in Figure 7 where price difference curves for the two markets are used showing how the price difference decreases with increased transmission capacity allocated to the market and vice versa. In **Fel! Hittar inte referenskälla.** the length of the diagram represents the total transmission capacity. The transmission capacity for market 1 is measured from left to right and for market 2 it is measured from right to left. The optimal allocation will be the point where the price difference is equal in the two markets.

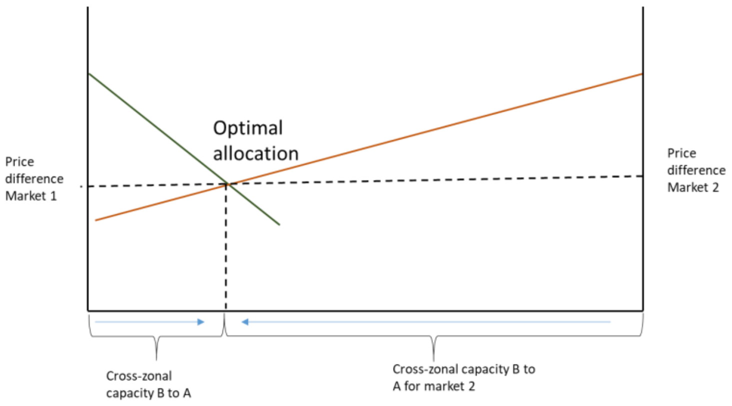

Figure 7. Bathtub diagram showing the optimal allocation of CZC between two markets

2.3.1. Practical aspects of the proposed methodology

There are of course several characteristics of the aFRR capacity market and the day-ahead energy market that differ from what is implicated with the simplistic example of area A and B in section 2.3 above. For instance, the bid curves are not continuous, but stepwise linear due to discrete bids. In the aFRR capacity market the demand side is characterized by a fixed TSO demand, i.e. the volume of aFRR capacity each market area will need access to in order to fulfil dimensioning rules does not change with the price. This does not, however, prevent using the price difference as indicator of market value.

The most important practical implication of the methodology considered is that a forecast based on a reference day for the energy market is used. Thus, the energy market bid curves of all the areas are not available when determining the allocation. Below are this and other important aspects of the method assessed.

2.3.2. Uncertainty of the energy market value and price impact of reallocated transmission capacity

There will be a risk for forecast errors regarding the market value of transmission capacity in the day-ahead market. Certain features of the proposed methodology will, however, make it less likely that a forecast error over time will lead to too much transmission capacity allocated for aFRR capacity. A maximum volume for allocation to aFRR capacity market equal to 10 percent of the forecasted NTC may often be a binding restriction preventing the optimal allocation given forecasted market value for energy market to be reached. In addition, there are uplifts on the price difference of the reference day that also will prevent over-allocation to the aFRR capacity market rather than energy market. As illustrated in **Fel! Hittar inte referenskälla.**, it may only be due to large under-estimation of market value in the energy market that over-allocation of transmission capacity to the aFRR capacity market will occur.

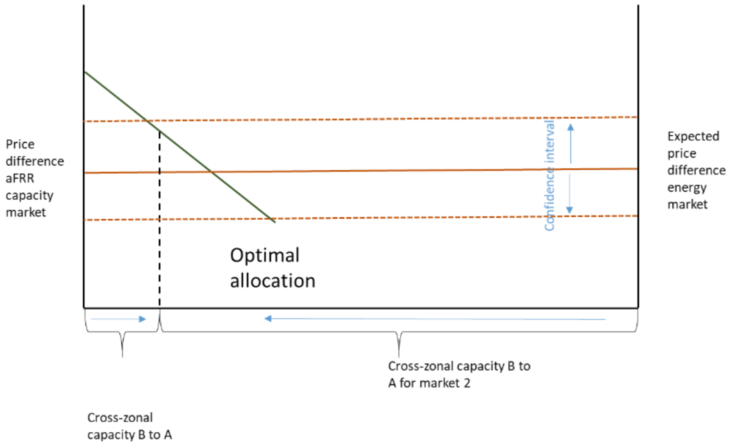

Figure 8

The evaluation of the Hasle pilot, which was based on a reference day forecast method, showed that about 50 percent of the potential gain from allocating transmission capacity for exchange of aFRR capacity, was realised. Allocation of more transmission capacity to the aFRR capacity market would be necessary in order to realise more of the potential.

2.3.3. Impact of pay-as-bid and complex bid formats in the aFRR capacity market

In the two area example presented in section 2.3 it is assumed that there was one equilibrium price/clearing price for all participants in both markets. In the aFRR capacity market the pricing will be based on the pay-as-bid principle for the first phase of the market, which can lead to some strategic bidding and possibly less efficient market results.

Complex bid formats, linking of bids and indivisible bids, creates non-convexities for the optimisation algorithm of the aFRR capacity market. A problem with this is that a monotonic increasing marginal price curve for different exchange volumes is not avalible, and it is therefor not possible to compare the price differences as the marginal value of CZC in the aFRR capacity market and the energy market as it is done in the simplistic two-market example in section 2.3. However, as all the aFRR capacity bids are avalible, the algorithm can ensure that a representative market value of the aFRR capacity market is used to compare with the forecasted market value for the energy exchange. In the algorithm, therefore the total reduction in energy cost of the aFRR capacity market, assumed reflected in the aFRR capacity bid prices, is compared with the forecasted energy market price difference multiplied with the CZC allocated to the aFRR capacity market, which is considered as a good estimate on socio-economic cost of reducing the CZC available for the energy market.

2.3.4. Impact of reservation of aFRR capacity for energy market

It is important to be aware that the energy market is affected by the aFRR capacity market not only through the potential allocation of transmission capacity from the energy market to aFRR capacity market, but also through the reservation of aFRR capacity itself. The alternative of offering aFRR for a BSP can be to participate in the day-ahead market. If aFRR capacity offered is just a bi-product of the expected accepted energy bids, the BSP would not ask for a high price to offer the capacity to the aFRR. This can typically be downward capacity corresponding to expected energy delivery in the day-ahead market, or upward capacity corresponding to the difference between maximum generation capacity and best-point generation for a hydro producer. However, if the BSP has to deliver its minimum capacity with loss in the day-ahead market to be able to be spinning and capable of delivering upward aFRR capacity, the capacity bid should be priced higher to compensate for that.

The TSOs have to procure a given volume of aFRR capacity in order to ensure access to sufficient balancing energy bids according to the dimensioning rules. If the TSOs have to use expensive aFRR capacity bids in their own area, it may require BSPs to change their bidding in the energy market substantially, rather than reserving cheaper bids in another area with corresponding allocation of transmission capacity. The consequence is that the overall impact on the energy market can be higher without allocation of transmission capacity for aFRR capacity exchange.

2.3.5. Conclusion

Based on both theoretical assessments and practical experience, the Nordic TSOs consider that the application of a market based CZC allocation methodology, as depicted in this proposal, will lead to a more socio-economic beneficial use of the CZC in the Nordic region in overall. To have the procurement less than two days prior to provision of the aFRR capacity is expected to increase the reliability of the market value forecast in the energy market significantly compared to having the procurement a week before the provision of the aFRR capacity or earlier. However, the Nordic TSOs consider it critical to monitor the performance of the aFRR capacity market carefully and make improvements in the methododlogy as more experience with the market is gained. All future changes in the methododlogy will be done in accordance with the process for methodology amendments stipulated in EB GL.

2.3 Performance of using the reference day method as forecast method

This section will analyse the reference day method as described in section 3.1.1. The analysis is based on the day-ahead prices for three years, 2016-2018. For the different bidding zone borders the actual price difference of each hour in the day-ahead market is compared to the price difference of the same hour of the reference day which equal the previous day in the proposal.

The forecast error is the difference between the forecasted market value and realized market value calculated for each hour, for each bidding zone border and flow direction. The market value equals the price difference in the congested direction and is set to zero in the opposite direction. The forecasted market value for a certain hour and day equals the market value of the same hour the previous day.

The forecast error calculated based on the data set of hourly market values for 2016-2018 does not show any systematic behaviour with respect to positive or negative errors, and on average the forecast error is close to zero. Below results based on the absolute value of the forecast error are shown, which is a general measure for the performance of the forecast method.

Table 4 shows quarterly averages of the absolute forecast error for different Nordic bidding zone borders. The total average of the absolute forecast error is less than 1 Euro for all connections and all hours and is also fairly stable over the different seasons. There are, however, differences between borders and flow directions. Comparing with table 5, which show the number of hours with congestions for the different borders and directions between 2016 and 2018, it is shown that the forecast error is larger for the connections with most frequent congestions and for these there are larger deviations between the different seasons.

Average absolute forecast error	2016				2017				2018				Total average
Connection	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
DK2-SE4	0,6	0,0	0,1	1,4	1,4	0,8	0,0	3,1	2,3	1,6	0,3	2,6	1,2
FI-SE1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
NO1-NO2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
NO1-NO5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
NO1-SE3	0,7	2,4	2,7	2,2	1,2	1,9	4,1	1,6	1,1	0,7	1,8	1,7	1,8
NO2-NO1	2,2	0,0	0,2	2,4	0,7	0,2	0,1	0,3	1,7	0,1	0,7	0,0	0,7
NO3-NO4	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,7	0,2	0,5	0,1
NO3-SE2	0,0	1,2	1,0	0,9	1,0	0,8	3,2	0,3	0,2	0,3	1,1	1,2	0,9
NO4-NO3	0,7	2,0	1,9	3,0	2,2	2,4	1,6	0,6	1,1	0,1	1,0	0,5	1,4
NO4-SE1	0,7	2,7	2,3	3,8	3,0	3,1	4,1	0,9	1,2	0,4	2,0	1,5	2,1
NO5-NO1	2,2	0,1	0,7	2,1	0,9	0,1	0,1	0,0	1,4	0,1	0,7	1,3	0,8
SE1-FI	6,0	3,6	2,0	0,8	1,6	3,0	3,2	3,2	4,1	3,9	1,8	2,4	3,0
SE1-NO4	0,1	0,1	0,2	0,2	0,2	0,4	0,0	0,4	0,1	1,8	0,3	1,0	0,4
SE1-SE2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
SE2-NO3	0,2	0,2	0,3	0,7	0,4	0,5	0,0	0,4	0,2	1,4	0,1	0,5	0,4
SE2-SE1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
SE2-SE3	1,1	0,0	0,1	0,1	0,1	0,0	0,7	1,2	0,2	0,0	0,4	1,0	0,4
SE3-NO1	0,1	0,0	0,0	0,4	0,7	0,6	0,0	0,5	0,2	1,0	0,1	0,5	0,3
SE3-SE2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
SE3-SE4	0,5	0,1	0,2	0,8	1,6	0,6	0,4	2,5	0,7	2,2	1,2	3,7	1,2
SE4-DK2	0,0	0,2	0,5	0,6	0,1	1,0	1,1	1,8	0,4	2,4	1,5	1,5	0,9
SE4-SE3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total average	**0,7**	**0,6**	**0,6**	**0,9**	**0,7**	**0,7**	**0,9**	**0,8**	**0,7**	**0,8**	**0,6**	**0,9**	**0,7**

Table 4. Average absolute forecast error according to reference day method for the bidding zone borders of the proposed Nordic capacity market and. Quarterly averages for hours between 01.01.2016-31.12.2018. Euro

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Connection	Hours with congestions
NO4-SE1	13344
NO4-NO3	13013
NO1-SE3	8809
SE1-FI	7360
NO3-SE2	3955
NO5-NO1	3896
SE4-DK2	3056
SE3-SE4	2772
NO2-NO1	2591
SE2-NO3	2205
DK2-SE4	1789
SE3-NO1	1680
SE1-NO4	1437
SE2-SE3	881
NO3-NO4	504
NO1-NO5	46
NO1-NO2	33
FI-SE1	1

Table 5. Numbers of hours with congestion (price difference in the day-ahead market) for each border and direction of the proposed Nordic capacity market. All hours between 01.01.2016-31.12.2018

Table 6 shows that the largest forecast errors typically can be expected during peak hours . During these hours the utilisation of the grid is the highest and grid congestions are more frequent.

Average absolute forecast error	Weekday							
Hour	1	2	3	4	5	6	7	Total
1	0,3	0,4	0,4	0,3	0,3	0,3	0,4	0,4
2	0,4	0,4	0,4	0,4	0,3	0,4	0,4	0,4
3	0,4	0,4	0,4	0,4	0,3	0,4	0,4	0,4
4	0,4	0,4	0,4	0,4	0,3	0,4	0,4	0,4
5	0,4	0,4	0,4	0,3	0,3	0,4	0,4	0,4
6	0,5	0,4	0,5	0,4	0,3	0,4	0,4	0,4
7	0,9	0,6	0,7	0,6	0,6	0,8	0,4	0,7
8	1,4	1,3	1,3	1,3	1,2	1,3	0,4	1,2
9	1,6	1,5	1,6	1,7	1,5	1,5	0,4	1,4
10	1,4	1,2	1,4	1,5	1,4	1,3	0,4	1,2
11	1,2	1,2	1,3	1,3	1,1	1,0	0,3	1,1
12	1,1	1,1	1,1	1,1	1,0	1,0	0,3	1,0
13	1,0	1,0	1,0	1,1	0,9	0,9	0,3	0,9
14	1,0	1,0	1,1	1,0	0,8	0,8	0,3	0,9
15	1,0	1,0	1,0	0,8	0,8	0,7	0,3	0,8
16	0,9	0,9	0,8	0,9	0,8	0,7	0,3	0,7
17	1,0	1,0	1,0	1,1	1,0	0,8	0,3	0,9
18	1,2	1,3	1,2	1,4	1,2	0,9	0,3	1,1
19	1,1	1,1	1,1	1,3	1,1	0,9	0,4	1,0
20	0,9	0,9	0,9	0,9	0,8	0,6	0,4	0,8
21	0,6	0,6	0,5	0,6	0,5	0,4	0,3	0,5
22	0,4	0,4	0,4	0,4	0,4	0,3	0,3	0,4
23	0,4	0,4	0,3	0,3	0,4	0,4	0,3	0,3
24	0,4	0,3	0,3	0,3	0,3	0,4	0,3	0,3
Total	0,8	0,8	0,8	0,8	0,7	0,7	0,3	0,7

Table 6. Absolute forecast error per hour and weekday. Average over for all connections of proposed Nordic capacity market and all hours between 01.01.2016-31.12.2018. Euro

The proposal is based on using the previous day as reference day without taking weekend and holidays into consideration. Initially it was expected that adjusting the reference day due to difference in price patterns between the weekend, weekdays and holidays could lead to a better forecast ability.
For instance, for Mondays it could be expected to be better to use Friday as reference day than Sunday, for holidays it could be expected to be better to use the last Sunday than the previous day if that is a working day. Table 7 shows, however, there is slightly less forecast errors on average using previous day as reference day also for these cases.

Absolute forecast error for Mondays		
Connection	Reference day: Friday	Reference day: Sunday
DK2-SE4	1,3	1,5
FI-SE1	0,0	0,0
NO1-NO2	0,0	0,0
NO1-NO5	0,0	0,0
NO1-SE3	2,2	2,2
NO2-NO1	0,8	0,5
NO3-NO4	0,2	0,2
NO3-SE2	1,1	1,1
NO4-NO3	2,0	1,7
NO4-SE1	2,8	2,7
NO5-NO1	1,1	0,8
SE1-FI	4,1	3,8
SE1-NO4	0,5	0,4
SE1-SE2	0,0	0,0
SE2-NO3	0,5	0,4
SE2-SE1	0,0	0,0
SE2-SE3	0,8	0,5
SE3-NO1	0,4	0,4
SE3-SE2	0,0	0,0
SE3-SE4	1,8	1,1
SE4-DK2	1,1	0,9
SE4-SE3	0,0	0,0
Total	**0,9**	**0,8**

Absolute forecast error for holidays		
Hour	Reference day: Previous Sunday	Reference day: Previous day
DK2-SE4	6,0	5,0
FI-SE1	0,0	0,0
NO1-NO2	0,0	0,0
NO1-NO5	0,0	0,0
NO1-SE3	0,1	0,2
NO2-NO1	0,2	0,1
NO3-NO4	0,7	0,6
NO3-SE2	0,0	0,0
NO4-NO3	0,3	0,4
NO4-SE1	0,3	0,4
NO5-NO1	0,0	0,0
SE1-FI	2,0	1,9
SE1-NO4	1,2	1,3
SE1-SE2	0,0	0,0
SE2-NO3	1,3	1,4
SE2-SE1	0,0	0,0
SE2-SE3	0,0	0,0
SE3-NO1	1,8	1,8
SE3-SE2	0,0	0,0
SE3-SE4	0,0	0,0
SE4-DK2	0,5	1,0
SE4-SE3	0,0	0,0
Total	**0,7**	**0,6**

Table 7. How choice of reference incluence on absolute forecast error. Forecast errors for Mondays on the left and for days with holidays in the whole Nordics on right. Average for all relevant hours between 01.01.2016-31.12.2018. Euro

This indicates that using the most recent information has a larger impact on the predictability than trying to capture systematic patterns of different type of days. This analysis has ignored the impact of reducing the CZC for the day-ahead market and allocating this to the exchange of balancing capacity. The next two sections will include an assessment of this based on simulations of both the Nordic aFRR capacity market and the impact of allocation on the European day-ahead market coupling optimisation algorithm.

2.4. Simulations of market-based allocation and the impact on day-ahead market

This section presents a simulation study of a Nordic aFRR capacity market with market-based allocation of CZC for exchange of aFRR capacity. The Norweigian based company Optimeering AS has developed the algorithm planned to be implemented for the Nordic aFRR capacity market and conducted the simulations based on the rules for market and allocation of CZC in the proposal pursuant to article 33 and 38 of EB GL. Simulations are done for every hour in 2018. Available market data including national aFRR capacity bid data for 2018 are used as basis for the simulations, but a number of assumptions where necessary in order to be able to carry out simulations for all hours of 2018. These assumptions are first presented before describing the results of the simulations. In the end also the impact of the CZC allocation for the day-ahead market is discuss. For this purpose the "Simulation facility" offered by European market coupling operators is used.

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2.4.1.Market assumptions

The simulations are based on actual aFRR capacity bids of 2018, available transmission capacity and day-ahead market prices of 2018 and a total demand of 300 MW aFRR capacity in all hours. Assumptions on bids is necessary for having a complete data set, as aFRR capacity is not procured in all areas and hours today. The goal is not to predict the performance of a Nordic aFRR capacity market, but give a presentation of a realistic scenario in order to get a better understanding of how the market will work. The resource situation and state of the Nordic power system may change substantially from year to year. The introduction of the market will in itself also potentially influence bidding behaviour of market participants and the availability of aFRR bids in different areas.

Bids

There are available historical bid data for 2018 for the Norwegian bidding zones NO1, NO2, NO5, for Sweden and for Finland. Swedish bid data have no geographical split in bidding zones. There have so far been no bids available from DK2.

The bids in NO3 and NO4 are assumed identical as in NO5, but prices for NO3 and NO4 are adjusted with a factor corresponding to the difference in day-ahead market price between NO5 and the respective region.

The Swedish bids are distributed randomly between the areas, but according to the following keys, which reflect distribution of delivering units:

- SE1 49%
- SE2 26%
- SE3 25%
- SE4 0%

Bids from DK2 are based on Finnish bids, but with an adjustment in bid prices corresponding to the difference in day-ahead price between FI and DK2.

There are different rules for bidding and pricing in national markets today. Norway only allow block bids for predefined blocks of hours. Here 50 percent of the block bids are converted to single hour bids for the same hours. Procured bids in Norway are priced with pay-as-cleard and procured bids in Sweden and Finland are priced with pay-as-cleared.

For Finland, the original data only had single hour bids. The structure is kept in the bid data of the simulation.

For Sweden, there was a mix of single and block bids in the original data and this is not changed.

In order to create synthetic bids for the missing days and hours, the missing days where first filled by copying the bid structure from the closest day with data.

Further bid prices where adjustedaccording to a linear interpolation between the days with existing data.

To create bids for missing hours of each day the assumption was that the distribution of bids within an hour follow a normal distribution with a given mean and standard deviation.

In order to generate the bids, a mean and standard deviation for each hour of the year hade to be found, as well as the minimum and maximum bid price. This was done by firstly find the data of the hours with existing data, then make a linear interpolation between the data points to get the mean, min, max and standard deviation for the missing hours. Whenthese numbers was found, bid data was created for the missing hours by randomly creating bids from the normal distribution with the mean and standard deviation numbers, as well as putting limits on minimum and maximum bid prices based on the original bid price data.

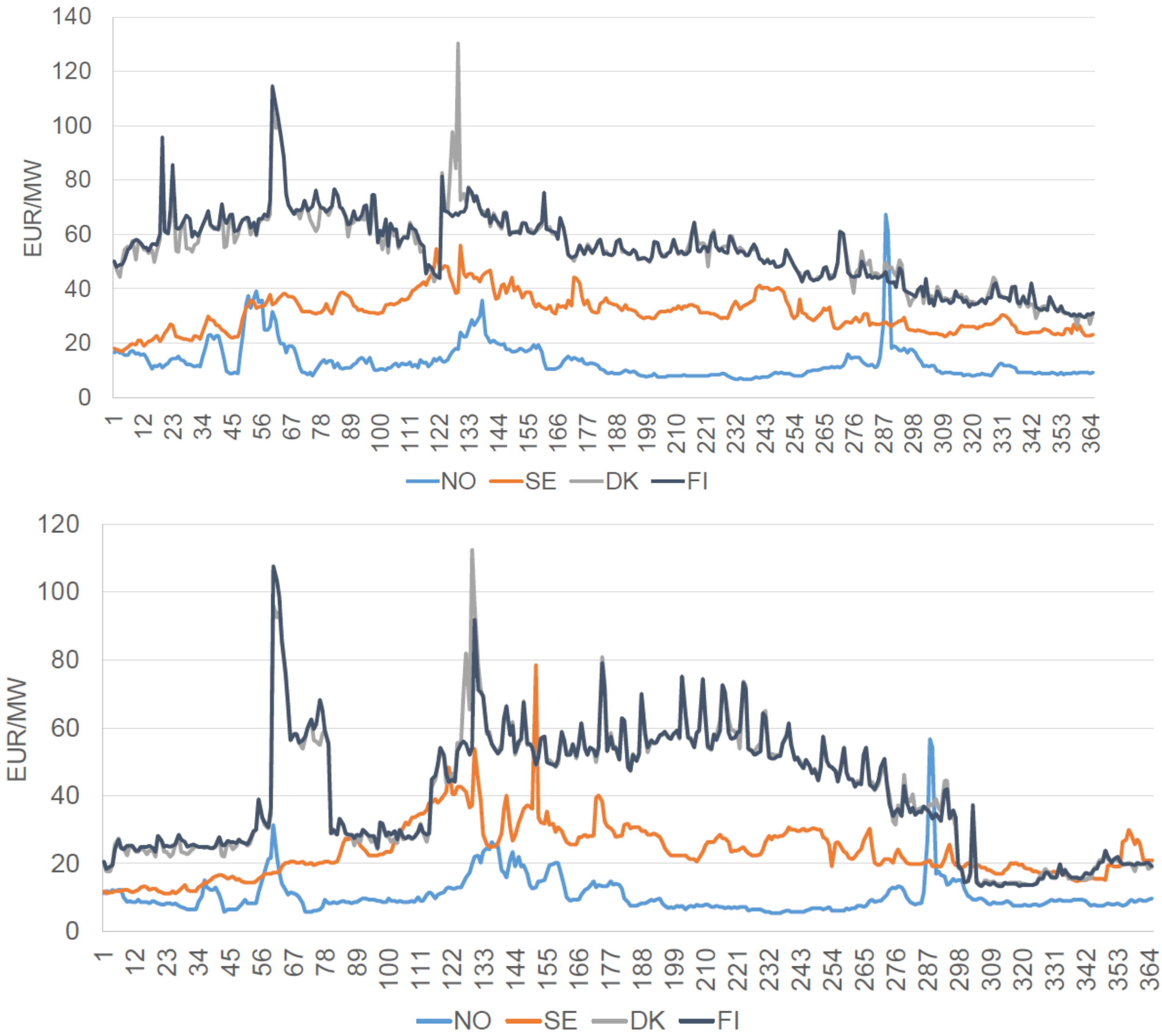

Figure 9. Weighted average of daily bid prices for up regulation (upper graph) and down regulation bids (lower graph) per country. EUR/MW/h

Figure 9 gives an overview of the bid data set, including the synthetic bids, used in the simulations. Norway has in general the bids with lowest prices and they vary relatively little over the year. Finland and DK have the highest bid prices and more variation over different periods of the year. Figure 9 also shows that that down regulation is on average priced lower than the up-regulation

Demand

Demand (procured aFRR capacity bids) in the analysis is 300 MW in total for all of Nordic bidding zones for both up and down regulation in all hours. This is what is planned from the start in the Nordic aFRR capacity market. It is uncertainty about the distribution of aFRR capacity demand between the bidding zones. The methodology for determining the distribution is not completely developed and decided and will also depend on the historical imbalance data used as input. For the simulations the distribution is in accordance with demand volumes presented in Table 8, which is calculated based on 2016 imbalance data.

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4
Down	20	45	15	30	10	20	20	35	25	50	30
Up	20	45	20	30	10	15	20	35	30	45	30

Table 8. Volume of aFRR demand for each bidding zone

Value of CZCs and maximal CZC available for exchange of aFRR capacity

The forecasted value of CZC for exchange of energy between two bidding zones is calculated according to the rules defined in the methodology proposal pursuant to article 33 and 38 of EB GL, with a slight modification of the reference day method[3]. As an example the value of CZC from NO1 to SE3 in hour 08:00-09:00 CET Tuesday equal the price difference between NO1 and SE3 in day-ahead market in hour 08:00-09:00 CET on Monday plus 1 € if this allocation follows the congested direction. If the allocation is in opposite direction of the congested direction the value is set to 0.1 Euro. This is the value used to determine the cost of reducing the NTC for the day-ahead market in the procurement optimisation function.

When calculating the actual cost of CZC allocated for aFRR capacity exchange in each hour, the actual price difference in the day-ahead market is applied.

The maximal MW of CZC that can be allocated to aFRR capacity exchange is 10 % of the NTC in the specific hour. It is assumed that the actual NTC of each hour equal the expected NTC D-2.

[3] For the simulations the following rules for defining reference day was applied.
For normal week days:
i. The reference day for Monday to Friday will be the previous working day
ii. The reference day for Saturdays will the previous Saturday
iii. The reference day for Sunday will be the previous Sunday
Reference day base case bank holidays:
i. When the reference day falls on a bank holiday the nearest working day previous to the reference day will be chosen
ii. When the day itself is a bank holiday, in the control area of two or more TSOs, the previous Sunday will be chosen

Based on analysis after starting the work with these simulations it has been decided to change the reference day to always be the previous day. This is not expected to have a large impact on the results and to the extent it has an impact the rules applied in the simulations should under estimate the gain of a Nordic capacity market with CZC allocation.

Scenarios

A national scenario without exchange of aFRR capacity between the Nordic countries and a scenario with exchange between all bidding zones according to the market rules of the proposal are simulated for all hours of 2018. This allow us to calculate the socio-economic benefit of exchange of aFRR capacity compared to the cost of allocating CZC for this purpose.

For the national scenario allocation of CZC between internal bidding zones in Sweden and Norway is allowed according to the same allocation methodology used in the case with Nordic exchange. There are, however, no allocation methodology applied for CZC allocation in national markets today. Still both Svenska kraftnät and Statnett do not completely rely on each area covering the required volume of aFRR capacity with local bids solely. In some situations without access to enough bids in a bidding zone, the NTC is reduced to facilitate access to bids in neighbouring bidding zone in order to keep the operational security within acceptable limits. This is difficult to replicate in the simulations. By applying the allocation methodology for internal bidding zone borders oneshouldbe aware of that it potentially will lead to more efficient aFRR capacity procurement in the national scenario and an underestimation of the benefits of allowing exchange on borders between the countries.

Bids and demand remains equal between the two scenarios. The only difference is the CZC that can be allocated for the purpose of aFRR capacity exchange.

2.4.2. Results

Focusing on the overall costs (bid costs + CZC reservation costs) for the two scenarios, it can be seen that the average cost is around 265 000 EUR per day for the National scenario. For the Nordic scenario, average daily cost drops to around 116 000 EUR. This represents a cost per MW of 18.40 EUR in the National scenario and a cost per MW of 8.06 EUR in the Nordic scenario. A peak in costs for both scenarios (and the delta) in May when bid costs are high can be seen in Figure 10 below.

The differences in cost between the two scenarios are shown with an area graph below and averages 148 000 EUR per day.

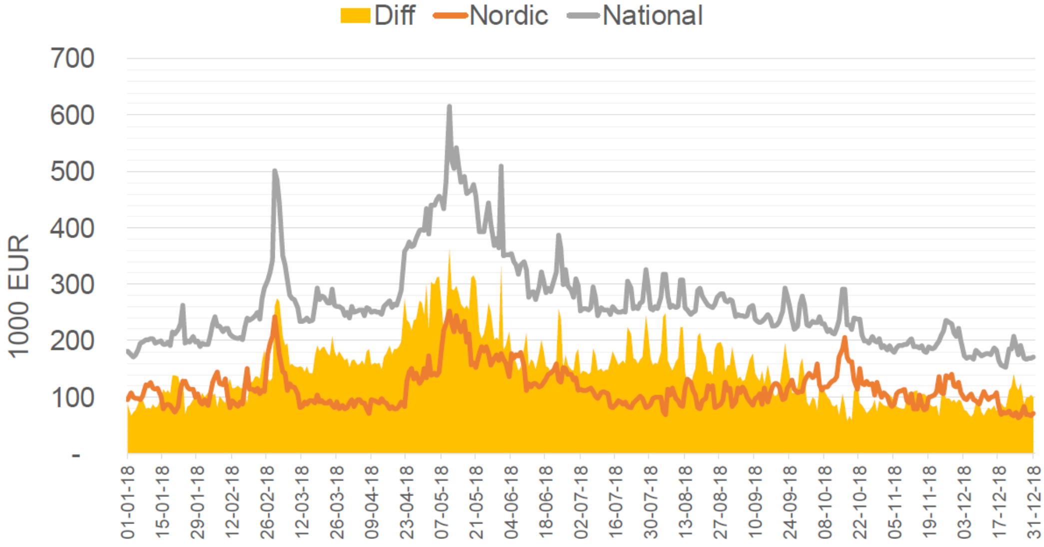

Figure 10. Overall daily costs from the market in the two scenarios (1000 EUR)

The cost of allocating CZC is calculated by multiplying the day-ahead price difference with allocated CZC for each border and summed together.

Looking at the results in more detail, Table 9 shows that a major part of the total volume of aFRR capacity is procured in Norway both for up and down regulation when allowing for trade between countries. This result is of course dependent on the difference of bid prices for 2018, which the bids used in the simulation study is derived from, and may change with introduction of the market.

.

	UP		DOWN	
	National	Nordic	National	Nordic
NO	859	2406	844	2169
SE	1247	183	1250	404
DK	175	26	175	35
FI	394	17	394	25
Total	*2676*	*2632*	*2663*	*2632*

Table 9. Total volume of aFRR capacity procured in each country. Comparison of national scenario with scenario allowing Nordic exchange

This is also reflected in the volumes of allocated CZC on the different borders. Looking at hourly average of allocated CZC for both scenarios, Figure 11 shows the numbers increase both internally in Norway and between the countries when going from a National to a Nordic scenario.

National

	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	DK2	FI
NO1		15			21						
NO2	20										
NO3				9							
NO4			11								
NO5	23										
SE1							34				
SE2						33		39			
SE3							44		30		
SE4								30			
DK2											
FI											

Nordic

	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	DK2	FI
NO1		48			43			96			
NO2	63										
NO3				10			51				
NO4			13			41					
NO5	68										
SE1				32			31				44
SE2			62			34		22			
SE3	68						39		48		
SE4								46		20	
DK2									20		
FI						43					

Figure 11. Hourly average allocated CZC for aFRR capacity exchange (From=left row, to=upper header), MW

The average volume from SE1 to FI is 44 MW and 43 from FI to SE1. This means that in almost all hours finnish up and down regulation are bought from foreign bidding zones. The same results can be seen with the 20 MW CZC reservation between SE4 and DK2.

Costs in 1000 EUR of reserving CZC is shown below and shows that the connections NO1-SE3, SE1-FI and SE3-SE4 represents almost 60% of total cost in the Nordic scenario.

National

	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	DK2	FI
NO1		8			17						
NO2	40										
NO3				2							
NO4			23								
NO5	51										
SE1							29				
SE2						28		117			
SE3							38		518		
SE4								26			
DK2											
FI											

Nordic

	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	DK2	FI
NO1		38			36			701			
NO2	149										
NO3				4			233				
NO4			10			259					
NO5	172										
SE1				95			23				700
SE2			168			28		23			
SE3	164						31		452		
SE4								40		111	
DK2									35		
FI						37					

Figure 12. Total cost of allocated CZC for exchange of aFRR capacity (from = left row, to = upper header), 1000 EUR

In order to assess the total benefits of allocating CZC for the exchange of aFRR capacity the impact on the clearing of the day-ahead market coupling algorithm is taken into account when considering the cost of reducing NTC in the day-ahead market. These simulations are presented in the next section 2.5.

2.5. Impact of allocated CZC on prices in the day-ahead

When allocating CZC for exchange of aFRR capacity, the NTC given to the market coupling of day-ahead market is reduced correspondingly. This will potentially increase the congestions and thereby lead to higher price differences. This impact would be neglected if the allocated CZC for aFRR capacity exchange were priced with empirical price differences of 2018 and not adjusted for the impact of reducing NTCs in the day-ahead market.

To get a better understanding of the significance of this impact the "simulation facility" offered by European market coupling operators is used.. This allows to see the results of an alternative run of the day-ahead market optimisation algorithm, Euphemia, after adjusting the NTCs according to the allocated volume that the capacity market simulations resulted in. The bids in the day-ahead market and other input variables are unchanged. This also means that the impact of changes in bidding behaviour in the day-ahead market can not be addressed for market participants that have their aFRR capacity bids accepted.

2.5.1. Benefit and costs of aFRR capacity exchange and CZC allocation

In Figure 13 the cost of allocating CZC for aFRR capacity exchange is calculated as the difference in total European socio-economic surplus of the day-ahead market with and without CZC reduced according to the simulation of the Nordic aFRR capacity market. This cost amounts to 4 million Euro and is very low compared to the benefit of exchanging aFRR capacity. Since the demand is the same in the two scenarios, the total benefits of aFRR capacity exchange can be calculated as the reduction in total procurement costs when allowing exchange on all borders. This amounts to approximately 57 million euro and the net-benefit is 53 million euro.

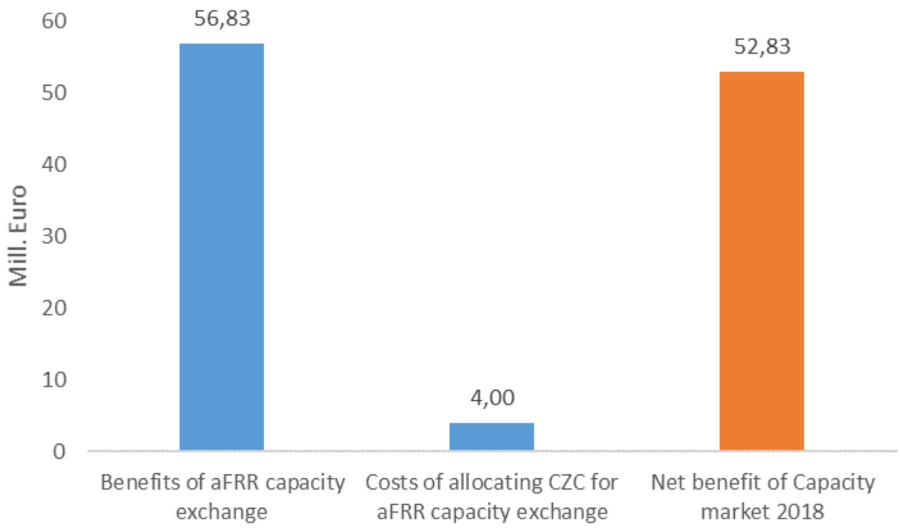

Figure 13. Comparison of benefits of aFRR capacity exchange, cost of allocating CZC for this purpose and total net benefits. Based on simulation of aFRR capacity market and impact on day-ahead market for all hours of 2018. Million Euro

If no access to the "simulation facility" for the day-ahead market would be possible, an approximation of the cost of allocating CZC for aFRR capacity exchange would be to use the reduction in congestion rent of each border neglecting the price impact of reducing CZC. In addition the impact on consumer and producer surplus is assumed to outweigh each other. This is calculated as the actual price difference on each border multiplied with the volume of CZC allocated for aFRR capacity exchange. This approximation would result in an cost of 3.8 million euro, slightly underestimating the total cost. With the example illustrated in Figure 14 where a high price area A get its net-import from low-price area B restricted, this approximation would represent the grey area neglecting the red and blue triangles. In total the grey area, and the triangles add up to the true socio-economic cost of CZC reduction.

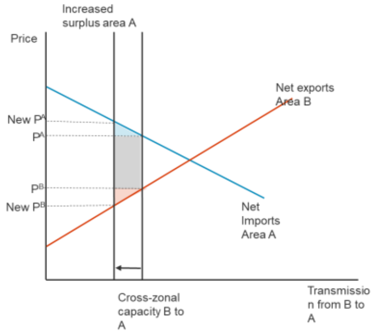

Figure 14. Impact of reducing CZC and reducing beneficial exchange on the total socio-economic surplus of two areas

The simulations based on market data of 2018 is characterized by a large volume of lower priced Norwegian aFRR capacity bids that is exported to other market areas. The large difference in bid prices makes the results less sensitive to the application of method for forecast value of CZC in the day-ahead market. When the demand in importing areas are covered or the maximum CZC allocation volume is utilized, the next unaccepted bid in the exporting area is still significantly cheaper than the next unaccepted bid in the importing area.

Table 10 shows that the costs due reduced CZC in the day-ahead market for the Nordic countries and rest of Europe, and is decomposed to change in congestion rent, consumer- and producer surplus. It is shown in table 8 that Finland gets the highest costs and Sweden actually ends up with a gain from the allocation.

However, one should also be aware that Finland will have the largest share of benefits from exchange of aFRR capacity. Assuming that the most expensive bids are exported from the export countries, the saving compared to using more expensive local bids in Finland would amount to approximately 20 million Euro.

	Change congestion rent	Change consumer Surplus	Chnage producer Surplus	Total cost of reduced CZC
Denmark	- 0,7	1,5	- 0,1	0,7
Finland	- 2,3	18,3	- 12,5	3,5
Norway	- 0,5	- 11,3	13,1	1,2
Sweden	- 6,5	5,9	- 2,4	- 3,0
Rest of Europe	- 2,6	14,2	- 10,1	1,5

Table 10. Distribution of costs of reducing CZC in day-ahead market due to the allocation of CZC in aFRR capacity simulations. Sum for all hours of 2018. Mill. Euro

Impact of CZC allocation on price differences

Below the average change in price difference per hour and border due to the allocation of CZC that the simulation of Nordic capacity market resulted in is shown. The impact is largest for the SE1-FI, SE3-SE4 and SE4-DK2 borders. A clear majority of the average changes is below 0.5 Euro.

Change in price difference in day-ahead market due to allocation of CZC (absolute values)												
HOUR	NO4-SE1	NO4-NO3	NO3-SE2	NO1-SE3	SE1-FI	SE1-SE2	SE2-SE3	SE3-SE4	SE4-DK2	NO1-NO5	NO1-NO2	AVERAGE
0	0,2	0,1	0,2	0,2	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,1
1	0,2	0,1	0,2	0,2	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,1
2	0,3	0,1	0,3	0,2	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,1
3	0,3	0,1	0,3	0,2	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,1
4	0,2	0,1	0,2	0,2	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,1
5	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,1	0,0	0,0	0,1
6	0,2	0,1	0,1	0,2	0,6	0,0	0,0	0,0	0,1	0,1	0,1	0,1
7	0,3	0,2	0,2	0,6	0,9	0,0	0,1	0,3	0,2	0,3	0,3	0,3
8	0,3	0,2	0,2	0,3	0,8	0,0	0,1	0,4	0,1	0,1	0,0	0,2
9	0,3	0,2	0,2	0,4	0,9	0,0	0,1	0,3	0,1	0,2	0,1	0,2
10	0,3	0,2	0,2	0,3	0,6	0,0	0,1	0,2	0,2	0,1	0,1	0,2
11	0,3	0,1	0,2	0,5	0,6	0,0	0,1	0,3	0,1	0,4	0,2	0,3
12	0,3	0,1	0,2	0,4	0,5	0,0	0,1	0,3	0,1	0,2	0,2	0,2
13	0,2	0,1	0,2	0,3	0,5	0,0	0,1	0,3	0,1	0,1	0,1	0,2
14	0,2	0,1	0,2	0,2	0,4	0,0	0,1	0,1	0,1	0,1	0,0	0,1
15	0,2	0,1	0,2	0,2	0,3	0,0	0,0	0,2	0,1	0,0	0,0	0,1
16	0,3	0,2	0,2	0,3	0,4	0,0	0,1	0,2	0,1	0,1	0,1	0,2
17	0,3	0,2	0,2	0,3	0,5	0,0	0,1	0,2	0,1	0,1	0,1	0,2
18	0,2	0,1	0,2	0,3	0,5	0,0	0,1	0,2	0,1	0,1	0,1	0,2
19	0,3	0,1	0,2	0,3	0,3	0,0	0,1	0,2	0,2	0,0	0,0	0,1
20	0,2	0,1	0,1	0,2	0,0	0,0	0,0	0,1	0,2	0,0	0,0	0,1
21	0,2	0,1	0,1	0,2	0,0	0,0	0,0	0,2	0,2	0,1	0,1	0,1
22	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,1	0,1	0,0	0,0	0,1
23	0,2	0,1	0,2	0,1	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,1
AVERAGE	**0,2**	**0,1**	**0,2**	**0,3**	**0,3**	**0,0**	**0,0**	**0,1**	**0,1**	**0,1**	**0,1**	**0,1**

Figure 15. Average absolute value of change in day-ahead market price difference when reducing NTC according to allocation of CZC in simulation of Nordic aFRR capacity market, Euro/MW/hour

The next figure shows how the change in price difference is dependent on the initial price difference without allocation of CZC due to aFRR capacity exchange. It can be seen that the impact on the price difference is larger the larger the price difference is initially. It is mainly when the price difference is large initially that impact on the price difference can be exepted to be the largest. For the largest share of hours the impact can be expected to be quite low. There will always be available CZC in one direction where CZC for aFRR

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capacity exchange can be allocated without having any impact on the clearing of the day-ahead market. If the there is a congestion from Sweden to Finland, down regulation bids can be exported to Finland for free as this will lead to allocation of CZC from Finland to Sweden. The reduction in CZC in this direction would lead to no cost in the day-ahead market.

Interval for price difference before allocation	Change in price difference in day-ahead market dependent on price difference before allocation										
	NO4-SE1	NO4-NO3	NO3-SE2	NO1-SE3	SE1-FI	SE1-SE2	SE2-SE3	SE3-SE4	SE4-DK2	NO1-NO5	NO1-NO2
(0,0]	0,1	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0
(0,1]	0,4	0,3	0,6	0,4	0,5	0,0	0,5	0,4	0,3	0,2	0,2
(1,2]	0,4	0,2	0,6	0,5	0,7	0,0	0,5	0,4	0,2	0,3	0,2
(2,3]	0,4	0,3	0,7	0,6	0,8	0,0	0,6	0,5	0,5	0,3	0,2
(3,4]	0,5	0,3	0,8	0,8	0,8	0,0	1,1	0,9	0,7	0,5	0,3
(4,5]	0,6	0,4	1,0	0,7	0,9	0,0	0,9	0,6	0,5	1,0	0,6
(5,6]	0,7	0,4	0,9	0,6	0,8	0,0	1,0	0,6	0,5	1,0	0,8
(7,8]	1,1	0,6	1,5	0,7	0,8	0,0	1,3	0,7	0,7	1,7	0,3
(9,10]	0,7	0,9	1,2	1,1	0,8	0,0	1,0	0,7	0,8	2,0	2,0
(10,15]	1,2	1,4	1,5	1,0	1,0	0,0	1,2	0,6	0,6	2,6	1,9
(15,30]	1,1	1,0	1,4	1,5	1,8	0,0	1,7	0,9	0,7	3,5	1,5
(30,200]	1,0	0,2	0,7	1,1	9,0	0,0	0,8	2,8	1,2	5,1	24,2
	Observations										
(0,0]	5745	6659	7107	6426	6705	8760	8384	7402	6522	7913	7916
(0,1]	564	520	389	433	182	0	68	93	255	271	229
(1,2]	489	431	262	366	165	0	40	115	530	190	207
(2,3]	375	292	185	229	141	0	29	68	176	82	133
(3,4]	317	202	143	214	138	0	33	75	110	68	83
(4,5]	224	124	136	153	126	0	30	76	113	34	48
(5,6]	158	85	83	133	135	0	31	63	90	30	30
(7,8]	108	49	68	110	99	0	18	52	64	16	13
(9,10]	64	41	45	83	102	0	13	60	70	6	6
(10,15]	260	141	96	234	335	0	23	224	264	28	26
(15,30]	194	83	108	153	309	0	36	286	293	24	15
(30,200]	42	13	14	21	99	0	14	92	114	59	11

Figure 16. Upper table: Average absolute value of change in day-ahead market price difference dependent on initial price different according to intervals given by first two columns, Euro/MW/hour. Lower table: Number of observations per border for the different intervals.

2.6. Conclusions

The Nordic TSOs consider the market based allocation of CZC D-2 to be the most efficient methodology for implementation in the short term. It is an aim to start out conservatively without risking non-beneficial CZC allocation for the exchange of aFRR capacity and causing large impacts on the day-ahead market. It is also an aim to have clear and transparent market rules for the market participants.

The simulations and analyses of section 2.5 indicates that the proposed methodology is consistent with these goals. A challenge with the market based approach is the use of forecasts for the value of CZC for exchange of energy. The analysis of day-ahead market prices of 2016 to 2018 shows that using the price difference of the previous day give in general fairly low forecast errors. The application of on markup of 1 euro for allocation in the congested direction combined with a cap on CZC allocation equal 10 percent of the CZC available for the day-ahead market will ensure that the day-ahead market is favored in dealing with the risk forecast errors. The simulation results based on 2018 data show multiple times higher benefits of aFRR capacity exchange compared to the cost of reduced CZC in the day-ahead market.

The market situation will most likely be change in the future, bidding behaviour and supply of aFRR can change and the volatility of price differences may change according to the resource situation. It is, however, little support for expecting that the proposed method should lead to non-beneficial use of CZC.

It is also important to stress that there is no alternative for having balancing reserves. Reserves are necessary for keeping operational security within acceptable limits. Without Nordic exchange and CZC allocation, reserves must be procured locally and this will also impact on the day-ahead market through change in supply. This effect is important to be aware of and it is also completely neglected in the simulations of the day-ahead market as the supply of bids are the same in the two cases with and without CZC allocation and aFRR capacity exchange.

3. The proposal

3.1. Determining the market value of CZC for the exchange of energy

As stated in Article 39(5) of EB GL, the forecasted market value of CZC shall be calculated based on the expected differences in market prices for the day-ahead market. Intraday market values are not taken into account in the Proposal, but once capacity pricing is introduced to intraday markets it is most likely both relevant and possible to include it in the CZC market value determination.

Two options have been considered for determining these price differences and hence the market value of CZC for the exchange of energy: the use of a reference day, that is a day in the recent past considered likely to be similar to the day in focus; and the use of a commercial forecast provided by an external service provider.

The proposed method is the use of a reference day for forecasting the market value. Both methods, however, have advantages and disadvantages which are outlined in the following sub-sections. Article 39(5) of EB GL mentions in particular the importance of transparency and accuracy in the forecasting method.

3.1.1.Reference day method

In this method, the forecasted market value of CZC between two bidding zones for an hour equals price difference of the corresponding hour of a reference day if it is in the congested direction. If the direction is opposite of the congested direction the forecasted market value is zero.

The reference day shall initially be defined as the day prior to the delivery day. It has also been considered more complex definitions taking adjusting the reference day to weekends, working days and holidays, but as explained in section 2.3 analysis has shown that this does not improve the forecast performance significantly and the simple method of using previous day for all days is considered as the best starting point.

It is important to note that there will be a weekly monitoring of the performance of the method based on reference day. Improvements will be considered continueously. This will however require an amendment of the proposal and thereby require time for consultation and NRA approval before implementation. Potential improvements could lie within the use of other relevant indicators which could be used to adjust the expected prices and price differences. In such cases, all indicators used should be public.

This method has the advantage of its transparency since:

- it is based on clear rules which are completely transparent to stakeholders
- prices and other indicators used shallbe publicly available.

Its main disadvantage lies within its accuracy and potential costs:

- Since there is limited use of new information affecting prices in between the reference day and forecast day, there will be issues with accuracy; there could be considerable forecast errors occurring in periods where essential market drivers are changing.
- It can also be foreseen that there would be considerable costs in assessing and improving the reference day method.

3.1.2. Commercial forecasts

Here, the forecasted price differences would be based on the use of an energy market model by an external commercial provider. This forecast service shall be accessible to all market participants before the auction.

The advantages of this method are considered to be:

- Likely a more accurate and reliable expectation of price differences;
- Shorter contracting periods and more frequent tenders could stimulate competition among the forecast service providers and thereby encourage them to deliver best possible quality of forecasts;
- Considered an easier method to implement than the reference day, with a lower cost than the evaluation and modification work which will be required with the use of a reference day forecast.

The disadvantages of this method relate mostly to transparency:

- For market participants to have access to the forecasts, they would likely need to pay for the service;
- The method behind the forecasts, with the use of energy market models, is not necessarily fully transparent;
- It is not yet certain whether the ex-post publication of forecasted prices would be possible; it shall be a requirement, however, in the tender for the forecast service provider;
- The role of the forecast service provider can be questioned as it will have the power to influence the allocation of CZC and thereby the results of the balancing capacity market. This could be mitigated by clear monitoring and frequent tenders where the provider can be changed.

3.2. Defining the maximum volume of allocated CZC

CZC will only be allocated to the balancing capacity market if the value of using the CZC is likely to be greater in the balancing capacity market than its value in the day-ahead market.

Since the Proposal is based on contracting of balancing capacity less than two days in advance of the provision of the balancing capacity, it is not bound by volume limitations according to the EB GL article 41(2). The maximum volume of CZC that can be allocated, however, is 10% of the forecasted day-ahead market transmission capacity. The volume is limited by the Nordic TSOs in order to avoid internal congestions due to the activation of balancing capacity and limit the impact of the CZC allocation on the day-ahead market.

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3.3. Determining the allocated CZC for exchange of balancing capacity

One of the main inputs to the allocation process will be the market value of CZC, as described in section 1.2.2. In order to take into account the uncertainty around this forecasted value, markups will be placed on the market value that is used to calculate the allocated CZC used for exchange of balancing capacity. This represents a conservative approach for allocating CZC for the balancing capacity market, favouring the day-ahead market:

- When calculating the value of CZC for up regulation in the forecasted flow direction, an markup will be placed on the value of day-ahead market transmission capacity:
  - if there is no forecasted day-ahead market price difference between the two bidding zones, there is no congestion between two the bidding zones and the value of the markup will be 0.1 EUR/MWh;
  - if there is a forecasted day-ahead market price difference between the two bidding zones, there is congestion between two the bidding zones and the value of the markup will be the forecasted price difference between the two bidding zones plus 1 EUR/MWh.
- When calculating the value of CZC for down regulation against the forecasted flow direction, an markup will be placed on the value of day-ahead market transmission capacity:
  - if there is no forecasted day-ahead market price difference between the two bidding zones, the value of the markup will be 0.1 EUR/MWh;
  - if there is a forecasted day-ahead market price difference between the two bidding zones, the value of the markup will be the forecasted price difference between the two bidding zones plus 1 EUR/MWh.
- When calculating the value of CZC for up regulation against the forecasted flow direction or for down regulation in the forecasted flow direction an markup equal 0.1 EUR/MWh will be placed on the value of day-ahead market transmission capacity.

Starting with this approach is conservative; once the market has gone live, more experience will allow for improving methods and allowing more allocation of CZC to the balancing capacity market. A fundamental assumption in the allocation process described previously is that the allocation of CZC for the balancing capacity market will not affect the price difference in the day-ahead market.

These values are then taken into an iterative process in the bid optimisation, where bids are selected and CZC is allocated until an acceptable solution is found. A more detailed account of the bid optimisation and selection process can be found in the separate proposal documents for Nordic balancing capacity exchange.

3.4. Impact of capacity calculation methodology on allocation methodology

The current capacity calcualtion method is based on NTC. As soon as implemented, the allocation of CZC will be in accordance with the Proposal for Capacity Calculation Methodology approved by all Regulatory authorities of CCR Nordic 10 July 2018, which is the flow-based methodology[4]. It is uncertainties about when this methodology will be implemented, but it is not expected to be earlier than summer 2021.

[4] See *All TSOs' of the Nordic Capacity Calculation Region proposal for capacity calculation methodology in accordance with Article 20(2) of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management*, which is published on nordic-rsc.net.

The flowbased methodology means that CZC is represented with Power Transfer Distribution Factor (PTDF) matrices and remaining available margins (RAMs) for critical network elements (CNEs).The PTDFs, CNEs and RAMs are derived from a detailed grid model and assumptions on the state of the power system for each market time unit. Transmission capacity allocated to exchange of balancing capacity is considered as Already Allocated Capacity (AAC) and is subtracted before arriving at the final RAM The allocatoion methodology needs to take into account that the CNEs are dynamic and can be located inside bidding zones.

As with the method based on NTCs, the final PTDFs and RAMs are not ready at the time of procurement of balancing capacity D-2, and the PTDFs and RAMs used in the day-ahead market D-1 is the best available representation of CZC to rely on. A zone to zone PTDF is used in the procurement optimisation function to claculate the utilisation of transmission capacity between bidding zones for different distributions of procurement volumes. The value of this CZC is still based on forecasts and flowbased does not have to impact the method for determining the forecasted value of CZC used for echange of energy.

After the procurement optimisation function has completed the optimisation and the final procurement volumes of each bidding zone are determined, these volume are used as input in the zone-to-CNE PTDF relevant for the actual delivery day which is ready D-1 and the AAC for all CNEs are claucated and included in the RAM before sending this to the market coupling.

3.5. 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:

- The CZC allocated for the exchange of balancing capacity. This will be published after the market clearing results are available.
- The use of allocated CZC for the exchange of 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 balancing 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 is not 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.

Annex 1. Answers to stakeholder consultation

After restructuring of the legal proposals this consultation note is most relevant for the legal proposal "All TSOs of CCR Nordic proposal for a methodology for a market-based allocation process of cross-zonal capacity for the exchange of balancing capcity in accordance with Article 41(1) of Comission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing"

Subject matter and scope, Defintions and interpretation and general remarks to the overall method

Vattenfall:
Vattenfall strongly supports the further integration of the balancing markets in the Nordics and the EU.

Energy Norway:
Energy Norway supports the objective of the NBC – maintaining a high frequency quality through a more effective balancing market design.

Lyse Produksjon:
We are generally positive to the Nordic TSOs' proposal for the methodology allocation process of CZC for the exchange of aFFR balancing capacity. However, we believe that the Nordic TSOs should strive to allow more allocation of CZC. The CZC should be used to exchange the products that gives the highest value, without any restrictions. The Nordic TSOs should set up a common plan with the objective to allow more allocation of CZC to the aFRR capacity market.

Danish Energy:
Danish Energy supports the integration of Nordic and European electricity markets, including in the balancing timeframe, but also believes in the fundamental principle that all cross-zonal capacity (CZC) must be made available to the day-ahead market in a transparent way. This proposal constitutes a trade-off between the two, as it facilitates a regional aFRR market by allowing TSOs to make to withhold capacity from the market.

Agder Energi:
We […] want to point out that in principle we find the "Co-optimised allocation" […] the best solution as it uses the actual market values from the market players in both energy exchange and aFRR capacity exchange.

Nord Pool:
[Under Article 6]: It is difficult to define an "optimisation model" that for most delivery periods (MTUs) will be able to efficiently determine what share, if any, of total CZC shall be allocated to aFRR instead of to day-ahead (and subsequently intraday).

Danish Energy:
[Under the comment on Article 3…] the proposal does not take into account any future valuation of intraday CZC. The final proposal should explicitly address how the intraday CZC value will be reflected in the forecasted value.

TSOs:
As stipulated in Article 39(5) of EB GL, we are obliged to take intraday markets into account "where relevant and possible". We agree that this could be considered for the forecasted value of CZC once capacity pricing is introduced to intraday markets and our general aim is to improve the method of forecasting the value of CZC after start-up of the market and with more experience.

Finnish Energy:
Finnish Energy supports the integration of Nordic and European electricity markets, including in the balancing timeframe, but underlines that the main principle is making all cross-zonal capacity (CZC) available to the day-ahead market in a transparent way.
[..] the proposal does not provide an underlying transparent and market-based method for the reservation of capacity, the TSOs should at a minimum present an analysis comparing the proposed solution to the use countertrading.
The explanatory document focuses on the costs of the TSOs rather than the benefit of the electricity market as a whole. The comparison of price differences just measures the marginal cost/utility to the TSO of reserving capacity and not the marginal benefit to the whole market.

TSOs:
The Nordic TSOs are of the opinion that CZC should be allocated to the market where its value is highest, which is not necessarily always the day-ahead market.
TSOs have expanded the discussion on different methods in the Explanatory Document. As described in the Explanatory Document to this Proposal, countertrading is not seen as a viable alternative to market-based allocation for exchanging balancing capacity; countertrading also requires reserves to be available. As stated in Article 38 of EB GL, the Nordic TSOs have three alternatives for exchanging balancing capacity, of which countertrading is not one; the alternatives, as also described in the Explanatory document, are co-optimisation, market-based allocation and economic efficiency analysis.

Fortum:
We feel that all capacity should always be used primarily in the spot market. If this will not be the case then any methodology used for reserving capacity should primarily ensure the social welfare gains from spot trading. We think that using the Hasle pilot as basis for decision to reserve capacity is not optimal. It seems that the Hasle pilot did not consider impacts on the spot market for bidding zones outside the pilot, for a thorough assessment on the benefits it would have been valuable to consider the impacts on spot market at least for the synchronous grid, not just the bidding zones directly involved in the pilot.

TSOs:
We appreciate the generally positive view on the proposal. We have tried in this first design of the method to balance transparency and feasibility against efficiency and mathematical optimisation, and our priority has been to start the market and develop it from the results seen. We certainly recognise the problems pointed out and while some can be resolved, the solution will always be some kind of compromise.

Regarding the Hasle pilot, as a pilot project it was simple and learnings have been taken from that pilot and have helped to form the first market design. It was decided to prioritise the introduction of the market itself rather than carrying out more pilots. It should also be noted that the analysis of the impacts on the spot market in the Hasle pilot did in fact take into account the impact on all bidding zones, not only those directly involved in the pilot.

Nord Pool (paraphrased here):
There are significant differences between the Hasle pilot and a Nordic aFRR capacity market which should limit the scope of its application:
- The Hasle border is not representative of the other borders in the Nordic synchronous area.
- The Hasle pilot involved only one border, but several borders make the impact of allocating CZC for aFRR much more complex.
- There will be more participants, which will lead to more efficient price formation.
- There is however risk for strategic bidding behaviour – some market participants could benefit from a reduced CZC in the day-ahead market whilst having a detailed understanding of pricing in the relevant bidding zones.

TSOs:
We are aware of the differences between the Hasle pilot and a Nordic market across all bidding zones. As a pilot project, the Hasle pilot was simple and, of course, more pilots could have been carried out. Learnings have been taken from this pilot and have helped to form the first market design. Priority has been placed on introducing the market itself rather than on more pilots, and improvements will be implemented in due course..

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Nord Pool:
Article 1.3: It is not clear under what circumstances it could be possible that "a)…market activities have been suspended" in the timeframe set for the daily procurement process for aFRR, i.e. late in the evening two days before the delivery date. While rules and procedures are to be established to consider possible instances of "market suspension" for events listed in the "Network Code on Emergency and Restoration", it is in our understanding no clear indication in that "NC ER" to on pan-EU level declare a "market suspension" for delivery periods 1-2 days ahead. Furthermore, it has preliminary in writing been indicated by at least Svenska Kraftnät that "market suspension" would not be applied for the day ahead stage, thus we recommend a clarification on this point in the proposal and in the explanatory document.

TSOs:
Thank you for noting this. We have taken this comment into account and have now removed Article 1(3)(a) from the Proposal.

Swedenergy/Finnish Energy:
Although the Electricity Balancing Guideline (EBGL) provides legal basis for the proposed reservation regime, we also would like to refer to article 38(5), which states that capacity reservation is only possible if cross-zonal capacity is calculated in accordance with the capacity calculation methodologies developed pursuant to Regulation (EU) 2015/1222 and (EU) 2016/1719.

TSOs:
TSOs acknowledge that the interpretation of Article 38(5) in the EB GL needs a better explanation than what was offered in the version that was first consulted with the stakeholders. The explanation has been clarified in the explanatory document. TSOs believe that the original proposal complies with said article but to make this more clear we have improved the legal document and added explanations for this in explanatory document.

Notification process for the use of the market-based allocation process

Swedenergy:
EBGL Article 41(1)(a) states that the methodology proposed by TSOs shall include "the notification process for the use of the market-based allocation process".
In our view, this means that TSOs shall prepare a process or mechanism to notify market participants of the actual, day-to-day, use of market-based capacity reservations. It is not sufficient to merely notify other European TSOs of the "detailed description of the approved methodology and time for entering into operation", and it does not seem logical that the EBGL requirement should be interpreted in this way. Clearly, a "notification process" is not necessary for a one-off information to other European TSOs.
We urge TSOs to include in the final proposal a description of a proper notification process to market participants. The notification process should inform market participants about every instance of CZC reservations on a daily basis.

Danish Energy:
EBGL Article 41(1)(a) states that ……
[The comment is identical to the above comment from Swedenergy]

Finnish Energy:
EBGL Article 41(1)(a) states that ……
[The comment is identical to the above comment from Swedenergy]

TSOs:
The Nordic TSOs interpret Article 41(1)(a) to originate from Article 150 of SO GL; it does not concern the publication of market information, rather the notification of other TSOs in the synchronous area. The publication of market information is detailed in other parts of the relevant articles in EB GL and described for the Nordic aFRR capacity market in other Articles in the Proposal. We have modified the legal proposal to make this more clear.

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Determining the actual CZC market value for exchange of balancing capacity and the forcasted CZC market value for exchange of energy

Vattenfall:
What regards the proposed methodology to forecast the market value of CZC Vattenfall notes challenges with both alternatives, but would express a slight preference for the use of a reference day with regards to simplicity and transparency and that it would allow the TSOs to gradually improve the method.
The need for improvement include that the reference day will generate a value that is insensitive to the flexibility of the full bid curve, as only a fixed price difference per hour will be provided, and that the method will be sensitive to peak power situations such as morning hours first day of a cold streak. The former may be for example be addressed through a more dynamic definition of the margin added to the spot market price difference, dependent on the relative price difference.

TSOs:
Vattenfall's support for the choice made is appreciated. We aim to gain experience with the reference day method to improve it as we gain more experience. We have made modifications to legal proposals to make them more precise in what we aim to improve with more expericen of the market. Any changes of the market which demand changes in legal methodologies will be according to the amendment processes set out in EB GL.

Fortum:
Regarding the choice of reference day, "when the day itself (for which capacity is contracted) is a bank holiday, the previous Sunday will be chosen." we have one concern. There are many bank holidays that are national and not synchronised between countries, how will these days be handled during the reservation process, by using a Sunday for the bank holiday bidding zone and previous working day for the other bidding zone? We are also worried that the use of reference day can be sub-optimal with a substantial increase in weather dependent production, and even more worrying is the use of one week old Sunday as a reference.

TSOs:
The specific situation mentioned, when one bidding zone has a bank holiday and the neighbouring bidding zone has not will not be taken into consideration in the first version of the market. The choice of reference day will be the day prior to the day when procurement is done. This is a change from the consulted version and motivation with analysis can be found in Explanatory document..

Swedenergy:
Describe more precise when deviation from 'reference day' will occur.
The detailed rules for defining the reference day and adjustments of the price difference, Article 4(5), should be part of the current proposal and regulatory approval. Alternatively, the proposal should set a clear deadline for finalization of these rules and a process for stakeholder consultation.

TSOs:
The key aim of using the reference day is to be transparent and as accurate as possible; The choice of reference day has been changed from the consulted version and will be the day prior to the day when procurement is done, motivation for this change with analysis can be found in Explanatory document

Danish Energy:
We question the robustness of the proposed methodology to forecast the market value of CZC based on reference day spot prices. The market clearing prices of the day-ahead market on the reference day (i.e. the day prior to aFRR capacity bids) will in many instances not reflect the actual CZC value. For instance, weather conditions may differ, or interconnectors and productions facilities may/may not be available. Similarly, the reference day has very little predictive power for some bidding zones, in particular DK2-SE4.
We also urge to revise the quality of the reference day method after 1 year to evaluate if the proposed model is performing as expected and the day-ahead interconnector capacities are not affected.

Finnish Energy:
Comment exactly as that of Danish Energy, and they reference the calculations in Danish Energy's response.

Energy Norway:
Another weakness of the proposed reference-day method is that this method does not contain information on marginal value of CZC between bidding zones since the basis for allocation is observed price differences on the reference day based on the full capacity allocated to the DA-market.

TSO:
Despite the scepticism, we read the comment as an acceptance of the reference day method. It is already planned to revise and improve the method. We are aware of some of the difficulties and appreciate the inputs on the subject.
The choice of reference day has been changed from the consulted version and will be the day prior to the day when procurement is done, motivation for this change with analysis can be found in Explanatory document. All changes of the market design that involve a change in our proposed legal methodologies will be accoring to the change/amendment process set out in EBGL

Agder Energi:
To mitigate the disadvantaged with the use a reference day to forecast the day-ahead market price differences we encourage the TSOs to implement potential improvements with the use of other relevant indicators as described in the Explanatory document (2.2.1). Example of relevant indicators could be the wind, outages on the interconnectors etc.

TSOs:
We appreciate inputs to potential future improvements.. All changes of the market design that involve a change in our proposed legal methodologies will be according to the change/amendment process set out in EBGL

Nord Pool:
Article 4.3: Application of a reference day to be used for day-ahead market is very difficult in general, given that fundamental conditions (e.g. availability of CZC, major production and consumption units, prognoses on temperature, precipitation, wind levels and solar influx) can shift very significantly from one day to the next. Also, it is as a minimum crucial to explicitly differentiate weekdays from weekends, which is not done now in the proposal while such distinctions are noted in the explanatory document (section 2.2.1). Therefore, we recommend to explicitly add such clarity in the proposal.

TSOs:
We acknowledge the difficulties and drawbacks to the reference day method. All changes of the market design that involve a change in our proposed legal methodologies will be according to the change/amendment process as set out in EBGL. The choice of reference day has been changed from the consulted version and will be the day prior to the day when procurement is done, motivation for this change with analysis can be found in Explanatory document

Hydro Energi:
We consider the proposed methodology for pricing the CZC (reference day) acceptable in the short term, although a more accurate forecast of CZC price differences would be preferable. But we also agree that the method should be transparent, public and impartial/not susceptible to third party influence.

TSOs:
Hydro Energi's support for the choice made is appreciated. All changes of the market design that involve a change in our proposed legal methodologies will be according to the change/amendment process set out in EBGL .

Defining the maximum volume of allocated cross-zonal capacity

Swedenergy:
Market participants have very negative experiences with undue CZC reservations by TSOs in the past. In several cases, for instance on Hassle, Storebælt and Skagerak, previous capacity reservations by TSOs have been found to be in conflict with fundamental market principles and consequently repealed by regulatory decision.
On this background, we welcome that TSOs have voluntarily decided to cap the maximum volume of CZC reservations. We would, however, like to see an assessment of different cap levels or, at least, justification or for the capping the volume at 10 per cent level rather than 5 per cent or other options. But from a strict theoretical view, a cap is not logical. The fundamental motivation is a socioeconomic efficient use of CZC, and IF the

method/model makes a correct valuation between using capacity in different markets, a cap is socioeconomic inefficient. The conclusion is that the TSOs should be very conservative in the reservation.

Danish Energy:
Market participants have very negative experiences with undue CZC reservations by TSOs in the past. In several cases, for instance on Storebælt and Skagerak, previous capacity reservations by TSOs have been found to be in conflict with fundamental market principles and consequently repealed by regulatory decision.
On this background, we welcome that TSOs have voluntarily decided to cap the maximum volume of CZC reservations. We would, however, like to see an assessment of different cap levels or, at least, justification or for the capping the volume at 10 per cent level rather than 5 per cent or other options.

Finnish Energy:
[Exactly the same as Danish Energy]

TSOs:
We understand your hesitations in embracing this topic and that this is based on previous experiences. The previous capacity reservations of Storebælt and Skagerak are however not directly comparable to the method proposed here since they were not dynamic reservations.
Please see below for TSO comment on the 10 % limit.

SFE Produksjon:
Open up for a higher CZC allocation to the aFRR market than 10% of NTC

Lyse Produksjon:
We are generally positive to the Nordic TSOs' proposal for the methodology allocation process of CZC for the exchange of aFFR balancing capacity. However, we believe that the Nordic TSOs should strive to allow more allocation of CZC. The CZC should be used to exchange the products that gives the highest value, without any restrictions. The Nordic TSOs should set up a common plan with the objective to allow more allocation of CZC to the aFRR capacity market.

TSOs:
Please see below for TSO comment on the 10 % limit. The 10 % limit is considered by TSOs to be a conservative starting value, but please also note that given the market size and the capacity on various interconnectors, that most probably the 10 % will be the constraining factor in relatively few hours in total.

Energy Norway:
Article 5(1): The current proposal is based on the market-based allocation principle. Based on this principle, CZC is allocated between markets based upon CZC market value in alternative markets measured as price differences. The limit of CZC allocated to exchange of aFRR between each bidding zone in this proposal has a static value of 10% even if the marginal value of allocating CZC for exchange of aFRR are different between bidding zones […is this] the best way of optimizing the allocation process[?]. This represents a starting point, and the method will likely be improved over time.
5(2): is about additional transmission constraints. The guidelines for additional transmission constraints should be published and the practice transparent in order to facilitate predictable framework conditions.

TSOs:
Regarding the lack of elasticity when just looking at price difference on a reference day: the uplift is to some extent an accommodation to this.
Please see below for TSO comment on the 10 % limit.

Agder Energi:
Art 5(1): We support 10 percent as a starting point, but think it is unnecessary to have such a rigid restriction in the future. The focus should be to increase socio-economic welfare on a Nordic level. As long as the consequences of the capacity allocation are examined in weekly reports, there should be a possibility to reserve more if that increase the welfare. We therefor suggest changing the wording in article 5(1) to 10 percent as a starting point and open for higher volumes as long as it can be proven that this will increase socio-economic welfare on a Nordic level.

Art 5(2): In article 5(2) it is suggested that additional transmission constraints may be provided to avoid situations that are not considered secure. If such constraints are used it is important that the information are made available for marked in due time in advance.

TSOs:
We certainly aim to harvest socio-economic benefits, the challenge is however to employ the right methods to optimise between two markets with different auction times, hence we start out conservatively.
To define the cap in such a way that leaves it open to change without involving regulators is most likely not possible.
All information will be made available to the market according to current transparency regulation.

General TSOs on the 10% limit:
As can be seen from the various comments on Article 5, there are contrasting views on limiting the amount of CZC that can be allocated for exchanging aFRR capacity. As mentioned by one respondent, theoretically in a co-optimisation approach a cap would not be needed. In the market-based allocation method for allocating CZC, however, it is considered a conservative approach to start with a limit. The selection of 10 percent corresponds to Article 41(2) in EB GL. We are not required to apply this limit by EB GL, but have chosen to in order to be conservative. In the

initial phases of the market, with a market size of 300 MW, the CZC volumes will generally be lower than 10 percent on many borders. The 10 percent limit will be evaluated once the market is in operation.

Determining the allocated volume of cross-zonal capacity for exchange of balanincg capacity

Hydro Energi:
We support the proposal to reserve CZC for exchange of aFRR capacity between bidding zones when it increases the total socio-economic welfare, and while such reservation do not have a detrimental effect on the liquidity of the day ahead market.

Vattenfall:
In a long series of consultations related to the Electricity Balancing Guidelines (EBG) Vattenfall have expressed concerns with the introduction of cross zonal reservation of Cross Zonal Capacity (CZC), as any change in cross border capacity may cause significant changes in welfare creation of the day-ahead and intraday market and that the alternative methods differ in terms of socioeconomic efficiency.
Vattenfall recognize the TSOs efforts to complement the proposal with measures to reduce the risk of unintended negative consequences for the spot and intraday trading. However, to ensure that this aim is achieved, Vattenfall recommends that any chosen method is subject to regular evaluation and regulatory oversight. We also encourage the Nordic TSOs to transparently describe their ambition to evaluate and improve the methodology, within the framework given by the EBG.

TSOs:
The aim with the CZC allocation methodology is to achieve a more socio-economic efficient utilisation of CZC in total by comparing the value of CZC for the energy market and the aFRR capacity market. In general, it is important to realise that not only the allocation of CZC but also the procurement of reserves itself, will have an impact on the day-ahead and intraday market as reserved aFRR capacity will lead to less bid volumes in the energy markets. Without any allocation of CZC for exchange of aFRR capacity, more expensive aFRR bids will be procured to fulfil the requirements in accordance with operational security. These bids may be more expensive because due ot a higher alternative value in the DAM and therefore may impact the day-ahead market clearing to a greater extent than the cheaper bids that cannot be procured without CZC allocation.

The method for determining value of CZC in the energy markets will involve an element of uncertainty. We will however start conservatively in the sense that the energy market is favoured in dealing with this uncertainty. This will lead to less socio-economic effient outcome, but the aim is to make improvements as more experience is gained.

Swedenergy:
Very small changes in available cross border capacity can result in significant changes in the clearing price of a volatile day-ahead market. Consequently, TSOs should be conservative in the methodology and actual reservation levels to cause as little interference in the market as possible. There is a considerable risk that TSOs withhold capacity for aFRR exchange that would have had a higher value in the day ahead market, and we believe that this risk is not sufficiently reflected in the current proposal. To address this, TSOs should establish clearer criteria for forecasting the CZC value; make use of higher uplift values; consider a more conservative reservation cap than 10 percent of the NTC; and establish a fully transparent notification process to market participants of the use of reservations.
…AND [same again]:
TSOs should be cautious when determining the allocated volume of CZC. Small changes in available CZC can significantly impact day-ahead prices and may lead to suboptimal - and too large - CZC reservation volumes.
Given the high uncertainty of the proposed methodology to forecast the market value of CZC, the proposed uplift values (0,1 EUR/MWh, 1 EUR/MWh) in Article 6(4) should be increased to ensure that reservation volumes are conservative.

Danish Energy:
The TSO's are urged to revise the 0.1 and 1 EUR/MWh values and eventually define an interconnector dependent uplift and eventually even a separate uplift for each direction of each interconnector.
TSOs should be cautious when determining the allocated volume of CZC. Small changes in available CZC can significantly impact day-ahead prices and may lead to suboptimal - and too large - CZC reservation volumes. Given the high uncertainty of the proposed methodology to forecast the market value of CZC, the proposed uplift values (0,1EUR/MWh; 1EUR/MWh) in Article 6(4) should be increased to ensure that reservation volumes are conservative.

TSOs:
Within both the proposal and explanatory documents, we aimed to highlight our acknowledgement that establishing a value of CZC is difficult and will be inaccurate at times. As with any method based on a proxy, there is a risk that the proxy is not in line with reality. It is true that at times there will be sub-optimal allocation, which could lead to both of "too little" or "too much" CZC allocation for the aFRR market. Both the 10 percent limit and the uplifts are conservative measures that favour the day-ahead market. It is our full intention to review these parameters regularly, improve the accuracy of the method, and ensure increased socio-economic benefits for the Nordic market.

Energy Norway / SFE Produksjon:
The uplift of 0.1 €/MWh "against the expected flow" should be dropped since a potential activation will reduce the flow.

TSOs:
The 0.1 EUR/MWh is implemented for technical reasons to ensure that CZC allocation isn't allocted for aFRR capacity exchange when there is a an equally good solution without allocation of CZC. Although the flow direction can be predicted with high certainty, there is always a certain risk for errors and therefore unnecessary CZC allocation for aFRR capacity should be avoided. A low uplift of 0.1 EUR/MWh is not expected to have significant impact on the realised socio-economic efficiency of the method.

Energy Norway:
The TSOs rightly states that one weakness of the proposed method is accuracy. The basis for our response to this consultation is therefore that the present method represents a starting point, and that it will be improved going forward, to provide for more effective market-based allocating of CZC. The ultimate goal could be to establish a D-2 Transmission Right auction (for X% of expected NTC) setting a market-based price between the price areas and making the optimization between aFRR-capacity, mFRR-capacity, Intra-Day and DA-markets based on the market players bidding

SFE Produksjon:
Establish a D-2 Transmission Right auction (for X% of expected NTC) setting a market based price between the price areas and making the optimization between aFRR-capacity, mFRR-capacity, Intra-Day and Day-Ahead markets based on the market players bidding.

TSOs:
The proposal can be interpreted as implementing a financial transmission right auction where the market players place bids on the right to receive the congestion rent of a certain bidding zone border. The purpose is to achieve a valuation of CZC in the energy market. However, the quality of the auction price as a proxy for the market value of CZC in the energy market depends on the interest of market players to participate in the auction and their motivation for bidding. For instance it is not unreasonable to expect that market players will have a required return that lead to a systematic under estimation of the realised price difference. The introduction of flow based market coupling also raises some practical questions for how the auction rules shall be adapted. This is not considered as robust approach for inclusion in this proposal.

Nord Pool (slightly reworded/shortened in parts):
Some more details can be good to include in the model:
- Uplift values per bidding zone and combination of bidding zones that are more reflective of the respective level of price elasticity. A standard static uplift for all bidding zones is not relevant.
- Some reflection of (compensation for) different level of CZC having been given for each border on the reference day versus what is expected for the delivery day in question.
- A greater, non-standard and non-static uplift value than 0.1 EUR/MWh when there is no congestion forecasted on a border, because:
(a) the CZC permitted to be removed from day-ahead in favour of aFRR can easily be larger than what the remaining CZC was on the reference day,
(b) since it seems logical that participants would use the day-ahead BZ prices from the reference day as benchmark for their aFRR orders, thus only give up-regulation orders above and down-regulation orders below the given BZ price and that regard less of if the BZ had equal price or not with the adjacent BZ on the reference day since orders reflect energy "activated" within the BZ and not a cross zonal position for any individual participant.

TSOs:
The initial method is conservative and intentionally simple. Potential improvements will be evaluated once the market has begun, with the valuable suggestions above being taken into account.

Publication of information

Nord Pool:
Article 7.1: it is good that publication of CZC capacity allocated for aFRR will be published before the GCT of the day-ahead market for the given delivery date, but it is hard to see why publication should be delayed until after the CZC for the day-ahead market have been published. 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 overall results, including both prices and the CZC capacity allocated to aFRR, should in our view be published to the overall market right after the procurement process has ended, e.g. "without undue delay" as stated in Art. 4.8 of the related proposal, consulted on in parallel, linked to Article 33(1) of the EB GL.

TSOs:
We understand your comments and have adjusted the Proposal accordingly.

SFE Produksjon:
The following "losses of socio-economic welfare" should be calculated and published:
a. Losses due to incorrect day-ahead price prognosis
b. Losses due to the 10% limit (CZC allocation as part of NTC)
c. Losses due to the uplifts

Agder Energi:
Finally, we want to encourage the TSOs to use the weekly report with estimated costs and benefits according to article 7(2) to also include an evaluation of the actual versus optimal volume of reserved cross zonal capacity (CZC). With simple sensitivity analyzes, it should be possible to include an evaluation of the "forecast error" based on the chosen method (reference day) to forecast the energy exchange.

TSOs:
There will be a regular monitoring based on standard calculations. The explanatory document is adjusted to include more detailed description about what will be included.

Energy Norway:
All publication of information should be made on the webpages of the respective TSOs in addition to the ENTSO Transparency platform.
Article 7(1): The CZC allocated for the exchange of aFRR capacity should be published without undue delay after the NTC-data have been submitted.
Article 7(2): The actual utilization of allocated capacity should be published on the same time interval. In addition, potential socio-economic losses due to incorrect DA-price difference prognosis, the 10% limit and the uplifts should be published.

TSOs:
We intend to publish information about market result/outcome no later than 30 minutes after the procurement of capacity. This will included procured volumes and allocated CZC. We will also monitor the market and potential socio-economic losses and gains and this will be made public to the market..

Swedenergy:
If the proposal is approved, and TSOs make use of CZC reservations for aFRR exchange, we also consider it crucial that TSOs are obliged to report on the volume and frequency of 'undue' reservations where forecasted CZC values are significantly lower than realized day-ahead. Also, any unused reserved capacity should be made available for the market participants as soon as possible.

Finnish Energy:
We also call that TSOs report on the volume and frequency of 'undue' reservations where forecasted CZC values are significantly lower than realized day-ahead.

TSOs:
We intend to publish information about market result/outcome no later than 30 minutes after the procurement of capacity. This will included procured volumes and allocated CZC. We will also monitor the market and potential socio-economic losses and gains and this will be made public to the market.
The request to make "unused reserved capacity" available for the market is hardly possible, since that information is not known in advance.

Firmness, Final provisions, Publication and implementation of the Proposal, Language and other issues

Vattenfall:
In addition would request a clarified explanation on of the role of counter trade as a measure to both uphold the CZC for the spot and intraday market and ensure the socioeconomic exchange of balancing capacity. One concrete way to develop the concept of countertrade would be to evaluate the potential of a regional intraday closing auction, where market participants could offer flexibility close to real time in a setting that would allow the TSO to access it in an efficient way.

Finnish Energy:
As the proposal does not provide an underlying transparent and market-based method for the reservation of capacity, the TSOs should at a minimum present an analysis comparing the proposed solution to the use countertrading.
One main concern is the lack of a full socio-economic analysis of the proposal. Rather the starting point is a cost-efficient method of achieving a model agreed between the TSOs themselves. There is no analysis why countertrade or using actual prices would be worse alternatives.

TSOs:
TSO has made extra analysis and motivation for our choice of the market based allocation method. Extra analysis and motivation can be found in the updated explanatory document for article 41(1)

Hydro Energi:
We urge the TSOs to conduct periodic reviews of the pricing methodology and the maximum share of CZC that can be allocated to aFRR capacity. It seems unlikely that the optimal share of capacity would be the same fixed percentage for all border in all hours due to (local) risk of internal congestions, which are known to vary in both time and space.

TSOs:
The TSOs will monitor the market and regularly consider improvements of methodology. *All changes of the market design that involve a change in our proposed legal methodologies will be according to the change/amendment process as stated in EBGL*

Nord Pool:
[It could be good to include in the pricing model…] a reconsideration of the pay-as-bid availability payment for aFRR orders since that leads to prices of individual up-/down-regulation orders being higher/lower then order prices of identical volumes (resources) in the day-ahead market where marginal pricing is applied.

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As noted in the longer-term outlook for the aFRR capacity market in the separate proposal, where pricing is discussed, the long-term aim is for settlement to be based on marginal pricing.

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Annex 2. Swedish case study

The Swedish power system consists of a structural surplus area in the north (SE1 and SE2) and a structural deficit area in the south (SE3 and SE4). The FRR balancing resources necessary to cover the dimensioning incident of 1450 MW in the deficit area is ensured via the Disturbance reserve, which consists of long-term pre-contracted gas turbines in combination with gas turbines owned and operated by Svenska kraftnät subsidiary company[5]. In addition to the Disturbance reserve, there is generally a very limited volume of dispatchable balancing resources available in the deficit area as shown in Table 11. Note that the table exhibits average values. There is a substantial fraction of hours with no additional Up or Down regulating bids at all in SE4.

Table 11: Average total volume of FRR capacity (hour data) in SE3 and SE4 during 2018 (1 Jan- 1 Dec). The data includes the Disturbance reserve. Source: www.nordpoolgroup.com/historical-market-data/

	mFRR Up [MW]	mFRR Down [MW]
SE3	1050	155
SE4	455	28
In addition, Svenska kraftnät and Energinet have a sharing agreement of 300 MW mFRR		

In addition to the limited balancing capacity in the deficit area, there is a significant number of hours where the possibilities to exchange balancing energy from adjacent areas are very limited due to the utilization cross-zonal capacity in the wholesale market. The Table exhibits the utilization on the relevant borders and directions.

Table 2: Utilization of cross-zonal capacity on the borders SE2 →SE3 and SE3 →SE4 (flow of capacity/allocated capacity). Source: www.nordpoolgroup.com/historical-market-data/

Utilization	100%	90 – 99%	Less than 90%
SE2 → SE3	5%	10%	85%
SE3 → SE4	20%	11%	69%

An alternative to the above representation is to count the number of hours when there is a price difference in the regulating power market. This figure indicates the occurrence of bottlenecks in real-time. These figures are shown in table Table 12 below.

Table 12: Percentage of time where there are price differences in the Power regulation market. This may be used as an indication for the occurrence of bottlenecks during operation. Source: www.nordpoolgroup.com/historical-market-data/

	Price difference when Up-regulation	Price difference when Down-regulation
SE2 / SE3	1%	1%
SE3 / SE4	13%	13%

[5] Svenska Kraftnät Gasturbiner AB, 11 gas turbines with a total installed capacity of 690 MW.

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There is also an increasing number of hours where the available resources (including the Disturbance reserve) in the deficit area of southern Sweden are insufficient to cover the dimensioning incident and the balancing need (refer to Table 11, which only show the average volume), and where the wholesale market would utilize all allocated cross-zonal capacity. In order to ensure a safe operation of southern Sweden, Svenska kraftnät are in these cases forced to withhold capacity from the wholesale market and allocate it for exchange of balancing capacity. The volumes are shown in Figure 1. below. As an important mitigation measure, Svenska kraftnät has decided to procure an additional volume of mFRR via long-term contracts[6].

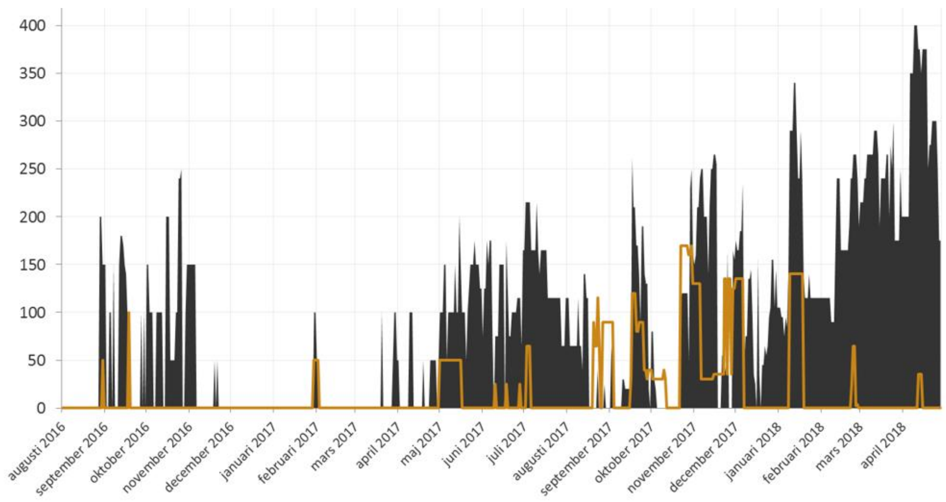

Figure 17: Cross-zonal capacity allocated for exchange of balancing services during the period from August 2016 to April 2018. The black line show cross-zonal capacity between SE2 and SE3. Yellow line shows cross-zonal capacity between SE3 and SE4. Source: Svenska kraftnät

The overall conclusions from the Swedish case study are summarized below:

- Availability of balancing capacity are unevenly distributed between the Swedish bidding zones.
- There are structural power flows and bottlenecks in the Nordic power system, which translates into a high level of utilization in wholesale market of allocated cross-zonal capacity. The same borders are essential for exchange of balancing services.
- These overall conclusions impact on the possibilities to efficiently use counter trade:
- Low availability of balancing capacity limits the possibility for counter trade

The high level of full utilization of allocated cross-zonal capacity implies at the same time an extensive need for counter trade if used as a sole method to free cross-zonal capacity for the exchange of balancing services. This would require additional capacity procurement (for counter trade purposes, withheld from DA)

The System operator are obliged to ensure safe operation in all hours, which require availability of balancing services to cover both the dimensioning incident and normal imbalances.

[6]https://www.Svenska Kraftnät.se/om-oss/press/Svenska-kraftnat-forstarker-den-snabba-aktiva-storningsreserven---3243408/

A transparent method for allocation of transmission capacity would allow market integration and exchange of balancing services across the bidding zone borders also in situations where counter trade is unfeasible. In the Swedish case, it would ensure availability of sufficient reserves in the southern deficit area and at the same time generate robust price signals to BSPs in all four Swedish bidding zones since the value of cross-zonal capacity is included in the allocation process. This is valid for FRR in general. In the case of automatic FRR, there are currently no volumes available in southern Sweden. The Nordic TSOs believe that aFRR capacity market underpinned by allocation of cross-zonal capacity is essential in order to establish a stable and integrated market environment also in cases where counter trade is unfeasible do to small bidding zones and limited availability of flexible resources.

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Annex 3. Nordic TSOs' legal assessment of EB GL, Article 38.5

Content

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Summary

The Nordic TSOs understand the rationale behind the legal considerations NordReg has put forward, based on EBGL, article 38.5. The Article require full implementation and use of Flow based before the cross-zonal capacity is allocated for exchange or sharing of balancing reserves. However:

- There is no clear link between the Capacity calculation method according to CACM (or FCA) seen from an operational or economic efficiency perspective.
- The calculation method Flow based has been approved
- An early establishment of a market based integrated balancing capacity market is clearly in line with the purpose of Regulation 714/2009 and serve the purpose of EB GL (i.e. to integrate balancing markets and to promote the possibilities for exchanges of balancing services while contributing to operational security)
- An early application of a capacity market, by two or more TSOs, would also be in line with recital 16 in EBGL
- In its monitoring report for the year 2017, ACER has stated that "the largest share of balancing costs continued to be the procurement costs of balancing capacity, which emphasises the importance of optimising balancing capacity procurement costs". TSOs and NRAs clearly share the objectives and need to work together on the way forward.

Background

The Nordic TSOs have drafted a proposal for a market-based allocation process of cross-zonal capacity for the exchange of FRR balancing capacity. The proposal has been referred to the national regulators and to the market, and the regulators have asked for an explanation on how the proposal meets the requirements in article 38.5 in Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (EBGL).

A calculation methodology for the cross-zonal capacity pursuant to Regulation (EU) 2015/1222 (CACM) and (EU) 2016/1719 (FCA) has been referred to the market and to the national regulators. CACM method has been approved and FCA method will be submitted for approval in January 2019. Question has arisen if it is sufficient, for the establishment of an integrated FRR capacity market, that the calculation methodology has been approved, or if it is a prerequisite that the approved methodology also must have been implemented.

Relevant regulation

Regulation (EC) No 714/2009 of the European Parliament and of the Council ("Regulation 714/2009")

According to article 1 in Regulation 714/2009 the regulation aims at:

a) setting fair rules for cross-border exchanges in electricity, thus enhancing competition within the internal market in electricity, taking into account the particular characteristics of national and regional markets. This will involve the establishment of a compensation mechanism for cross-border flows of electricity and the setting of harmonised principles on cross-border transmission charges and the allocation of available capacities of interconnections between national transmission systems;

b) facilitating the emergence of a well-functioning and transparent wholesale market with a high level of security of supply in electricity. It provides for mechanisms to harmonise the rules for cross-border exchanges in electricity

According to article 4, all transmission system operators shall cooperate at Community level through the ENTSO for Electricity (ENTSO-E), in order to promote the completion and functioning of the internal market in electricity and cross-border trade and to ensure the optimal management, coordinated operation and sound technical evolution of the European electricity transmission network.

According to article 12, TSOs shall establish regional cooperation within the ENTSO-E. TSOs shall further promote operational arrangements in order to ensure the optimum management of the network and shall promote the development of energy exchanges, the coordinated allocation of cross-border capacity through non-discriminatory market-based solutions, paying due attention to the specific merits of implicit auctions for short-term allocations, and the integration of balancing and reserve power mechanisms.

Regulation (EU) 2017/2195 of 23 November 2017 (EB GL)

According to article 3 in EBGL, the regulation *inter alia* aims at integrating balancing markets and promoting the possibilities for exchanges of balancing services while contributing to operational security. Moreover, it is stated that when applying this regulation, it shall be ensured that TSOs make use of market-based mechanisms, as far as possible, in order to ensure network security and stability.

In accordance with article 38.5, TSOs may allocate cross-zonal capacity for the exchange of balancing capacity or sharing of reserves only if cross-zonal capacity is calculated in accordance with the capacity calculation methodologies developed pursuant to Regulation (EU) 2015/1222 and (EU) 2016/1719.

In recital 16 it is stated that once a methodology for the allocation process of cross-zonal capacity is approved by the relevant regulatory authorities, early application of the methodology by two or more TSOs could take place to gain experience and allow for a smooth application by more TSOs in the future. The application of such a methodology, where existing, should nevertheless be harmonised by all TSOs in order to foster market integration.

Analysis

EBGL is based on Regulation 714/2009. The main purpose of Regulation 714/2009 is to setting fair rules for cross-border exchanges in electricity, thus enhancing competition within the internal market in electricity. One could argue that an early establishment of a market based joint balancing capacity market serves the purpose of this regulation, since it will lead to a common capacity market that supports trade between EU member states and supports the free movement of goods (electricity). Coordinated allocation of cross-border capacity through market-based solutions as well as integration of balancing and reserve power mechanism are further especially mentioned in article 12 of Regulation 714/2009, as motives for the establishment of ENTSO-E. Moreover, an early integration would also serve the purpose of EBGL as the purpose is described in article 3 in EBGL, i.e. to integrate balancing markets and to promote the possibilities for exchanges of balancing services while contributing to operational security, and would also be in line with recital 16 in EBGL in order "*to gain experience and allow for a smooth application by more TSOs in the future*".

In a monitoring report for the year 2017, ACER has stated that *"the largest share of balancing costs continued to be the procurement costs of balancing capacity, which emphasises the importance of optimising balancing capacity procurement costs"* and that "*an integrated cross-zonal balancing market is intended to maximise the efficiency of balancing by using the most efficient balancing resources while safeguarding operational security*.[7] These statements support the importance of an efficient and integrated balancing market, including a balancing capacity market.

Considering the above, there is much to suggest that it would be in line with the objectives and purpose of EBGL and Regulation 714/2009 to interpret article 38.5 in EBGL in accordance with the TSOs interpretation, and that an early integration also could serve as an important step to an even more integrated and efficient market solution which also would be in line with the main objectives of the EU-cooperation.

Arguments for an early implementation of a cross-zonal capacity market

- The methodology for calculating the capacity is not of any significance when deciding a methodology for the allocation process of cross-zonal capacity. The present calculation method is in line with the fundamental principles of the EU-cooperation and is in line with the relevant parts of Regulation (EU) 2015/1222 and (EU) 2016/1719

[7] ACER/CEER - Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017 – Electricity Wholesale Markets Volume, paragraph 231-232.

- Moreover, an early allocation of cross-zonal capacity could be justified on the following grounds:
  - The method for calculating the capacity pursuant to Regulation (EU) 2015/1222 has been approved by the NRAs and (EU) 2016/1719 is planned to be submitted for NRA approval in January 2019.
  - An early establishment of a market based integrated balancing capacity market is in line with the purpose of Regulation 714/2009, i.e. to setting fair rules for cross-border exchanges in electricity, thus enhancing competition within the internal market in electricity. An integrated capacity market will support trade between EU member states and support the free movement of goods (electricity), which are main objectives for the EU-cooperation.
  - An early integration would also serve the purpose of EBGL (as the purpose is described in article 3 in EBGL), i.e. to integrate balancing markets and to promote the possibilities for exchanges of balancing services while contributing to operational security.
  - An early application of a capacity market, by two or more TSOs, would also be in line with recital 16 in EBGL in order "*to gain experience and allow for a smooth application by more TSOs in the future*".
- In its monitoring report for the year 2017, ACER has stated that "the largest share of balancing costs continued to be the procurement costs of balancing capacity, which emphasises the importance of optimising balancing capacity procurement costs" and that "an integrated cross-zonal balancing market is intended to maximise the efficiency of balancing by using the most efficient balancing resources while safeguarding operational security". These statements underline the importance of an efficient and integrated balancing market, also including the balancing capacity markets.