Evaluation Report 2025

The Baltic Balancing Capacity Market for aFRR and mFRR

31.10.2025

Contents

Summary

The document at hand aim presents key information about the Baltic Balancing Capacity Market (BBCM), which operates in Estonia, Latvia, Lithuania. The market go-live was on the 4th of February (first auction day) with first balancing capacity delivery on the 5th of February 2025. For the entire operation period of the market, the Baltic TSOs have used the market-based allocation method for allocating cross-zonal capacity for the exchange of balancing capacity and sharing of reserves in accordance with article 41(1) *Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing*.

For the purpose of all analysis presented in this document, all data from the BBCM operation and impacts on the Single Day-Ahead Coupling (SDAC) is presented from the time period of 05.02.2025-30.09.2025 (delivery days, inclusive).

The analysis on forecast errors identified that despite the high allocation limits for allocation of the cross-zonal-capacity (CZC) for the exchange of balancing capacity and sharing of reserves on the Baltic internal borders, most of the time the forecast error is zero. This is due to the fact that the Baltic internal borders are mostly uncongested on the day-ahead market. This is especially true for the border between Latvia and Lithuania. The border between Estonia and Latvia with the direction towards Latvia was found to be the most congested border. On this border the forecast errors are also most significant, with the average absolute forecast error reaching up to an average of 6,63 €/MWh. As the reference day methodology has been used in the studied period and the adjustment factor has exclusively been used with a zero value, the average errors are close to zero.

The analysis of impact of the allocation process on the price formation on SDAC shows a limited change in SDAC welfare. Modelling with Simulation Facility yields an estimated total welfare loss of 4,1 million euros in SDAC. However, the modelling results indicate that under some circumstances Simulation Facility might not be appropriate to investigate the welfare impact of miniature changes in market configuration, especially if already in the baseline situation the level of congestions is low or non-existing. Thus, a simple alternative approach was also utilized to estimate a worst-case impact on SDAC form the CZC allocation process. This approach yielded an estimated 8,24 million euros of welfare loss on SDAC. The analysis with Simulation Facility on the impact of price formation on SDAC also indicated a limited influence. CZC allocation has had a price lowering effect in Estonian day-ahead market (-2,2 €/MWh) and an increasing effect on Latvian (+0,7 €/MWh) and Lithuanian (+0,4 €/MWh) prices.

The cases of over 50% of net transmission capacity (NTC) allocations all indicate that higher than the default limit of 50% allocations only occurred during the periods where the Estonia-Latvia border NTCs were heavily restricted. During the whole hourly period, this only happened 102 times in the Estonia-Latvia direction, and 21 times in the Latvia-Estonia direction. Since for the Lithuania-Latvia border NTCs were usually much larger in comparison to the Estonia-Latvia border, no occurrences of over 50% of NTC allocations were detected.

Similarly, as the overall impact of CZC allocations was quantified, specifically the welfare impact of CZC allocations above 50% was quantified. The welfare effect was found out to be almost insignificant, with the total welfare loss amounting to 0,01 million Euros (according to Simulation Facility modelling) and 0,015 million Euros (according to pessimistic assessment).

On the other hand, benefits of the allocation process were calculated on the balancing capacity market. This was realized in a modelling exercise with balancing capacity market assuming there was no common capacity market, and only local auctions took place (0 NTC for balancing capacity exchange and sharing available). The modelling results indicate that the cost jumps are extraordinary – procurement would be 1,5 billion euros more expensive. More importantly, the reserve coverage in the local procurement scenarios – a total of 3,78 million MW of unmet demand were observed, meaning that scarcity is enormous and security of supply cannot be ensured, which would lead to the reduction of the reference incidents. The economic impact of such

actions cannot be quantified in this study and thus the inability to meet TSO demand was quantified with the price cap of the balancing capacity market. Accordingly, regarding socioeconomic welfare, the difference is even more staggering – welfare would decrease by more than 30 billion euros, which completely eclipses the potential welfare taken away from the SDAC due to balancing capacity allocations (4,1 million Euros).

Analysis on TSO resource usage highlights the used volumes of TSO resources in the BBCM. Balancing capacity price impacts of using TSO resources is indicated. Furthermore, total cost indicators from three scenarios are compared – business as usual, without any TSO resources and with TSO resources but remuneration from the market. It can be observed that without TSO resources, balancing capacity procurement costs in BBCM would have been intolerable – completely removing TSO resources would have increased costs by more than 1,9 billion euros. In the additional scenario where TSO resources would receive renumeration, the additional costs are still significant – over 90 million euros higher. It can be concluded that TSO resources are vital assets in the capacity market at the moment of preparation of this document, in which there is a vast shortage of flexible supply. Without such resources, must-run generation would usually be necessary, leading to the immense increase of procurement costs.

1. Introduction

This report is prepared in accordance with requirements described in the *Methodology for the market-based allocation process of cross-zonal capacity for the exchange of balancing capacity for the Baltic CCR* (hereinafter: "MB Methodology"). The aim of the report is to analyse the effectiveness of the forecast of the market value in cross-zonal capacity ("CZC") for SDAC for the purpose of market-based allocation for CZC for the exchange of balancing capacity and sharing of reserves. Furthermore, additional requirements for the contents of this report are established in *Augstsprieguma tīkls, Elering and Litgrid proposal for the Baltic balancing capacity market in accordance with Article 33(1) and Article 38(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing* (hereinafter: "Market Rules Methodology")

Accordingly, the report must contain the following analysis according to the MB Methodology Article 12:

- *a comparison of the forecasted and actual market values of cross-zonal capacity for the Exchange of energy;*
- *assessment of the impact on the price formation of the single day-ahead coupling due to the allocation of cross-zonal capacity for the exchange of balancing capacity and sharing of reserves;*
- *assessment of impacts on the economic surplus of the SDAC and economic surplus from the exchange of balancing capacity and sharing of reserves from the application of the market-based allocation process and the specific impact following an increase of a default limit for the maximum volume of cross- zonal capacity allocated for the exchange of balancing capacity and sharing of reserves pursuant to the process described in Article 5(1)(c);*
- *assessment of the adjustment process according to Article 6 (2), including assessment of the number of hours the adjustment has been made and assessment on the magnitude of the adjustments made;*
- *where necessary, proposals to improve the accuracy of the forecasted market values, including a different limit for the maximum volume of cross zonal capacity pursuant to Article 5(1) or different mark-up values per bidding zone border pursuant to Article 6(2) based on the results of the relevant analysis;*
- *an assessment on the need to adjust the percentage limits on cross-zonal capacity allocation described in Article 5(1);*
- *assessment of occurred increases of the limits for the maximum volume of cross-zonal Capacity allocated for the exchange of balancing capacity and sharing of reserves in accordance with Article 5(1)(b), including statistics on the amount of incidents, increased volumes and percentages, reasons for the incidents and an analysis of the economic surplus effects on the SDAC;*

and according to the Market Rules Methodology:

- *Baltic TSOs, [..] shall publish and submit information to the relevant regulatory authorities about the volumes and usage of demand reduction resources and back-up resources.*

All of the listed aspects have been analysed in the preparation of this report and the results are described in the following chapters.

For the assessment of welfare impact on SDAC, the Simulation Facility tool has been used. The Simulation Facility is a modelling framework maintained by Market Coupling Steering Committee TSOs and NEMOs and in which historical SDAC market data and the Euphemia algorithm can be used to simulate day-ahead market alternative scenarios.

At the time of writing the analysis, the data for the following dates was missing in the Simulation Facility dataset: 21.07, 25.07, 26.07, 27.07, 29.07, 01.08, and 02.08. Therefore, the analysis presented in Chapters 2 and 4 does not include simulation data for those dates.

2. Comparison of the forecasted and actual market values of CZC for the exchange of energy and sharing of reserves

This chapter compares the forecasted cross-zonal-capacity (CZC) cost with the ex-post actual alternative cost of reserving CZC in the BBCM.

CZC on an interconnector reserved for the BBCM is made unavailable for the day ahead market (SDAC) auction, which is cleared later that day. Therefore, the value of this reserved capacity can be estimated as its alternative or opportunity value in the SDAC. The (marginal) alternative value is then equal to the difference (spread) in SDAC prices on each side of the border in question.

The cost of reserving CZC in the BBCM clearing is calculated based on this alternative value. However, since the SDAC is cleared after the BBCM, a forecast alternative value is used, based on the SDAC prices from the reference day.

The reference day is:

(c) the previous working day whenever cross-zonal capacity is allocated for a working day;

(c) the previous weekend day or bank holiday whenever cross-zonal capacity is allocated for a weekend day; and

(c) the previous Sunday or bank holiday whenever cross-zonal capacity is allocated for a bank holiday in any of the relevant bidding zones.

In addition, a dynamic markup is added to the forecasted value of CZC.

2.1. SDAC spread errors

The method to forecast the SDAC spread uses SDAC prices from reference day:

$$SDACspread_{t',r,r'} = \max(0, SDACprice_{t',r'} - SDACprice_{t',r})$$

The SDAC spread is set equal to the price in the importing region (r') minus the price in the exporting region (r). If the price in the exporting region (r) is greater than the price in the importing region (r') i.e., the spread is negative, the forecasted value will be zero.

The SDAC spread for hour t' of reference day is used to set the CZC cost for hour t. For example, the SDAC spread part of the CZC cost for the border from Estonia (EE) to Latvia (LV) in hour 6 on 5 March is the maximum of 0 and SDAC price in hour 6 on 4 March for LV minus the SDAC price in hour 6 on 4 March for EE.

Below, we analyse the SDAC spread error caused by using the SDAC spread on reference day (t') as a forecast for the SDAC spread for hour t. The SDAC spread error is calculated as the difference between the SDAC spread for t' and the SDAC spread for hour t for each given border.

Note that in the exposition below, we refer to SDAC spreads and SDAC spread errors in €/MW rather than €/MWh. This is because the BBCM is a capacity (MW) market, and the CZC costs are calculated as €/MW.

Frequency of SDAC spread errors

Figure 1 shows SDAC spread errors split into three groups – no difference, positive difference (forecast spread higher than actual), and negative difference (forecast spread lower than actual) for all borders and directions.

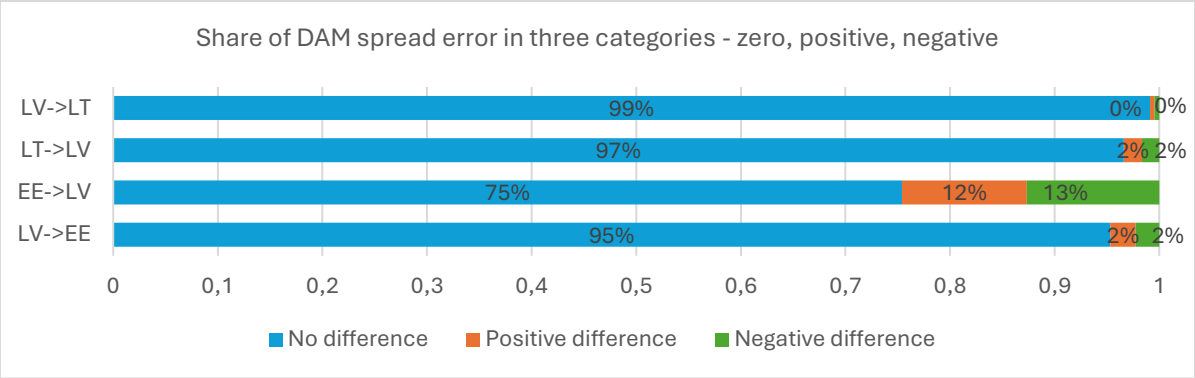

Figure 1 - SDAC forecast error distribution

Three of the four borders have SDAC spread errors in fewer than 5% of hours in the period analysed. Only EE -> LV border has SDAC spread errors in 25% of the hours. This is caused often by lower prices in Finland which causes a significant flow from North to South. Additionally, the calculated NTC value on the EE->LV border is often the lowest of the NTCs calculated between the Baltic bidding zones. Since the day-ahead market prices in the Baltic countries are often the same, the SDAC spreads on the borders tend to be zero, so the forecasts are quite accurate.
The number of hours with positive and negative SDAC spread errors tend to be similar on each border (albeit different from others on EE->LV border).

Average SDAC spread errors

Figure 2 shows the average SDAC spread error for each border. For three out of the four borders, the mean SDAC spread errors are, as expected, close to zero. However, on the EE -> LV border, the average error is larger than for other borders. This is likely due to more frequent congestion on this border, leading to more spread errors. Over a longer period, this value is likely to also approach zero. A positive number means that by using the t' spread to forecast we overestimate the actual spread. A negative number means that the forecasted spread is underestimated compared to the actual spread.
Examining the absolute SDAC spread errors on figure below, gives us better insights into the real errors of the forecast. On average over all border directions, the absolute error is 2.51 €/MW. The smallest error occurs on the LV -> LT border, amounting to only 0.24 €/MW. In terms of mean absolute errors, the EE -> LV border still differs from the others, but not so significantly anymore.

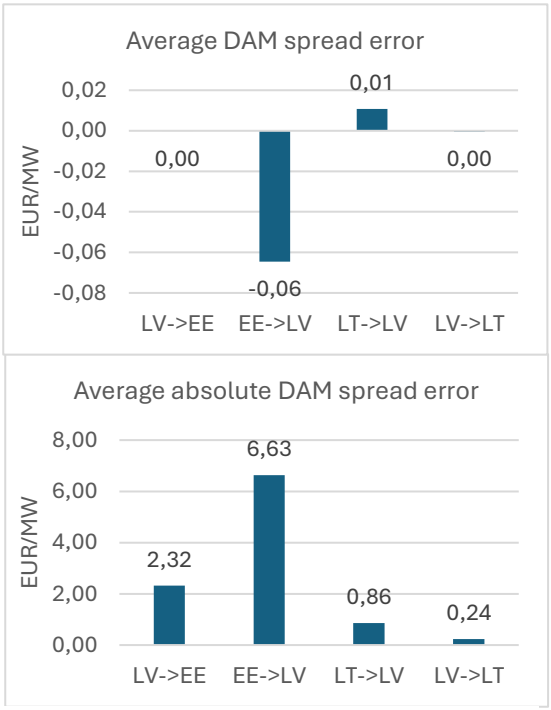

Figure 2 - Average SDAC forecast error values

2.2.Mark-ups

According to the Market-Based allocation methodology, a mark-up shall be added to the initial forecasted market value of cross-zonal capacity calculated in order to take into account the uncertainty of the forecasted market value of cross-zonal capacity. The default markup values are as follows:

- if there is a negative or zero market spread for the initial forecasted market value of cross-zonal capacity in accordance with paragraph 1, the mark-up will be 0.1 EUR/MWh; and
- if there is a positive market spread, for the initial forecasted market value of cross-zonal capacity in accordance with paragraph 1, the mark-up will be 1 EUR/MWh.

The application of mark-ups showed no significant difference in allocation of balancing capacity per border in cases where the 1 EUR/MWh value had been set according to the methodology. Due to prioritisation of development of core BBCM features and technical infeasibilities, higher mark-up calculation was not used during live runs, meaning that the applied mark-up values were either 0.1 EUR/MWh (when no price difference forecasted) or 1 EUR/MWh (when price difference forecasted). The fully intended higher mark-up calculation shall be applied by the end of 2025.

3. Allocations of CZC above the 50% limit

According to the MB Methodology, the default limit for maximum cross-zonal capacity allocation is 50% of NTC. However, this limit can be breached in certain cases where TSOs cannot satisfy their reserve requirement, up to the maximum possible value of 70% of NTC. In this chapter, the cases where CZC allocation was above the default 50% limit in any Baltic borders shall be presented and analysed for the analysis period. Overall statistics of the occurrence of these events is delivered in Table 1.

Table 1 - Over 50% of NTC allocation occurrences during the period 2025.02.05-2025.09.30

Border direction	EE>LV	LV>EE	LV>LT	LT>LV
Total number (#)	102	21	0	0
% of all MTUs	1,79%	0,37%	0,00%	0,00%
Average NTC (MW)	490	417	N/A	N/A
Average allocation (MW)	265	286	N/A	N/A

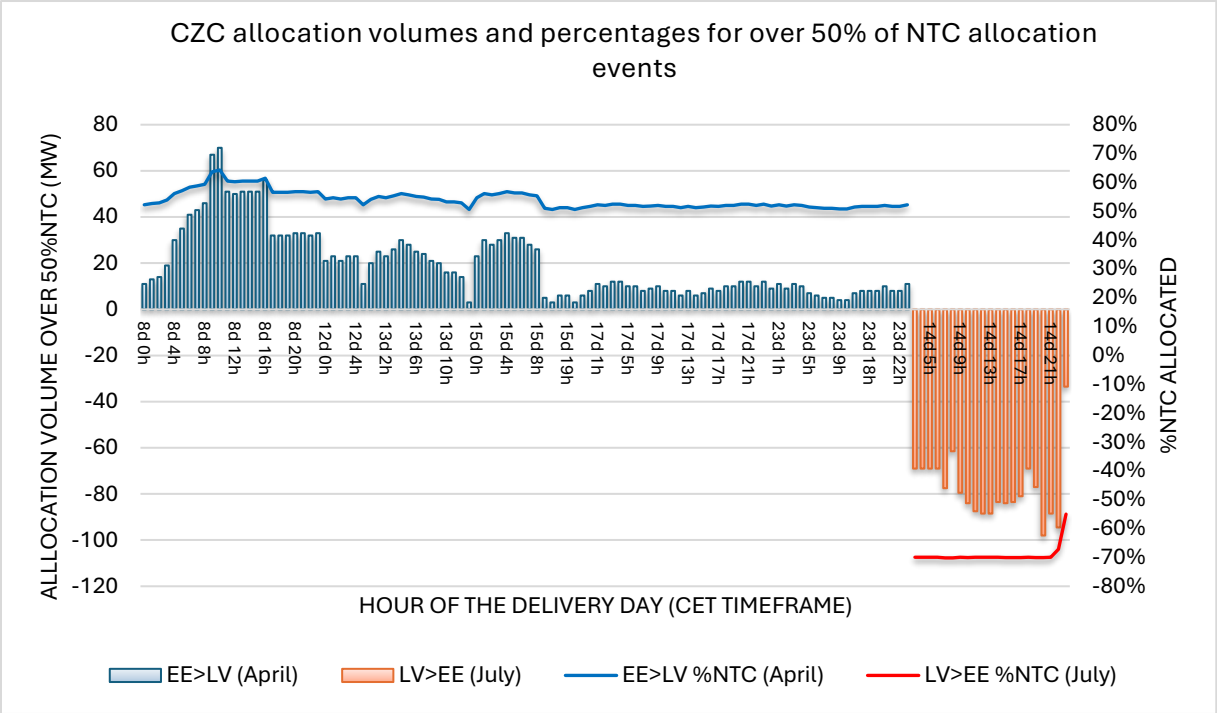

Figure 3 - CZC allocation volumes and percentages for over 50% of NTC allocation events

During the analysis period, only for the Estonia-Latvia border over 50% CZC allocations were observed, with 102 occurrences for EE>LV direction, and with 21 occurrences for LV>EE direction. Together, this is less than 2% of all hours of the investigated period mainly caused by significantly reduced NTC values on the border between Estonia and Latvia.

The EE>LV overallocations were due to Estonia importing mFRR down from Latvia/Lithuania. All 102 of the discovered cases occurred during the maintenance period where EE-LV NTC was restricted to 490 MW. Since there was a considerable lack of mFRR down suppliers in Estonia, the total allocations (284 MW) were significant compared to the NTCs (490 MW), especially during the maintenance period. On average 54% of NTC was used in order to cover Estonia's mFRR demand during the affected periods.

For the LV>EE direction, allocations above 50% of NTC occurred because of the heavily restricted LV>EE NTC during the one single day in July, as Estonia usually imports a significant amount of FRR up reserves to cover their large demand. As a result, on average 69% of NTC was used for FRR up balancing capacity import, which is almost the maximum possible amount. During that period, the SDAC flows were in the EE>LV direction, therefore the FRR up balancing capacity import from Latvia to Estonia had no effect on the SDAC.

For the LT-LV border, no allocations above 50% of NTC were observed, as in comparison, LT-LV NTCs are almost always larger than EE-LV NTCs (see Figure 4 and Figure 5). This is further aided by the fact that Lithuania is the main reserve provider in the Baltics, therefore Lithuania is usually always exporting their procured balancing capacity, as a large portion of their demand is covered locally.

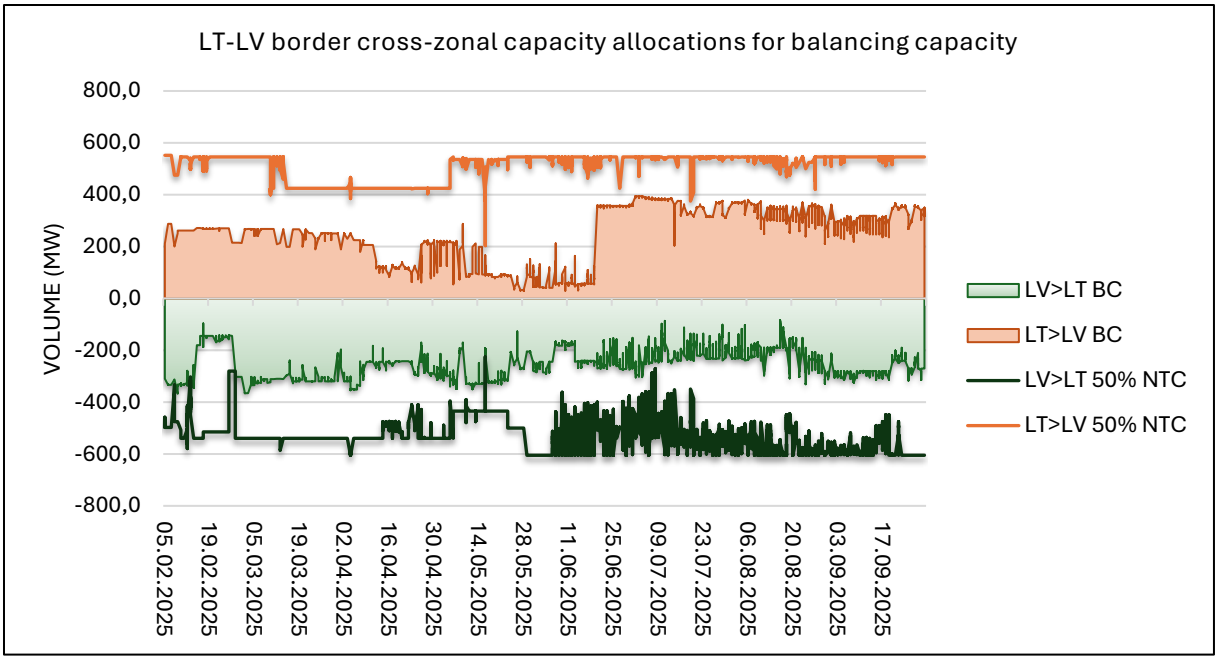

Figure 4 – Allocated cross-zonal capacity for balancing capacity exchange and sharing for the LT-LV border

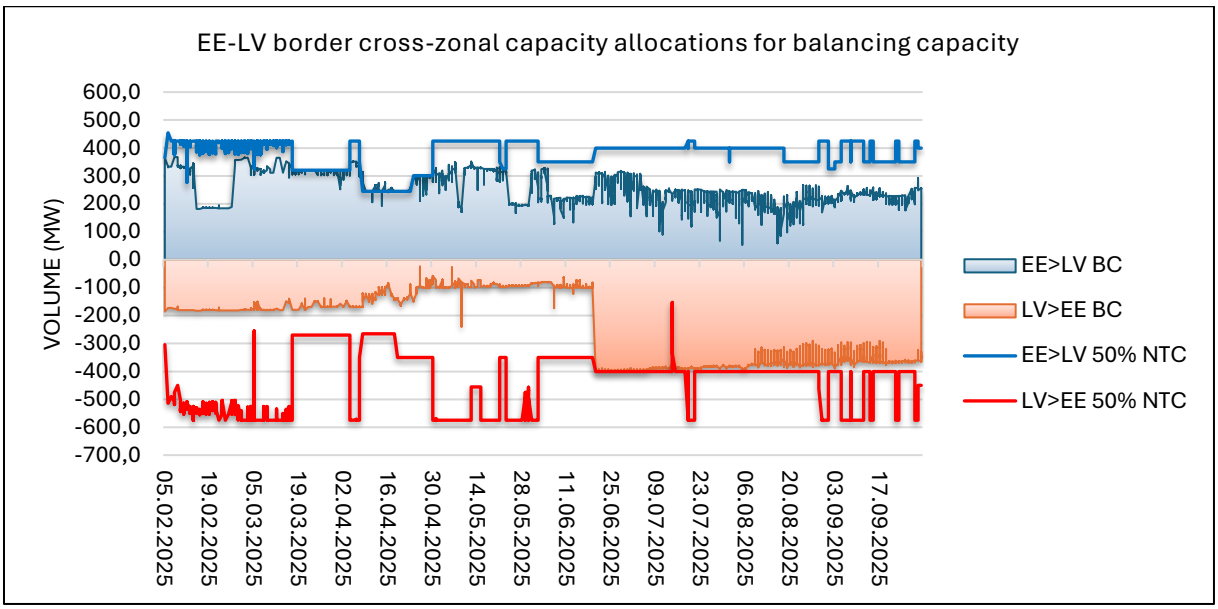

Figure 5 – Allocated cross-zonal capacity for balancing capacity exchange and sharing for the EE-LV border

Overall, it can be concluded that 50% NTC breaches only occurred during heavy NTC restriction period on the Estonia-Latvia border. During April, Estonia's import of mFRR downward and, during a single July day, Estonia's import of FRR upward reserves was heavily restricted due to reduced NTC values.

4. Impact on SDAC due to allocation of cross-zonal capacity for the exchange of balancing capacity and sharing of reserves

In this chapter, the impact on the SDAC has been assessed using the Simulation Facility. We analyse how the allocation of cross-zonal capacity for the exchange of balancing capacity and the sharing of reserves affects the price formation in the single day-ahead coupling. Furthermore, the resulting effects on the overall economic surplus of the SDAC are assessed.

To calculate the change in economic surplus and price formation in the SDAC, we utilize a Simulation Facility tool allowing us to conduct the analysis based on the actual DA market supply and demand curves. The Simulation Facility tool allows us to rerun the DA market clearing with higher capacities (original capacity + CZC reservation) to estimate the changes following from the CZC allocation.

For the purpose of analysis in this report, other impacts on balancing capacity market clearing on the SDAC are disregarded, such as reservation of assets by the balancing capacity market as well as bringing new generation into the day-ahead market due to accepting bids form thermal power plants in the balancing capacity market. Thus, as the only impacting factor on SDAC investigated is the cross-zonal capacity allocation for the exchange of balancing capacity and sharing of reserves, the impact on SDAC should be strictly zero or negative. This is due to the fact that reservation of cross-zonal capacity for balancing capacity strictly reduces the possible solution space for SDAC, it can never increase it.

4.1. Impact on SDAC price formation

The allocation of cross-zonal capacity for balancing services can have a notable impact on day-ahead market prices. By reserving part of the transmission capacity for balancing capacity exchange, the available capacity for day-ahead market decreases.

Figure below shows the price differences between the base case and the case without reservation. A positive price difference indicates that the base case price was higher, suggesting that the reservation of capacity led to an increase in prices in that bidding zone. Conversely, a negative difference means that prices would have been higher in the scenario without reservation, implying that the reserved capacity had a mitigating effect on prices in that zone.

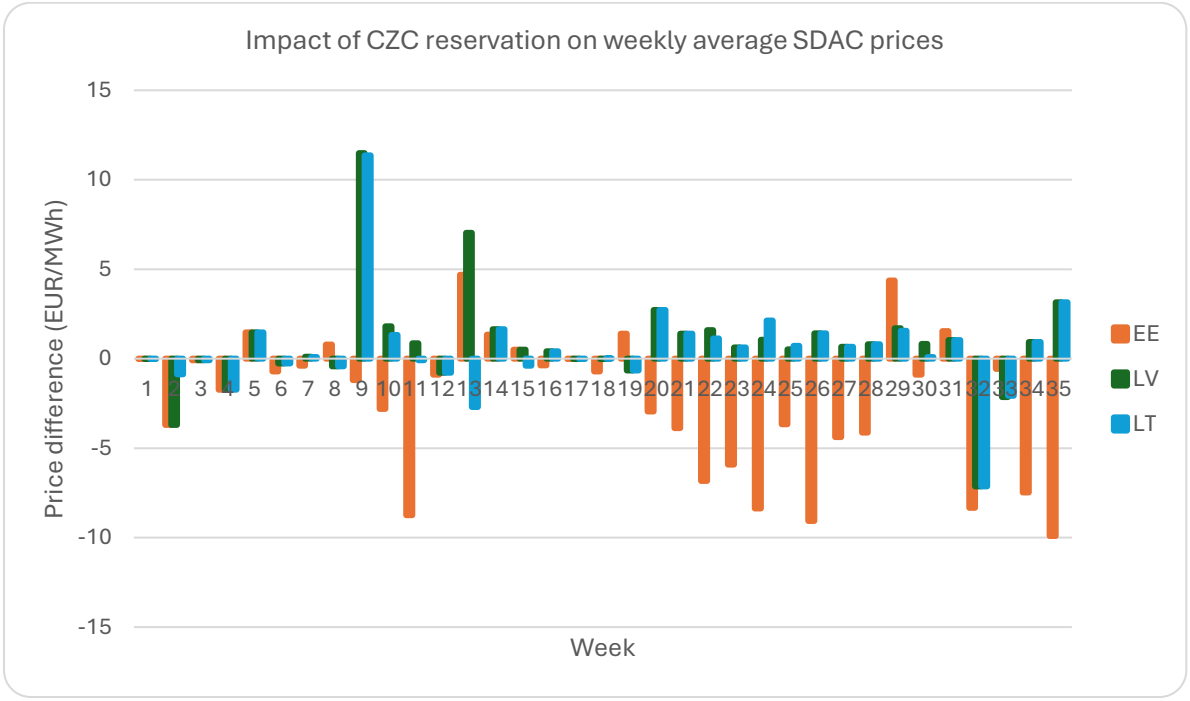

Figure 6 - Impact of CZC reservations on weekly average SDAC prices

The figure highlights the differences in price impacts between Estonia and the other Baltic countries, Latvia and Lithuania. In Estonia, prices are often lower due to CZC reservation, as this strengthens the connection to typically lower Finnish prices. In contrast, when CZC is reserved, Finnish prices have a weaker influence on Latvia and Lithuania, leading to somewhat higher day-ahead market prices in these zones compared to the situation without reservation. Over the entire period, the average price difference was -2.20 €/MWh in Estonia, +0.65 €/MWh in Latvia, and +0.40 €/MWh in Lithuania, confirming that the reservation tends to lower prices in Estonia while slightly increasing them in Latvia and Lithuania.

In Table 2, we can see the monthly average price differences in each region.

Table 2 - Impact of CZC reservations on monthly average SDAC prices

MONTH	EE, Δ€/MWh	LV, Δ€/MWh	LT, Δ€/MWh
February	-1,6	-1,6	-0,7
March	0,5	2,2	2,2
April	-2,4	2,6	0,0
May	0,2	0,5	0,2
June	-1,9	0,9	0,9
July	-6,7	1,1	1,3
August	-1,2	1,0	0,8
September	-4,5	-1,4	-1,4
AVERAGE	**-2,2**	**0,7**	**0,4**

4.2.Impact on economic surplus

We calculate the economic surplus by summing, for each hour, the total consumer surplus, producer surplus, and congestion income of the entire Capacity Calculation Region (CCR). The congestion income, in turn, is obtained for each hour by summing the net position and clearing price of each region and multiplying the result by -1:

$CI_{CCR} = -\sum_{j \in Z_{CCR}} NP_j \times P_j$, where

NP_j is regional net position of bidding zone j resulting from the SDAC,

P_j is clearing price of bidding zone j resulting from SDAC,

Z_{CCR} is set of bidding zones in the CCR.

From the graph, we can see on a weekly basis how the reservation of cross-zonal capacity has affected consumer surplus, producer surplus, and congestion income across the entire Capacity Calculation Region. Producer surplus and congestion income have generally increased compared to the case without reservation, while consumer surplus has tended to decrease. The increase in congestion income was mainly driven by a higher number of congested hours across the region. On average, congestion income increased by 23 993 € per day.

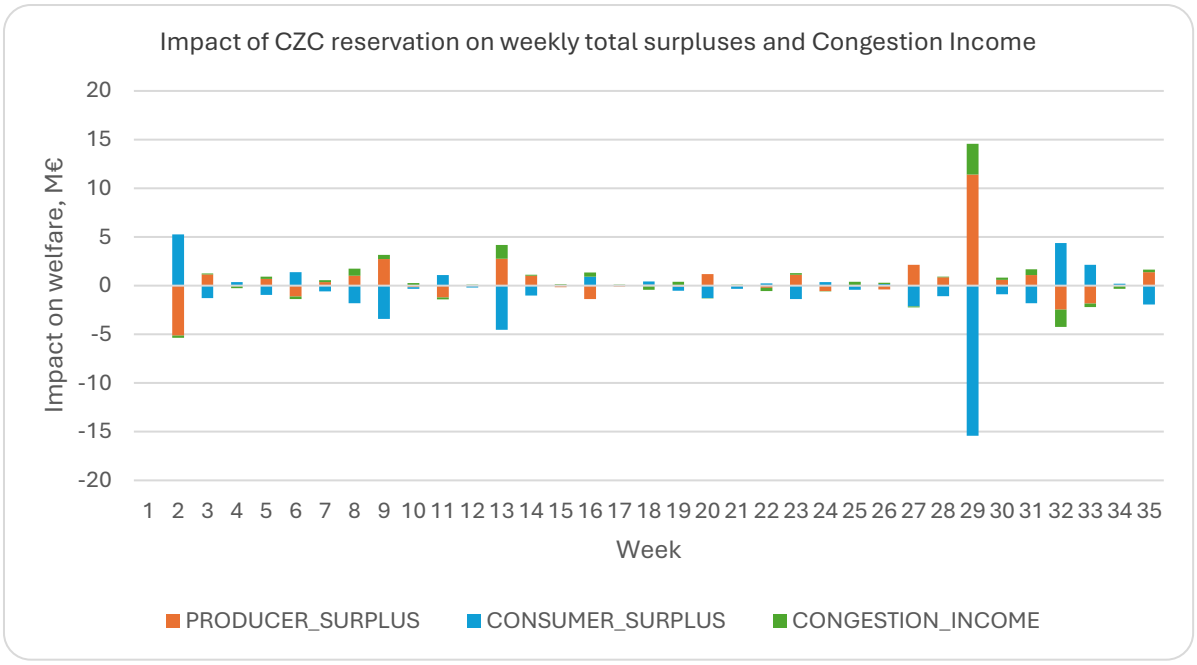

Figure 7 - Impact of CZC reservation on weekly total surpluses and congestion income

When allocating capacity for the exchange for balancing capacity, the capacity is by default reduced in other markets. The possibility of exchanging balancing capacity between price areas has thus affected the SDAC by reducing the available transfer capacity and, consequently and isolated seen, a negative economic effect on the market. In summary, the total economic surplus has decreased, which is also expected when considering the context of this specific simulation. On average, the economic surplus declined by 17 750 € per day.

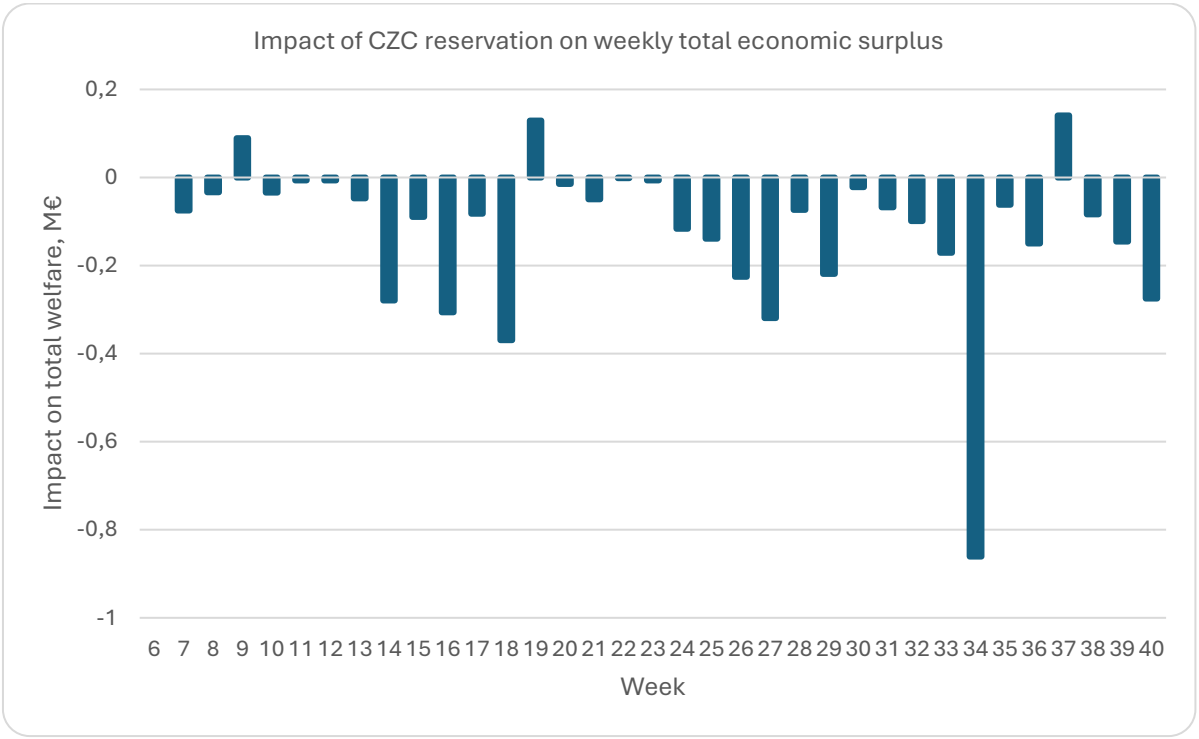

Figure 8 - Impact of CZC reservations on weekly total economic surplus

In the table below, we can see the monthly total differences in economic surplus, which consists of producer surplus, consumer surplus and congestion income.

Table 3 Impact of CZC reservations in monthly welfare components

Month	Producer surplus (M€)	Consumer surplus (M€)	Congestion income (M€)	Economic surplus (M€)
2	-4,43	4,77	-0,41	-0,07
3	3,71	-5,42	1,47	-0,24
4	1,86	-4,29	1,50	-0,93
5	-0,71	0,12	0,62	0,04
6	0,72	-1,07	-0,23	-0,58
7	0,41	-1,60	0,58	-0,61
8	15,02	-19,53	3,32	-1,19
9	-1,75	2,88	-1,64	-0,51
TOTAL	**14,83**	**-24,14**	**5,21**	**-4,10**

The table indicates that the impact of CZC allocation for balancing during the month of May is positive. This is not theoretically possible as explained in the beginning of chapter. However, in practice as Euphemia is not guaranteed to find the fully optimal solution, and in different situations the Euphemia algorithm might end up choosing a different slightly non-optimal solution. As such it can be challenging to use Euphemia to investigate welfare impact of changes which have a minor impact on SDAC. As historically the SDAC price difference between the Baltic bidding zones was very small (monthly average price difference between Estonia and Lithuania in May 2025 was 0,26 €/MWh), then it can be concluded that the impact of CZC allocation on SDAC was not large in magnitude.

In order to reduce the impact of Euphemia possibly on settling different SDAC clearing solutions, an alternative pessimistic approach is investigated in Chapter 4.4 to measure the worst-case impact of CZC allocation on SDAC.

4.3.Impact of allocations of CZC above the 50% limit allocations on SDAC

The default limit for maximum cross-zonal capacity allocation is 50% of NTC. However, in certain cases this limit may be exceeded. In this part, we analyse, similarly to the previous one, how the allocation of CZC above the 50% limit has affected prices and economic surplus. We do this by simulating the hours in which the reserved CZC exceeded 50% and reducing it back to 50%. Since such hours are relatively few of the total period, their impact becomes negligible when averaged over the week. In addition, it should be taken into account that such increases above 50% may not necessarily affect the price if the full capacity was not being used beforehand.

After 30.04.2025, there were no hours in which the day-ahead price changed due to CZC reservations above 50%, so the charts are shown only up to that date for better readability. Similarly, later allocations above 50% did not affect consumer surplus, producer surplus, or congestion income.

In the graph below, we can see the daily average impact on day-ahead prices. The effects range approximately between -8.5 €/MWh and 3.5 €/MWh. As a result, the average price changed over 0.01 € on only 379 hours (15 days and 19 hours) in total. If the change was smaller, it could simply be due to simulation error. The average price change on those 379 hours was -1.48 €/MWh in total. However, when calculating the average over all hours of the period, allocations above 50% affected the average day-ahead price by only -0.04 €/MWh.

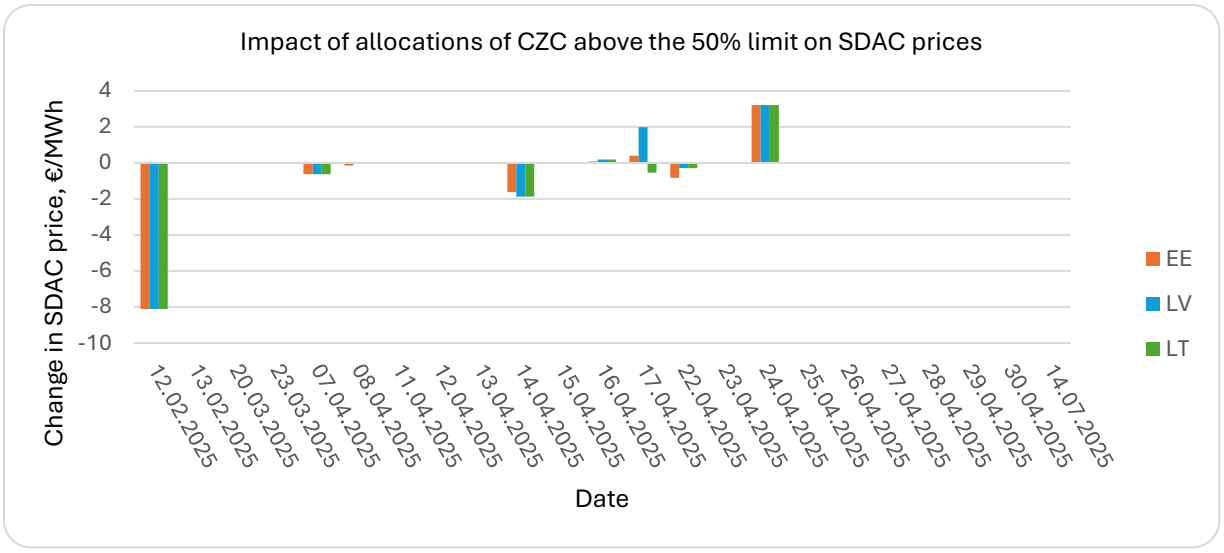

Figure 9 - Impact of CZC allocations above the 50% limit to SDAC prices

From the graph, we can see on a daily basis how the reservation of cross-zonal capacity over the 50% limit has affected consumer surplus, producer surplus, and congestion income across the entire Capacity Calculation Region. Counting similarly to before, the CI changed by at least 0.01 € in 192 hours. The average CI change during these hours is -943.69 €. Over the entire period, however, the hourly average CI change was only -31.72 €.

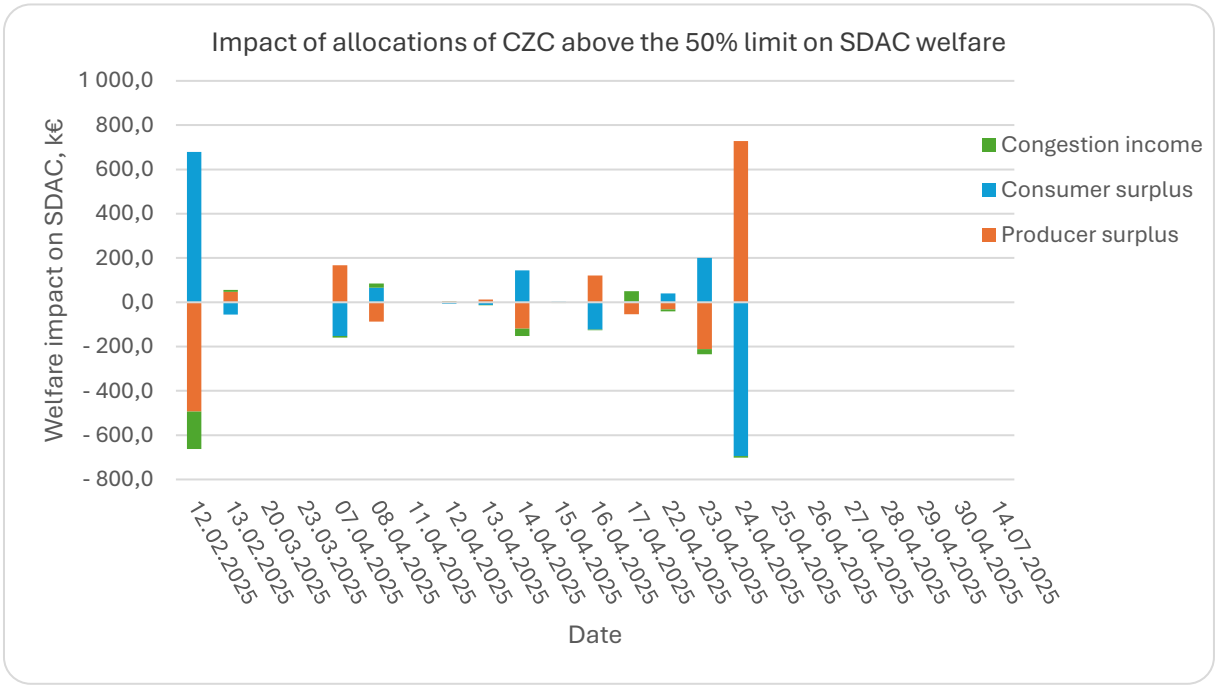

Figure 10 - Impact of allocations of CZC above 50% limit on SDAC welfare

Over the entire period, the total economic surplus across the capacity calculation region changed by -11 010.18 €. The total economic surplus changed by at least 0.01 € in 217 hours and on these hours the mean change was only -50.74 €.

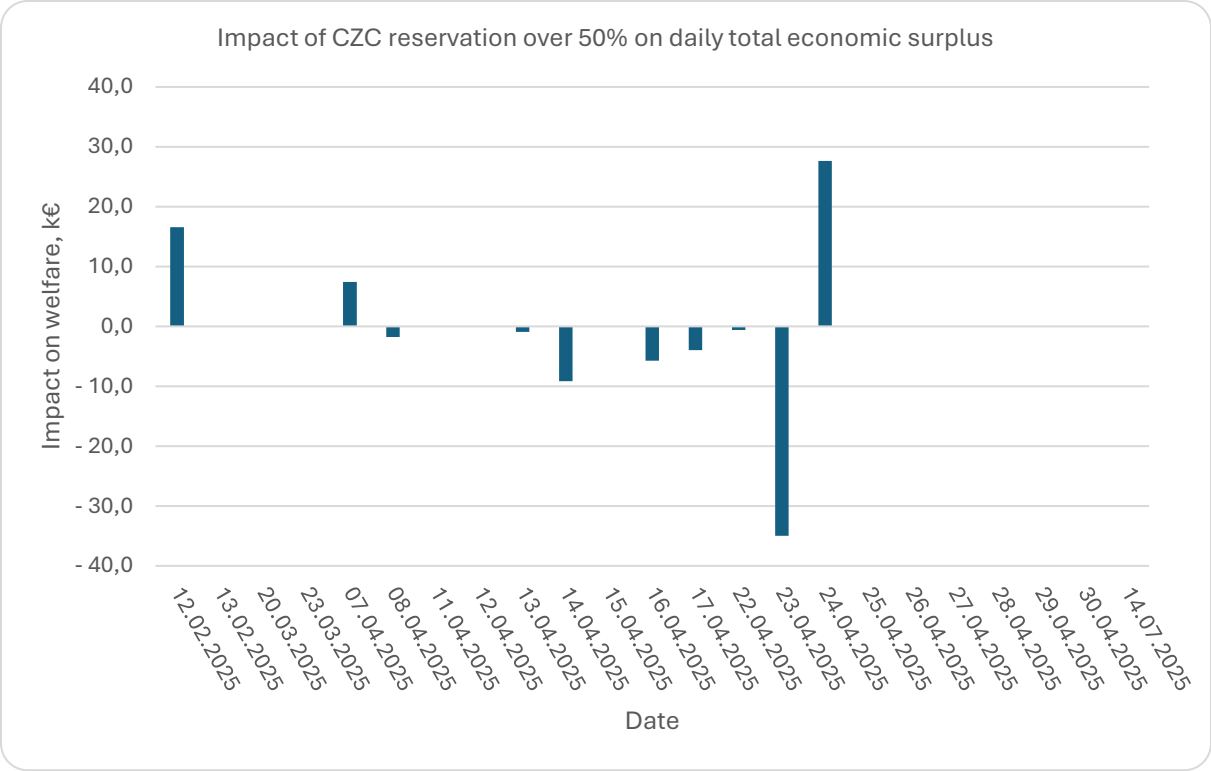

Figure 11 - Impact of CZC reservation over 50% on daily total economic surplus

In addition to the previous charts, the table below also shows that the effects of CZC reservations above 50% are actually very small on average. We can see the monthly total differences in economic surplus, which consist of producer surplus, consumer surplus, and congestion income.

Table 4 - Impact of CZC reservation over 50% on montly SDAC welfare

Month	Producer surplus **(M€)**	Consumer surplus **(M€)**	Congestion income **(M€)**	Economic surplus **(M€)**
2	-0,48	0,67	-0,18	0,02
3	0,00	0,00	0,00	0,00
4	0,41	-0,44	0,00	-0,03
TOTAL	**-0,07**	**0,24**	**-0,18**	**-0,01**

As was also highlighted in Chapter 4.2, in this analysis as well, miniscule positive welfare impacts can be seen on some days. The context of the results is identical and thus similarly, a simple pessimistic approach for the impact analysis is indicated in Chapter 4.4 below.

4.4. Alternative assessment on impact on SDAC due to allocation of cross-zonal capacity for the exchange of balancing capacity and sharing of reserves

As indicated in the two previous chapters, here a pessimistic evaluation is given for the welfare loss of SDAC in a simplified manner and in pessimistic terms, ignoring the change of CZC value for SDAC due to changes in available CZC. In essence here the SDAC welfare loss is estimated by multiplying the realized SDAC price spreads between the Baltic bidding zones and multiplying them with the CZC which was allocated for the exchange of balancing capacity and sharing of reserves:

$$for\ each\ border\ (r, r')\ and\ hour\ t:$$
$$loss_{t,(r,r')} = CZCreservation_{t,(r,r')} \times \max\left(0, DAMprice_{t,r'} - DAMprice_{t,r}\right)$$

The welfare impact methodology described is used both to analyse the overall impact of CZC allocation, but also to assess the impact of allocations which are above the 50% CZC limit.

Overall impact on SDAC

The overall impact on SDAC according to the above-described calculation principles was found to be 8,2 million Euros during the studies period. Due to the border EE->LV being most heavily congested, the majority of impact is identified to being on that border. The distribution of welfare loss across the borders is displayed in Figure 12. Notably, the impact here is roughly twice as large as was indicated by the Simulation Facility analysis. This is probably impacted both by the inaccuracy of the Simulation Facility and, more importantly, due to the pessimist nature of the calculation performed in this chapter. In the Figure 13, the distribution of SDAC welfare impact is also visualized per calendar months.

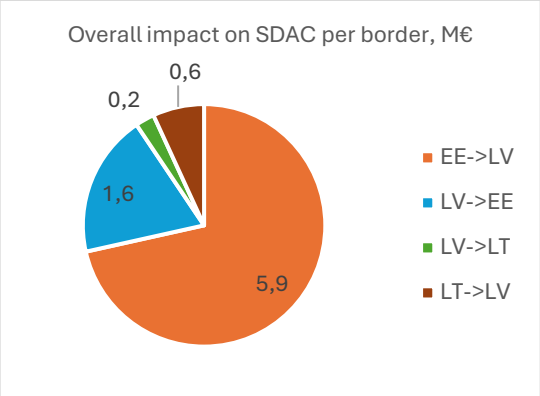

Figure 12 Distribution of SDAC welfare impact on Baltic bidding zone borders

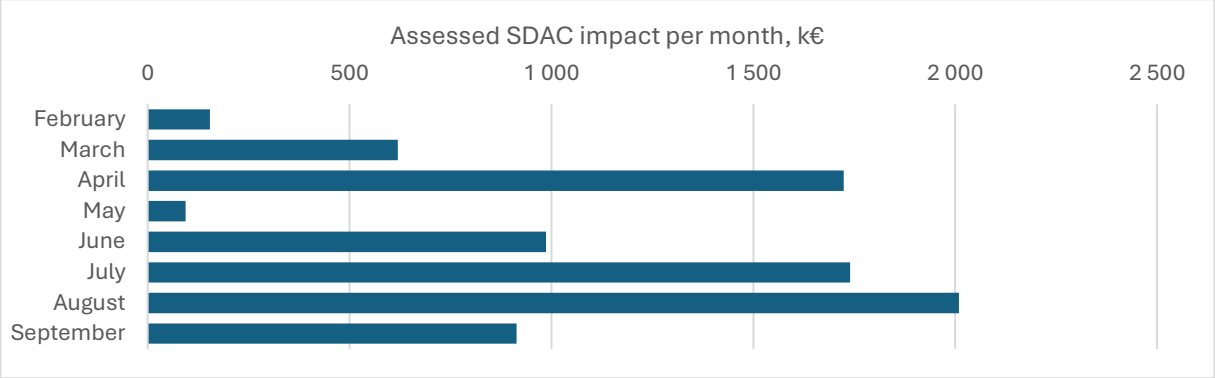

Figure 13 - SDAC welfare impact of CZC allocations over months

Impact of CZC allocations above 50% CZC allocation limit on SDAC

As the instances of CZC allocations above 50% are relatively rare, the impact is rather limited. The overall welfare impact is found to be 15 488,5 €, of which almost all occurs on the border EE->LV. A miniscule amount – 40,9 € of this impact occurs on LV->EE. The impact identified in this analysis is similar to the result identified with the analysis done by using the Simulation Facility.

5. Impact of the adjustment process

The BBCM estimates the forecast CZC value for SDAC by observing the forecast marginal clearing prices of the SDAC in each of the bidding zones. The forecast marginal clearing price of SDAC is always established according to the following mathematical expression:

$$MCP_{1,a}^{SDAC} = MCP_{0,a}^{SDAC} + \alpha_a^{SDAC} \times V_a$$

Where:

$MCP_{0,a}^{SDAC}$ – the forecast SDAC price from the reference day methodology in bidding zone a;

$MCP_{1,a}^{SDAC}$ – the anticipated SDAC price after the shift in net position in bidding zone a;

α_a^{SDAC} – SDAC price volume sensitivity of bidding zone a;

V_a – change of net position from the forecast value for bidding zone a.

The α_a^{SDAC} parameter allows for an adjustment process to take place in the BBCM and modify the forecast marginal clearing price of SDAC during BBCM procurement and bid selection process. During the analysed period, the α_a^{SDAC} has had no other value apart from zero. This essentially means that BBCM has been using the reference day methodology without any further adjustment during the analysed period. The decision to use zero value for the α_a^{SDAC} was derived from the acknowledgment of the fact that the adjustment process can increase as well as decrease the quality of the forecasting process. It was further identified that for the purpose of validating concrete α_a^{SDAC} parameter values which would be capable of improving the forecast process quality, on average, empirical tests with production-like market data would be required. However, unfortunately this was not possible before the go-live of the market. Furthermore, TSOs did not for a period of time have access to a simulation environment of BBCM which would allow the TSOs to conduct analysis on the determination of α_a^{SDAC} parameter values. Therefore, a conservative approach of using zeros for the parameter and relying on the proven reference day methodology was chosen.

Nevertheless, the Baltic TSOs aspire to implement non-zero values for the α_a^{SDAC} parameter once values have been identified which provide positive impact to the forecasting process with sufficient confidence. However, it must be stressed that non-zero α_a^{SDAC} values are not implemented without solid empirical evidence of positive welfare impact of such values on SDAC.

6. Benefits of the process of allocation of CZC for the exchange of balancing capacity and sharing of reserves

In this chapter the benefits of the market-based CZC allocation process are analysed. The benefits arise from the balancing capacity procurement process and are driven by two main drivers: usage of CZC between the Baltic bidding zones in the joint procurement of balancing capacity allows to:

- Make efficient decisions in the bid-selection process and use resources in the bidding zone in which they are most affordable;
- Implement sharing of reserves between bidding zones where an asset in one bidding zone can be used to satisfy the demands of several TSOs in parallel, reducing the total amount of balancing capacity procured.

The economic impacts are quantified by a modelling process where the actually BBCM market clearing results are compared to an alternative Baltic balancing capacity market clearing modelling. In the alternative modelling scenario, all CZC values are set to zero. For both modelled scenarios welfare indicators are calculated, and similarly to the assessment on the impact on the SDAC, three welfare components are calculated and compared: consumer (TSO) surplus, producer surplus and congestion income.

In this analysis, total TSO surplus is defined as follows:

$$Surplus_{TSO} = \sum_{t,product,r} \left(Demand_{t,product,r} \times MCP_{max}\right) - \sum_{t,product,r} MCP_{t,product,r} \times VolAccept_{t,product,r} - \sum_{t,product,r} DemandUnmet_{t,product,r} \times MCP_{max}$$

Where:
$Demand_{t,product,r}$ – demand for balancing capacity product in a bidding zone per product per MTU [MW];
MCP_{max} – maximum possible price for a balancing capacity product, equal to 4000 EUR/MW/h;
$VolAccept_{t,product,r}$ – accepted amount of balancing capacity in a bidding zone per product per MTU [MW];
$DemandUnmet_{t,product,r}$ – unsatisfied amount of demand for balancing capacity product in a bidding zone per product per MTU [MW];
$MCP_{t,product,r}$ – the clearing price for balancing capacity product in a bidding zone per product per MTU [MW];
The BSP surplus shall be regarded as the producer surplus as follows:

$$Surplus_{BSP} = \sum_{t,product,r} \left(VolAccept_{t,product,r} \times \left(MCP_{t.product,r} - P_{t,product,b}\right)\right)$$

Where:
$VolAccept_{t,product,r}$ – accepted amount of balancing capacity in a bidding zone per product per MTU [MW];
$MCP_{t,product,r}$ – the clearing price for balancing capacity product in a bidding zone per product per MTU [MW];
$P_{t,product,b}$ – the offered price for balancing capacity product in a bidding zone per product per BSP bid [MW];

Producer surplus is defined for each bid by accepted bid volume multiplied by the difference in bid price and clearing price. As a result of the modelling exercise, a significant amount of TSO demand is unmet. A total of 3,78 million MW of unmet reserve demand has been identified across the modelled hours. This accounts to on average, to almost one third of total Baltic TSO demand over the analysed period. The large number of unmet demand multiplied by the BBCM price cap yields an extremely high number which cannot be representable of actual financial costs in case of not implementing a market-based allocation process. In reality, TSOs would have to resort to reducing the reference incident in case of unmet demand after which significant costs will

manifest in the SDAC and other markets. Accordingly, unmet TSO demand does lead to significant direct financial losses in other markets, but those losses are extremely difficult to quantify.

The modelling results and the resulting welfare impacts are depicted in the table below.

Table 5 - Benefits of the market-based allocation process to the balancing capacity market

	Difference, millions of Euros
TSO surplus	-31 717
Congestion income	-102
BSP surplus	1 178

Naturally BSP surplus shows a significant increase of more than one billion euros in the modelling exercise without CZC allocation. This is due to a much larger accepted BSP offer volume due to no sharing of reserves as well as increased marginal price in the scenario without CZC allocation. It should be noted that in addition to significant welfare loss due to unmet reserve demand, the TSOs also faced extremely high procurement costs in the scenario without CZC allocation – roughly 1,76 billion Euros for the three TSOs combined. This means a cost increase of roughly 1,51 billion euros compared to the actual costs.

7. Proposals for increasing of efficiency of the forecast market values and assessment of needing to change the CZC limits

7.1. Proposals for increasing of efficiency of the forecast market values

The Baltic TSOs have no proposals to change the mathematical concepts of the forecast methodology defined in the current version in the MB methodology. As indicated by the statistics in chapter 2, the Baltic internal bidding zone borders are often uncongested even after allocation CZC for balancing capacity in the BBCM. This further leads to no forecast errors due to lack of SDAC market spread (and of course, forecast market spread). Nevertheless, the TSOs aim to implement the adjustment process as described in chapter 5, after which additional proposals to change the forecast methodology could be possible.

7.2. Assessment on the need to adjust the percentage limits on cross-zonal capacity allocation

The analysis conducted in this study shows limited impact on SDAC welfare as well as price formation due to the CZC allocation process. On the other side, the benefits to the balancing capacity market are monumental – without CZC allocation TSOs would face unbearably high costs as well as significant amounts of unmet demand which would cause costs in other markets in turn. Therefore, the Baltic TSOs find that there is no reason to lower the CZC allocation limits in the BBCM.

On the other hand, the TSOs have encountered 123 MTUs where the initial CZC allocation limit has been breached, which indicates that on one side of the border all of the balancing capacity bids are exhausted, no matter the price. This means that under some circumstances a lower limit too low can cause significant cost hikes for TSOs.

Therefore, in the future the Baltic TSOs may investigate and propose an increase of CZC limits under some circumstances – for example in the opposite direction of the forecast SDAC flow.

8. Volumes, usage and impact of demand reduction resources

Baltic TSOs identified already in 2021 that at the start of the joint balancing capacity market between the three Baltic TSOs, that the market could face high costs and a shortage of balancing products from market-based assets provided from market participants. Therefore, as a measure to curb extreme costs at the start of the market, mitigate the risk of lack of reserves while the market develops, TSOs developed a methodology to temporarily reduce the amount of reserves procured from the market by using TSO resources (hereinafter: "TSO resources"). TSO resources are assets capable of providing ancillary services which are in the control of Baltic TSOs. As such, TSO resources are used to ensure reserve sufficiency and security of supply but are not remunerated from the Balancing capacity market according to the marginal price principle similarly to ordinary market participants.

Throughout the first months of the BBCM, TSOs have gradually increased participation of TSO resources as demand reduction resources, totalling 290 MW FRR Up and 80 MW FRR Down by the end of the report period (see Figure 14).

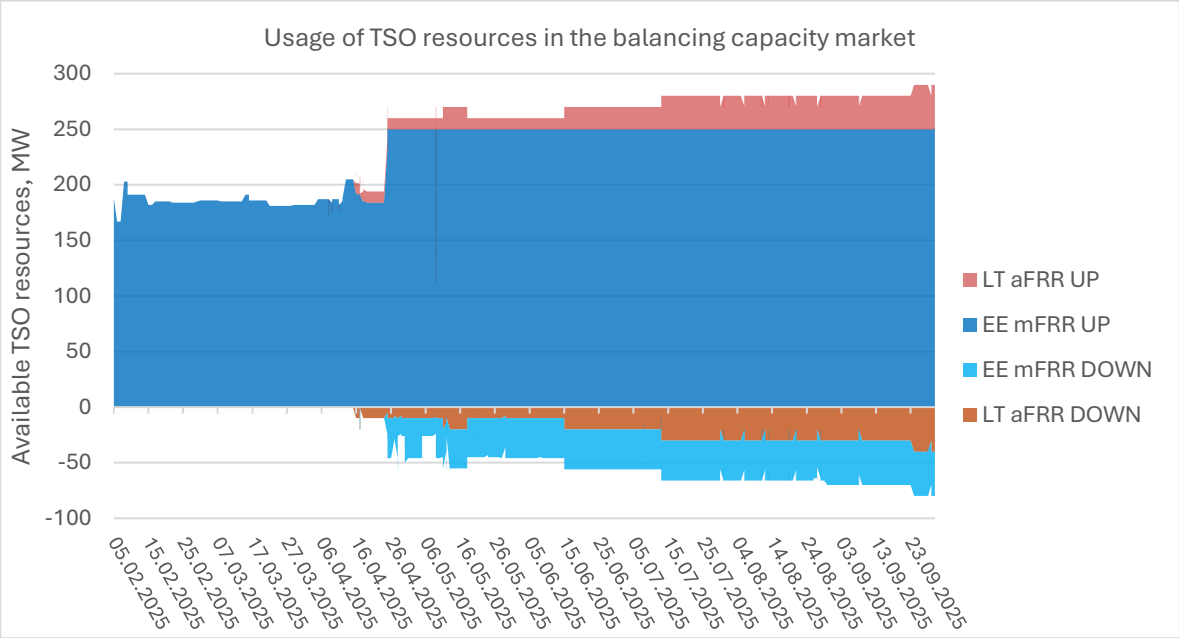

Figure 14 - Accepted TSO resource bids for each Baltic bidding zone per product and direction

Table 1 lists the developments in TSO resource usage that lead to the build-up of demand reduction resources in BBCM.

Table 6 - Developments in TSO resource usage[1]

Date	TSO	Resource	Development
04.02.2025	Elering	Kiisa powerplant	Use as mFRR Up DRR up to volume necessary to counteract TSO cost share
16.04.2025	Litgrid	Energy Cells BESS	Use as aFRR Up+Down DRR 10MW/20MW intermittently
25.04.2025	Elering	Kiisa resistors	Use as mFRR Down DRR up to 40 MW
26.04.2025	Elering	Kiisa powerplant	Use as mFRR Up DRR up to 250 MW

[1] AST BESS has started market operation on 30.10.2025 and thus the start of operation has fallen outside of the scope of the analysis of this report. TSO resource usage and impact from 01.10.2025 and onwards shall be investigated in subsequent BBCM evaluation reports.

16.06.2025	Litgrid	Energy Cells BESS	Use as aFRR Up+Down DRR up to 20 MW
15.07.2025	Litgrid	Energy Cells BESS	Use as aFRR Up+Down DRR up to 30 MW
24.09.2025	Litgrid	Energy Cells BESS	Use as aFRR Up+Down DRR up to 40 MW

8.1. Simulations without TSO resources

For the purpose of this report, simulation auctions had been done using the BBCM algorithm to establish prices, volumes and costs if TSO resources had not been employed to stabilize the market and reduce risk of reserve insufficiency.

The primary outcome of simulating BBCM results without TSO resource input is unmet reserve demand. A total on 90 356 MW of unmet mFRR up demand in Estonia and 10 100 MW of unmet mFRR up demand in Lithuania was identified to occur due to excluding TSO resources from BBCM. These numbers exemplify that TSO resources have been imperative to ensure security of supply in the Baltic countries after synchronization.

To assess the financial impact of excluding TSO resources, mFRR and aFRR price statistics with and without TSO resource usage can be seen below with the box and whisker graph showing percentile boundaries, mean and median values for each TSO's area per reserve direction.

For the mFRR product, Estonia consistently faces high mFRR prices, as observed in Figure 15. Although the months of April and March were anomalous when considering the actual prices (see Figure 16) usually mFRR capacity is relatively cheap. But without TSO resources, with high demands but lacking supply, the most expensive assets are constantly activated in Estonia, and because all available cross-zonal capacity is used up for balancing capacity reservation, the extreme prices do not spread to Latvia and Lithuania. Lithuania has a much higher available supply of mFRR up and down, which greatly mitigates the price increase in both Lithuania and Latvia. Although during some periods, for example, September, every country sees a vast increase in mFRR price, because one large market asset is unavailable in Lithuania during that time.

Since there are much less offered bids for aFRR than for mFRR (the most expensive assets are bidding only mFRR) the prices increases are not so drastic in comparison to the actual aFRR prices (see Figure 17). Nevertheless, the price of aFRR in the scenario without TSO resources is higher in all countries during the analysis period, as demonstrated in Figure 18. Even though aFRR demand is significantly lower, all available aFRR bids are exhausted for the coverage of FRR demand (if deemed to generate more welfare in comparison to mFRR), leading to increased prices.

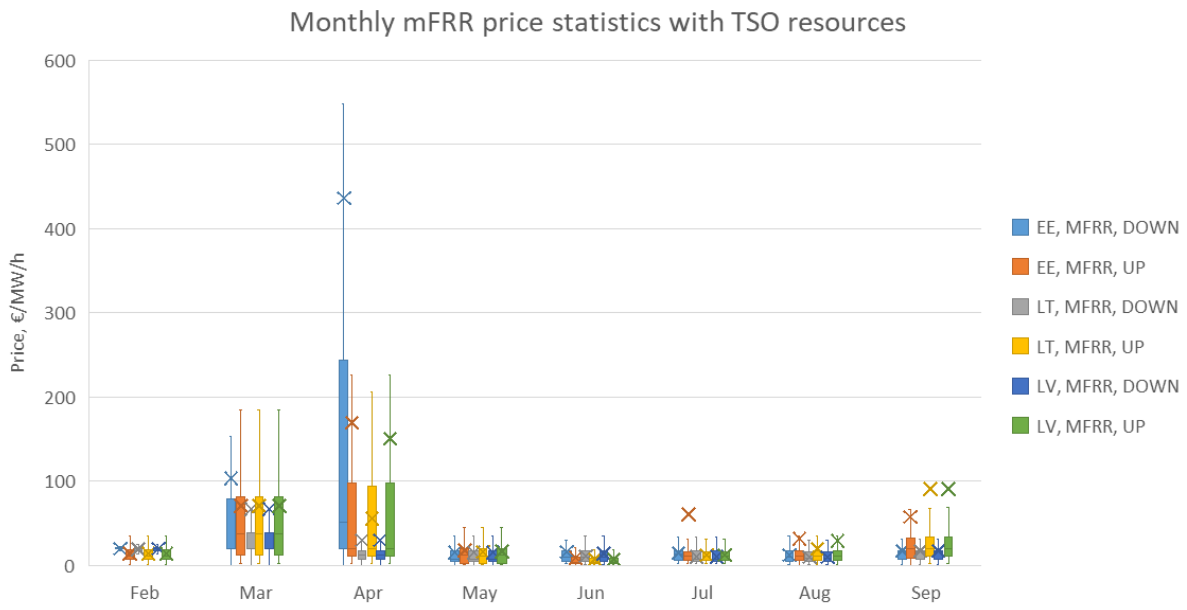

Figure 15 - Monthly mFRR price statistics in all Baltic bidding zones for the scenario with TSO resources

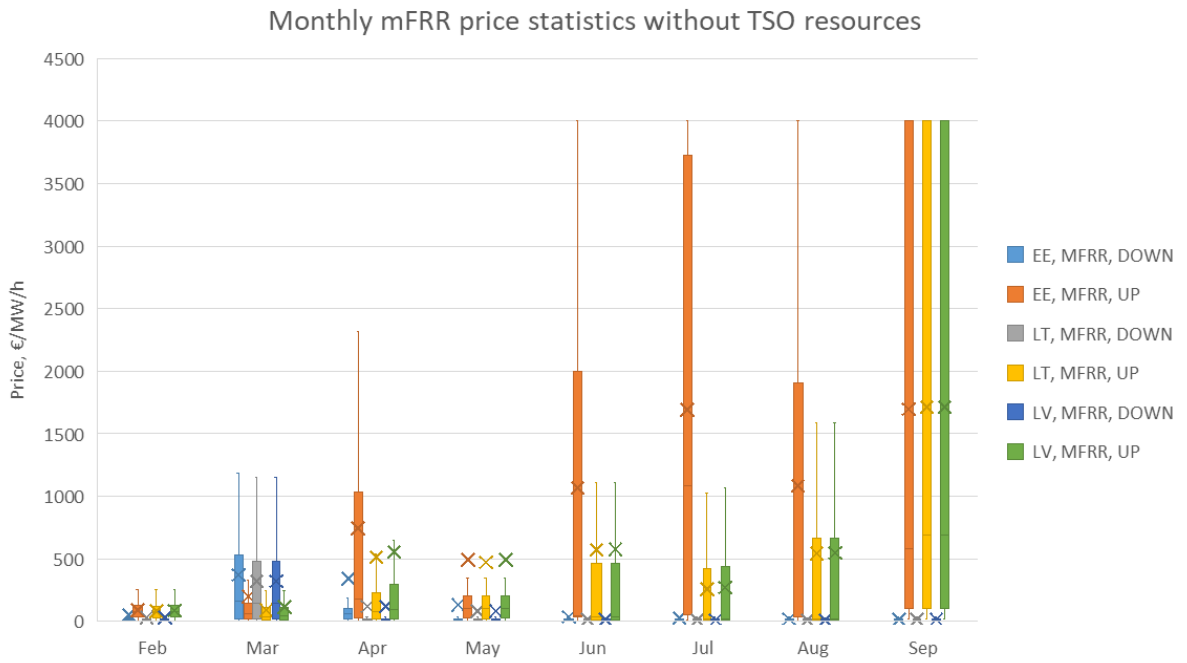

Figure 16 - Monthly mFRR price statistics in all Baltic bidding zones for the scenario without TSO resources

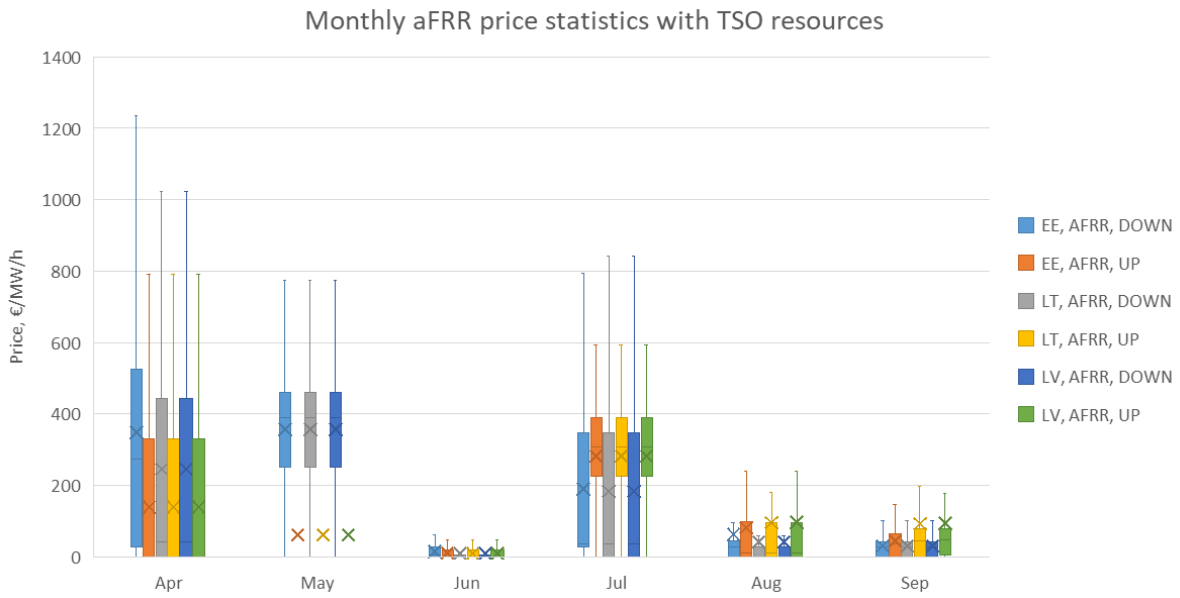

Figure 17 - Monthly aFRR price statistics in all Baltic bidding zones for the scenario with TSO resources

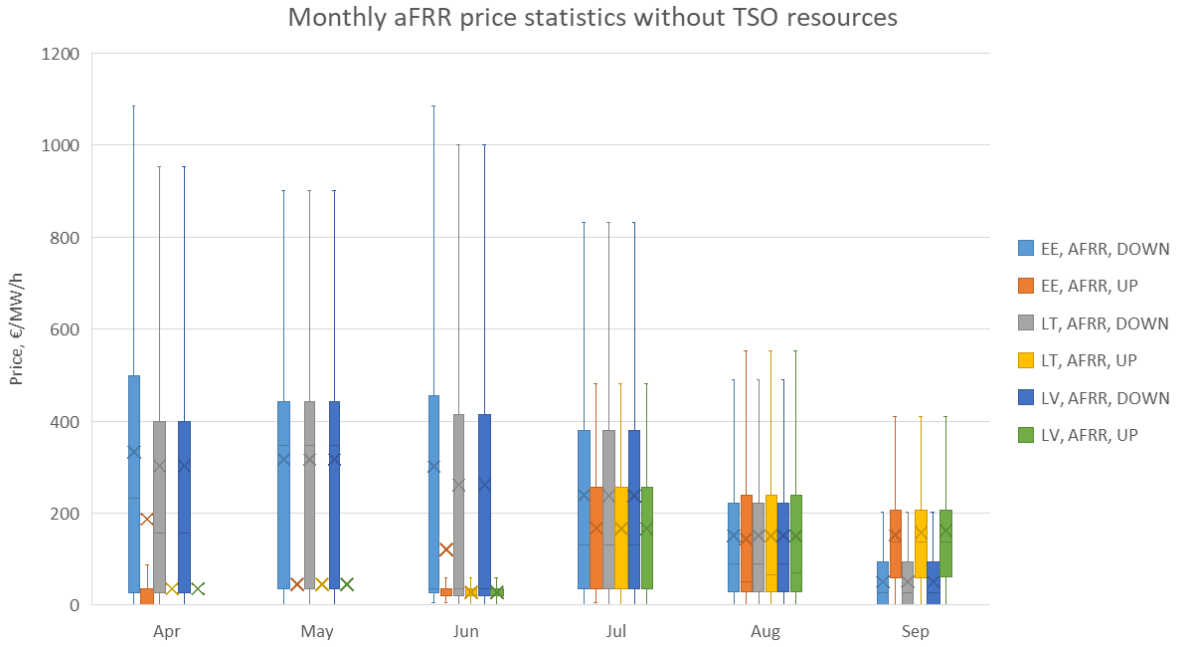

Figure 18 - Monthly aFRR price statistics in all Baltic bidding zones for the scenario without TSO resources

Procurement costs (BSP payout) incurred without consideration of congestion income based on actual market results, results if TSO resources were remunerated, and without TSO resources shows a picture of the current necessity for demand reduction resources. Figure 19 and Table 7 contains the procurement cost results for the simulations done.

Without using TSO resources, the FRR procurement cost increase is extraordinary, amounting up to additional 1,9 billion euros over just 8 months. The lack of TSO resources means that must-run

generation is heavily relied upon, which leads to significant price spikes as evident from Figure 16 and Figure 18, especially during market periods where maintenance of usual market assets take place. Since the biggest portion of FRR demand is mFRR, any expensive asset selection for mFRR coverage significantly increases procurement costs.

Additional considerations

Another hypothetical situation has been analysed, in which the following assumptions are put forward:

- TSO resources are not used according to the established methodology, but participate in the market similarly to other market participants;
- TSO resources participate in the market in exactly the same volume as historically;
- TSO resources participate in the market in a way which does not alter the marginal price of the market (i.e always make zero priced bids).

If the above-described optimistic assumptions would have been true during the analysed period, the cost increase is much less significant but still noteworthy: procurement costs would increase by 91 million euros compared to the historically established costs. This means that if the volume provided by TSO resources was instead covered by BSPs, assuming they would bid at a price of 0 EUR/MW/h, or partially decided to participate in other markets (such as the SDAC) this would still lead to substantial procurement cost increases. This demonstrates that even when utilising TSO resources, the balancing capacity prices can still be high, as must-run generation is occasionally required.

Deriving from the analysis described above, it can be concluded that TSO resources are an absolute necessity for minimising costs which can become exceedingly high. The simulation shows that the market is extremely illiquid – there is not enough flexible generation (RES+BESS) to cover the volume provided from TSO resources.

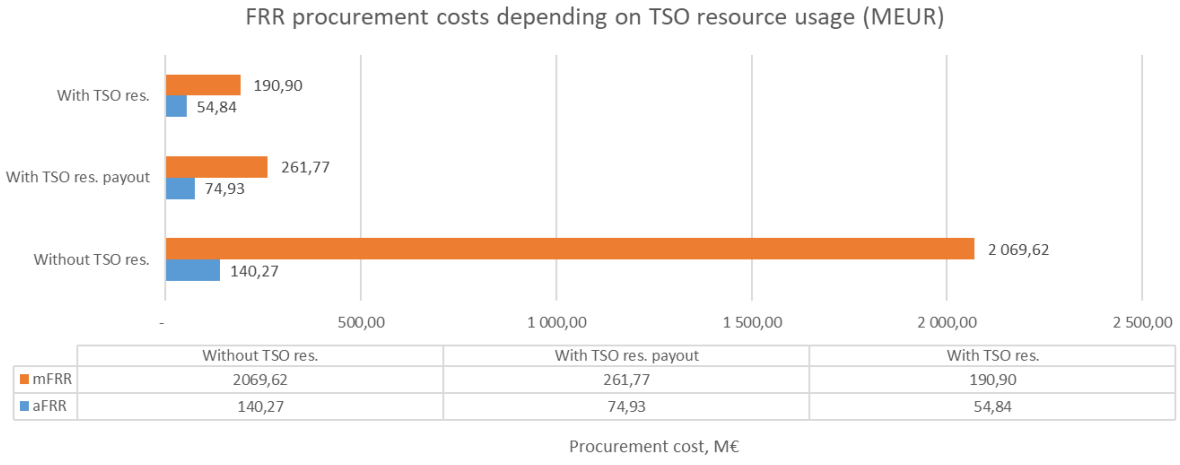

Figure 19 - FRR procurement costs depending on TSO resource usage strategy

Table 7 - FRR procurement costs depending on TSO resource usage strategy

Scenario	Total FRR procurement costs (MEUR)
Without TSO res.	2209,89
With TSO res.	245,75
With TSO res. payout	336,71