



## 3. Executive summary of EPR

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# FB: a capacity calculation methodology representing the physical grid as market constraints

## Why?

- To increase the flexibility which is necessary for the Green Transition

But also...

- A Requirement from EU Reg. 2015/1222, guideline on capacity allocation and congestion management





# Current NTC vs. the FB capacity calculation Higher level of details and coordination

Today = NTC

Future = FB



Local TSO capacity calculation, based on experience

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Local TSO input data, a.o. individual grid model

Common grid model creation  
24 timestamps

Central capacity computation with a local validation by the TSOs

Per hour:  
34 NTC constraints

Per hour: roughly  
150 FB constraints

Market coupling

Market coupling



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# External parallel run (EPR)

- The TSOs have been performing EPR since Q1 2022.
- During the EPR the capacity calculation processes for both FB and NTC have been performed in parallel on a daily basis.
- The FB domains have been and are published on the JAO website, but they are “only” available 2 years back.
- Objectives of the EPR:
  - 1) Ensure that the capacity calculation process works
  - 2) Show the differences between the 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



# EPR results

- Since December 2022 simulations of the market results with the Nordic FB have been published.
- Market simulations have been performed in the test environment for the market algorithm.
- The simulation with the Nordic FB domain is a sensitivity analysis, where only one parameter has changed
- Comparing DA production data and the simulated FB results, enables a fair comparison of the two capacity calculation methods. It isolates the impacts solely from FB without further assumptions.
- Those results are not a forecast of the future, but a calculation and comparison of the daily impact of a change in the capacity calculation.

## What changed:

- Capacities in capacity calculation region Nordic and their external borders to the continent.

## What did not change:

- Production orderbooks used in all BZs
- Production capacities used in the rest of Europe



# Nordic region in NTC during the EPR-period

The Nordics have been through some extreme periods during EPR with extreme prices due to e.g. the energy crisis, and the flooding in Norway.

- In the NTC production data for the EPR-period the lowest average prices are in NO4 being the Northern part of the Nordics and then prices are increasing through the Nordic Region with the highest prices in DK2 and even higher prices in the Baltic and the Continent.
- In the beginning of the EPR (Winter 22/23) there were really high prices in the Nordics with prices over 450 EUR/MWh in all bidding zones.
- Through the Summer of 2023 and 2024 there were 143 hours with negative prices in all bidding zones.
- The average price spread in the Nordics was 66 EUR/MWh with a maximum spread of 1842 EUR/MWh and 140 hours with 0 spread.
- The Nordics were exporting in 85% of the hours with an average of 5151 MWh/hour and were importing in 15% of the hours with an average on 2995 MWh/hour.

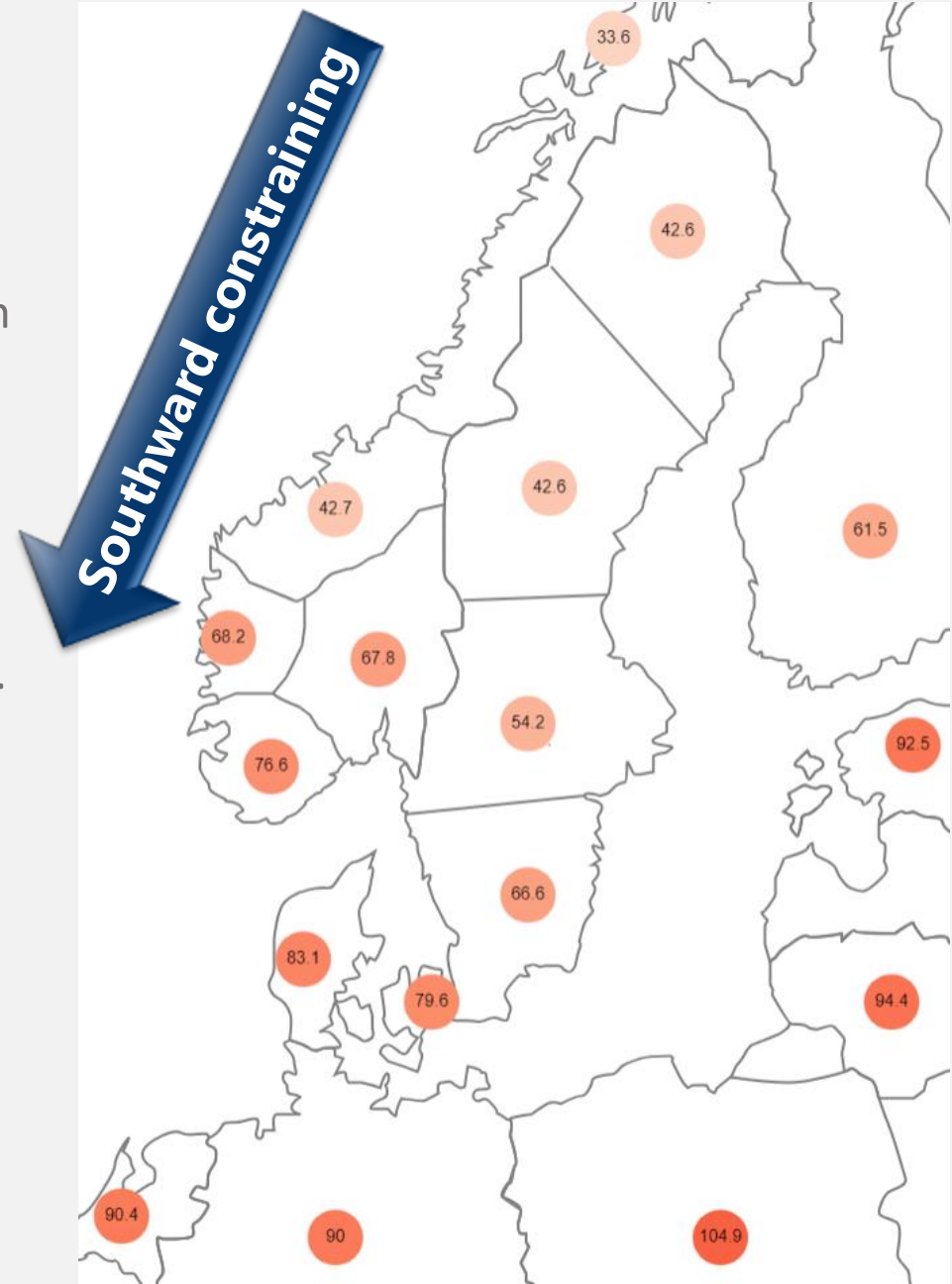


Figure: Average prices in each BZ in NTC for EPR (W50 22 – W26 2024)





# Nordic region in FB during the EPR-period

- FB was subjected to the same challenges as NTC; most hours were managed slightly better while others were worse with FB.
- Overall, the market results with FB show the same pattern as the NTC ones.
  - Low prices in the North and high prices in the South.
- But with FB:
  - The average price spread in the Nordic decreased from 66 to 63 EUR/MWh.
  - The maximum spread decreased from 1842 to 1658 EUR/MWh.
  - The hours with 0 spread increased from 140 to 262.
- This indicates that FB increased the utilization of the grid and was able to flow more electricity over the constraining elements than in NTC.

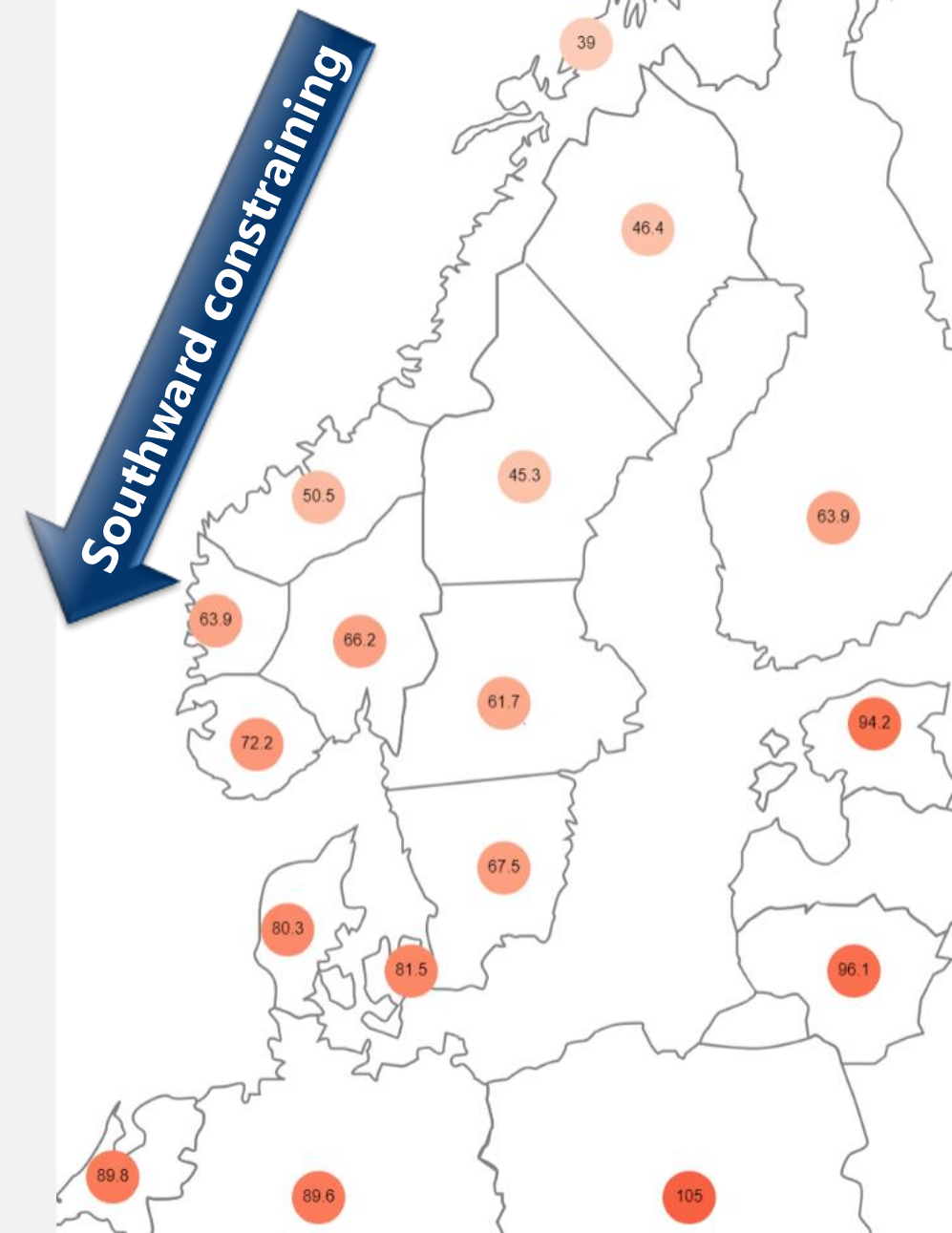
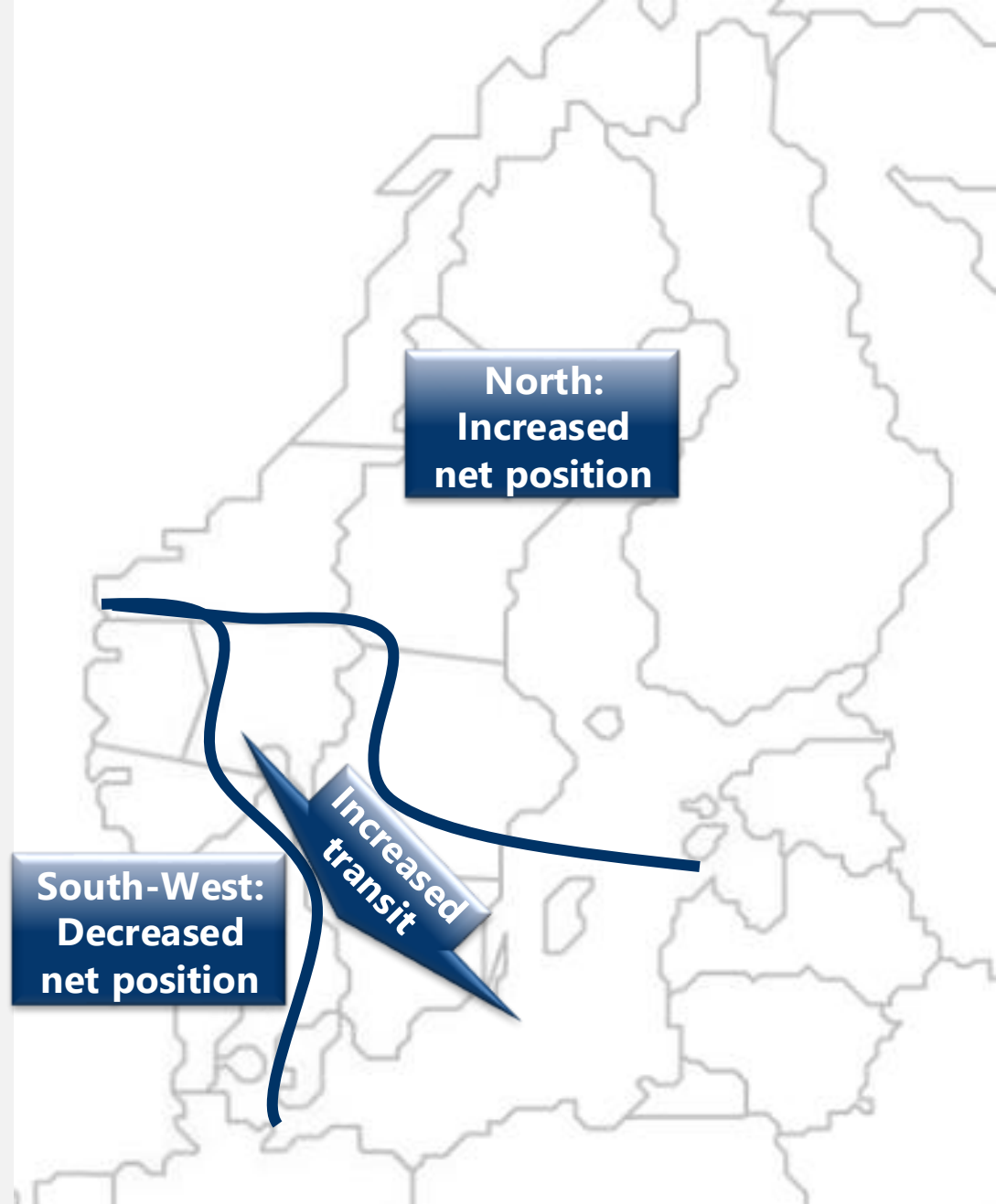


Figure: Average prices in each BZ in FB for EPR (W50 22 – W26 2024)



**Improved utilization of the Nordic grid enables an increased flow from North to South-West with around 10 TWh or 74% with FB that was not possible in NTC.**

FB impact December 2022 - June 2024





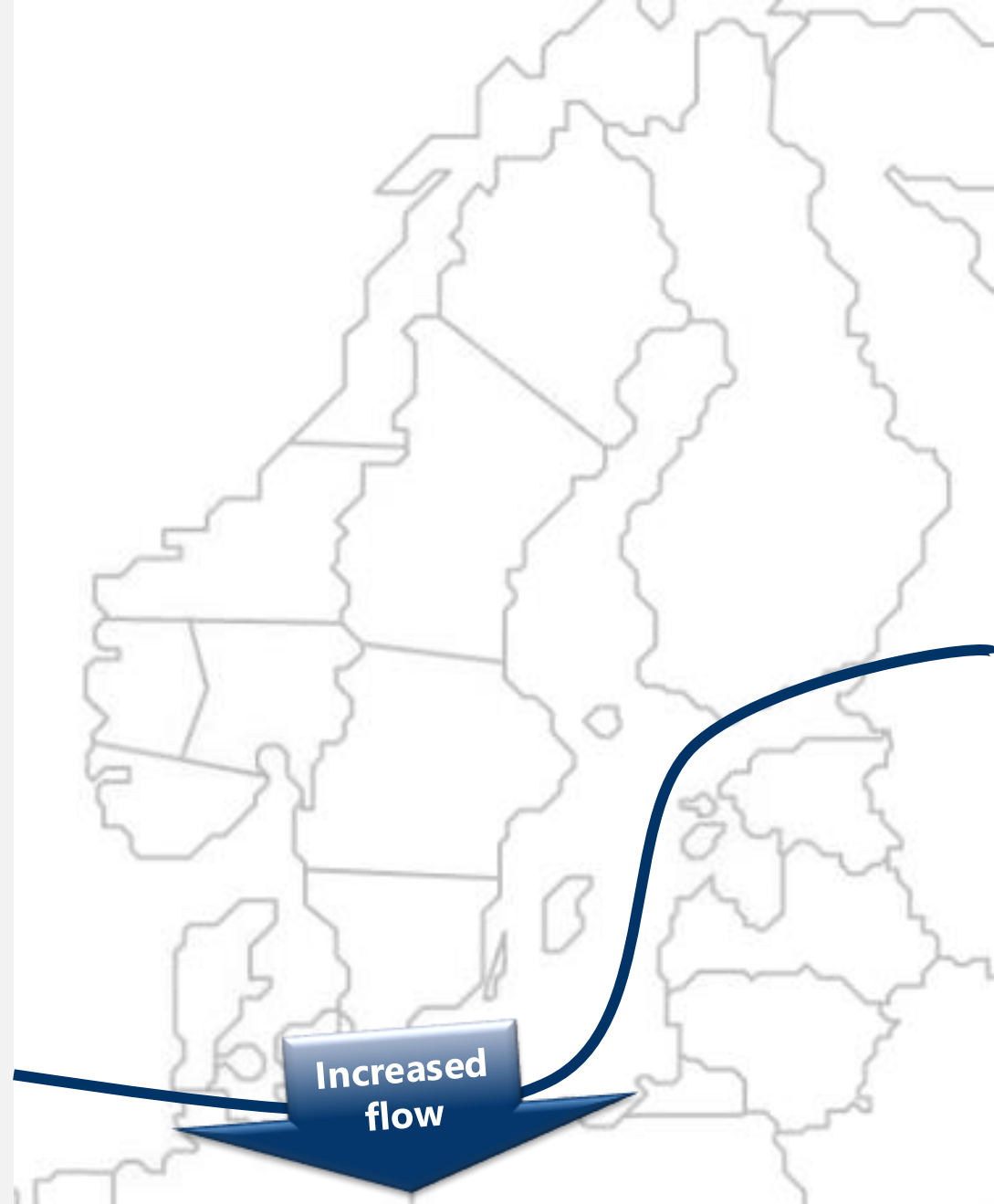


**With FB a 2 TWh or 4% increased export to the continent is established.**

FB impact December 2022 - June 2024

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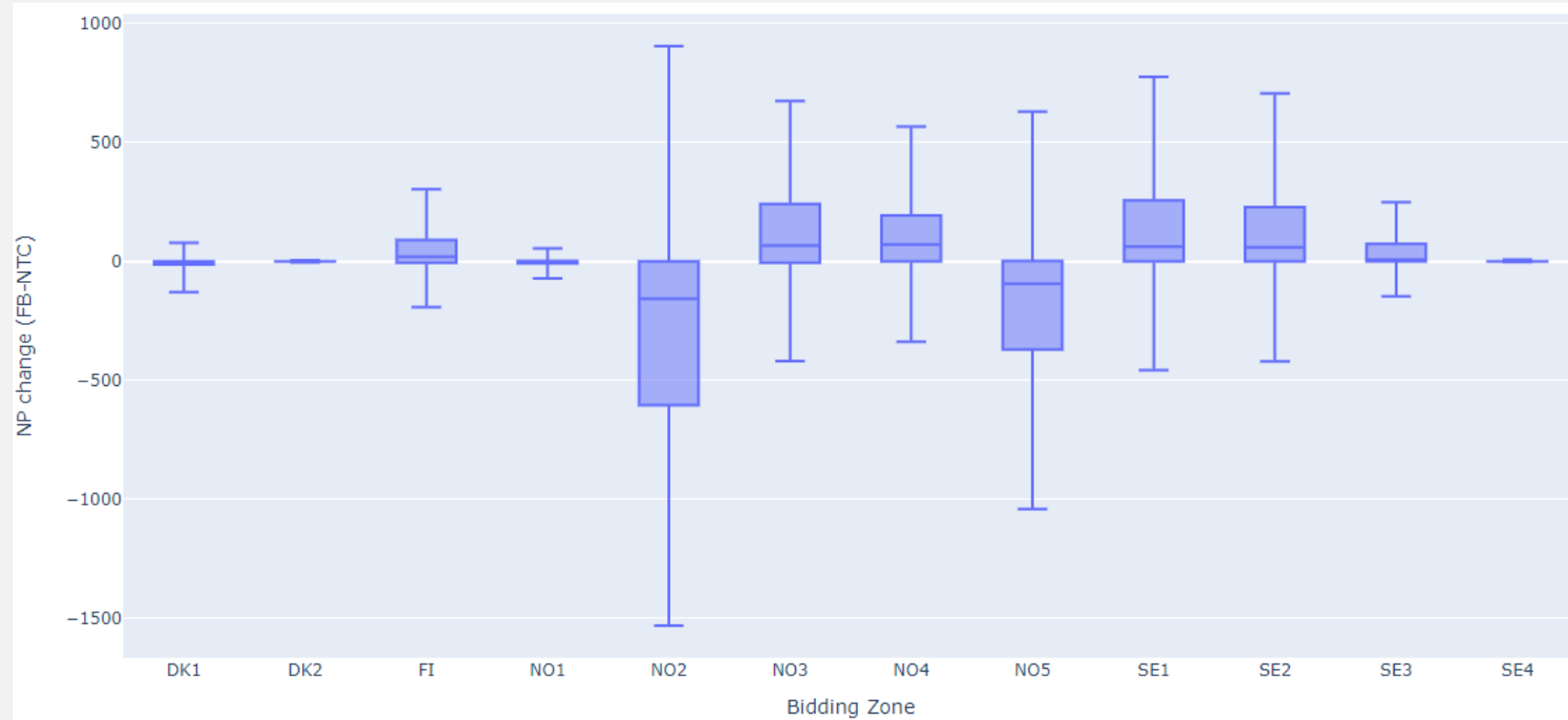
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# The impact of FB is different from bidding zone to bidding zone

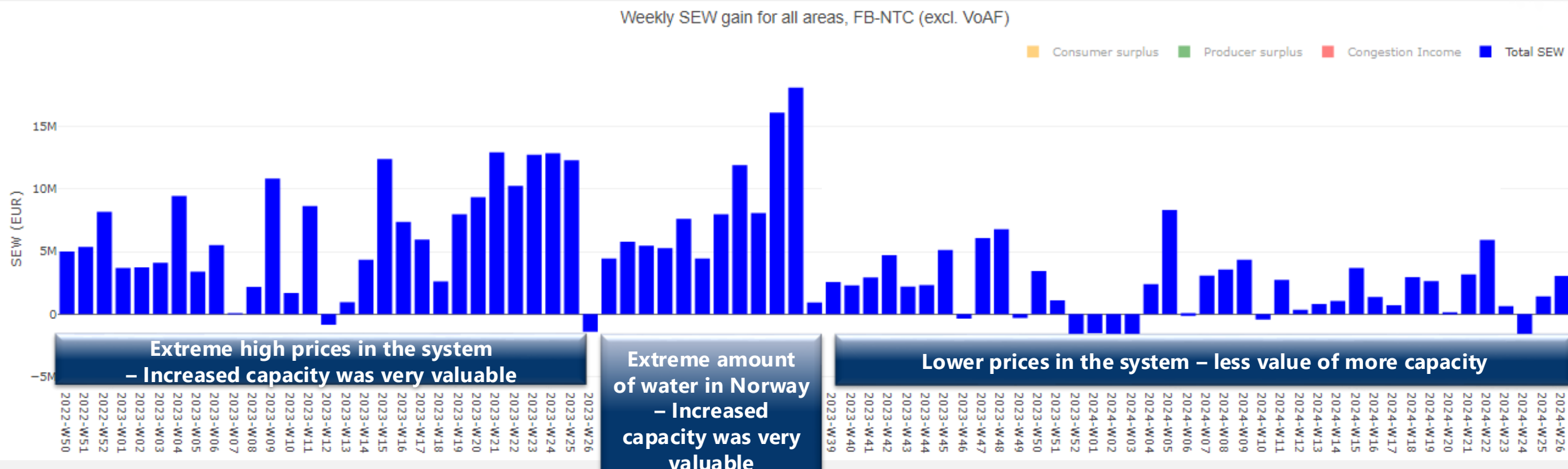
- Boxplot shows the DA net position (NP) change in MWh/h (FB-NTC) per bidding zone
- FB impact July 2023 - June 2024
- Positive value: The BZ exporting more with FB
- Negative value: The BZ importing more with FB





# Social welfare change

- Higher welfare with FB than NTC per day indicates higher, or economically more efficient, flows
- Socio-economic welfare change between FB and NTC:
  - Positive welfare change: 70 weeks (84%), 13583 days (76%),
  - Negative welfare change: 11 weeks (16%), 3266 days (24%)





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

- **When FB enables more capacity provided to the DA market, it is likely that there will be other changes in the markets**
  - The EPR enables the stakeholders to learn how to read, analyze, and use FB domains
  - The EPR is not a forecast of future prices and flows
- **Why can the EPR not be designed to use “FB order books”?**
  - No such information is available from market participants
  - Introducing FB water values will change the inputs ( $F_{ref}$ ) to the capacity calculation which results in different FB domains



# Hydro production in the Nordics

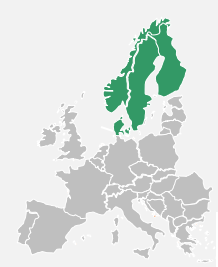
- **The Nordic power system is dominated by hydro production and the Nordic prices, especially for some bidding zones, are impacted by water values**
  - However, the production mix is diverse for the Nordics as a whole (together with the Continent)
- **Increased socio-economic welfare is an indicator 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 bidding zone prices and socio-economic welfare**
  - If there is more energy to be traded in the FB DA 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 socio-economic welfare is affected by this but cannot be calculated without knowledge on how the price in all bidding zones are affected over time by the change in water
    - E.g is the change in water value/bidding curve in the South larger than the change in water value/bidding curve in the North?
  - The purpose of computing socio-economic welfare is to indicate that the capacity calculation works per MTU, not to forecast the market development



# The uncertainty of hydro on the welfare does not undermine the positive impacts from FB

- **FB enables a more objective handling of grid limitations and allocates flows where it creates the highest welfare.**
  - 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**
- **The EPR has proven that FB enables higher flows in the Nordic grid**
  - Even if hydro volumes do not materialize fully as in the NTC orderbooks, it does not remove the EPR results - observed over various seasons and market settings - that higher transmission possibilities exist.

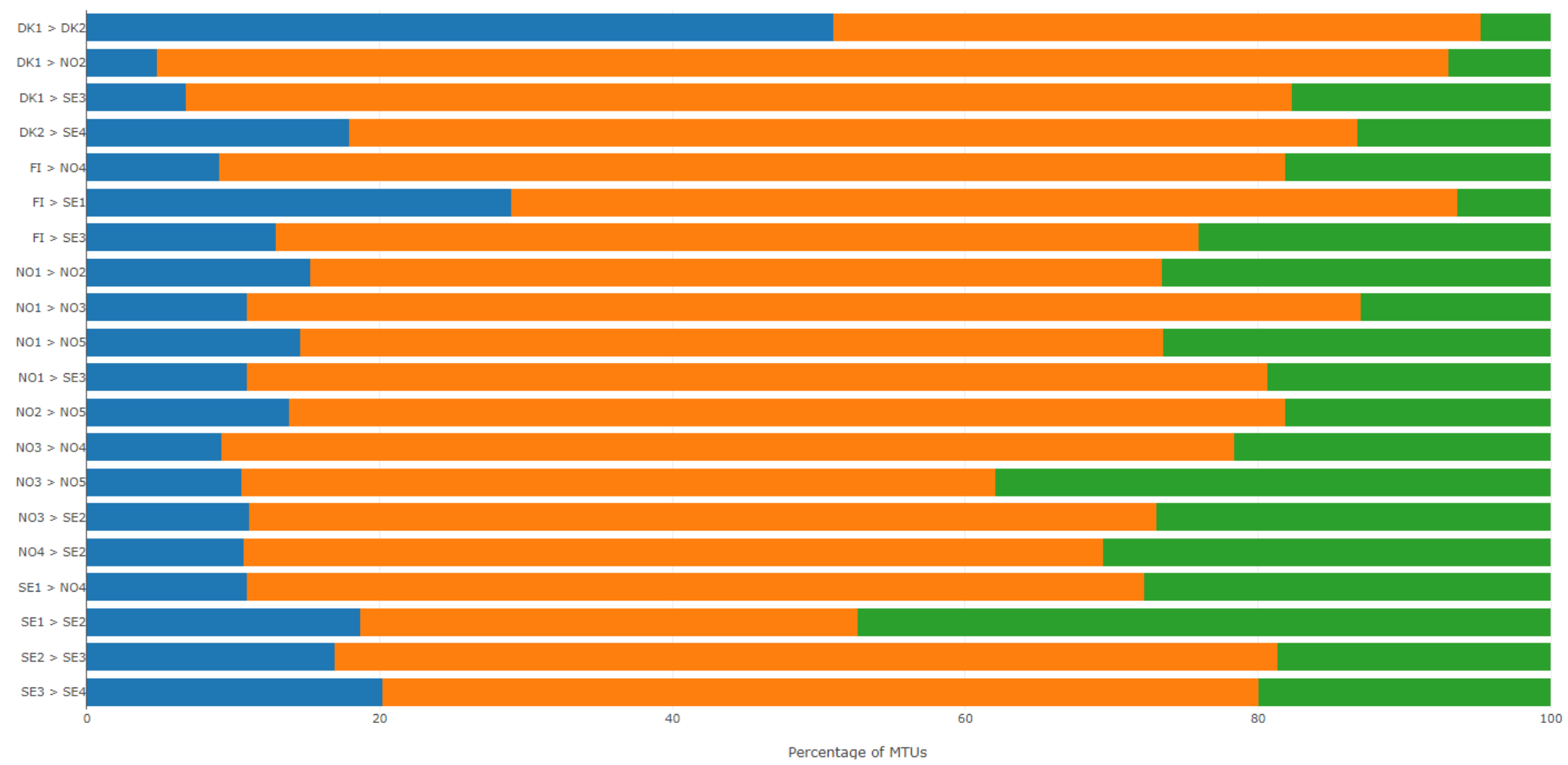




# Non-intuitive flows – a part of FB

- Non-intuitive
- Intuitive
- Zero-spread

Share of MTUs in FB by flow type for Nordic borders (2022-12-12 - 2024-07-07)





# Intraday gate opening capacity

- Flow based in the day-ahead market provides new domains and capacities based on CNECs
- XBID (the intraday trading platform) still requires capacities for the intraday market on cross-border-level, i.e., NTC-like capacities
- Real flow-based domains based on CNECs are not expected in intraday before earliest 2026
  - Requires a lot of work from NRCC, the TSOs and XBID itself



# ATC extraction

- The CCM project has created a methodology to translate the results from flow based day-ahead to intraday cross-border capacities called ATC extraction (ATCE)
- ATCE uses the PDTFs and the already allocated flow from the day-ahead results to provide as much capacity to the intraday market while maintaining an accepted level of operational security



# Main difference between current NTC and ATCE

Higher utilization and optimised flows on FB-DA result in less ID-capacities

## All capacities are dynamic and depends on the flow direction

- For FB DA the market turnout optimise the capacities depending on the flow direction

ATCE takes into account all flow scenarios likely as well as unlikely resulting in more strict ID-capacities

## More flow scenarios affects capacities

- NTC-world considers only forecasted/likely flows and optimise the capacities where there needed the most
- The ATCE-world considers "all flows" to be possible and allocates capacities to manage all of these
  - Capacities derived from one scenario can limit the flow in another scenario (even if the two will not happen at the same time)

ATCE takes into account loop-flows which increase operational security and limits ID-capacities

## Accounting for loop-flows

- The NTC world assumes trade from BZ to BZ in a straight line
- In reality the same trade will transfer through several bidding zones (as in the ATCE-world)
- Example: Trade in Sweden might be limited by bottlenecks in Norway (and vice versa)



# Operational security vs trading volume

- Due to the aforementioned differences between ATCE and NTC, ATCE provides lower capacities than today's NTC market
- To facilitate higher trading volumes, the CCM project introduced relaxations to the intraday domain
  - RAM relaxation takes a calculated risk that all "loading" flows won't happen at the same time (10 MW more RAM on each CNEC)
  - PTDF relaxation neglects unrealistic loop-flows

**Relaxation:** A trade-off between increased capacities and operational security



# Data publication

- During the EPR, ATCE results have been published alongside day-ahead results
- In early 2024, operators expressed concern about the relaxation parameters and the potential overload they could create
- Thus, the PTDF relaxation level was adjusted from 5% to 2%, meaning only loop-flows with less impact than 2% would be neglected
  - This decreased the potential overloads, but also reduced the intraday capacities
- Data from week 26, 2023 to week 12, 2024 were re-calculated with new parameters using a Statnett-made tool, and from week 13, NRCC has used the ATCE tool that will be used at go-live to publish weekly results





# Results from the intraday EPR

- More than a year of ATCE data available
- General trends:
  - Lower and more volatile capacities than in today's market
  - More operationally secure

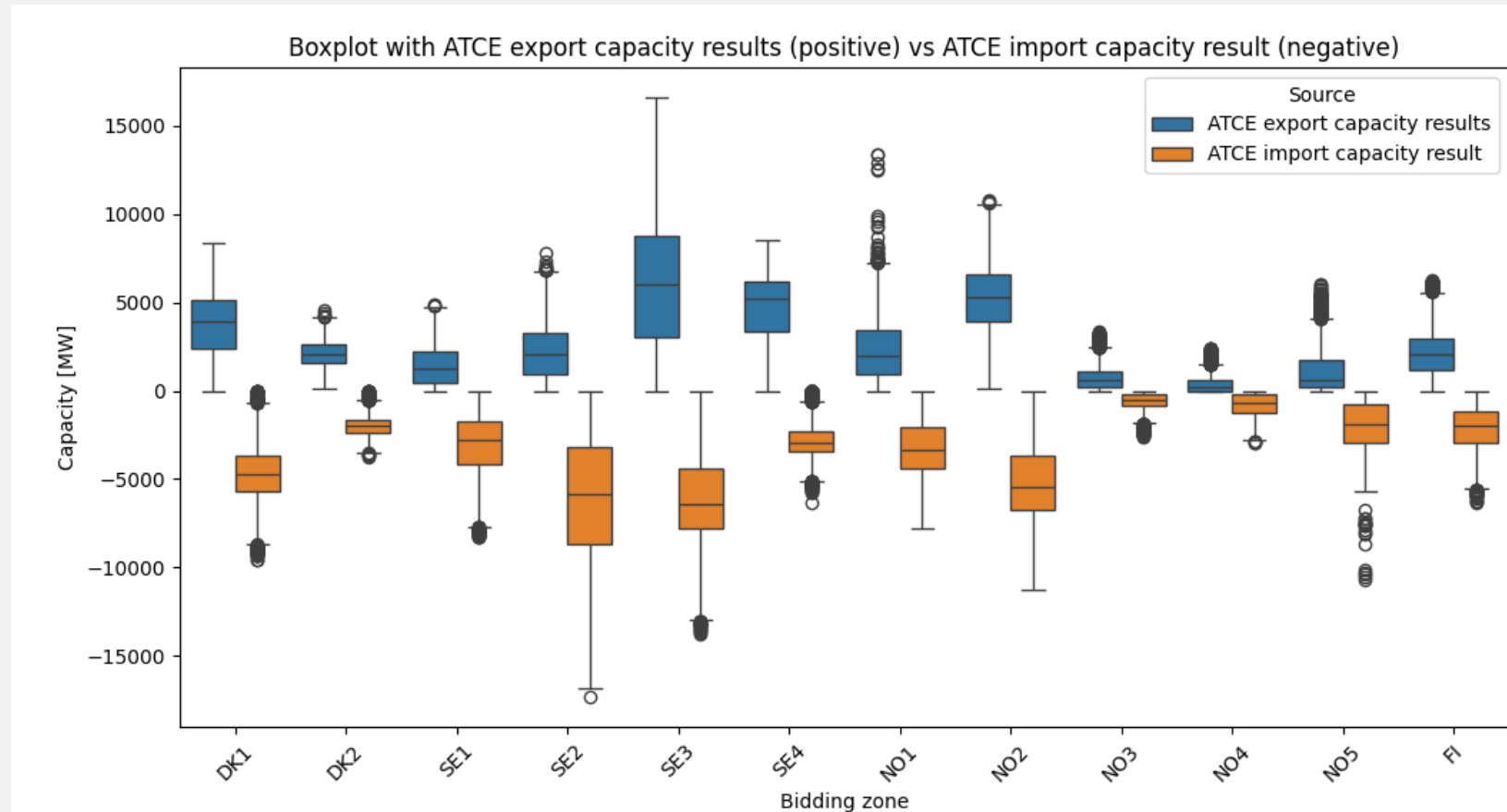


Figure: data for ATCE export and import results for week 26, 2023 to week 28, 2024



# Comparison of ATCE export results (blue) and NTC intraday export capacities given to the market (orange)

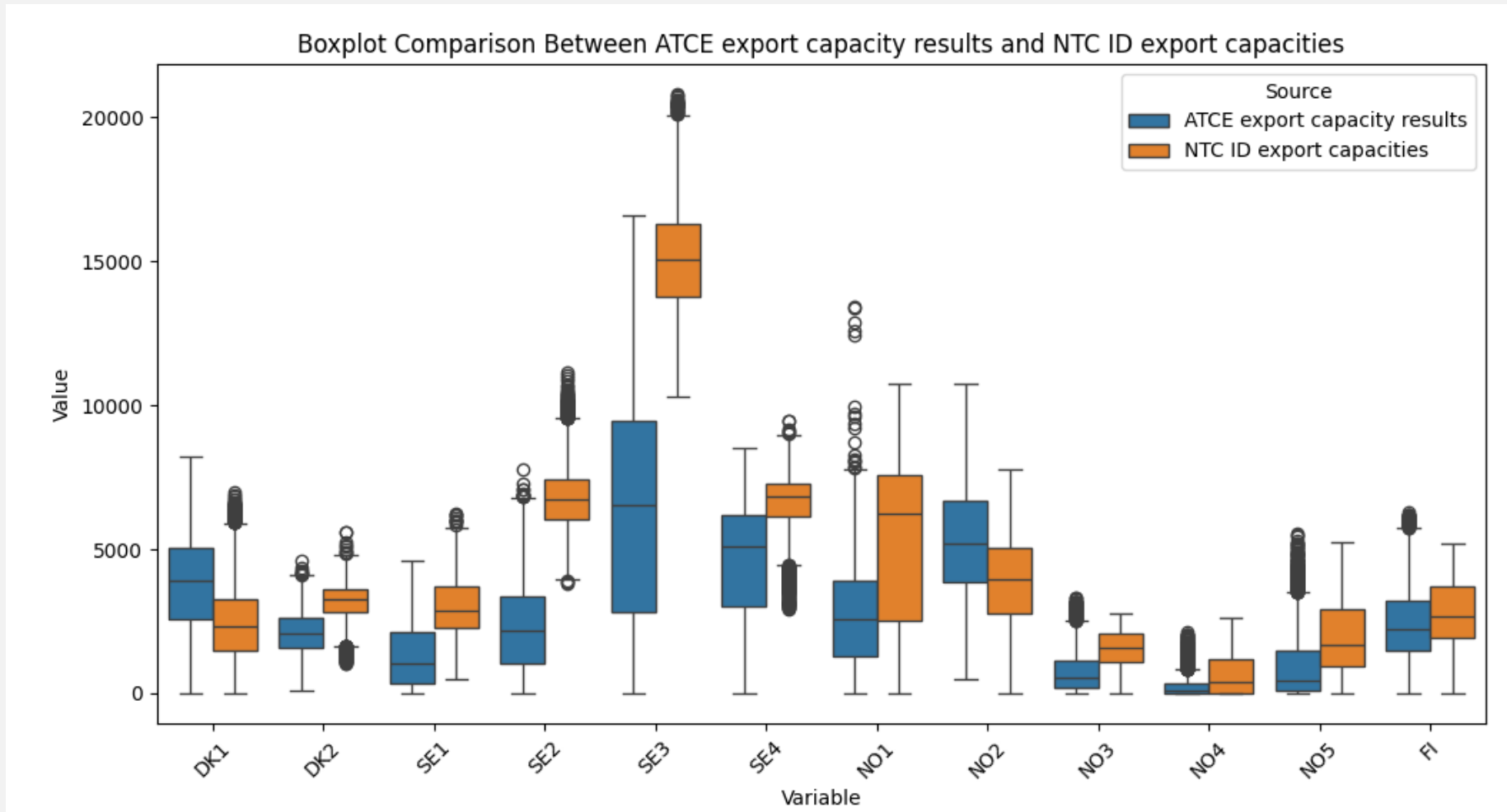


Figure: data for ATCE export and NTC capacities from the market for week 26, 2023 to week 12, 2024



# Comparison of ATCE import results (blue) and NTC intraday import capacities given to the market (orange)

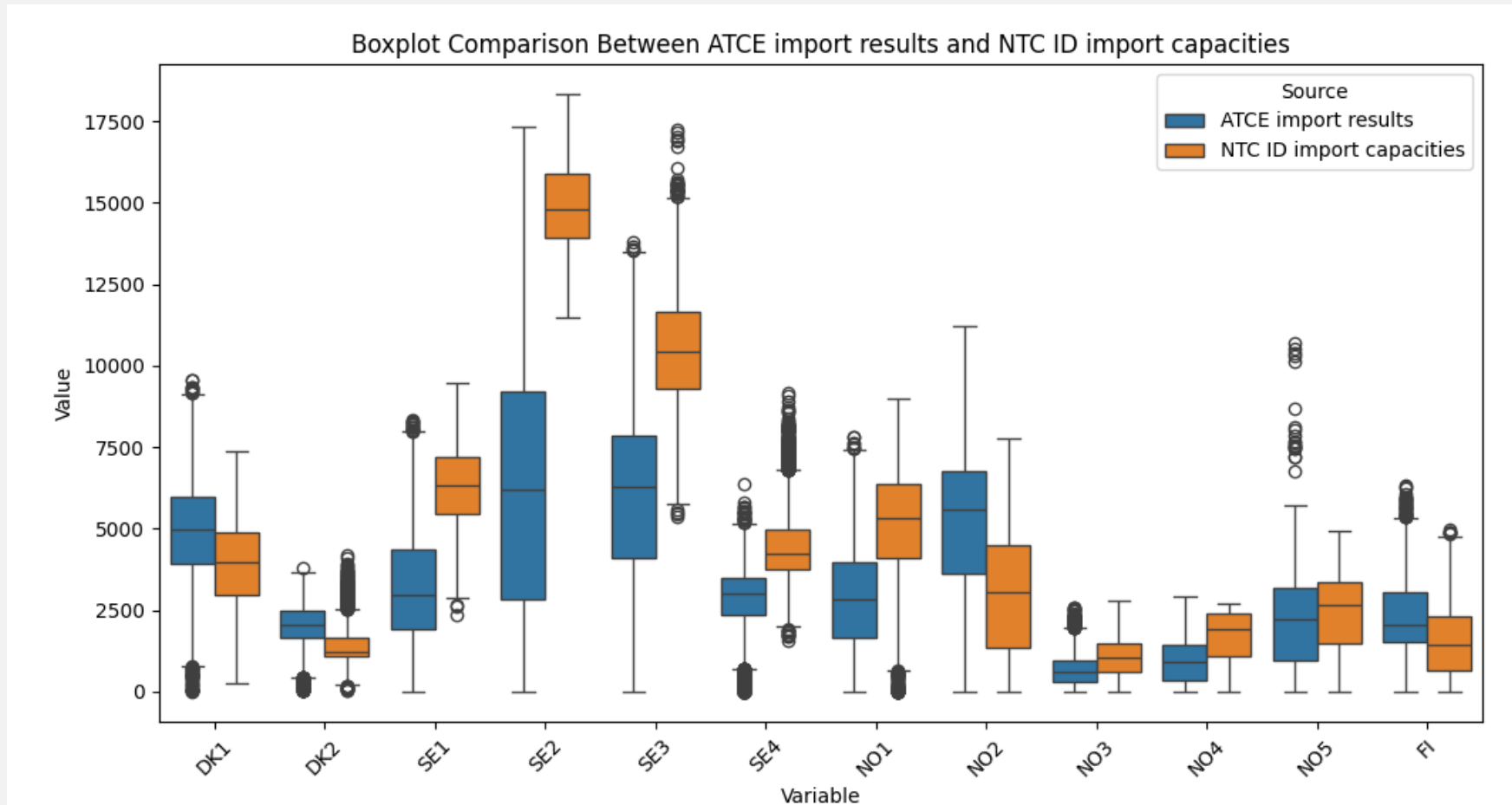


Figure: data for ATCE import and NTC capacities from the market for week 26, 2023 to week 12, 2024



# Comparison of ATCE export results (blue) and actual traded intraday export volumes (orange)

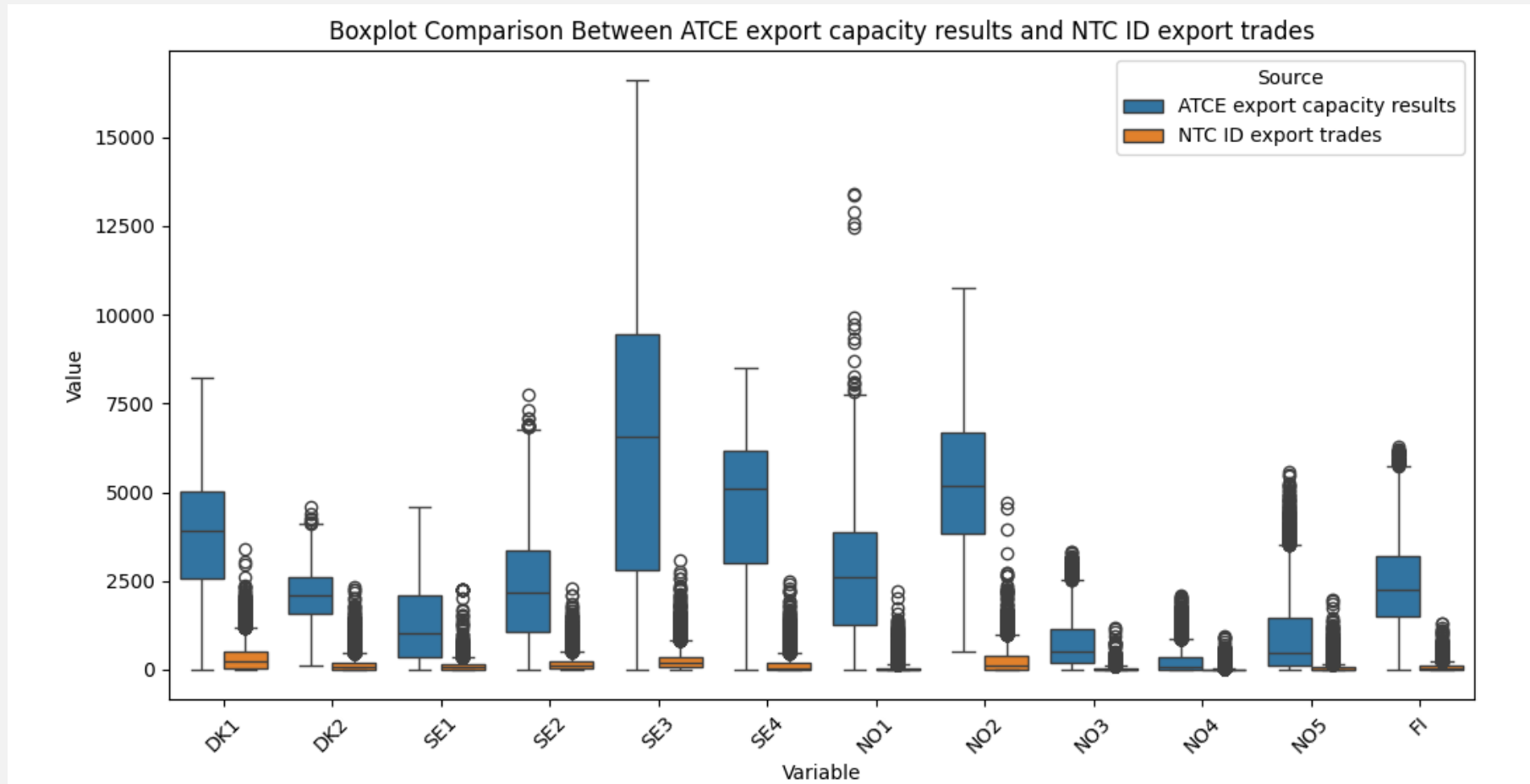


Figure: data for ATCE export and ID trades from the market for week 26, 2023 to week 12, 2024



# Comparison of ATCE import results (blue) and actual traded intraday import volumes (orange)

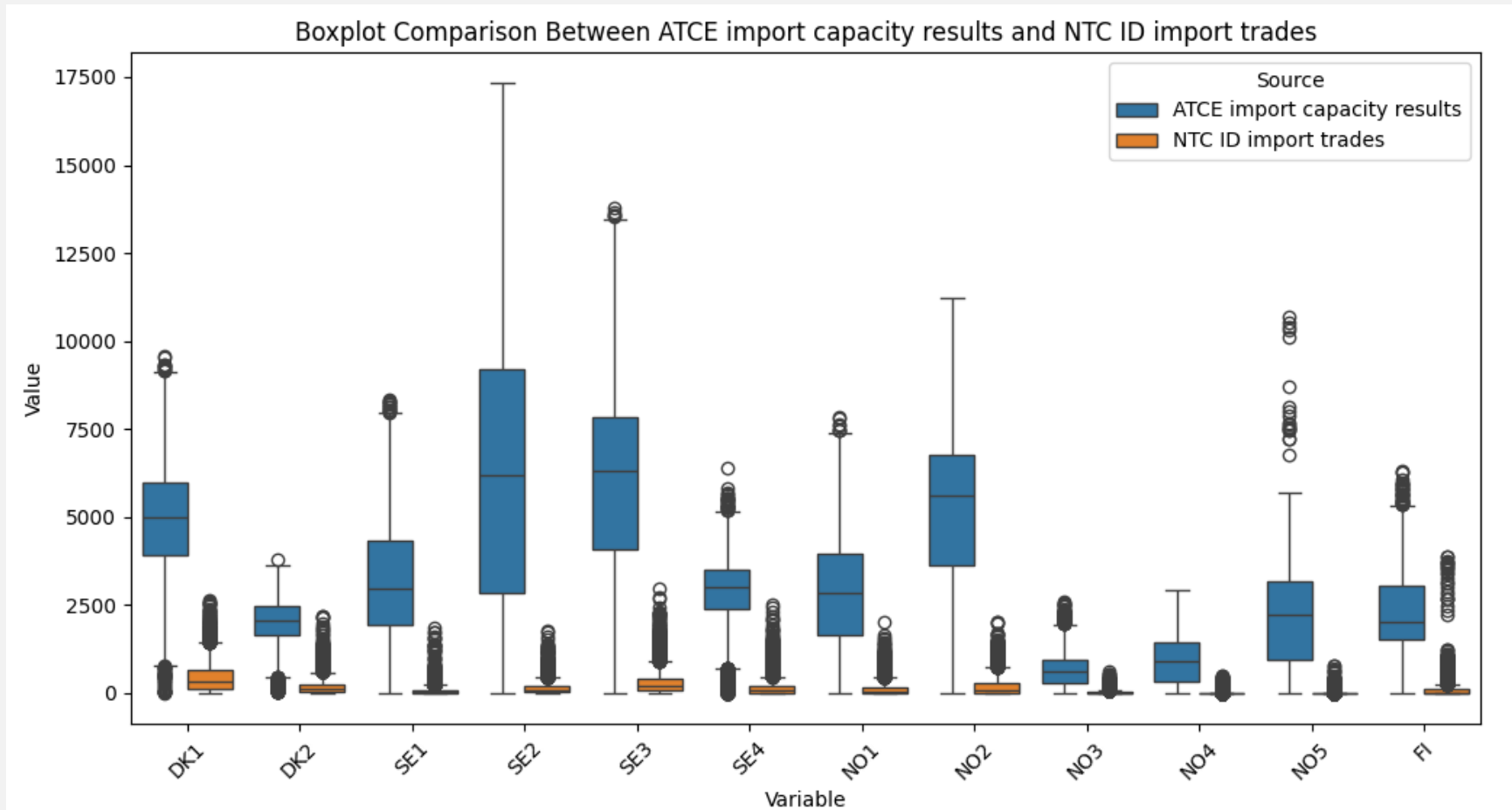


Figure: data for ATCE import and ID trades from the market for week 26, 2023 to week 12, 2024



# Overview of ID trades larger than ATCE capacity

Bidding zone	Percentage of time ID export trade > ATCE export capacity [%]	Average excess ID export trade > ATCE export capacity [MW]	Percentage of time ID import trade > ATCE import capacity [%]	Average excess ID import trade > ATCE import capacity [MW]
DK1	2.5	365	0.6	417
DK2	0.4	338	0.4	182
SE1	14.0	113	0.7	116
SE2	7.8	161	4.0	183
SE3	7.7	331	2.1%	275
SE4	1.9	152	1.6	197
NO1	1.1	149	2.66	147
NO2	0.06	337	3.0	156
NO3	4.4	73	3.5	76
NO4	28.3	24	4.1	37
NO5	10.9	100	1.4	69
FI	1.2	176	1.0	146





# Need for ID capacity

- Difficult to say how the need for ID capacity will change with flow-based
- Some aspects might have a positive effect
  - More precise DA capacities will avoid overloads that will have to be balanced
- Some aspects will probably not change
  - Renewable forecasts will not improve over night, so market participants in this market will still have the same ID trade needs
  - Trip of a generator can still occur, and market participants will still need the same ID trades