Evaluation Report

The SE1->FI border aFRR capacity allocation

17 June 2024

Fingrid Oyj

Katuosoite
Läkkisepäntie 21
00620 Helsinki

Postiosoite
PL 530
00101 Helsinki

Puhelin
030 395 5000

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Fingrid Oyj

Katuosoite
Läkkisepäntie 21
00620 Helsinki

Postiosoite
PL 530
00101 Helsinki

Puhelin
030 395 5000

1 Introduction

This report evaluates the effects on the aFRR Nordic capacity market (CM) by opening up the SE1->FI border for aFRR capacity trade.

The figure below shows the maximum capacities that can be allocated for the aFRR capacity trade on the lines connecting SE1 and Finland from 1st February 2024 until 17th May 2024.

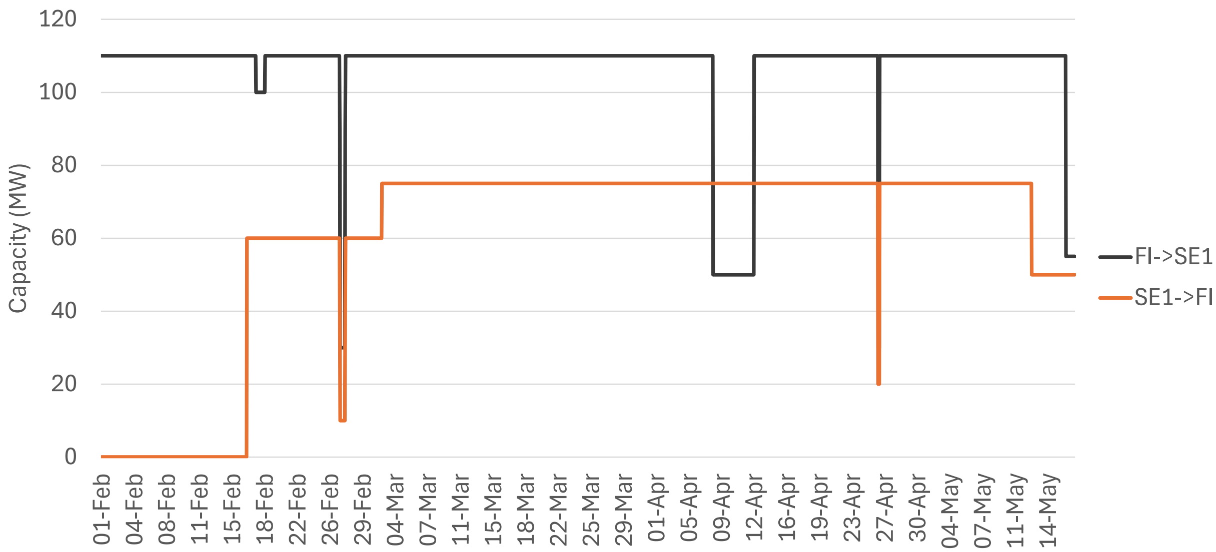

Figure 1 – Capacity (MW) on the SE1->FI border for aFRR capacity

The line FI->SE1 has been available for trading of aFRR capacity (capacity > 0 MW) since the Nordic aFRR CM started in December 2022. For the analysis period, we see that this line has around 110 MW for most of the hours. In the opposite direction however, there has been no available capacity for the trading of aFRR until 17th February 2024. As we can see from Figure 1, the line increased capacity from 0 to 60 MW on the 17th February 2024 and a further increase to 75 MW on the 2nd March 2024. The last five days of the analysis horizon (13-17th May) the capacity was reduced to 50MW.

Opening up the SE1->FI border for trading aFRR capacity, makes it possible to trade up capacity from SE1 (and the rest of Sweden, Norway and Denmark) to Finland, as well as down capacity from Finland to the rest of the Nordics.

Fingrid Oyj

Katuosoite
Läkkisepäntie 21
00620 Helsinki

Postiosoite
PL 530
00101 Helsinki

Puhelin
030 395 5000

2 Forecasted vs. Actual market values of cross-zonal capacity

In this Chapter, we will compare the forecasted CZC cost with the ex-post actual alternative cost of reserving CZC in the aFRR CM. The formulas used to calculate the forecast error is shown below.

Forecasted	$\max\left(0, SDACprice_{t-24,r'} - SDACprice_{t-24,r}\right) + markup_{t,r,r'}$
- Actual	$\max\left(0, SDACprice_{t,r'} - SDACprice_{t,r}\right)$
=Forecast Error	$forecasted - actual$

Cross-zonal capacity (CZC) on a line allocated for the aFRR CM is made unavailable for the day-ahead market (SDAC) auction, which is cleared later that day. Therefore, the value of this allocated 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 allocating CZC in the aFRR market clearing is calculated based on this alternative value. However, since the SDAC is cleared after the aFRR CM, a forecast alternative value is used, based on the SDAC prices from the previous day (24 hours prior). In addition, a dynamic markup is added to the forecasted value of CZC, which is a number between 1 and 5 EUR/MW, depending on the size of the forecast error for the previous (rolling) 30 days.

$$CZCcostForecast_{t,r,r'} = SDACspread_{t-24,r,r'} + markup_{t,r,r'}$$

Where t is the delivery hour, r is the export ("from") price area and r' is the import ("to") price area. This value is used as the cost of reserving CZC in the clearing algorithm.

The analysis is structured by first analyzing the SDAC spread, then the markup, and finally combining both to find the forecast errors.

2.1 SDAC spread error

To reiterate, the method to forecast the *SDAC spread* uses SDAC prices from the day before (D-1):

$$SDACspread_{t-24,r,r'} = \max\left(0, SDACprice_{t-24,r'} - SDACprice_{t-24,r}\right)$$

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.

Below, we analyze the *SDAC spread error* caused by using the SDAC spread 24 hours before (that is, *t-24*) 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-24* 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 aFRR market is a capacity (MW) market, and the CZC costs are calculated in €/MW.

The graph below shows SDAC spread errors for each hour sorted from negative to positive errors.

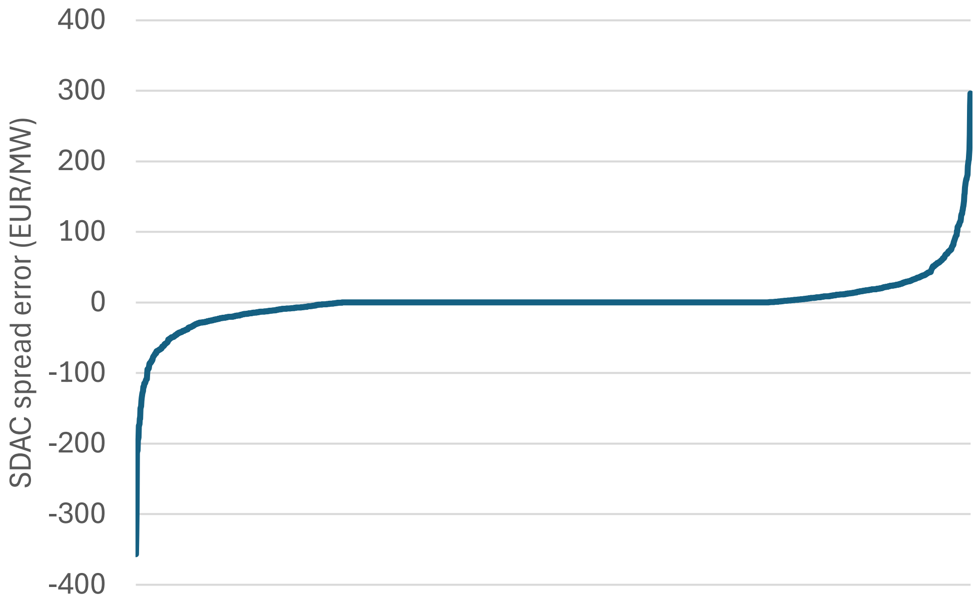

Figure 2 – SDAC spread error duration curve (18th Feb – 17th May)

In this report, a non-zero value is defined as a SDAC spread error. For 51% of the hours there is no difference between the actual spread and the D-1 spread. About 25% has a negative error (actual spread is higher than the D-1 spread) and 24% has a positive error (D-1 spread is higher than the actual spread).

The average SDAC spread error is 0.01 EUR/MW which essentially means that negative errors are balanced out by positive errors. The absolute error is 15.37 EUR/MW. Comparing this with the average absolute error of 5.1 EUR/MW over all borders in the 2023 Evaluation report, the SE1->FI border is a border with high SDAC spread errors.

2.2 Markup

Recall that the cost of reserving CZC consists of two components, the *SDAC spread* and a *dynamic markup*. The dynamic markup is calculated based on the average forecast error of the last 30 days and set to a value between 1 and 10 EUR/MW (in 1 EUR/MW steps), depending on the size of the average forecast error. The method only uses the positive errors and excludes the top 5% of error values.

The percentage of total hours with the different markups on the SE1->FI border are shown in the pie chart below.

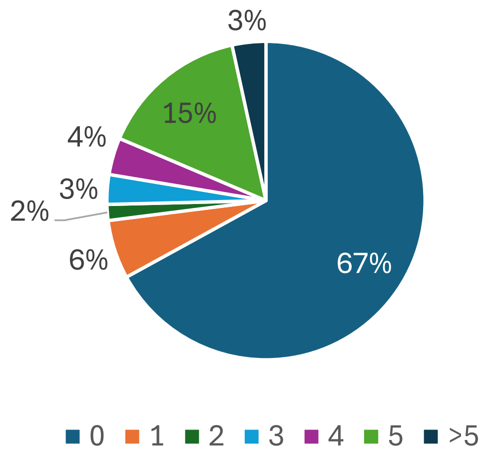

Figure 3 – Share of total hours of different markup values

From the pie chart we see that 67% of the hours have no markup. This would be the hours with no SDAC D-1 spread. Typically, markup values on a given border are either 0.1 or 1 €/MW, or 0.1 or 5 €/MW. For the hours with a positive SDAC D-1 spread we see that 6% of the hours have markup of 1 EUR/MW and 15% a markup of 5 EUR/MW.

The average markup over all hours on the SE1->FI border from 18th February 2024 to 17th May 2024 is 1.35 EUR/MW.

2.3 CZC forecast error

Combining the forecast SDAC spread and the markup for each border results in the forecast CZC cost used in the aFRR CM. **Error! Reference source not found.** summarizes the SDAC spread errors and average mark-up level, and the total CZC forecast error (both average error and average absolute error) for each border. We also include the 2023 numbers for comparison.

Border	Time horizon	Average spread error	Absolute spread error	Average markup	**Average forecast error**	**Absolute forecast error**
SE1->FI	*2023*	0	18.2	1.5	**1.5**	**18.9**
SE1->FI	*18th Feb - 17th May 24*	0.01	15.4	1.4	**1.4**	**16.1**

Table 1 – CZC forecast error SE1->FI (EUR/MW)

Error! Reference source not found. shows how errors for each border are distributed in predefined ranges.

		[-inf,-100>	[-100, -50>	[-50,-10>	[-10,-5>	[-5,-2>	[-2,-1>	[-1,0.1>	0.1	<0.1,1]	<1,2]	<2,5]	<5,10]	<10,50]	<50,100]	<100,inf]
SE1->FI	*2023*	2%	4%	9%	2%	2%	1%	1%	57%	0%	0%	1%	3%	12%	5%	2%
SE1->FI	*18th Feb - 17th May 24*	1%	3%	12%	4%	2%	1%	1%	51%	0%	0%	1%	5%	14%	3%	2%

Table 2 - Distribution of forecast errors (percent of hours in error ranges)

Approximately 51% of the combined borders and hours have no errors. 25% have a forecasted CZC cost greater than the actual value, and 24% are below the actual value. The main reason for this minor skewness is the markup (note that all markups >= 0.1), introducing a bias for positive CZC forecast errors.

The CZC forecast error distribution is multi-modal, with a peak negative error value, a peak positive error value, and a peak at an error of 0.1 €/MW. The most likely positive and negative errors are typically greater than 10€/MW. That is, in most hours the error is either 0.1 or it is greater than 10€/MW.

Overall, about 20% of the hours have forecast errors below -5 EUR/MWh and about 24% of the hours have forecast errors higher than 5 EUR/MWh. We also see that, the errors are most often in the 10-50 EUR/MW range (in absolute terms).

The drivers behind the large errors are:

- different DAM prices on both sides of the border
- changes in DAM prices from one day to the next

The D-1 approach to forecast CZC values used in the aFRR CM can also be referred to as a naïve forecast (a technique in which the last period's actuals are used as this period's forecast). For the next period, assuming relatively moderate changes in the underlying information, we may reasonably expect relatively moderate changes in market prices. In such a case, the naive forecast can be a fairly good short-term predictor. As we have seen, the naïve forecast gives 0 €/MW errors in 51% of the cases (hours + border directions). These larger errors are caused by changes in the spread from one day to the next. Drivers of such volatility can be hypothesized to include changes in weather conditions, change from business day to non-business day (and vice versa), and plant and grid unavailability.

3 Impacts on economic surplus

The impact that exchange of balancing capacity in aFRR CM has on economic surplus can be split into two main parts: impact on the SDAC and impact on the aFRR CM. In this chapter we will calculate these impacts and compare a scenario with no availability for aFRR trade on the SE1->FI border with the actual auctions (possibility of trade on SE1->FI).

3.1 Market impact

To understand the economic impact numbers, we will first show the impact on procured aFRR, trade and prices.

In the table below we show the difference in procured aFRR between the actual auctions and a scenario with no capacity on the SE1->FI border.

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4
aFRR up	0	-243	13	106	17	24	38	16	30	0	0
aFRR down	0	278	-3	-60	-41	-45	-1	-74	-55	-1	0
aFRR total	0	35	10	46	-24	-21	37	-58	-24	-1	0

Table 3 – Daily average of difference in procured aFRR (MW), positive values indicate an increase in procured volume with SE1->FI

In the charts below, we illustrate Fingrid's demand and the amount of procured aFRR Up and Down capacities in Finland right before, and during the reporting period.

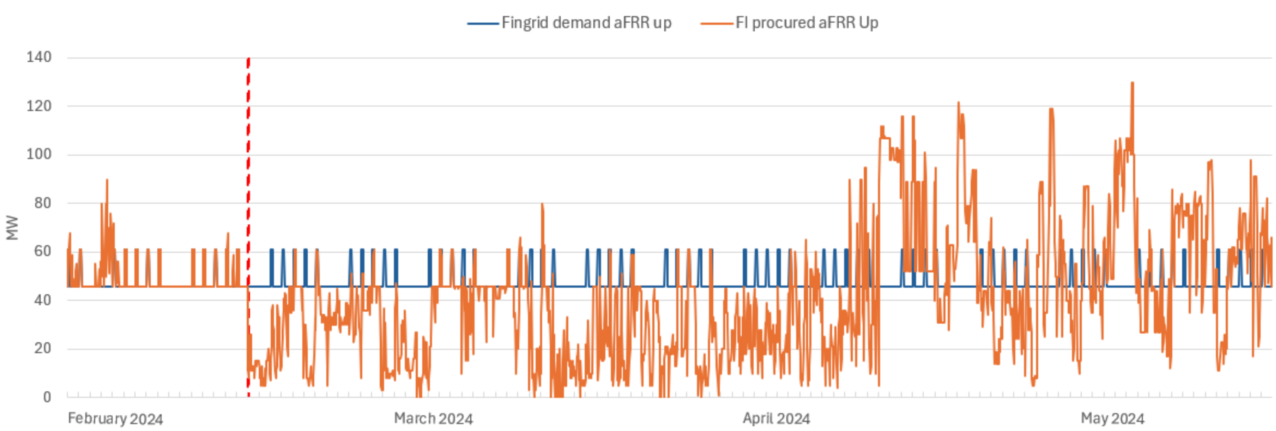

Figure 4 – Procured hourly capacity in Finland and Fingrid's demand for aFRR up (MW) from 1st February – 17th May 2024. SE1-FI capacity allocation opening represented by the red dashed line. Hours without Fingrid's aFRR demand excluded.

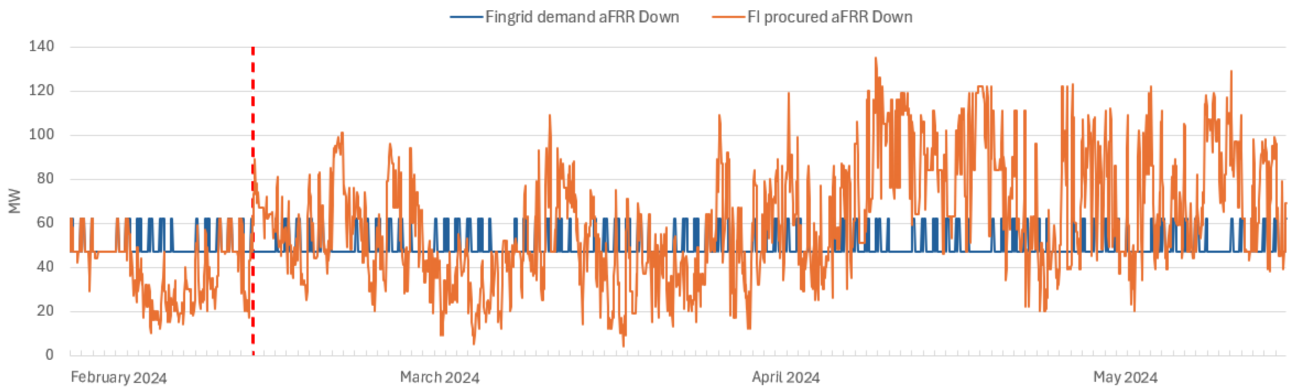

Figure 5 – Procured hourly capacity in Finland and Fingrid's demand for aFRR down (MW) from 1st February – 17th May 2024. SE1-FI capacity allocation opening represented by the red dashed line. Hours without Fingrid's aFRR demand excluded.

Allowing trade on the border SE1->FI means that the clearing algorithm can reserve up capacity from SE1 to FI and down capacity from FI to SE1. We see that procured up capacity in Finland goes down due to cheaper bids from the rest of the Nordics being made available to meet Finnish demand. All bidding zones except DK2, SE3 and SE4 have an increase in procured volume, and the biggest increase comes from NO2 and NO5 which normally have the cheapest bids. For down capacity we see the opposite - an increase in procured aFRR in Finland being used to meet reserve requirements in the rest of Nordics. In total procured aFRR, there is an increase for FI, NO1, NO2 and NO5 and a decrease in NO3, NO4, SE1 and SE2.

Looking at reserved CZC in the figure below, we see that the lines going from the relatively cheap bidding zones NO2 and NO5 through NO1->SE3->SE2->SE1 and to FI all show an increase in reserved CZC compared to a scenario without the SE1->FI line open for aFRR trade. This is not surprising given the difference in procured volumes in the table above, i.e. to 'send' the cheaper up bids to Finland and cheaper down bids from Finland.

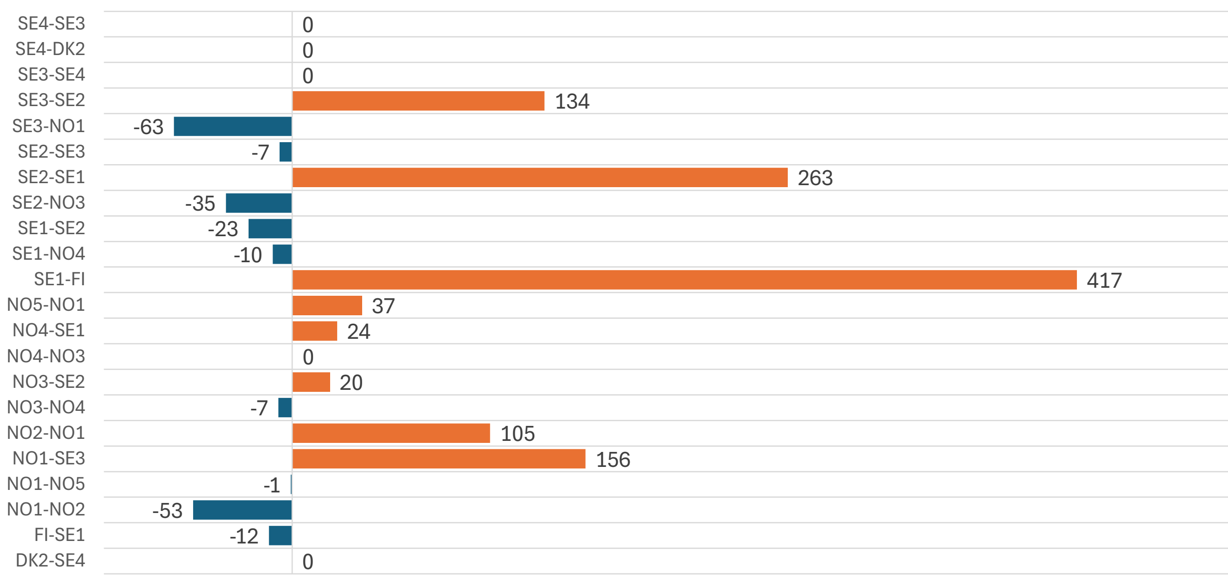

Figure 6 – Difference in Reserved CZC per day (average) MW from 18th February – 17th May 2024

The changes in clearing prices are shown in the table below.

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4
aFRR up	0.5	-8.7	0.3	0.3	0.8	0.8	0.3	0.6	0.5	0.5	0.5
aFRR down	-10.1	7.8	-2.0	-1.5	-10.3	-4.8	-0.2	-10.3	-10.3	-10.3	-10.1

Table 7 – Difference in average prices (EUR/MW) 18th Feb - 17th May 24. Positive number is higher prices with SE1->FI

From the pricing table we see that for aFRR up, prices decrease on average by 8.7 EUR/MW in Finland due to the possibility of reserving CZC on the line SE1->FI. All other bidding zones have a small increase varying from 0.3 in NO5 to 0.8 in NO3 and NO4. The reason is that more bids are selected in the rest of Nordics (i.e. bids higher up on the supply curve) and fewer (the most expensive) are selected in Finland. For aFRR down we see the opposite effect – more bids selected in Finland increase prices by 7.8 EUR/MW on average and fewer bids in the rest of the Nordics reduce prices ranging from -0.2 in NO5 to -10.3 EUR/MW in NO3, SE1, SE2 and SE3.

Looking closer at the prices, we see that there is a period in April with very high prices for down when taking out the SE1->FI border compared to the actual auctions with the SE1->FI included. The table below shows differences in median prices which reflects that the big reduction in average prices for down is driven to some extent by this period.

Fingrid Oyj

Katuosoite
Läkkisepäntie 21
00620 Helsinki

Postiosoite
PL 530
00101 Helsinki

Puhelin
030 395 5000

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4
aFRR up	0.4	-8.0	0.5	0.9	0.1	0.5	0.7	0.0	0.0	0.4	0.4
aFRR down	-2.5	5.4	-0.4	-0.3	-1.0	-0.7	0.0	-2.5	-2.5	-2.5	-2.5

Table 8– Difference in median prices (EUR/MW) 18th Feb-17th May 24. Positive number is higher prices with SE1->FI

3.2 SDAC impact

To calculate the change in economic surplus for the SDAC, we follow the method outlined below:

$$for\ each\ border\ (r, r')\ and\ hour\ t:$$

$$if\ flow_{t,(r,r')} = capacity_{t,(r,r')}:$$

$$loss_{t,(r,r')} = CZCreservation_{t,(r,r')} \cdot (DAMprice_{t,r'} - DAMprice_{t,r})$$

$$else:$$

$$loss_{t,(r,r')} = 0$$

In more detail this means that if a line in SDAC has a flow equal to the capacity, we multiply the CZC reservation from the aFRR with the spread in DAM prices for the border. A more sophisticated approach would be to rerun the DAM clearing with higher capacities (original capacity + CZC reservation), but as mentioned in the introduction, Simulation Facility with actual bid curves is not available. Since we remove capacity from the SDAC due to the aFRR CM coupling, the impact on the economic surplus for the SDAC will always be negative or zero.

Following the method outlined above on data from 18th February to 17th May 2024, we get the results for each border stated in the table below.

	Hours Congested	withSE1->FI	noSE1->FI	Diff
DK2-SE4	1%	14'173	14'173	0
FI-SE1	3%	1'269	1'306	-37
NO1-NO2	12%	83'882	90'272	-6'390
NO1-NO5	12%	44'179	44'198	-19
NO1-SE3	12%	293'828	284'733	9'096
NO2-NO1	3%	2'892	2'936	-44
NO3-NO4	0%	720	720	0
NO3-SE2	7%	14'678	13'834	844

NO4-NO3	57%	91'081	88'052	3'028
NO4-SE1	38%	19'355	13'081	6'273
NO5-NO1	7%	41'887	39'698	2'189
SE1-FI	**47%**	**527'724**	**0**	**527'724**
SE1-NO4	40%	29'413	33'521	-4'107
SE1-SE2	1%	1'691	1'772	-81
SE2-NO3	41%	165'403	185'565	-20'162
SE2-SE1	0%	0	0	0
SE2-SE3	22%	120'486	125'253	-4'767
SE3-NO1	6%	64'782	67'987	-3'205
SE3-SE2	0%	0	0	0
SE3-SE4	30%	859'307	859'307	0
SE4-DK2	42%	436'021	436'021	0
SE4-SE3	2%	60'308	60'308	0
Total	**17%**	**2'873'080**	**2'362'737**	**510'343**
Per day		*31'923*	*26'253*	*5'670*

Table 4 – SDAC loss (EUR) from 18th[t] Feb – 17th May 2024

We saw from Figure 6 above that the total reserved CZC had increased. Due to this, we also see that the total loss from SDAC increases by 5'670 EUR per day. By dividing the total loss with total reserved CZC we get a loss of 1.80 EUR/MW for the actual auctions (with SE1->FI) compared to a loss of 1.61 EUR/MW for the scenario with no SE1->FI capacity. From Chapter 2 we found that the CZC forecast error is relatively high for this line, and together with the high (47%) numbers of hours with congestion in SDAC, these factors drive this increase in loss/MW reserved CZC.

3.3 aFRR benefits

The method for estimating the economic benefits from the coupling of price areas in the aFRR CM follows the TSOs own benefit calculations, which are calculated as a comparison between how the market would be cleared without the possibility of exchange and the actual market results for 2023. Therefore, the clearing and pricing algorithms used for the actual market results have also been used to clear the markets with no CZC between bidding zones.

When clearing the market without exchange possibility, only local bids are chosen. In bidding zones without sufficient bids, the unprocured demand is priced at the highest of the bidding zone's market prices in the two cases – with and without exchange. In the reference case without exchange, the highest price among local bids is taken as the market price. If there are no local bids, the local price of the market case (with exchange) is used also in the reference case.

As a consequence, in cases where there are some, but not enough, local bids, the calculated benefits can be high if the highest accepted bid price in the reference auction is high, but they can also be 0 if there are no local bids at all, since it is not possible to value the security of supply in the absence of local bid prices.

This is not optimal, and we could have used an arbitrary value for the prices of lacking reserves, based on e.g. historical prices, highest price in neighboring area, or otherwise, but this could result in very high benefits, which do not necessarily reflect reality. We have therefore decided on a conservative approach, where benefits are set to zero if the demand cannot be covered from local clearing and there are no local bids at all.

The overall results shown below are therefore also conservative, since the benefit of having access to reserves to cover demand at all points in time is not always priced and part of the analysis.

In the following analysis, we refer to the actual market results as 'market' and the results without exchange as 'reference.' Economic surplus in the aFRR CM consists of three main elements: producer surplus, consumer surplus, and congestion income (when there is no change in the volumes produced and consumed, these three elements add up to the reduction of overall energy costs).

Case	Producer (BSP) surplus	Consumer surplus	Congestion income
Market	The BSP Surplus in the market case is the difference between the clearing price in the market case and offered price times the accepted volume in the market case per bid.	TSO procurement cost for the market case (Procured capacity * market case clearing price).	For each price area, the sum of reserved czc*price spread over all lines out of the price area divided by two.
Reference	The BSP Surplus in the reference case is the difference between the clearing price and the offered price times the accepted volume in the reference case per bid.	TSO procurement cost for the reference case (Procured capacity * clearing price reference case).	0 for all price areas since no exchange is allowed/possible.

Table 5- Producer surplus, consumer surplus and congestion rent definitions.

The economic surplus from the exchange of balancing capacity from the application of the market-based allocation process is the difference between these values between the market and the reference case:

$$
\begin{aligned}
economic\ surplus \\
&= \left(prodsurplus_{market} - prodsurplus_{ref}\right) \\
&+ \left(conssurplus_{market} - conssurplus_{ref}\right) + congestionrent
\end{aligned}
$$

Producer surplus numbers for the period 18th February to 17th May for the two scenarios are shown in the three tables below, first for up, then down and total.

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	0.10	-0.11	0.69	0.24	0.17	1.34	0.08	-0.01	0.00	0.00	2.49
No SE1->FI (mill EUR)	0.00	0.64	-0.12	0.60	0.21	0.13	1.29	0.07	-0.03	0.00	0.00	2.78
Diff. (mill EUR)	0.00	-0.53	0.01	0.09	0.03	0.03	0.05	0.01	0.02	0.00	0.00	-0.29
Diff. per day (EUR)	**0**	**-5'932**	**80**	**1'020**	**329**	**346**	**573**	**93**	**213**	**0**	**0**	**-3'277**

Table 6 – Producer surplus Up

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	1.05	-0.04	0.69	0.44	0.28	0.13	0.28	0.01	0.03	0.00	2.87
No SE1->FI (mill EUR)	0.00	-0.07	-0.03	0.95	1.06	0.47	0.14	0.67	0.30	0.04	0.00	3.53
Diff. (mill EUR)	0.00	1.12	-0.01	-0.27	-0.63	-0.19	-0.01	-0.39	-0.29	-0.01	0.00	-0.66
Diff. per day (EUR)	**0**	**12'496**	**-83**	**-2'970**	**-6'961**	**-2'060**	**-139**	**-4'308**	**-3'237**	**-72**	**0**	**-7'334**

Table 7 - Producer surplus Down

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	1.16	-0.16	1.37	0.67	0.45	1.47	0.36	0.00	0.03	0.00	5.36
No SE1->FI (mill EUR)	0.00	0.57	-0.16	1.55	1.27	0.60	1.43	0.74	0.27	0.04	0.00	6.31
Diff. (mill EUR)	0.00	0.59	0.00	-0.18	-0.60	-0.15	0.04	-0.38	-0.27	-0.01	0.00	-0.96
Diff. per day (EUR)	**0**	**6'564**	**-3**	**-1'950**	**-6'632**	**-1'714**	**434**	**-4'214**	**-3'024**	**-72**	**0**	**-10'612**

Table 8 - Producer surplus Total

We clearly see that producers in Finland benefit from the possibility of allowing trade on the line SE1->FI. The amount of benefit from the increasing prices and procured volume for aFRR down is about double the decrease in benefit from decreasing prices and produced volume for aFRR up. In total the difference is about 600’000 EUR which is 6’564 EUR per day.

For the rest of the bidding zones except NO5, there is a decrease in total producer surplus. This is driven mainly by the relatively larger reduction in prices and procured volume for down than the increase in prices and procured volume for up, i.e. the loss for down product is higher than the gain for the up product.

Procurement benefit numbers for the period 18th February to 17th May for the two scenarios are shown in the three tables below, first for up, then down and total.

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	0.37	0.28	-0.23	1.50	1.29	-0.49	0.53	0.93	0.00	5.76	9.94
No SE1->FI (mill EUR)	0.00	-0.41	0.30	-0.21	1.53	1.32	-0.48	0.55	0.95	0.00	5.77	9.33
Diff. (mill EUR)	0.00	0.77	-0.02	-0.02	-0.03	-0.03	-0.02	-0.02	-0.02	0.00	-0.01	0.61
Diff. per day (EUR)	**0**	**8'567**	**-221**	**-242**	**-299**	**-318**	**-185**	**-235**	**-205**	**-1**	**-89**	**6'772**

Table 9 – Procurement benefit Up

Fingrid Oyj

Katuosoite
Läkkisepäntie 21
00620 Helsinki

Postiosoite
PL 530
00101 Helsinki

Puhelin
030 395 5000

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	-0.63	0.21	-0.29	1.35	1.46	-0.07	0.37	0.52	0.06	12.72	15.69
No SE1->FI (mill EUR)	0.00	0.10	0.17	-0.40	0.99	1.27	-0.08	-0.01	0.13	0.05	12.63	14.85
Diff. (mill EUR)	0.00	-0.73	0.04	0.11	0.36	0.19	0.01	0.38	0.38	0.02	0.09	0.84
Diff. per day (EUR)	**0**	**-8'093**	**485**	**1'171**	**3'970**	**2'072**	**89**	**4'230**	**4'266**	**180**	**959**	**9'328**

Table 10 – Procurement benefit Down

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	-0.26	0.49	-0.52	2.85	2.75	-0.57	0.90	1.45	0.06	18.48	25.63
No SE1->FI (mill EUR)	0.00	-0.31	0.47	-0.61	2.52	2.59	-0.56	0.54	1.08	0.05	18.40	24.18
Diff. (mill EUR)	0.00	0.04	0.02	0.08	0.33	0.16	-0.01	0.36	0.37	0.02	0.08	1.45
Diff. per day (EUR)	**0**	**473**	**264**	**928**	**3'671**	**1'753**	**-96**	**3'996**	**4'061**	**178**	**871**	**16'100**

Table 11 – Procurement benefit Total

A positive procurement surplus tells us that the cost of procuring aFRR has been reduced. Both the market and the reference case have the same demand, but different clearing prices.

For both up and down aFRR, the benefit is positive compared to the scenario with no capacity on the SE1->FI line. The relatively small increase in prices (for all bidding zones except FI) for up aFRR is small compared to the decrease in prices for aFRR down. The large price decrease for down products for all bidding zones except Finland together with the price decrease in Finland for up aFRR drives the positive benefit from the SE1->FI line of 16'100 EUR per day. We also see that only one bidding zone (NO5) has a lower procurement benefit with the SE1->FI line open.

Congestion rent numbers for the period 18th February to 17th May for the two scenarios are shown in the three tables below, first for up, then down and total.

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	0.02	3.03	0.00	0.02	0.00	0.00	0.02	0.02	0.96	0.00	4.07
No SE1->FI (mill EUR)	0.00	0.00	2.80	0.00	0.03	0.00	0.00	0.00	0.03	0.88	0.00	3.74
Diff. (mill EUR)	0.00	0.02	0.23	0.00	-0.01	0.00	0.00	0.02	-0.01	0.08	0.00	0.33
Diff. per day (EUR)	**0**	**245**	**2'512**	**-8**	**-101**	**15**	**2**	**252**	**-112**	**868**	**0**	**3'672**

Table 12 – Congestion rent Up

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	0.03	3.00	0.05	0.03	0.03	0.17	0.04	0.01	1.88	0.46	5.69
No SE1->FI (mill EUR)	0.00	-0.01	4.17	0.09	0.14	0.13	0.20	0.00	0.03	2.72	0.46	7.92
Diff. (mill EUR)	0.00	0.04	-1.17	-0.04	-0.11	-0.10	-0.03	0.04	-0.01	-0.84	0.00	-2.23
Diff. per day (EUR)	**0**	**419**	**-13'006**	**-393**	**-1'210**	**-1'126**	**-347**	**391**	**-124**	**-9'368**	**41**	**-24'723**

Table 13 – Congestion rent Down

	DK2	FI	NO1	NO2	NO3	NO4	NO5	SE1	SE2	SE3	SE4	Total
Actual (mill EUR)	0.00	0.05	6.02	0.05	0.05	0.03	0.17	0.06	0.03	2.83	0.46	9.76
No SE1->FI (mill EUR)	0.00	-0.01	6.97	0.09	0.17	0.13	0.20	0.00	0.05	3.60	0.46	11.66
Diff. (mill EUR)	0.00	0.06	-0.94	-0.04	-0.12	-0.10	-0.03	0.06	-0.02	-0.77	0.00	-1.89
Diff. per day (EUR)	**0**	**663**	**-10'494**	**-401**	**-1'311**	**-1'112**	**-345**	**643**	**-236**	**-8'500**	**41**	**-21'051**

Table 14 – Congestion rent Total

The congestion income is the CZC reservation multiplied with the difference in clearing price on both sides of a border. To distribute the income from border to price area, the value is divided by two for the two price areas. A price area will therefore have congestion income if there is CZC reservation in and out of the area and a difference in clearing prices on both sides. The value gets higher if the CZC reservation and/or the clearing price difference is high.

We see that by allowing trade of aFRR on the SE1->FI line, there is a reduction in total congestion rent of 21’051 EUR per day. Even though the total reserved CZC goes up, the reduction in price differences for hours with trade goes from 1.92 EUR/MW to 1.67 EUR/MW when allowing for trade on SE1->FI. For aFRR up there is an increase by about 3’672 EUR per day, but for aFRR down there is a reduction of about 24’723 making the total reduction in congestion rent 21’051 EUR/day.

By looking more closely at the congestion rent numbers, we see that a large portion of the reduction in congestion rent comes from a few days in April and on the line SE3-NO1, where the price difference between the bidding zones dropped from around 300 EUR/MW to 100 EUR/MW. The figure below shows price differences for the period analysed.

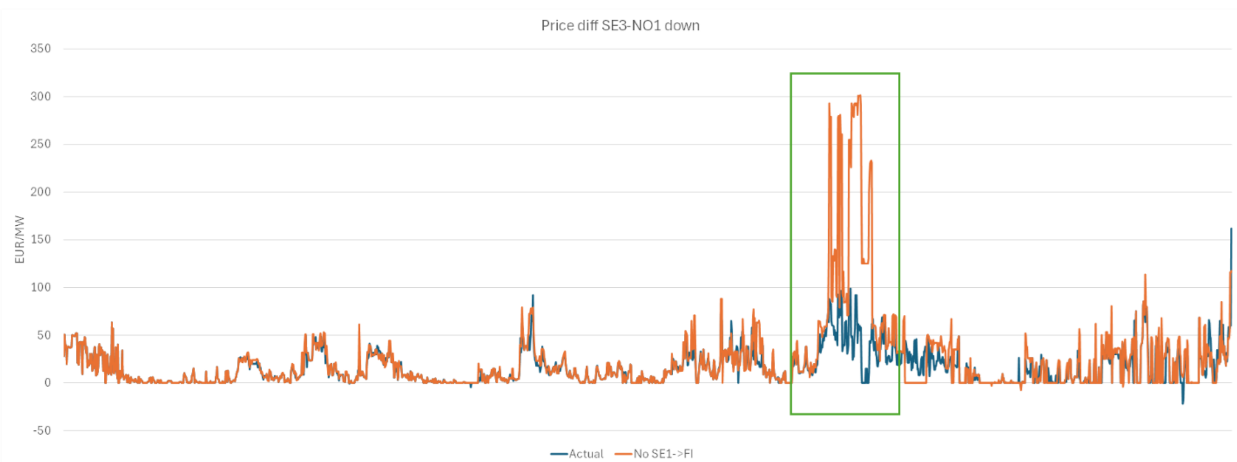

Figure 9 – Price differences SE3-NO1 (EUR/MW)

Fingrid Oyj

Katuosoite
Läkkisepäntie 21
00620 Helsinki

Postiosoite
PL 530
00101 Helsinki

Puhelin
030 395 5000

If we add everything together, we get a total economic surplus of the exchange of balancing capacity.

	SDAC loss	Producer benefit	Procurement benefit	Congestion rent	Total benefit
Actual (mill EUR)	-2'873'080	5'356'787	25'628'833	9'763'597	37'876'136
No SE1->FI (mill EUR)	-2'362'737	6'311'847	24'179'807	11'658'167	39'787'084
Diff. (mill EUR)	-510'343	-955'060	1'449'026	-1'894'570	-1'910'948
Diff. per day (EUR)	**-5'670**	**-10'612**	**16'100**	**-21'051**	**-21'233**

Table 15 – Total economic benefit

Total benefit per day for each bidding zone is shown in the figure below.

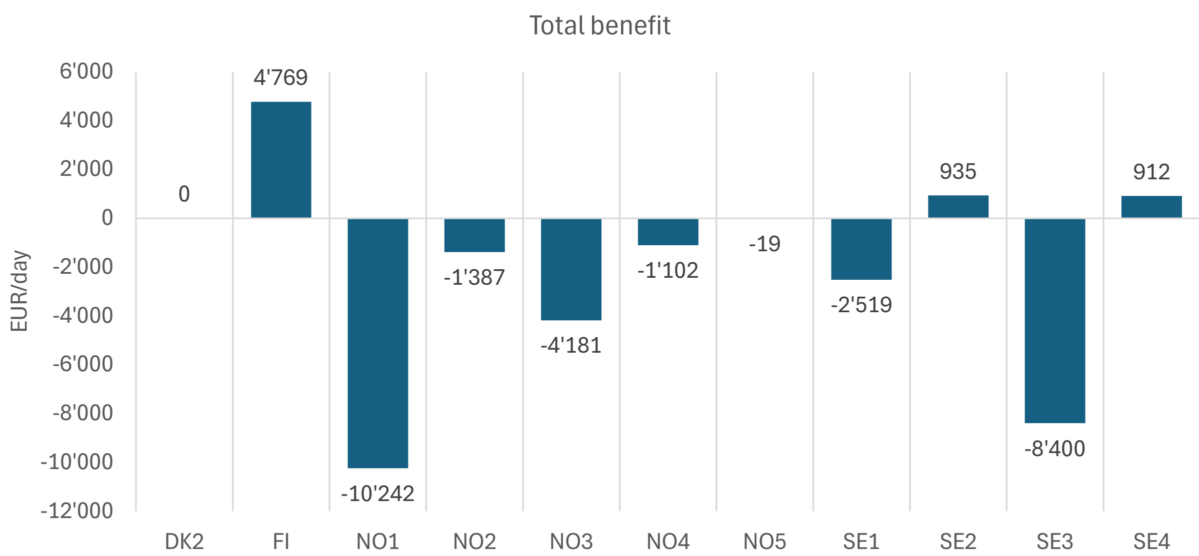

Figure 10 – Total benefit per day for each bidding zone (EUR/day)

We see that three bidding zones have a positive benefit from the SE1->FI line, namely Finland, SE2 and SE4. All other bidding zones except DK2 have a negative economic benefit.

The biggest contributor to the negative benefit is the loss in congestion rent, and especially congestion rent on the line NO1-SE3 which can also be seen in the low numbers for these two bidding zones. Almost half of the reduction in congestion rent for this line comes on 5 days in April where prices in Sweden for down regulation goes from levels around 300 EUR/MW to 50 EUR/MW when adding the SE1->FI line compared to when it has no capacity.

Without taking congestion rent into account, the total benefit of the SE1->FI line is close to 0.

Fingrid Oyj

Katuosoite
Läkkisepäntie 21
00620 Helsinki

Postiosoite
PL 530
00101 Helsinki

Puhelin
030 395 5000

4 Conclusions

The main finding of this report is that allowing 5% aFRR capacity allocation in the SE1->FI line has a positive impact on the Finnish socio-economic benefit. However, the socio-economic benefits are negative for the Nordic region as a whole, mainly due to the large decrease in congestion rents. A large share of the reduction in congestion rent comes from a few days in April and on the line SE3-NO1. The estimated aggregate effect of the balancing capacity allocation on the Finnish socio-economic benefit is 4’769 EUR per day. The estimated effect for the whole Nordic region is -21’233 EUR per day with majority of the loss experienced by NO1 and SE3. The estimated Nordic aggregate benefit is close to 0 if we do not consider the change in congestion rents.

Fingrid Oyj

Katuosoite
Läkkisepäntie 21
00620 Helsinki

Postiosoite
PL 530
00101 Helsinki

Puhelin
030 395 5000