European Network of
Transmission System Operators
for Electricity

Explanatory document to the 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 Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

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Contents

1. Introduction

This document gives background information and the rationale for Energinet, Fingrid, Statnett and Svenska kraftnät proposal's for the methodology for a market-based allocation process of cross-zonal capacity (hereinafter referred to as "CZC") 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 (hereinafter referred to as "EB GL"). This proposal is hereinafter referred to as the "Proposal", and Energinet, Fingrid, Statnett and Svenska kraftnät are hereinafter collectively referred to as the "Nordic TSOs".

1.1. 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 the EB GL, shall later be replaced by a 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 a 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 includes a methodology for the allocation of CZC. The initial choice of methodology is a market-based allocation process as described in Article 41 of the EB GL. This methodology was also tested in a project – the "Hasle pilot" (see section2.2). The proposal for establishment of common and harmonized rules and processes for the exchange and procurement of aFRR capacity is consulted on separately. The two proposals are, however, carried out in parallel and may advantageously be read in conjunction.

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

1.2. Legal basis

Regional balancing capacity markets are not mandatory under European legislation, but they are regulated. Title III Chapter 2 of the EB GL and Article 33 in particular are relevant for the Nordic aFRR capacity market. Furthermore, the Nordic TSOs have agreed to allocate CZC for the exchange of aFRR capacity; consequently Title IV Chapter 1 of the EB GL and, in particular, Articles 38, 39 and 41 are of relevance for the 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.

Option (b) has been chosen and the development of that method is subject to Article 41 of the EB GL. The choice of option (b) is further elaborated on in section 2.1.3.

In accordance with Article 38(5) of the EB GL, TSOs may allocate cross-zonal capacity for the exchange of balancing capacity or the 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 required 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 the early application of the allocation methodology pursuant to the Proposal.

1.2.1. NRA Approval and Implementation timeline

According to Article 5(3) of the EB GL:

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

(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 the relevant regulatory authorities for approval at the latest two years after the EB GL entered into force, which is translated to the 18th of December 2019 and the proposal shall cover the CCR Nordic.

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

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 the 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 for the establishment of common and harmonised rules and processes for the exchange and procurement of balancing capacity and for the application of a market-based allocation process in accordance with Article 33(1) and Article 38(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing" with an accompanying explanatory document.

1.4. Definitions

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

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

This section aims to motivate the decision to allocate CZC for the exchange of balancing capacity and more specifically the use 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 briefly presented in section 2.2. In section 2.3, a theoretical framework is given to provide a general understanding of the socio-economic benefits of allocating CZC for the exchange of balancing capacity. This section also explains how the proposed methodology relates to the theoretical framework. This serves as a basis for the next three sections, sections 2.4, 2.5 and 2.6, which include 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 the 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 the allocation of cross-zonal capacity in accordance with a market-based allocation process (EBGL, article 41). This section aims 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 uses 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 ACER[1]. 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.

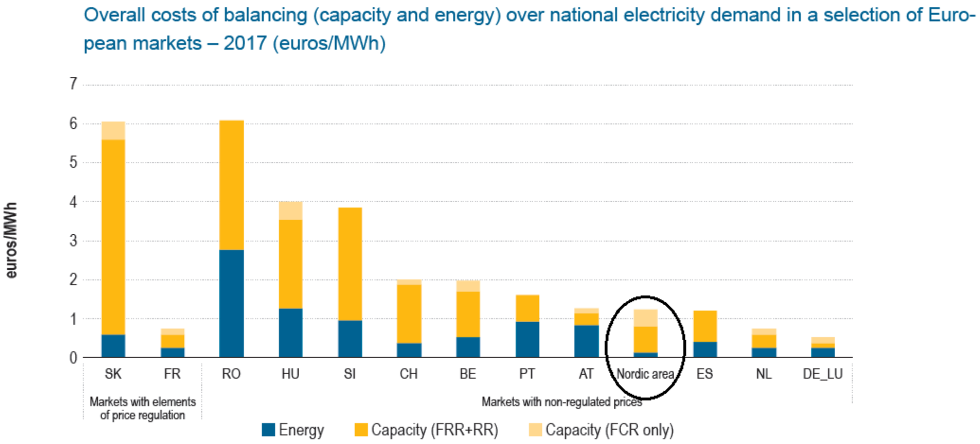

Figure 1: Overall cost for balancing. Source: NRAs and ACER calculations, Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017 (October 2018)

[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

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 are 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, 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 is 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.

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	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.

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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 probabilistic 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 predicts 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 Instead 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 affects the bids submitted to the energy market. 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 is 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 1.

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 Foster liquidity of balancing markets while preventing undue market distortions	Yes, the method is objective and transparent if market indicators are adequately published. 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	Uncertain long-term investment incentives, depending on the efficiency and volume of countertrading. Unlikely to provide correct signals as it dampens energy price differential artificially

	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	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.

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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.

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

[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/

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 Figure 2 for a market without any congestions and transport costs.

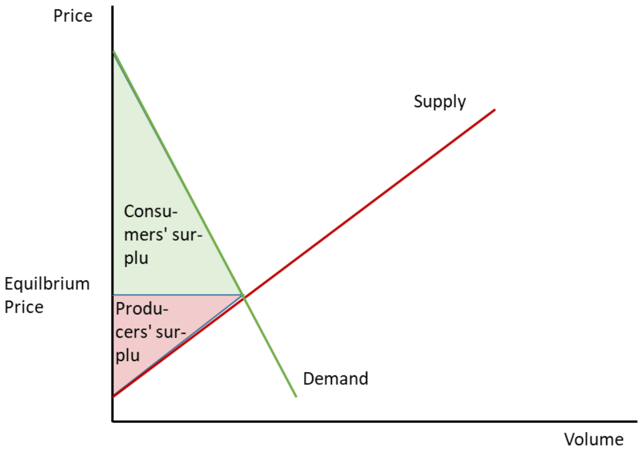

Figure 2. Socioeconomic surplus in market with no congestion and no transport costs

Figure 3 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.

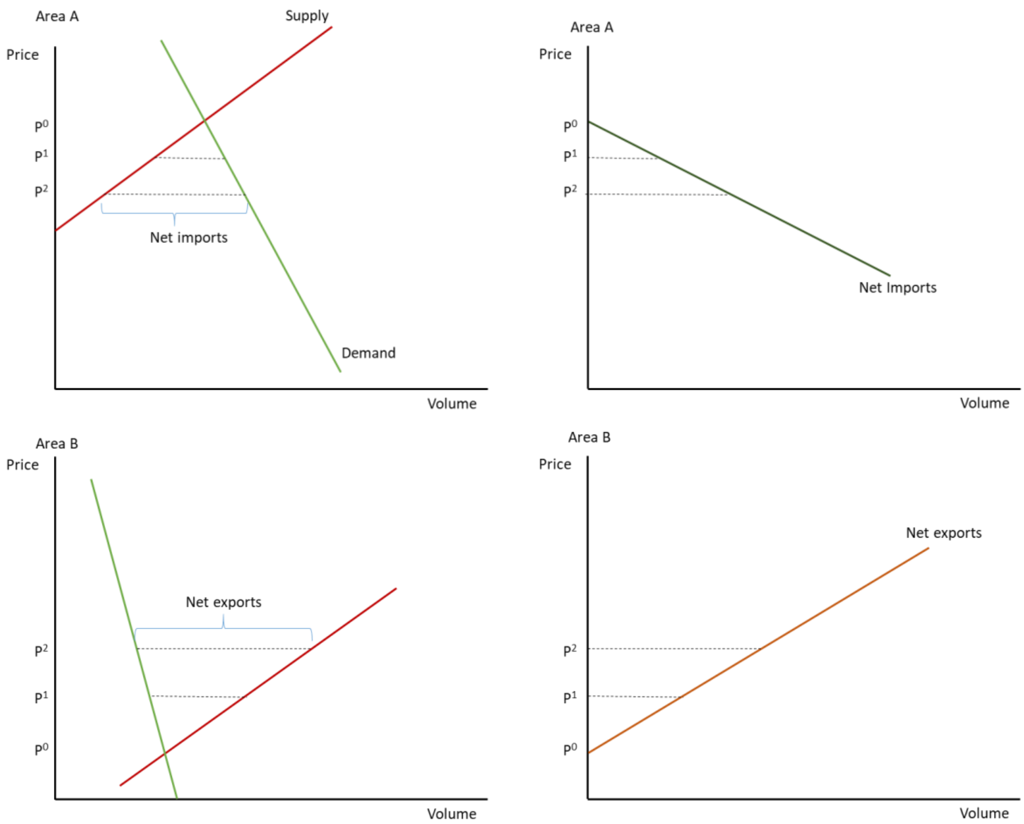

Figure 3. Net import curve for high price area A (above) and net export curve for low price area B (below)

Putting the net exports and net import curves of Figure 3 together in one diagram as done in Figure 4, allows to find 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 Figure 2. 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.

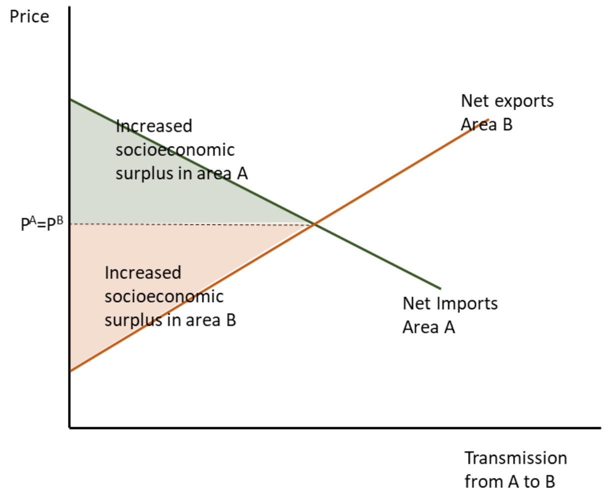

Figure 4. Optimal volume of exports from area B to A in terms of total socioeconomic surplus

In Figure 5 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.

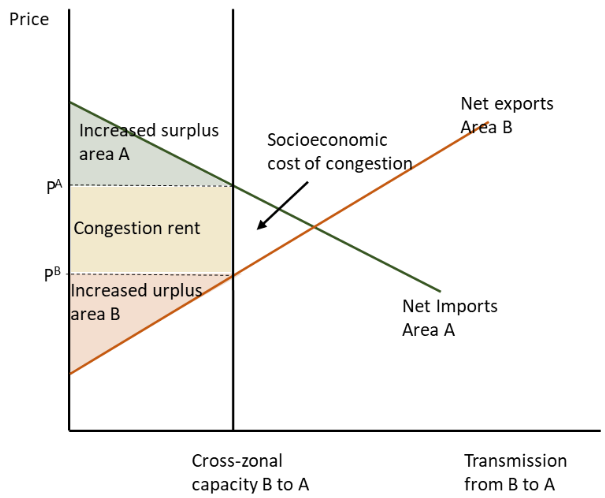

Figure 5. Socioeconomic surplus in market with congestion

This is illustrated in Figure 6 where two 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.

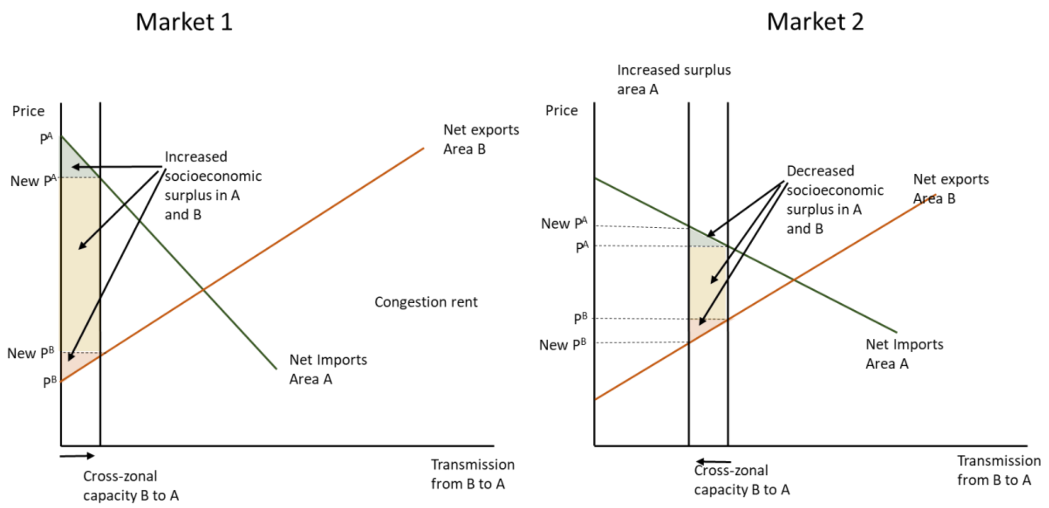

Figure 6. Change in socioeconomic surplus in two interconnected markets

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 Figure 7 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.

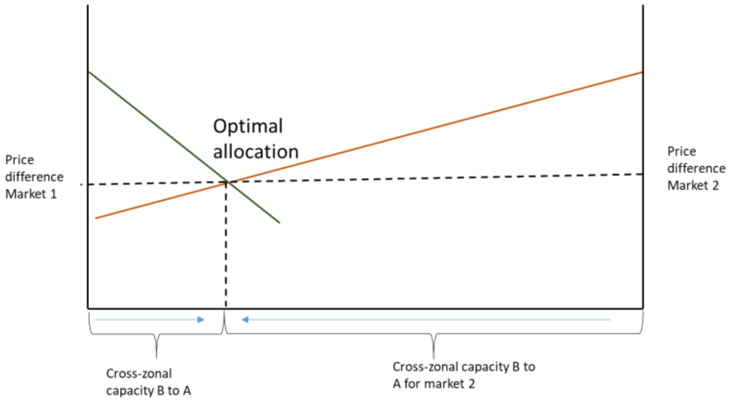

Figure 7. Bathtub diagram showing the optimal allocation of CZC between two markets

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 Figure 8, 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.

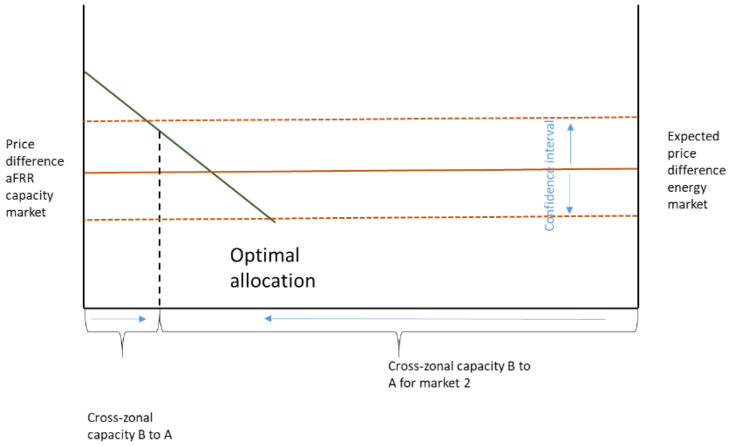

Figure 8

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. Complex bid formats in the aFRR capacity market

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 available, and it is therefore 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 available, 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 methodology as more experience with the market is gained. All future changes in the methodology will be done in accordance with the process for methodology amendments stipulated in EB GL.

2.4. Performance of using the reference day method as forecast method

This section will analyse the reference day method as described in section 3.1.2. 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 is defined as the previous day in the proposal.

The forecast error is the difference between the forecasted market value and realised market value calculated for each hour, for each bidding zone border and flow direction. The market value equals the price difference

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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 is based on the data set of hourly market values for 2016-2018 and does not show any systematic behaviour with respect to positive or negative errors. 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 shows the number of hours with congestions for the different borders and directions between 2016 and 2018, it can be seen that the forecast error is larger for those connections with the most frequent congestions and, for these connections, 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 the 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

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 the reference day without taking weekend and holidays into consideration. Initially, it was expected that adjusting the reference day for differences in price patterns between the weekend, weekdays and holidays could lead to greater accuracy.
For instance, for Mondays it was expected to be better to use Friday as the reference day, rather than Sunday. For holidays, it was expected to be better to use the last Sunday, rather than the previous day if that day was a working day. Table 7 shows, however, that there is a lower forecast error on average when using the previous day as the reference day even in 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 influences 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 accuracy than trying to capture the systematic patterns of different types of day. This analysis ignores the impact of reducing the CZC available for the day-ahead market. The next two sections include an assessment of these CZC allocation impacts based on simulations of both the Nordic aFRR capacity market and the European day-ahead market coupling optimisation algorithm.

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

This section presents a simulation study of the Nordic aFRR capacity market with market-based allocation of CZC for the exchange of aFRR capacity. The Norwegian based company Optimeering AS has developed the algorithm expected to be used as part of any implementation of a Nordic aFRR capacity market. It has also conducted the simulations described here. These are based on the rules for the market-based allocation of CZC and the market rules described 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 a 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, including the impacts of CZC allocation on the day-ahead market. A separate simulation of the impacts of reduced NTCs in the day-ahead market has been conducted with the "simulation facility" offered by the European market coupling operators and this analysis takes the hourly allocation of CZC from the aFRR capacity market simulations as an input.

2.5.1. Market assumptions

The simulations are based on the actual aFRR capacity bids from 2018, available transmission capacity and day-ahead market prices from 2018 and a total demand for aFRR capacity of 300 MW in all hours. Assumptions on bids were necessary to generate a complete data set, as aFRR capacity is not procured in all areas and all hours today. The goal of this analysis was not to predict the exact performance of a Nordic aFRR capacity market, but to present 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 itself also potentially influence the 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 in total and for Finland. Swedish bid data is not split among bidding zones. There have so far been no bids available from DK2.

We have assumed a set of bids for NO3 and NO4 that are based on the actual bids in NO5. The prices offered for aFRR in NO3 and NO4 were adjusted using a factor corresponding to the difference in the day-ahead market price between NO5 and the respective region. NO5 is considered representative of these other zones both with respect to the volume and the type of production units that will offer aFRR.

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

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

As there is no locational information for the Swedish bid data, there is no reliable basis for assessing which areas have the highest and lowest priced bids. Therefore a random distribution of the Swedish bids that respects the overall volume distribution among Swedish bidding zones is assumed to give the most representative set of bids.

Bids from DK2 are based on Finnish bids, as the type of production units are considered to be similar in these areas. Again, bid prices were adjusted proportionally based on the difference in the day-ahead price between FI and DK2.

There are different rules for bidding and pricing in the national markets today. Norway only allows block bids to be submitted and the blocks are predefined for specific blocks of hours. It is expected that, with the bidding rules of the Nordic aFRR capacity market, we will see a mix of block bids and single hour bids. To reflect this, 50 percent of the block bids are converted to single hour bids covering the same hours.

At present, procured bids in Norway are priced using pay-as-cleared pricing, while procured bids in Sweden and Finland are priced using pay-as-bid. We have no firm basis for predicting any systematic impact of changing to pay-as-cleared in Sweden and Finland and the bid prices are not adjusted in response to the change of pricing regime.

For Finland, the original data only had single hour bids. This 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 thus this distribution is kept unchanged.

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

Then bid prices were adjusted according to a linear interpolation between the days with existing data.

To create bids for the 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 had to be found, as well as the minimum and maximum bid price. This was done by firstly finding the data for the hours with existing data, and then make a linear interpolation between the data points to get the mean, minimum, maximum and standard deviation for the missing hours. When these numbers were found, bid data was created for the missing hours by randomly creating bids using a normal distribution based on these mean and standard deviation numbers, as well as limits on minimum and maximum bid prices based on the original bid price data.

This method is considered to give a "best guess" for bids in days and hours where we did not procure aFRR capacity in 2018.

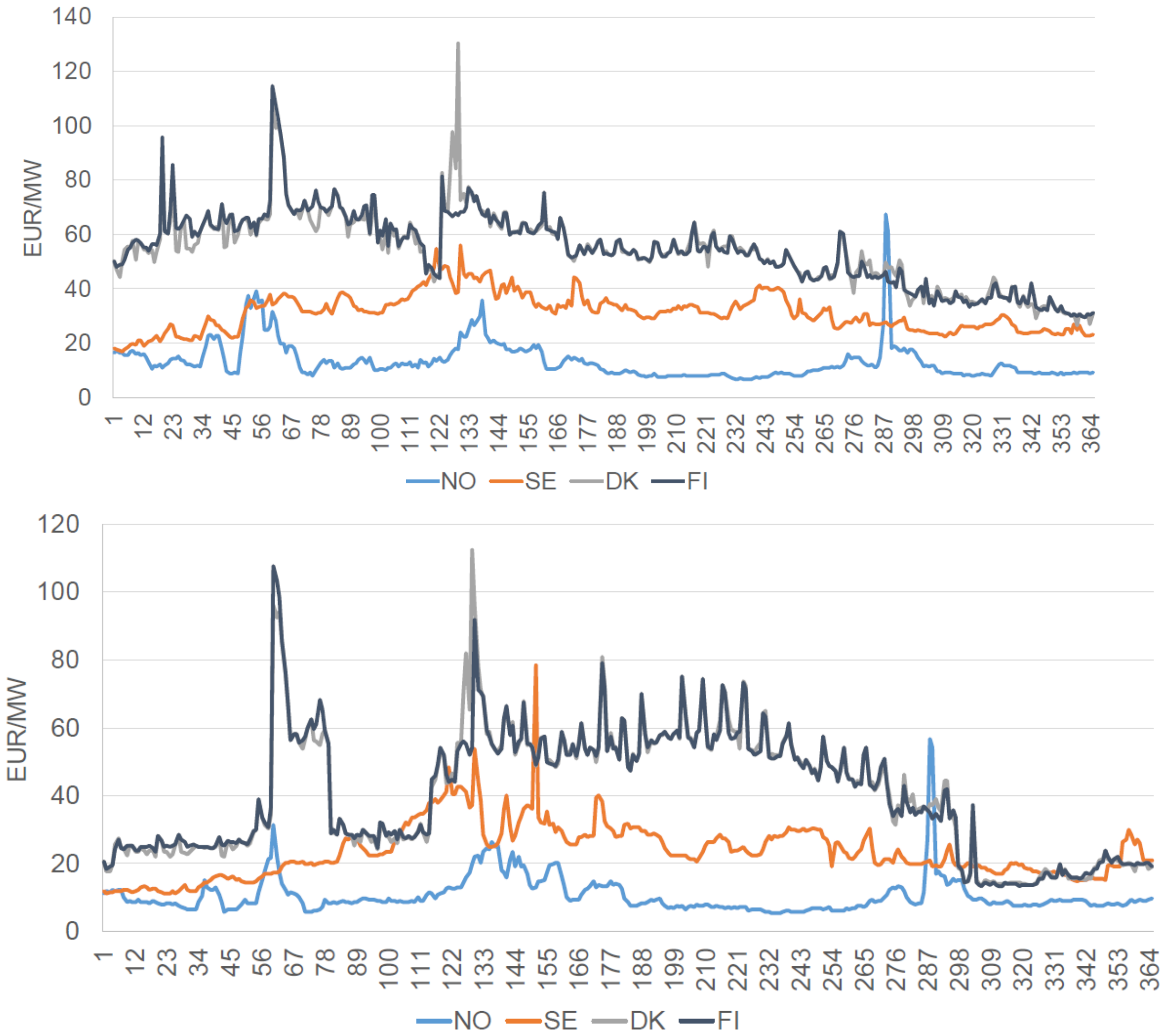

Figure 9. Weighted average of daily bid prices for up regulation (upper graph) and down regulation bids (lower graph) per country. EUR/MW/h

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 the 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. The distribution of aFRR capacity demand between the bidding zones is unknown. The methodology for determining the distribution has not been finalised but is expected to use historical imbalance data as an input. For the purpose of the simulations, the distribution of demand is as 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 article 5 of the Proposal, 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 the morning D-1.

[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.

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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 one should be aware 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 remain equal between the two scenarios. The only difference is the CZC that can be allocated for the purpose of aFRR capacity exchange.

2.5.2. 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.

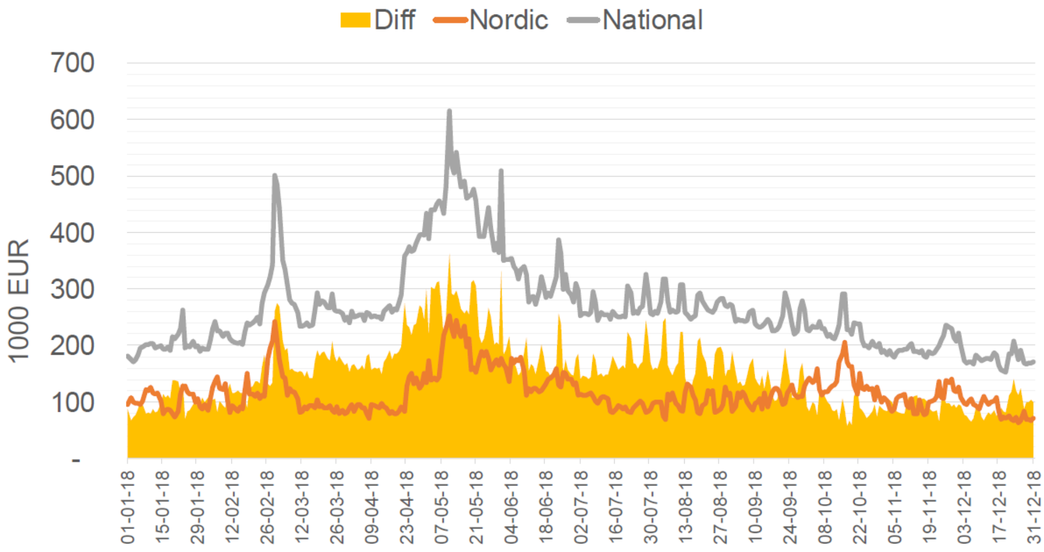

Figure 10. Overall daily costs from the market in the two scenarios (1000 EUR)

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 are 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.

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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 Table 10 the average price in the aFRR capacity of each bidding zone is presented.

Direction	Bidding Zone	Nordic	National
Up	NO1	10,8	7,6
	NO2	9,6	7,1
	NO3	9,0	7,9
	NO4	8,8	7,7
	NO5	9,6	7,0
	SE1	12,5	33,2
	SE2	12,0	33,6
	SE3	13,0	34,4
	SE4	14,8	36,4
	DK2	15,8	35,7
	FI	15,3	49,4
Down	NO1	8,0	6,2
	NO2	7,8	6,2
	NO3	7,0	5,9
	NO4	6,6	5,9
	NO5	6,6	6,1
	SE1	9,5	28,6
	SE2	9,1	29,1
	SE3	9,6	29,7
	SE4	9,9	29,8
	DK2	10,6	22,8
	FI	10,0	39,1

Table 10. The average marginal prices of all hours 2018 per bidding zone for scenarios with and without common Nordic aFRR capacity market. EUR

We see the effect of the lower priced Norwegian bids in the marginal price results. For up regulation without trade between countries, prices in Norway are on average between 7.0 and 7.9 EUR/MW while prices in Sweden and Denmark are between 33.2 and 35.7 EUR/MW. For Finland, the average price for 2018 is almost 50 EUR/MW. For down regulation we see the same regional differences, but for all bidding zones prices are slightly lower than for up regulation.

When allowing for trade between countries, prices in the Nordics move closer together, i.e. Norwegian bidding zones have a higher marginal price compared to the scenario without trade and the prices in the other countries are lower. The reasons for this are driven by the amount of relatively cheap Norwegian bids available in the market and the fact that when allowing for trade between countries, the algorithm selects more bids from Norwegian BSP's and less bids from BSP's in the other Nordic countries.

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.

2.6. Costs and benefits of aFRR capacity market and impacts on the day-ahead market

When allocating CZC for the exchange of aFRR capacity, the NTC given for the coupling of the day-ahead market is reduced correspondingly. This will potentially increase congestions and thereby lead to higher price differences. This impact would be neglected if the allocated CZC for aFRR capacity exchange were priced using the empirical price differences of 2018 and not adjusted for the impact of lower 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 one to see the results of an alternative run of the day-ahead market optimisation algorithm, Euphemia, after adjusting the NTCs to account for CZC reserved for the exchange of balancing capacity. The bids in the day-ahead market and other input variables are unchanged. This also means that any changes in market participants' bidding behaviour in the day-ahead market, notably by market participants that have their aFRR capacity bids accepted or rejected, is not accounted for.

In Figure 13, the cost of allocating CZC to aFRR capacity exchange is calculated by taking the difference in the total European socio-economic surplus of the day-ahead market across simulations with and without the reduction in CZC available to the day-ahead market due to the CZC requirements of the Nordic aFRR capacity market. These capacity requirements are taken from the simulation results of the Nordic aFRR capacity market. The implied cost amounts to 4 million Euro and is very low compared to the estimated benefits of exchanging aFRR capacity. These benefits can be calculated as the reduction in the sum of aFRR capacity costs evaluated at bid prices. Since the quantity of aFRR capacity procured is the same in simulations with and without the exchange of aFRR capacity, this cost reduction reflects the more efficient provision of aFRR capacity. The reduction in the social costs of aFRR procurement due to allowing the exchange of aFRR capacity amounts to 57 million euro. Netting off the costs to the day-ahead market, we are left with a net social benefit of 53 million euro.

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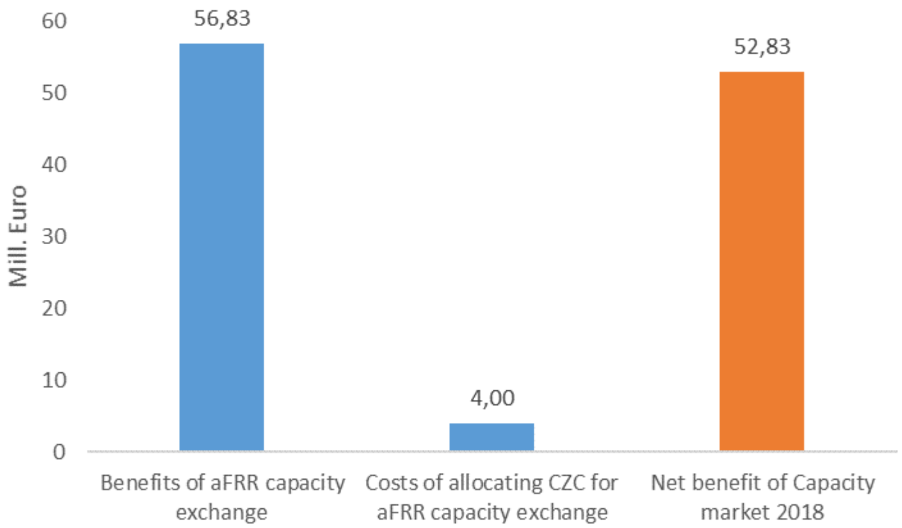

Figure 13. Comparison of benefits of aFRR capacity exchange, cost of allocating CZC for this purpose and total net benefits. Based on simulation of aFRR capacity market and impact on day-ahead market for all hours of 2018. Million Euro

A less accurate by easier-to-follow approximation of the costs of allocating CZC for aFRR capacity exchange, which does not rely on use of the "simulation facility" for the day-ahead market, can also be derived by looking only at the reduction in the implied congestion rent at each border, neglecting the price impact of reducing the available CZC. Under this simplified approach, we assume that the impacts on consumer and producer surplus cancel out. Under this approach, the cost of aFRR capacity exchange is calculated as the actual price difference on each border multiplied by the volume of CZC allocated to aFRR capacity exchange. Using this approximation gives an estimated cost of 3.8 million euro, slightly underestimating the total cost as detailed by the more sophisticated analysis above, but nevertheless providing a fairly good estimate. Looking at the example illustrated in Figure 14, in which high-price area A get its net-imports from low-price area B restricted, this approximation gives us the grey area, neglecting the red and blue triangles. The grey area plus the triangles gives the true socio-economic cost of CZC reduction, as presented by the more complicated simulation facility analysis.

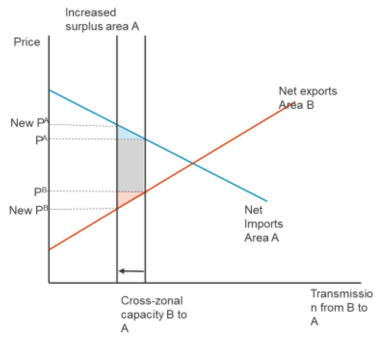

Figure 14. Impact of reducing CZC and reducing beneficial exchange on the total socio-economic surplus of two areas

The simulations are based on market data from 2018 and the results are characterized by a large volume of low-priced Norwegian aFRR capacity bids being accepted and exported to other market areas. The large difference in aFRR bid prices, and therefore the clear efficiency gains from using the lower cost aFRR capacity, implies that these results will be relatively insensitive to the method for forecasting value of CZC in the day-ahead market. When demand in the importing areas is covered or the maximum CZC allocation volume is filled, the next unaccepted bid in the exporting area is still significantly cheaper than the next unaccepted bid in the importing area.

2.6.1. Distribution of the costs of CZC allocation in the day-ahead market

Table 11 shows the costs due to the reduction in CZC available to the day-ahead market for the Nordic countries and the rest of Europe disaggregated into changes in congestion rent and consumer and producer surplus. Finland experiences the highest total costs and Sweden actually ends up with a net gain from the allocation in terms of the day-ahead market effect.

	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 11. 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

The congestion rent is calculated for each connection by taking the price difference between the regions and multiplying by the reserved CZC in each hour and up-down direction.

$$(\text{marginalprice}_{r,d,t}-\text{marginalprice}_{r',d,t})\cdot \text{CZCres}_{r,r',d,t} \quad \text{for all connections } (r\rightarrow r'), \text{ directions } d, \text{ hours } t$$

In Table 12, we show the congestion rent from day-ahead energy market transfers for all the Nordic connections covered by aFRR market extracted from the simulations based on 2018 data. These numbers take account of the CZC allocated to the exchange of aFRR capacity in each hour, using the numbers form the simulation of the Nordic aFRR capacity market, as well as the effect of the CZC allocation on prices in the day-ahead market, as simulated using Euphemia and day-ahead market data.

Bidding Zone	Nordic	National	Difference (Nordic-National)
NO1	14	12,8	1,2
NO2	1,4	1,3	0,1
NO3	6,6	5,9	0,7
NO4	5,6	5,3	0,3
NO5	5,5	5,2	0,3
SE1	21,2	19,9	1,3
SE2	11	10	1
SE3	50,8	48,6	2,2
SE4	40,1	39,5	0,6
DK2	7	7,1	-0,1
FI	18	16,8	1,2
Norway	33	30,5	2,5
Sweden	123,1	118	5,1
Denmark	7	7,1	-0,1
Finland	18	16,8	1,2
Total	181,1	172,4	8,7

Table 12. Congestion rent per bidding area and country for scenario with Nordic aFRR capacity market in comparison with a national scenario without allocation of CZC for aFRR capacity exchange between Nordic countries. Mill. Eur

We see from the results above that the energy market congestion rent increases for all bidding zones except DK2, which experiences a 0.1 mill. Eur decrease when aFRR CZC reservation is added. There are two drivers behind the congestion rent results, the total flow on the line and the price difference between the two connected bidding zones. In this case, the general increase in congestion rents associated with removing capacity from the DAM implies that the effect on prices outweighs the reduction in flows.

2.6.2. Distribution of the benefits from the aFRR capacity market

The total benefits of the aFRR capacity market can be divided between changes in TSO procurement costs on one hand and changes to BSP surpluses on the other hand. In Table 13, the TSO procurement cost impacts are further split between bid payments and congestion rent. The bid payments are calculated based on selected volume + imports - exports in each bidding zone, up-down direction and hour.

$$\Big(\sum_{\substack{i\, \in\, bids \\ in\ region\ r, \\ direction\ d, \\ hour\ t}} selectedVol_i + import_{r,d,t} - export_{r,d,t}\Big) \cdot marginalprice_{r,d,t}$$

The congestion rent is calculated for each connection by taking the price difference between the regions multiplied by the reserved CZC in each hour and up-down direction.

$$(\mathrm{marginalprice}_{r,d,t} - \mathrm{marginalprice}_{r',d,t}) \cdot \mathrm{CZCres}_{r,'r,d,t} \qquad \text{for all connections } (r \rightarrow r'), \text{ directions } d, \text{ hours } t$$

aFRR demand is not used in the equation above because, in some hours, the volume procured is higher than the demand for aFRR due to the presence of bids with minimum volume constraints and block bidding. The congestion rent on each border is split in two and divided between the connected bidding zones.

Bidding Zone	Procurement of bids		Congestion rent		Total		Difference (Nordic-national)
	Nordic	National	Nordic	National	Nordic	National	
NO1	2,9	2,1	1,7	0,1	1,3	2,1	-0,8
NO2	4,6	3,5	0,2	0,1	4,4	3,5	0,9
NO3	1,4	1,3	1,1	0,0	0,3	1,3	-1,0
NO4	2,3	2,2	0,8	0,0	1,5	2,1	-0,6
NO5	2,9	2,3	0,5	0,1	2,3	2,3	0,1
SE1	6,7	21,1	1,3	0,2	5,4	21,0	-15,6
SE2	5,1	15,6	1,4	0,4	3,8	15,2	-11,4
SE3	9,3	26,6	1,3	0,5	8,0	26,1	-18,1
SE4	6,5	17,4	0,4	0,3	6,1	17,1	-11,0
DK2	4,6	10,3	0,1	0,0	4,5	10,3	-5,7
FI	10,0	34,9	0,5	0,0	9,5	34,9	-25,3
Norway	14,1	11,4	4,3	0,3	9,8	11,2	-1,3
Sweden	27,7	80,7	4,4	1,3	23,3	79,4	-56,1
Denmark	4,6	10,3	0,1	0,0	4,5	10,3	-5,7
Finland	10,0	34,9	0,5	0,0	9,5	34,9	-25,3
Total	56,4	137,2	9,2	1,6	47,2	135,6	-88,5

Table 13. TSO procurement costs per bidding area and country for simulated scenarios with and without common Nordic aFRR capacity market. Mill. EUR

We see from the table above how TSO procurement costs decrease in all the Nordic countries. The decrease is largest in Sweden and Finland and quite small in comparison in Denmark and Norway. Denmark has a lower procurement volume than the other countries and, in Norway, aFRR prices increase due to the export of aFRR capacity, which increases the cost of procuring bids. However, this price increase for aFRR in Norway is still dominated by the congestion rent benefits associated with the export of aFRR capacity. For the Nordic region considered as a whole, we see that by far the largest contributor to reduced TSO costs are the bid cost efficiency savings, which represent more than 90% of the aggregate savings.
Table 14 shows how congestion rents from the aFRR capacity market are distributed among the connections of the Nordic aFRR capacity market. In the scenario with national market, we only have allocation of CZC for connections between bidding zones inside the Nordic countries and consequently there are no congestion rents associated with connections between countries.

From	To	Nordic	National
DK2	SE4	15'550	-
SE4	DK2	168'314	-
FI	SE1	1'342	-
SE1	FI	893'034	-
NO1	NO2	11'749	31'243
NO2	NO1	413'532	58'789
NO1	NO5	2'979	11'343
NO5	NO1	1'053'114	81'621
NO3	NO4	17'188	36'263
NO4	NO3	26'670	34'391
NO1	SE3	1'848'169	-
SE3	NO1	1'428	-
NO3	SE2	2'176'551	-
SE2	NO3	3'437	-
NO4	SE1	1'541'160	-
SE1	NO4	2'829	-
SE1	SE2	7'175	328'009
SE2	SE1	225'309	63
SE2	SE3	228'532	464'864
SE3	SE2	61'306	704
SE3	SE4	544'922	544'294
SE4	SE3	1'834	-

Table 14. The congestion rent in the aFRR capacity market in the simulated scenarios with and without a Nordic aFRR capacity market for the Nordic connections. EUR

As shown in the table, the NO3 to SE2 border has the highest congestion rent in the Nordic scenario. This is because of a combination of high 'flow' from NO3 to SE2 and the relatively high price difference between the bidding zones. Other connections with high congestion rents are the NO1-SE3 border, the NO4-SE1 border and the connection between NO5 and NO1. In the national scenario, all connections between countries are effectively closed to the exchange of aFRR and the largest congestion rent numbers are between Swedish bidding zones.

The implied BSP surpluses, shown in Table 15, are calculated as the difference between marginal price and bid cost for the selected volumes.

$$selectedVol_i \cdot marginalprice_{r,d,t} - selectedVol_i \cdot bidcost_i \qquad for\ all \begin{array}{c} i \in bids \\ if\ region\ r, \\ direction\ d, \\ hour\ t \end{array}$$

Bidding Zone	Nordic	National	Difference (Nordic-national)
NO1	0,127	0,036	0,091
NO2	2,819	0,596	2,223
NO3	1,326	0,041	1,286
NO4	0,998	0,098	0,9
NO5	1,911	0,38	1,531
SE1	0,446	14,103	-13,657
SE2	0,209	7,23	-7,021
SE4	0,279	7,705	-7,426
DK2	0,148	0,788	-0,64
FI	0,182	9,101	-8,919
Norway	7,182	1,151	6,03
Sweden	0,934	29,038	-28,104
Denmark	0,148	0,788	-0,64
Finland	0,182	9,101	-8,919
Total	8,446	40,078	-31,633

Table 15. BSPs' surpluses in simulated scenarios with and without a Nordic aFRR capacity market. Mill. EUR

The effects of going from national markets to a common Nordic market for aFRR capacity are inverted for BSPs as compared to TSOs; where the TSOs reduce aFRR costs, BSPs register lower surpluses. For Norwegian BSPs, the total surplus increases by 6.03 mill EUR. For the other countries, BSP surpluses are reduced by 28.104 mill. EUR, 0.640 mill EUR and 8.919 mill EUR for Swedish, Danish and Finnish BSPs respectively. This reflects the fact that less capacity is selected from these areas and marginal prices decrease.

In Table 16 we provide a summary of the total socio-economic benefits of the Nordic aFRR capacity market based on the simulation results. All countries benefit from the aFRR capacity market. In Norway the increase in BSPs' surpluses is the main contributor to the benefits. In Sweden, Denmark and Finland, BPSs' surpluses decrease compared to the national markets case, but this is far outweighed by the decrease in TSOs' procurement costs in these countries.

	Reduction in TSO procurement cost	Change in BSPs' surpluses	Change in socio-economic benefits
Norway	1,34	6,03	7,37
Sweden	56,06	-28,10	27,96
Denmark	5,73	-0,64	5,09
Finland	25,33	-8,92	16,41
TOTAL	**88,46**	**-31,63**	**56,83**

Table 16. Reductions in TSOs' procurement costs, BSPs' surpluses and the total change in socio-economic benefits of going from national aFRR capacity markets to Nordic aFRR capacity market. Mill. EUR
Note: Benefits are shown as positive numbers

2.6.3. Impact of CZC allocation on price differences

The average change in the DAM price spread due to the allocation of CZC for the exchange of aFRR capacity is shown by hour and border below. These results are taken from the simulation analysis. The largest impacts are for the SE1-FI, SE3-SE4 and SE4-DK2 borders. The vast majority of average changes are less than 0.5 Euro.

It is important to note that these results reflect changes to CZC capacity allocation only and not changes to the offer curve for energy. In the future, without any Nordic exchange of reserves or the supporting CZC allocation, reserves would instead need to be procured locally and this alternative approach would also impact on the day-ahead market through changes to available supply. This effect is important to be aware of, not least since it is not apparent from these simulations of the day-ahead market based on historic data. In these scenarios, the energy market bids are the same both in both cases.

	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 changes in the day-ahead market price spread as a result of allocating CZC to the Nordic aFRR capacity market, Euro/MW/hour

The next figure shows how the change in price spreads is dependent on the initial price spread, i.e. the spread when no CZC is used for aFRR capacity exchange. It can be seen that the impact on the price spread is larger the larger the initial price spread. When the price difference is initially large, the impact tends to be greater. For most hours however, the impact is fairly low. On each border, there will always be available CZC in one direction, i.e. in the direction opposing the flow of energy. Here, CZC for aFRR capacity exchange can be allocated without having any impact on the clearing of the day-ahead market. If there is a congestion from Sweden to Finland for example, down regulation bids can be exported to Finland without competing for CZC, as this exchange requires an allocation of CZC from Finland to Sweden, against the flow of energy. 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 spread dependent on initial price spread according to intervals given by first column, Euro/MW/hour. Lower table: Number of observations per border for the different intervals.

2.6.4. Risk of forecast errors and the role of the mark-up

A critical part of the market-based allocation methodology is the forecasted value of CZC to the day-ahead market. Forecast errors may result from changes in supply, demand and available CZC in the day-ahead market. Changes to the available CZC will result from changes in the allocation of CZC to the aFRR capacity market. Section 2.4 analyses the error associated with using the price difference on the reference day as the forecast value while ignoring the impact of CZC allocation for the exchange of aFRR. Section 2.6.3 shows the simulated effect of aFRR capacity market CZC allocations on prices in the day-ahead market.

When interpreting these results, it is important to be aware that it has not been possible to link from day to day the day-ahead market simulation with the aFRR capacity market simulation. This means that some of the potential self-correcting dynamics of the system aren't represented in the results. For example, if the forecasted value of CZC to the day-ahead market is initially underestimated, the resultant over-allocation of CZC to the aFRR market will lead to a higher price spread in the DAM and a corresponding correction in the aFRR allocation the next day.

Based on these analyses, it is clear that there will be forecast errors and that these can vary substantially over time, between borders and based on the allocation of CZC. The mark-up of 1 EUR, which is added to the price spread observed on the reference day when determining the allocation of congested CZC, is introduced in response to the known risk of forecast errors. However, the purpose of the mark-up is not to correct for the forecast error itself. In fact, the mark-up will bias the market towards overestimating the value of CZC to the day-ahead market and thereby result in the market allocating a less than optimal amount of CZC for aFRR capacity exchange. Rather, the reason for explicitly favouring the day-ahead market with this mark-up is to begin moving conservatively away from the current market arrangements and to limit the impact on CZC allocations until more experience is gathered. The maximum limit on the quantity of capacity to be used for the exchange of aFRR, set at 10 percent of NTC, serves the same purpose. In both cases, we have decided to err on the side of caution. The mark-up ensures that CZC is reserved for the exchange of aFRR only when the case for reservation is strong.

The mark-up is set uniformly equal to 1 EUR. Given the average absolute forecast error and the average impact of the CZC allocations on day-ahead market prices, as shown in previous sections, 1 EUR appears to be large enough to meaningfully counteract many of the estimated errors and impacts without unduly restricting the exchange of aFRR capacity.

The mark-up could be set using a more complicated method, for example by having the mark-up vary by bidding zone border, reservation volume and other market indicators reflecting the likelihood of forecast errors. However, such rules would presumably have to be developed based on a very granular analysis of market data and, at this level of detail, changing market conditions are likely to imply significant changes to the implied mark-ups from year to year anyway. Given this, our intention with the mark-up is not to attempt an accurate correction of the forecast value, but rather to insert a clear conservative bias against the allocation of CZC for the exchange of aFRR. Given this rationale, we think it appropriate to have a clear and transparent rule for determining the mark-up, which can then easily be accounted for among market participants.

The simulation results, which include the 1 EUR mark-up as part of the market rules, show a clear benefit from the aFRR capacity market that is many times higher than the implied cost of removing CZC from the day-ahead market. It indicates that the bias against reserving CZC to enable the exchange of aFRR, created by the mark-up, is not so large as to prevent the realisation of benefits, and keeps the costs in the day-ahead market relatively low.

2.7. Conclusions

The Nordic TSOs believe that the proposed common Nordic aFRR capacity market will deliver annual net benefits for the Nordic region of approximately 50 million euros and that each nation will be a net beneficiary from the market's implementation. They also consider market-based allocation of CZC to be the most efficient method for enabling the exchange of aFRR capacity in the short term. The proposal has been designed such that CZC is reserved for the exchange of aFRR in a conservative manner, erring always in favour of reserving too little capacity. This mitigates the impacts on the day-ahead market. The proposal also aims to use clear and transparent market rules, for the benefit of market participants.

A key challenge with the market-based approach is the need to use forecasts for the value of CZC for the exchange of energy. The analysis of day-ahead market prices from 2016 to 2018 shows that using the price spread on the previous day results in fairly low forecast errors in general. The application of a mark-up of 1 euro when allocating scarce CZC in the congested direction, combined with a cap on CZC allocation equal to 10 percent of the CZC available, ensures that CZC reservation is biased in favour of the day-ahead market and will help mitigate any harm to the day-ahead market arising from forecast errors. The simulation results, based on 2018 data, clearly show that the benefits of the proposed market are many times the implied cost to the day-ahead market.

The market context will most likely change in the future – bidding behaviour and the supply of aFRR may change, as may the volatility of price differences between zones. However, there is little evidence to suggest that the proposed method would lead to CZC being reserved in a way that was not socially beneficial.

3. The proposal

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

As stated in Article 39(5) of the 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 for the reasons explained in the section 3.1.1, but, as noted below, once capacity pricing is introduced to the intraday market, it will likely become relevant and possible to include intraday prices in the CZC market value determination.

Two options have been considered for determining these cross-zonal 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 delivery day; and the use of a commercial forecast provided by an external service provider.

The proposed method uses a reference day to forecast the market value of CZC on the delivery day. Both methods have advantages and disadvantages which are outlined in sections 3.1.2 and 3.1.3 below. Article 39(5) of EB GL mentions, in particular, the importance of transparency and accuracy in the forecasting method, and this has guided our choice of forecasting approach.

3.1.1. Use of intraday price data

The TSOs have decided that the 'relevance' of intraday prices in providing a transparent and accurate indicator of the value of CZC is questionable and that, at least under the current intraday market design, incorporating intraday prices into the forecast of CZC's value may actually result in a less transparent and less accurate indicator of the value of CZC. Specifically:

- Intraday trading is currently based on continuous trading, where incoming orders are executed one by one based on a "first come first serve" principle. Each matched trade has a price of its own and there is therefore no commonly recognised bidding zone price. Possible metrics that could be used include the value of the last accepted bid or some average of trading prices, for example weighted by volume. The absence of a commonly accepted price and the resultant need to define a new intraday price indicator leads us to conclude that attempting to incorporate this price data into the approach would ultimately harm the transparency of the process relative to using the widely-accepting pricing metrics established through the day-ahead auction.
- Volumes of intraday trading are low in the Nordic market area compared to day-ahead volumes, especially in some bidding zones. This lack of liquidity impairs the quality of price formation in these areas and results in prices that are volatile and potentially inaccurate as a measure of the clearing price for the wider energy market. This inaccuracy is liable to be especially pronounced for measures like the last accepted bid, or for averages that only take a small sample of trades close to real time.
- Finally, in the current continuous intraday market design, cross-zonal capacity is not priced and essentially released for free, where available, to the intraday market. As a result, some trades may clear at prices that are distorted by the allocation of CZC for free. Take for example two zones with a congested border. The high-price zone has a price p_h and the low-price zone has a price of p_l. If we release a marginal amount of CZC to the intraday market, traders should be willing to trade at any price between p_h and p_l because they don't need to pay for the necessary CZC and therefore can split the congestion rent associated with the trade. If we then take the arbitrary price of this trade as the relevant price of energy

in either of the zones, we'll be getting an inaccurate indication of the true value of energy in these zones and consequently and an inaccurate picture of the value of CZC.

In light of these problems, the TSOs do not consider intraday prices as currently relevant to the development of a transparent and accurate forecast of the market value of CZC. However, the TSOs will reassess the relevance of intraday prices as an indicator when intraday auctions have been implemented, as this change to the market design has the potential to overcome some of the fundamental problems noted above.

3.1.2. Reference day method

Using this method, the forecasted market value of congested CZC between two bidding zones for any given MTU equals the price difference of the corresponding MTU on a reference day. Only the congested direction has a market value. The uncongested direction, i.e. the direction that could be used to flow power from a high-price to a low-price zone, has a forecasted market value of zero.

The reference day shall initially be defined as the day prior to the delivery day. More complex definitions were considered, including adjustments for weekends, working days and holidays but, as explained in section 2.4, analysis has shown that adopting more complex definitions does not improve the forecast performance significantly and the simple method of using the previous day for all days is considered to be the best starting point for the market.

It is important to note that there will be weekly monitoring of the performance of the proposed method, i.e. the reference day method. Potential improvements to improve forecast accuracy will be continuously considered. Implementing any changes will however require an amendment to the proposal and thereby require time for consultation and NRA approval before such improvements could be implemented. Potential future improvements could lie with the use of other relevant indicators, which could be used to adjust expected prices and price differences. However, we believe that any indicators used in the price forecast should be public.

The proposed reference day method has the advantage of transparency since:

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

Its main disadvantages relate to its accuracy and potential costs:

- Since information affecting prices between the reference day and forecast day is not accounted for (at least in the initial setup), forecast errors can occur when essential market drivers change during this period.
- Considerable administrative costs can also be expected in the assessment and improvement of the reference day method.

3.1.3. Commercial forecasts

Using this method, the forecasted price differences would be based on the use of an energy market model developed 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 to be 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 the 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 by the use of a reference day forecast.

The disadvantages of this method relate mostly to transparency:

- Market participants would likely need to pay for the service in order to have access to the prices used in the market clearing process;
- The method behind the forecast, notably the detail of the energy market model, is not necessarily fully transparent;
- Ex-post publication of forecasted prices may not be acceptable to potential forecast service providers;
- The impartiality of the forecast service provider may be questioned as it will have the power to influence the allocation of CZC and thereby the results of the balancing capacity market. The risk of manipulation could be mitigated by clear monitoring and frequent tenders through which the provider could 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 entails the contracting of balancing capacity less than two days in advance of the capacity's provision, it is not bound by volume limitations set out in EB GL Article 41(2). The Proposal itself however includes a provision establishing that the maximum volume of CZC that can be reserved for the exchange of balancing capacity is 10% of the forecasted day-ahead market transmission capacity. The limit was put in place by the Nordic TSOs in order to avoid internal congestions due to the activation of balancing capacity and in order to limit the impact of the CZC allocation on the day-ahead market.

3.3. Determining the allocated CZC for exchange of balancing capacity

One of the main inputs into the allocation process will be the reservation cost of CZC, as described in section 2.4.3. of the explanatory document accompanying the proposal pursuant to article 33 and 38 of EB GL. In order to take into account the uncertainty around this forecasted value of CZC, mark-ups will be placed on the CZC's forecasted market value. The results in the conservative allocation of CZC for the exchange of balancing capacity market, and favours CZC's use by the day-ahead market. Specifically:

- When calculating the reservation cost of CZC for up regulation in the forecasted flow direction, a mark-up will be placed on the forecasted value of day-ahead market transmission capacity:
    - if the forecasted day-ahead market price difference between the two bidding zones is zero, the value of the mark-up will be 0.1 EUR/MWh;
    - if there is a forecasted day-ahead market price difference between the two bidding zones such that there is expected congestion between the two the bidding zones, the value of the

mark-up 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 mark-up will be placed on the value of day-ahead market transmission capacity:
  - if the forecasted day-ahead market price difference between the two bidding zones is zero, the value of the mark-up will be 0.1 EUR/MWh;
  - if there is a forecasted day-ahead market price difference between the two bidding zones such that there is expected congestion between the two the bidding zones, the value of the mark-up 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 a mark-up equal 0.1 EUR/MWh will be placed on the value of day-ahead market transmission capacity.

The role of the mark-up and the motivation for setting it equal 1 EUR is discussed in section 2.6.4. This approach is intentionally conservative. Once the market has gone live, more experience will allow for improved methods and should allow more CZC to be efficiently allocated to the balancing capacity market.

3.4. Impact of capacity calculation methodology on allocation methodology

The initial capacity calculation method under the Proposal is based on the current NTC system. As soon as CZC allocation occurs in accordance with the Capacity Calculation Methodology approved by all Regulatory authorities of CCR Nordic 10 July 2018, i.e. the flow-based methodology,[4] the Proposal will also assign capacity in accordance with that methodology. The flow-based methodology is not expected to be implemented earlier than summer 2021.

Under the flow-based methodology, CZC is represented by 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. Under the flow-based implementation, transmission capacity allocated for the exchange of balancing capacity will be considered Already Allocated Capacity (AAC) and is subtracted before arriving at the final RAM. The allocation methodology will need to take into account the fact that CNEs are dynamic and can be located inside bidding zones.

Similar to the market process as implemented under the transitionary NTC period, the final PTDFs and RAMs will not be ready when balancing capacity is procured. Instead, the PTDFs and RAMs as used in the day-ahead market D-1 can be expected to reflect the best available representation of available CZC at the time balancing capacity is procured. A zone-to-zone PTDF is likely to be used in the procurement optimisation function in order to calculate the implied utilisation of transmission capacity between bidding zones for different distributions of procurement volumes. The value of this CZC will still be based on forecasts and the move to flow-based will not affect the method for determining the forecasted value of CZC used for exchange of energy.

After the procurement optimisation function has completed the optimisation and the final procurement volumes of each bidding zone are determined, these procurement volumes will be used as inputs into the

[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.

calculation of the zone-to-CNE PTDF relevant for the actual delivery day. They will also inform the AAC for all CNEs that are included in the RAM before sending this information on to the market coupling process.

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 the 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 the realised costs and benefits of the allocation process. The Nordic TSOs will monitor the efficiency of the CZC allocation process and, based on the balancing capacity bid data, calculate the reduction in procurement costs compared to fulfilling the initial distribution of capacity without allocating CZC for the exchange of balancing capacity. As long as energy activation is done through pro-rata activation, without an energy activation market, the efficiency of realised energy activation will not be estimated. The estimated costs and benefits will be published as values per day for the entire market region within one week after the delivery day.

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 capacity in accordance with Article 41(1) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing"

Subject matter and scope, definitions 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 relevant 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 the start-up of the market and as we gain experience.

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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 the 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 on with the stakeholders. The explanation has been clarified in the explanatory document. The TSOs believe that the original proposal complies with the said article but to make this more clear we have improved the legal document and added an explanations related to this in the 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 the 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 clearer.

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 the legal proposals to make them more precise in describing our aim to improve the design with more experience of the market. Any changes of the market which demand changes in legal methodologies will be made 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 motivated by the analysis contained in the 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. The motivation for this change is the analysis that can be found in the explanatory document

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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. The motivation for this change is the analysis found in the explanatory document. 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

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 on potential future improvement.. 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 with 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 the 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. The motivation for this change is the analysis found in the 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 the 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 the TSOs' comment on the 10 % limit. The 10 % limit is considered by the 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 % limit will be the constraining factor in a 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 the price difference on a reference day, the uplift intended to help accommodate this.
Please see below for the TSOs' 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 have chosen to 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 the current transparency regulation.

General TSO comment 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 balancing 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 operational security requirements. These bids may be more expensive due to a higher alternative value in the DAM and therefore 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 the 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 a less socio-economically efficient outcome, but the aim is to make improvements as more experience is gained.

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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 a sub-optimal allocation, which could lead to both "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 the 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 a 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 leads 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.

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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 has been adjusted to include a 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 results/outcomes no later than 30 minutes after the procurement of capacity. This will include procured volumes and allocated CZC. We will also monitor the market and potential socio-economic losses and gains and this information 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 results/outcomes no later than 30 minutes after the procurement of capacity. This will include procured volumes and allocated CZC. We will also monitor the market and potential socio-economic losses and gains and this information will be made public to the market.
The request to make "unused reserved capacity" available for the market is not possible, since that information will not be 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:
The TSOs have undertaken extra analysis and added a clearer motivation for our choice of the market-based allocation method. This 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 the 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 the 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.

TSOs:
The revised proposal is now based on the use of marginal pricing.

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 17. 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 17: 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 18 below.

Table 18: 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.

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 17, 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].

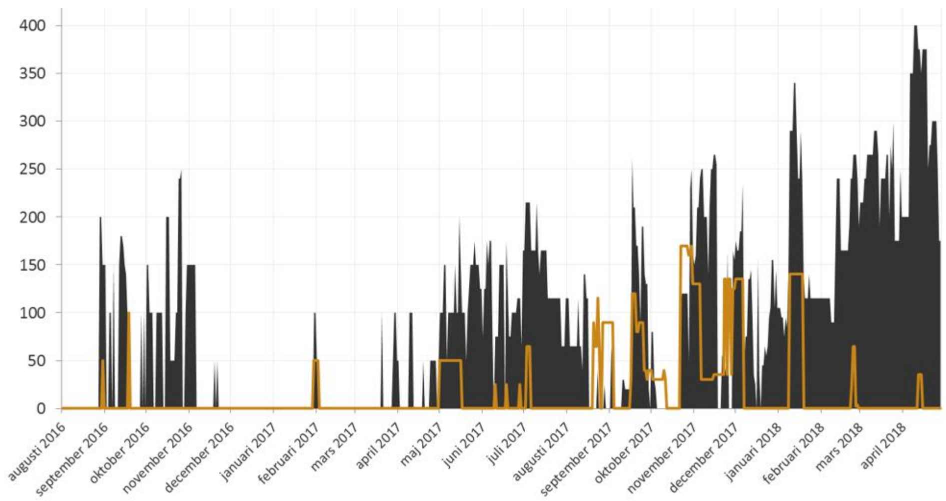

Figure 17: Cross-zonal capacity allocated for exchange of balancing services during the period from August 2016 to April 2018. The black line show cross-zonal capacity between SE2 and SE3. Yellow line shows cross-zonal capacity between SE3 and SE4. Source: Svenska kraftnät

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.

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

Content

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.

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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.

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