



DA results from the external parallel run (EPR) of Nordic flow-based

SH bi-weekly meeting
18 January 2024

Vilma Virasjoki, Linus Johansson,
Rikke Bjerregaard Jørgensen & Krishna Solberg

Contact: ccm@nordic-rcc.net



Agenda

1. Updates since last meeting & upcoming events
2. Background information on the EPR
3. EPR results: the impacts on SEW, prices, flows, net positions, constraining CNECs
 - Overall results for weeks 45-50
 - Weeks 45-46
 - Weeks 47-48
 - Weeks 49-50
4. Case studies with specific days and hours



Publication schedule and upcoming events

- **W46-48 market reports were published on 5 January 2024.**
 - The reports were delayed due to changes in the data format for the simulations and due to Christmas holiday.
- **W49-50 market reports were published on 12 January 2024.**
- **Hybrid stakeholder meeting 7 February in Stockholm Airport**
 - Pre-registration is needed for physical participation. The link is available in the newsletter.
 - Registration is not necessary if you will participate via Teams.



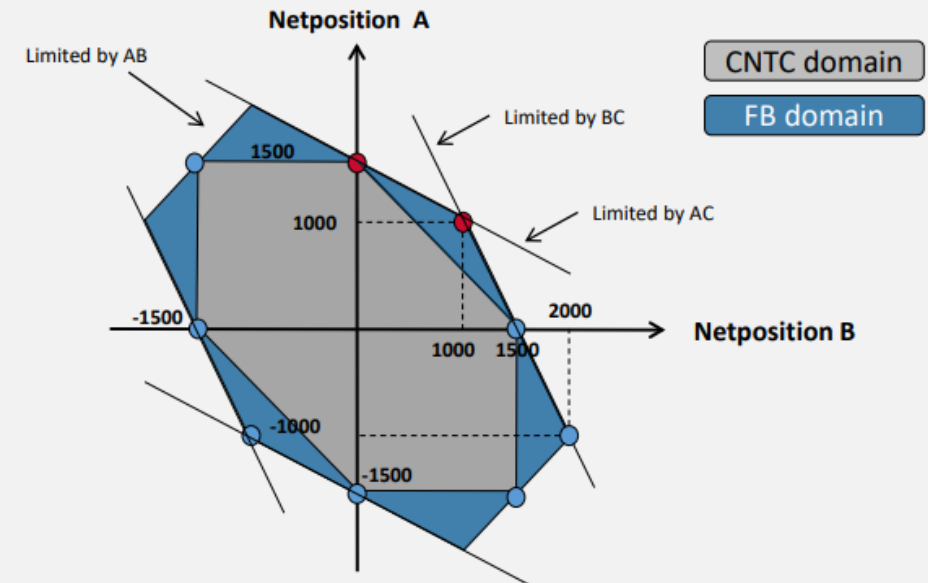
External parallel run (EPR)

- In EPR, the capacity calculation process for both FB and NTC is performed in parallel. Market results are available for:
 - NTC = actual day-ahead market coupling results, “production”
 - FB = simulated market coupling results with FB constraints
- **Goals of the EPR:**
 - 1) Ensure that the capacity calculation process works
 - 2) Show the differences between FB and NTC capacity calculation methods
 - 3) Intended for market participants to become familiar with FB capacity calculation and the impacts FB may have on the market outcome
 - 4) “Learning by doing” for TSOs



Increasing transmission capacity increases SEW

- **An increase in transmission capacity to the market will provide a higher social economic welfare.**
 - Larger domain allows for more trade, and increased opportunity for trade provides increased economic efficiency in any market.
 - SEW gain can be anywhere in the Nordics or SDAC (Europe).
- **TSOs can offer more transmission capacity to markets, e.g., by**
 - Changing the capacity calculation method
 - Building more transmission capacity between bidding zone borders
- **In FB, a larger domain than possible in NTC is provided directly to the market in the form of PTDFs, RAMs, and CNEs.**
 - This has the same effect as installing more capacity to the entire Nordic CCR. The setup, where and how much more flow is enabled, depends on forecasted flows and market bids.
 - FB development will continue after DA FB go-live.

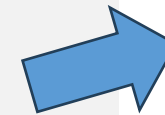




The role of TSOs and EPR

- **The role of TSOs is to provide as much transmission capacity to the markets, as operationally secure, to ensure efficiency.**
 - Other market participants are responsible for other segments of the day-ahead market; TSOs should not intervene or speculate in these.
- **Assumption in the EPR: Different capacity calculation method, but same market coupling algorithm and same order books**
 - Changing nothing else as the capacities enables a fair comparison of the two capacity calculation methods. It isolates the impacts solely from FB capacity calculation without further assumptions.
- **Why we measure the SEW impact of FB?**
 - EPR is done the way NRAs and CACM require TSOs to perform it.*
 - Higher SEW **per MTU** indicates **higher or economically more efficient flows** in the system
 - Higher SEW **over a long time** indicates a **trend of the above** in the system

- The report shall include at least the following, based on a per MTU level of granularity:
 - A calculation of DA socio-economic effects (as measured by delta in consumers' surplus, producers' surplus and congestion income) from flow-based capacity calculation compared to the current capacity calculation method in use. The geographical area for this calculation shall be the Nordic market area plus neighboring countries if possible.
 - If the accumulated DA socio-economic effect of flow-based is negative over any two-week period, the TSOs shall provide analysis and explain why this occurred.



* <https://www.fingrid.fi/globalassets/dokumentit/fi/tiedotteet/sahkomarkkinat/2020/paatos-cacm-suuntaviivojen-202-artiklan-mukaisen-nordic-kapasiteetin-laskenta-alueen-yhteisen-kapasiteetin-laskentamenetelman-muuttamisesta.pdf>



FB enables higher utilization of the grid and will result in other changes in the market

- When FB enables more capacity provided to the day-ahead market, it is likely that there will be other changes in the markets.
 - EPR enables SHs to learn how to read, analyze, and use FB domains.
 - EPR is not a forecast of future prices and flows.
- Why EPR cannot be designed to use “FB order books”?
 - No such information available from market participants.

Not presented in the stakeholder meeting on
18. January 2024. Included as extra information
(from 7 December 2023 meeting).



Hydro production in the Nordics

- **Nordic power system is dominated by hydro production and Nordic prices, especially for some BZs, are impacted by water values.**
 - However, the production mix is diverse for Nordics as a whole (together with the continent)
- **SEW is an indicator of higher grid use per MTU:**
 - It can be assumed that water values are not affected within the day by the change in the capacity calculation.
- **However, there is an effect of using more water in the north and saving water in the south over a longer period, and it has an impact on BZ prices and SEW.**
 - If there is more energy to be traded in FB day-ahead market than in NTC, it is expected that the hydro producers in the north would adjust their orders accordingly to save water.
 - Also, it is expected that hydro producers in the south would adjust their orders, so that their reservoirs wouldn't overflow.
 - The simulated FB SEW is affected by this, but the purpose of computing SEW is to indicate that capacity calculation works per MTU, not to forecast the market development

Not presented in the stakeholder meeting on
18. January 2024. Included as extra information
(from 7 December 2023 meeting).



The uncertainty of hydro on SEW does not undermine positive impacts from FB

- FB enables more objective handling of grid limitations and allocates flows where it creates highest SEW. This is especially useful for a meshed grid and is not likely only hydro utilization.
 - Enabling higher flows from FI to SE3 (Fennoskan)
 - Enabling higher flows from SE3 to NO1 and DK1
- FB enables higher grid utilization with the same level of operational security in the changing energy system.
- Enabling higher flows in the Nordic grid has been proven in the EPR.
 - Even if hydro volumes do not materialize fully as they do with NTC orderbooks, it does not remove the EPR-result, observed over various seasons and market settings, that the possibility for higher transmission exists.

Not presented in the stakeholder meeting on
18. January 2024. Included as extra information
(from 7 December 2023 meeting).



Total socio-economic welfare on hourly level W45-50

- The trend through these 6 weeks is positive SEW and thereby a better utilization of the grid.
- However there is period where the changes are small and FB provides a similar market solution as NTC.

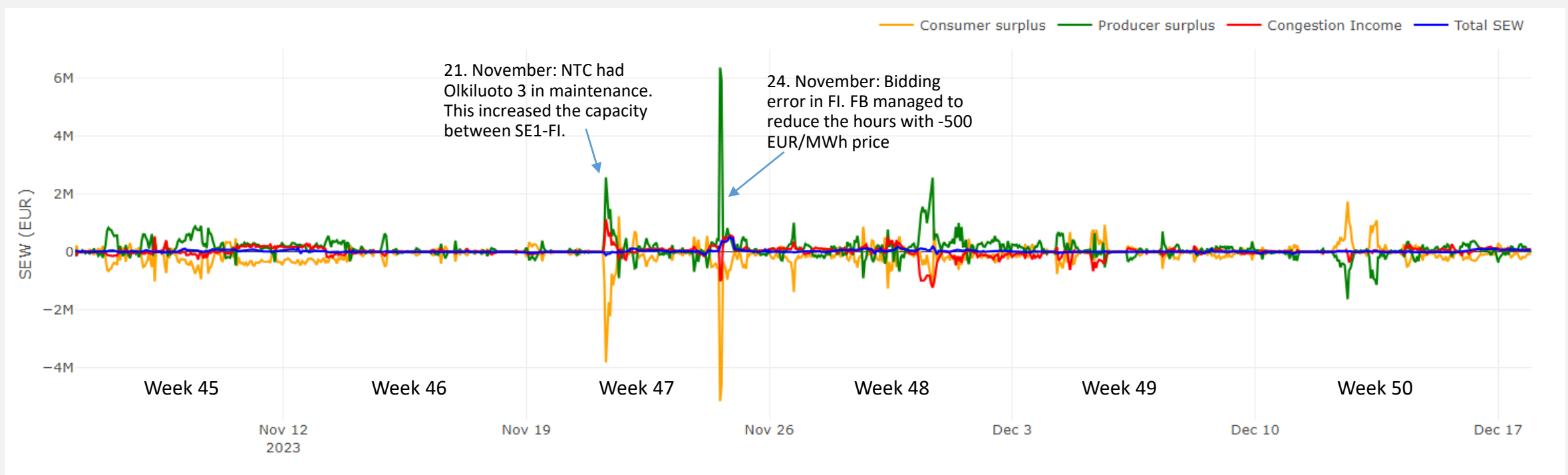
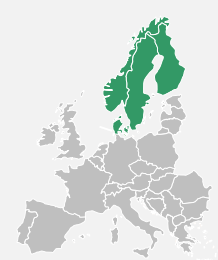


Figure: Hourly SEW change from FB to NTC for the total SDAC region.



Social welfare change W45-W50

- Flow-based results in a higher SEW compared to NTC for both the Nordic region and the whole market coupling region (SDAC).
 - Total Nordic SEW change 30 M€
 - Total SEW change in the SDAC region 20 M€
- Through this period week 46 and week 49 had a total SDAC negative SEW, but a positive Nordic SEW.
- The constraints and price differences in the Nordic system were minor for these weeks in NTC.
 - Increasing the utilization of the grid with FB had therefore no significant impact on the solution.

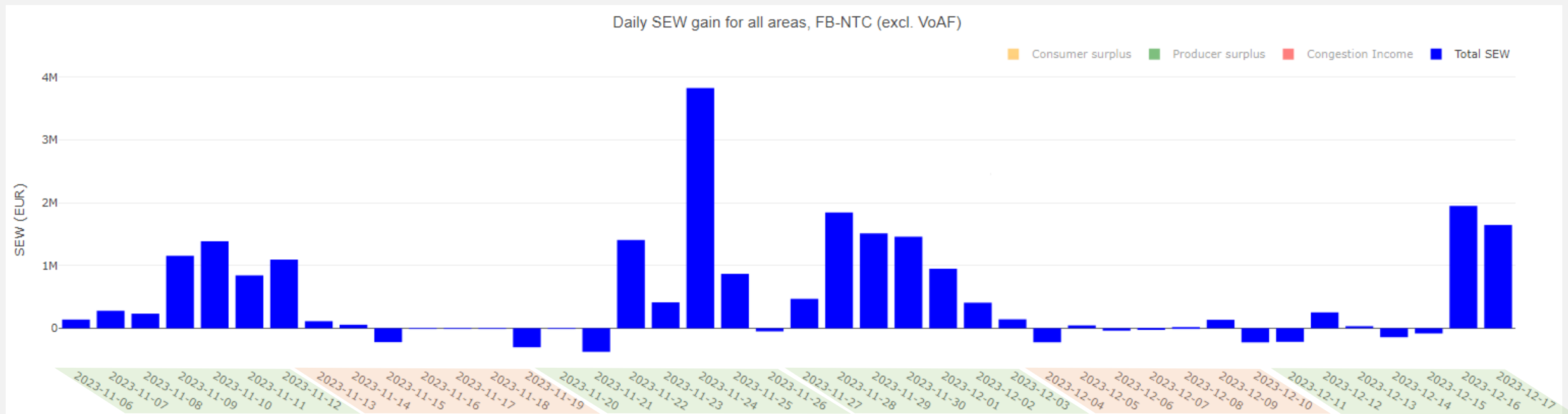


Figure: SEW change in the whole SDAC region on daily level



Nordic net position impacts W45-50

- FB allows for more export to the Continent also for this period, this has been trend seen since beginning of April.
- Week 48 had an increase in Nordic NP of 101 GWh, while week 46 only had an increase of 4 GWh.
- Generally net position increases in northern areas and decreases in southern areas.

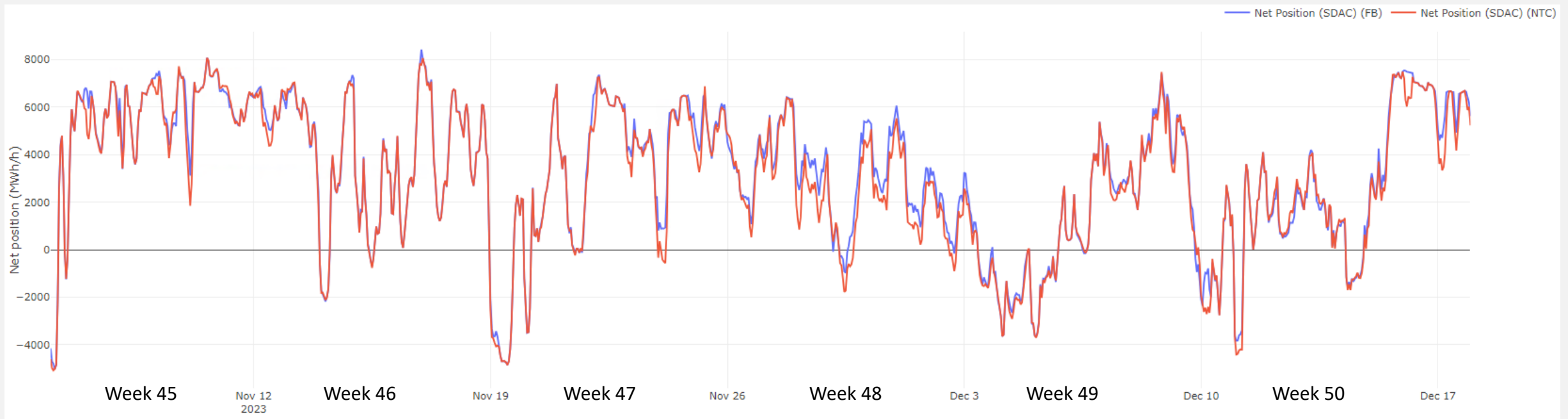


Figure: Net position in CCR Nordic (FB and NTC)



Constraining CNECs in FB W45-50

- The CNECs with highest shadow prices are HVDC interconnectors connecting the Nordics to the continent.
- High shadow prices indicate that more flow would have increased the total SDAC welfare.

* For some MTUs the shadow price is unrealistic high due to multiple constraints at once. The value does not represent the increased SEW of increasing the RAM in these cases, However this issue does not impact the market solution. The TSO are investigating a fix to solve this.

** 24. November had a bidding error FI and the price was -500 EUR/MWh MTU 15-24. The shadow price on the constraining elements was around 35.000 EUR/MW.

⊕CNEC	⊕Count of hours	⊕Average shadowprice	⊕Total shadowprice
FI_PTC_FI_EL_EXPORT **	338	788.80	266,615.09
FI_PTC_RAC_FI-SE1 **	43	5,858.70	251,923.96
FI_PTC_FI_FS_EXPORT **	14	12,969.03	181,566.36
AC_Minimum_SE4_SWL *	334	292.84	97,807.19
AC_Minimum_SE3_SWL *	248	387.34	96,060.51
AC_Minimum_FI_FS **	16	4,437.56	71,000.90
7a04cc61e51b458894cb261473229479	619	32.34	20,021.25
FI_PTC_RAC_SE1-FI	470	36.03	16,932.30
AC_Minimum_SE3_KS *	297	47.99	14,254.40
DK1_SV_EXP *	108	130.89	14,136.37
2bba376d9db242f79f0818fd88f63dc6	78	147.00	11,465.93
FI_RAC_SE1-FI_VUENNONKOSKI-PETAJASKOSKI_OLG3_SIPS	58	177.72	10,307.71
67c42ed5f0284829953209ba76ce022a	182	53.73	9,778.24
AC_Minimum_SE3_FS	185	47.36	8,760.77
AC_Minimum_SE4_SP	276	30.42	8,394.99
8953dfc73caf45fb96fb0faef3e7eda5	73	114.97	8,393.00
7e6f65c1a0db46738b29de08ed51fc1c	166	43.68	7,251.52
AC_Minimum_FI_EL	159	44.79	7,121.82
AC_Minimum_SE4_NB	187	37.48	7,008.61
5cc845dc1c3a4852a4e15400c3278c42	7	976.23	6,833.61
AC_Minimum_DK2_KO	326	20.83	6,789.01
AC_Minimum_NO2_ND	403	16.56	6,674.09
f0a06b59e997485e90038e40692a432d	33	197.78	6,526.66
71a9d8bf2b6a417a98c08d20391e37aa	326	19.82	6,459.76
ACLineSegment ENDK DK1 E_FOU-MOSV 1 F Terminal : F	83	77.16	6,404.53

Table: Top 25 aggregated shadow prices on CNEC level



Nordic region in W45-46 NTC

- Prices in Northern Nordics are higher than previous weeks, with high volatility and price spikes >140 EUR
- Prices in DK and southern Norway are higher than the rest of the Nordic, but slightly lower than the continent.
- The prices in FI, SE3 and SE4 are quite normal on average but with multiple price spikes during the period(100-180 EUR/MWh).
- Constraint in the grid:
 - North Nordics -> South Nordics
 - Northern NO and SE -> FI
 - South Sweden -> South Norway + Denmark
 - Nordic -> Continent

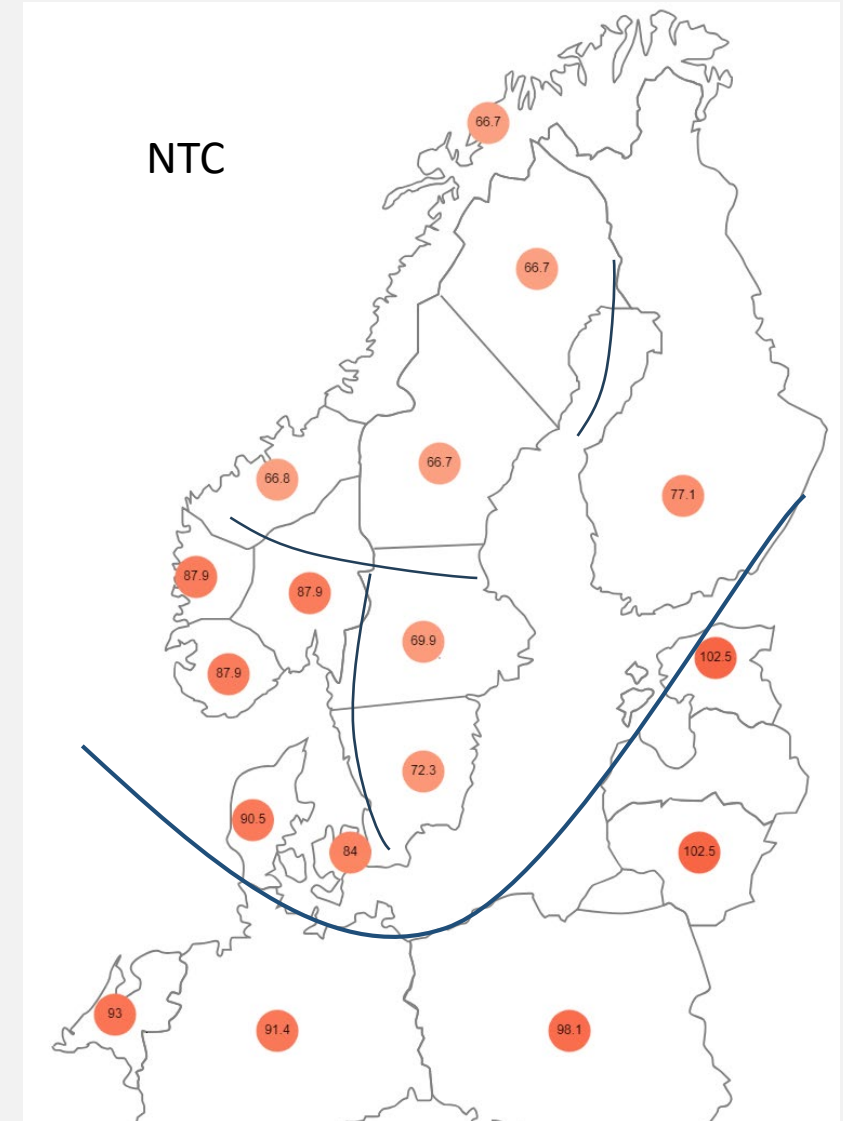


Figure: Average price in each BZ in NTC



Average prices in the Nordic region W45-46

- For these weeks there are few internal constraints in the Nordics
- Also not large constraints between the Nordics and the continent -> quite similar prices
- The price decreases with ~2-3 EUR/MWh in NO1, NO2 and NO5
- 25 GWh more export from the Nordics with FB than NTC
- 154 GWh more export from NO3 and SE2 to NO1, NO5 and SE3
- 120 GWh more export from SE3 and SE4 to NO1 and DK

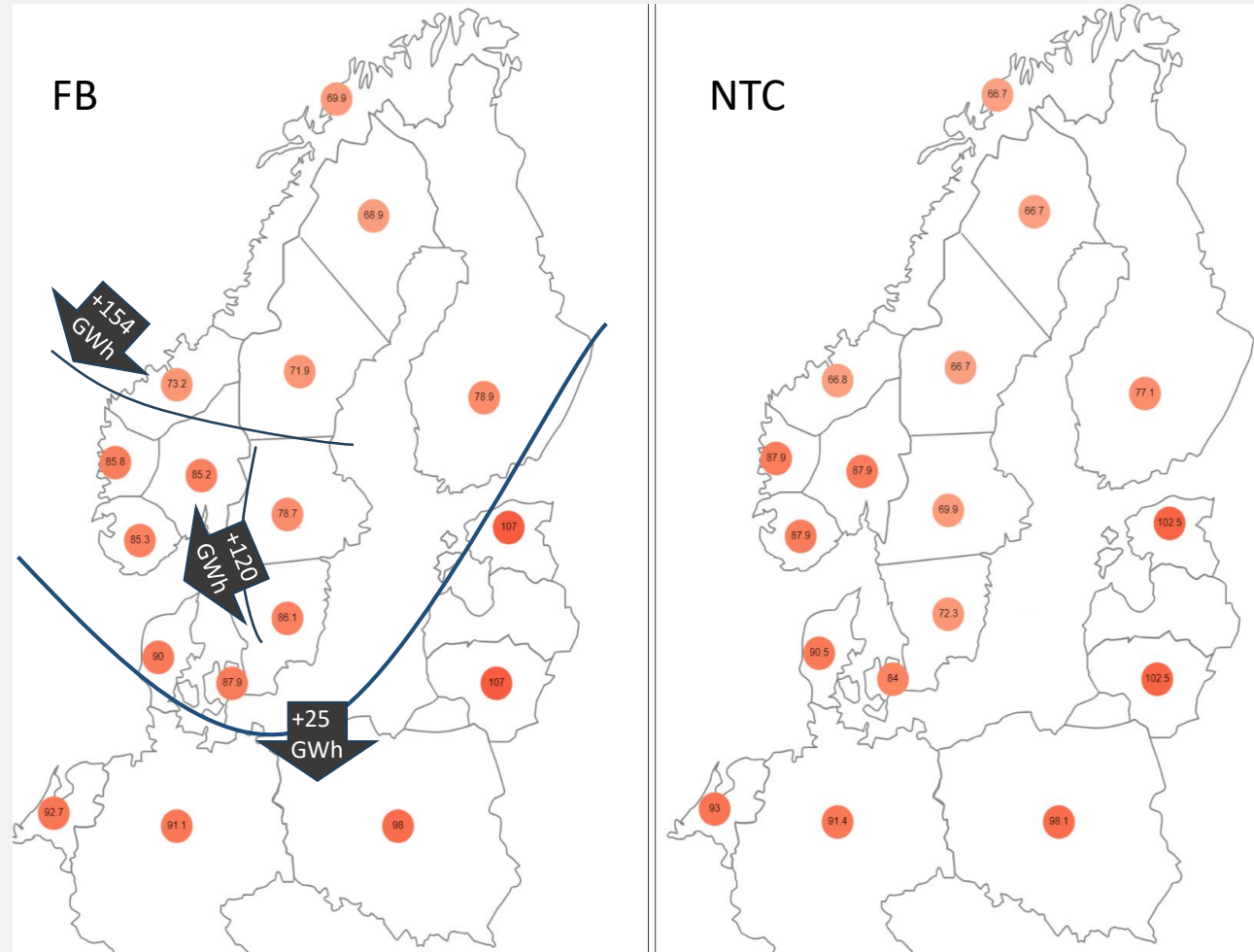


Figure: Average price in each BZ in FB and NTC. Arrows show the increased flow over constraining elements.



Prices W45-46

- Generally, quite similar prices in all the Nordic bidding zones through the period, Sweden average price increases on all areas.
- For the somewhat higher price areas DK1, NO1, NO2 and NO5, prices stay around the same or decrease a little in FB
- The maximum prices decreased for FI, otherwise about the same for all other bidding zones
- SE4 price increase mostly due to 10 to 12 November where the price is closer to the price in the continent, rather than SE3

Bidding zone	Min. price		Max. price		Avg. price		FB-NTC
	FB	NTC	FB	NTC	FB	NTC	
DK1	0	0	182	182	90	91	-1
DK2	14	17	181	182	88	84	4
FI	17	17	186	195	79	77	2
NO1	30	35	181	182	85	88	-3
NO2	36	35	181	182	85	88	-3
NO3	25	19	181	182	73	67	6
NO4	19	17	181	182	70	67	3
NO5	40	35	181	182	86	88	-2
SE1	17	17	181	182	69	67	2
SE2	17	17	181	182	72	67	5
SE3	15	17	181	182	79	70	9
SE4	15	17	181	182	86	72	14

Table: Min, max and mean prices for all bidding zones in FB and NTC



SE3 and SE4 prices

- Very low prices for several days in SE3 and SE4 in NTC
- FB prices are closer to the rest of the system
- Results in increase in SE3 price by 9 EUR/MWh, and SE4 price by 14 EUR/MWh

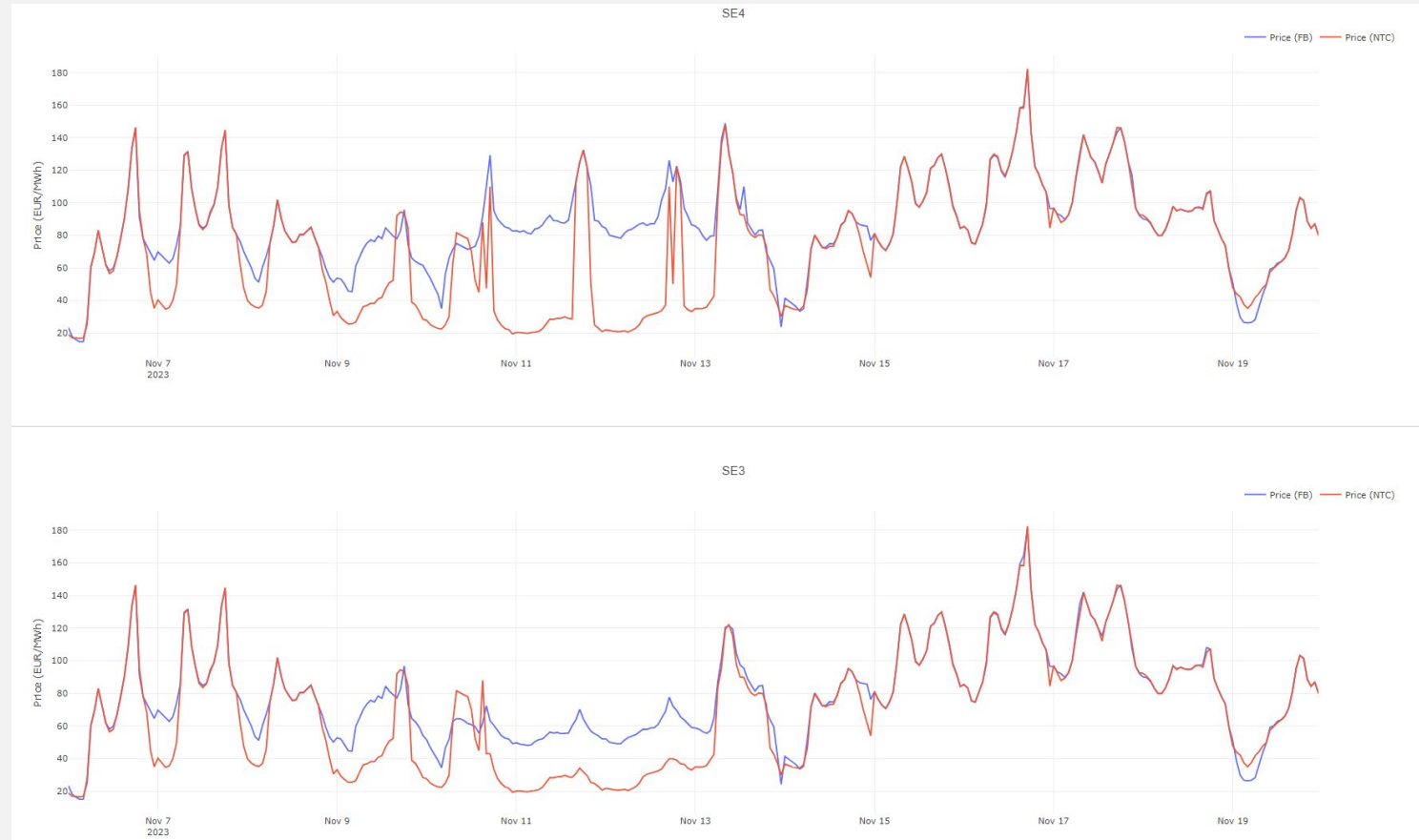


Figure: Prices in FB (blue) and NTC (red) in SE3 and SE4 for week 45 and 46.



SEW Impact on bidding zone level W45-46

- The impact on the different parts of the SEW from FB differs significantly between the Nordic bidding zones.
- Largest positive total SEW change in SE2, SE3 and NO1.
- Negative difference in SEW is observed in DK1, DK2, NO2, NO5 and SE4.
- FB results in a gain for consumers in NO1, NO2 and NO5, while the producers in SE2, SE3, FI and NO3 experience the largest gain with FB compared to NTC.

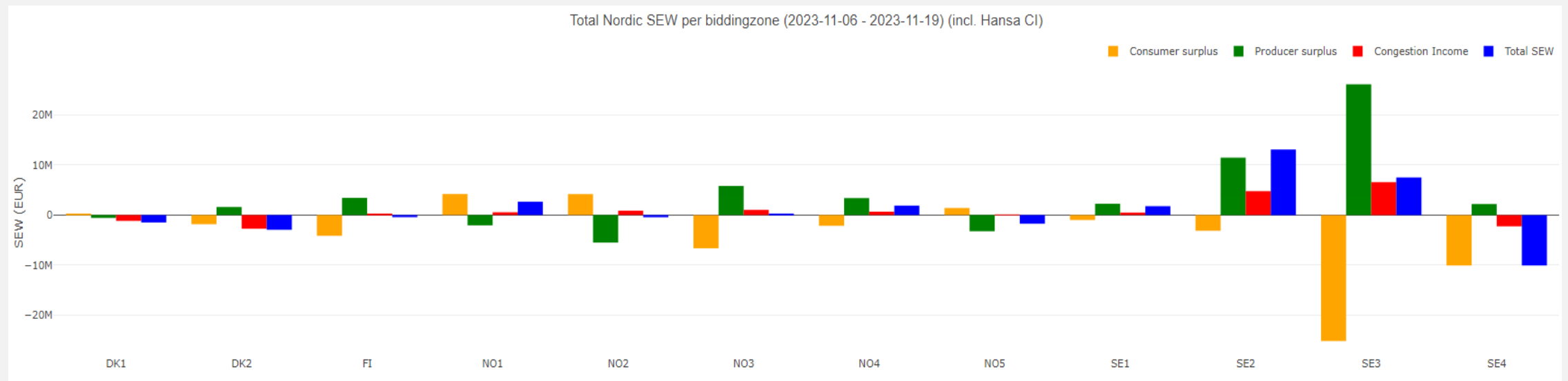


Figure: SEW change per stakeholder in CCR Nordic per BZ



Nordic region in W47-48 NTC

- Prices through these weeks in NO3, NO4, SE1 and SE2 are around 60 EUR/MWh.
- Prices in DK, SE4 and southern Norway are higher than the rest of the Nordic, but lower than the continent.
- Important note: the black Friday incident in Finland was in week 47
- Constraint in the grid:
 - North Nordics -> South Nordics
 - South Sweden -> South Norway
 - Norway -> Denmark
 - Sweden -> Denmark
 - Nordic -> Continent

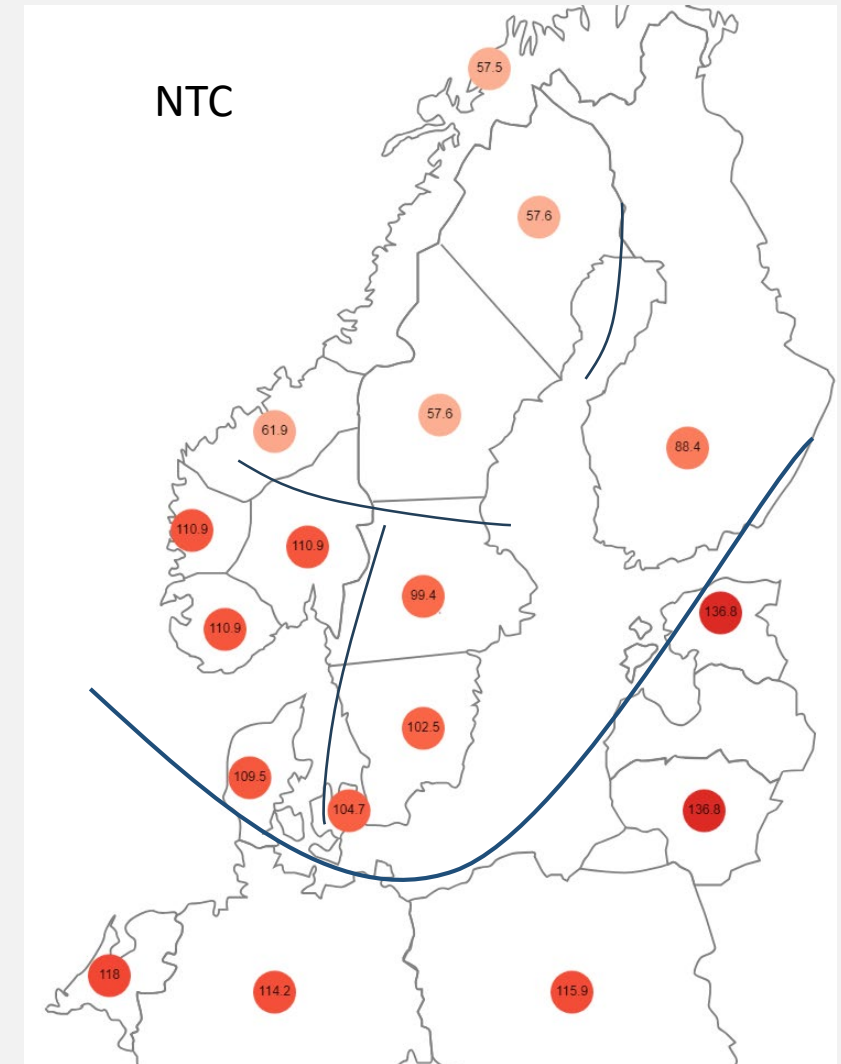


Figure: Average price in each BZ in NTC



Average prices in the Nordic region W47-48

- The price decreases with ~4-5 EUR/MWh in NO1, NO2 and NO5
- 124 GWh more export from the Nordics with FB than NTC.
- 217 GWh more export from NO3 and SE2 to NO1, NO5 and SE3.
- 65 GWh more export from NO and SE to DK.

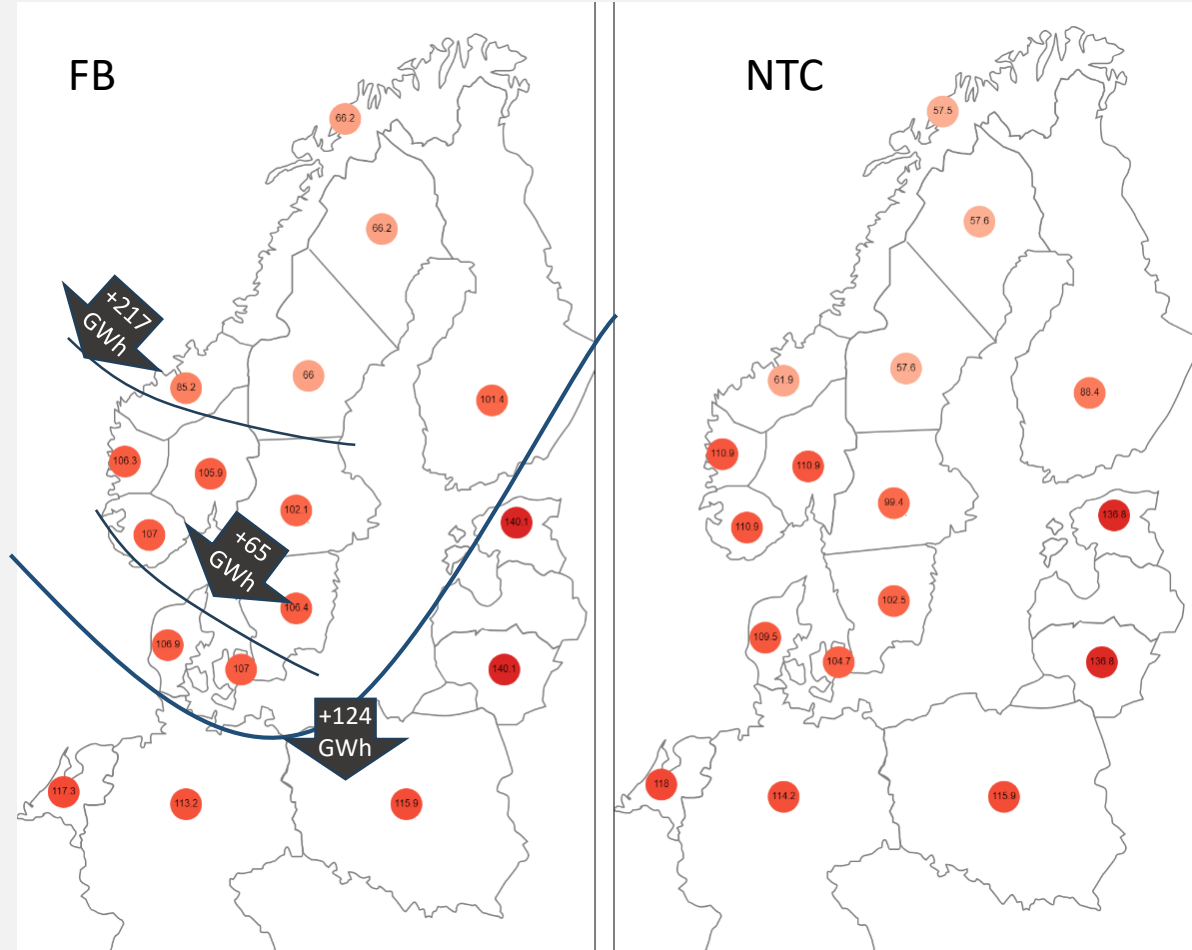


Figure: Average price in each BZ in FB and NTC. Arrows show the increased flow over constraining elements.



Prices W47-48

- Generally equal prices in Norway, Finland and Sweden through the period, Sweden average price increases on all areas.
- For the somewhat higher price areas DK1, DK2, NO1, NO2 and NO5, prices stay around the same or decrease a little in FB
- The maximum prices decreased for NO, SE3 and SE4 (and DK1 and DK2).

Bidding zone	Min. price		Max. price		Avg. price		
	FB	NTC	FB	NTC	FB	NTC	FB-NTC
DK1	0	0	253	261	107	109	-3
DK2	0	0	269	269	107	105	2
FI	-500	-500	800	777	101	88	13
NO1	32	21	248	260	106	111	-5
NO2	37	21	249	260	107	111	-4
NO3	27	12	234	147	85	62	23
NO4	15	12	226	147	66	58	9
NO5	48	21	248	260	106	111	-5
SE1	3	0	224	147	66	58	9
SE2	2	0	223	147	66	58	8
SE3	1	0	255	260	102	99	3
SE4	0	0	253	260	106	103	4



SEW Impact on bidding zone level W47-48

- The impact on the different parts of the SEW from FB differs significantly between the Nordic bidding zones.
- Largest positive total SEW change in NO1, NO4, SE1 and SE2.
- Negative difference in SEW is observed in DK2, FI, NO2, NO3, NO5, SE3 and SE4.
- FB results in a large gain for consumers in NO1, NO2 and NO5, while the producers in SE1, SE2, SE3, FI, NO3 and NO4 experience the largest gain with FB compared to NTC.

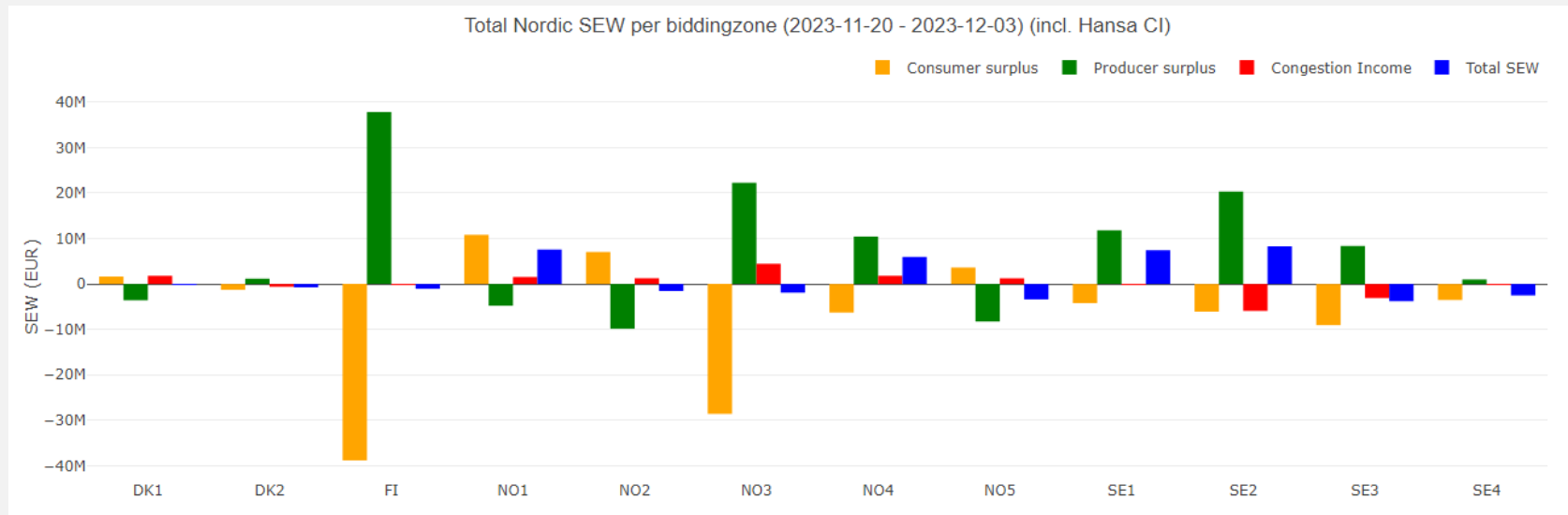
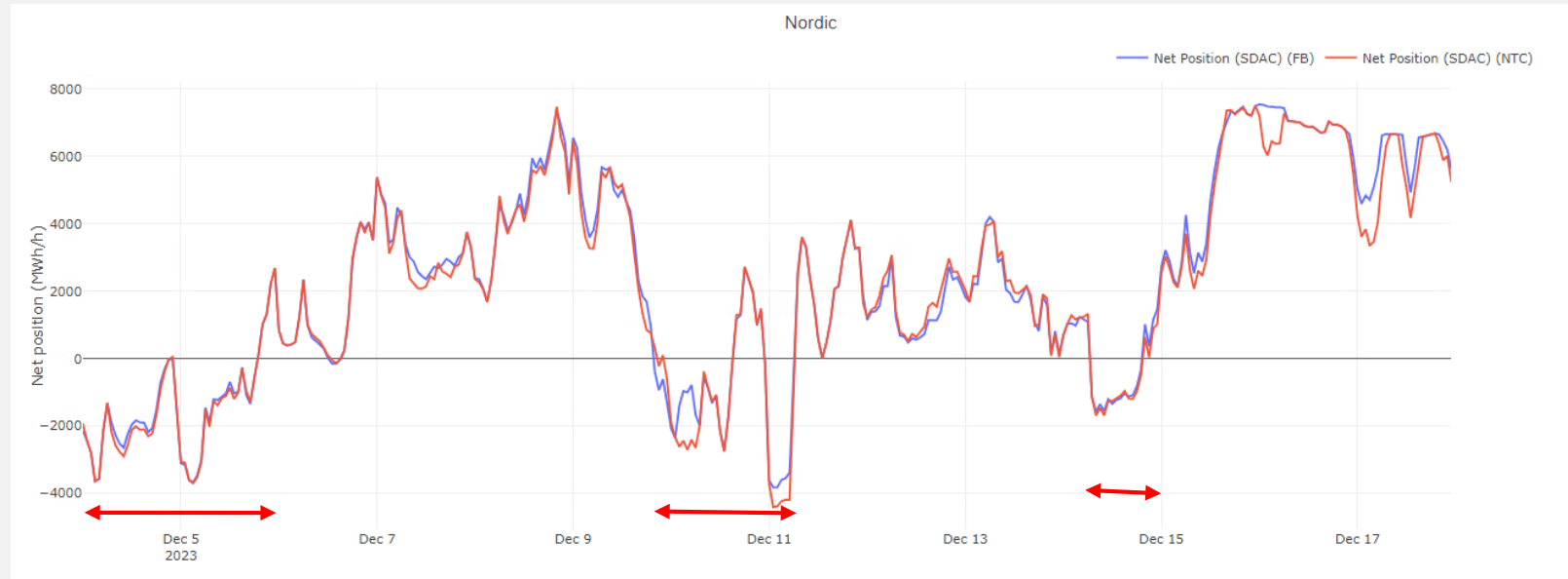


Figure: SEW change per stakeholder in CCR Nordic per BZ



Remark on the results for Nordic region in W49-50

- Remark! During week 49-50 there is three periods with Nordic net import both in FB and NTC. This should be considered when interpreting the following average numbers, especially average flows.
- A deep dive of the first highlighted period, 4-5 December will be presented after this section.
- In general, a higher net position in FB in the Nordic region, even during net import hours.





Nordic region in W49-50 NTC

- Prices are fairly high overall in the Nordic region, 82-107 EUR/MWh in average, during this period mainly due to cold weather.
- Nordic net import for several days during this period and lower prices in DE, NL & DK1 than southern Nordic areas and FI
- Prices in SE1, SE2, NO3 and NO4 is closer to DE & NL than southern areas in SE and NO.
- Highest price in Baltic areas
- Constraint in the grid:
 - North Nordics -> South Nordics
 - South Norway -> South Sweden
 - South Sweden -> South Norway
 - Norway -> Denmark
 - Sweden -> Denmark
 - Nordic -> Continent
 - Continent-> Nordic

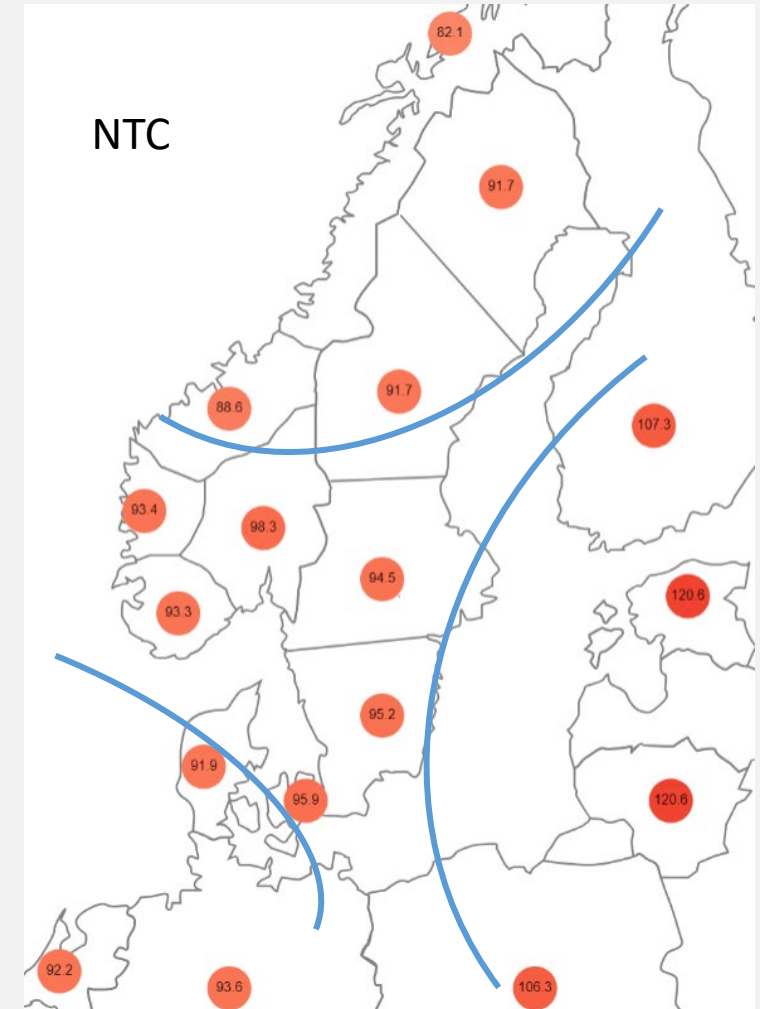


Figure: Average price in each BZ in NTC



Average prices in the Nordic region W49-50

- Very small price difference on average
- The price changes with less than 1 EUR/MWh in all Swedish areas, DK2 & NO5
- Lower prices in NO1, NO2, NO4
- Higher prices in NO3 and FI
- 42 GWh more export from the Nordics with FB than NTC.
- 134 GWh more export from NO3 and SE2 to NO1, NO5 and SE3.
- 26 GWh more export from NO and SE to DK.

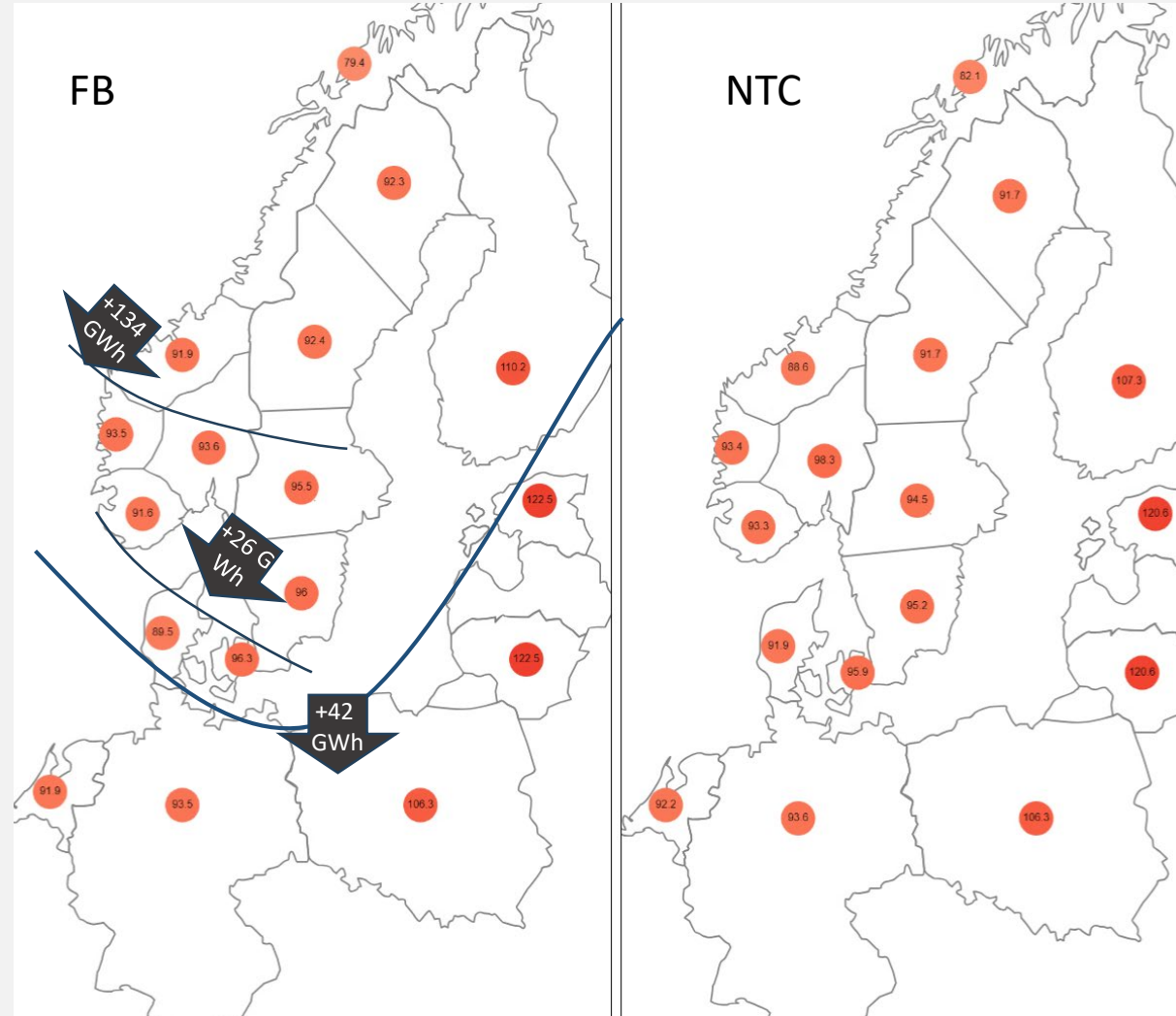


Figure: Average price in each BZ in FB and NTC. Arrows show the increased flow over constraining elements.



Prices W49-50

- Generally small change on average
- Maximum price decreased in high price areas
- Minimum prices very similar in FB and NTC

Bidding zone	Min. price		Max. price		Avg. price		FB-NTC
	FB	NTC	FB	NTC	FB	NTC	
DK1	5	6	179	178	89	92	-2
DK2	-1	-1	311	332	96	96	0
FI	0	-1	311	332	110	107	3
NO1	25	27	306	332	94	98	-5
NO2	26	27	174	173	92	93	-2
NO3	13	3	300	332	92	89	3
NO4	5	3	309	332	79	82	-3
NO5	24	27	268	173	94	93	0
SE1	1	-1	310	332	92	92	1
SE2	1	-1	311	332	92	92	1
SE3	-2	-1	311	332	95	95	1
SE4	-3	-1	311	332	96	95	1



SEW Impact on bidding zone level W49-50

- Small impact on the total Nordic SEW change but the impact on the different parts of the SEW from FB differs significantly between the Nordic bidding zones.
- Largest positive total SEW change in NO1, SE2 and SE3.
- Largest negative difference in SEW is observed in DK1, NO2 and NO5.
- FB results in a large gain for consumers in NO1 and largest loss in FI while the producers in FI, NO3 and SE3 experience the largest gain with FB compared to NTC.

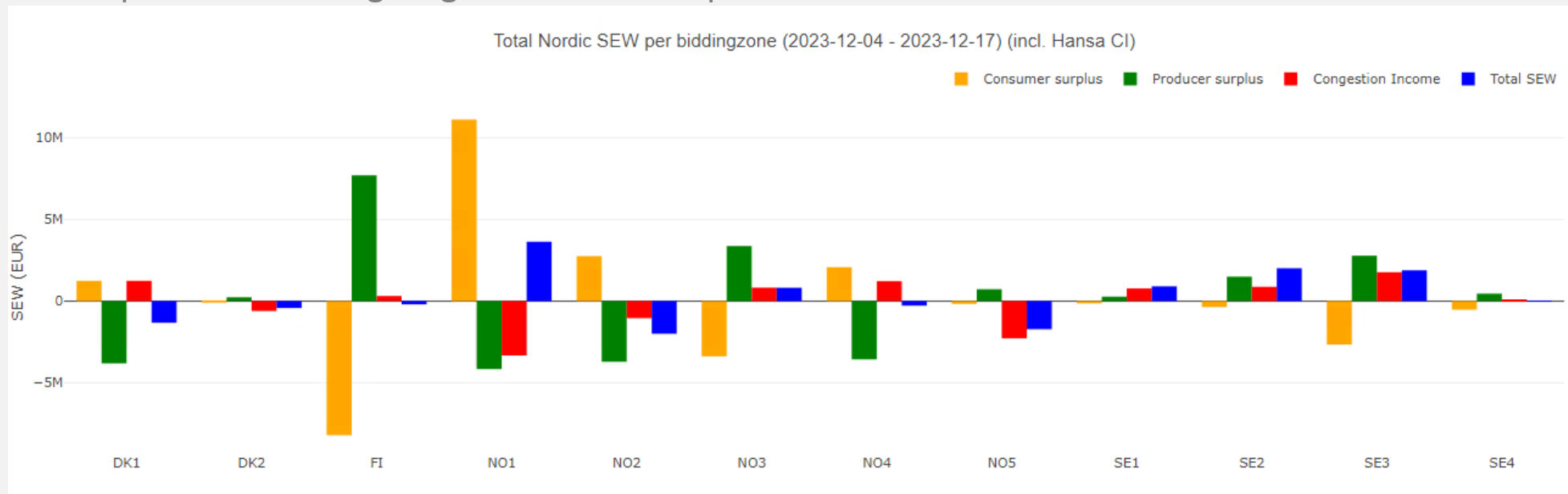


Figure: SEW change per stakeholder in CCR Nordic per BZ



Walk through specific hours and periods

11. November 15:00-16:00
Increased flow to south Norway

30. November 17:00-18:00
Increased flow to south Norway

4.-5. December
Import from the continent to the Nordic

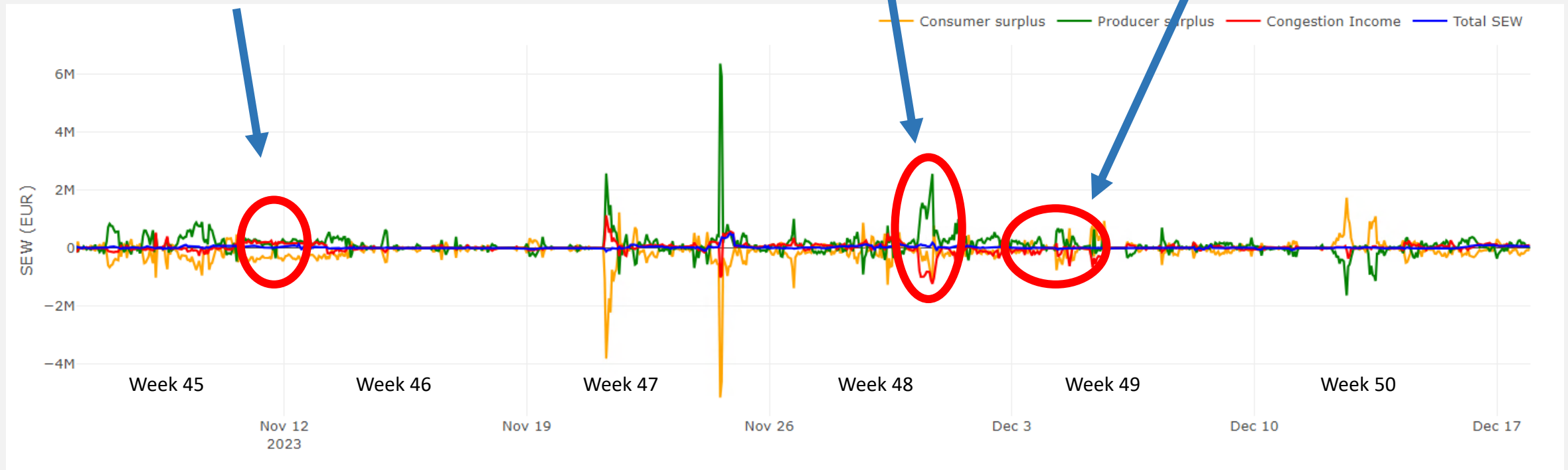
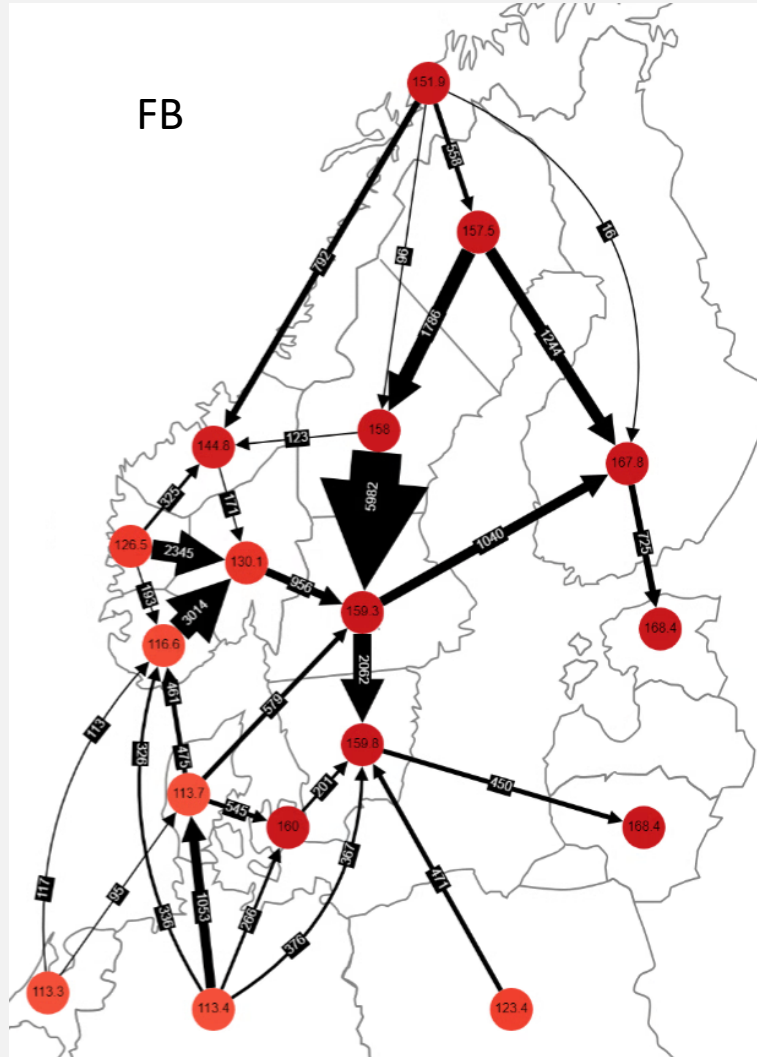


Figure: Hourly SEW change from FB to NTC for the total SDAC region.

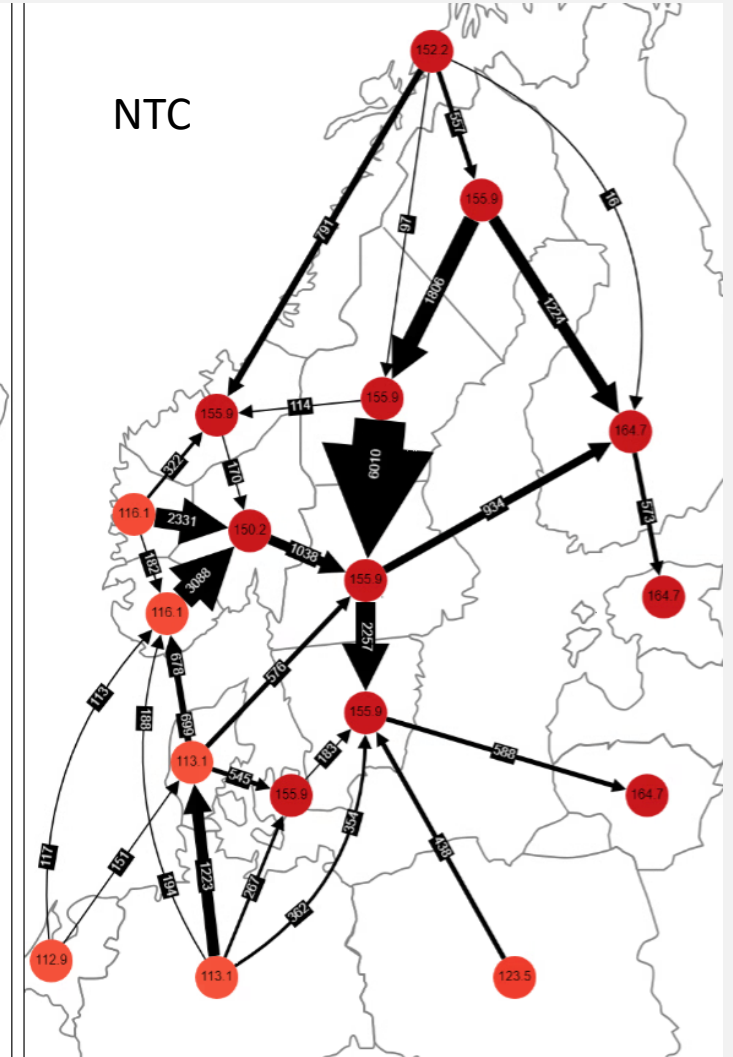


4-5 December

- Period when the Nordic net position is -72 GWh FB and -75 GWh in NTC meaning slightly higher Nordic import in NTC.
- Much lower prices in NO1 and NO3, slightly higher in the other Nordic areas
- Total Nordic SEW change: **-126 kEUR**
- A Norwegian CNE limits the flow on **NO1→SE3** more than what we see in NTC which at least partly explains the negative SEW results. The CNE is affected by the North Sea Link prognosis which was wrong for this week. With high import on NSL, the CNE limits **NO1→SE3** due to the possibility of outage on NSL. In NTC, this issue is rather solved in operation, instead of using prognosis. Thus, the FB approach to this is more accurate, but in this case too limiting. The operators are looking further into the issue.



Map: Average price and flows from FB

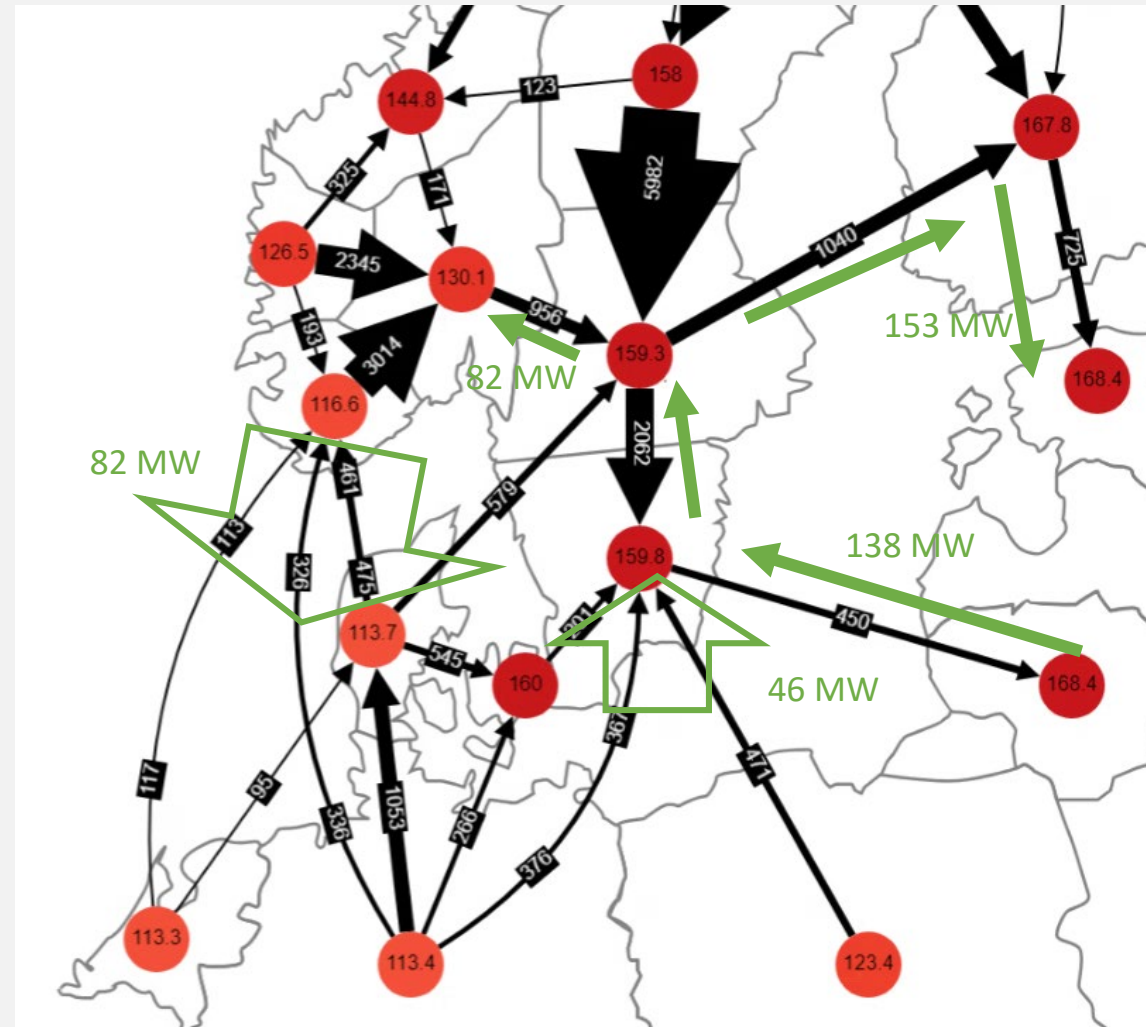


Map: Average prices and flows from NTC



4-5 December

- Lower capacity on NO1>SE3 results in a reduced flow on average of 82 MW on this border and in total on the borders to NO2 from DE, NL & DK1. For some hours we see a very high shadow price on the limiting Norwegian CNE thus a large impact on the prices.
- The decreased import to NO2 is partly compensated on DE>SE4 and PL>SE4.
- The change of flows on SE4->LT and FI->EE is more related to market and is an effect of the Norwegian CNE.

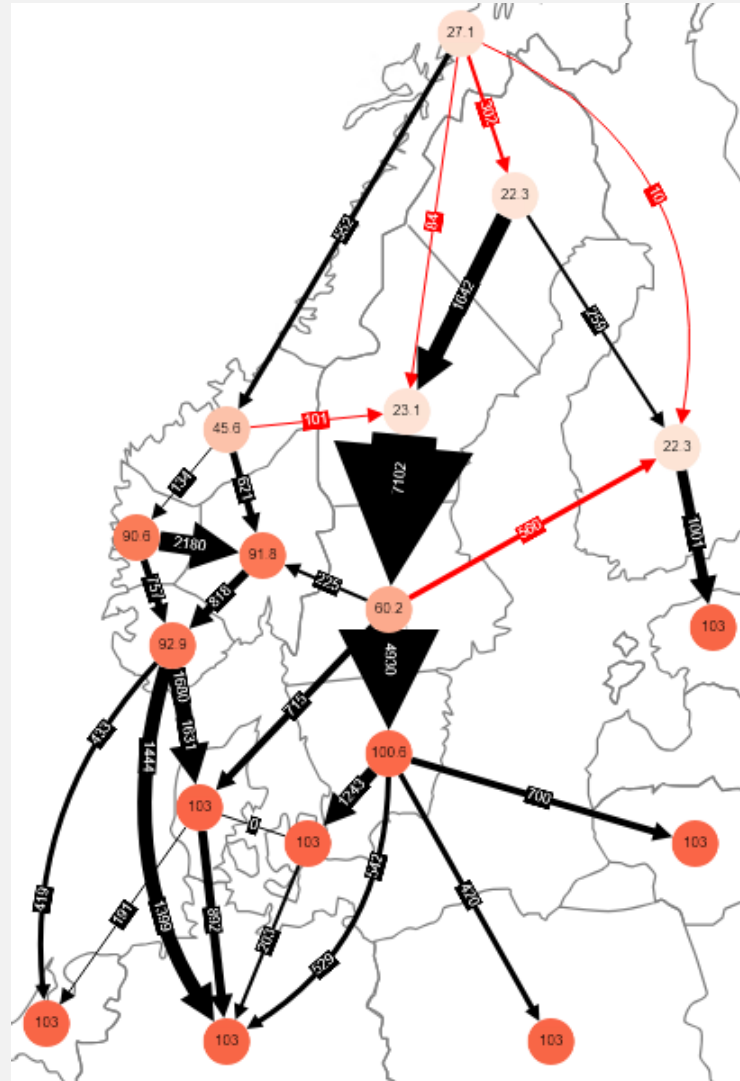


Map: Average FB flow, flow change (green arrows) and prices

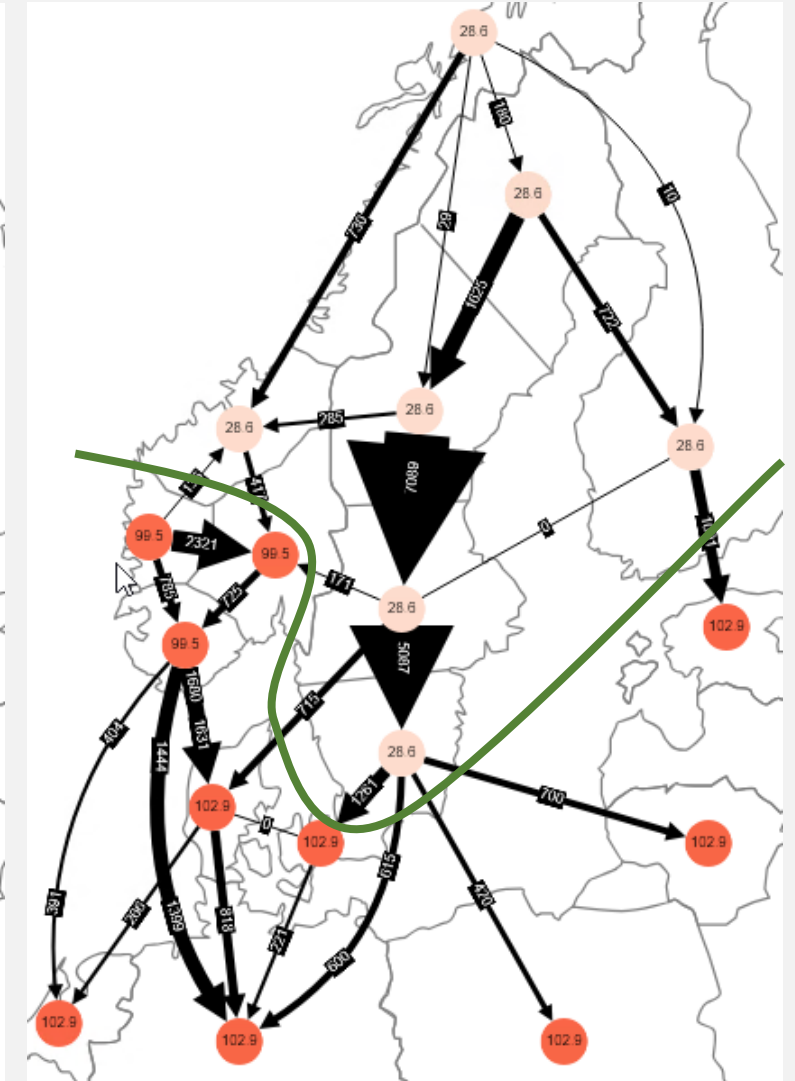


11. November 15:00-16:00

- Highest Nordic prices in Southern Norway and Denmark.
- Minor change in the total Nordic NP.
- The price difference between NO2 and DK1+DE+NL is due to implicit net loss and not grid constraints.
- Lineset out of SE3 to NO1+DK1 was constraining in NTC (867 MW), whereas FB allowed a higher flow over these borders.
- Congestions are moved from SE4-> Hansa to inside Sweden.
- Congestion income are moved from Hansa to Nordic.
- Positive SEW for both Nordic and SDAC.



Map: Price and flows from FB

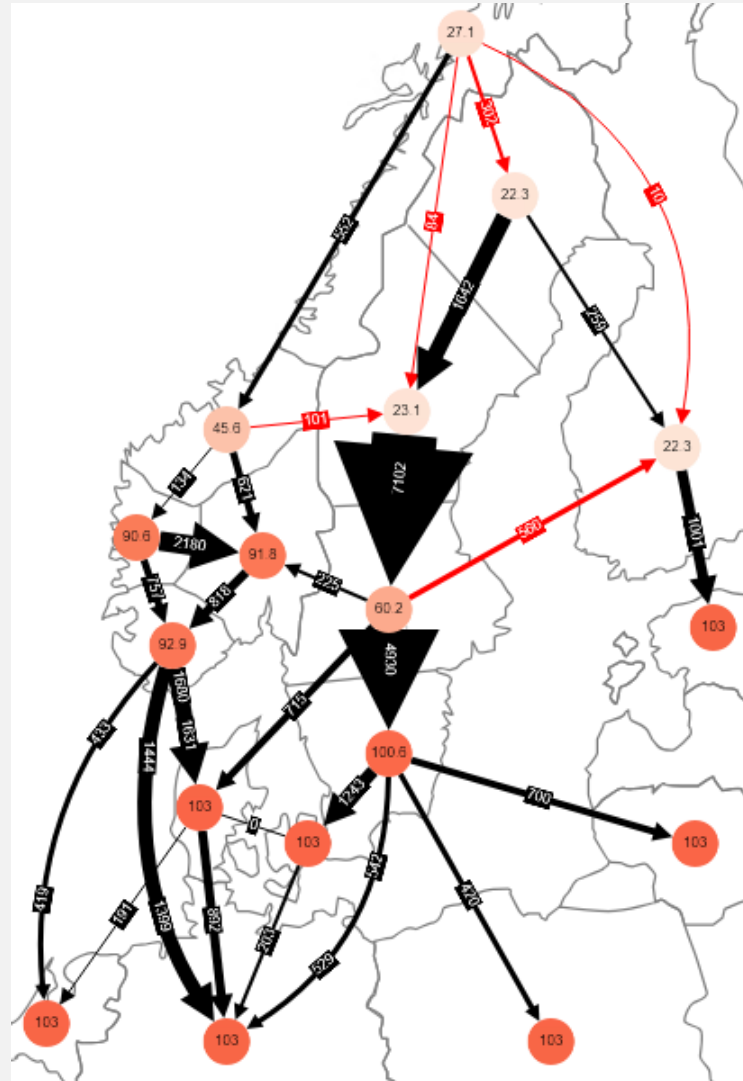


Map: Prices and flows from NTC

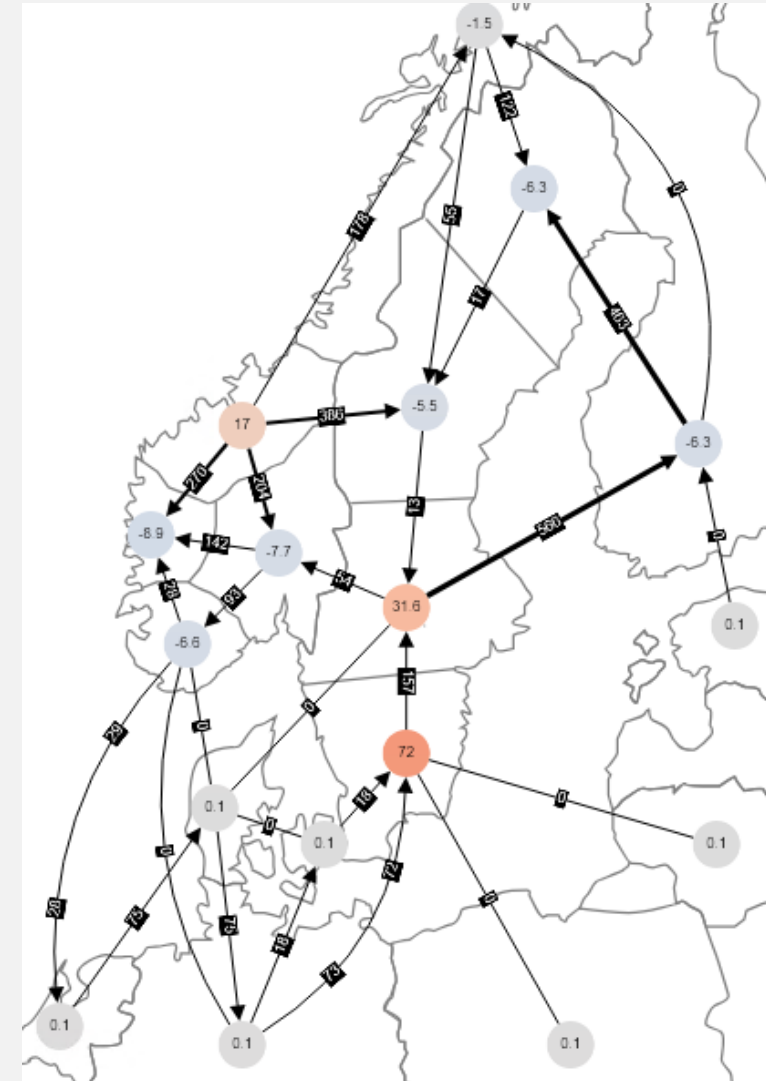


11. November 15:00-16:00

- The solution from NTC cannot be allocated in FB, due to overload on a Swedish element.
 - If $RAM < PTDF * NP_NTC$ that indicant an overload.
 - A SVK CNEC: $6.154 \text{ MWh} < 6.406 \text{ MWh}$
- The SEW for this MTU is higher with FB → FB still finds a better solution.
- FB lower import in SE3 (450 MWh) and SE4 (55 MWh).
- FB flip NO3 from an import area to an export area with 760 MWh
- Flow on Fennoskan (SE3->FI) relieves the most constraining CNEC.



Map: FB flow and prices



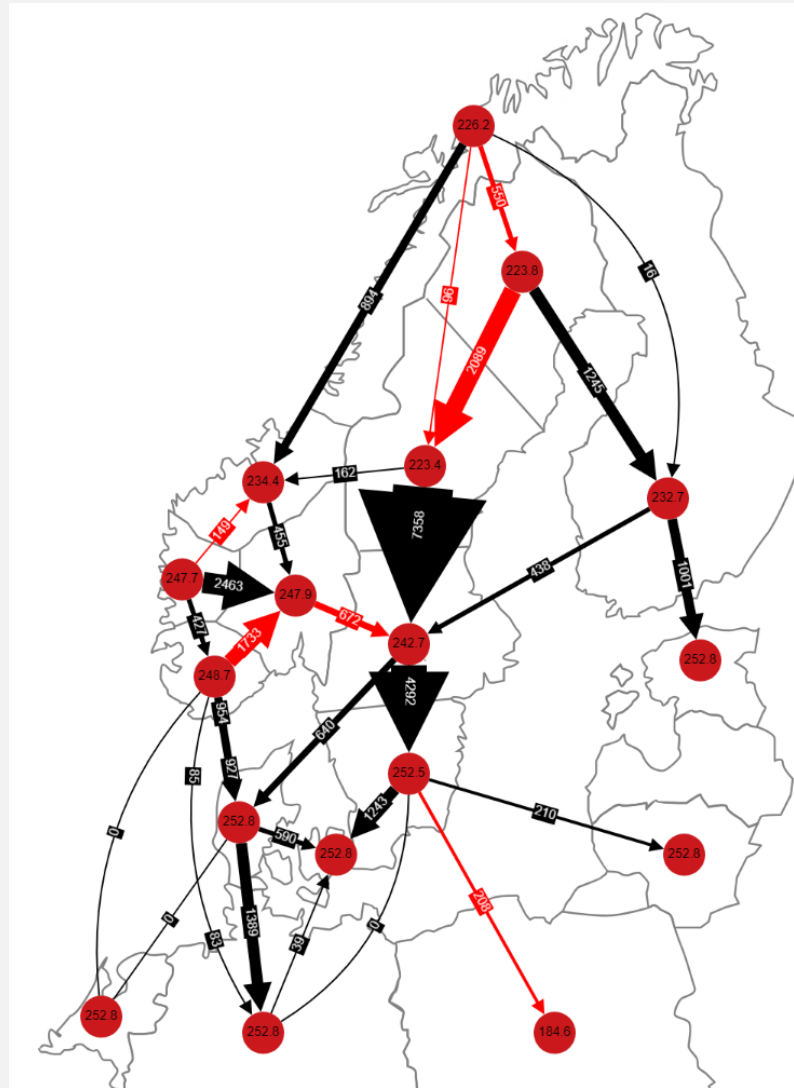
Map: Changes in prices and flows (AAF) (FB-NTC)



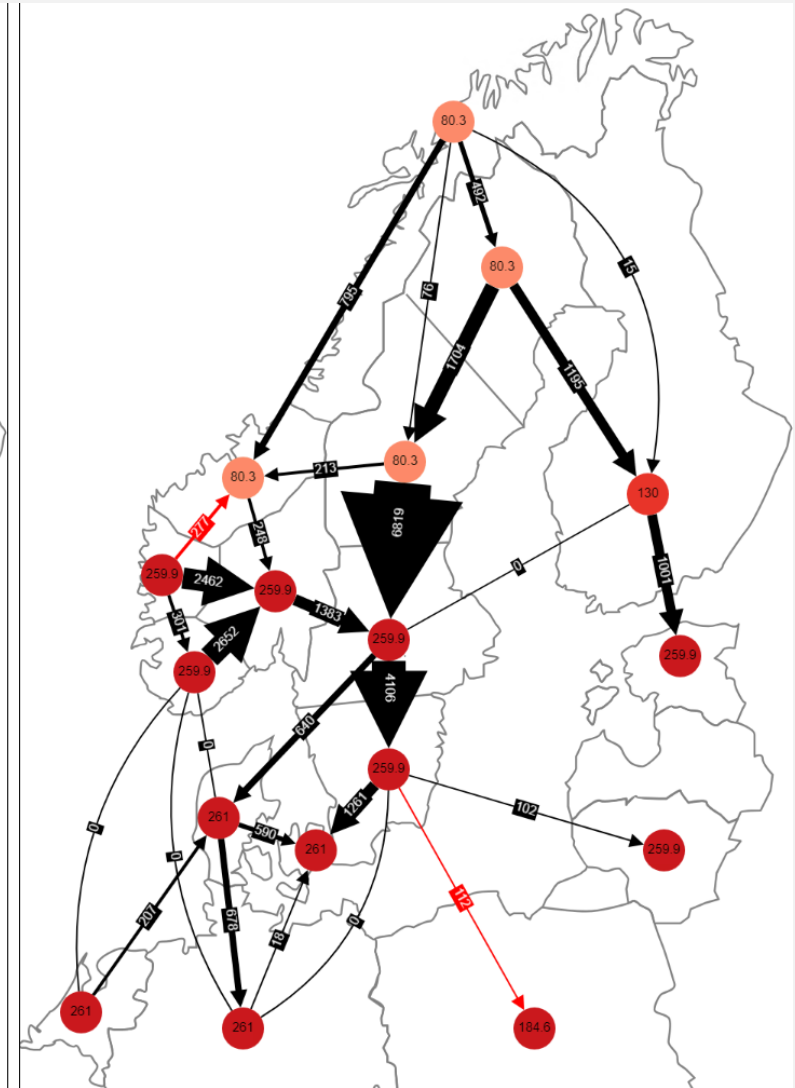
30. November 17:00-18:00

Situation

- High price differences between north and south in NTC.
- Southern Nordic couple with the continent.
- Nordic NP in NTC is 1668 MWh and changes to 2882 MWh in FB caused by
 - Higher export DK1->DE, DK1->NL (+919)
 - Higher export SE4->PL, SE4->LT (+214)
- The price difference between NO2 and DK1+DE+NL is due to implicit net loss and not grid constraints.



Map: Price and flows from FB



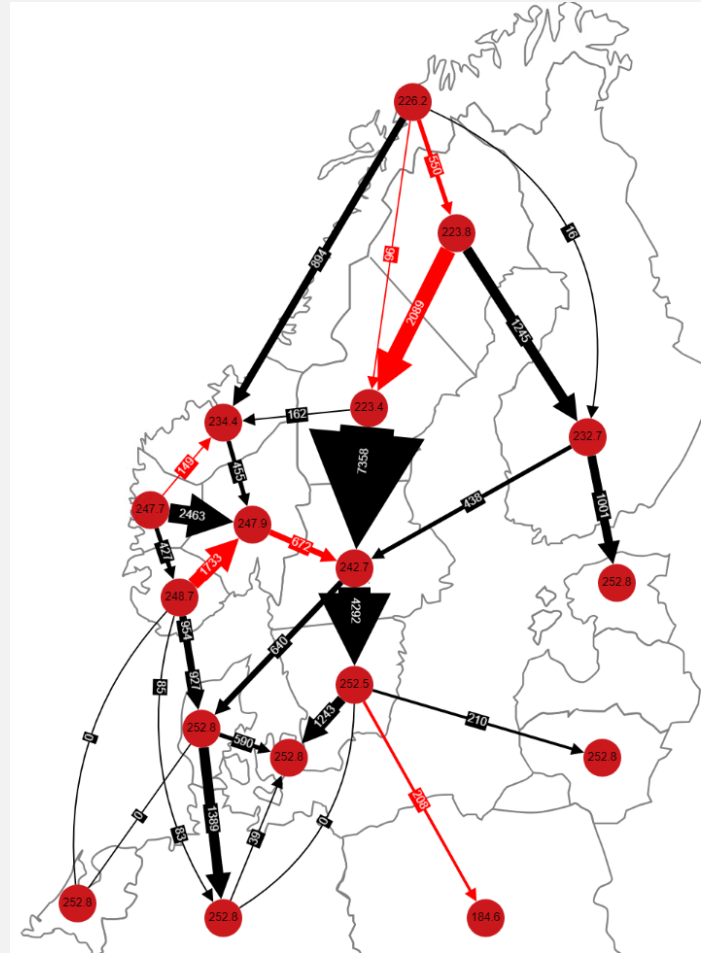
Map: Prices and flows from NTC



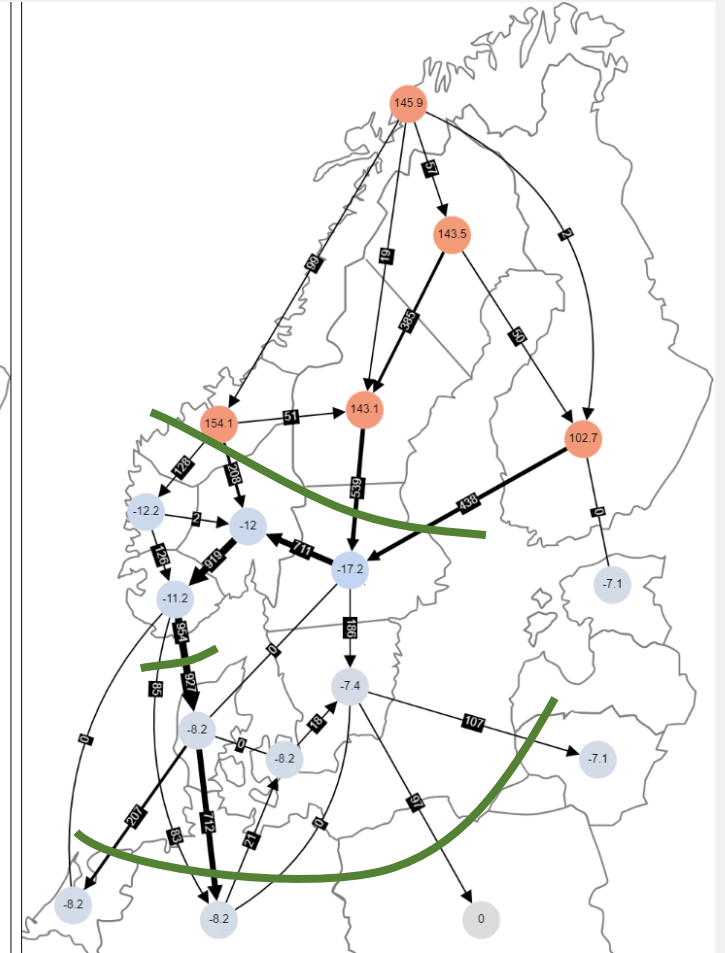
30. November 17:00-18:00

What happened:

- FB increases the flow over the constraining elements from north to south (constraints mostly in SE3 and its' borders)
- FB reduced the flow from NO1->SE3 and increased the flow from SE2->SE3 and FI->SE3.
- FB allowed export from FI to SE3 on Fenno-Skan (NTC capacity was set to 0 during the period).
- FB increases the export to DE (774 MWh), PL and LT (~100 MWh). Also, DK1 doesn't import from NL in FB.



Map: FB flow and prices



Map: Changes in prices and flows (AAF) (FB-NTC)



Questions?

ENERGINET

 **SVENSKA
KRAFTNÄT**

FINGRID

Statnett



Thank you!

Contact: ccm@nordic-rcc.net

ENERGINET

 **SVENSKA
KRAFTNÄT**

FINGRID

Statnett