Nordic CCM – External Parallel Run Market Report for Week 11

2022/06/04

Abstract

This market report presents the comparison of the simulated market results between the current capacity calculation method (i.e. the NTC methodology) and the flow-based (FB) capacity calculation method for the day-ahead market timeframe.

Chapter 1 introduces the work on developing and implementing a common Nordic Capacity Calculation Methodology where the NTC methodology is replaced by the FB methodology.

Chapter 2 addresses the issue of data quality and the simplifications of the simulations as disclaimers that could potentially influence the simulation results.

Chapter 3 presents data reporting and TSO remarks regarding the FB domains.

Chapter 4 elaborates on the overall comparison of FB vs. NTC for the simulated period of week 4 to 6.

Abbreviations

CCC – Coordinated Capacity Calculator

CCR – Capacity Calculation Region

CGM – Common Grid Model

CNEC – Critical Network Element with Contingency

EDD – Energy Delivery Day

ENDK – Energinet

EPR – External Parallel Run

FAV – Final Adjustment Value

FB – Flow-based

FG – Fingrid

Fmax – operational limits of the critical network elements

IGM – Individual Grid Model

IVA – Individual Validation Adjustment

JAO – Joint Allocation Office

LHF – Last Hour Flow

MTU – Market Time Unit

MAS – Modeling Authority Set

NEMO – Nominated Electricity Market Operator

NP – Net Position

NTC – Net Transfer Capacity

PTC – Power Transfer Corridor

PTDF – Power Transfer Distribution Factor

RAM – Remaining Available Margin

SA WG – Simulation & Analysis Working Group

SDAC - Single Day-Ahead Coupling

SEW – Socio-economic Welfare

SF – Simulation Facility

SN – Statnett

Svk – Svenska kraftnät

VBZ – Virtual bidding zone

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1 Introduction

The four Nordic TSOs work together in order to develop and implement a common Nordic Capacity Calculation Methodology (CCM). This common methodology is in line with the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (CACM). The flow-based (FB) methodology is being implemented by the Nordic Regional Security Coordinator (NRSC). Before going live with the new capacity calculation methodology for the day-ahead market, a few phases are foreseen along the implementation timeline, such as the internal and external parallel runs.

During the parallel runs the market outcome based on the NTC methodology is compared with a market simulation result using the FB methodology. The comparison is presented in a market report written by the CCM project. The analysis presented in the market reports will focus on the socio-economic welfare (SEW) outcome of the Nordic power systems.

Capacity allocation in the Nordic CCM parallel runs

The new capacity calculation methodology (i.e. FB) differs in many ways from today's NTC methodology. However, both aim to maximize the socio-economic welfare, in terms of capacity allocation. Both in the NTC and the FB methodology, the network capacities are sent to the NEMOs. The NEMOs utilize Euphemia, the market coupling algorithm, to maximize the socio-economic benefits of the market while respecting the network constraints of the TSOs (being NTC or FB), which results in a market outcome with traded volumes and prices.

Where each TSO determines its NTC capacities, in the FB methodology it is a much more coordinated, formalized, and automated process. The input datasets provided by the TSO to the NRSC - that acts as a coordinated capacity calculator (CCC) – include critical network elements with associated contingencies (CNECs), power transfer corridors (PTCs) and the operational limits (Fmax) for these elements. Those are sent for each market time unit (MTU), for each day, and are used by the CCC to calculate – based on an hourly common grid model (CGM) - the Remaining Available Margin (RAM) and Power Transfer Distribution Factors (PTDFs): the FB parameters that are sent to the NEMOs, after the TSOs have validated them.

When TSOs today calculate NTC capacities, they do this individually by looking mostly at their own grid constraints and critical network elements and by translating these into a capacity on the bidding zone borders that are subject to the market allocation. With FB the TSOs provide the critical network elements as is to the market allocation / optimization – as a simplified grid model – instead of pre-calculating resulting capacities on each border in the form of a MW-value.

When the TSOs provide capacities in the form of NTC values, all border capacities are available at the same time to the market for allocation, at least conceptually. One of the advantages with FB is that each TSO does not have to make a distribution of the capacity between different bidding zone borders before the capacity is sent to the NEMOs. Instead, the maximum available capacity is given to the NEMOs and the market coupling algorithm. The capacity is then allocated to the energy transactions that provide the most socio-economic welfare, when prices and flows are calculated by the NEMOs.

Social economic welfare

Socio-economic Welfare (SEW) is calculated as the sum of Consumer surplus, Producer surplus and distributed Congestion income for each hour. SEW is used as the main optimization parameter and the Euphemia coupling algorithm tries to maximize the overall SEW gain among all bidding zones participating in Single Day-Ahead Coupling (SDAC).

Consumer and producer surplus are calculated by Euphemia and used as is without any further calculations.

Congestion income is calculated per border, based on the flows and price differences. Flows are calculated based on border PTDF's, and the net positions and prices are calculated by Euphemia. Congestion income per border is then summed and the total is distributed among all borders based on the Congestion Income Distribution methodology[1].

Bidding zone prices

Prices for each bidding zone are calculated by Euphemia.

Net positions

Net positions of actual bidding zones are calculated by Euphemia and used as is. Euphemia does not calculate net positions for virtual bidding zones (which are used for modelling HVDC links) but it calculates the flows on these links. Net positions of virtual bidding zones are calculated based on these flows.

Border flow calculation

Border flows are calculated by summing the products of each bidding zone PTDFs and corresponding bidding zone net positions to the F_0-flow. The F_0-flow is defined as the reference flow on a certain CNEC when the NP is 0.

Flow for FB is calculated using the border CNEC PTDF's and net positions from FB market coupling and flow for NTC is calculated using the same border CNEC PTDF's but taking the net positions from NTC market coupling instead. The results from these calculations are not the same as scheduled exchanges which are currently used as commercial border flows.

The flows presented here are the physical flows, calculated by:

$$\boldsymbol{Physical\ flow_k = F_{0,k} + \sum PTDF_k \times NP}$$

Where $F_{0,k}$ and $PTDF_k$ are the F_0 and PTDF parameters corresponding to the CNEC on Border k.

[1] ACER Decision 07-2017 on CIDM.pdf (europa.eu)

Business process during parallel run

During the internal parallel run, the Nordic CCM project's Simulation and Analysis working group (SA WG) took on the responsibilities of the market simulations. In the external parallel run the market simulations are performed by the Nordic Regional Security Coordinator (NRSC) together with the NEMOs. The daily process, illustrated in Figure I, starts with each TSO creating and sending their IGMs, CNEs and CNECs (input data) to the NRSC. The NRSC merges the IGMs to one CGM and performs FB calculations based on the TSOs' input data. The NRSC, together with the NEMOs, then run FB simulations on a validated (by the TSO operators) FB domain (RAM and PTDF) in Simulation Facility. The FB domains are accumulated for a one-week period before running the simulations.

The NRSC then provide the SA WG with the market results from Simulation Facility for analysis. The market algorithm Euphemia provide prices, net positions, consumer and producer surplus for all bidding zones. The SEW is calculated by summing up consumer surplus, producer surplus and congestion income. The resulting SEW for the FB outcome is then compared to the NTC outcome, hour-by-hour, to evaluate the impact of the new capacity calculation and allocation.

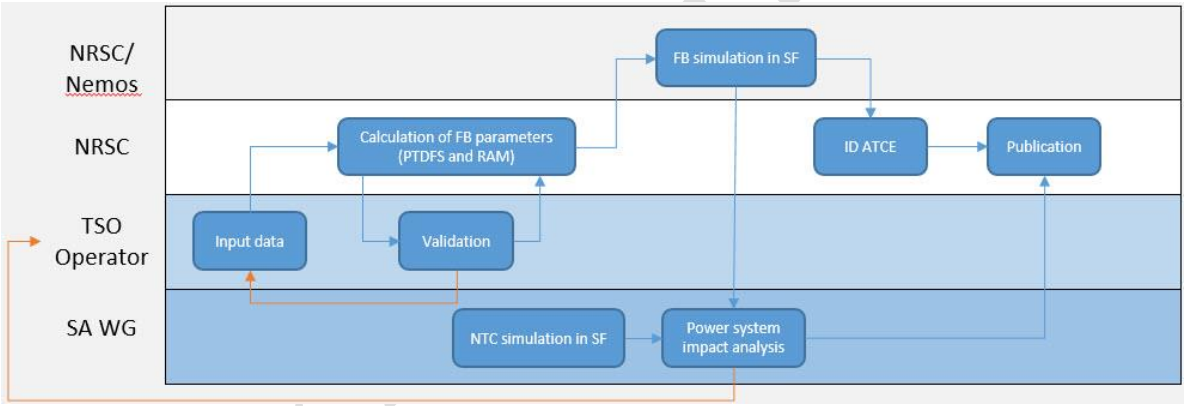


Figure I: The high-level business process illustrating the roles, responsibilities and interactions among the Nordic RSC, TSO operators and the Nordic CCM SA WG during the external parallel run

2 Disclaimers

2.1 Disclaimers for data publication at JAO during external parallel run

Data quality

The capacity calculation tool and the data used for the capacity calculation is continuously being improved, and TSO operators are improving their processes by using the Domain validation tool in daily operations. The outcome of the FB calculations are considered valid for comparison with NTC even with some known disclaimers that are being continuously evaluated and improved by the TSOs.

Domain validation process

The TSO operators are in the 'learning-by-doing' phase in the parallel run process. The validation tool that is supporting the domain validation activities is still under active development.

SE1-FI border

The capacity calculation for FB calculates wrong border capacity between SE1-FI, 1390 MW in Flow-based vs. 1520 MW in NTC.

DK2-SE4 border

Due to a problem with the PTC definition and the slack node in the model there was a discrepancy on the border between DK2 and SE4 where Flow-based gave a too high capacity.

2.2 Disclaimers related to market analysis report (Nordic CCM)

The market analysis reporting is under development by the Nordic CCM project. Stakeholder inputs is gathered and improvements are being implemented. During the external parallel run weekly reports will be published along with supplementary data and in-depth additional documents.

The Nordic TSOs welcome comments and questions from the stakeholders. Please send an email to CCM@nordic-rsc.net.

Market results are calculated by Simulation Facility

The market coupling is calculated by Simulation Facility (SF) during the internal and external parallel runs. SF uses the same market coupling algorithm that is used for day-ahead market coupling. However, SF is a testing environment and therefore the availability of SF (e.g. impacted by content-wise and/or IT-wise changes in the SF) is not guaranteed. This may increase the necessary time to produce market analysis reports. Also, the simulation facility imposes a grace period, currently set to 2 weeks after the energy delivery date. The production of the market report will need to comply with the grace period.

NTC order books being used in the FB market simulations

The market simulations of the FB methodology use the NTC order books, due to the unavailable dedicated FB order books. This means that the bids (and also final market solution) of the FB calculations are based on the order books of the actual NTC-based electricity market.

Typically, a FB simulation results in a less-constrained power market and more production in areas with cheaper power production. This often means more hydro power production in the northern bidding zones in the FB simulations compared to the NTC simulations. The use of the NTC order books however, implies that a greater release of hydro power under FB is not reflected in the following order books and FB market simulations, potentially leading to a sustained greater production of "cheap" hydro power in FB compared to NTC.

If this effect is sustained over a longer period of time, and the cumulative difference in production is significant, this may lead to a biased cumulative SEW comparison between FB and NTC, benefitting the FB simulation with "cheaper bids" in relation to the underlying hydro reservoir situation.

Simulation set up in Simulation Facility - Last hour flow

The last hour flow is relevant for the ramping restrictions from one day to the next. When starting the SF simulations, as an input requirement, the market flows of the last hour of the previous day is needed in the SF as a starting point of simulating the first hour of the simulation batch. For consistency purposes, the last hour setting for Flow-based simulation as well as for the NTC simulations is set to zero. This is done because there are no historical data available in the production system of Euphemia for the Nordic Flow-based topology.

Additionally, when there is a (few) missing day(s) in the simulations, the LHFs of FB and NTC are set to zero as default. Consequently, the simulated market results may not be strictly comparable to the market results from the production environment.

Simulation set up – Lineset ramping

A new FB topology had to be created in order to incorporate the previously missing South-West link and the newly formed bidding zone NO2A. NO2A was created in order to limit the total ramping on Norned and Nordlink. In the new topology, this is managed by introducing a lineset ramping – a ramping limitation for multiple line segments.

When performing the initial simulations with the new topology, an error occurred. The simulations failed applying both the individual line ramping and the lineset ramping. The reason why the simulations fails when applying both individual line ramping and lineset ramping is still under investigation. In the meantime, in order to produce any simulation results, the lineset ramping was removed from both FB and NTC. This means that the total ramping for Norned and Nordlink can exceed 900 MW as long as the individual ramping restrictions are respected.

Congestion income computation as post-processing of the market data

Market results require post-processing to create a readable format of the results and to calculate and share generated congestion incomes. Currently, congestion incomes are calculated by Nordic TSOs in accordance with the congestion income distribution methodology. Later this will be calculated by JAO

with production-grade tools. FB and NTC congestion income methodologies are the same but the distribution of negative congestion incomes is different[2].

SEW comparison in the operational security perspective

Fair comparison between FB- and NTC-market results requires same level of operational security as a basis for the two methodologies. In other words, it is not fair to compare SEWs if FB respects the operational security and yields smaller SEW outcome, whereas NTC breaches the operational security and yields larger SEW outcome. Additionally, the remedial actions and the associated costs to solve the operational security issues in 'real-time' are not known to make a fair comparison.

Checks have been made comparing the NTC market outcome and the security domain. The TSOs recommend viewing the SEW comparison outcome both from a socio-economic and an operational security perspective.

[2] Annex I - Congestion income distribution methodology

3 Data reporting

The following tables provides input to the quality of the submitted FB domains.
Below follows a description of what the numbers in the rows entails:

Invalid/missing IGMs (before subst.) - Number of IGMs that for any reason was labeled as invalid and/or number of IGMs that was missing at the initial data transfer from the TSOs

Substituted IGMs (MTUs*MAS) – Number of IGMs that was substituted before the capacity calculation.

Invalid/missing CGMs – Number of CGMs that for any reason was labeled as invalid and/or number of IGMs that was missing at the initial data transfer from the TSOs

FB domain back-up – Number of MTUs where back-up domains had to be used.

FAV provision (no. of TSOs) – Numbers of TSO's that applied FAV/IVA in the domain validation process.

Final domain acceptance (1TSO = 25%) – The percentage of how many TSOs that accepted the final domain.

Energy Delivery Day:	Mon. 15.3.	Tue. 16.3.	Wed. 17.3.	Thu. 18.3.	Fri. 19.3.	Sat. 20.3.	Sun. 21.3.
Invalid/missing IGMs	0	0	48	0	2	3	0
Substituted IGMs	0	0	48	0	2	3	0
Invalid CGMs	0	0	20	1	1	0	0
FB domain back-up	0	0	24	24	0	0	0
FAV provision	0	0	1	0	0	0	0
Final domain acceptance (1 TSO =25%)	100	100	0	0	100	100	100
FB-domains sent to SA WG/SF	Yes	Yes	No	No	Yes	Yes	Yes

Table 1. Norcap reporting from the process.

3.1 EPR remarks

As seen in Table 1, after adjustments the final FB domain was accepted by all TSOs for 5 out of 7 days for weeks 11. For March 17th and 18th, Fref values were over boundaries and the domains was rejected. Error persisted for two consecutive days and proved to be due to a data change at FG, being intersected by an old script running at the NRSC. Decommissioning the script resolved the situation.

3.2 Nordic CCM remarks

The analysis in this report shows the SEW comparison between the current NTC methodology and the FB methodology approved for the Capacity Calculation Region (CCR) Nordic. Besides the congestion income generated for the bidding zone borders included in CCR Nordic, the figures in this report also include the SEW of the Nordic bidding zone borders connected to CCR Hansa (NO2-NL, NO2-DE/LU, DK1-NL, DK1-DE/LU, DK2-DE/LU and SE4-DE) and to CCR Baltic (SE4-LT, FI-EE) to have a full picture of the effect on the entire Nordic SEW.

In SF, some HVDC cables are modelled to include the power transfer losses, and some are not.

- Norned, Nordlink, Skagerak, Baltic cable consider losses in SF.
- Cobra cable, Storebelt, Kontiskan, Swepol, Nordbalt, Fennoskan, Estlink and Kontek do not consider losses.

4 Simulated Market outcome FB vs. NTC

This chapter presents a comparison of the market simulation for the week 11 (14–20 of March 2022) between Flow Based and NTC with regards to changes in socio-economic welfare along with individual bidding zone price changes. More detailed market results of each Nordic country are presented the Appendix.

More detailed studies and observations are given by separate reports to allow better in-dept analysis from all previous weeks.

4.1 Aggregated results for the week 11

Week 11 had slightly lower consumption and higher oil and gas prices compared to earlier weeks. In addition, low water reserves continued to decline. In general, these market situations have impact to simulations.

Simulation period shows that FB has reduced the average prices in the areas with the highest prices and increased them in the rest of areas. FB introduces lower average price in nine areas compared to NTC. Previously, SE2, SE3 and SE4 prices have often been higher compared to NTC. During week 11, the FB price is now lower on these areas compared to NTC. Price of the areas SE1 and NO3 continued to be higher with FB compared to NTC. The highest change in price occurred in FI area where historically the FB price have been lower compared to NTC. During the period, price was 30 % higher compared to NTC.

One major reason was lower import capacity on SE1 -FI border during the planned outage of one Finnish internal CNE close to the border.

Bidding area	Average price €/MWh		Price difference %	Price difference €/MWh
	FB	NTC		
DK1	181,14	184,58	-1,9 %	-3,44
DK2	177,71	181,12	-1,9 %	-3,41
FI	91,86	70,61	30,1 %	21,25
NO1	180,2	188,1	-4,2 %	-7,9
NO2	185,84	188,1	-1,2 %	-2,26
NO3	30,78	14,94	106,0 %	15,84
NO4	12,56	14,53	-13,6 %	-1,97
NO5	183,77	188,1	-2,3 %	-4,33
SE1	25,09	18,13	38,4 %	6,96
SE2	16,62	18,13	-8,3 %	-1,51
SE3	125,87	132,52	-5,0 %	-6,65
SE4	139,41	153,59	-9,2 %	-14,18

Table 2. Average price, price difference per bidding zone with NTC and flow based, week 11

Looking at the prices on hourly level, cf. figure II and III, week 11 introduced price fluctuations in both FB and NTC for all Nordic bidding zones. The fluctuation is generally higher with FB in the Nordics. As seen from the table 2, this have resulted lower average price in nine Nordic bidding zones. NO1 area showed the most stable price in the Nordics.

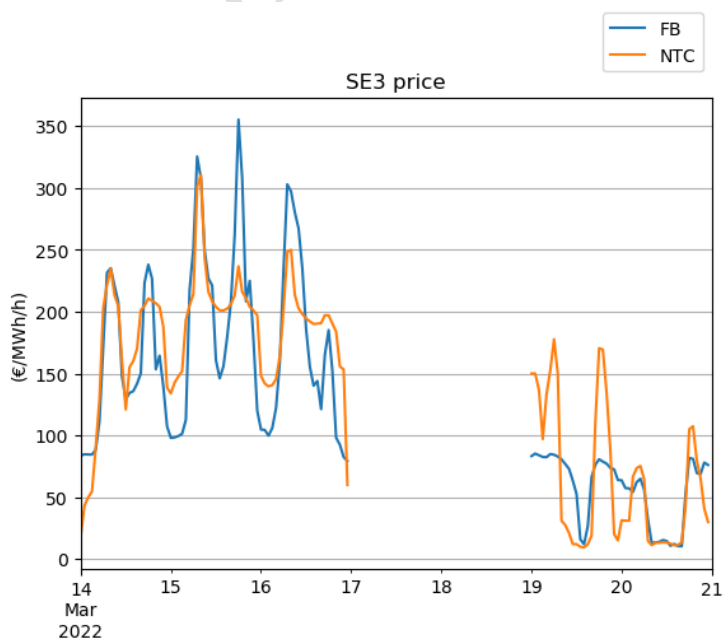


Figure II. Day-ahead price in SE3 on hourly level for both FB and NTC

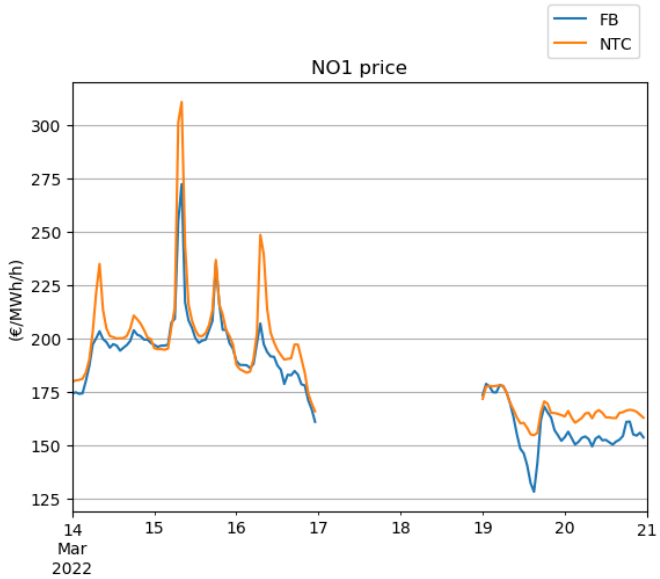


Figure III. Day-ahead price in NO1 on hourly level for both FB and NTC

Simulation period shows a Nordic SEW gain of 8.8M€, cf. Figure IV. In general, the gain and loss fluctuate highly between analysed weeks. During week 11, gain is introduced by the Nordic producers´ net gain. Negative congestion income (Nordic TSO) was expected as FB allocates better the flows between the areas and enables lower price spreads.

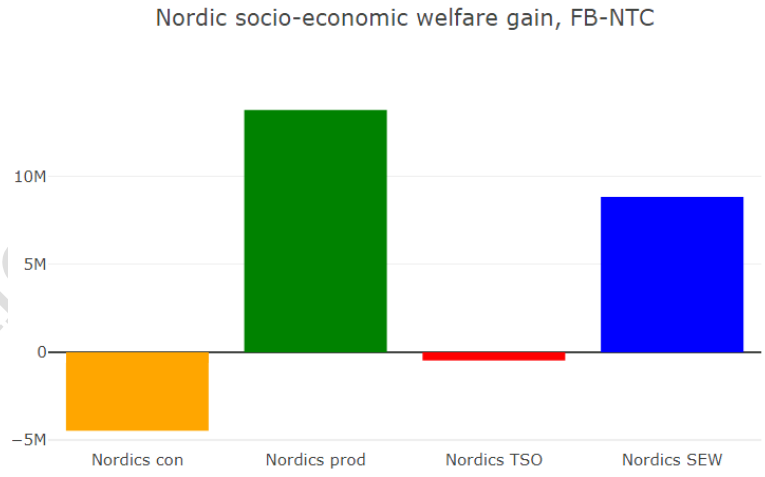


Figure IV. Nordics consumer, producer and congestion income change. Total Nordic socio-economic welfare gain over the simulation period is the sum of the previous three.

SE bidding zones contributes majority of the total socio-economic gain as seen from Figure V. Positive SEW gain in Sweden is mainly due to SE4 where the total gain is 7.9M€ as seen from Figure VI. SE4 positive gain is contributed by lower price which introduce consumer gain of 5.4 M€ while producer loss was limited to 1.0M€. Also, high congestion income further assists to gain higher benefit to SE4 area.

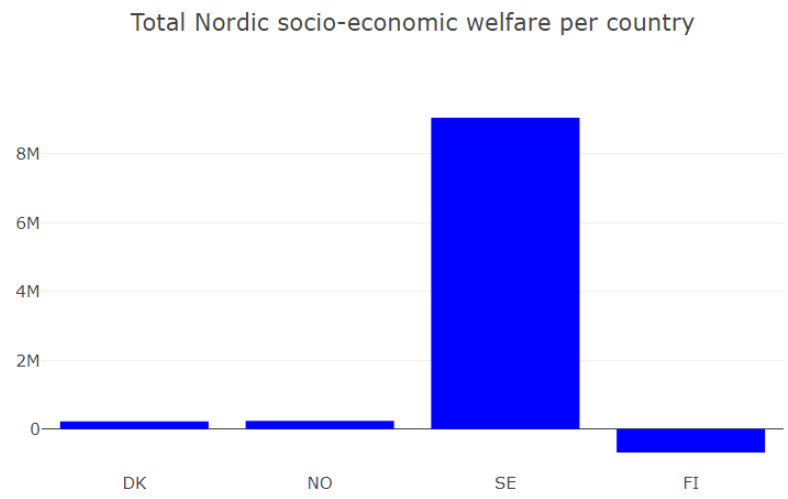


Figure V. Nordic socioeconomic welfare pr. country – (FB –NTC) (€), week 11

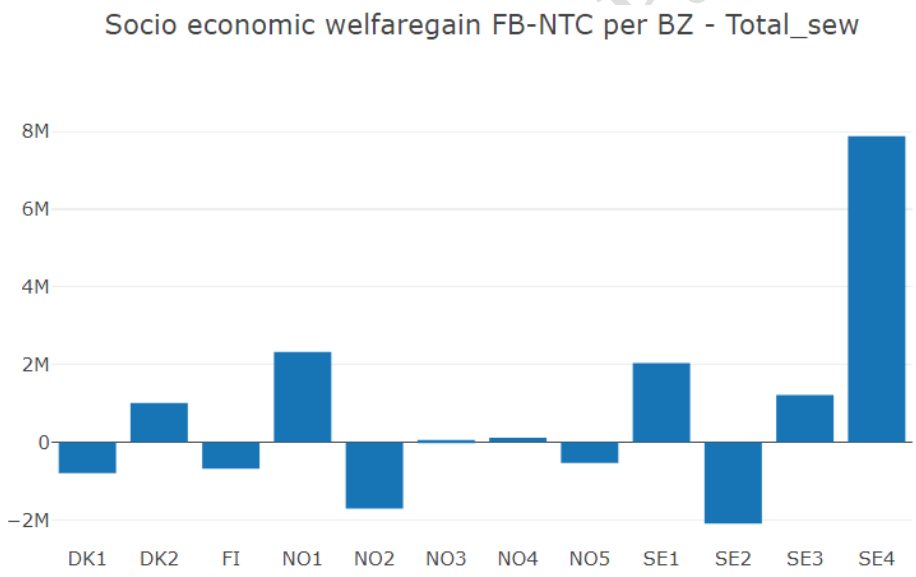


Figure VI. Change in Nordic socio-economic welfare per bidding zone

High changes between FB and NTC are mainly caused during 14–17 of March as seen from Figure VII. Especially during the evening of March 15 and morning of March 16 contributed highly to Nordic socio-economic welfare. Between the time period, very high price fluctuation was also measured e.g. 15.3. at 18.00 SE3 FB price was 355€/MWh and eight hours later the price was 100€/MWh, introducing 255€/MWh price change. In the same period, NTC price change was under 100€/MWh.

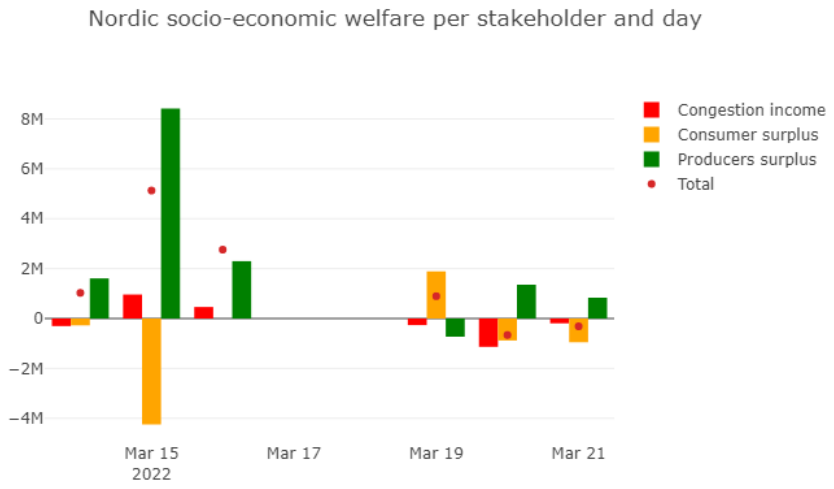


Figure VII. Socio-economic welfare change (FB – NTC) per stakeholder and day.

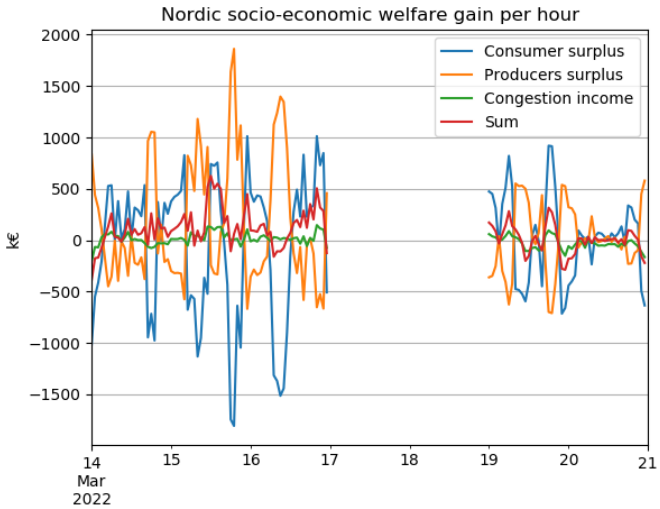
Appendix:

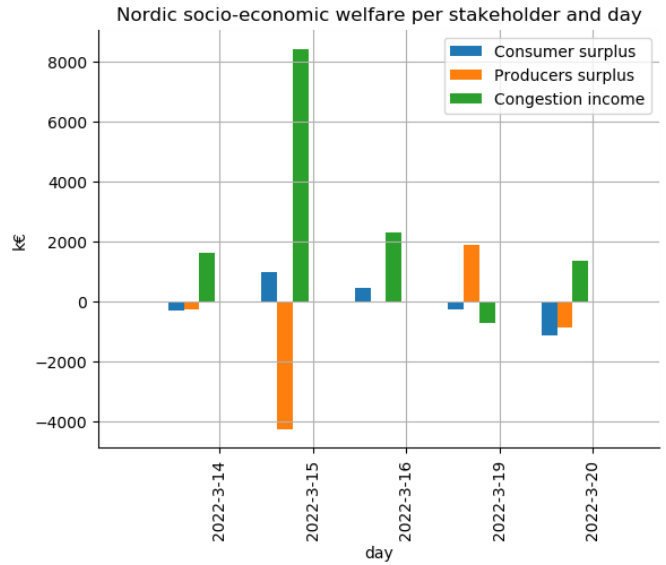
The appendix provides simulation results presented in more detail for each country. The results presented are:

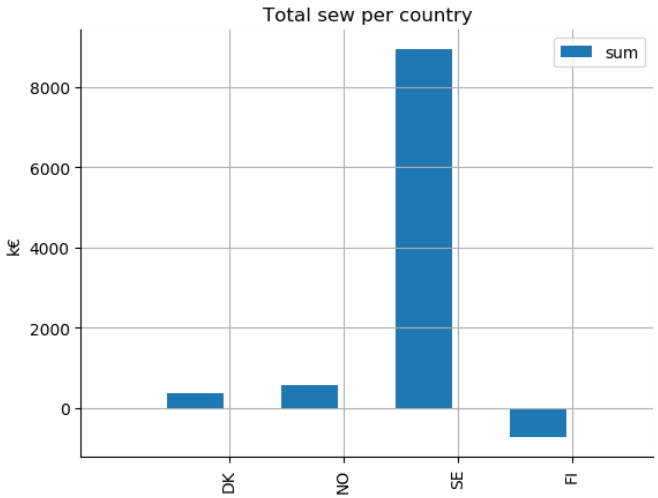
- Social economic welfare
- Prices per bidding zone
- Net positions
- Border flows

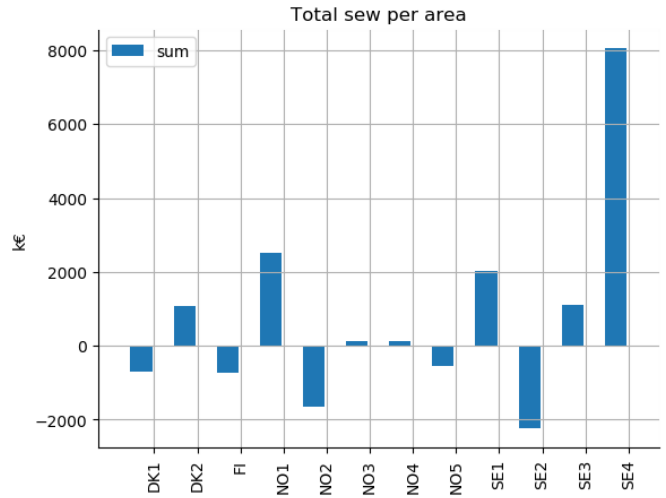
4.2 Social economic welfare

4.2.1.1 Nordics

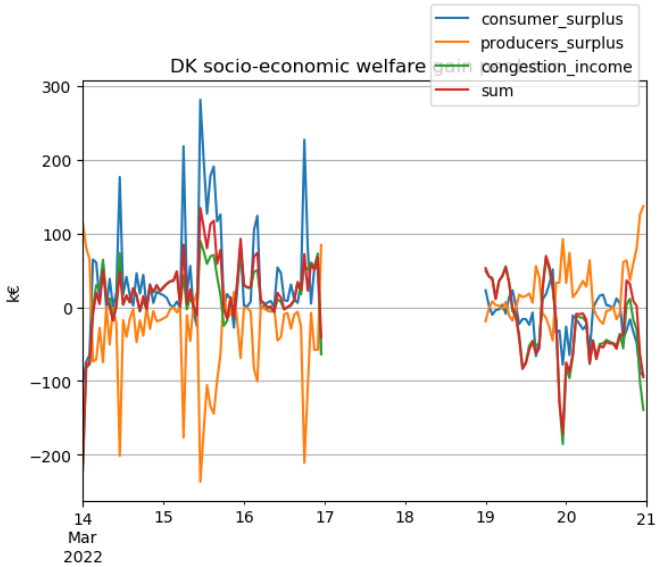


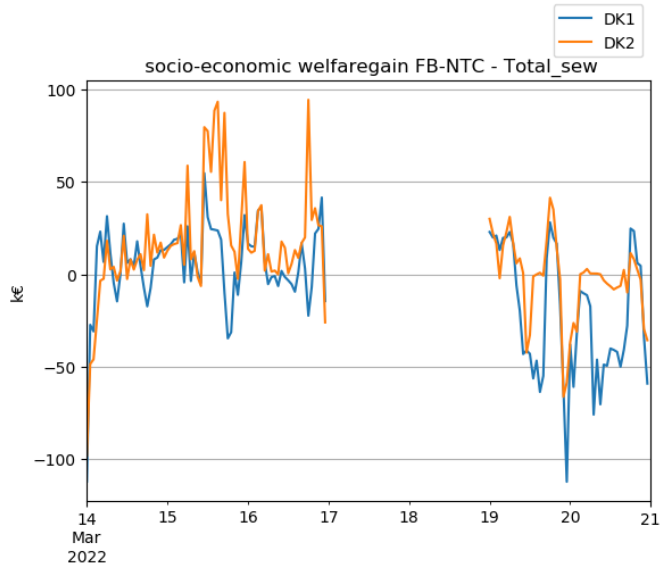


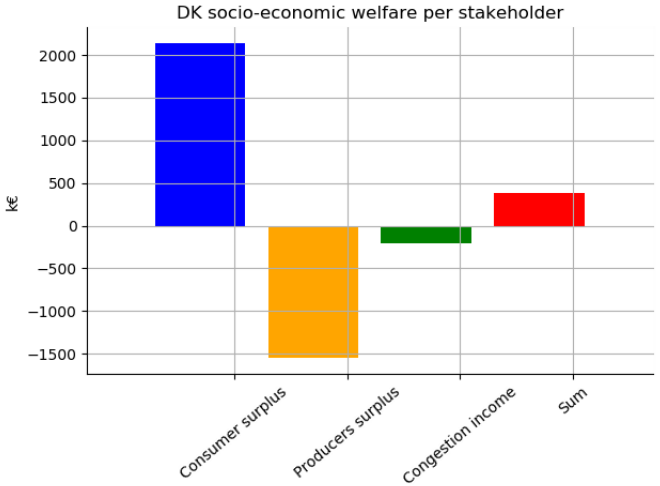




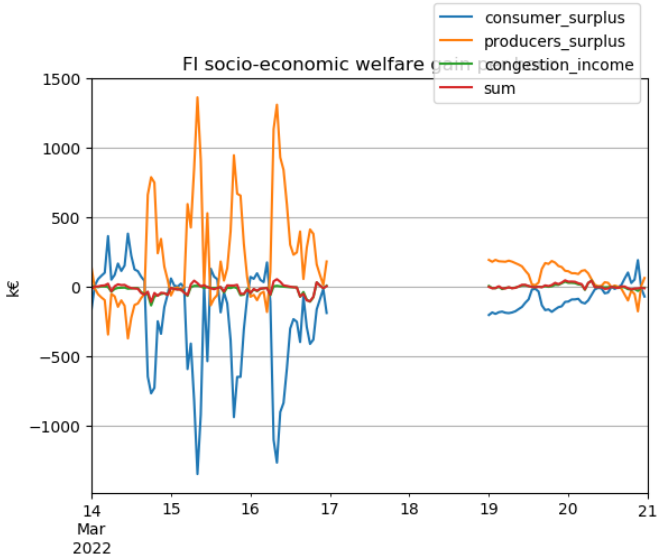
4.2.1.2 Denmark

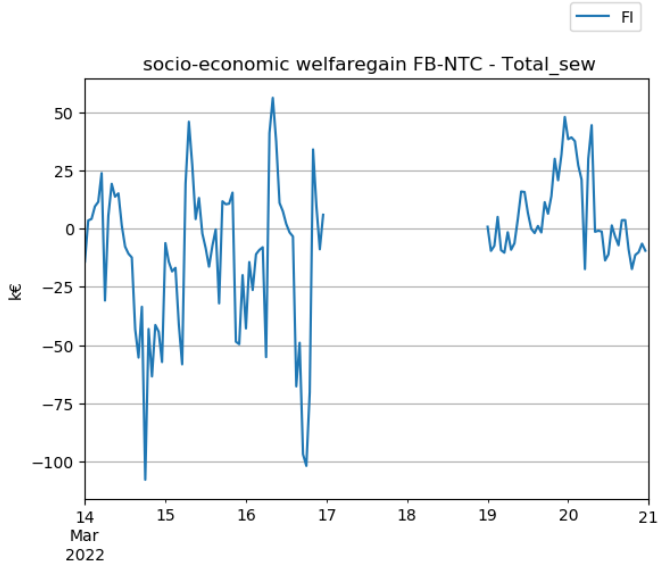


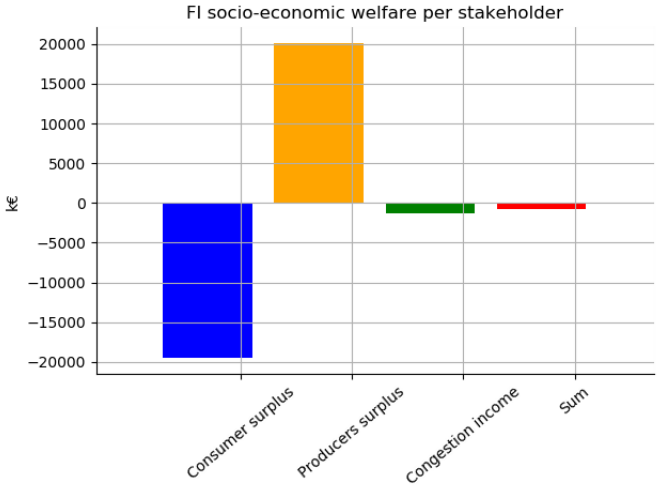




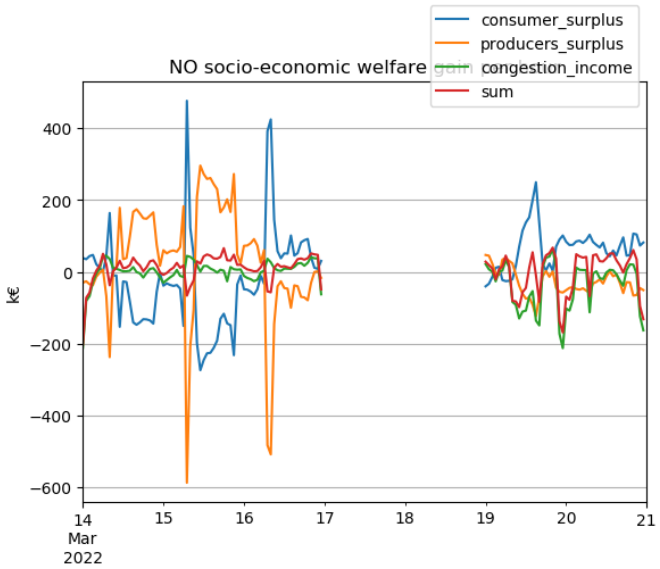
4.2.1.3 Finland







4.2.1.4 Norway


NO socio-economic welfare gain
consumer_surplus
producers_surplus
congestion_income
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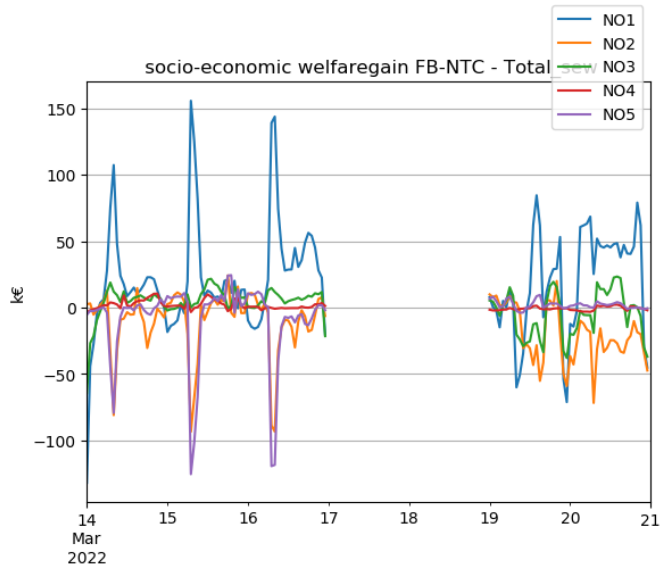
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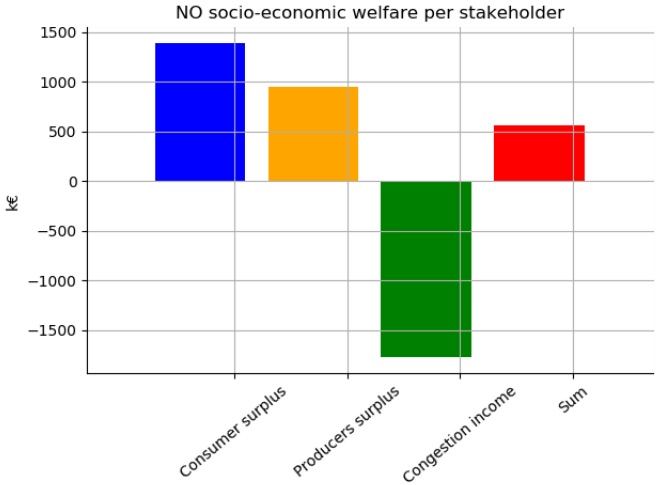
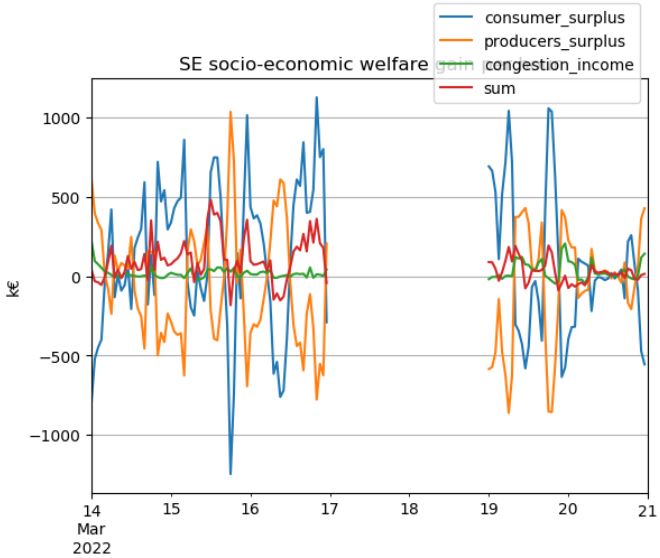
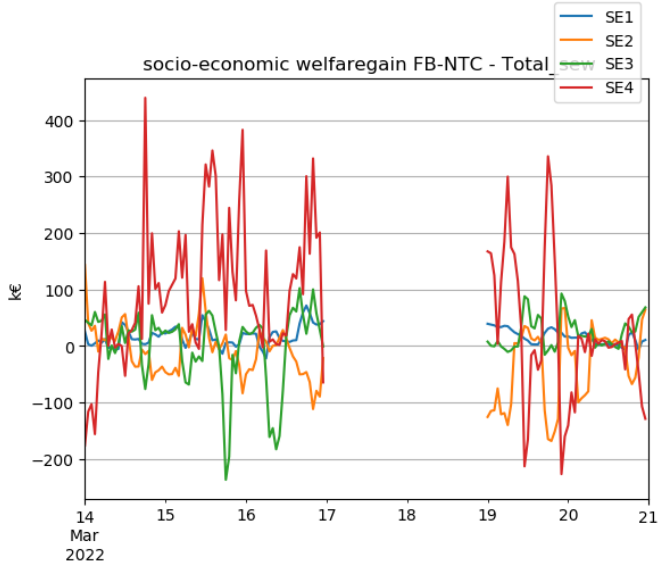
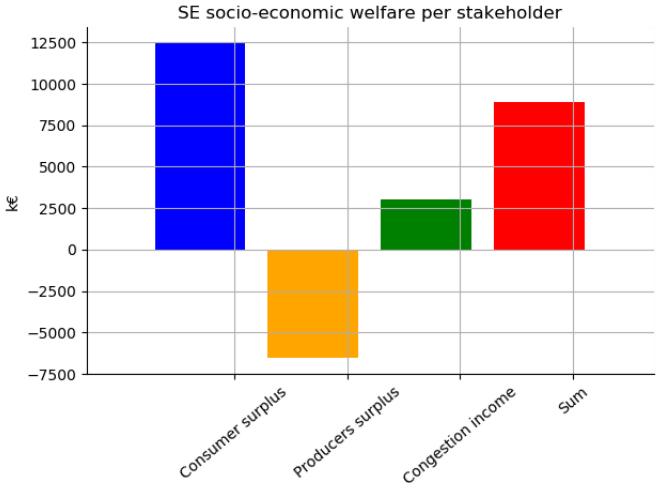
20
21


NO socio-economic welfare per stakeholder
k€
1500
1000
500
0
−500
−1000
−1500
Consumer surplus
Producers surplus
Congestion income
Sum

4.2.1.5 Sweden

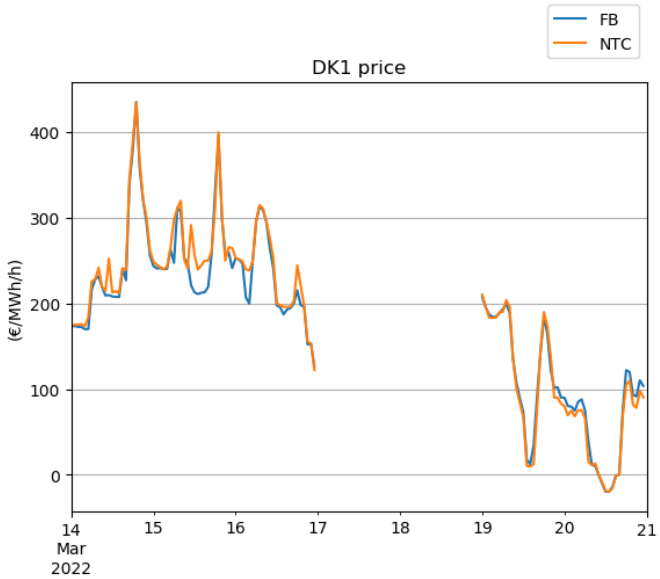

SE socio-economic welfare gain
consumer_surplus
producers_surplus
congestion_income
sum
k€
1000
500
0
−500
−1000
14
Mar
2022
15
16
17
18
19
20
21

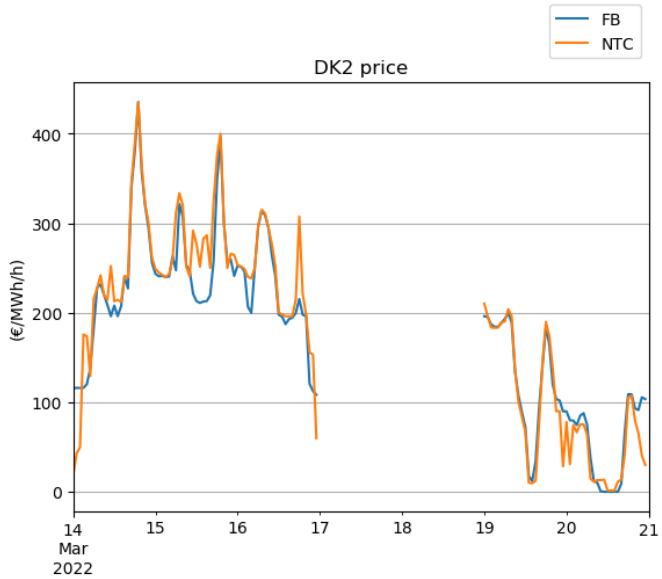

socio-economic welfaregain FB-NTC - Total_sew
SE1
SE2
SE3
SE4
k€
400
300
200
100
0
−100
−200
14
Mar
2022
15
16
17
18
19
20
21


SE socio-economic welfare per stakeholder
k€
12500
10000
7500
5000
2500
0
−2500
−5000
−7500
Consumer surplus
Producers surplus
Congestion income
Sum

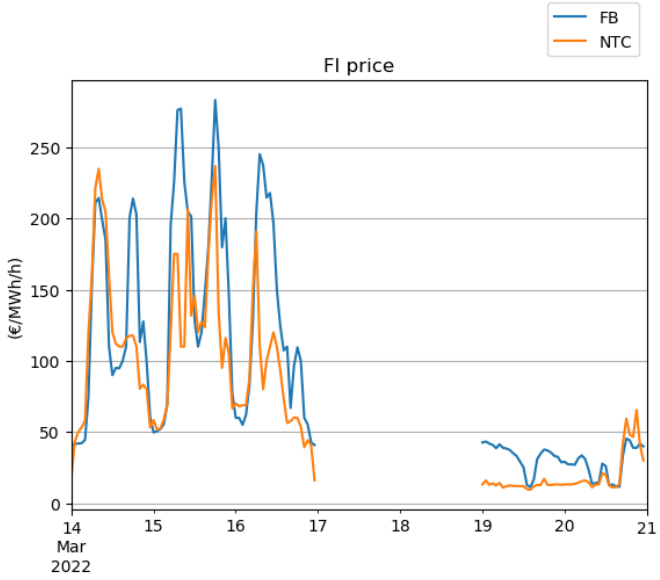
Price

4.2.1.6 Denmark

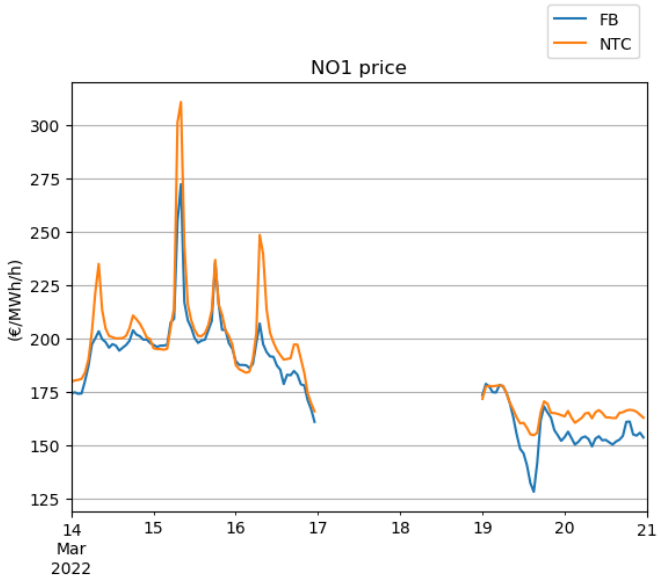


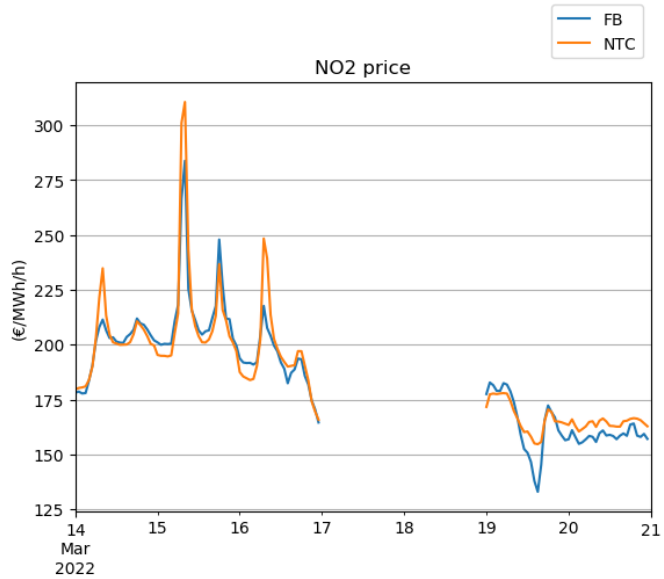


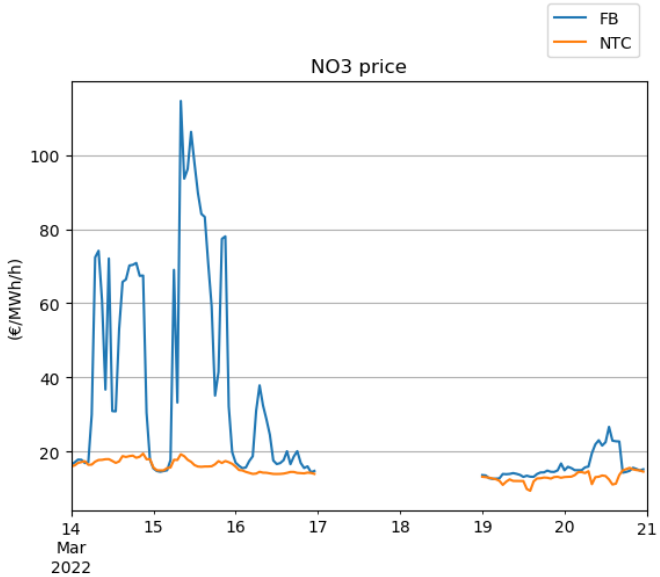
4.2.1.7 Finland

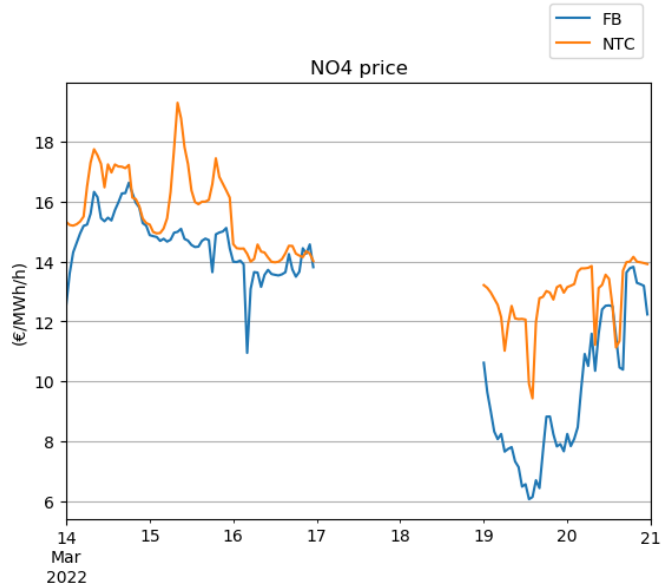


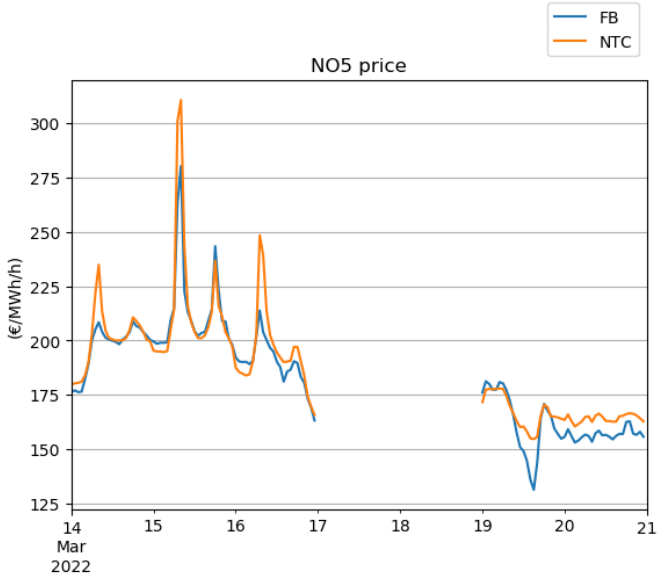
4.2.1.8 Norway


FB
NTC
NO1 price
(€/MWh/h)
300
275
250
225
200
175
150
125
14
Mar
2022
15
16
17
18
19
20
21

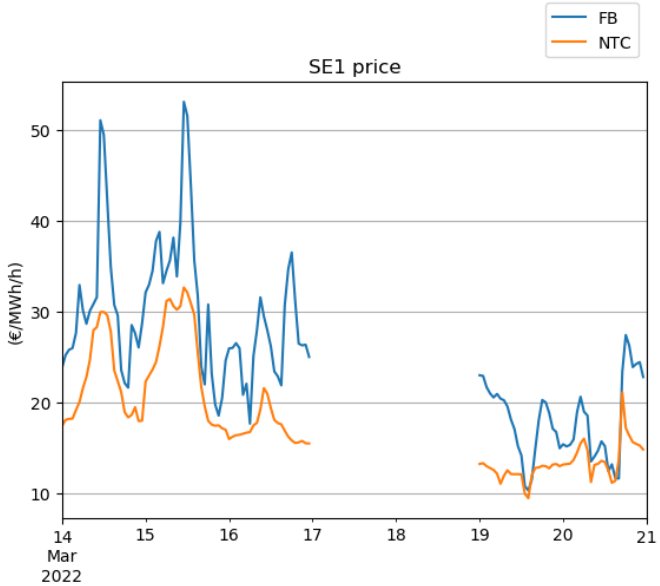

FB
NTC
NO2 price
(€/MWh/h)
300
275
250
225
200
175
150
125
14
Mar
2022
15
16
17
18
19
20
21

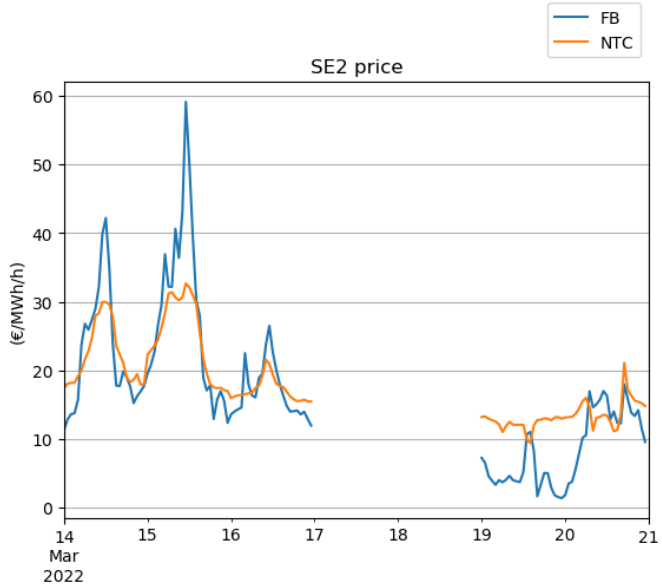

FB
NTC
NO3 price
(€/MWh/h)
100
80
60
40
20
14
Mar
2022
15
16
17
18
19
20
21

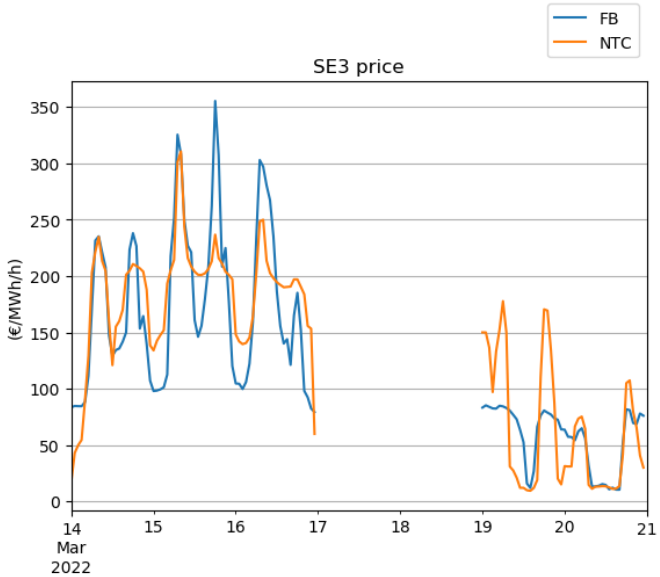

FB
NTC
NO4 price
(€/MWh/h)
18
16
14
12
10
8
6
14
Mar
2022
15
16
17
18
19
20
21

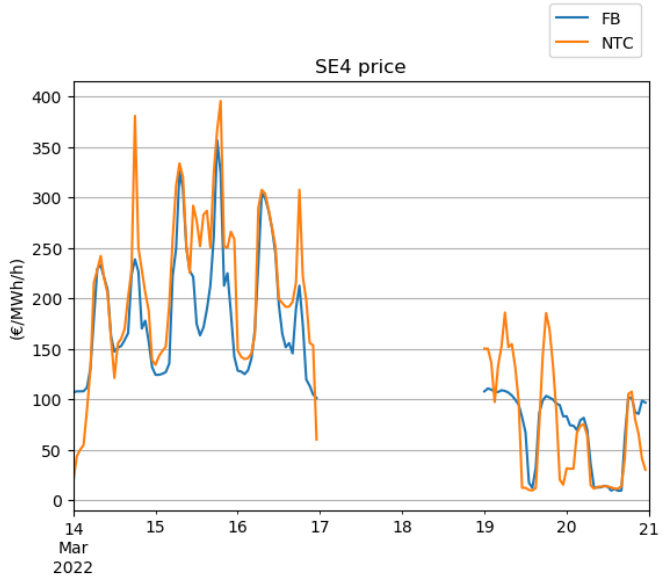


4.2.1.9 Sweden


FB
NTC
SE1 price
(€/MWh/h)
14
Mar
2022

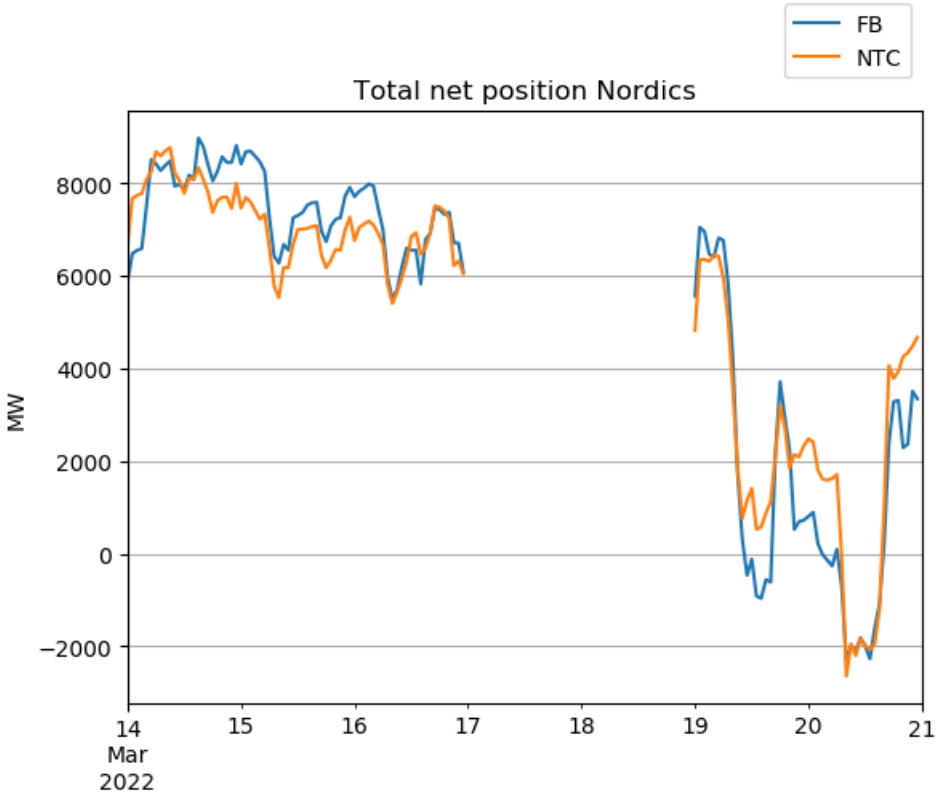

FB
NTC
SE2 price
(€/MWh/h)
14
Mar
2022


FB
NTC
SE3 price
(€/MWh/h)
14
Mar
2022

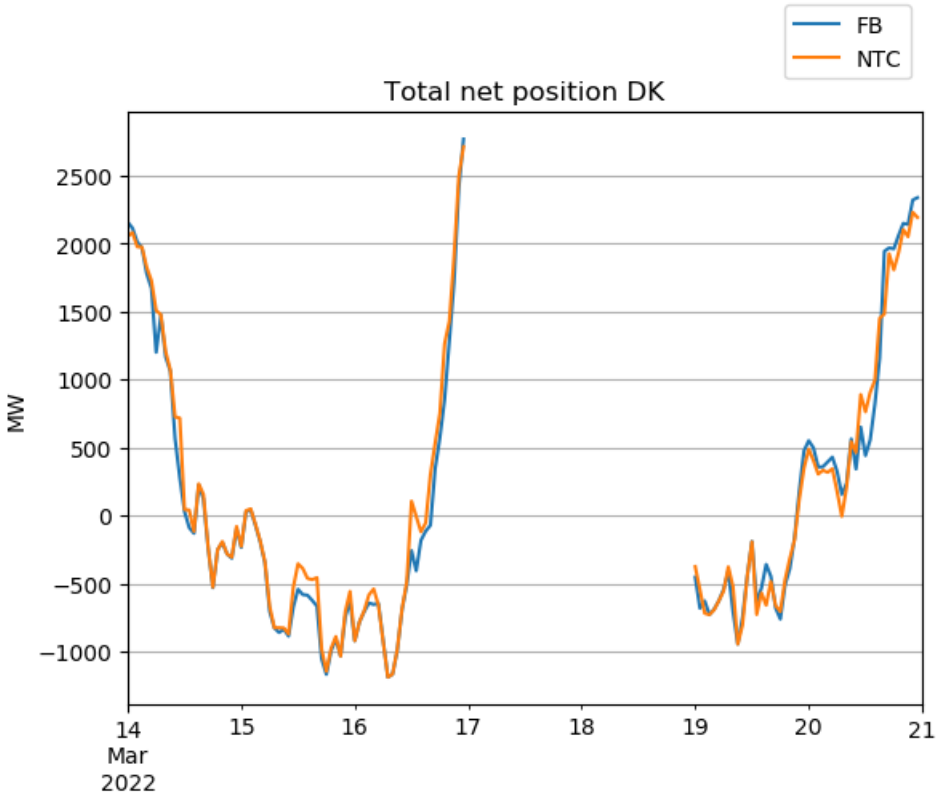

FB
NTC
SE4 price
(€/MWh/h)
14
Mar
2022

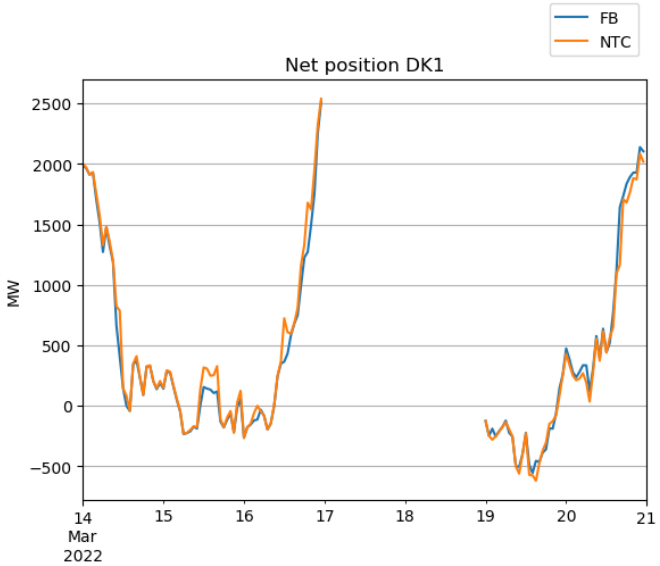
Netposition

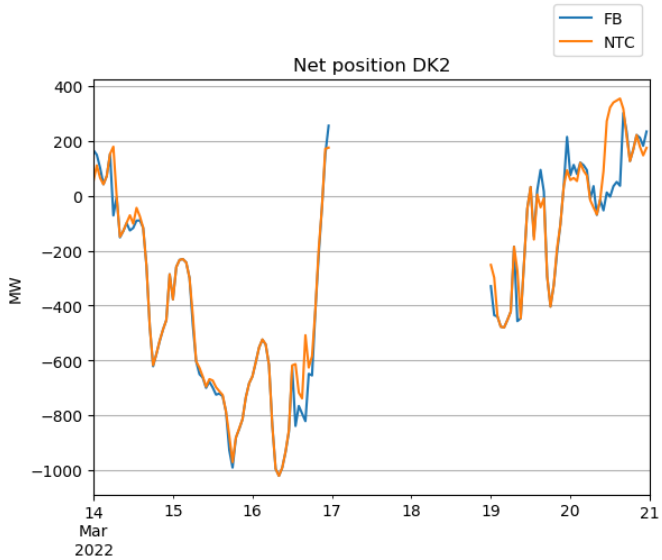
4.2.1.10 Nordics



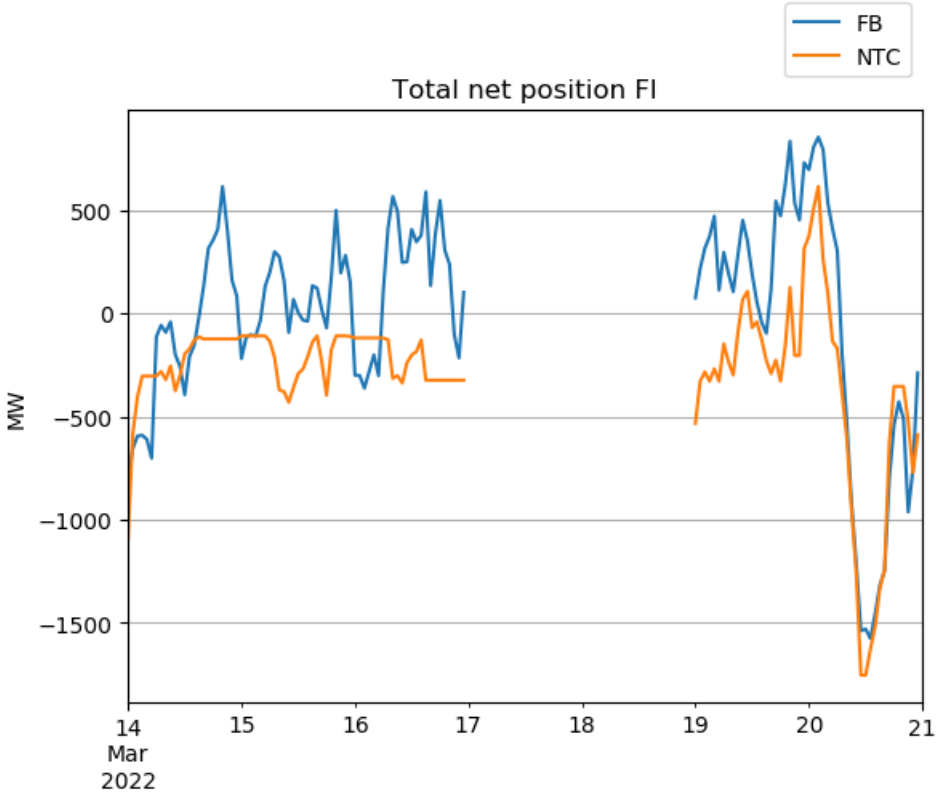
4.2.1.11 Denmark



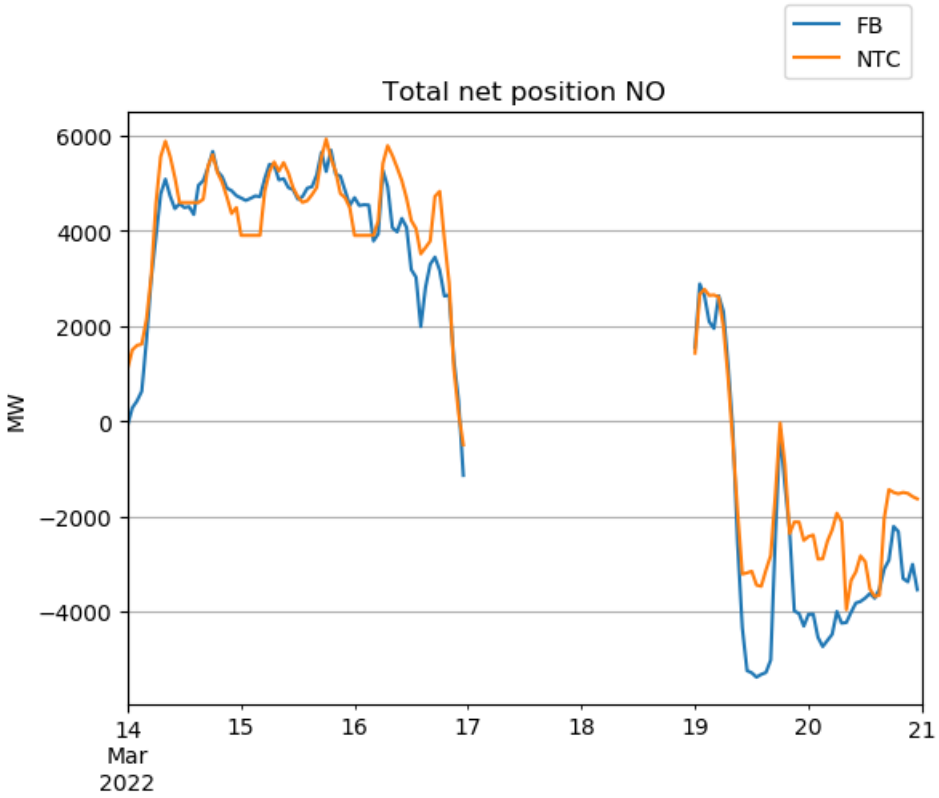


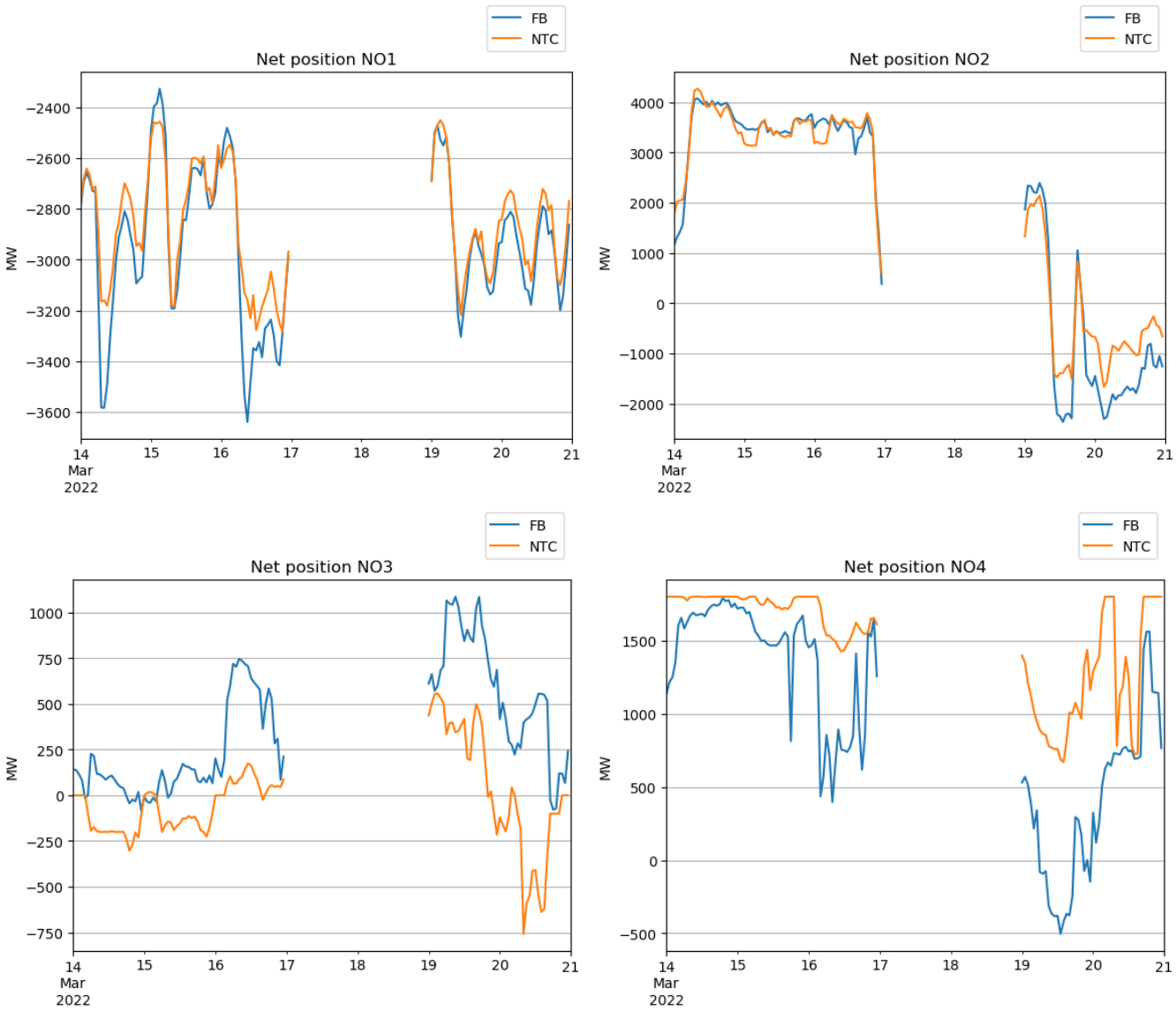


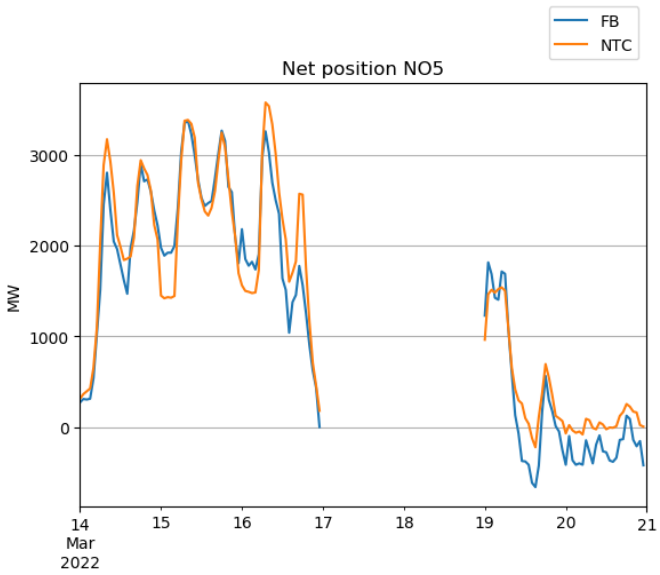
4.2.1.12 Finland



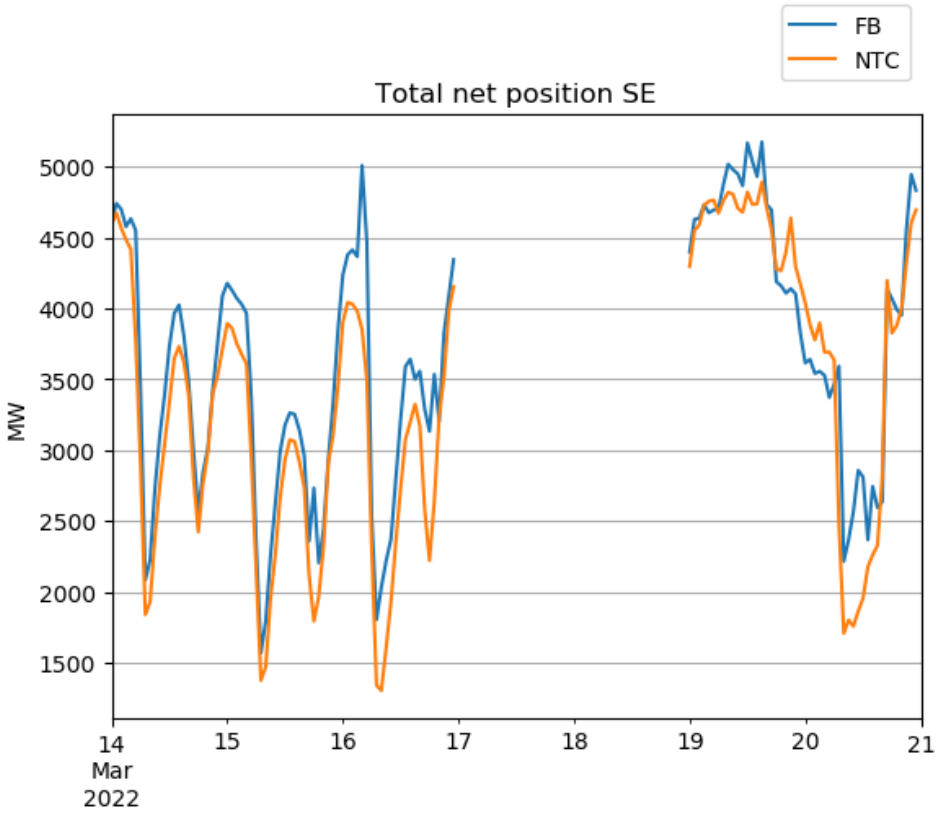
4.2.1.13 Norway

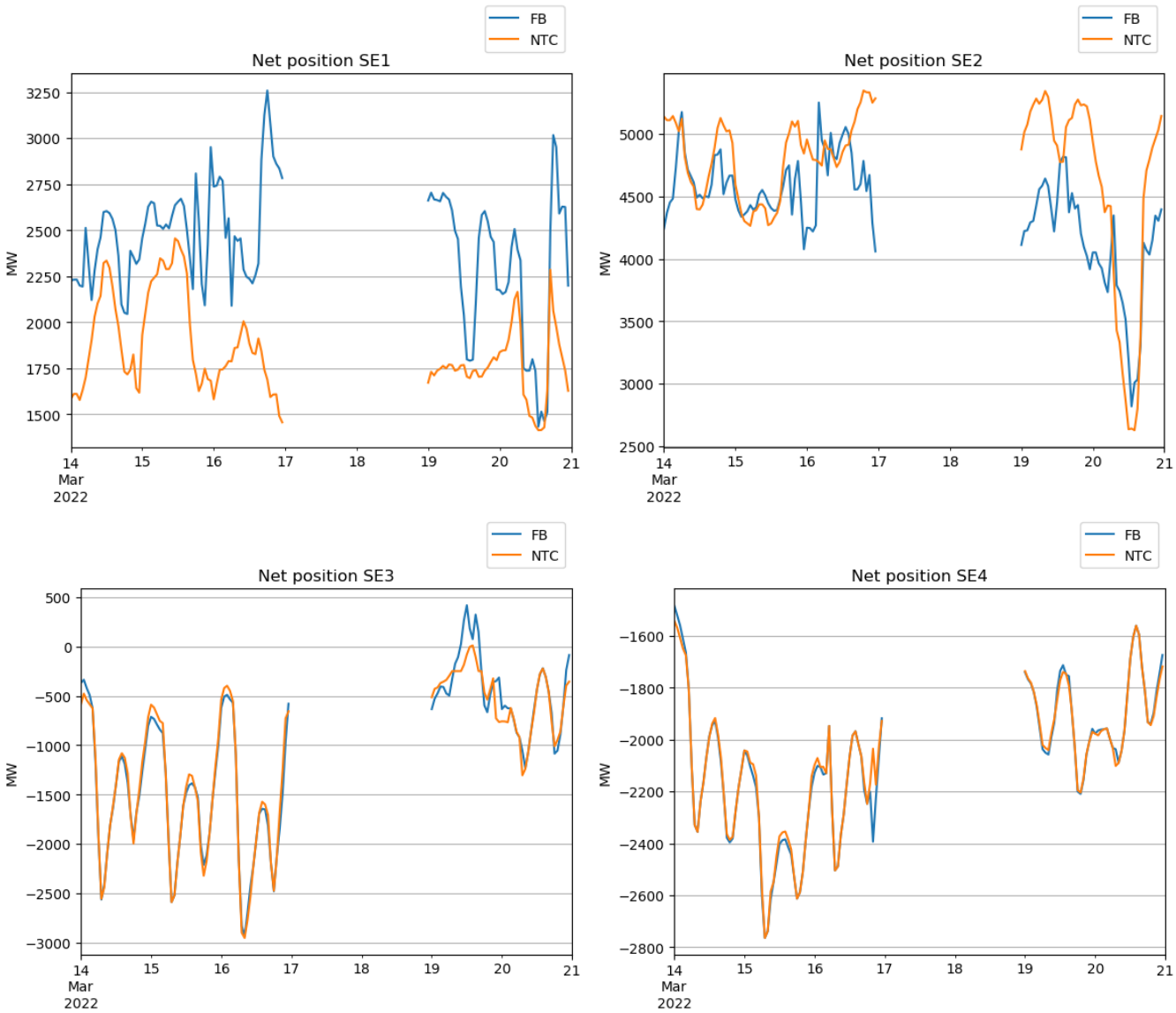



FB
NTC
Net position NO1
MW
−2400
−2600
−2800
−3000
−3200
−3400
−3600
14
Mar
2022
15
16
17
18
19
20
21
Net position NO2
4000
3000
2000
1000
0
−1000
−2000
Net position NO3
1000
750
500
250
0
−250
−500
−750
Net position NO4
1500
1000
500
0
−500

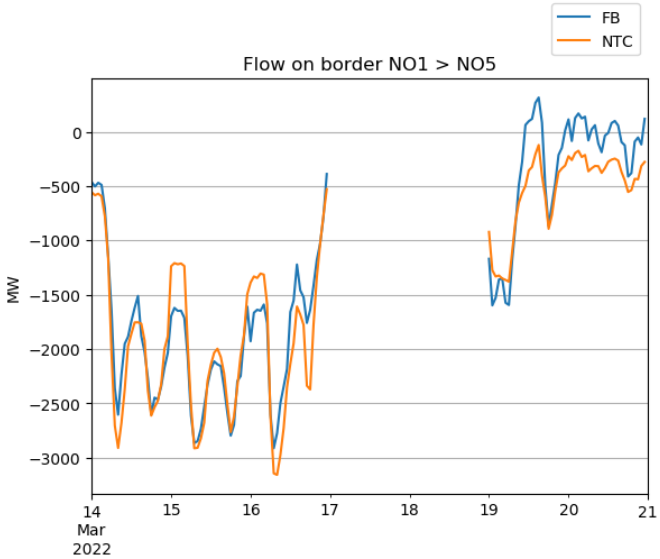


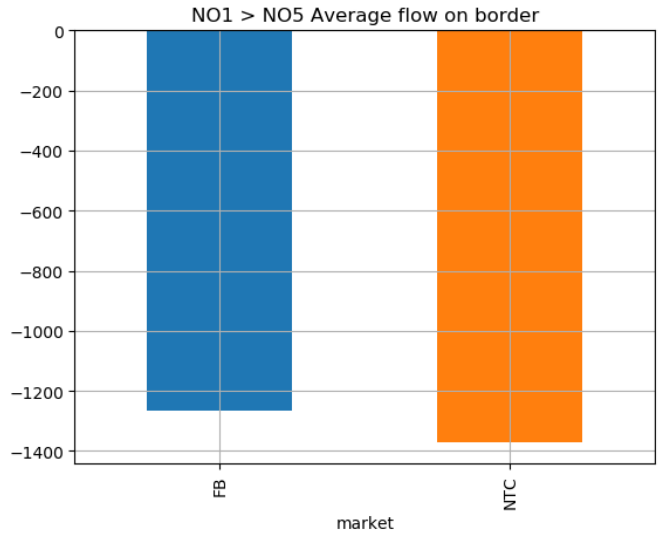
4.2.1.14 Sweden

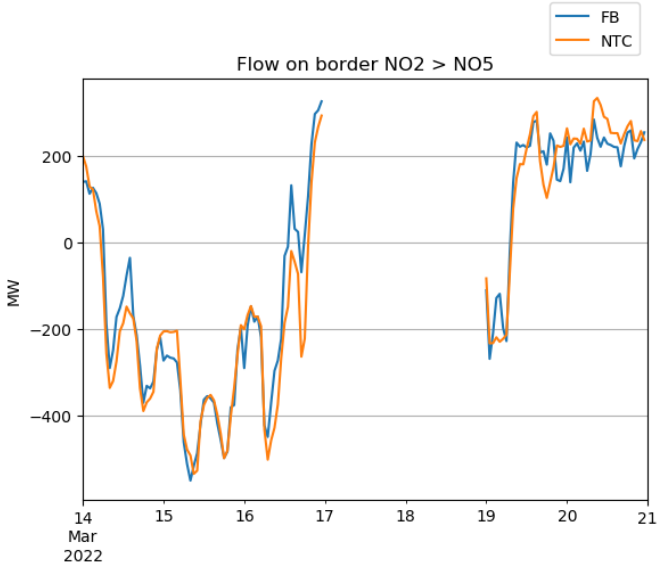


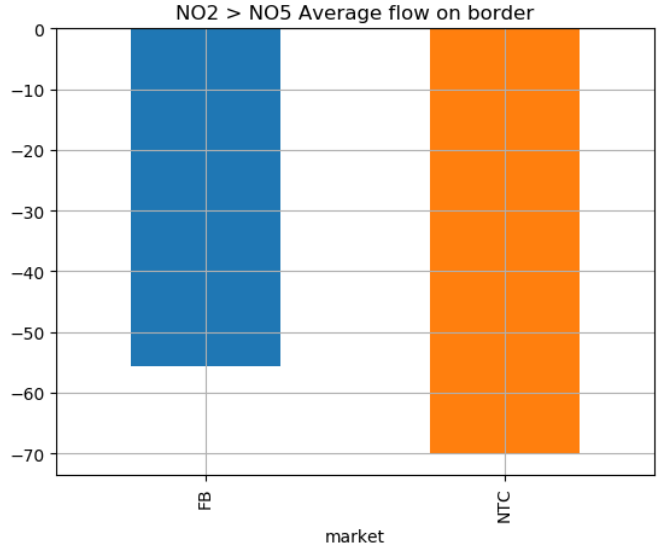

FB
NTC
Net position SE1
MW
3250
3000
2750
2500
2250
2000
1750
1500
14
Mar
2022
15
16
17
18
19
20
21
Net position SE2
5000
4500
4000
3500
3000
2500
Net position SE3
500
0
−500
−1000
−1500
−2000
−2500
−3000
Net position SE4
−1600
−1800
−2000
−2200
−2400
−2600
−2800

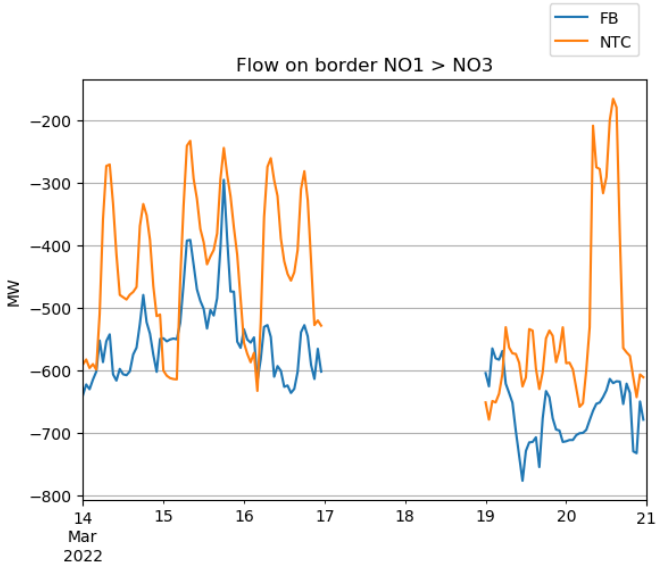
Border Flows

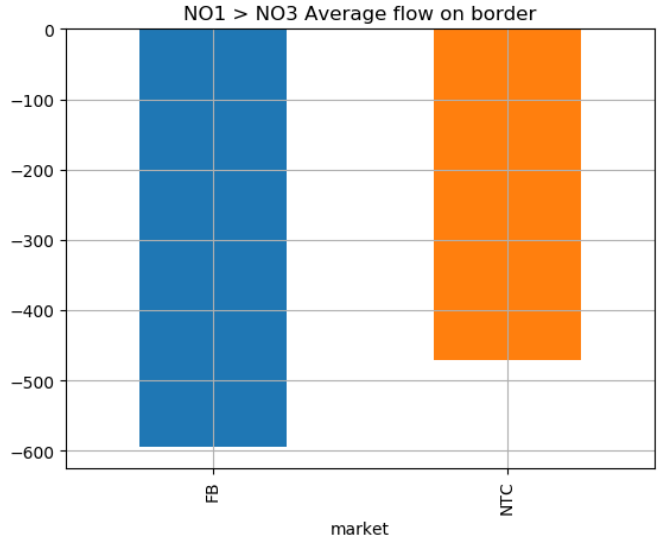


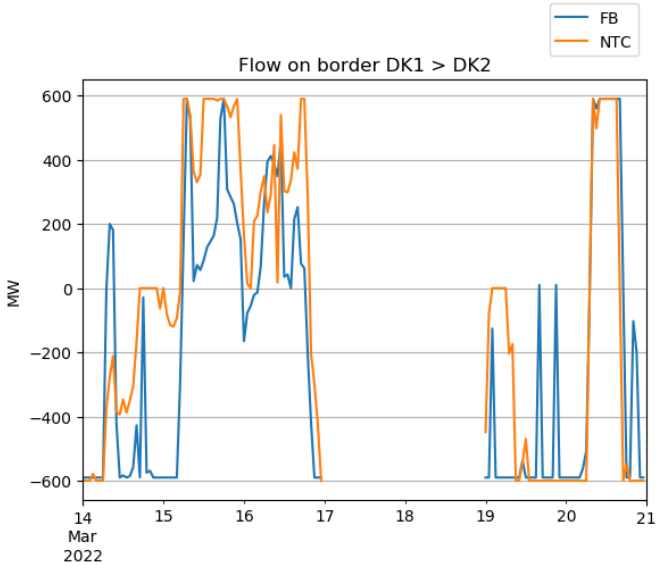


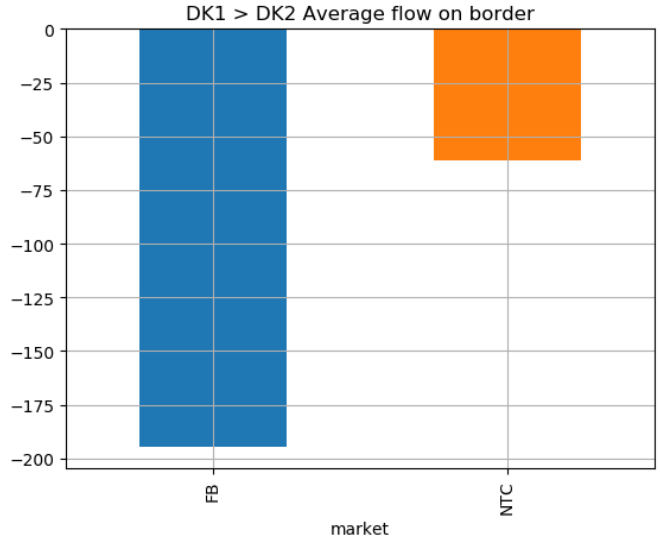


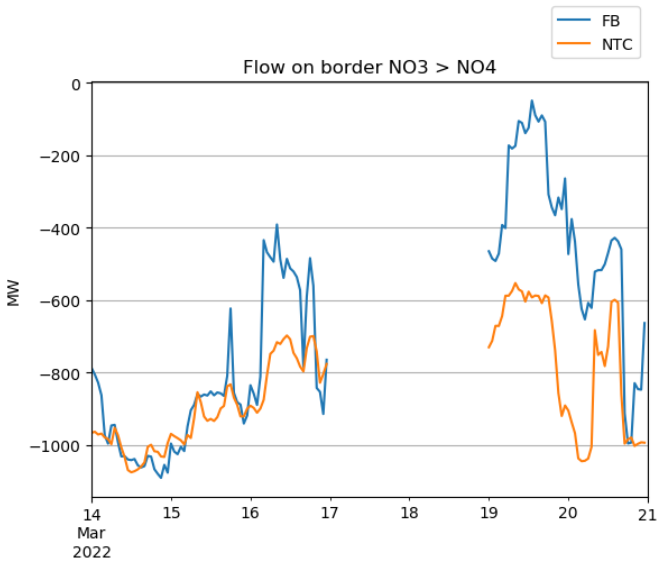


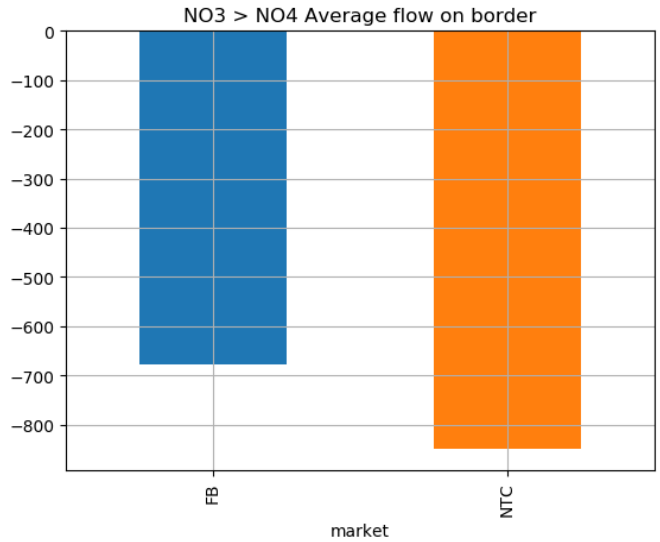

FB
NTC
Flow on border NO1 > NO3
MW
−200
−300
−400
−500
−600
−700
−800
14
Mar
2022
15
16
17
18
19
20
21

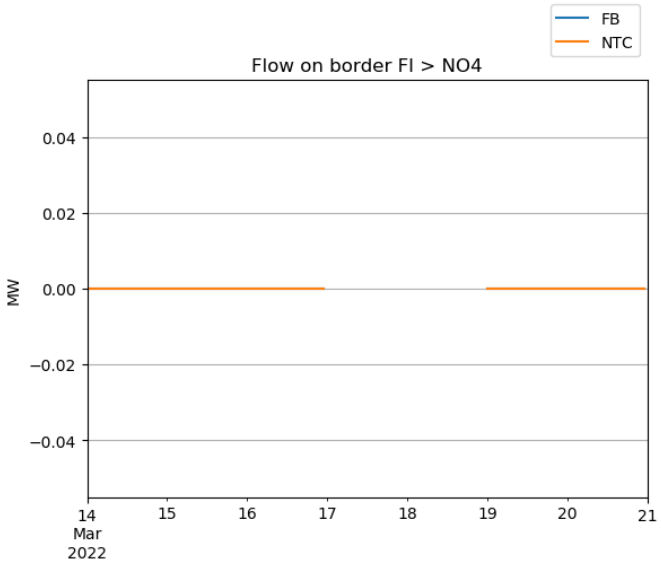

NO1 > NO3 Average flow on border
0
−100
−200
−300
−400
−500
−600
FB
NTC
market

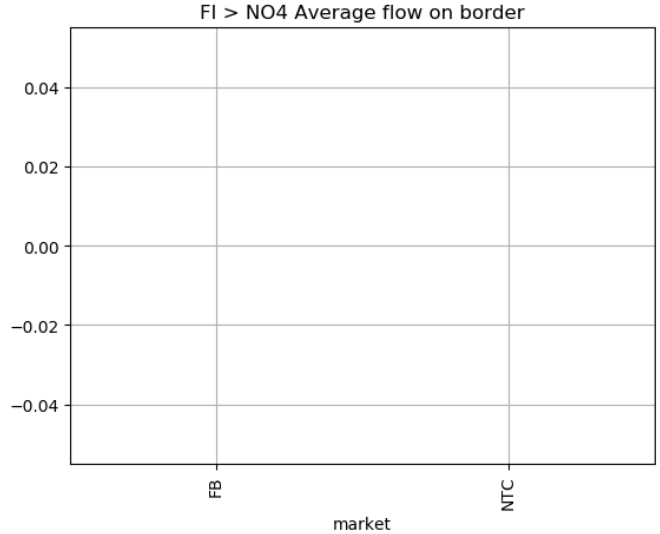

FB
NTC
Flow on border DK1 > DK2
MW
600
400
200
0
−200
−400
−600
14
Mar
2022
15
16
17
18
19
20
21

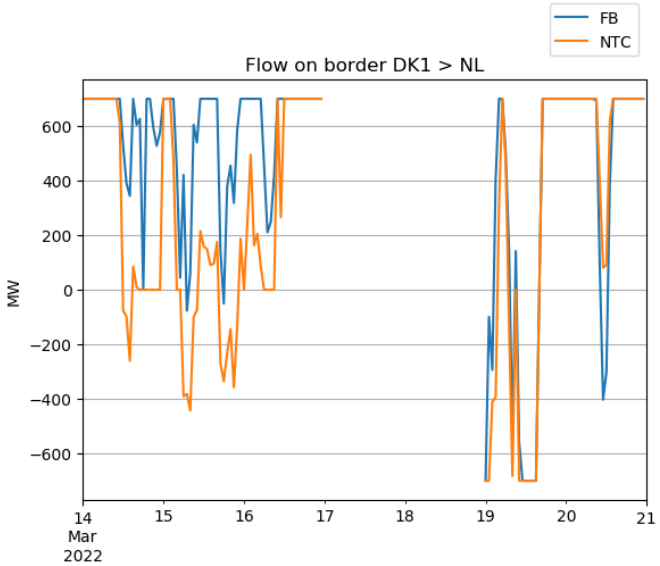

DK1 > DK2 Average flow on border
0
−25
−50
−75
−100
−125
−150
−175
−200
FB
NTC
market

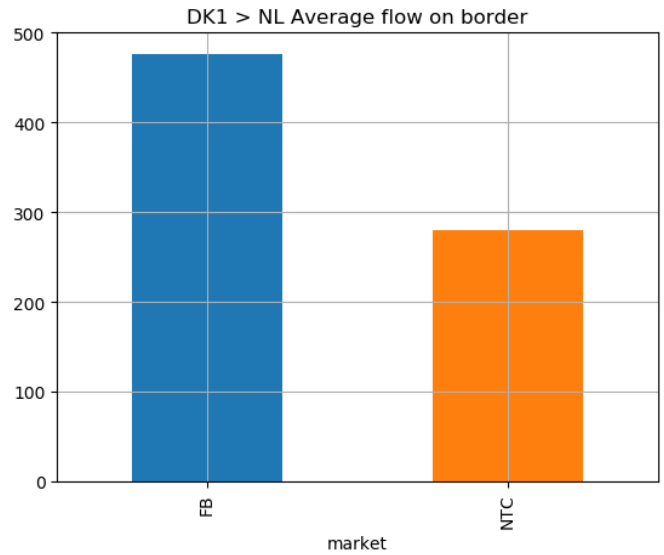

FB
NTC
Flow on border NO3 > NO4
MW
0
−200
−400
−600
−800
−1000
14
Mar
2022
15
16
17
18
19
20
21

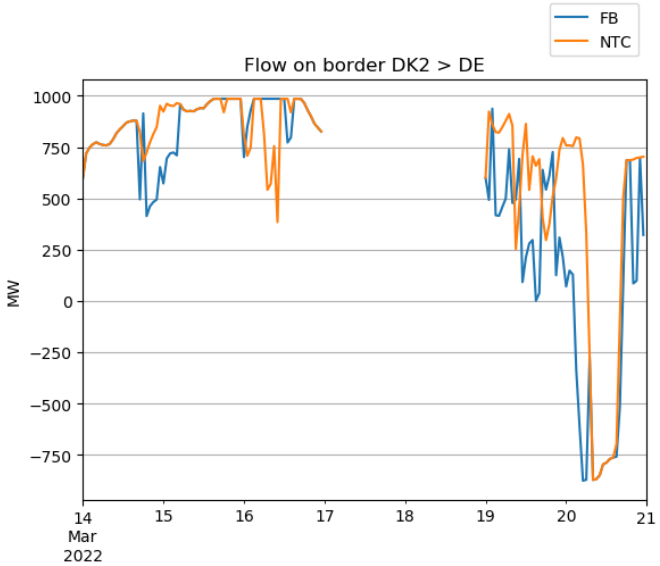

NO3 > NO4 Average flow on border
0
−100
−200
−300
−400
−500
−600
−700
−800
FB
NTC
market

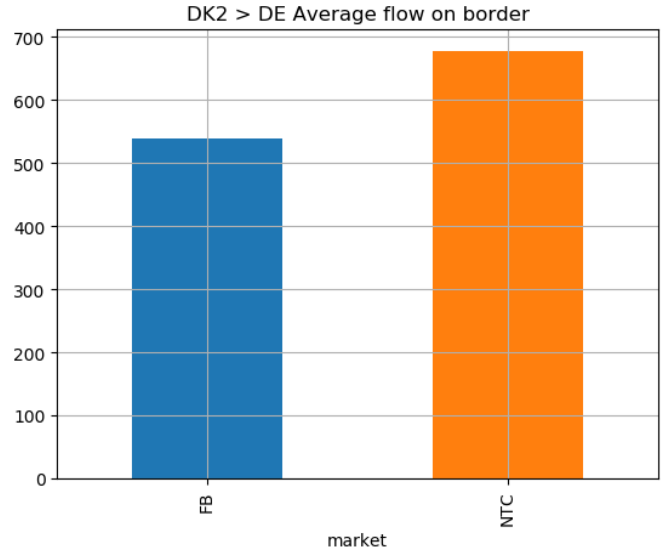

FB
NTC
Flow on border FI > NO4
MW
0.04
0.02
0.00
−0.02
−0.04
14
Mar
2022
15
16
17
18
19
20
21

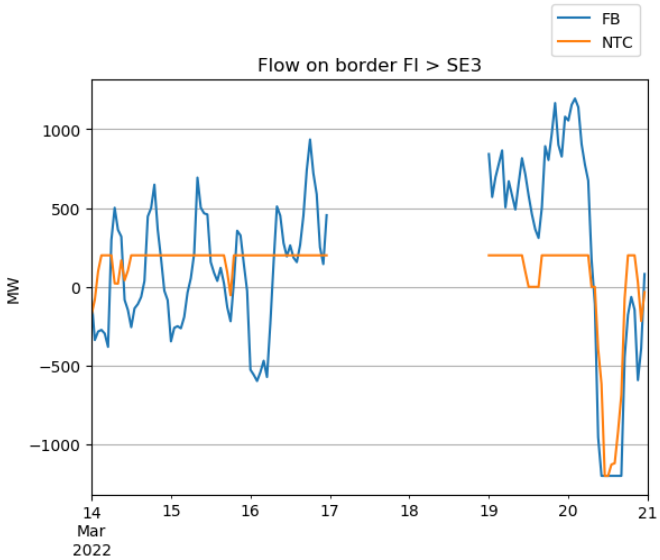

FI > NO4 Average flow on border
0.04
0.02
0.00
−0.02
−0.04
FB
NTC
market

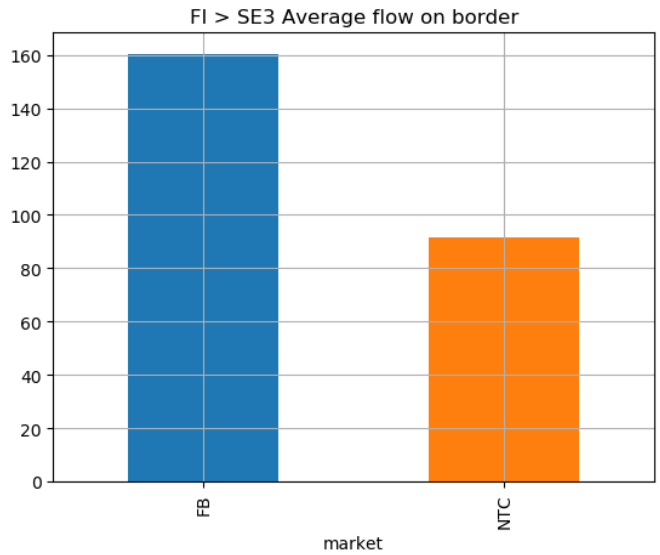

FB
NTC
Flow on border DK1 > NL
MW
600
400
200
0
−200
−400
−600
14
Mar
2022
15
16
17
18
19
20
21

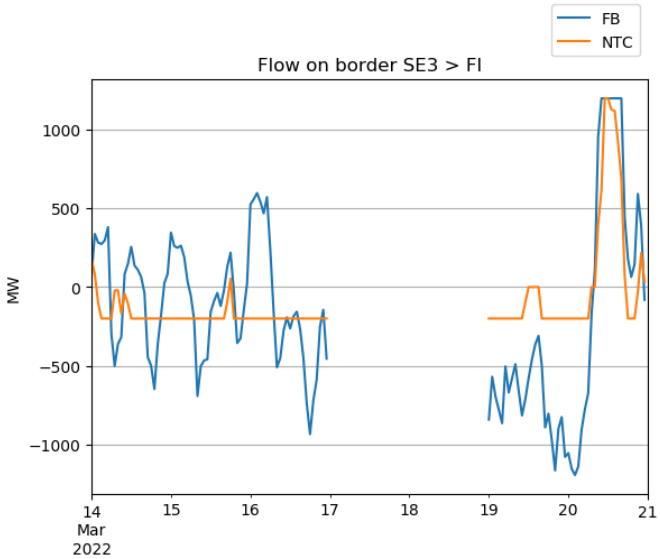

DK1 > NL Average flow on border
500
400
300
200
100
0
FB
NTC
market

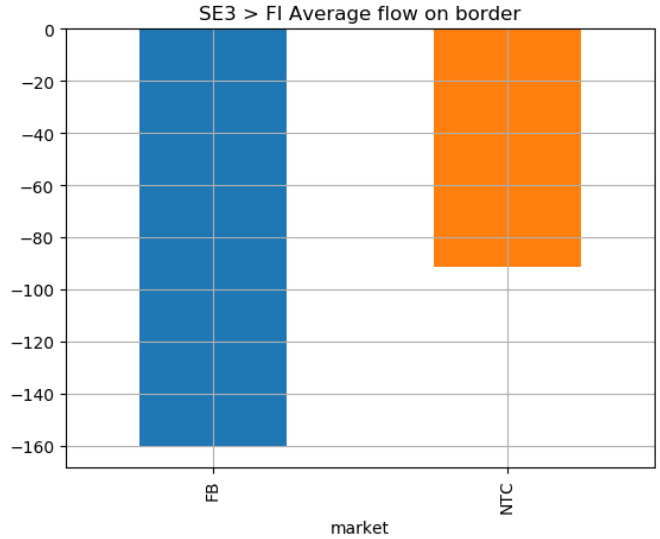

FB
NTC
Flow on border DK2 > DE
MW
1000
750
500
250
0
−250
−500
−750
14
Mar
2022
15
16
17
18
19
20
21

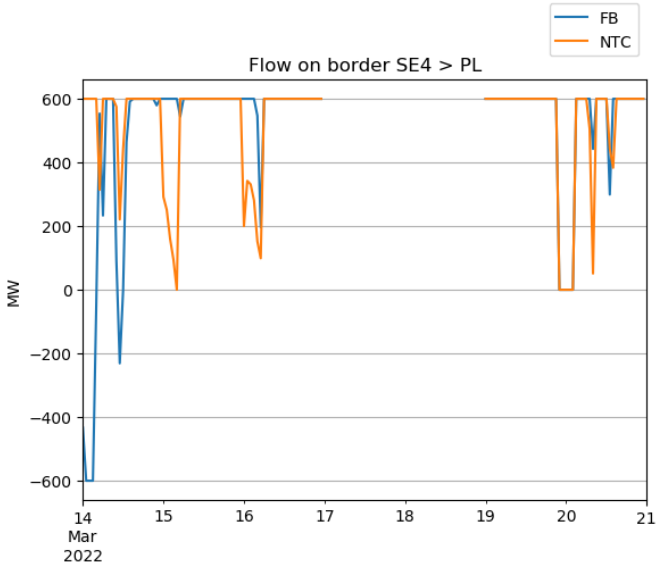

DK2 > DE Average flow on border
700
600
500
400
300
200
100
0
FB
NTC
market


FB
NTC
Flow on border FI > SE3
MW
1000
500
0
−500
−1000
14
Mar
2022
15
16
17
18
19
20
21


FI > SE3 Average flow on border
160
140
120
100
80
60
40
20
0
FB
NTC
market


FB
NTC
Flow on border SE3 > FI
MW
1000
500
0
−500
−1000
14
Mar
2022
15
16
17
18
19
20
21


SE3 > FI Average flow on border
0
−20
−40
−60
−80
−100
−120
−140
−160
FB
NTC
market


FB
NTC
Flow on border SE4 > PL
MW
600
400
200
0
−200
−400
−600
14
Mar
2022
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20
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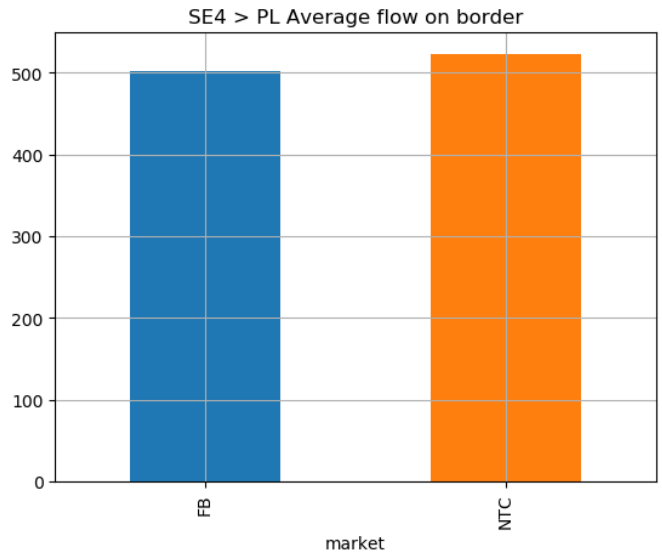
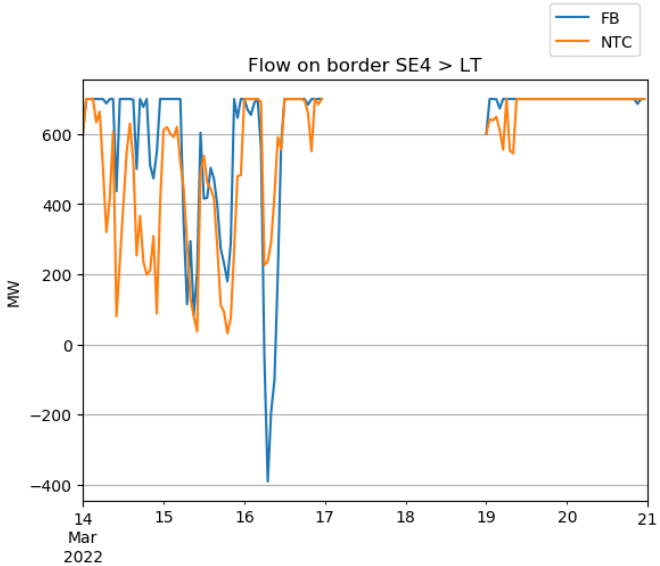

SE4 > PL Average flow on border
500
400
300
200
100
0
FB
NTC
market


FB
NTC
Flow on border SE4 > LT
MW
600
400
200
0
−200
−400
14
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2022
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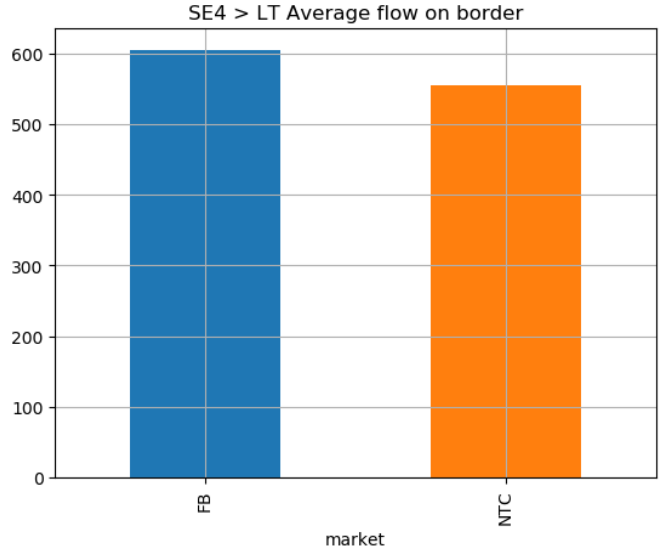
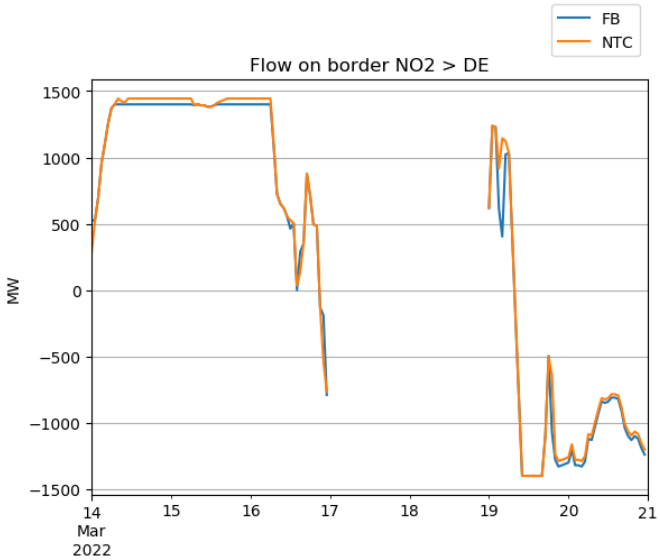

SE4 > LT Average flow on border
600
500
400
300
200
100
0
FB
NTC
market


FB
NTC
Flow on border NO2 > DE
MW
1500
1000
500
0
−500
−1000
−1500
14
Mar
2022
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20
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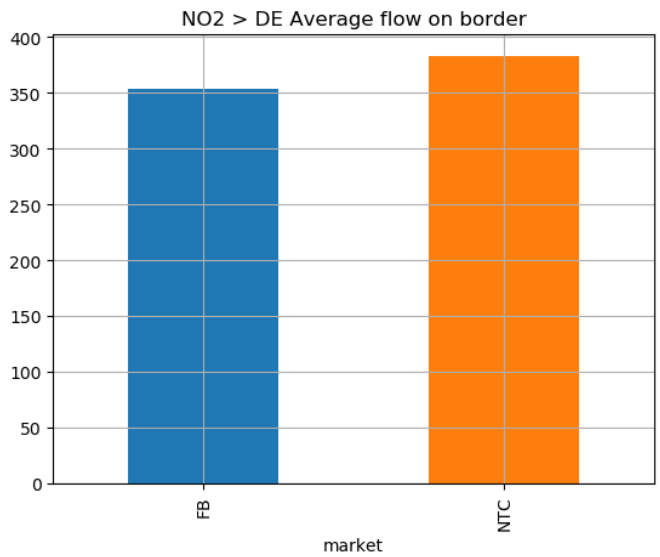
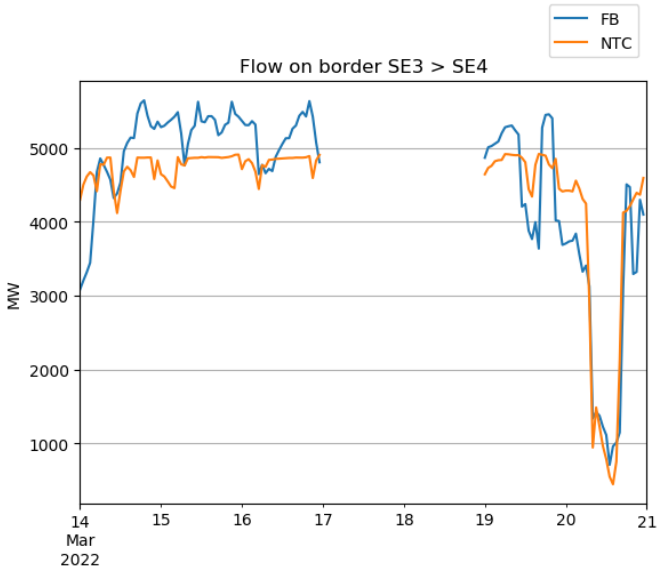

NO2 > DE Average flow on border
400
350
300
250
200
150
100
50
0
FB
NTC
market


FB
NTC
Flow on border SE3 > SE4
MW
5000
4000
3000
2000
1000
14
Mar
2022
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20
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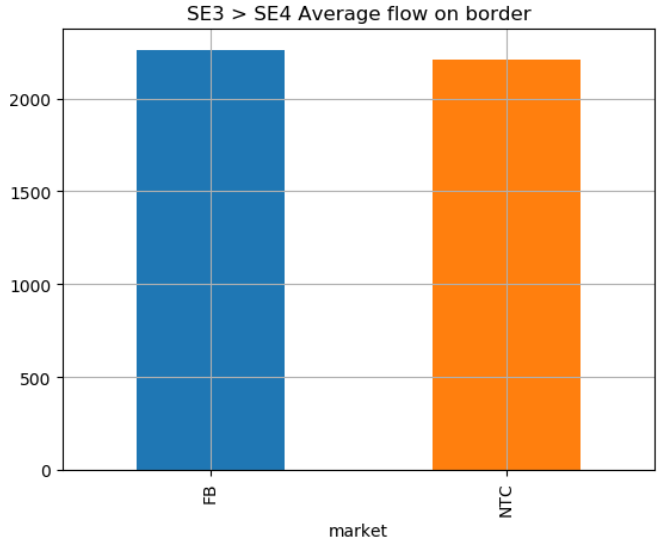
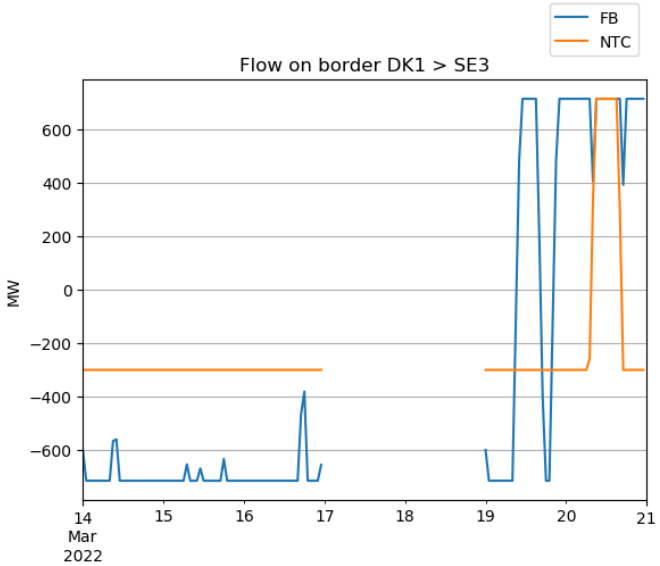

SE3 > SE4 Average flow on border
2000
1500
1000
500
0
FB
NTC
market


FB
NTC
Flow on border DK1 > SE3
MW
600
400
200
0
−200
−400
−600
14
Mar
2022
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18
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20
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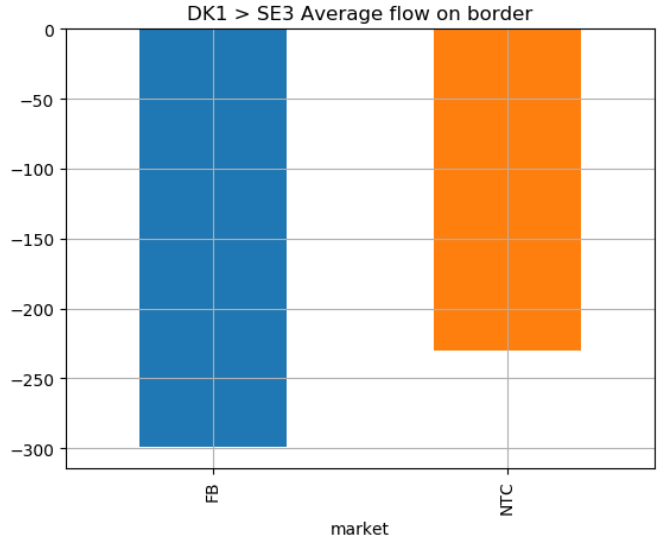
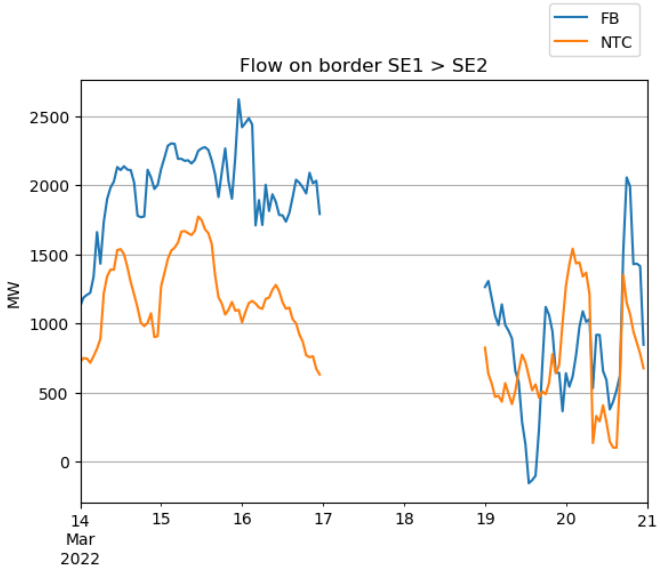

DK1 > SE3 Average flow on border
0
−50
−100
−150
−200
−250
−300
FB
NTC
market


FB
NTC
Flow on border SE1 > SE2
MW
2500
2000
1500
1000
500
0
14
Mar
2022
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16
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18
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20
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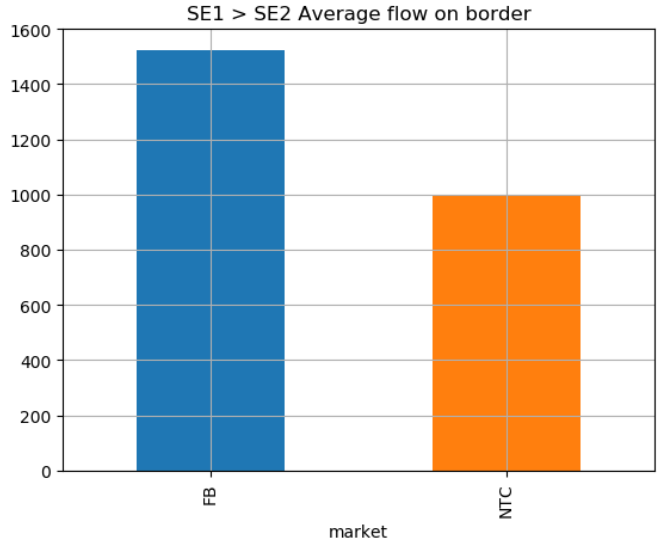
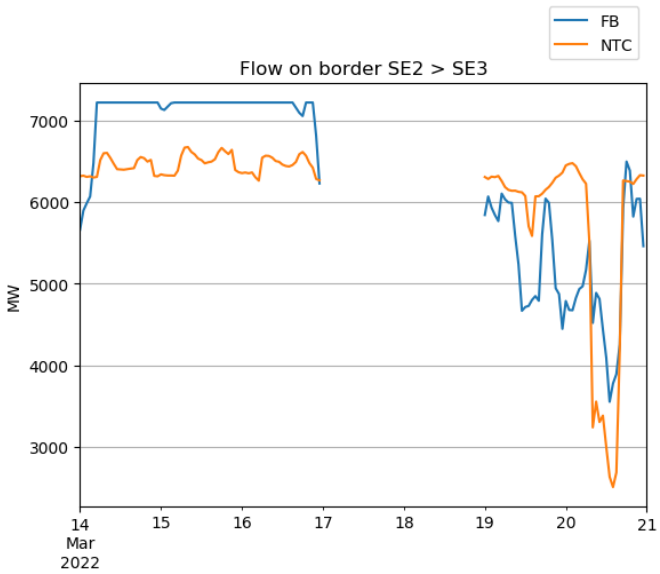

SE1 > SE2 Average flow on border
1600
1400
1200
1000
800
600
400
200
0
FB
NTC
market


FB
NTC
Flow on border SE2 > SE3
MW
7000
6000
5000
4000
3000
14
Mar
2022
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20
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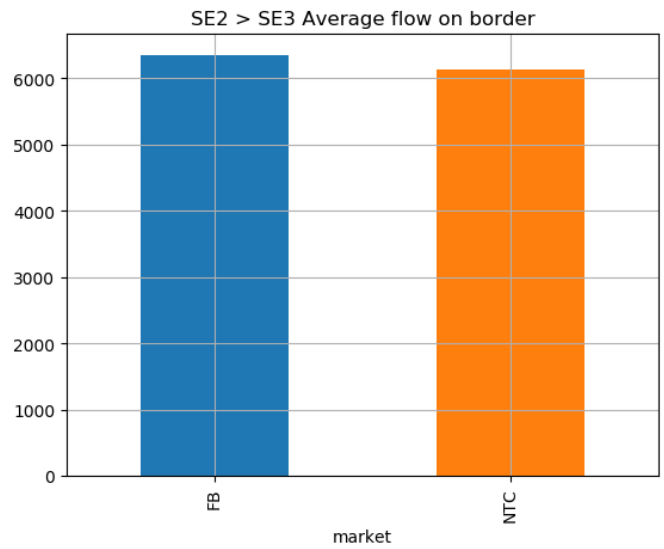
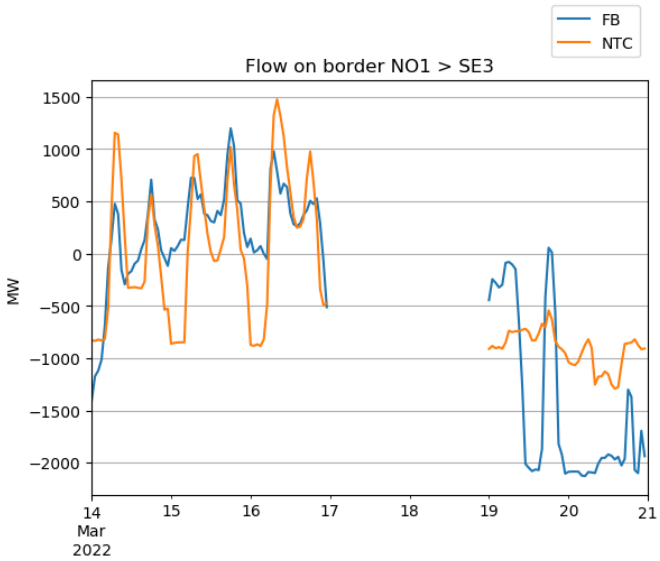

SE2 > SE3 Average flow on border
6000
5000
4000
3000
2000
1000
0
FB
NTC
market


FB
NTC
Flow on border NO1 > SE3
MW
1500
1000
500
0
−500
−1000
−1500
−2000
14
Mar
2022
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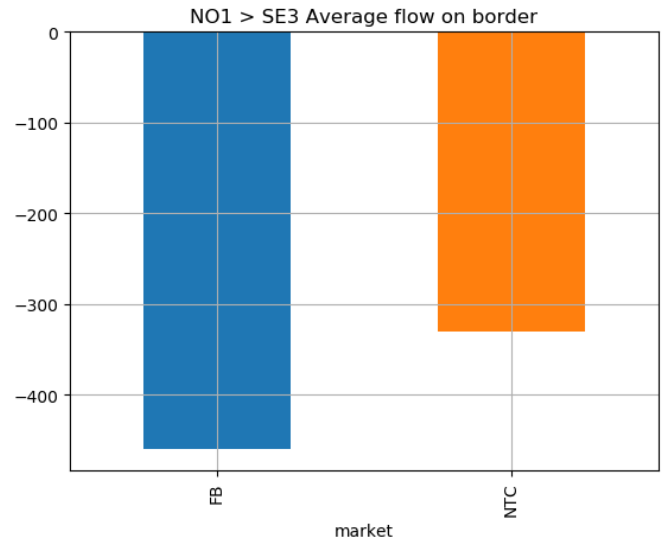
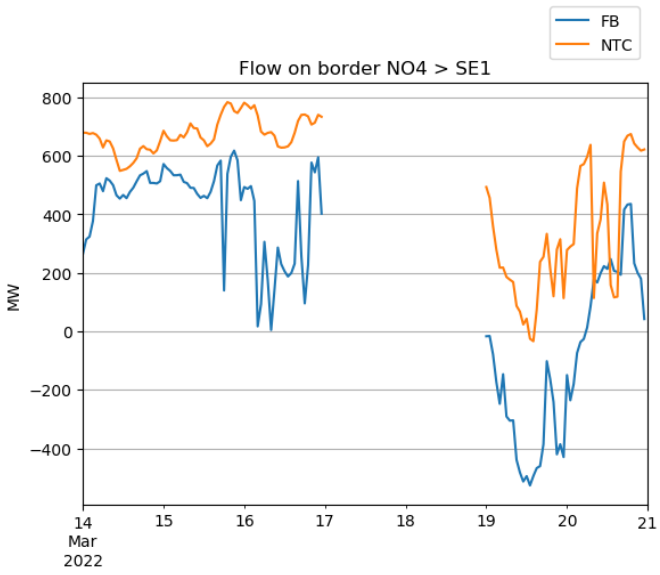
21


NO1 > SE3 Average flow on border
0
−100
−200
−300
−400
FB
NTC
market


FB
NTC
Flow on border NO4 > SE1
MW
800
600
400
200
0
−200
−400
14
Mar
2022
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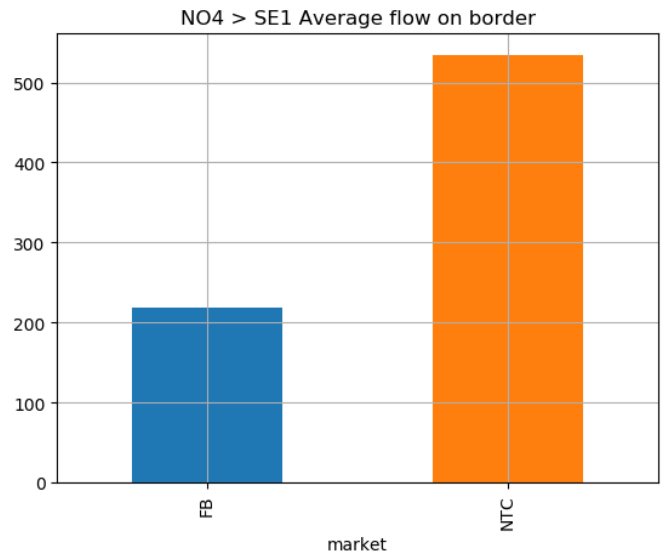
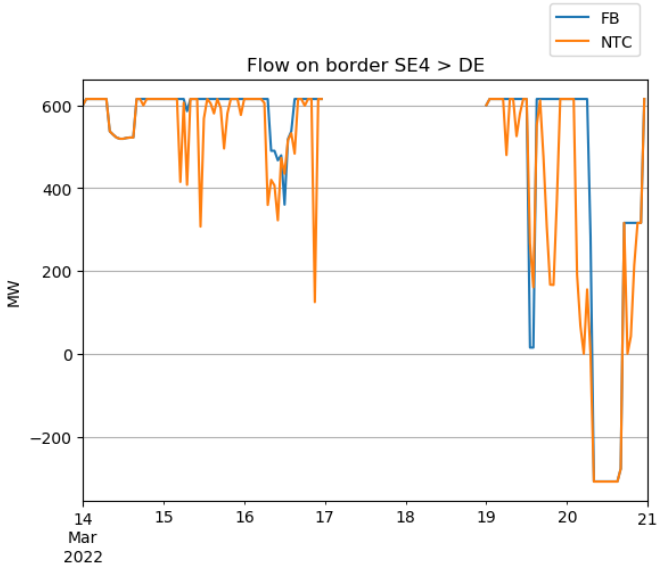

NO4 > SE1 Average flow on border
500
400
300
200
100
0
FB
NTC
market


FB
NTC
Flow on border SE4 > DE
MW
600
400
200
0
−200
14
Mar
2022
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16
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18
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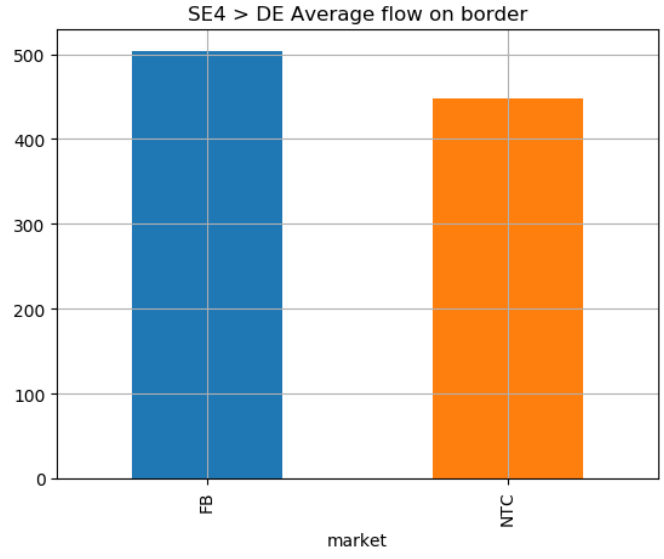
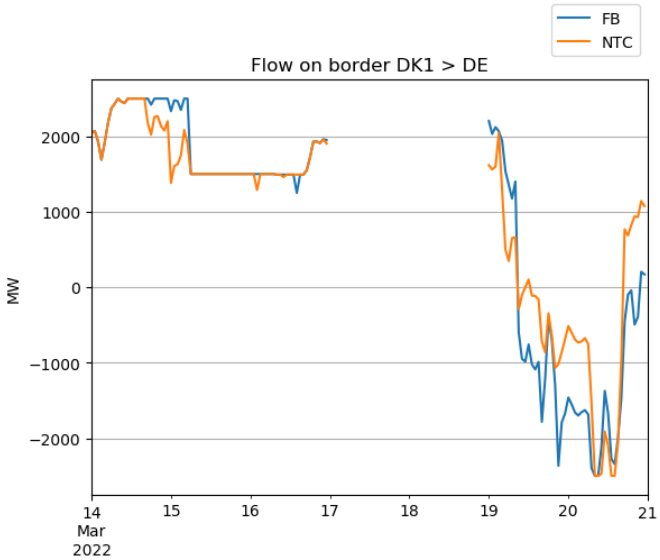
20
21


SE4 > DE Average flow on border
500
400
300
200
100
0
FB
NTC
market


FB
NTC
Flow on border DK1 > DE
MW
2000
1000
0
−1000
−2000
14
Mar
2022
15
16
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18
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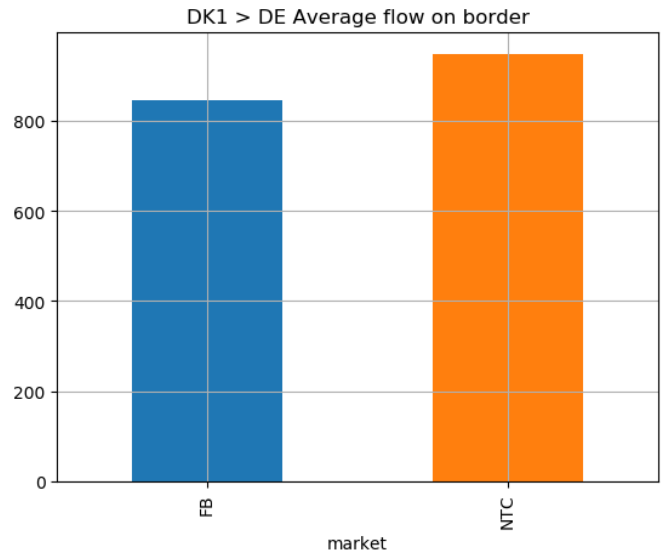
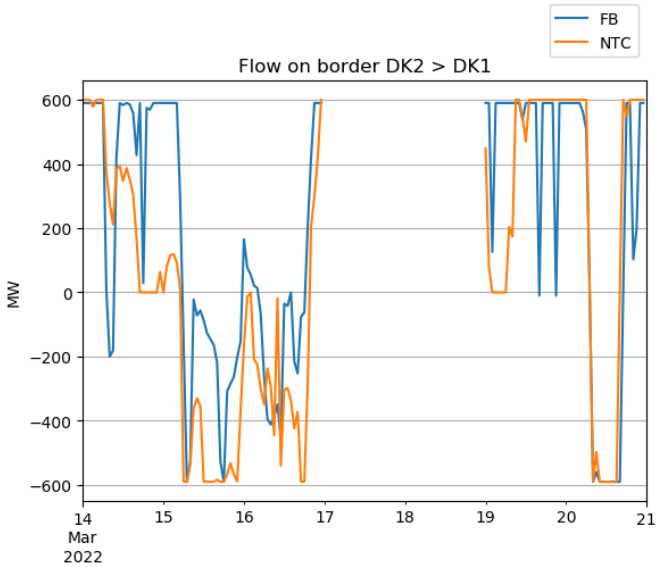
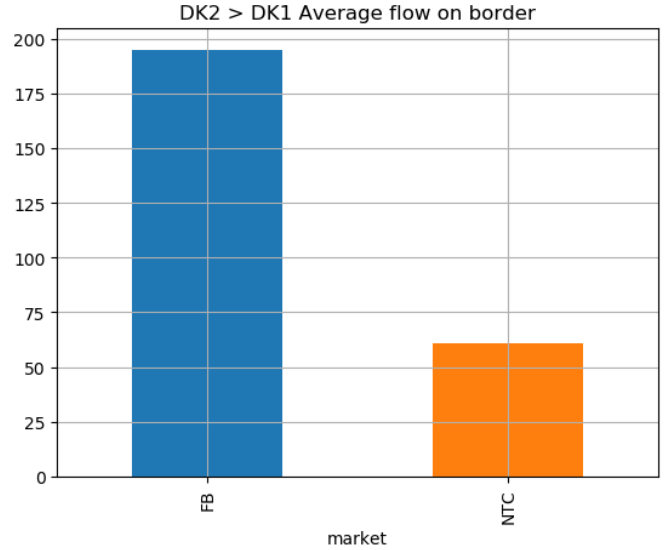
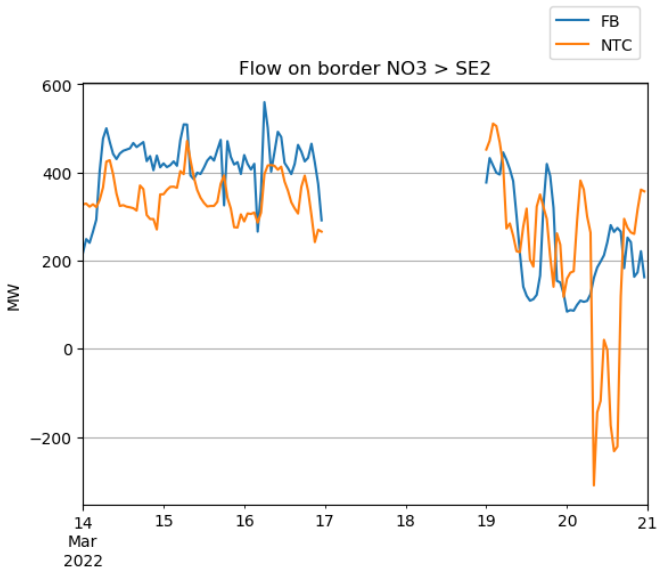
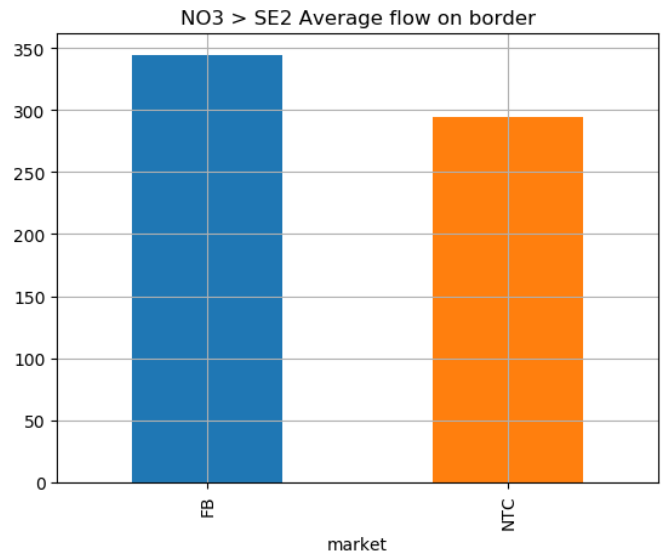
20
21

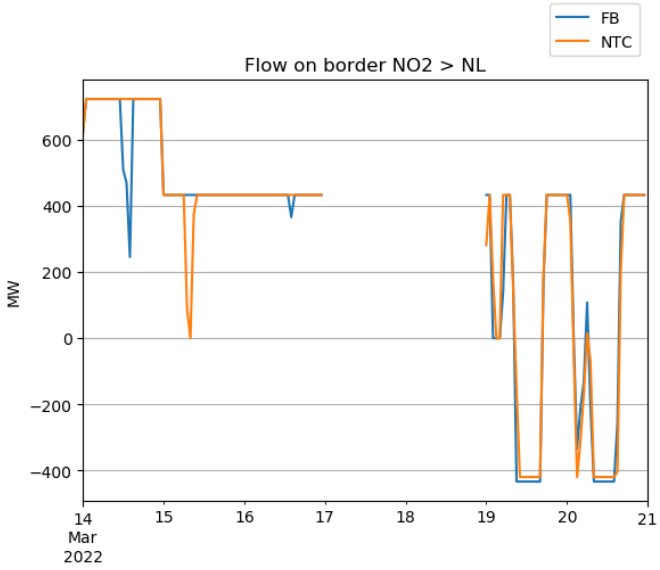

DK1 > DE Average flow on border
800
600
400
200
0
FB
NTC
market


FB
NTC
Flow on border DK2 > DK1
MW
600
400
200
0
−200
−400
−600
14
Mar
2022
15
16
17
18
19
20
21


DK2 > DK1 Average flow on border
200
175
150
125
100
75
50
25
0
FB
NTC
market


FB
NTC
Flow on border NO3 > SE2
MW
600
400
200
0
−200
14
Mar
2022
15
16
17
18
19
20
21


NO3 > SE2 Average flow on border
350
300
250
200
150
100
50
0
FB
NTC
market


FB
NTC
Flow on border NO2 > NL
MW
600
400
200
0
−200
−400
14
Mar
2022
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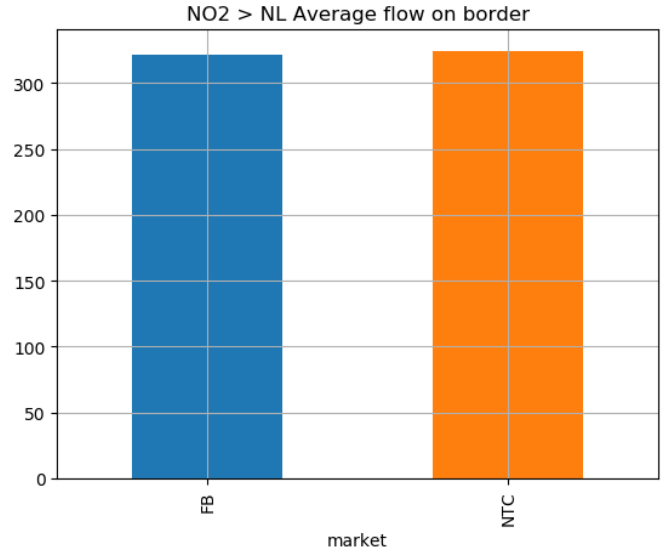
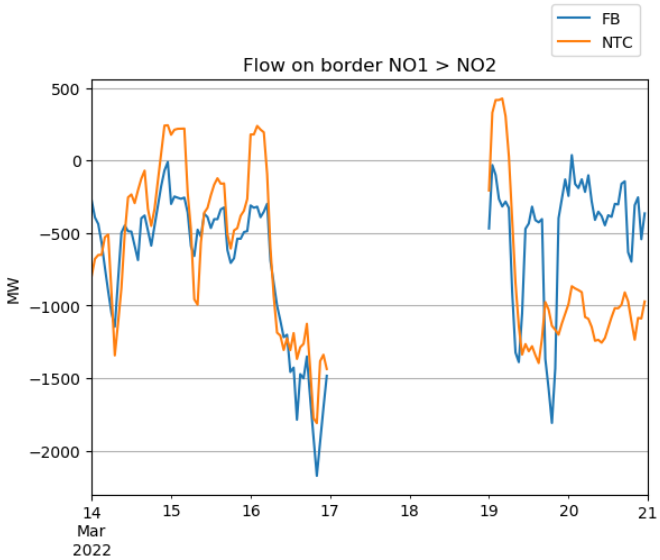
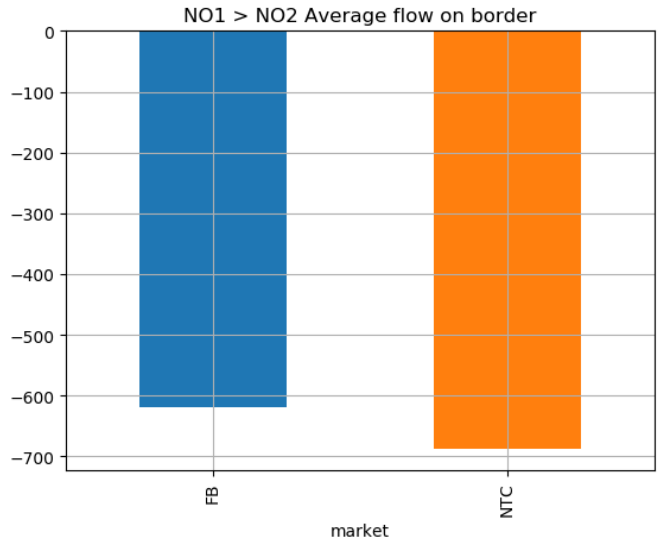
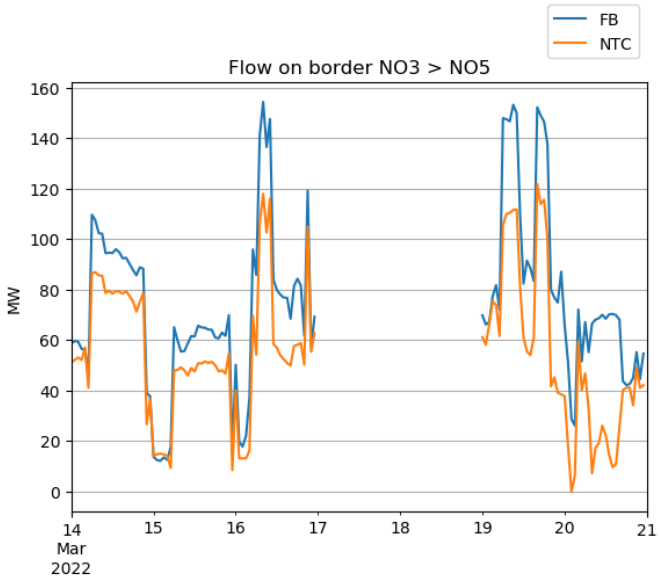
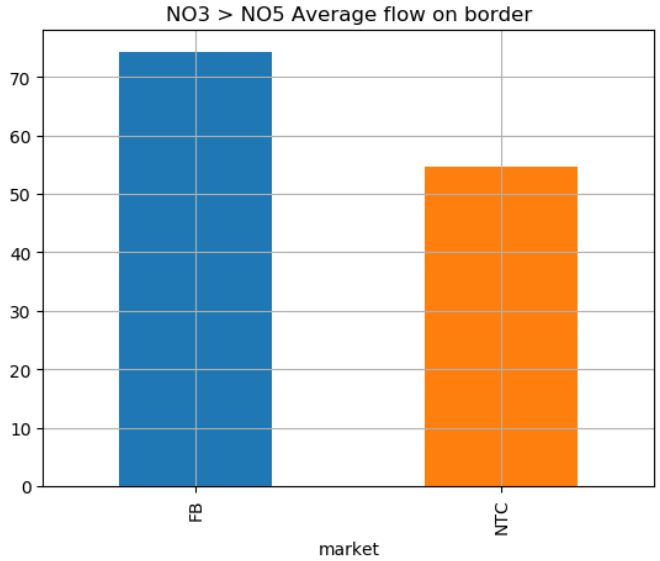
18
19
20
21

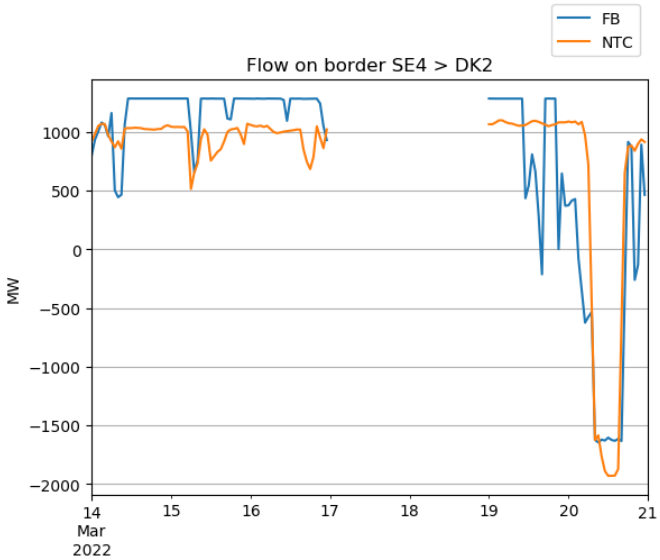

NO2 > NL Average flow on border
300
250
200
150
100
50
0
FB
NTC
market


FB
NTC
Flow on border NO1 > NO2
MW
500
0
−500
−1000
−1500
−2000
14
Mar
2022
15
16
17
18
19
20
21


NO1 > NO2 Average flow on border
0
−100
−200
−300
−400
−500
−600
−700
FB
NTC
market


FB
NTC
Flow on border NO3 > NO5
MW
160
140
120
100
80
60
40
20
0
14
Mar
2022
15
16
17
18
19
20
21


NO3 > NO5 Average flow on border
70
60
50
40
30
20
10
0
FB
NTC
market


FB
NTC
Flow on border SE4 > DK2
MW
1000
500
0
−500
−1000
−1500
−2000
14
Mar
2022
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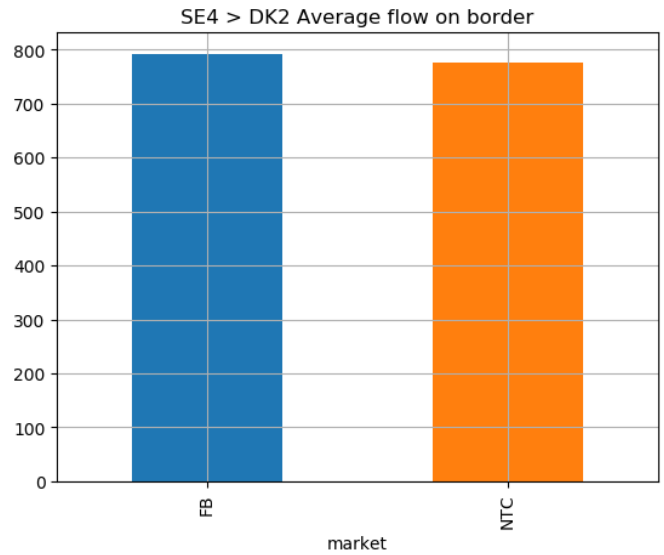
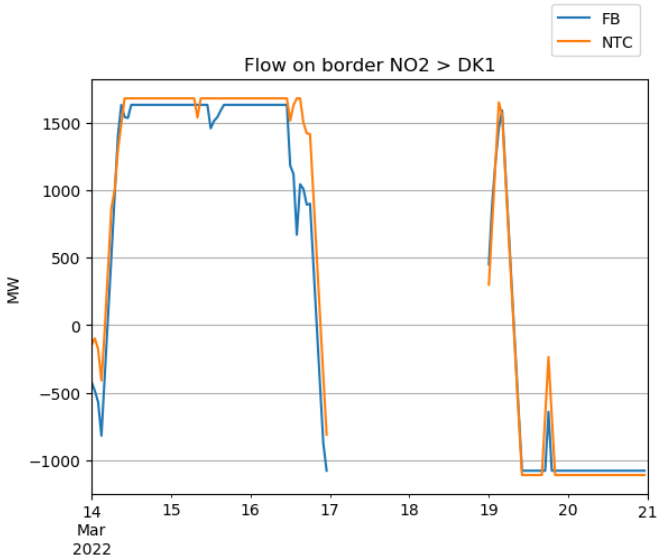
21


SE4 > DK2 Average flow on border
800
700
600
500
400
300
200
100
0
FB
NTC
market


FB
NTC
Flow on border NO2 > DK1
MW
1500
1000
500
0
−500
−1000
14
Mar
2022
15
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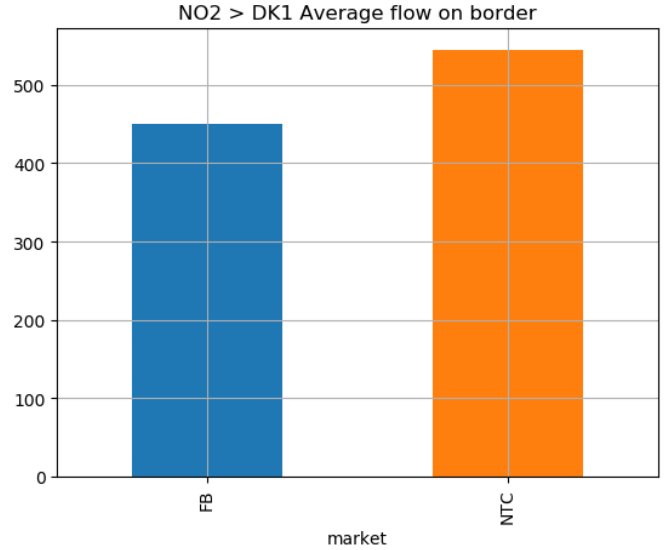
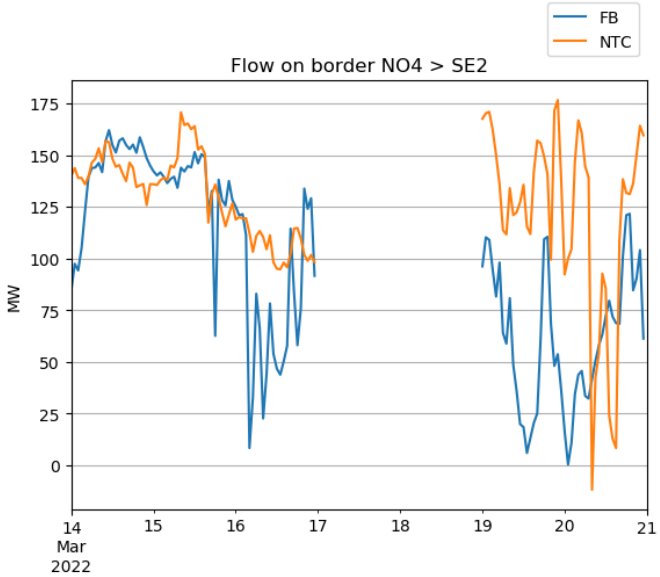
20
21


NO2 > DK1 Average flow on border
500
400
300
200
100
0
FB
NTC
market


FB
NTC
Flow on border NO4 > SE2
MW
175
150
125
100
75
50
25
0
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2022
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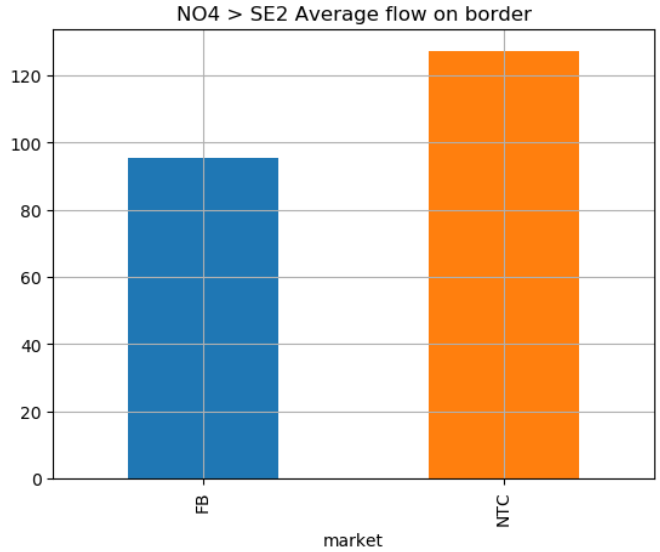
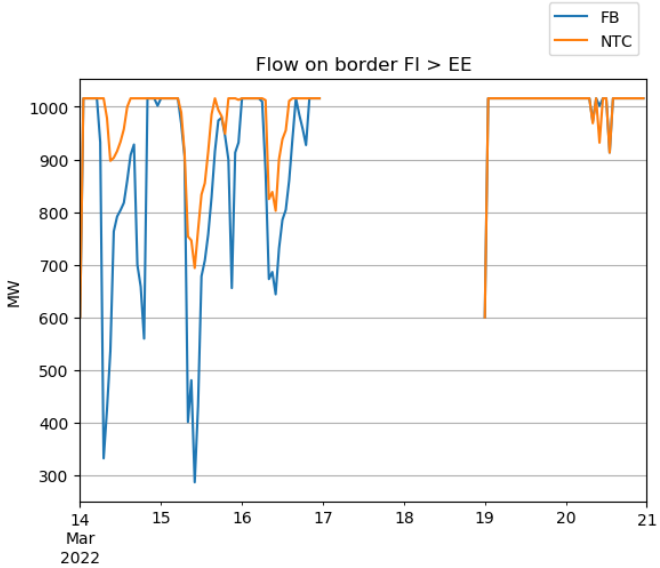

NO4 > SE2 Average flow on border
120
100
80
60
40
20
0
FB
NTC
market


FB
NTC
Flow on border FI > EE
MW
1000
900
800
700
600
500
400
300
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2022
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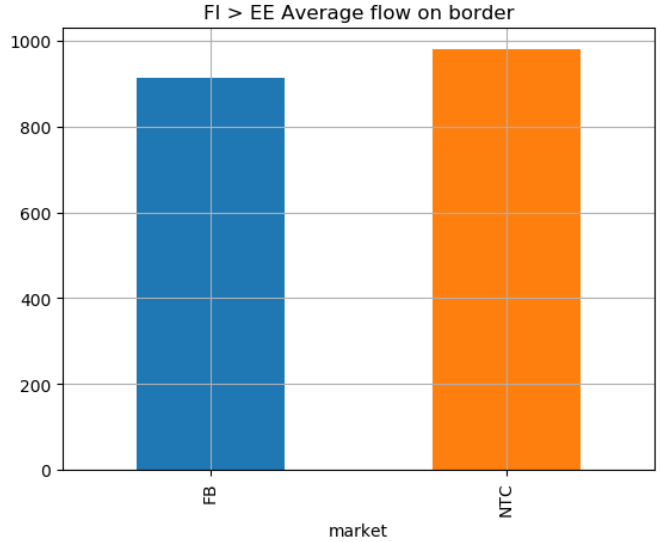
FI > EE Average flow on border
1000
800
600
400
200
0
FB
NTC
market