Explanatory document to Energinet, Fingrid, Statnett and Svenska kraftnät proposal for the methodology for a market-based allocation process of cross-zonal capacity for the exchange of aFRR balancing capacity in accordance with Article 38(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

Date of the approval

Contents

1. Introduction

This document gives background information and rationale for Energinet, Fingrid, Statnett and Svenska kraftnät proposal for the methodology for a market-based allocation process of cross-zonal capacity (hereinafter referred to as "CZC") for the exchange of aFRR balancing capacity; this is in accordance with Article 38(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (hereinafter referred to as "EB GL"). This proposal is hereinafter referred to as "Proposal", and Energinet, Fingrid, Statnett and Svenska kraftnät are hereinafter collectively referred to as the "Nordic TSOs".

1.1. Why should we allocate CZC for balancing capacity?

The Nordic TSOs need to ensure that the necessary volumes of balancing energy bids are accessible in each bidding zone according to the LFC block dimensioning rules, thereby ensuring operational security. A Nordic aFRR capacity market will be an important instrument to accomplish this in a cost efficient manner.

The exchange of balancing capacity between bidding zones cannot be an adequate alternative to local procurement within bidding zones without ensuring that that there will be sufficient CZC available from the areas exporting balancing capacity to the areas importing balancing capacity. If the CZC made available for the day-ahead and intraday markets is not reduced and allocated to the balancing timeframe, TSOs must be prepared to use the proper actions to reestablish operational security when the available CZC after the intraday timeframe is less than needed for the exchange of balancing capacity. The TSOs can use countertrading to reestablish the CZC needed for enabling activation of balancing energy consistent with the exchange of balancing capacity. Alternatively, the TSOs can do the procurement after the day-ahead market coupling stage, but this will limit the access to reserves as the market players commited to delivery in the day-ahead market will not be available for delivering 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 purposes of the aFRR capacity market are both to ensure the availability of the aFRR resources necessary to keep the operational security within acceptable limits as well as to increase socio-economic welfare on a Nordic level. The Nordic TSOs consider that the best approach to achieve these purposes is an aFRR capacity market with the allocation of CZC for exchange of aFRR capacity when the value of CZC is higher for the exchange of aFRR capacity compared to exchange of energy.

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1.2. Background

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

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

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

The Nordic TSOs therefore propose that the capacity procurement optimisation function for the common aFRR market shall include a methodology for the allocation of CZC. The initial choice of methodology is the market-based allocation process as described in Article 41 of EB GL. This methodology was also tested in a project denoted "Hasle pilot" (see section 1.4). The proposal for establishment of common and harmonized rules and processes for the exchange and procurement of aFRR balancing capacity is consulted separately. The two consultations are, however, carried out in parallel and may advantageously be read in conjunction.

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

1.3. Legal basis

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

1.3.1. Market-based allocation of CZC

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

The option (b) is chosen and the development of that method is subject to Article 41 of EB GL. The choice of option (b) is further elaborated in section 2.1.

1.3.2. NRA Approval and Implementation timeline

According to Article 5(3) of EB GL:

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

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

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

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

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

1.3.3. 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).

1.4. 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 evaluate market-based allocation of transmisison capacity for the exchange of aFRR capacity on the so-called Hasle

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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[1] from the two phases of the Hasle pilot showed the following:

- Coordinated procurement of reserves and allocation of transfer capacity is possible.
- 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.

Experiences and learnings from this pilot project have been taken into account when forming the market rules and methodology for the Nordic aFRR capacity market described in the proposal.

1.5. Exchange of aFRR balancing capacity

The consultation documents for the overall proposal for the exchange of aFRR balancing capacity are separate to these 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 establishment of common and harmonized rules and processes for the exchange and procurement of aFRR balancing capacity in accordance with Article 33(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing” with an accompanying explanatory document.

1.6. Definitions

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

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

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

(3) ‘capacity procurement optimisation function’ means the function of operating the algorithm applied for the optimisation of the procurement of balancing capacity for TSOs exchanging balancing capacity.

[1] More detailed descriptions of the pilot itself, the results and conclusions can be found in two published documents: “The Hasle pilot project” published on 2015-03-17, and “Memo: Hasle pilot experiences” published on 2015-12-21.

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

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

(6) ‘force majeure’ means any unforeseeable or unusual event or situation beyond the reasonable control of a TSO, and not due to a fault of the TSO, which cannot be avoided or overcome with reasonable foresight and diligence, which cannot be solved by measures which are from a technical, financial or economic point of view reasonably possible for the TSO, which has actually happened and is objectively verifiable, and which makes it impossible for the TSO to fulfil, temporarily or permanently, its obligations in accordance with this Regulation;

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

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

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

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

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

2. The proposal

2.1. Choice of allocation process

Under all three methodologies mentioned in section 1.3.1, the market values of CZC for the balancing and day-ahead markets are compared, with the highest market value indicating the highest welfare gains of allocating CZC. The main difference between the methodologies is reliance on either actual or forecasted market values of CZC.

The choice of methodology for TSOs will depend on when balancing capacity is contracted and when allocation of CZC is performed. Allocation based on an economic efficiency analysis relies on forecasted values of CZC for both exchange of balancing capacity and energy. It will typically be used for longer periods, from a week up to a year, and the Nordic TSOs do not consider to have the same potential in terms of socio-economic benefits as methodologies based on a more dynamic allocation process taking into account actual bids of the balancing capacity market. As for the other two methodologies, the figure below illustrates the co-optimisation and the market-based processes.

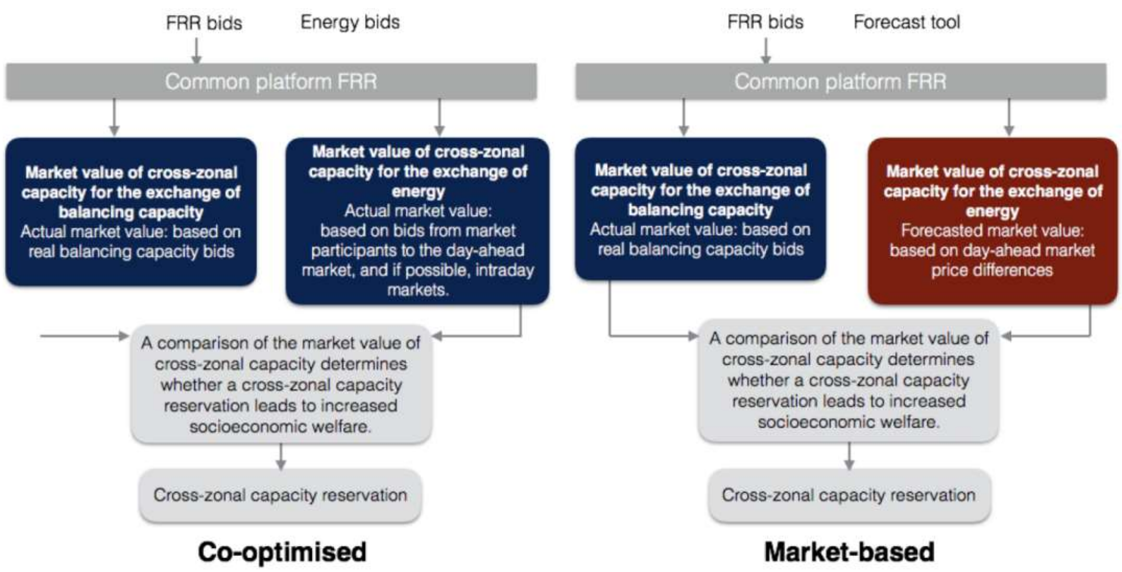

Figure 1Co-optimised and market-based cross-zonal transmission capacity allocation. Source: Sweco

The co-optimisation process may be used when TSOs contract balancing capacity on a daily basis, and is based on a combined day-ahead and balancing capacity allocation process where the actual market value of CZC for the exchange of balancing capacity and the actual market value of CZC for the exchange of energy is compared. It is a more complex and demanding methodology, which requires an adaptation of the algorithm in the day-ahead market, and introducing it is not feasible in the near future.

The market-based allocation process may be used when TSOs contract balancing capacity not more than one week in advance of the provision of the balancing capacity. The allocation process is based on actual market value of cross-zonal capacity for the exchange of balancing capacity and the forecasted market value of cross-zonal capacity for the exchange of energy and is the methodology chosen in this Proposal.

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

As stated in Article 39(5) of EB GL, the forecasted market value of CZC shall be calculated based on the expected differences in market prices for the day-ahead market. Intraday market values are not taken into account in the Proposal.

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

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

2.2.1. Reference day

In this method, the expected price differences between bidding zones are based on the day-ahead market prices of a reference day.

The reference day shall initially be defined by the following:

- for Monday to Friday, the last previous working day will be chosen,
    - when the reference day falls on a bank holiday, the nearest working day previous to the reference day will be chosen,
- for Saturday, the previous Saturday will be chosen,
- for Sunday, the previous Sunday will be chosen,
- when the day itself (for which capacity is contracted) is a bank holiday, the previous Sunday will be chosen.

It is important to note that there will be a weekly monitoring of the performance of the method based on reference day. Improvements will be considered and implemented continuously, and any changes in allocation rules shall be notified to market participants in advance. Potential improvements could lie within the use of other relevant indicators which could be used to adjust the expected prices and price differences. In such cases, all indicators used should be public.

This method has the advantage of its transparency since:

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

Its main disadvantage lies within its accuracy and potential costs:

- Since there is limited use of new information affecting prices in between the reference day and forecast day, there will be issues with accuracy; there could be considerable forecast errors occuring in periods where essential market drivers are changing.

- It can also be foreseen that there would be considerable costs in assessing and improving the reference day method.

2.2.2. Commercial forecasts

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

The advantages of this method are considered to be:

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

The disadvantages of this method relate mostly to transparency:

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

2.3. Defining the maximum volume of allocated CZC

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

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

2.4. Determining the allocated CZC for exchange of balancing capacity

One of the main inputs to the allocation process will be the market value of CZC, as described in section 1.3.3. In order to take into account the uncertainty around this forecasted value, uplifts will be placed on the market value that is used to calculate the allocated CZC used for exchange of aFRR capacity. This represents a conservative approach for allocating CZC for the aFRR market, favouring the day-ahead market:

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

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

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

2.5. Socioeconomic benefit and impact of allocating CZC

2.5.1. Theoretical framework for comparing value of CZC between two market

In order to assess 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 reducing or increasing CZC. First, when we use 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. We assume 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.

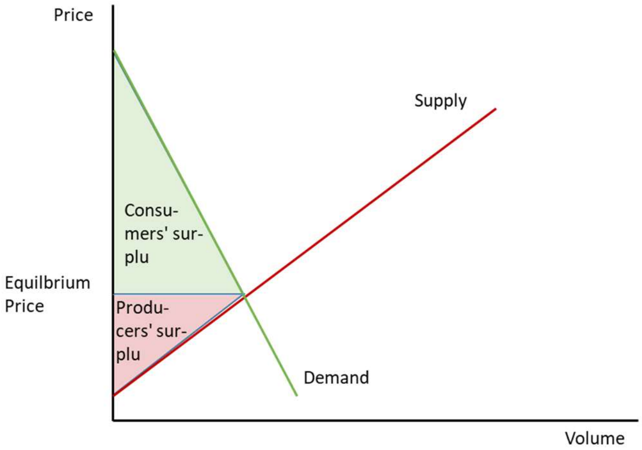

Figure 2. Socioeconomic surplus in market with no congestion and no transport costs

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, we can construct a net imports curve for area A and a net exports curve for area B, as illustrated in Figure 3. Putting them together in one diagram as in Figure 4 allows us to find the the optimal volume of exports from area B to A in terms of total socioeconomic surplus.

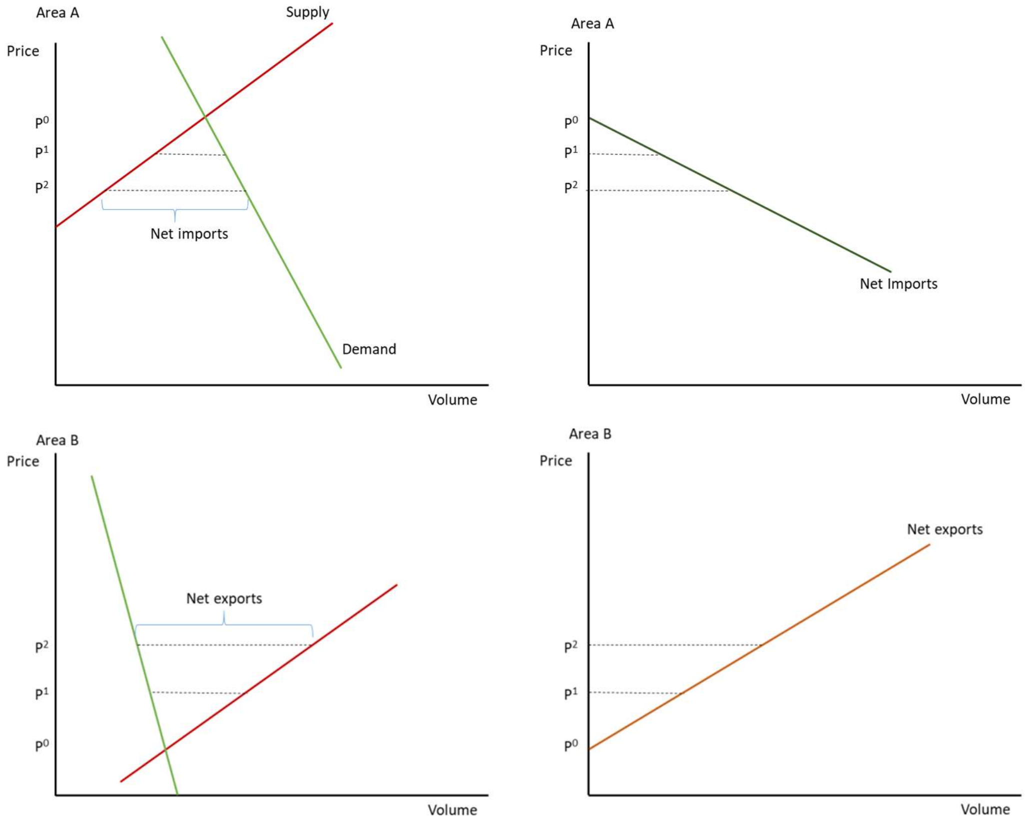

Figure 3. Net import curve for high price area A (above) and net export curve for low price area B (below)

We have the same price in both markets and if we aggregated supply curves and demand curves of both areas in one diagram we 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 getting access to a new market with higher willingness to pay.

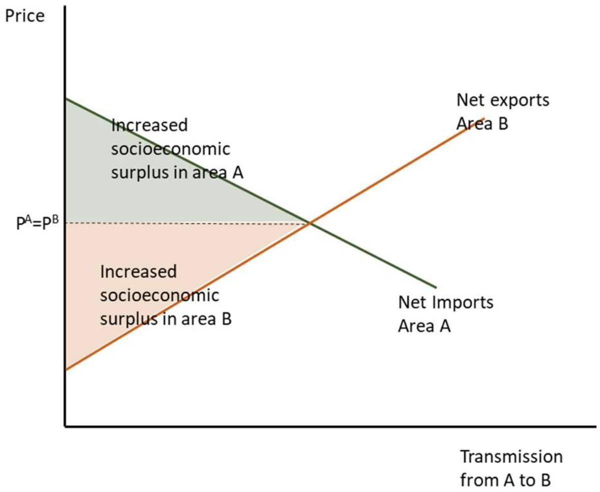

Figure 4. Optimal volume of exports from area B to A in terms of total socioeconomic surplus

In Figure 6 the CZC constraint is introduced and this limits the 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 we reach 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, as we are now able to compare the the use of CZC between two markets. We should aim at allocating CZC to the market where the marginal increase in socioeconomic surplus is the highest.

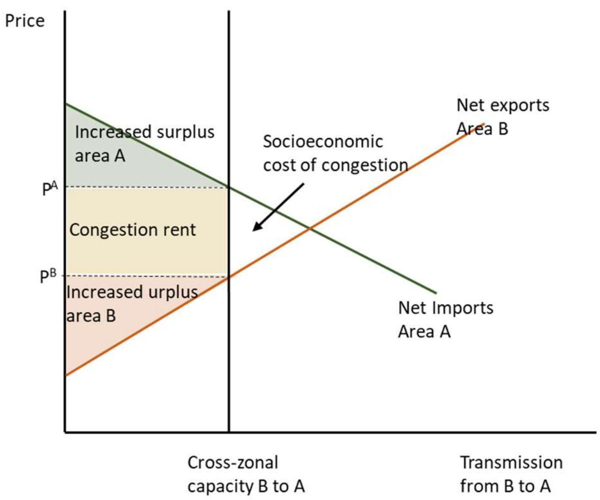

Figure 5. Socioeconomic surplus in market with congestion

This is illustrated in Figure 6 where we have two markets involving area A and B. 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. We see 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.

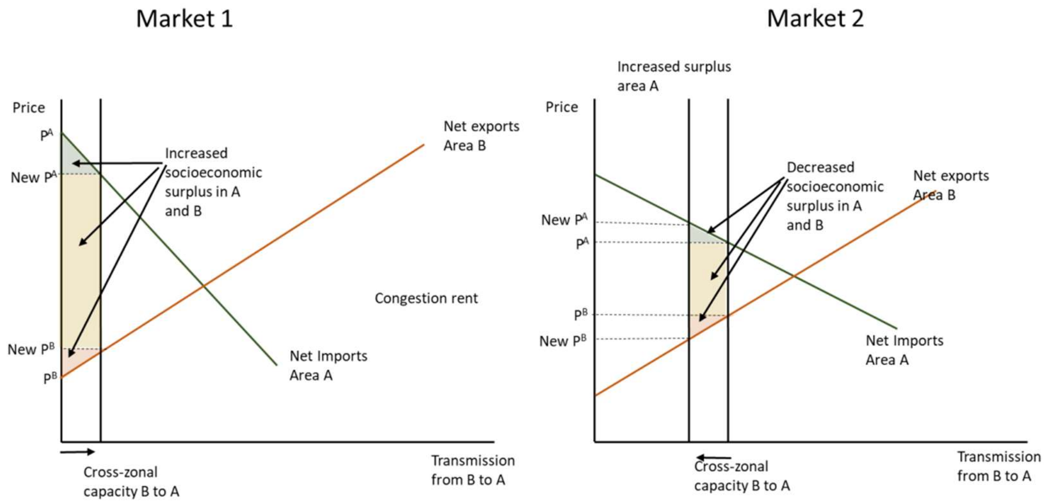

Figure 6. Change in socioeconomic surplus in two interconnected markets

A popular way to illustrate the optimal allocation of capacity between two markets is to use bathtub diagram where we use price difference curves for the two markets 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 in 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.

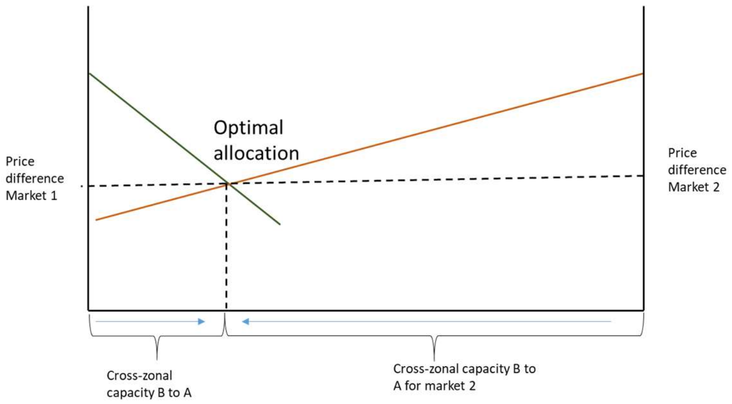

Figure 7. Bathtub diagram showing the optimal allocation of CZC between two markets

2.5.2. Assessment of the proposed methodology

There are of course several characteristics of the aFRR capacity market and day-ahead energy market that differ from what is implicated with the simplistic example of area A and B above in section 2.5.1 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. This does not, however, prevent using the price difference as indicator of market value.

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

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. There will, however, be certain features of the methodology making it less likely that a forecast error will lead to too much transmission capacity allocated for aFRR capacity over time. 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. As illustrated in Figure 8, it may only be due to extreme under-estimation of market value in the energy market where this will lead to over-allocation of transmission capacity to the aFRR capacity market. In addition, there are have uplifts on the price difference of the reference day that also will contribute to systematic over-allocation to the energy market rather than the aFRR capacity market.

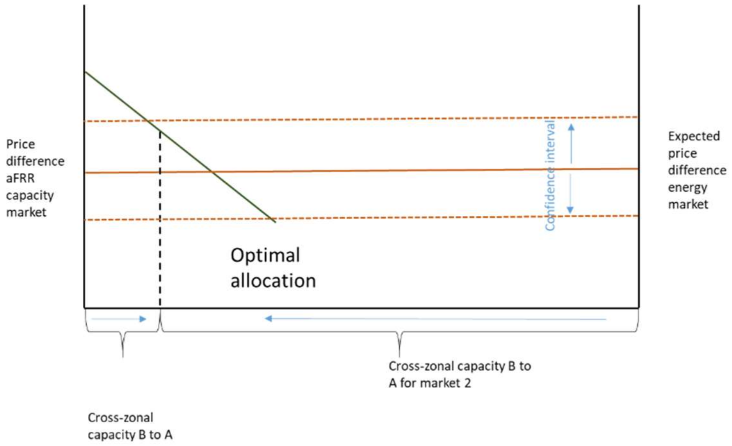

Figure 8

The evaluation of the Hasle pilot, which was based on a reference day forecast method, showed that about of 50 percent of the potential gain from allocating transmission capacity for exchange of aFRR capacity given the ex-post known energy prices, was realised and in general, allocation of more transmission capacity to the aFRR capacity market would be necessary in order to realise more of the potential.

Another aspect, which can lead to an under-estimation of price differences in the energy market is the impact on the energy prices of reduced transmission capacity for the energy market. When a price difference of a certain hour of the reference day, where no transmission capacity was allocated to the aFRR capacity market, is used as basis for the forecast, we can expect that the allocation itself can lead to higher price difference in the day-ahead market. The fact that we introduce uplifts on the price difference will compensate for this, but the question is still whether the price impact of reduced transmission capacity for the energy market can have a considerable effect on the true optimum allocation of transmission capacity.

A specific study of the price impact of reduced transmission capacity between NO1 and SE3 in the day-ahead market was carried out by Nord Pool as part of the evaluation of Hasle pilot phase 1. The clearing algorithm with the same historic bid data and transmission capacities were run with different amounts of reduced NTC between NO1 and SE3.

The conclusions from this analysis were the following:

- In general, the impact of the allocation of CZC for the aFRR market on day-ahead prices was small, however, the impact was bigger when price differences were bigger.
- This study also highlighted that the day-ahead market clearing is not guaranteed to find the optimal solution and this gave some some counter-inituitive results where the price difference decreased as transmission capacity was reduced.

The clearing algorithm of the day-ahead market runs for a limited time and chooses the best solution found within this time period in terms of socioeconomic surplus. When new transmission capacity is given as input we have a new starting point for the algorithm and it is not guaranteed that it finds a more optimal solution.

In general, for normal market situations, the bid curves are generally flat which means that the prices are not changing much with smaller changes in consumption, generation and exchange.

It can be argued that the methodology for allocation is robust in the sense that it should increase the socioeconomic surplus compared to not having any allocation to the exchange of aFRR capacity while the risk for unjustified negative impacts on the day-ahead market should be very small. More experience will allow for improvements of the methodology aiming to realize more of the potential socioeconomic gains over time.

<u>Impact of pay-as-bid and complex bid formats in the aFRR capacity market</u>

In the two area example presented in section 2.5.1, we assumed that there was one equilibrium price/clearing price for all participants in both markets. In the aFRR capacity market the pricing will be based on the pay-as-bid principle for the first phase of the market, which can lead to some strategic bidding and possibly less efficient market results. In addition we allow indivisible bids in the aFRR capacity market which create non-convexities for the optimisation algorithm.

A problem with this is that we do not have a monotonic increasing marginal price curve for different exchange volumes, and it is not possible to compare the price differences as the marginal value of CZC in the aFRR capacity market and the energy market as we do in the simplistic two-market example above However, as we have all the bid information for aFRR capacity, the algorithm can ensure that we use a representative market value of the aFRR market to compare with the forecasted market value for 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 market, which is considered as a good estimate on socio-economic cost of reducing the CZC available for the energy market.

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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 reserve a given volume of aFRR capacity in order to ensure access to balancing energy. 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.

2.5.3. 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 provison 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 provison of the aFRR capacity or earlier. However, the Nordic TSOs consider it critical to monitor the performance of the methodology carefully and make improvements as more experience with the market is gained.

2.6. Publication of market information

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

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