



## **CWE Flow Factor Competition, part II: Quantitative Analysis (Appendix)**

**By order of ACM, BNetzA, CRE, CREG, ILR and e-Control**

**29 September 2017**

**Version: Final Report**

***Disclaimer: The outcomes of the study are only supported by CWE NRAs and have not been reviewed yet by CWE Partners.***





# CWE FLOW FACTOR COMPETITION, PART II: QUANTITATIVE ANALYSIS (APPENDIX)

INDICATORS OF FFC AND MODELING  
INACCURACIES

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29 September 2017

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# CONTENT

<b>Appendix: Detailed monitoring results</b>	<b>4</b>	
<b>A.0</b>	<b>Boxplots</b>	<b>4</b>
<b>A.1</b>	<b>FFC aspects</b>	<b>5</b>
A.1.1	Classification	5
A.1.2	Net exchange positions (+ = export)	6
A.1.3	Prices	8
A.1.4	External constraints	8
A.1.5	Final Adjustment Value	11
A.1.6	Flow-Based Intuitive patch	13
A.1.7	Volume of flow-based domain	15
A.1.8	LTA inclusion	16
A.1.9	CBCOs	17
A.1.10	FRM	19
A.1.11	Fmax	21
A.1.12	Remedial actions	22
<b>A.2</b>	<b>FFC Indicators</b>	<b>41</b>
A.2.1	FFC frequency	41
A.2.2	FFC severity	42
A.2.3	FFC systematics	45
A.2.4	FFC sensitivities	47
A.2.5	Typical FFC cases	54
<b>A.3</b>	<b>Modelling accuracies</b>	<b>56</b>
A.3.1	Bidding zone positions	56
A.3.2	Nodal positions	58
A.3.3	GSKs	82
A.3.4	Flows	109

# Appendix: Detailed monitoring results

Preliminary note: For ease of readability in graphs the bidding zone "DE/AT/LU" is commonly abbreviated by "DE".

## A.0 Boxplots

Boxplots are used throughout this report to show a simple representation of the statistical characteristics of an observed phenomenon. From the observed samples first a best fitting normal distribution is found and the 1 and 99 percentile values of this fitted normal distribution are represented by the vertical extreme lines of the boxplot. Observations outside the 1 to 99 percentile range are shown as individual dots. Other vertical lines in the boxplot represent the 25, 50 and 75 percentile value of the observed distribution. The range from the 1 percentile value of the fitted normal distribution to the 25 percentile value of the observed distribution is represented by a vertical line, as is the range from the 75 percentile value of the observed distribution to the 99 percentile value of the fitted normal distribution. The observed range of samples from the 25 percentile to the 50 percentile value is represented by a rectangle as is the range from the 50 to 75 percentile of the observed distribution. This is graphically explained in the figure below.

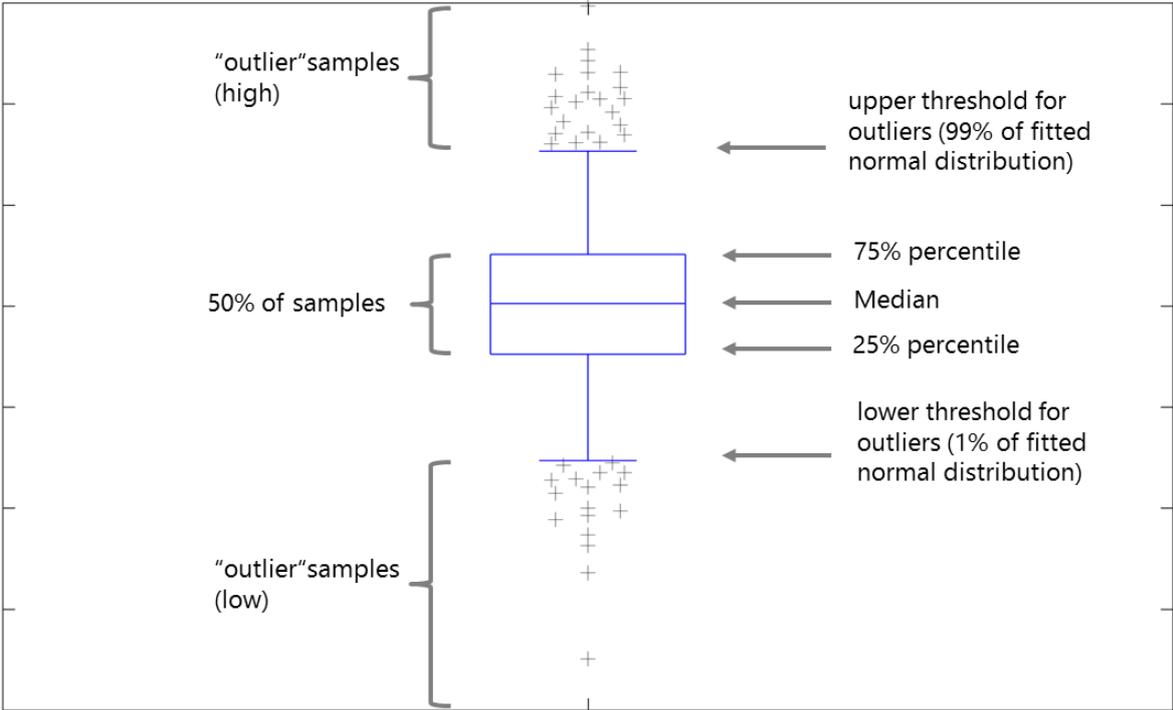
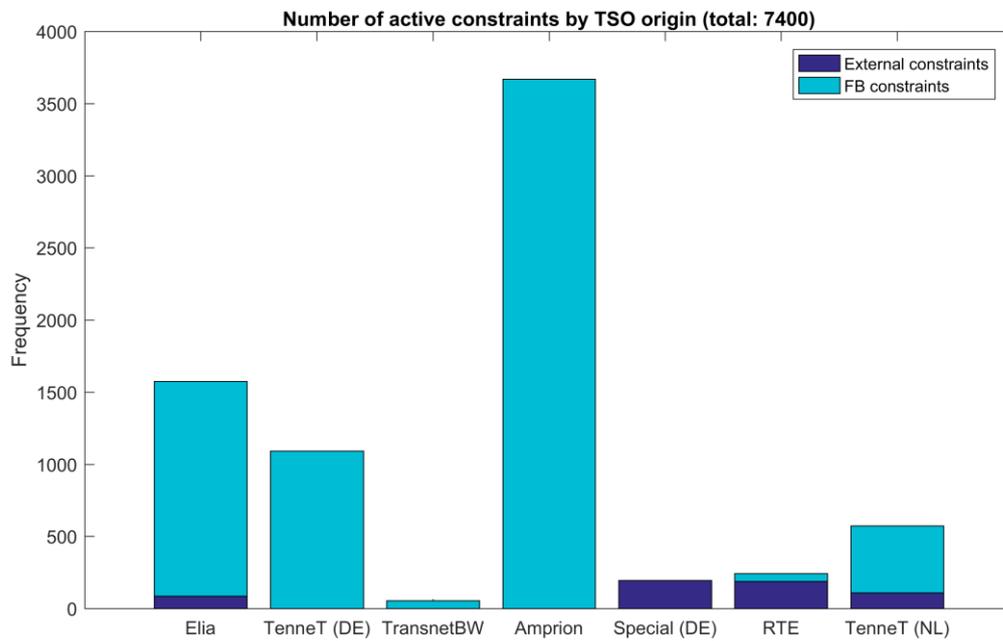
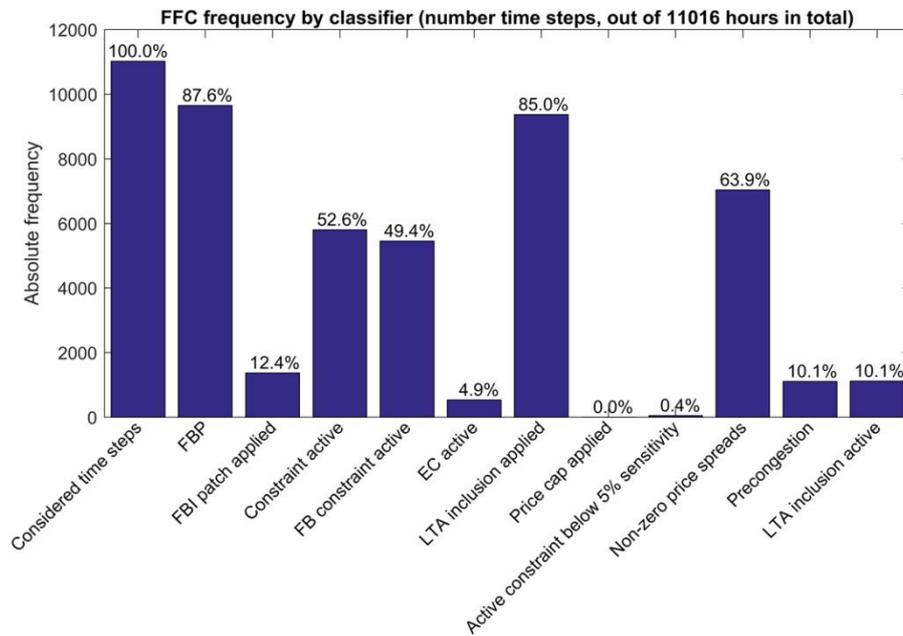


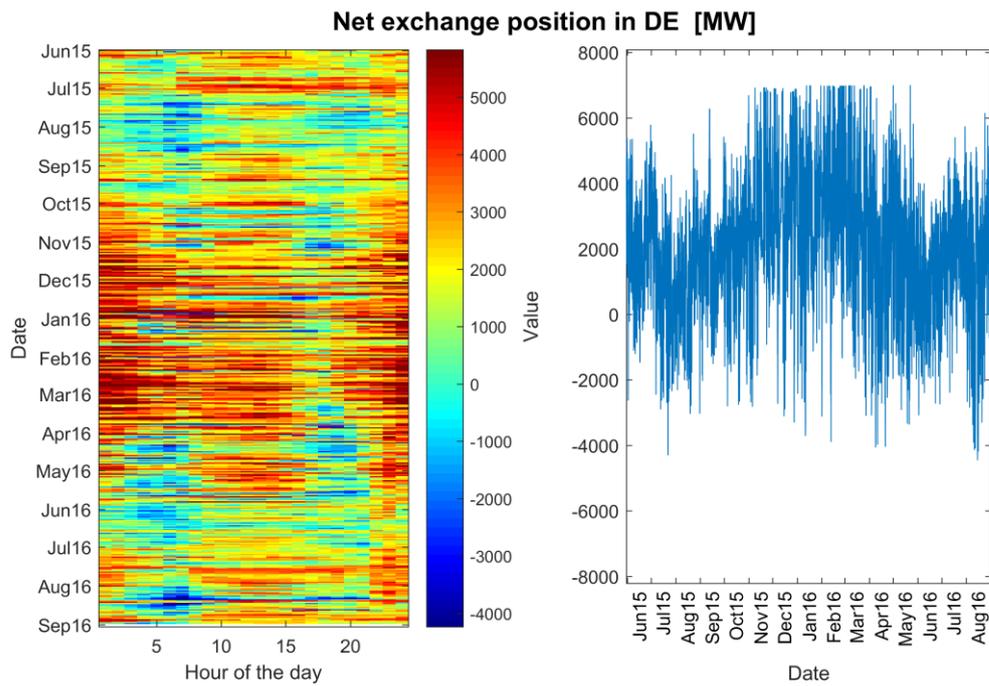
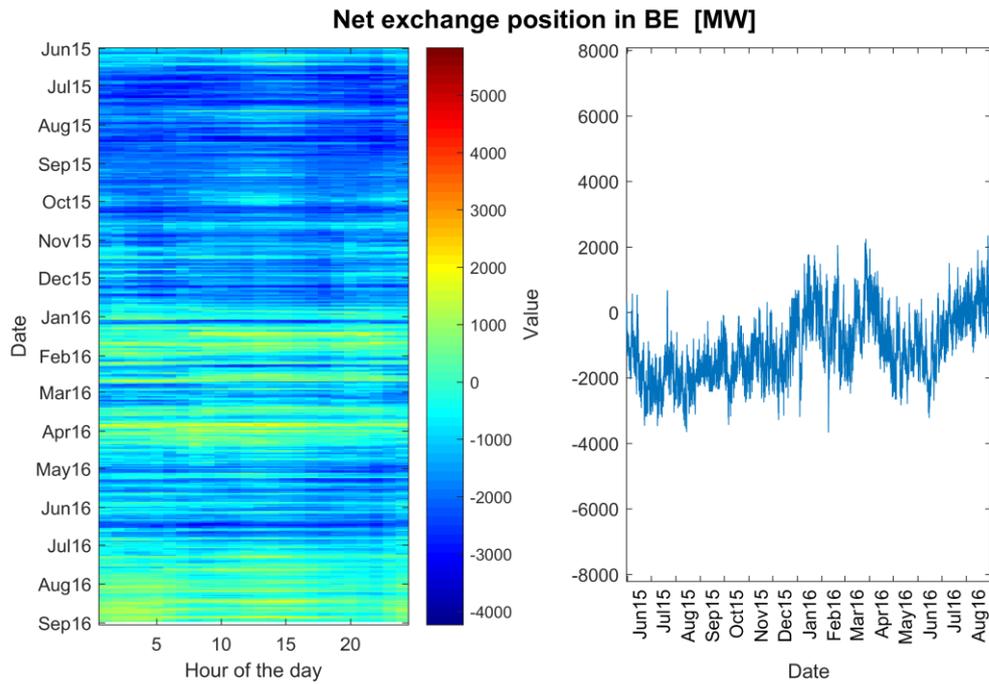
Figure 1: Explanation of the use of a boxplot

## A.1 FFC aspects

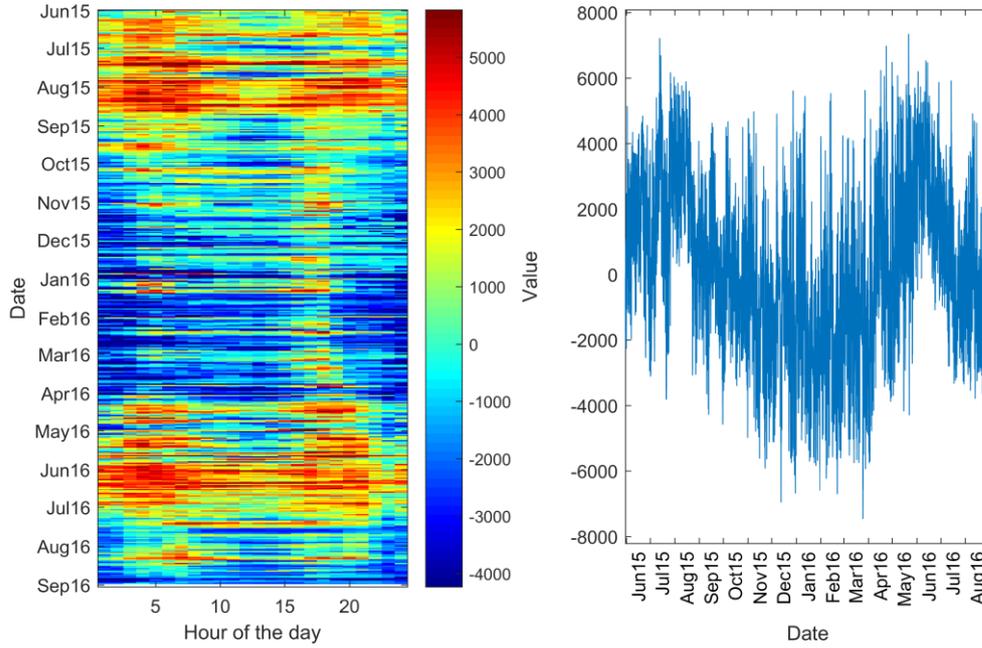
### A.1.1 Classification



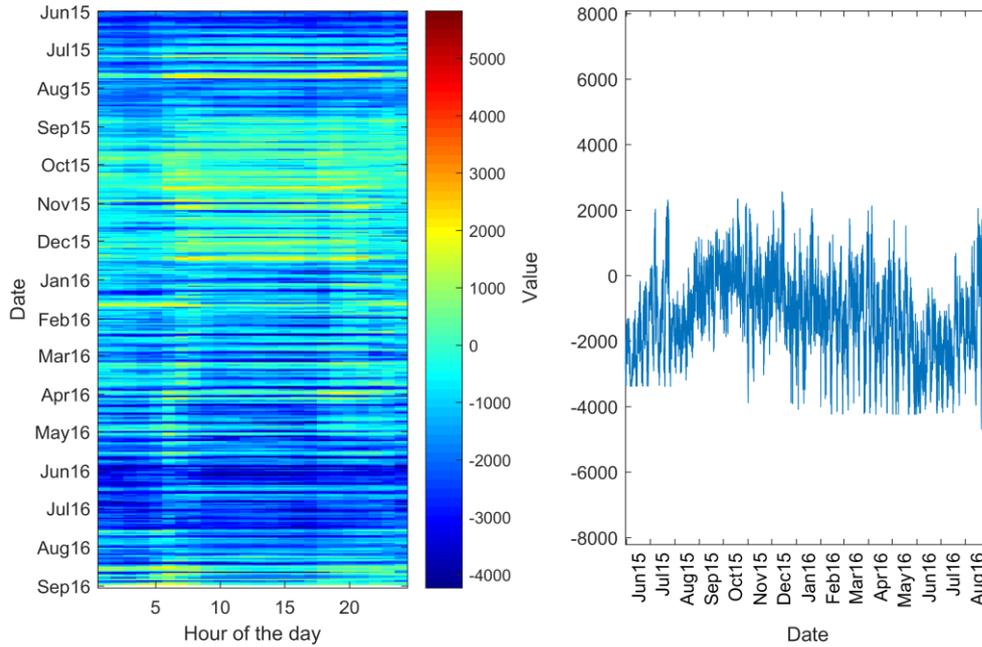
## A.1.2 Net exchange positions (+ = export)



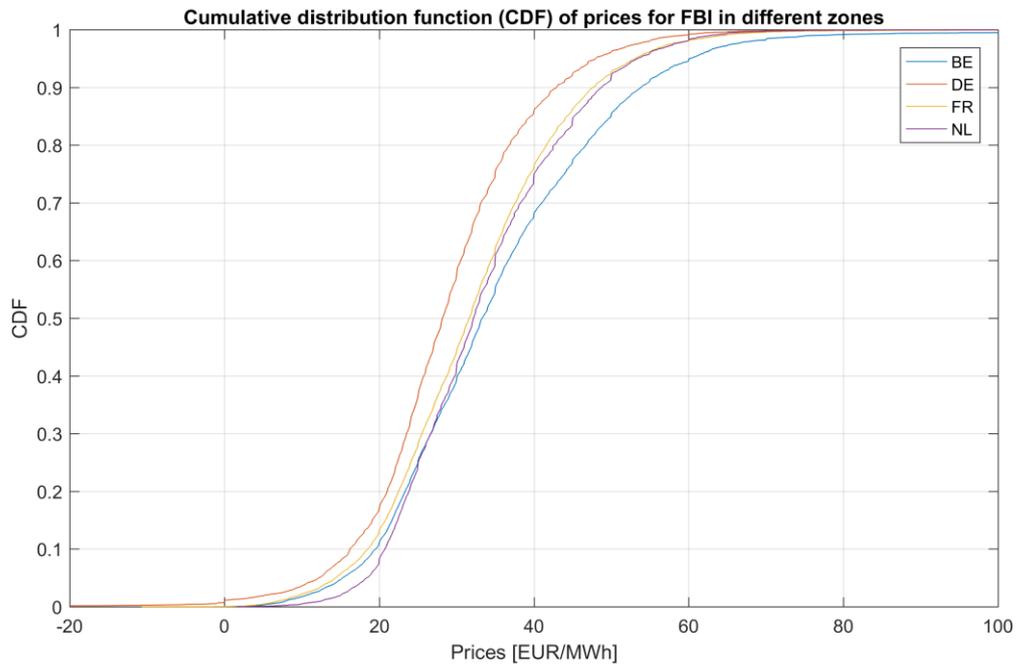
### Net exchange position in FR [MW]



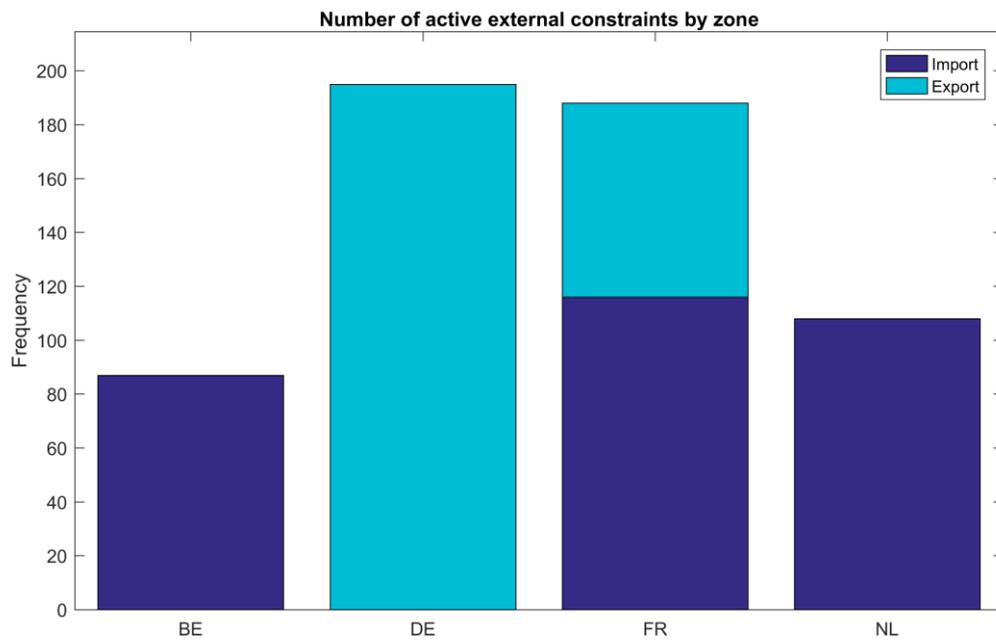
### Net exchange position in NL [MW]



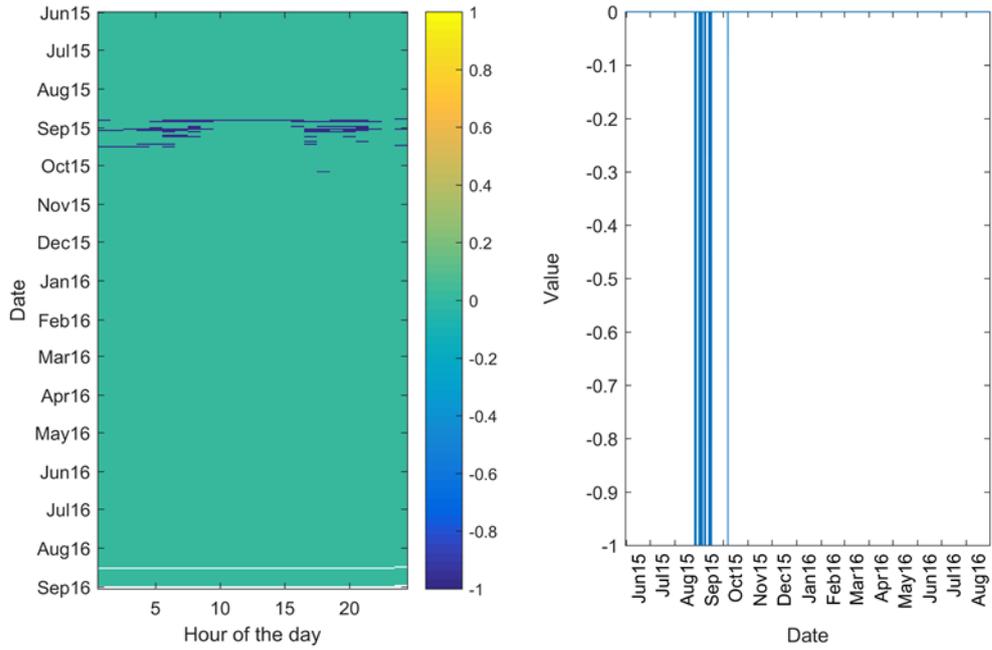
### A.1.3 Prices



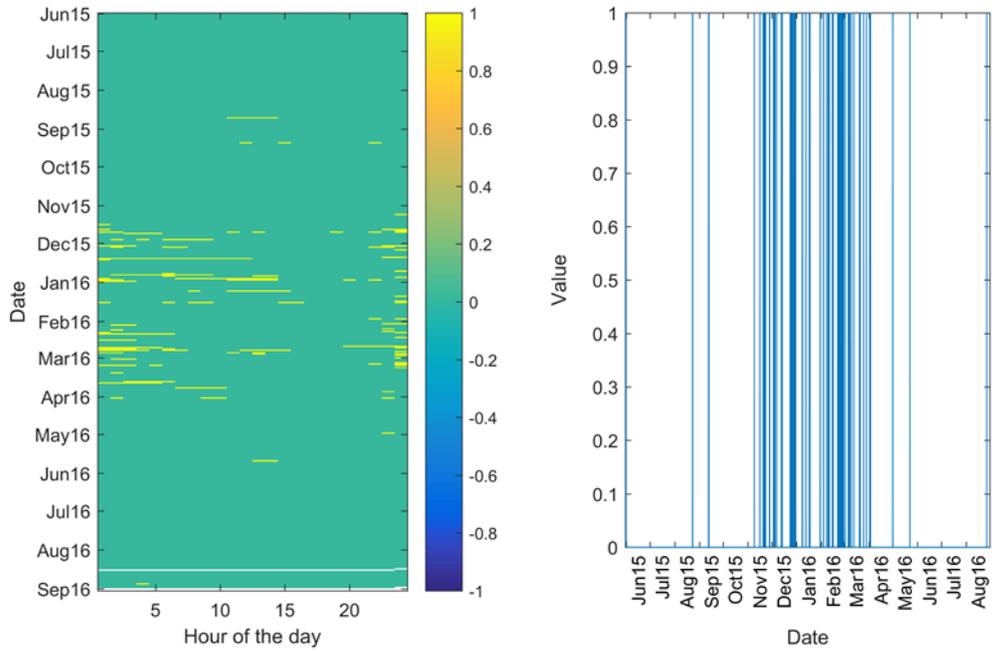
### A.1.4 External constraints



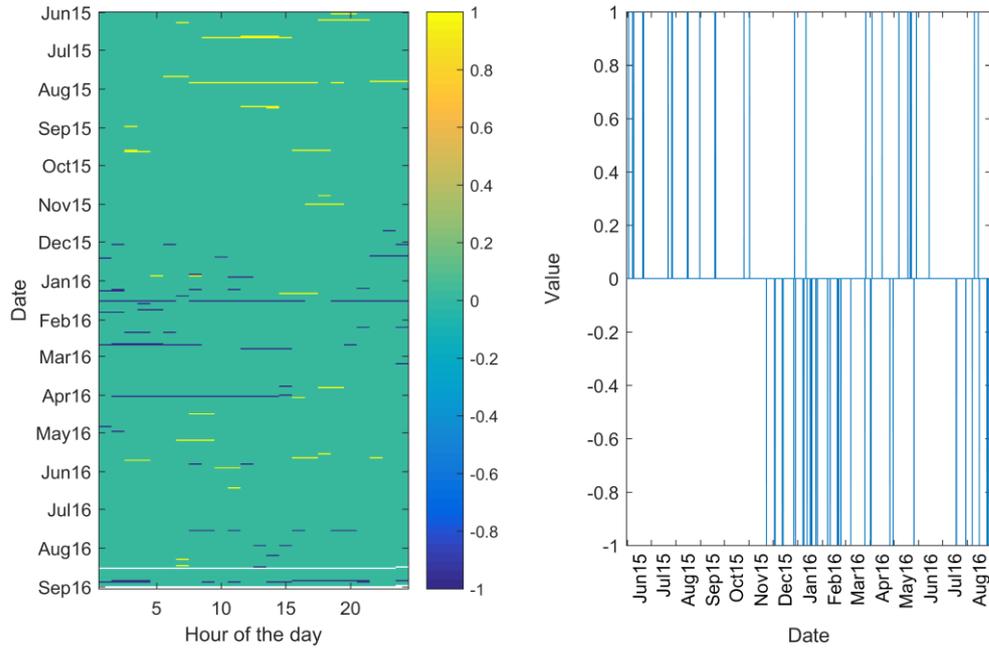
**External constraint active from BE [1 for export, -1 for import]**



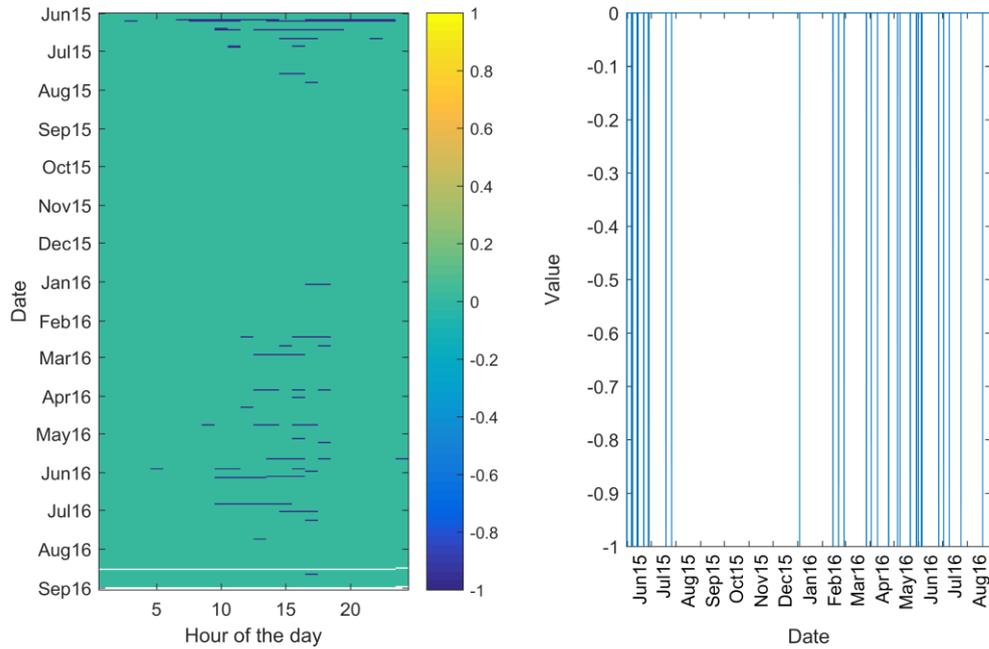
**External constraint active from DE [1 for export, -1 for import]**



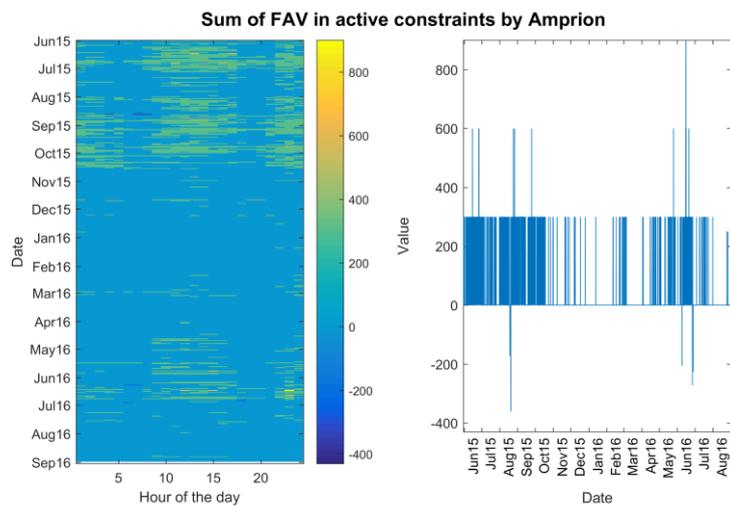
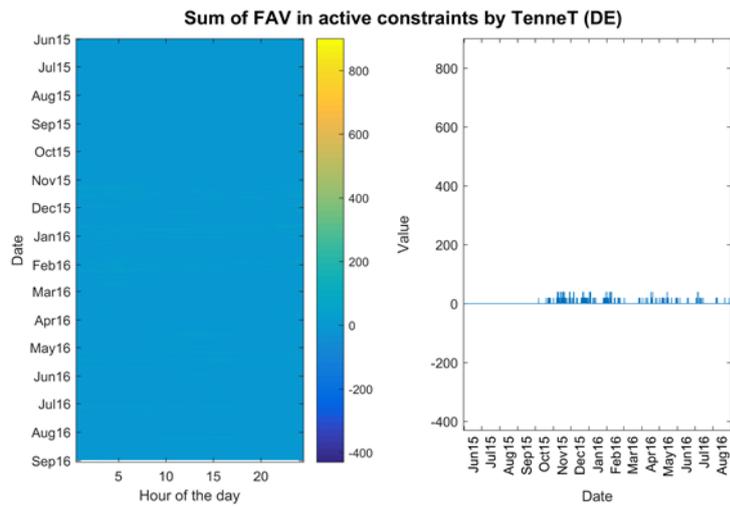
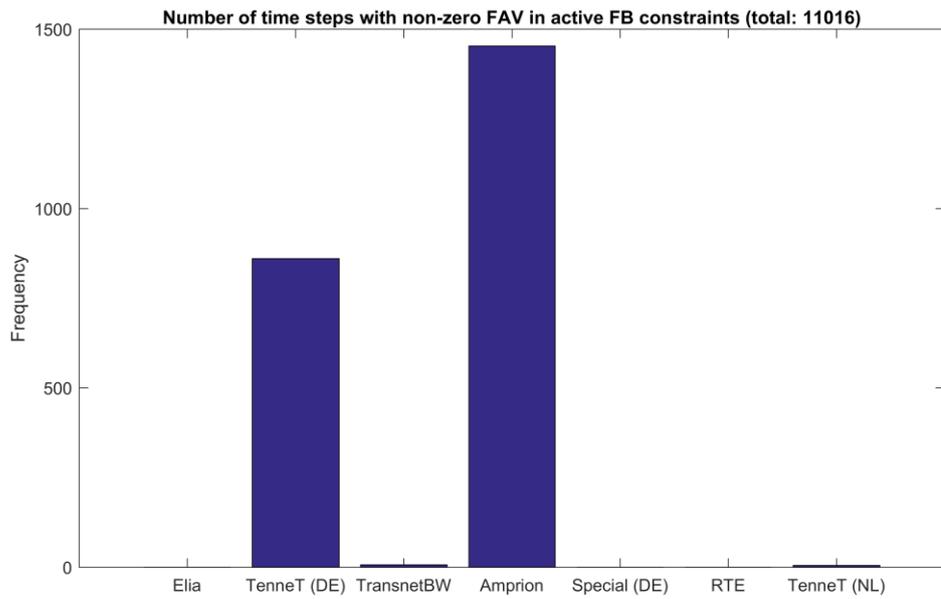
**External constraint active from FR [1 for export, -1 for import]**

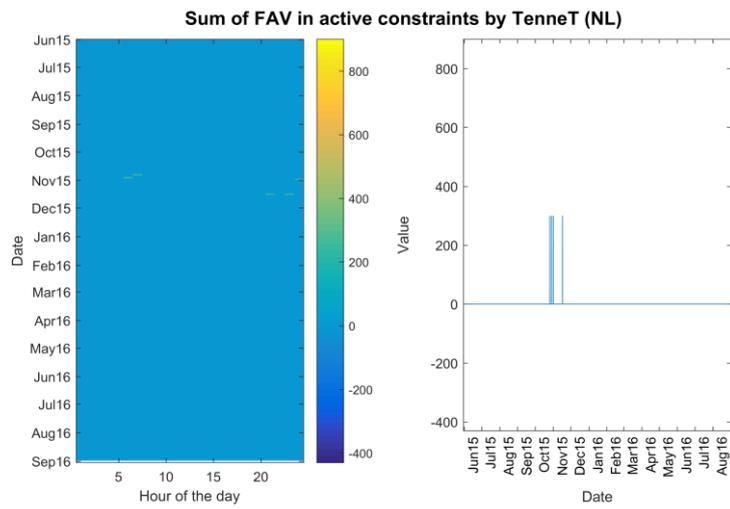
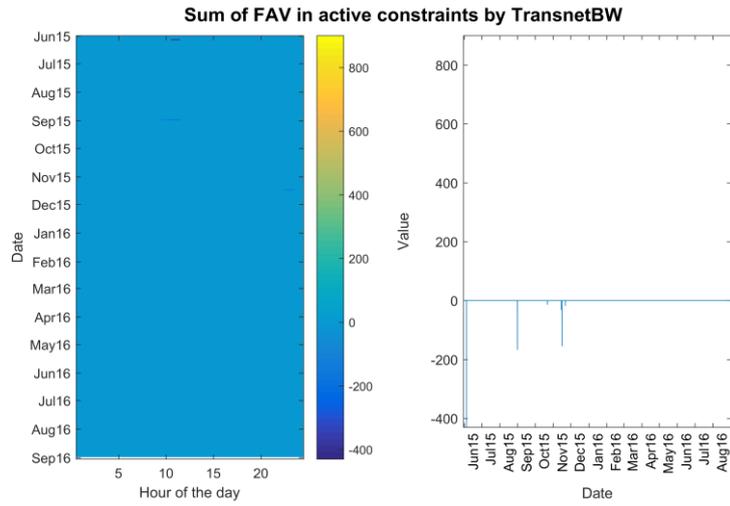


**External constraint active from NL [1 for export, -1 for import]**

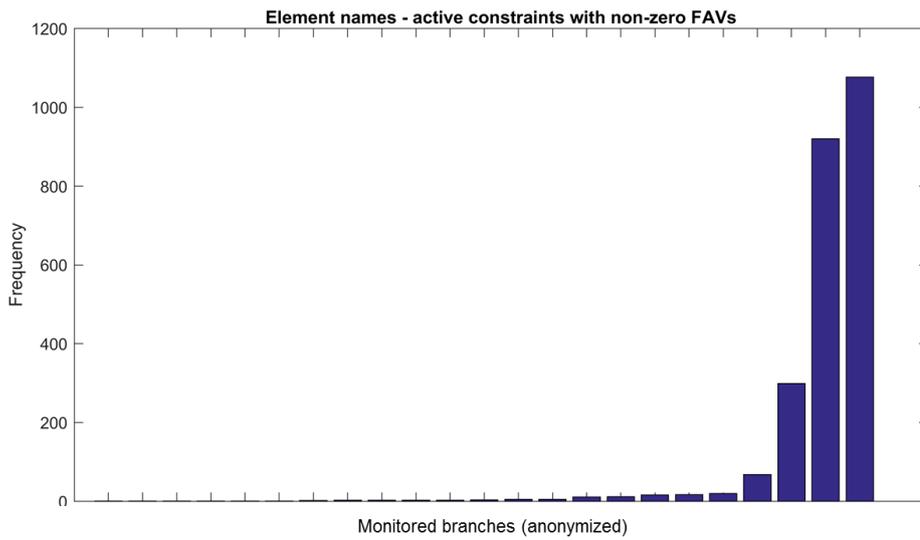


## A.1.5 Final Adjustment Value

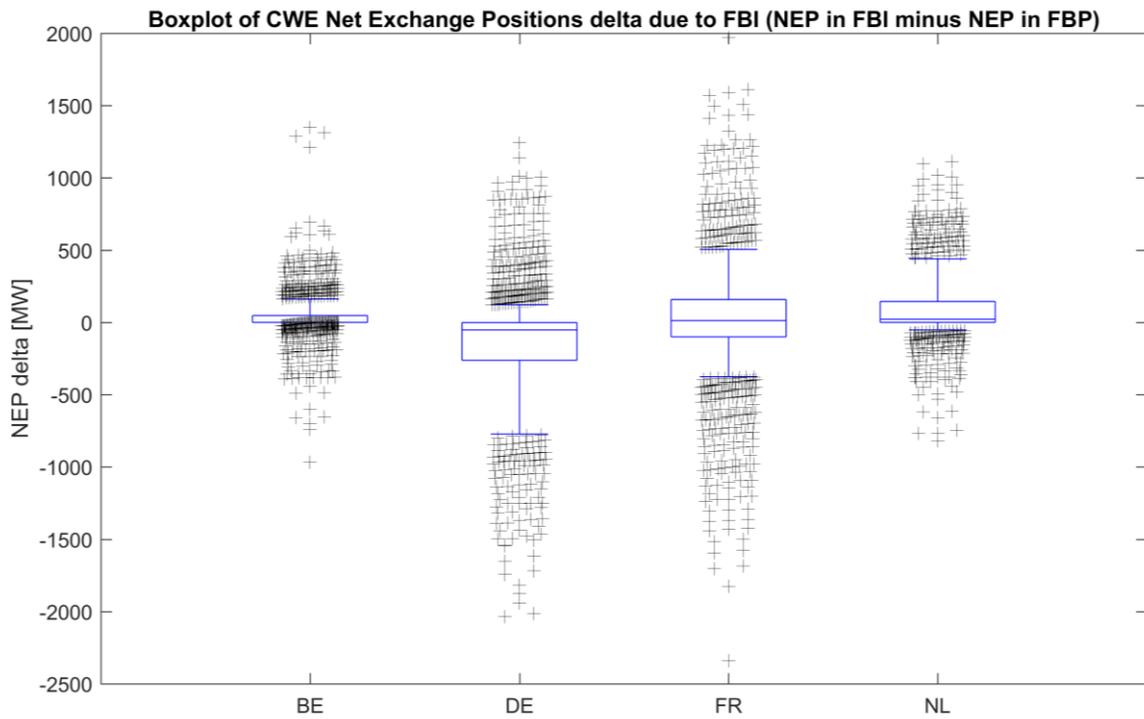
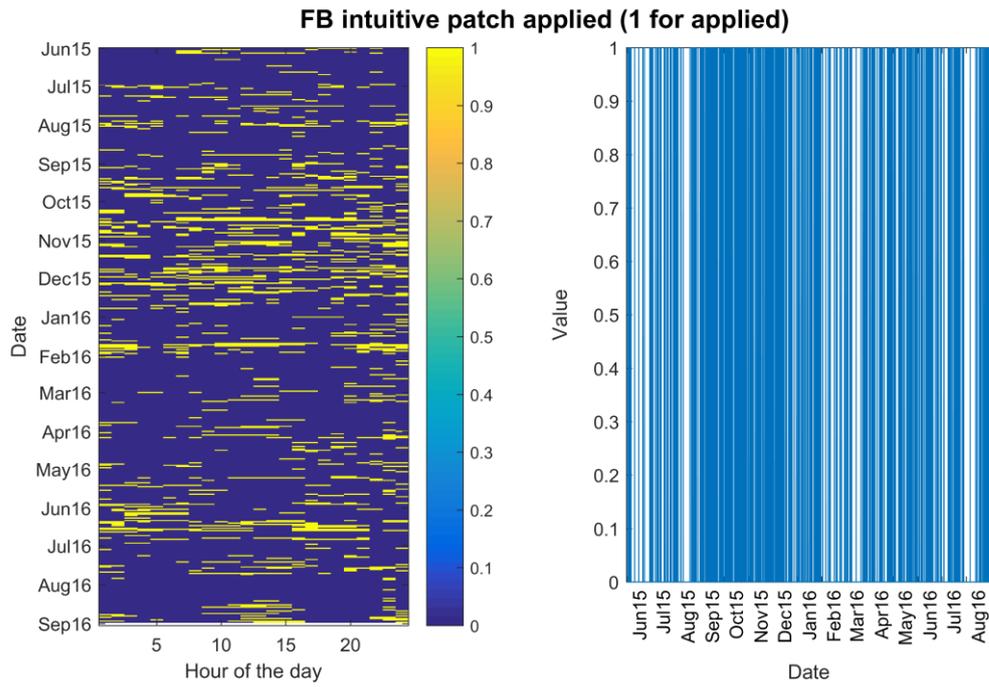


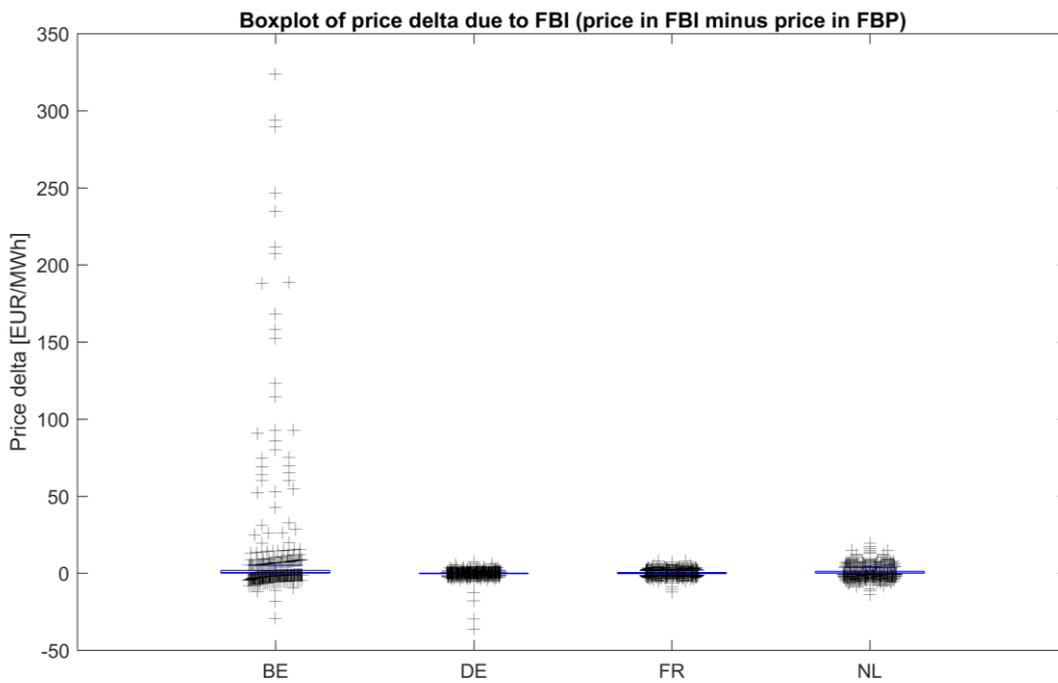
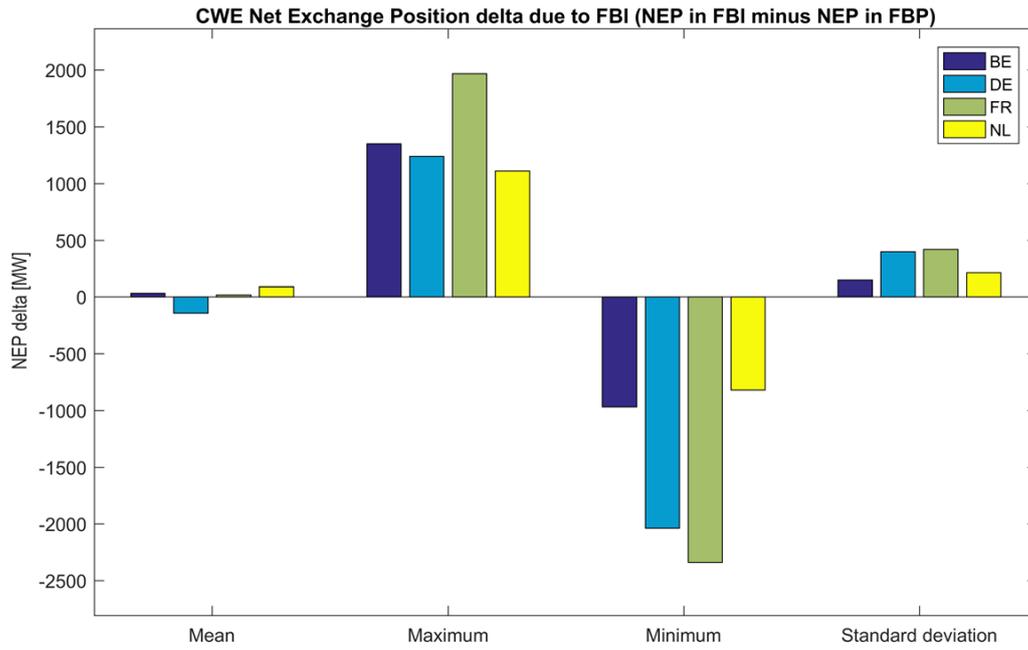


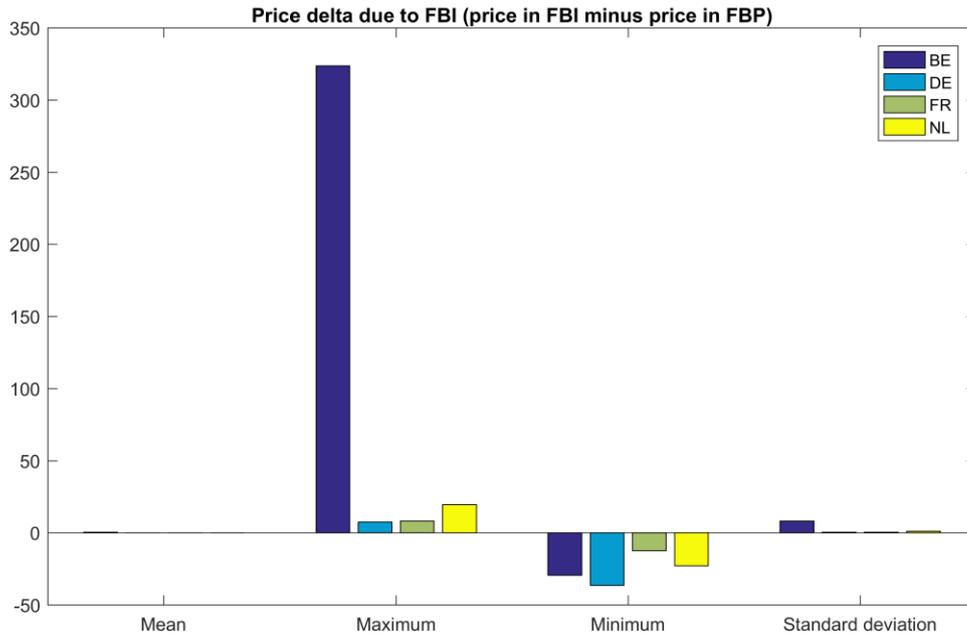
## Final Adjustment Values in constraining FB domain (summed)



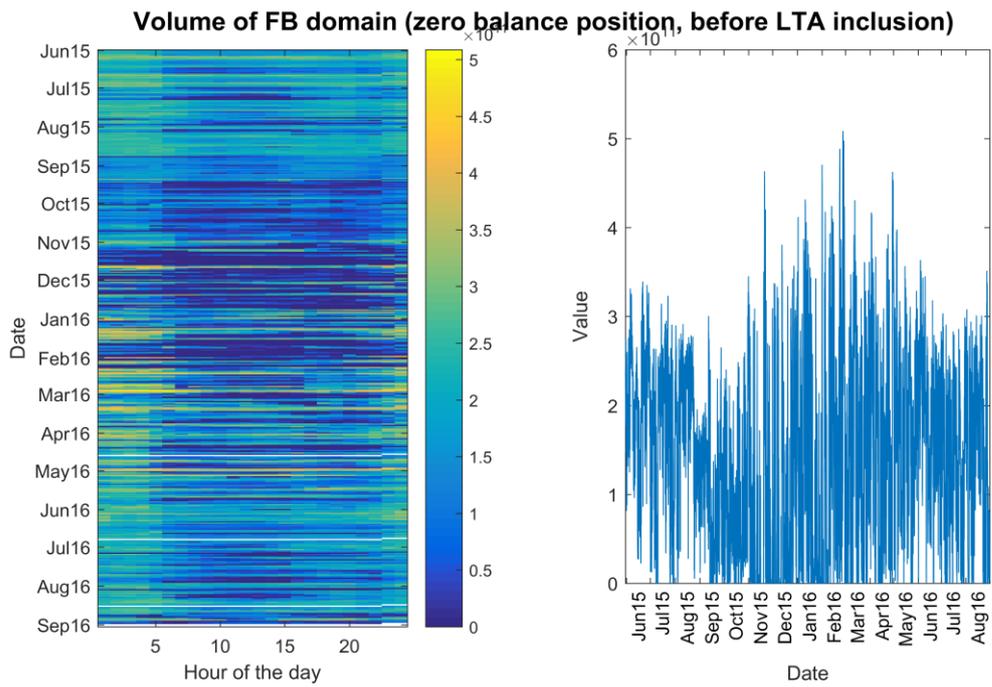
## A.1.6 Flow-Based Intuitive patch



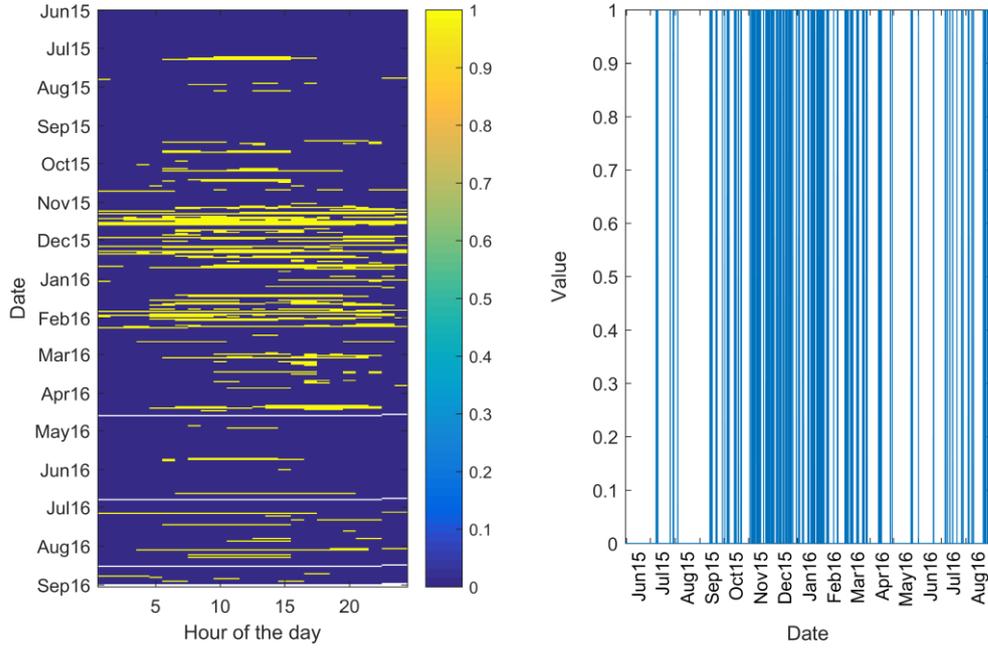




### A.1.7 Volume of flow-based domain



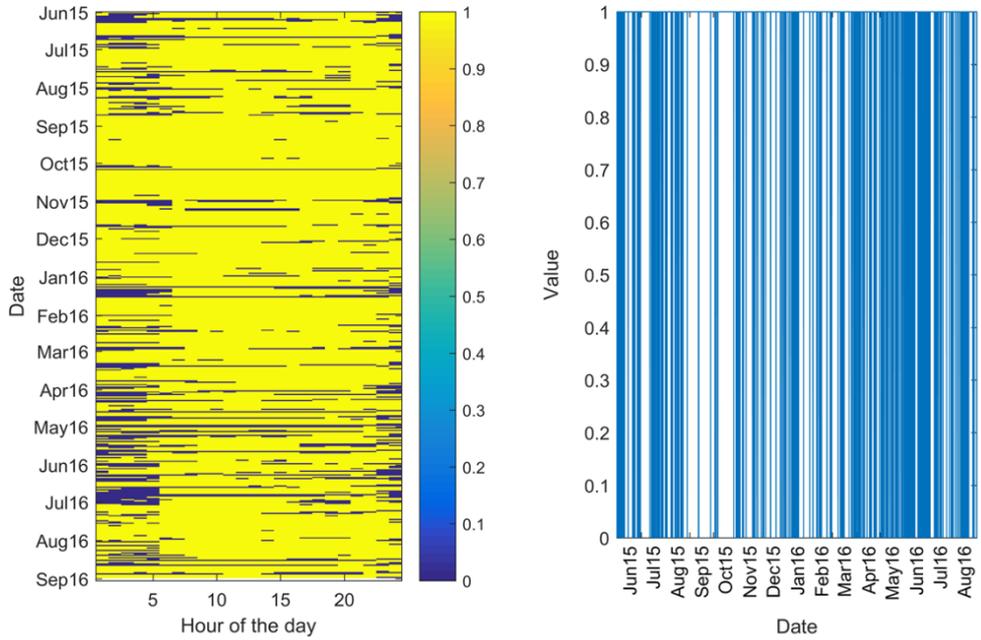
### Empty FB domain (zero balance position, before LTA inclusion)



### A.1.8 LTA inclusion

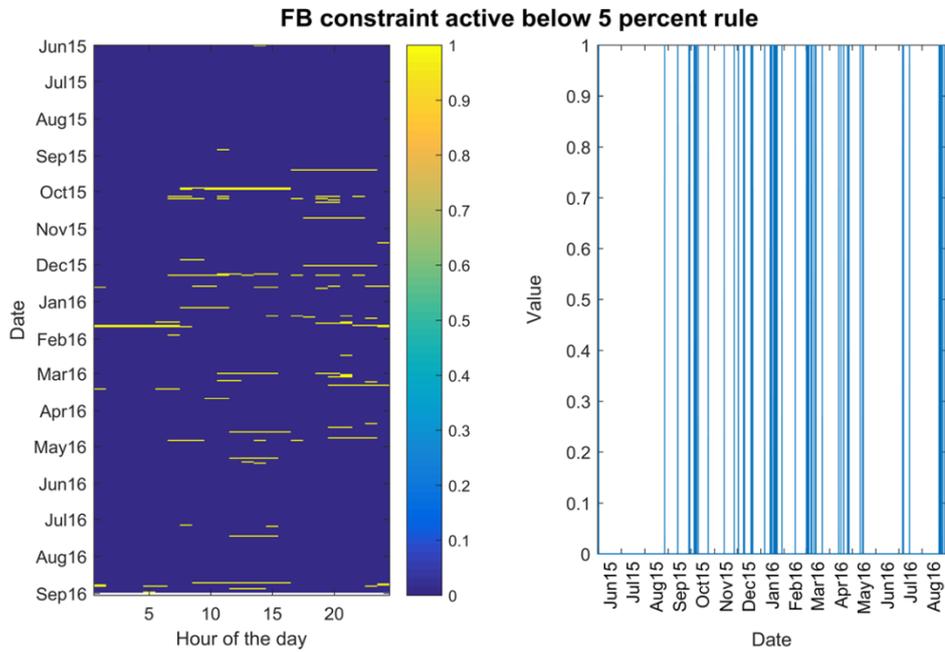
„1“ indicates domain has been increased

### LTA inclusion applied

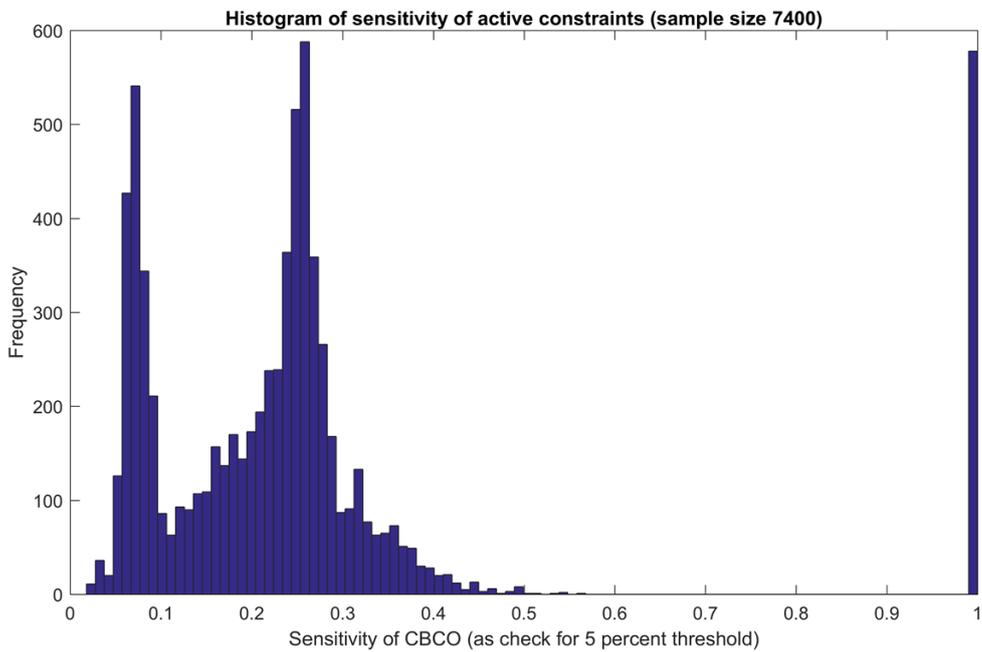


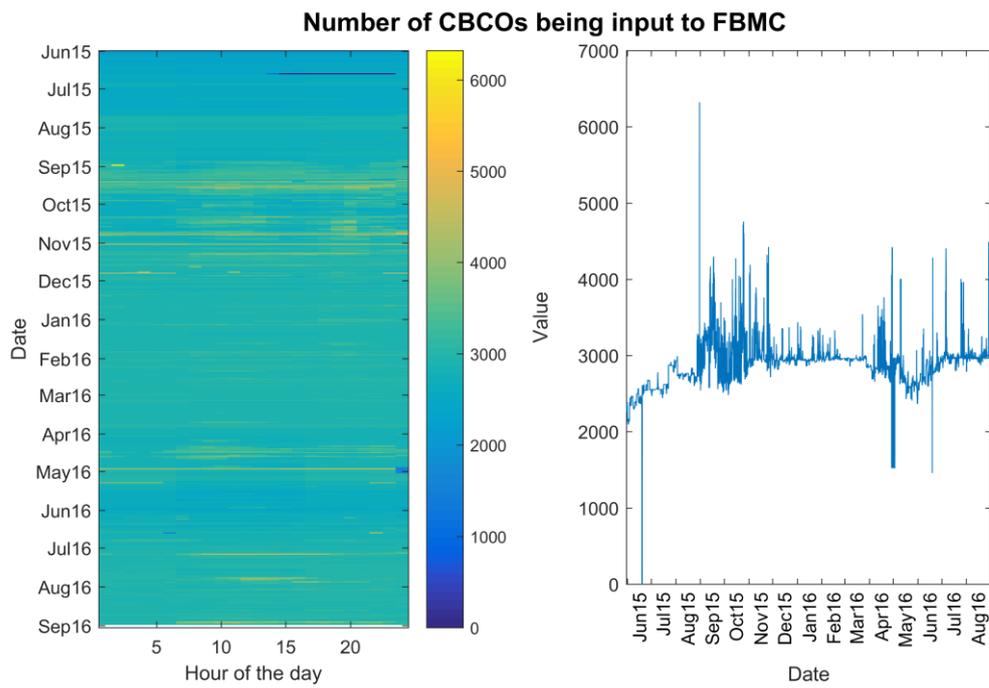
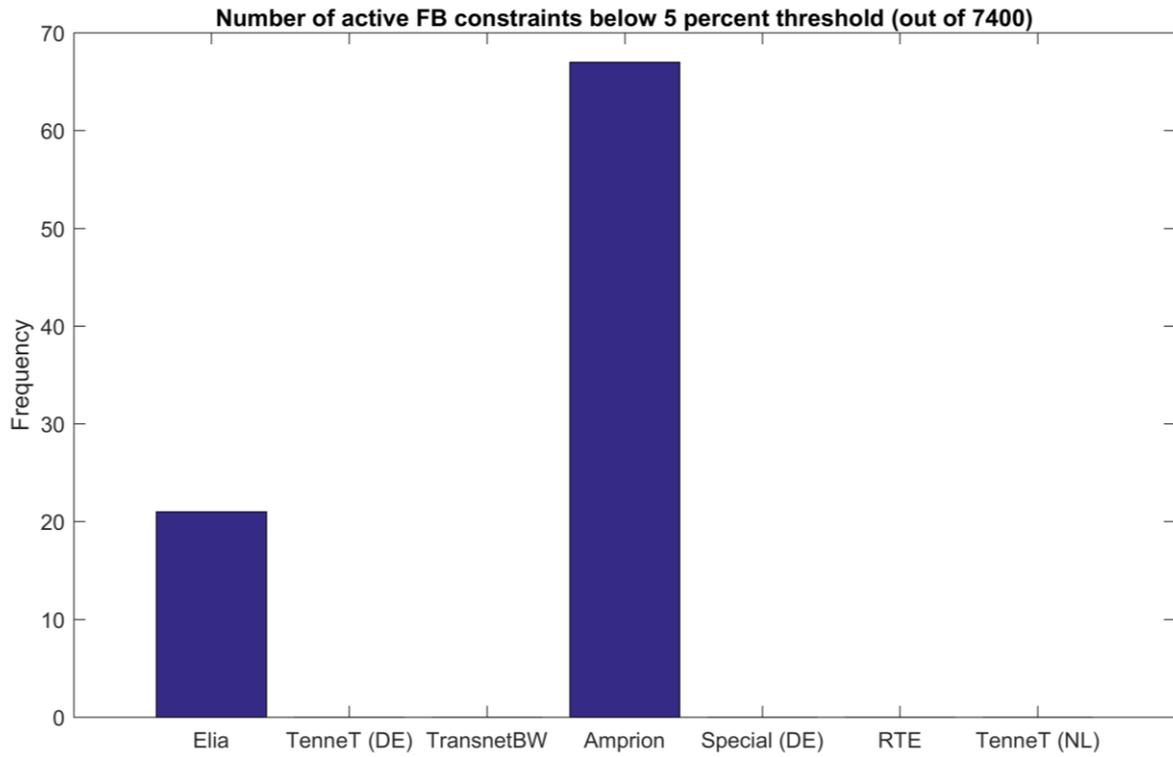
A.1.9 CBCOs

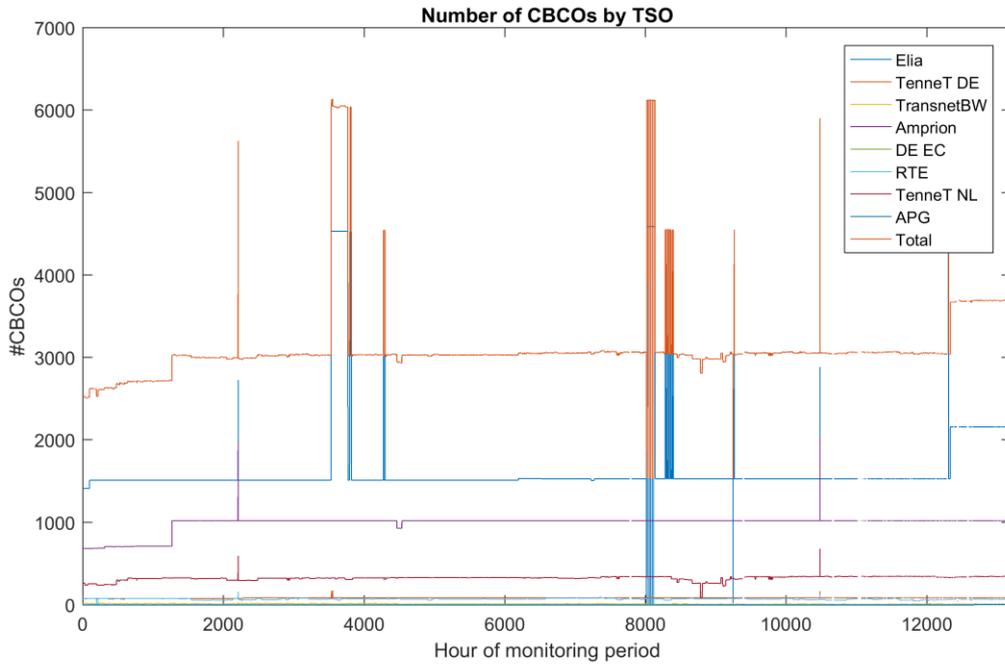
„1“ indicates active FB constraint below 5% sensitivity has been observed



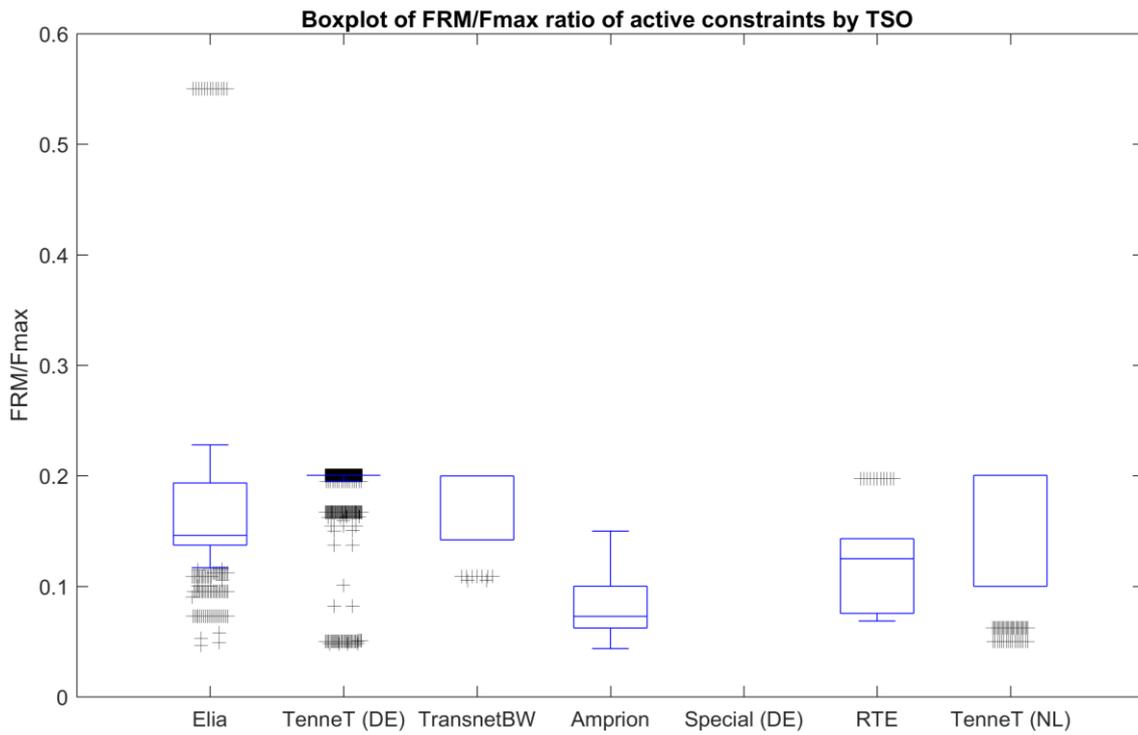
$$\text{Sensitivity} = \max(\text{PTDF}_{z1,z2}) - \min(\text{PTDF}_{z1,z2})$$



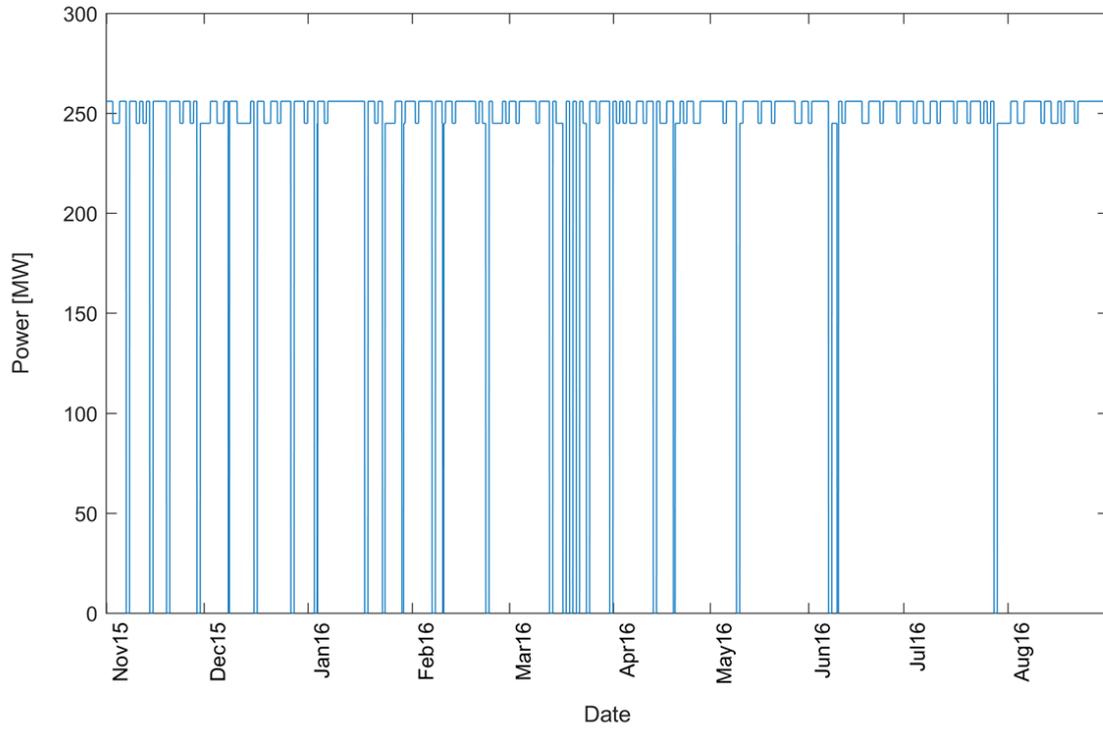




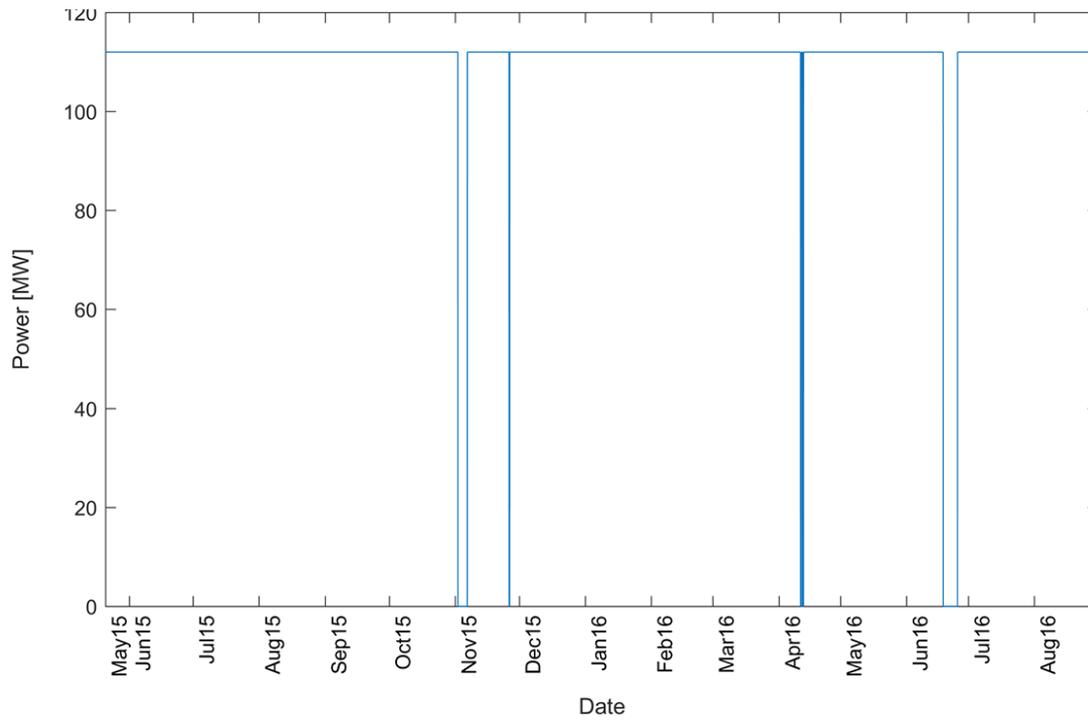
#### A.1.10 FRM



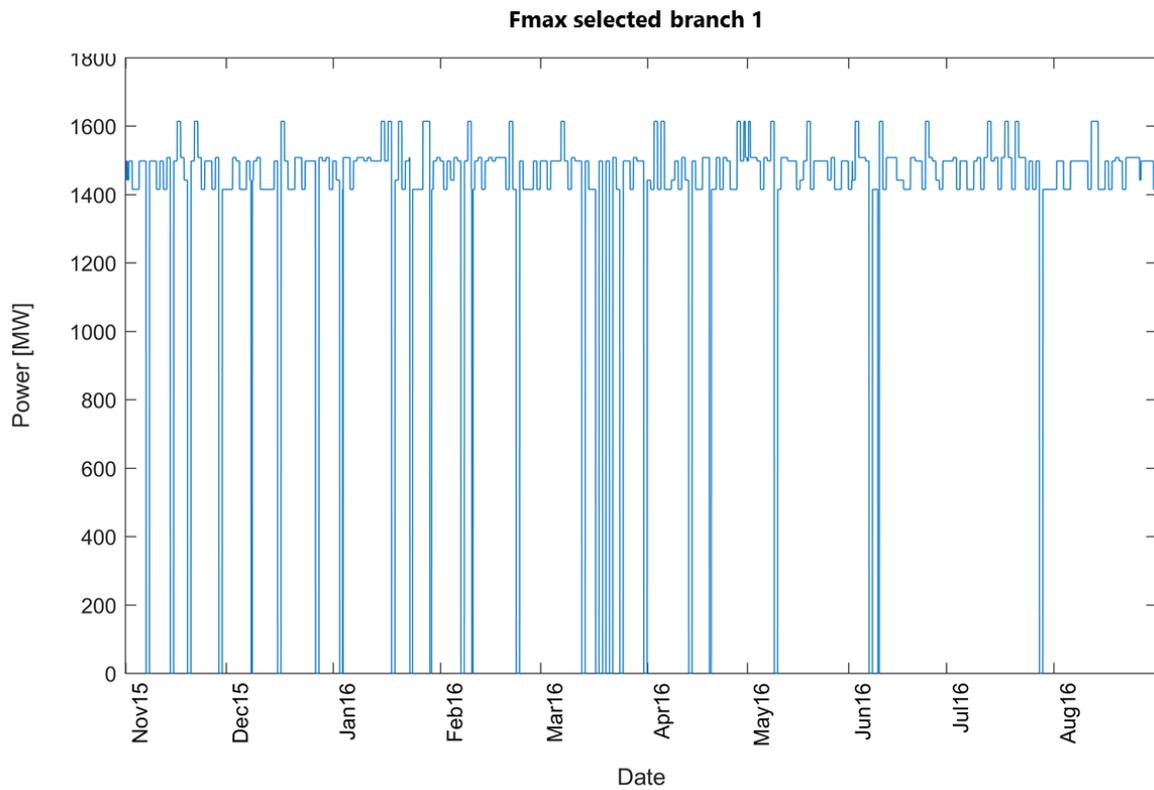
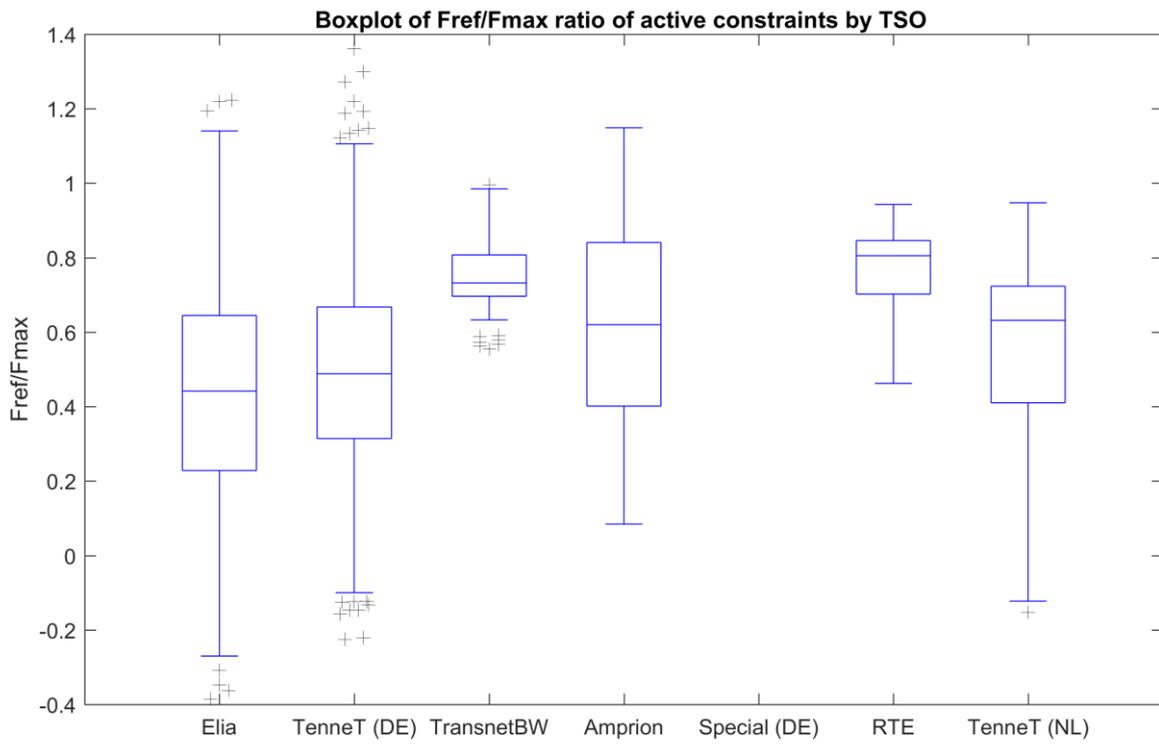
**FRM selected branch 1**

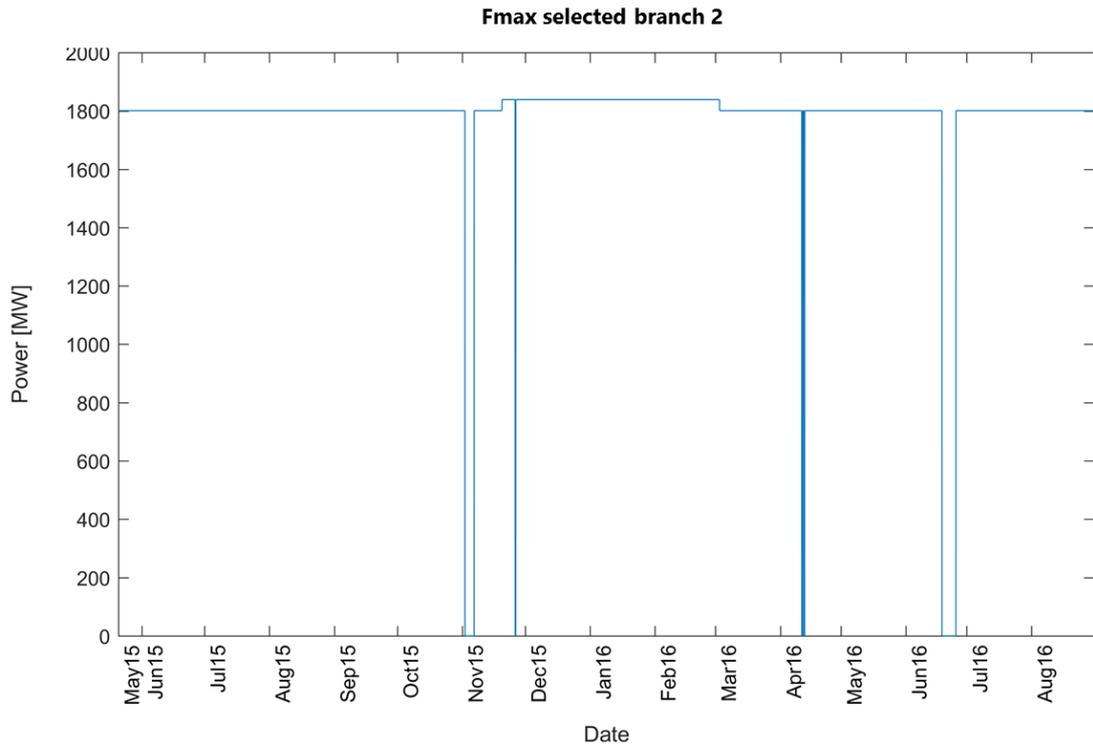


**FRM selected branch 2**

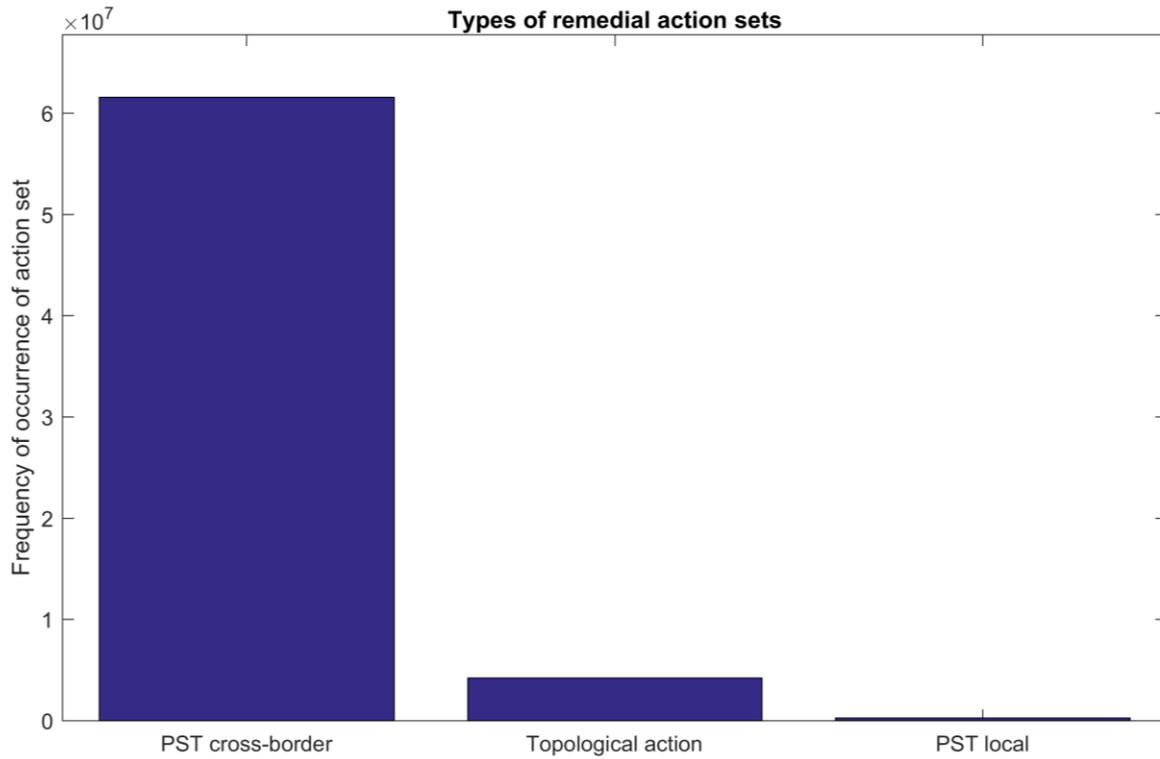


### A.1.11 Fmax

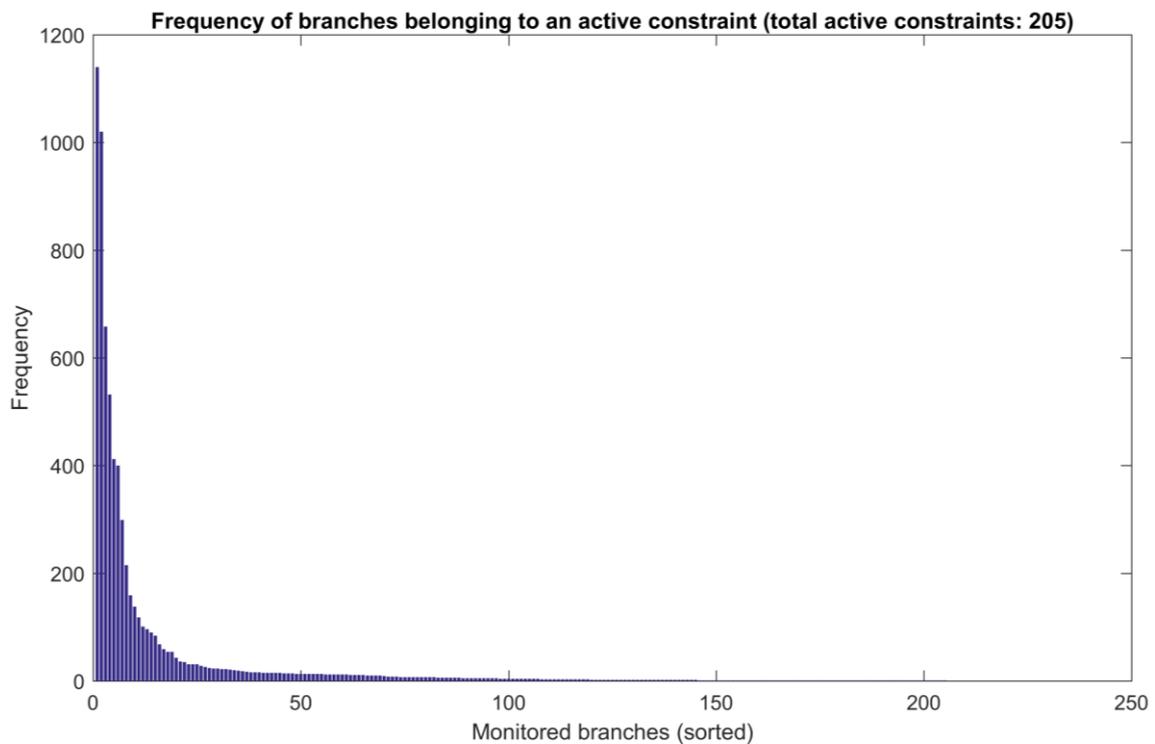
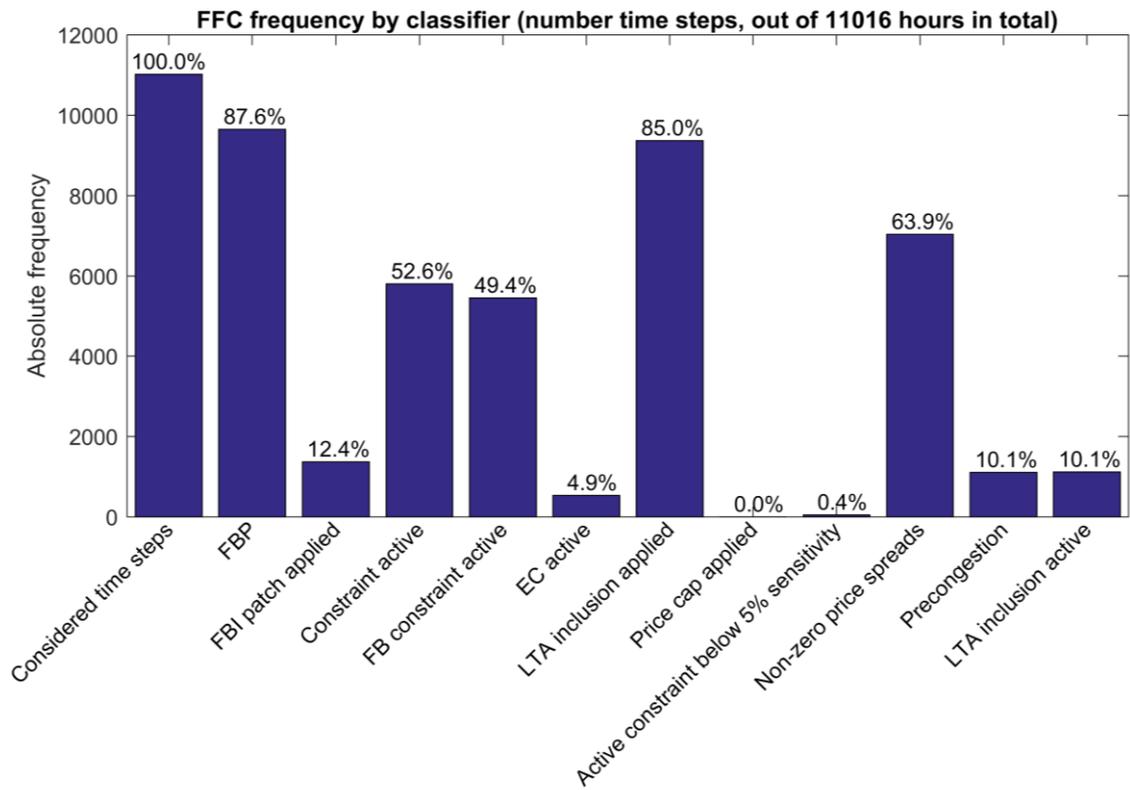




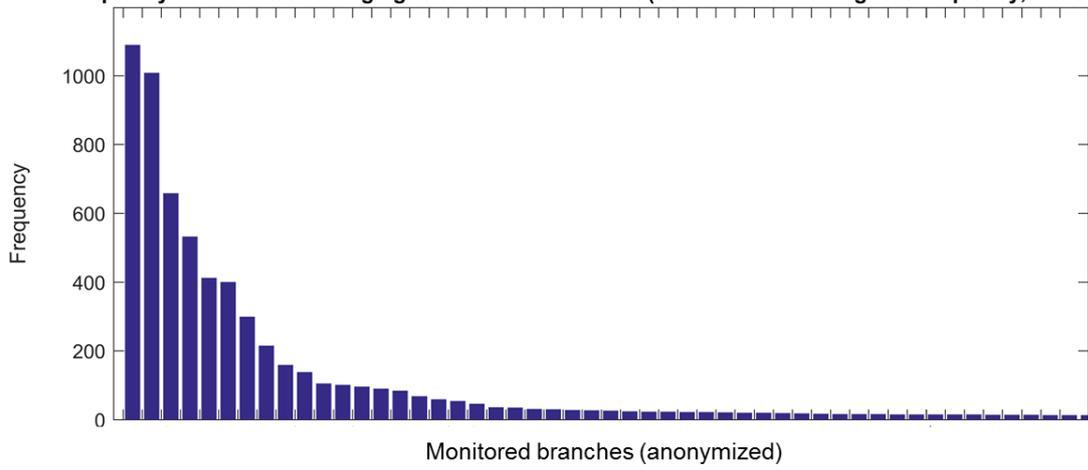
#### A.1.12 Remedial actions



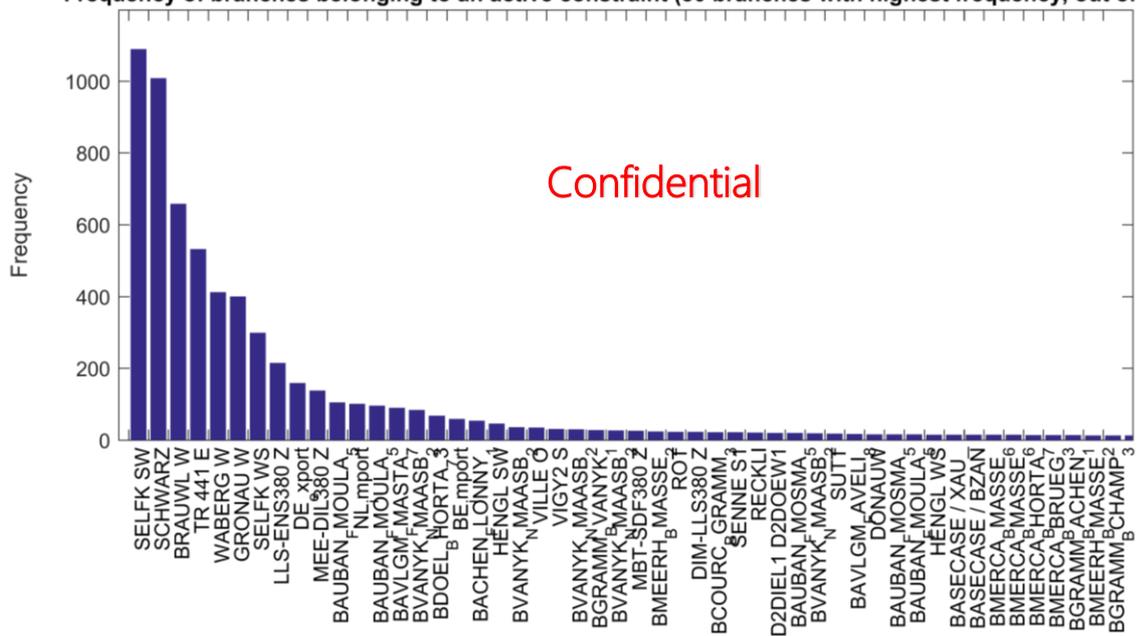
## A.1 Indicators

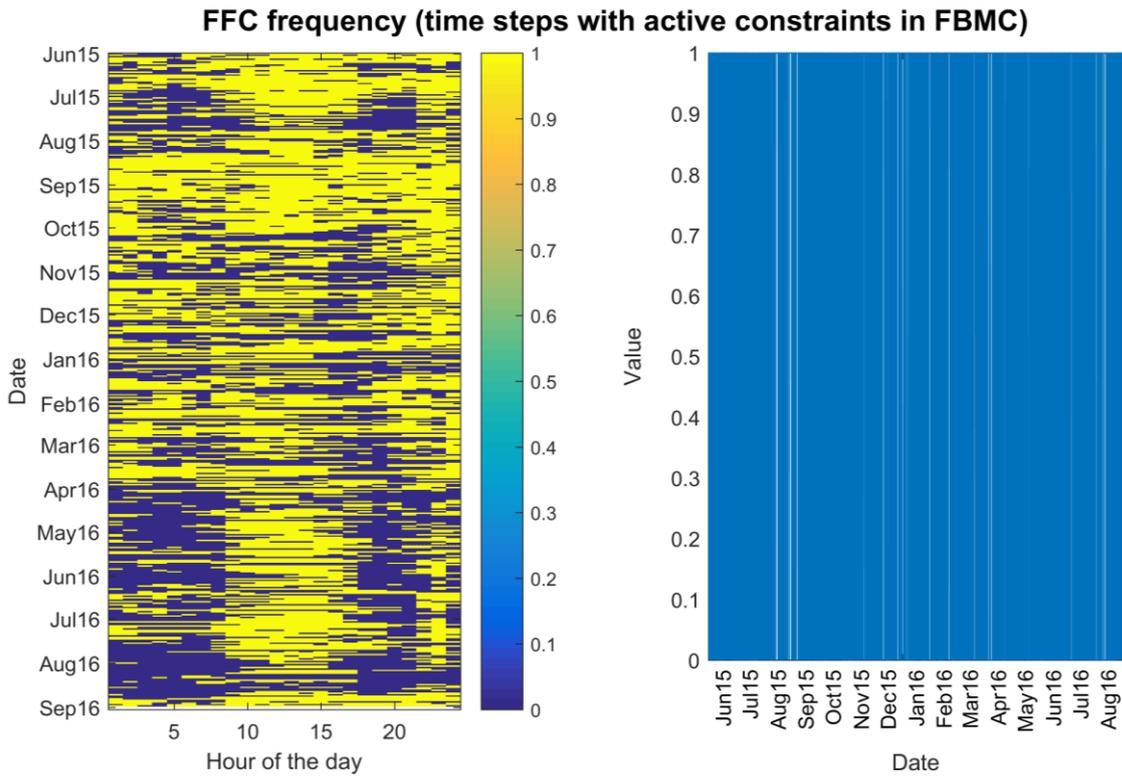
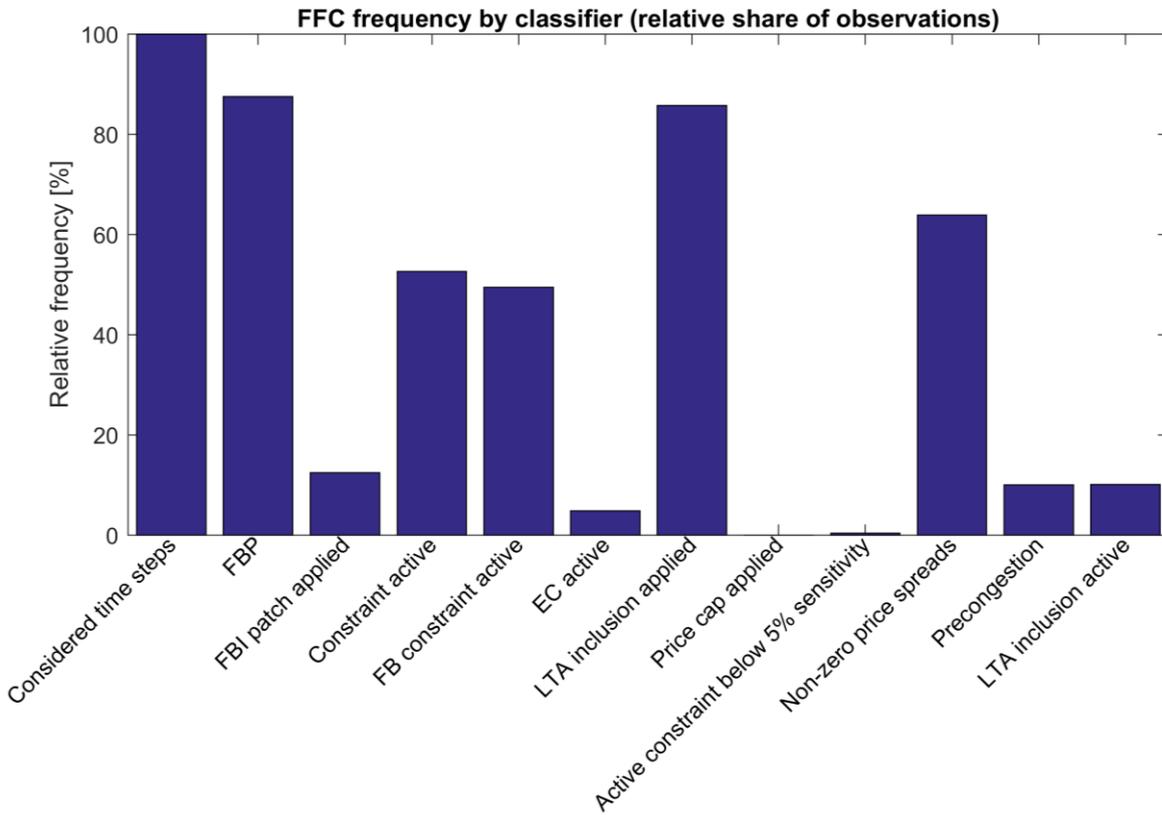


Frequency of branches belonging to an active constraint (50 branches with highest frequency, out of 204)

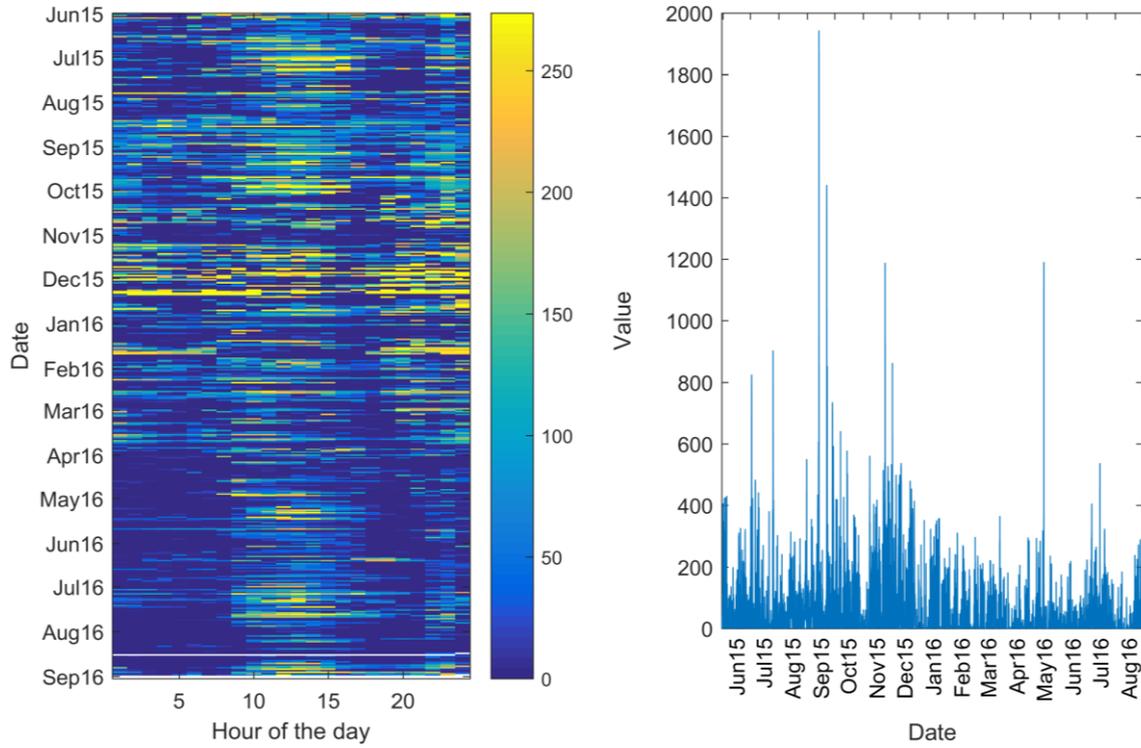


Frequency of branches belonging to an active constraint (50 branches with highest frequency, out of 204)

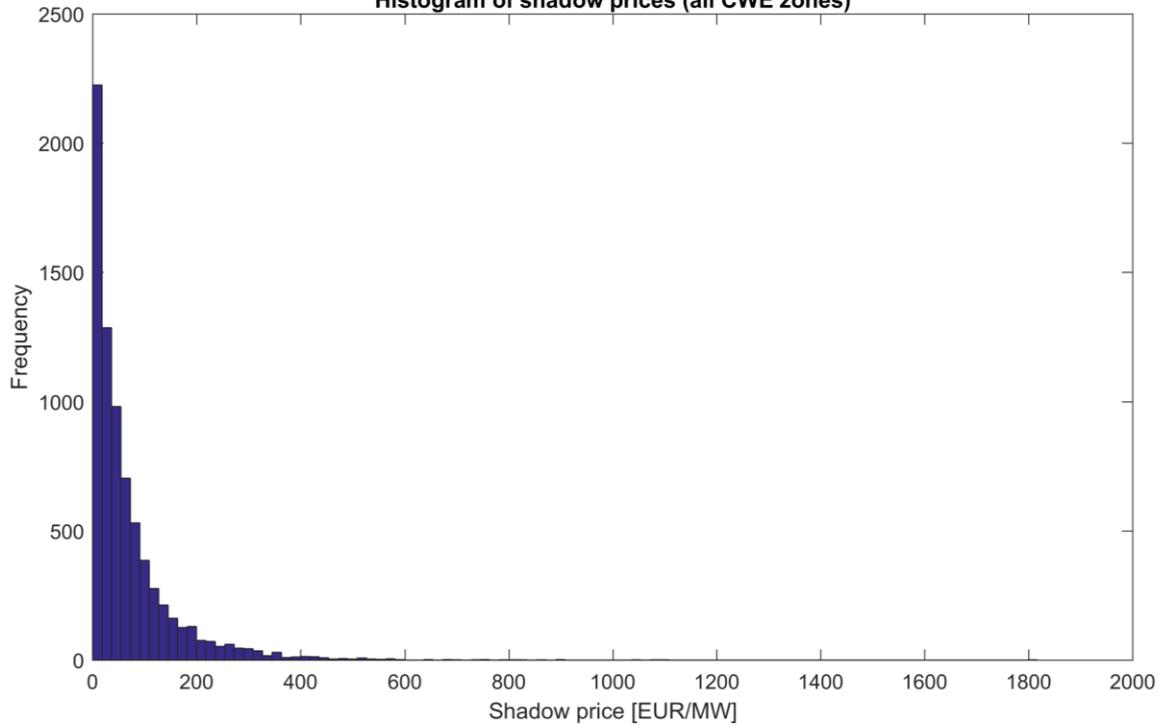


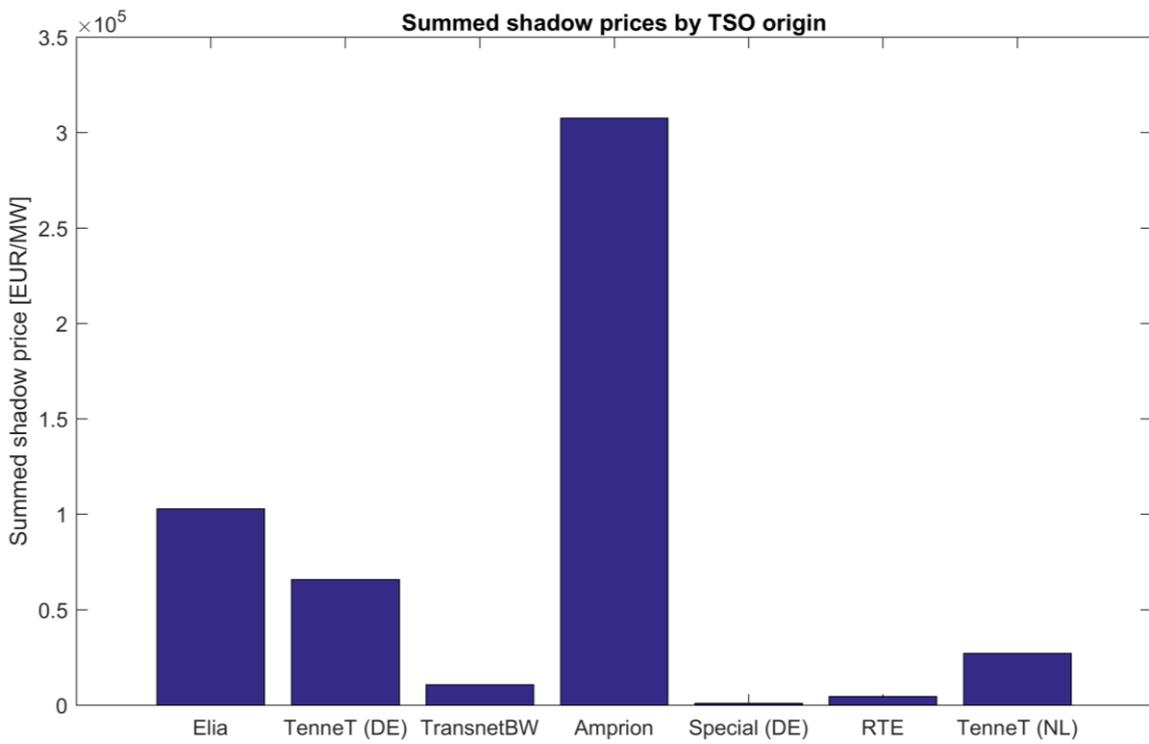
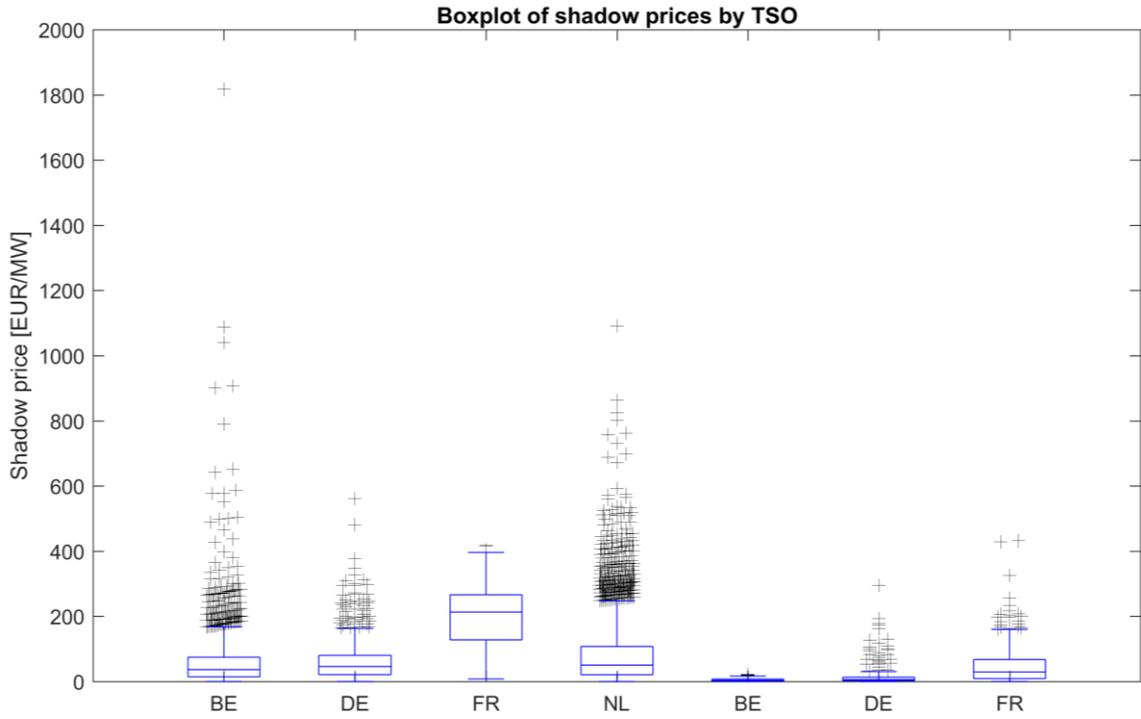


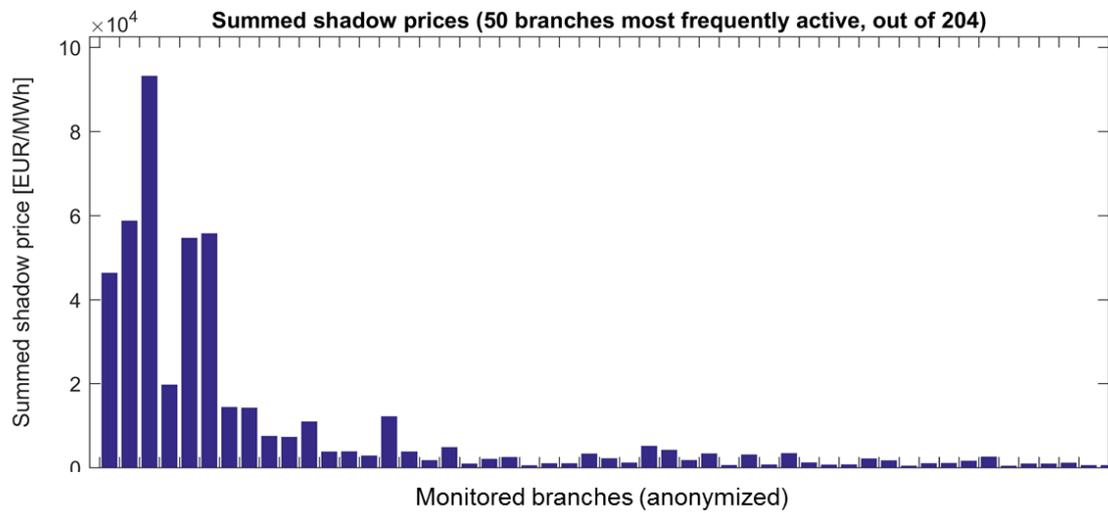
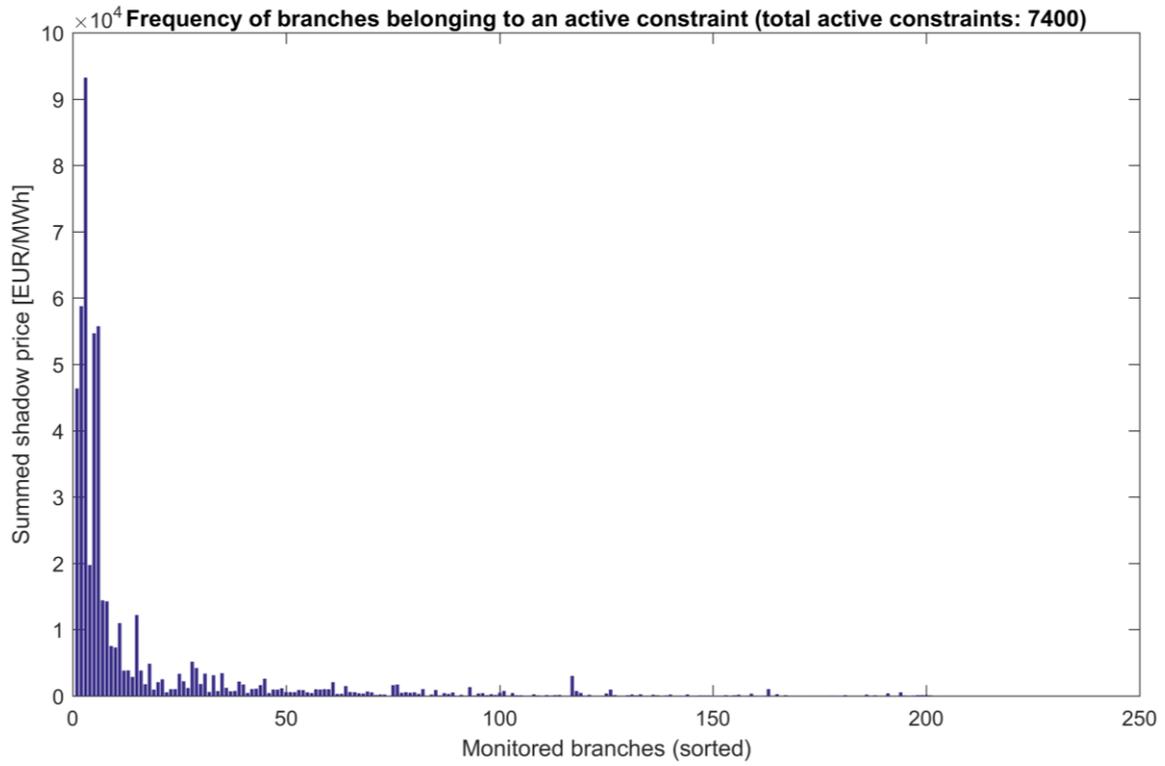
### Summed shadow price [EUR/MWh]

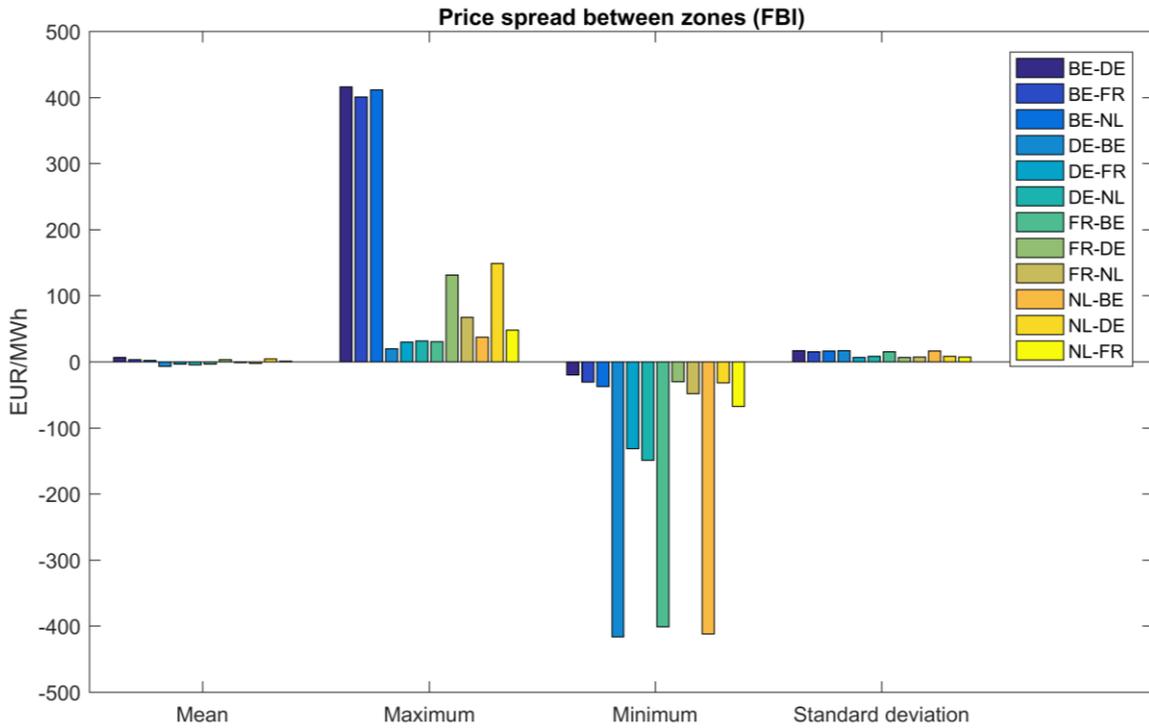
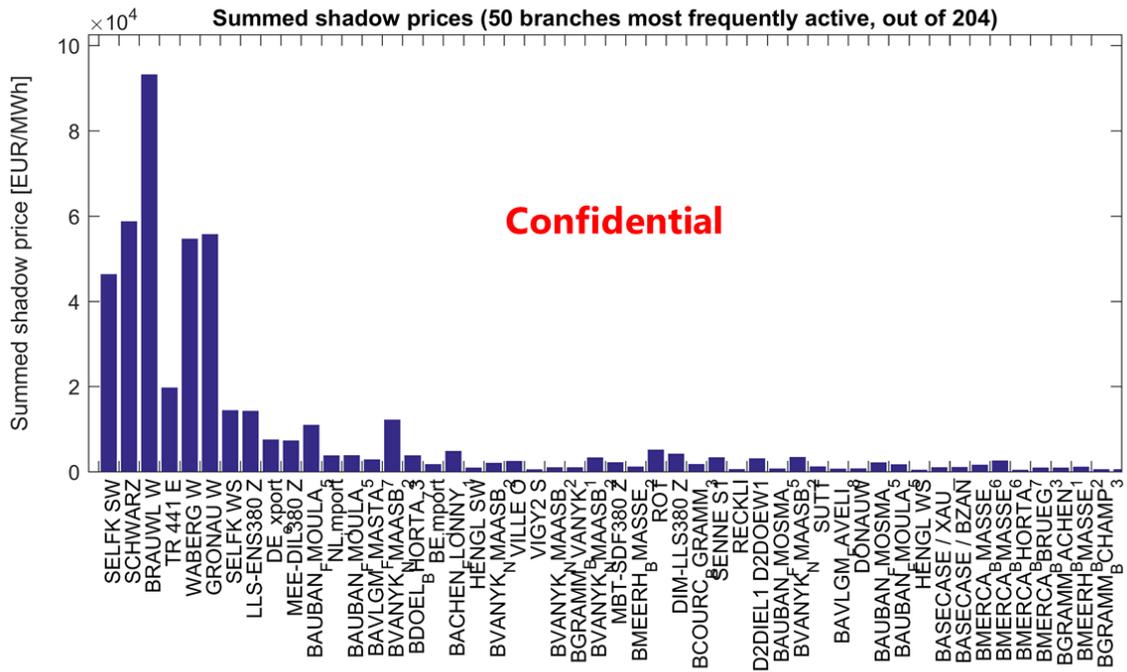


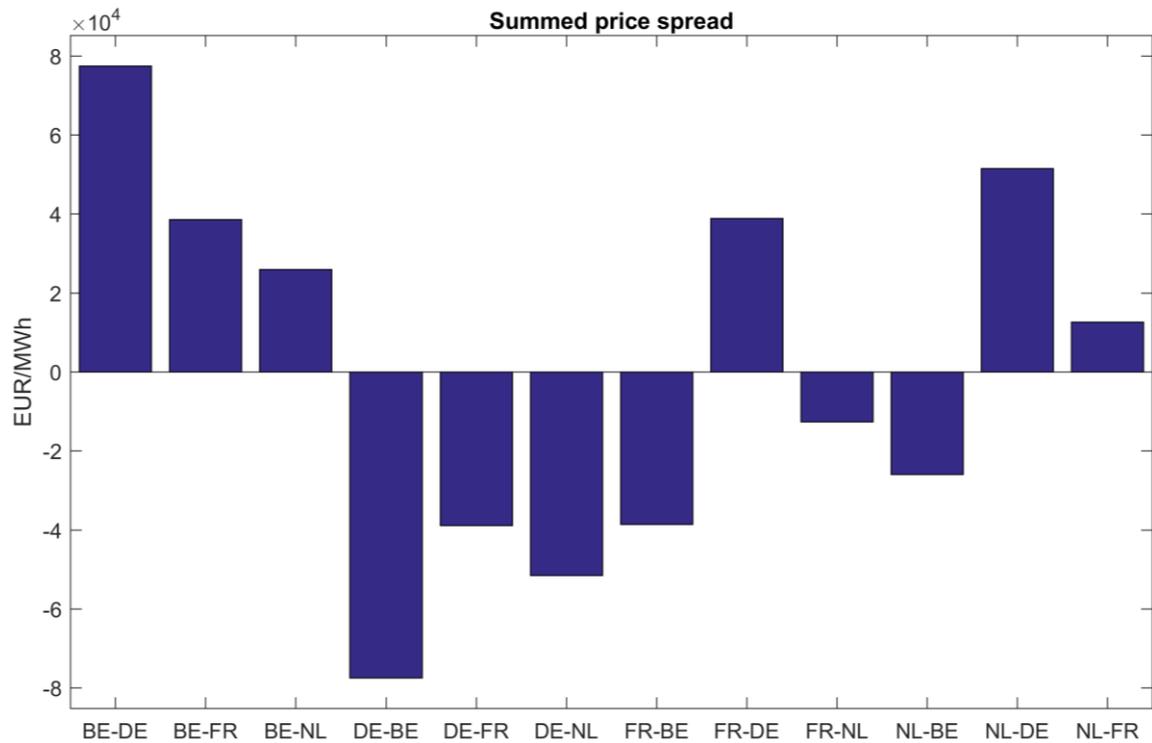
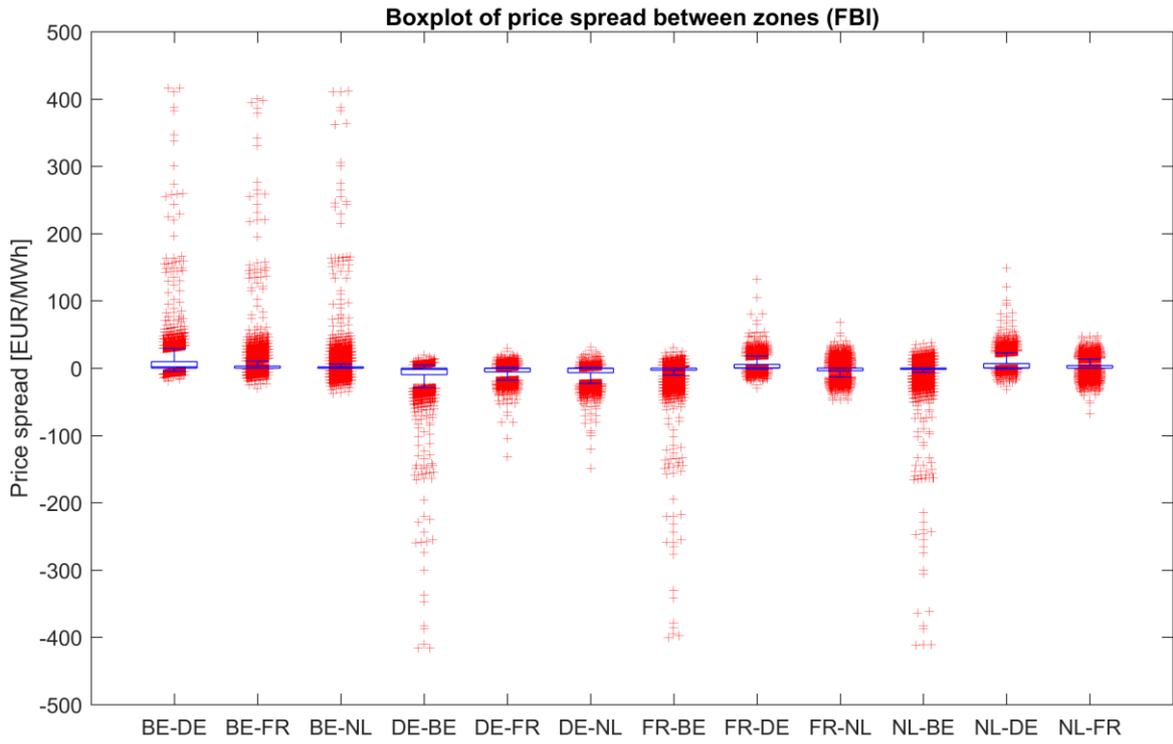
### Histogram of shadow prices (all CWE zones)



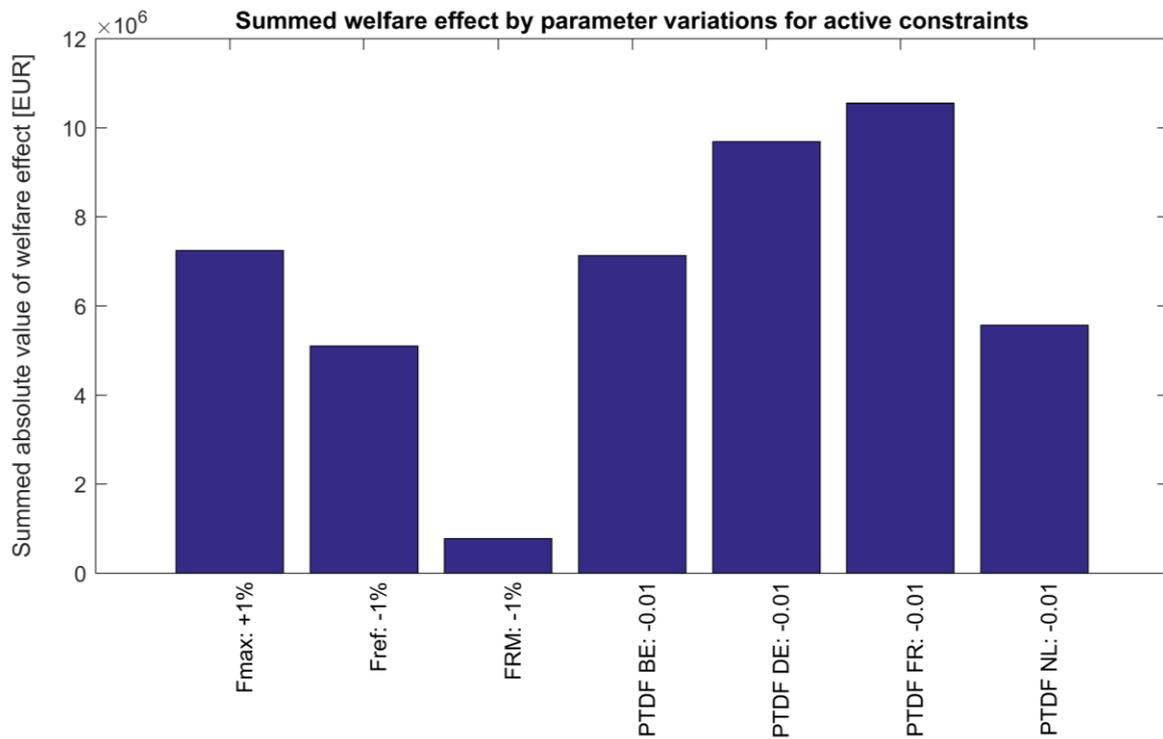
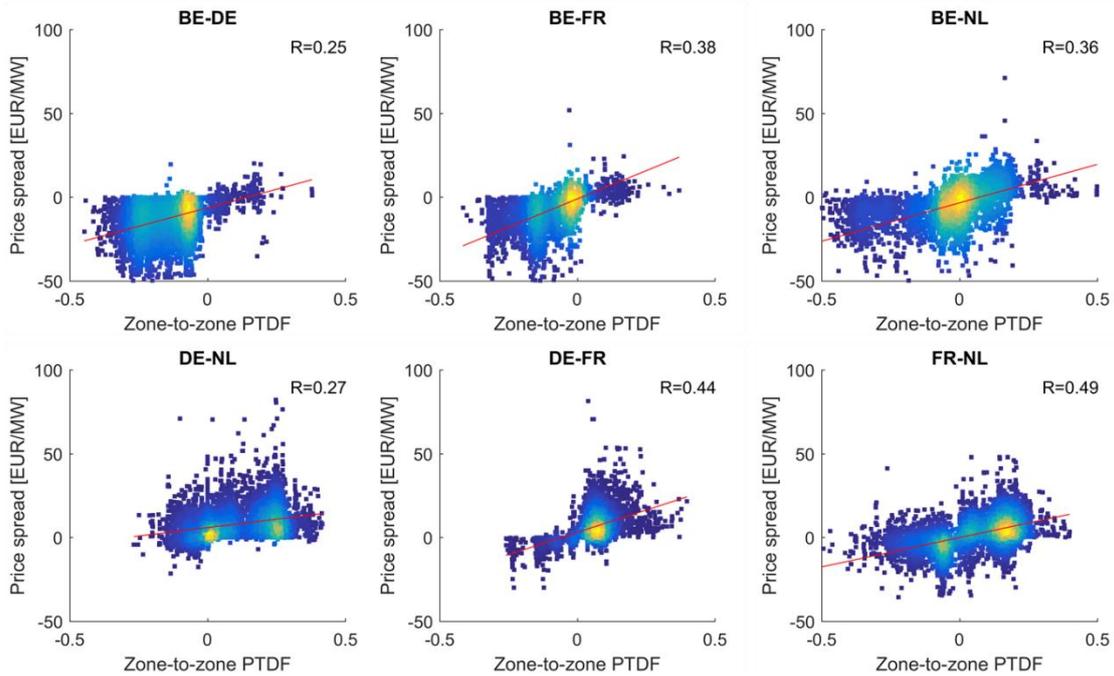


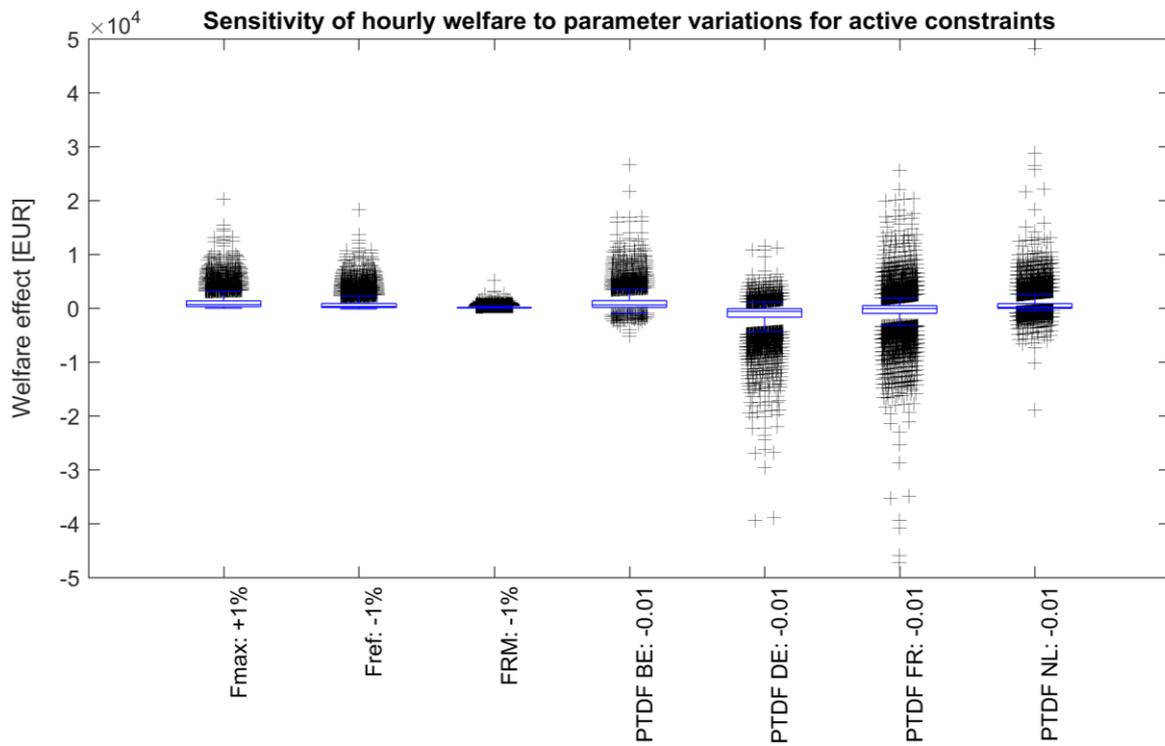
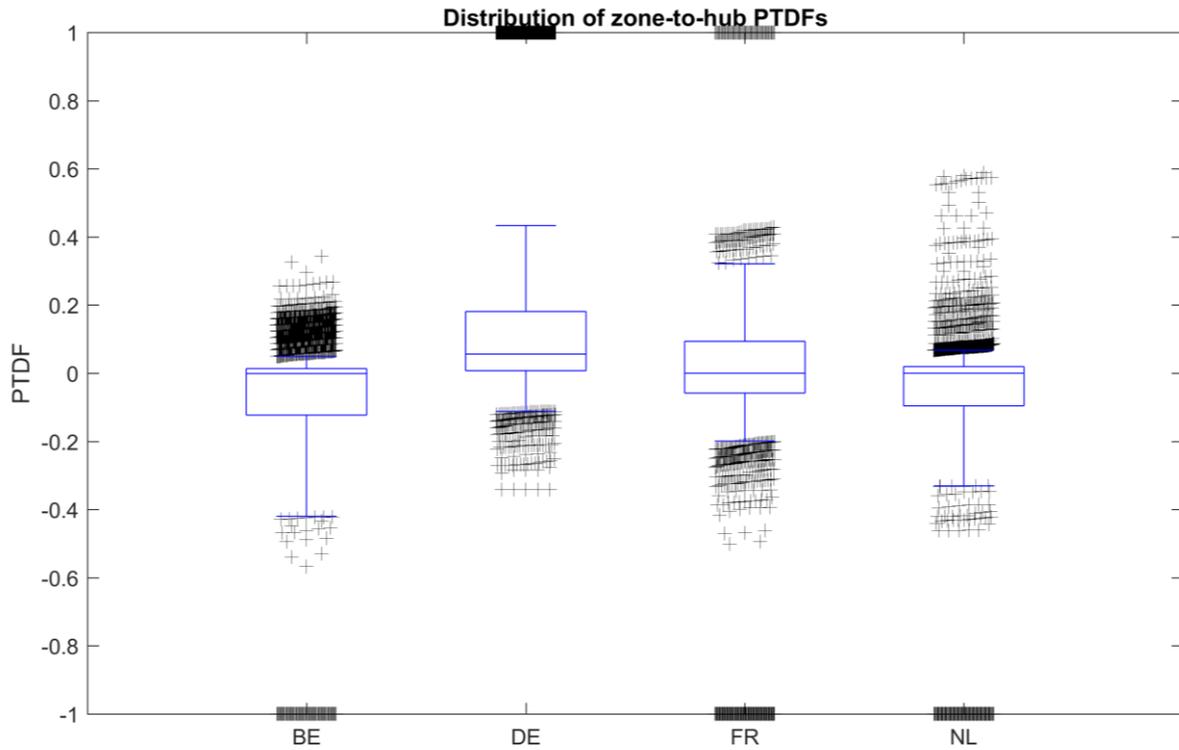


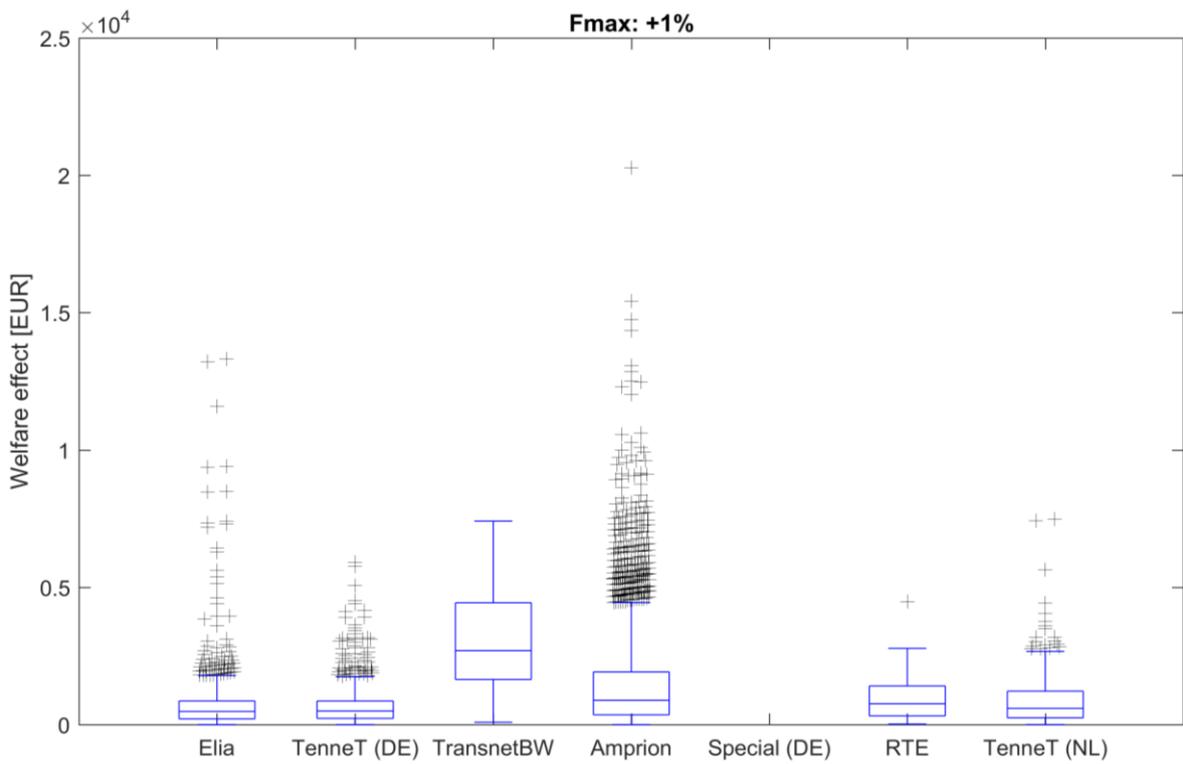
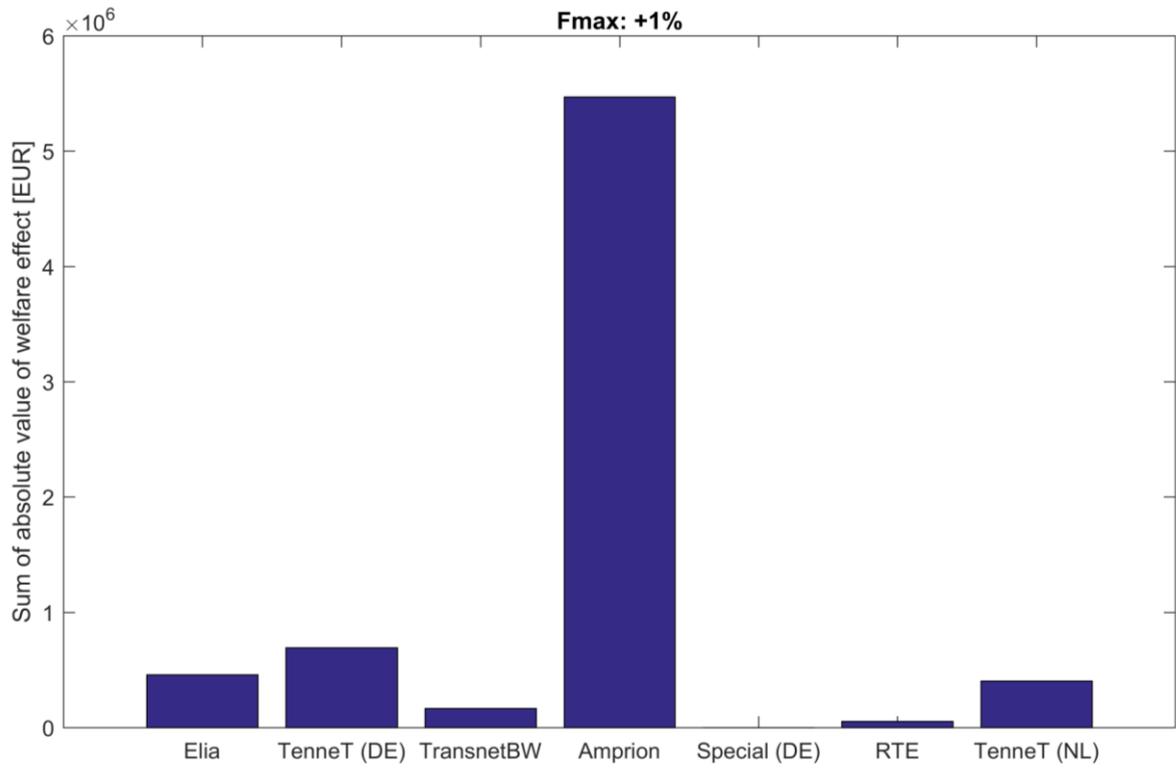


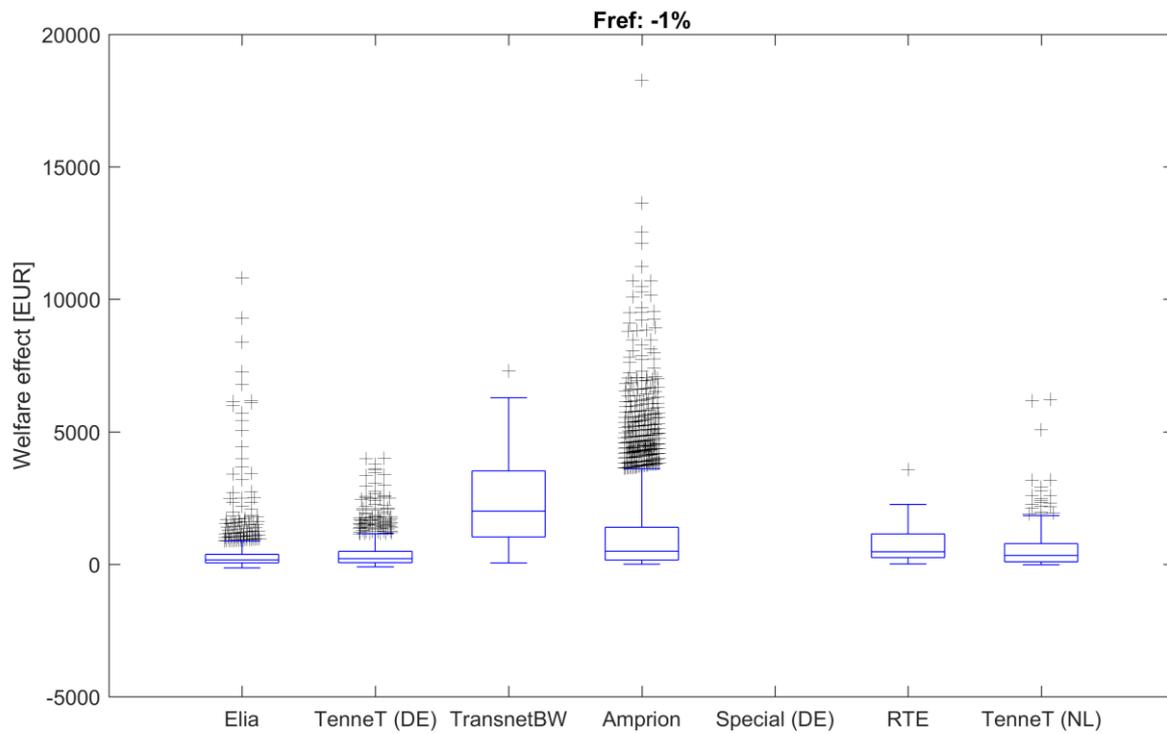
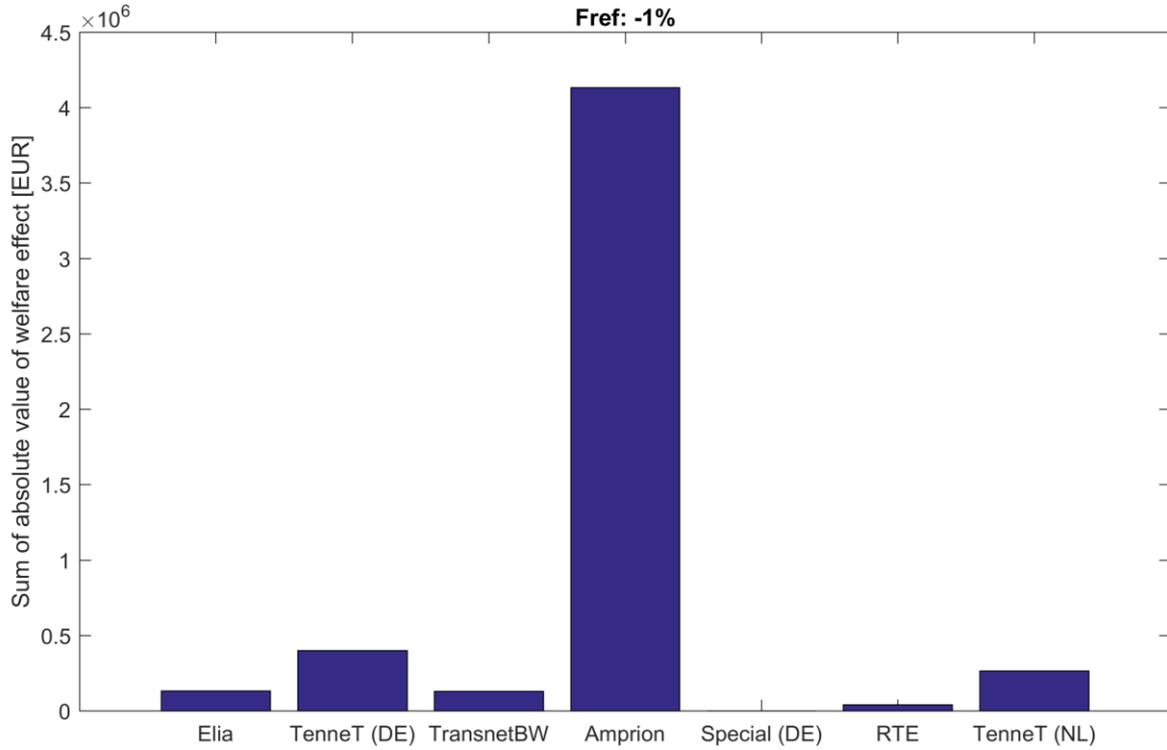


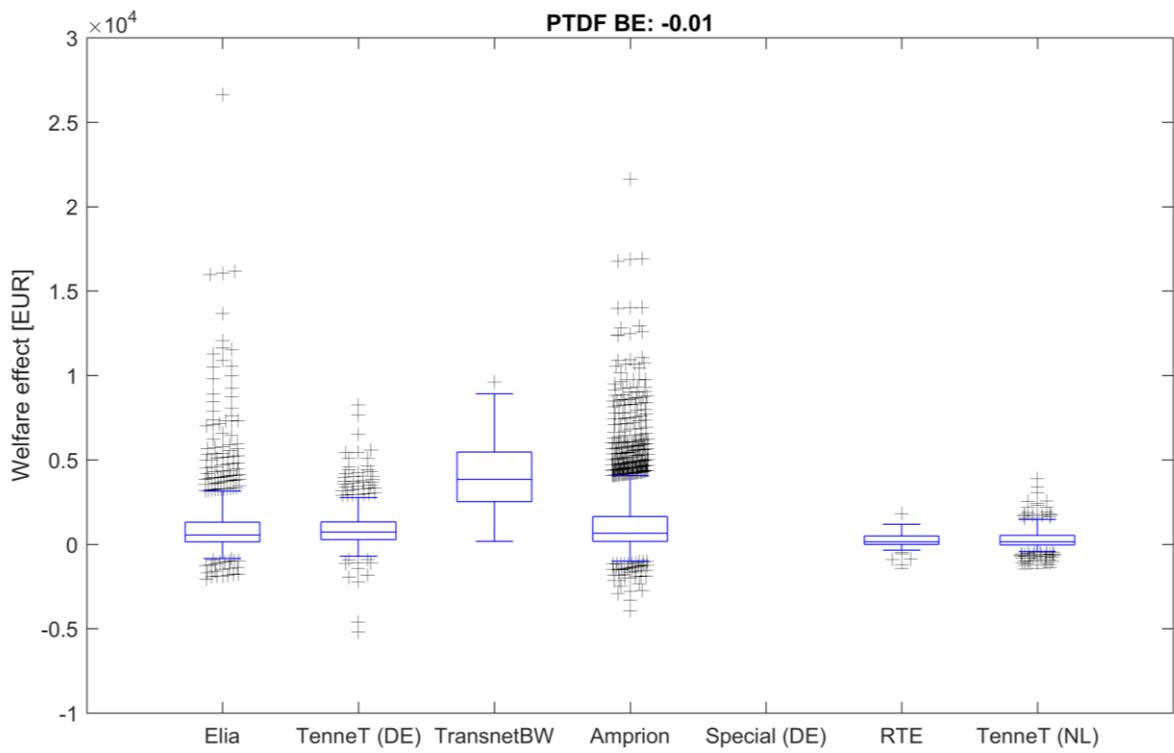
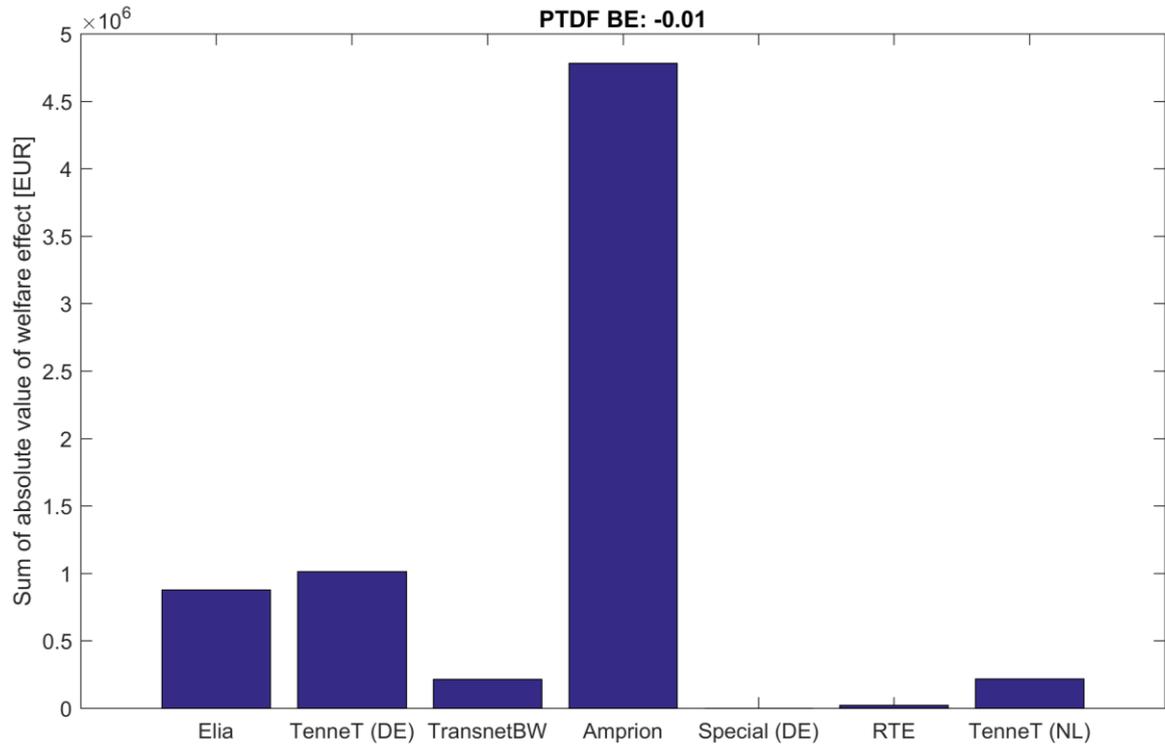
## Correlation of zone to zone PTDFs and price spreads

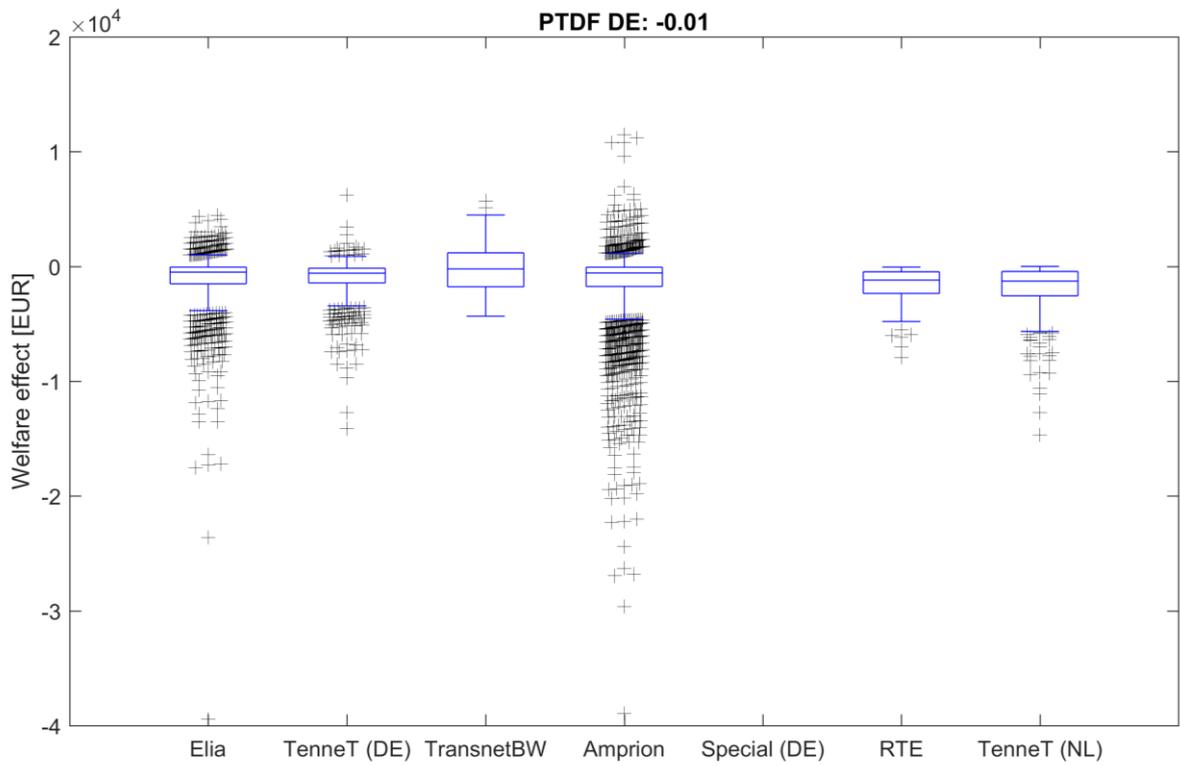
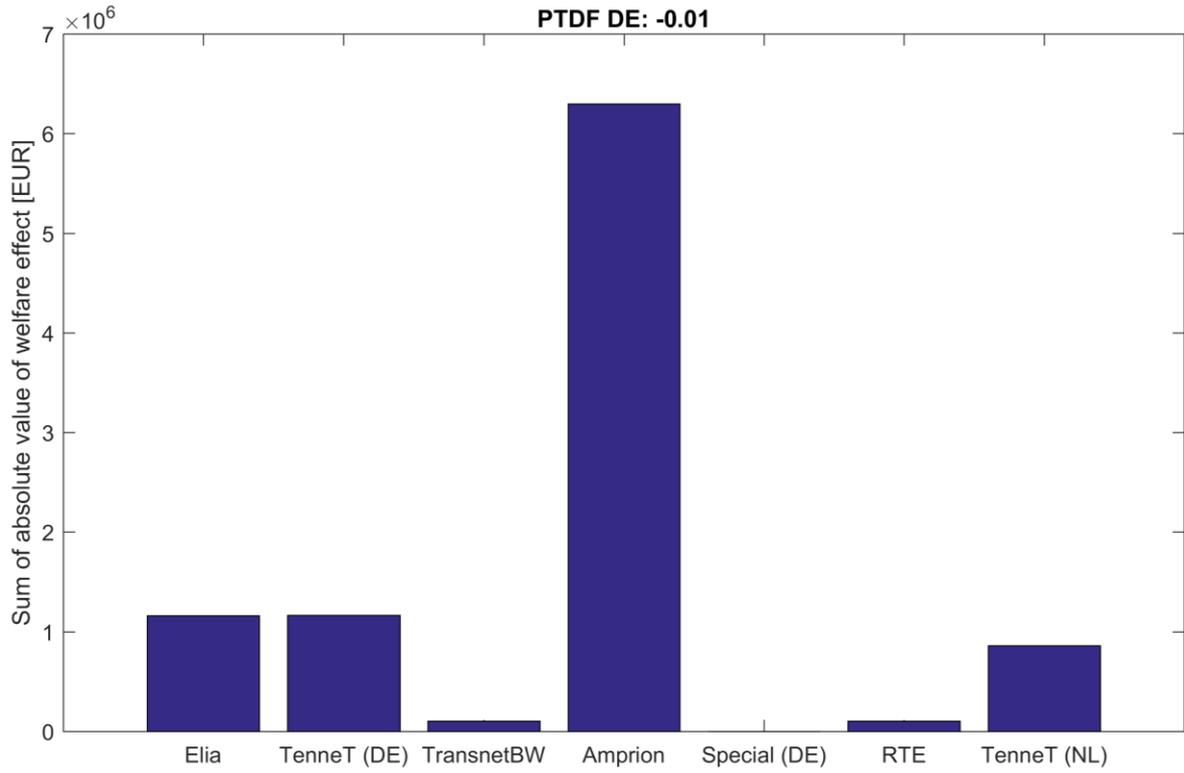


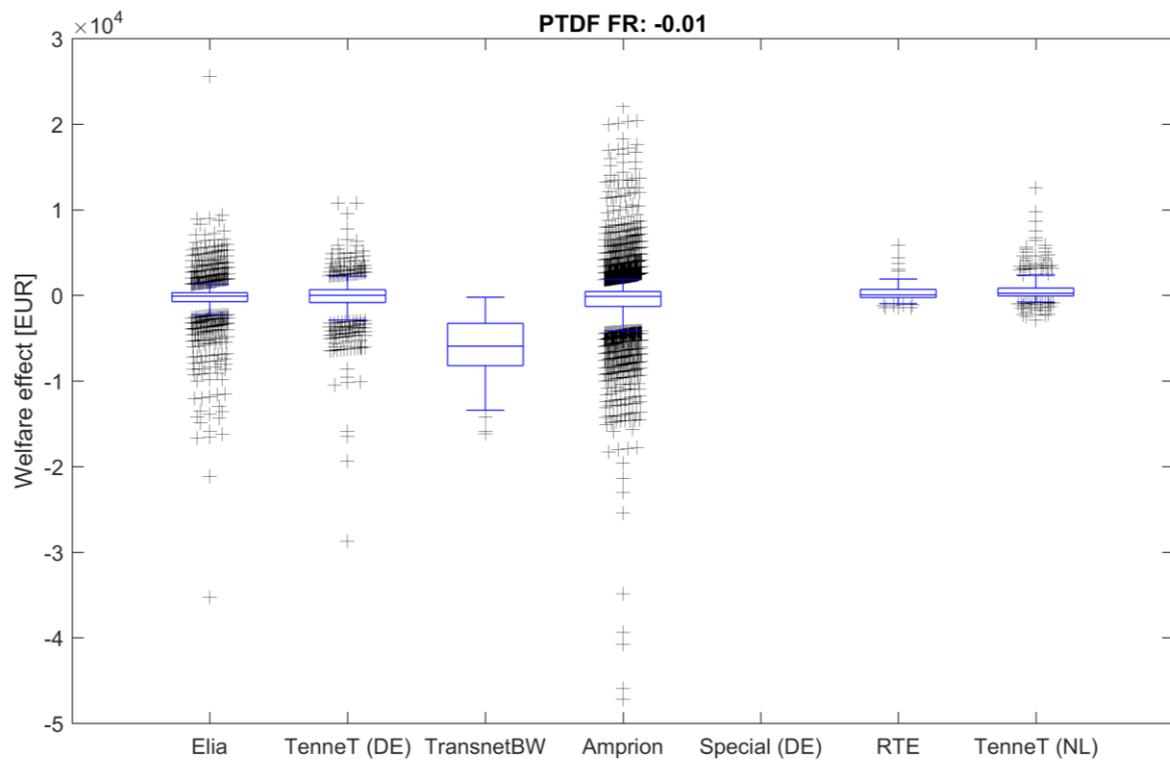
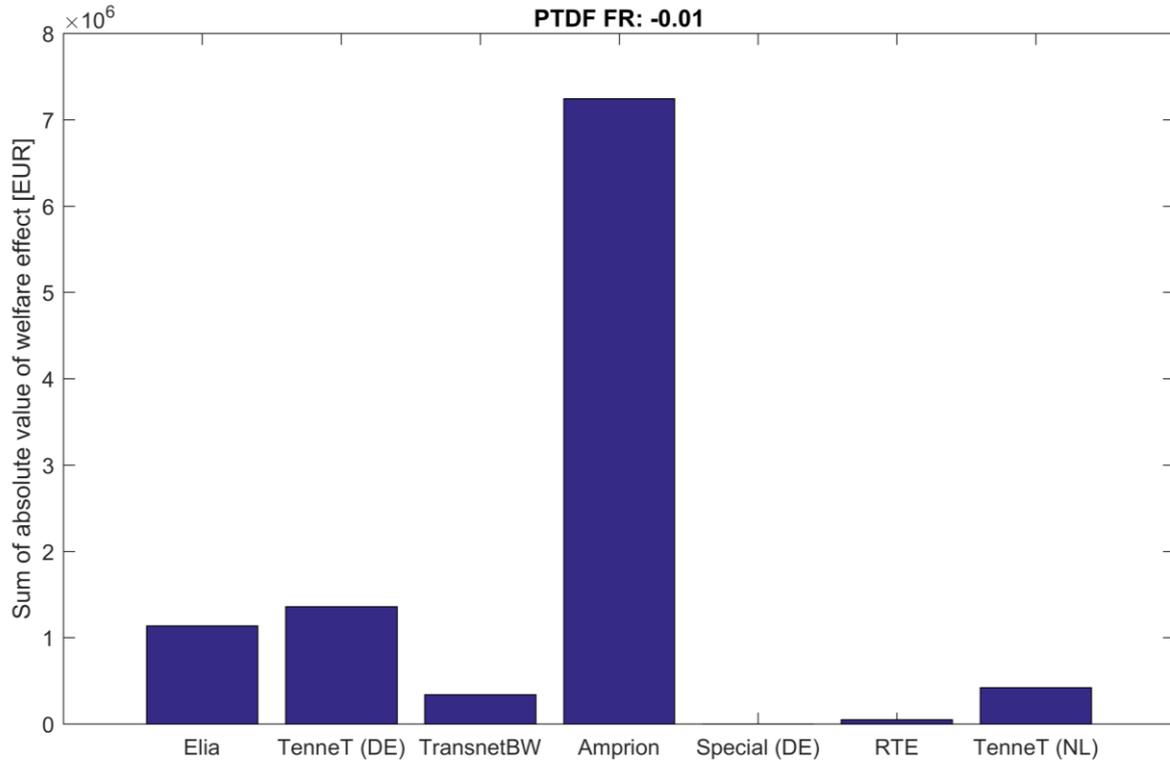


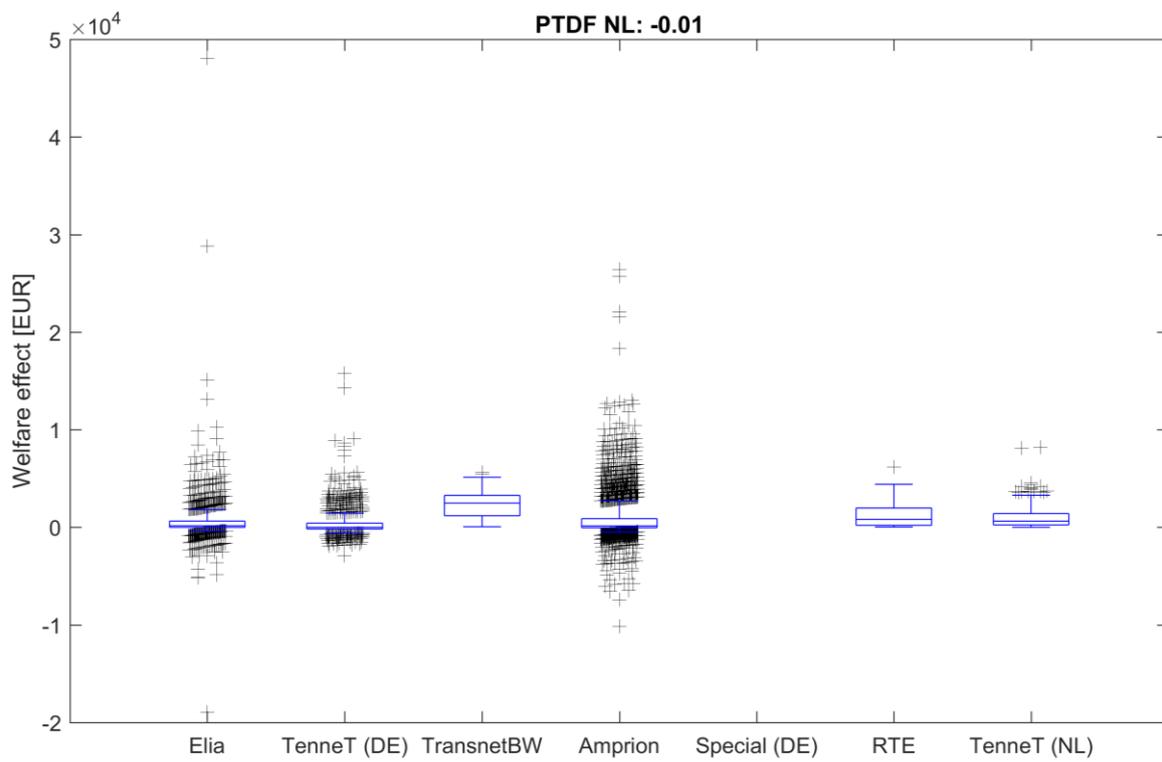
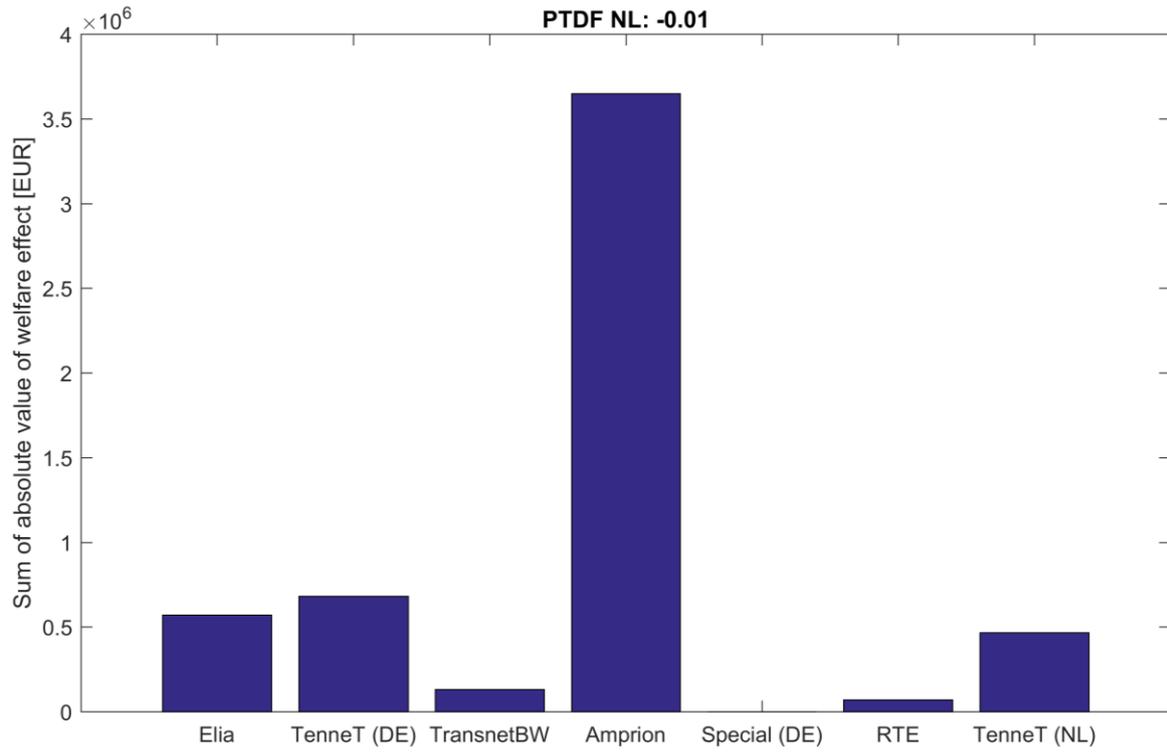


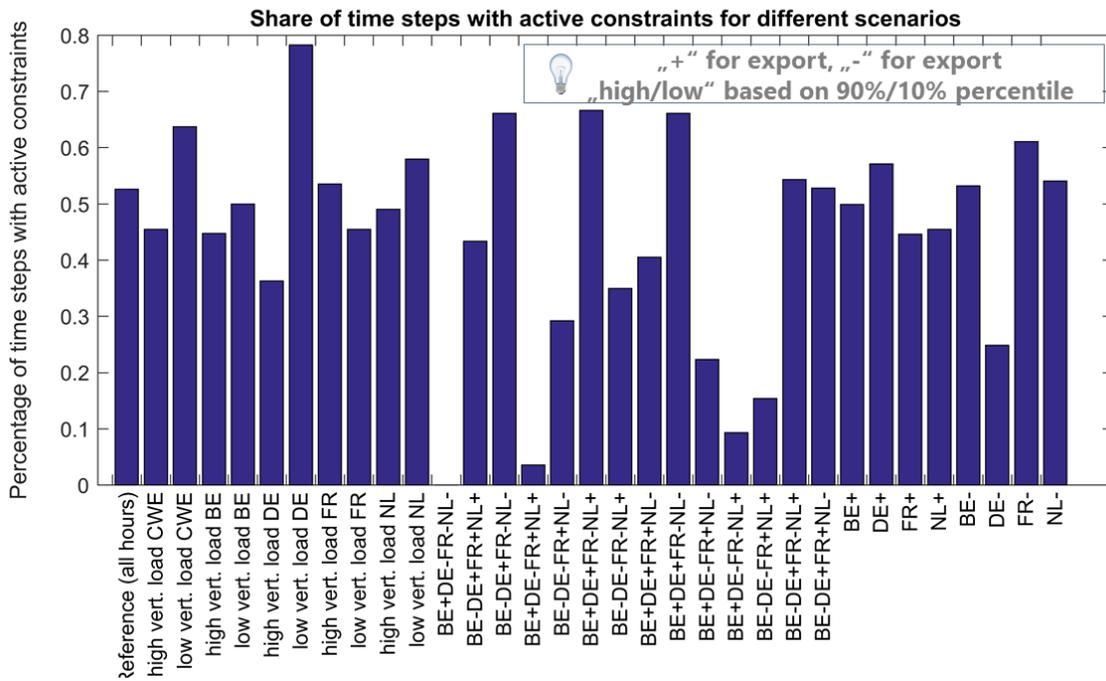
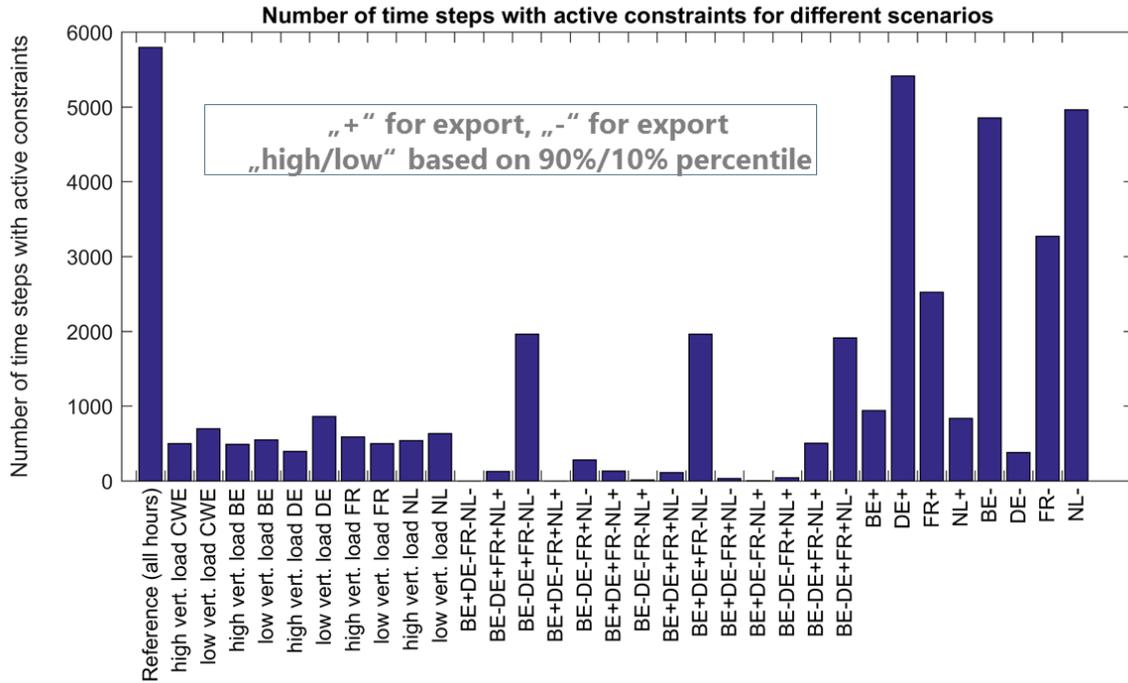






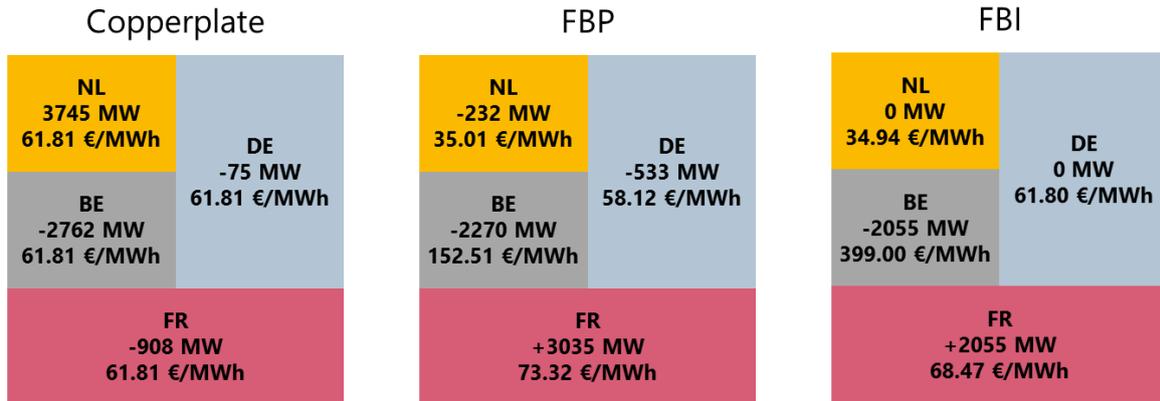






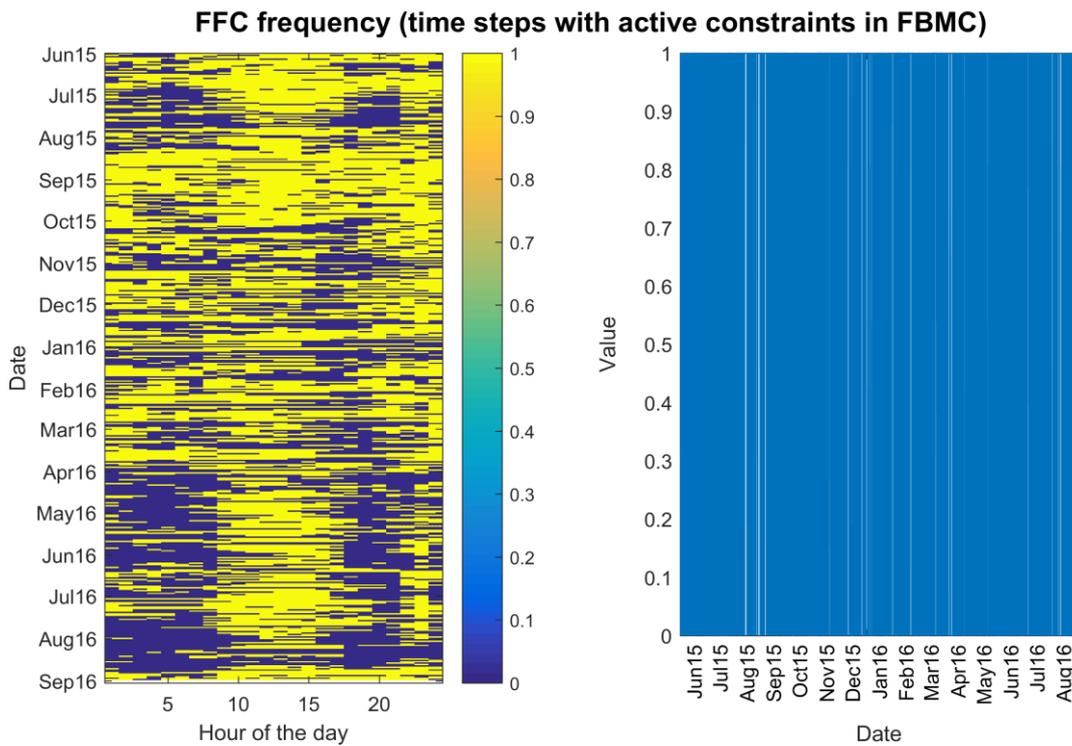
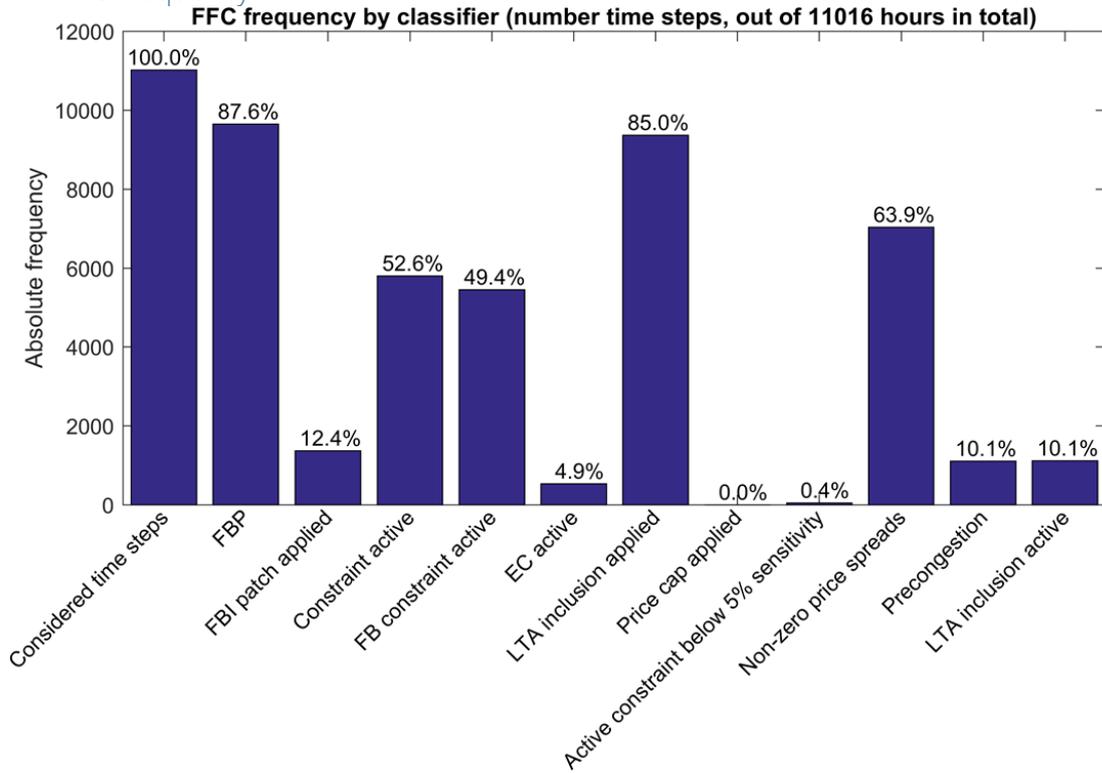
## Selected case for FBP versus FBI

Oct. 16<sup>th</sup>, 2015, 8:00 h (Hour of maximum price spread of FBI vs. FBP)

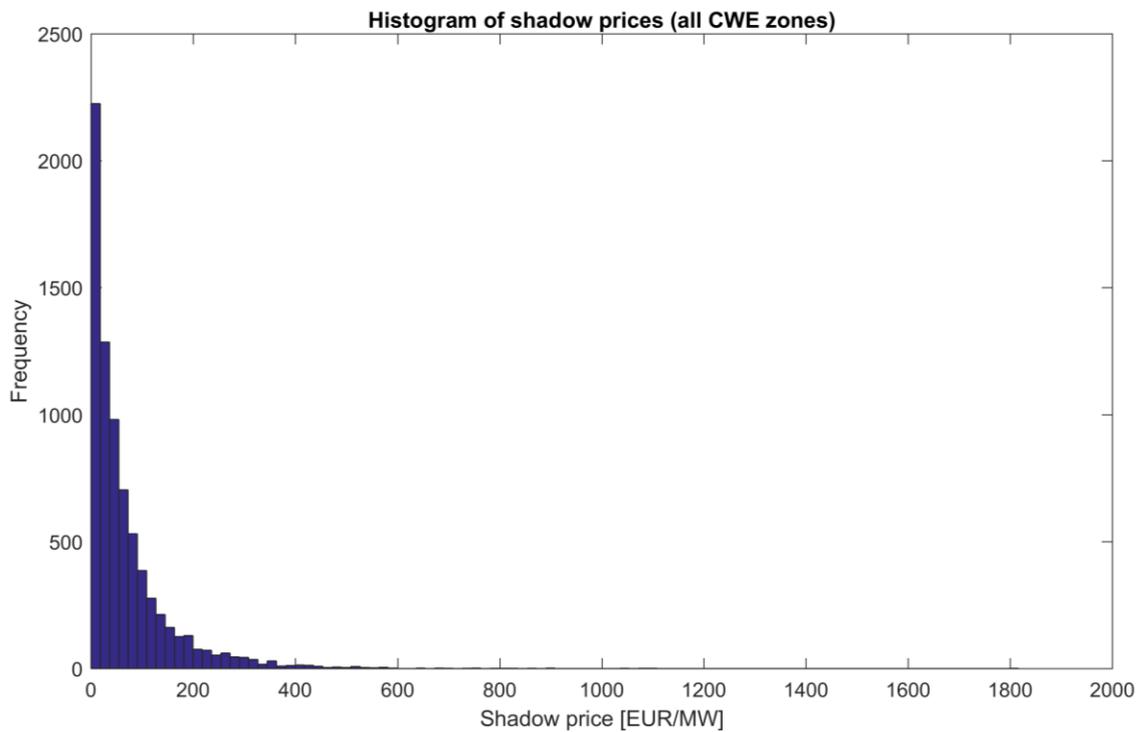
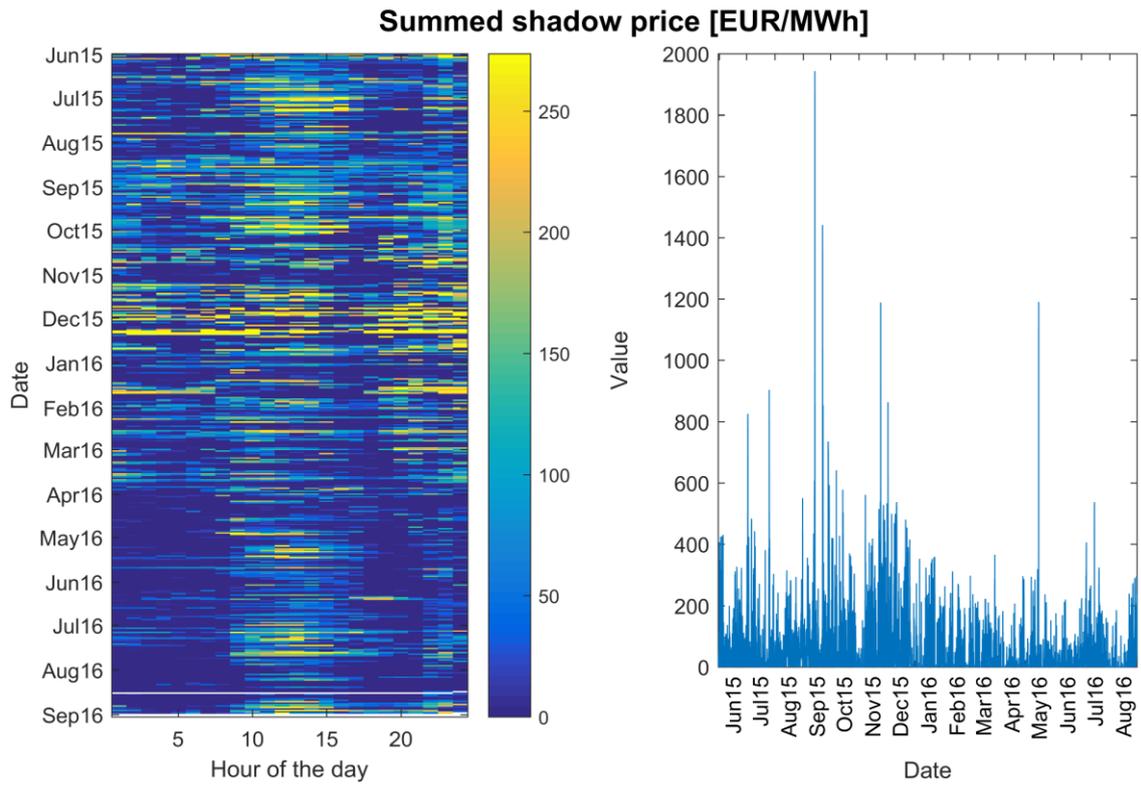


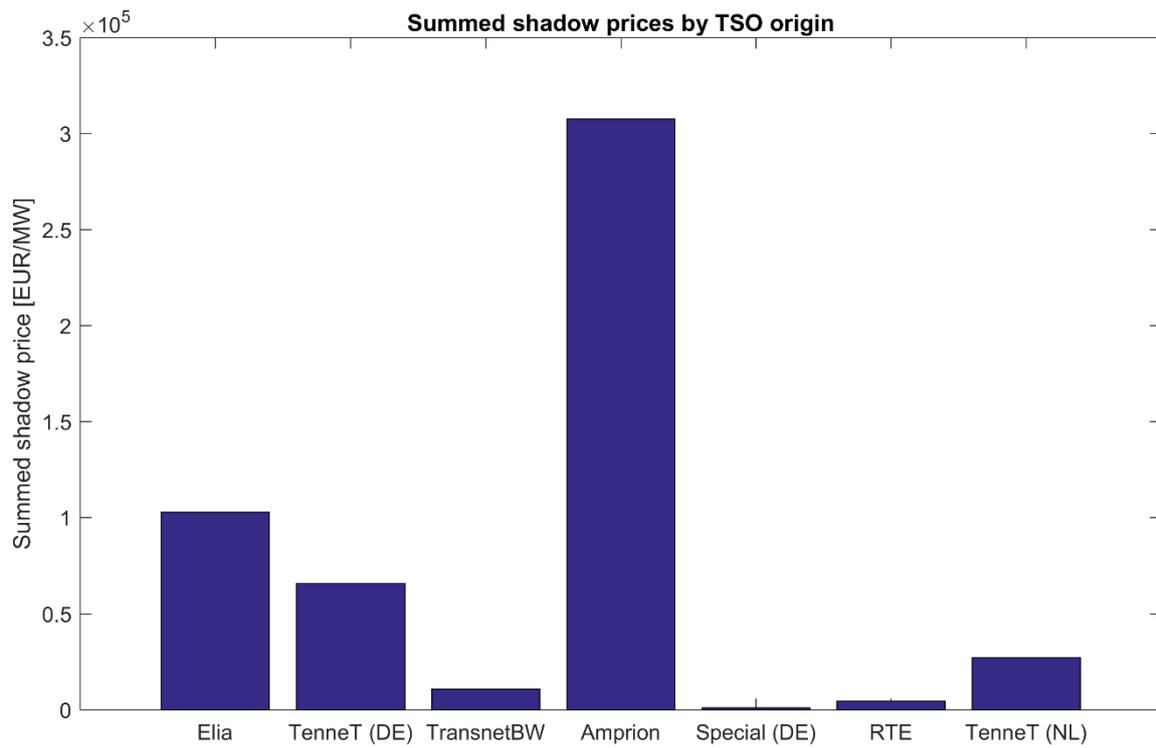
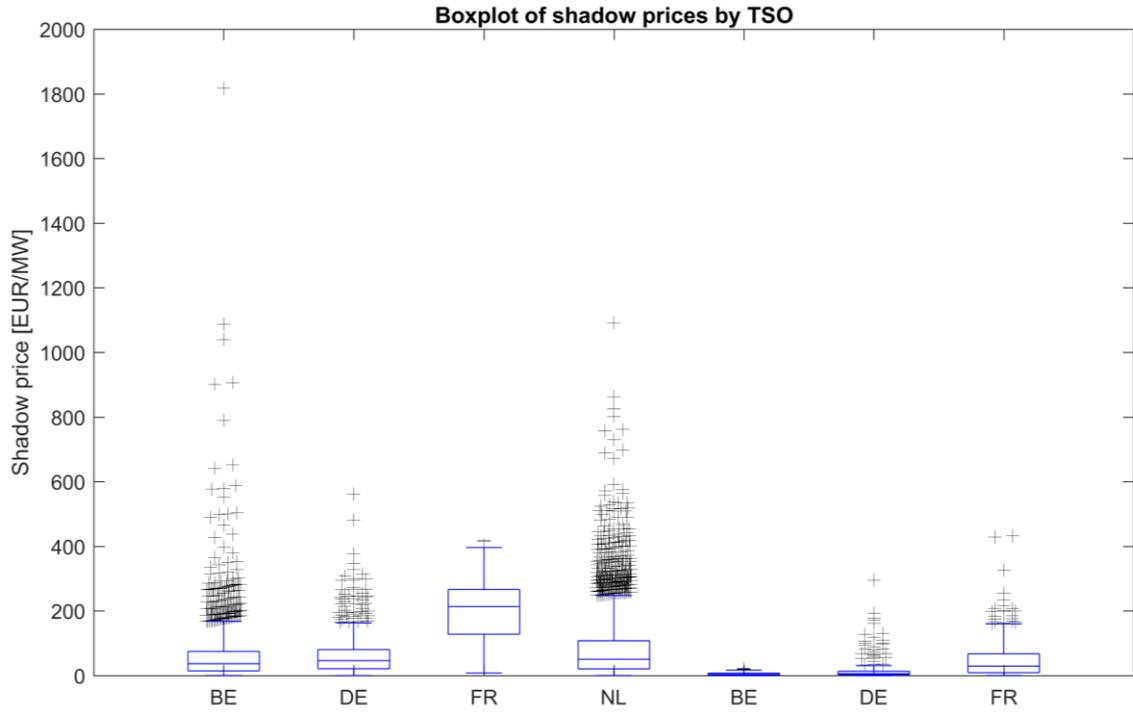
## A.2 FFC Indicators

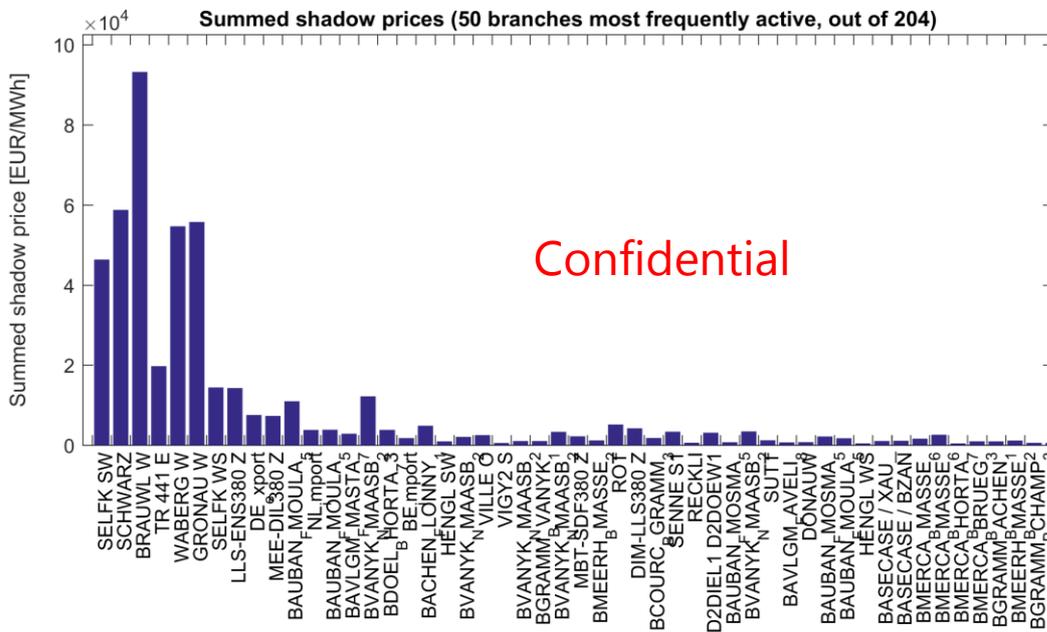
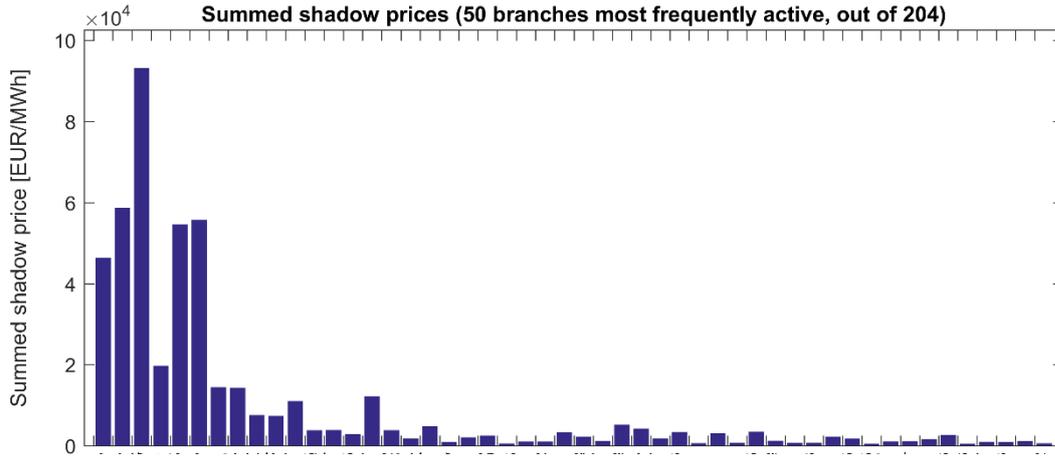
### A.2.1 FFC frequency

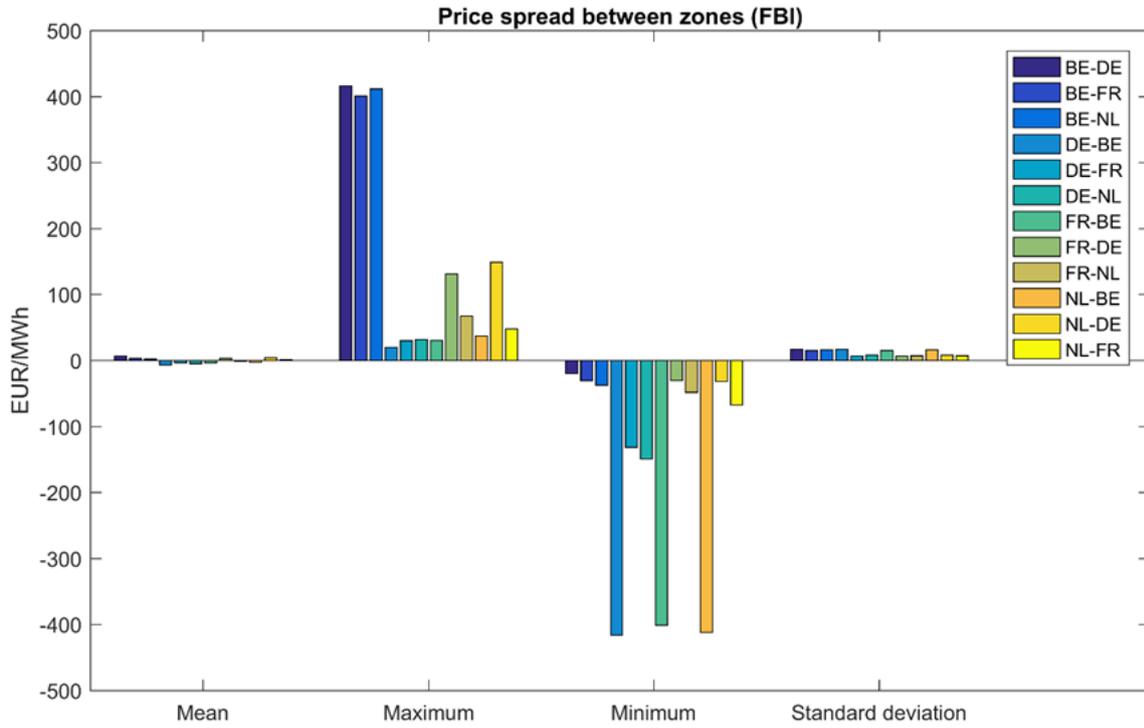


## A.2.2 FFC severity

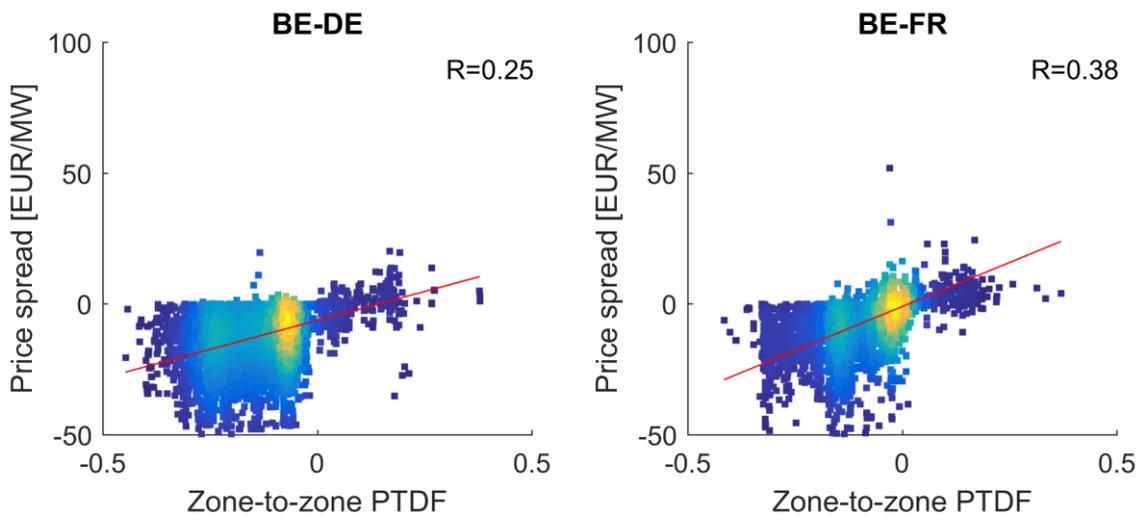


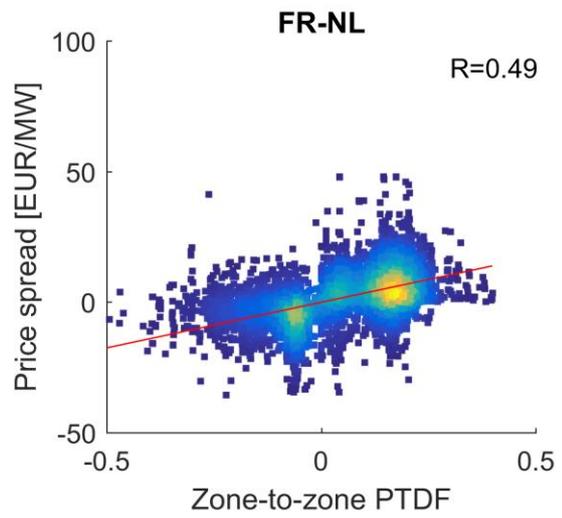
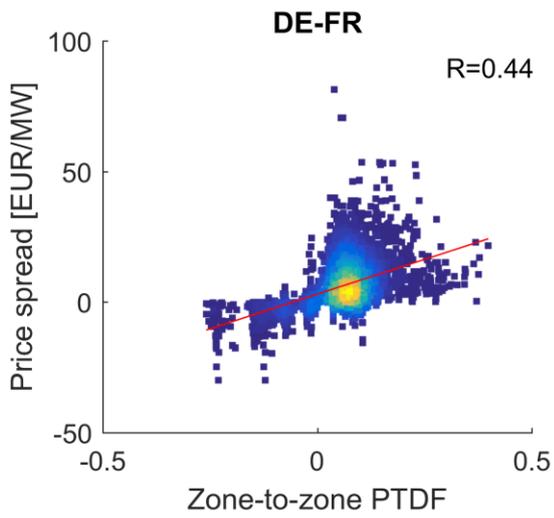
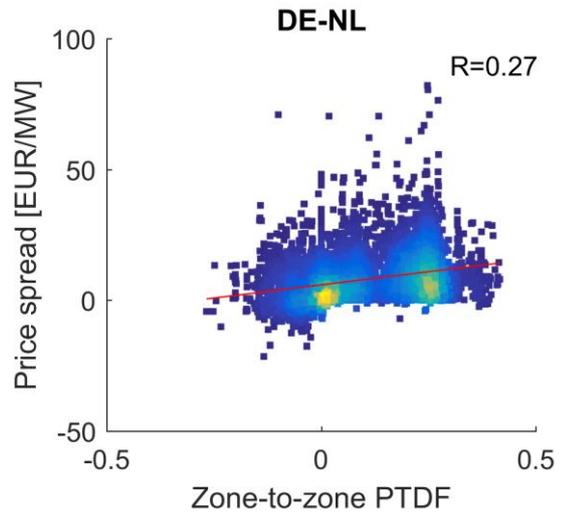
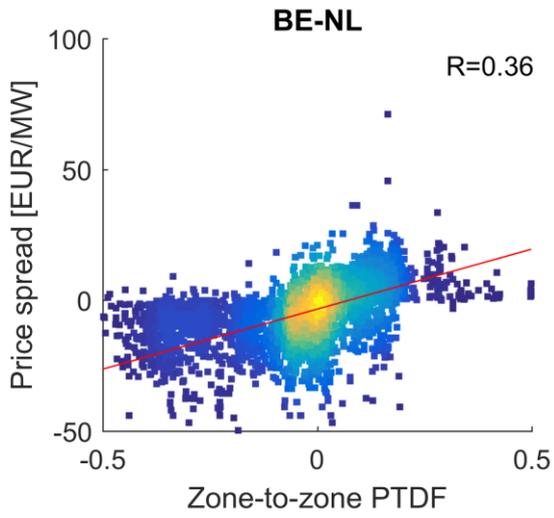




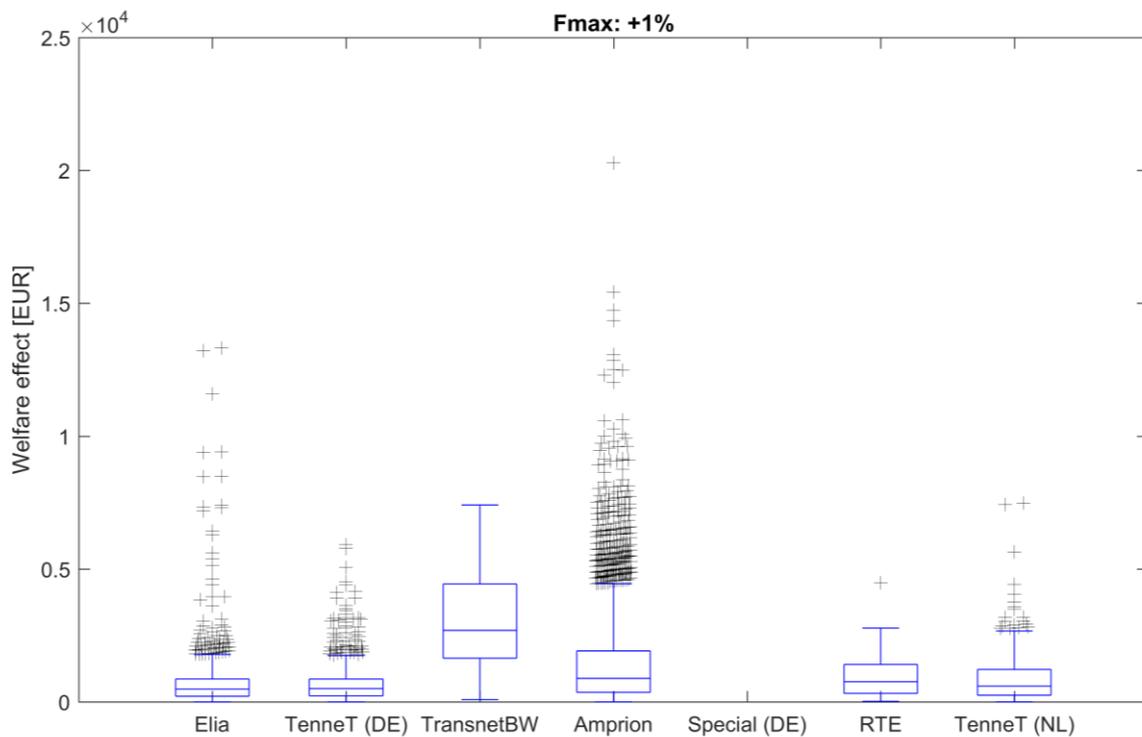
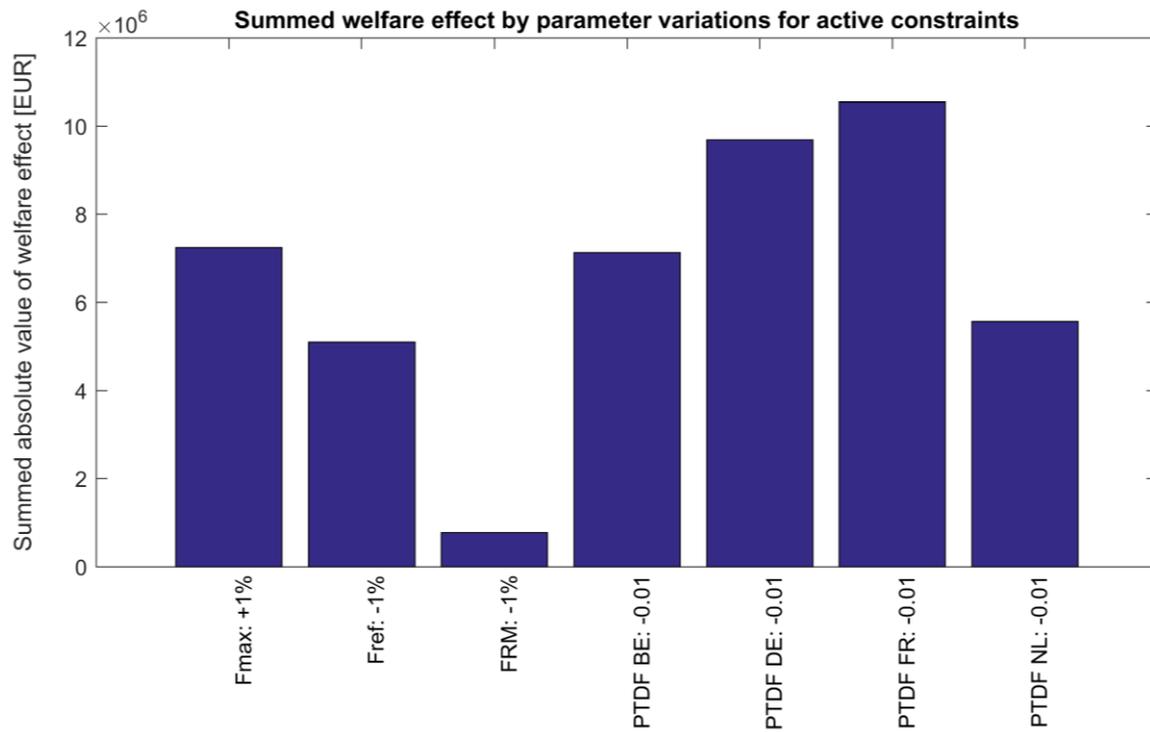


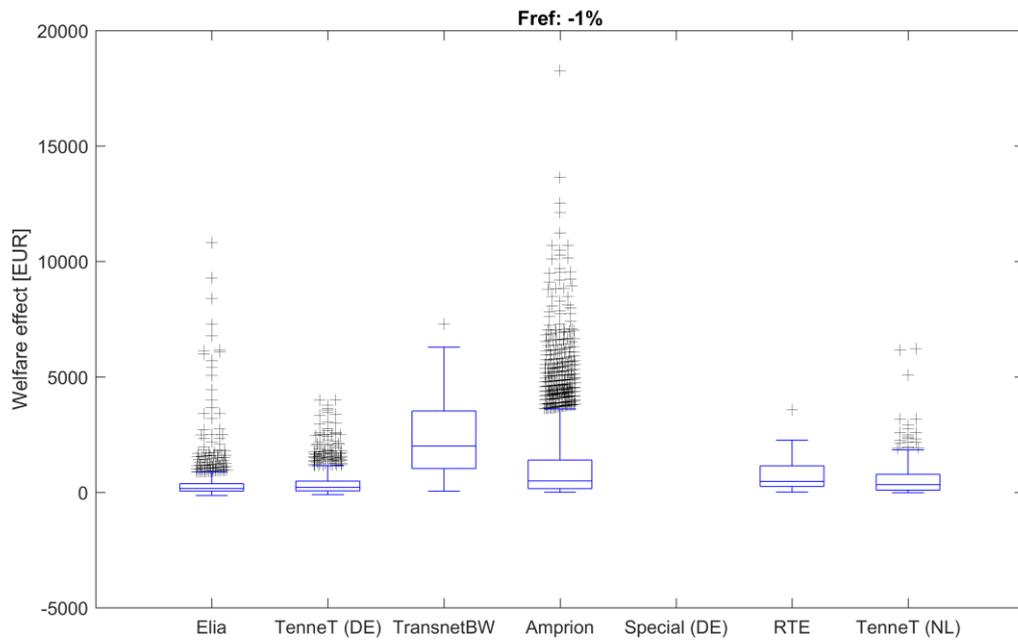
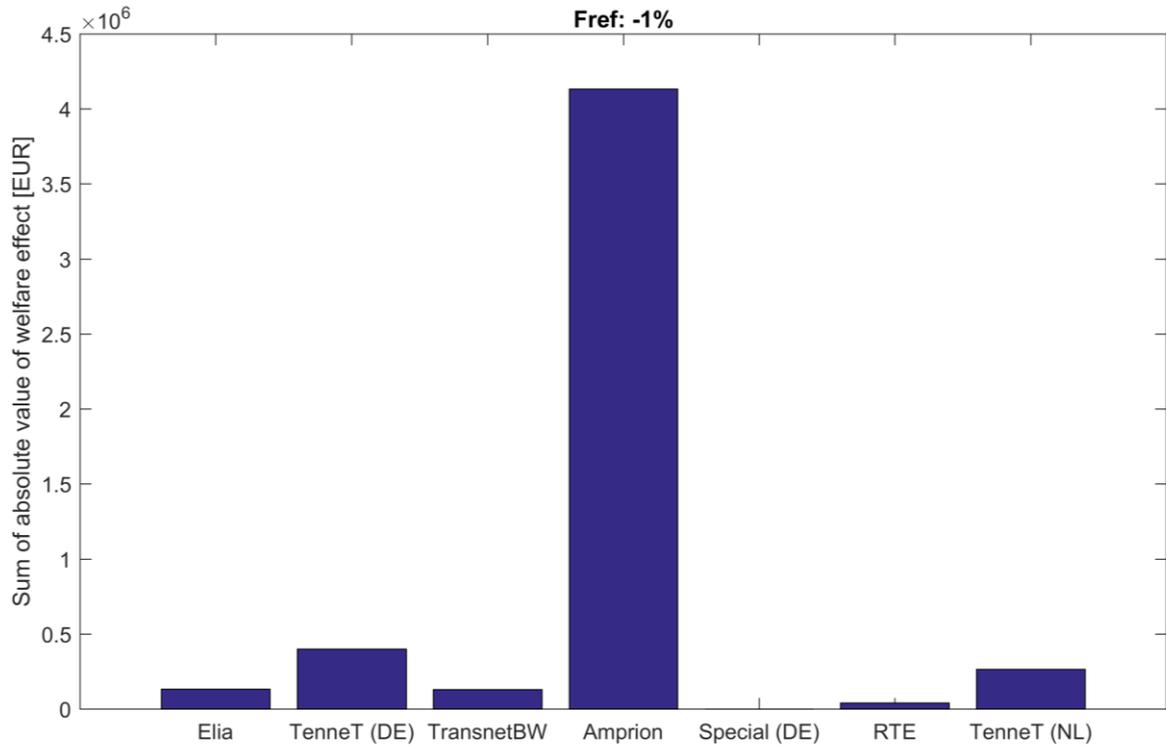
### A.2.3 FFC systematics

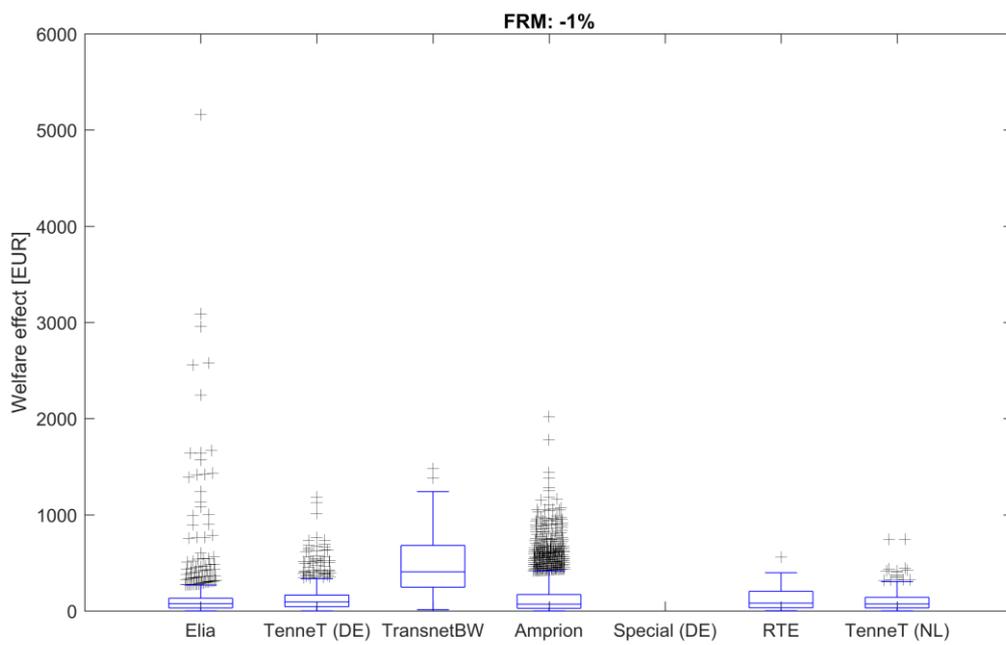
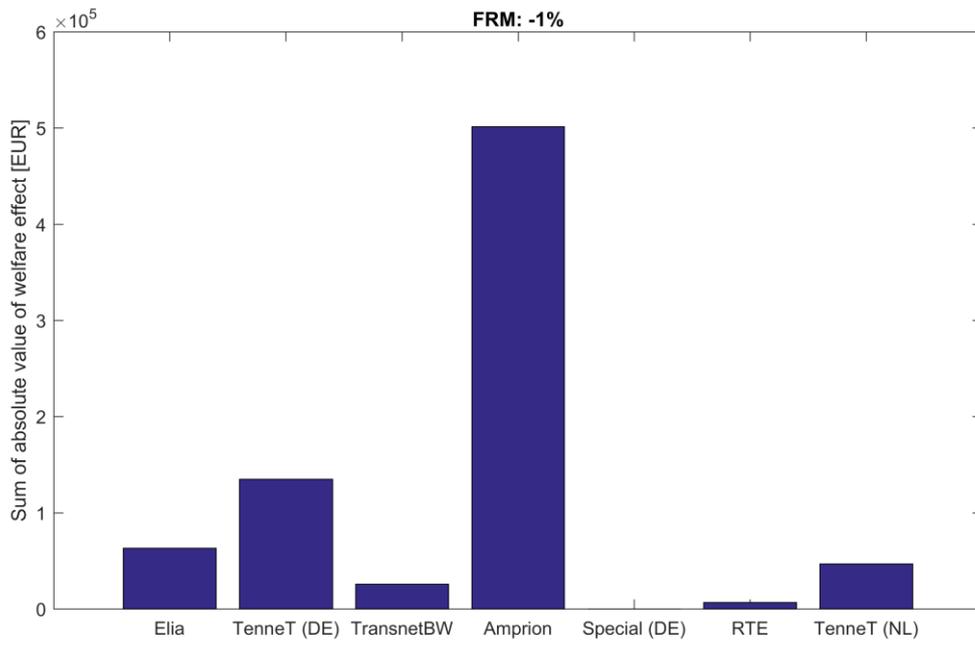


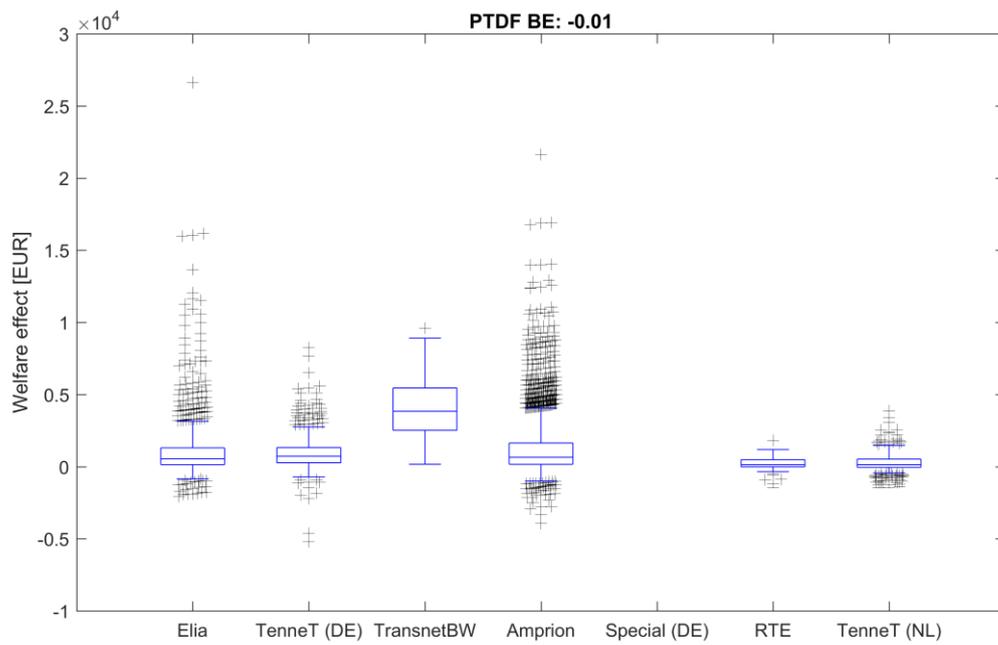
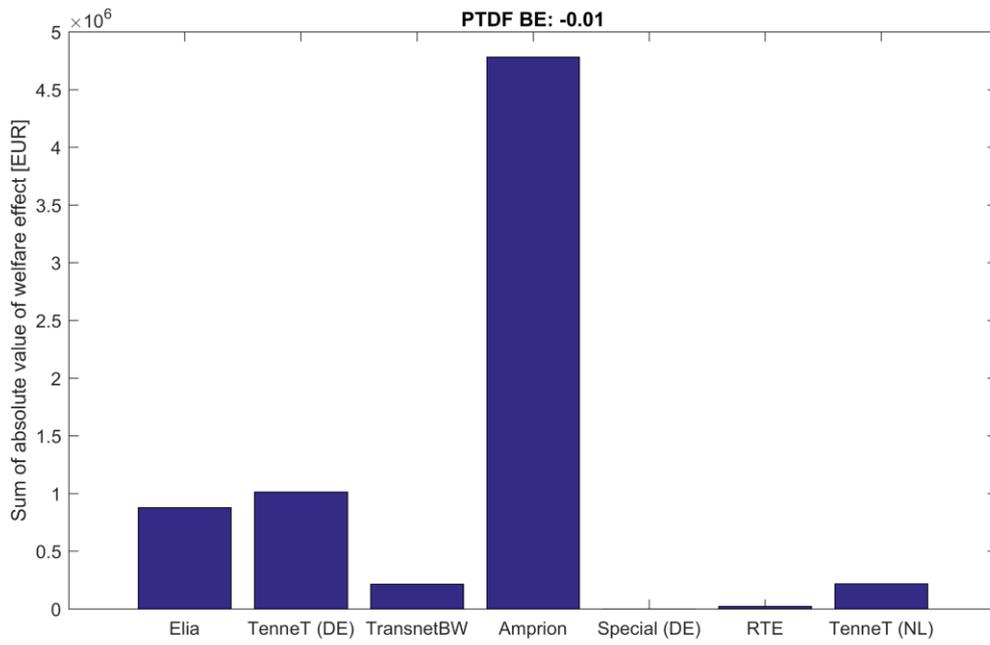


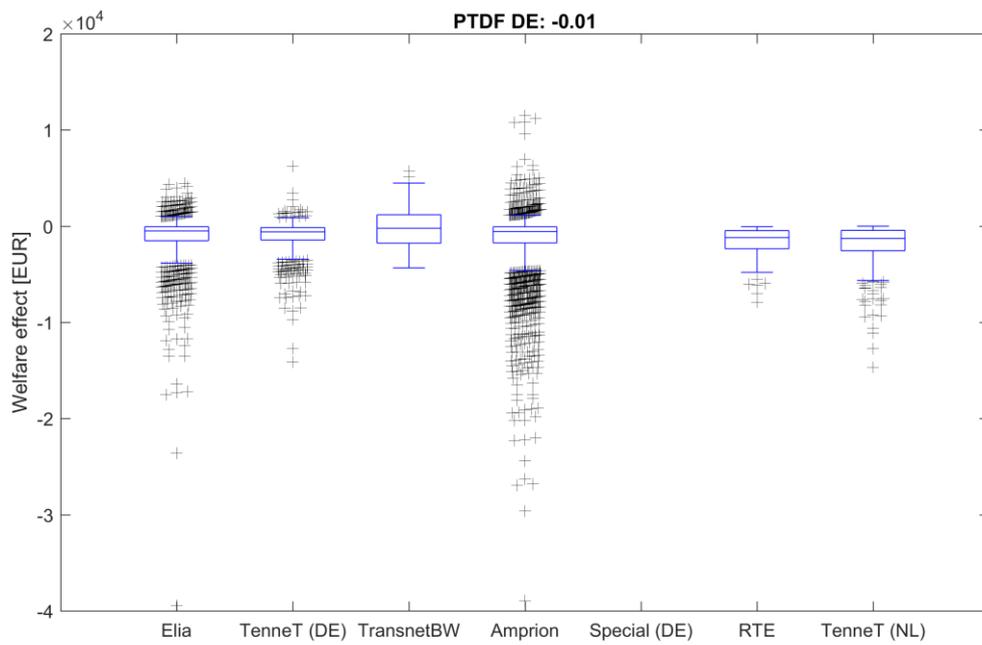
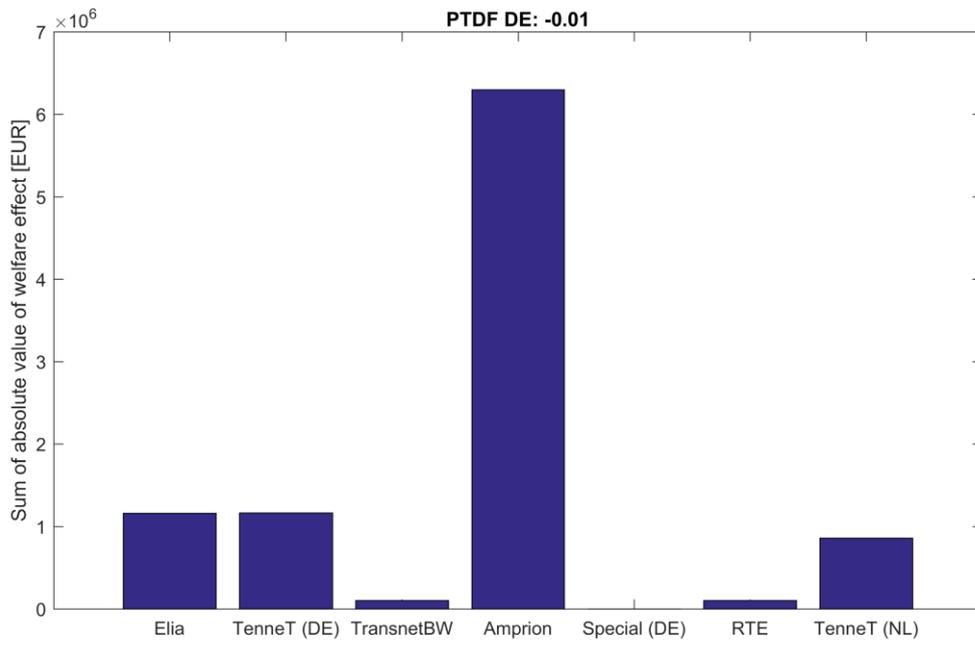
## A.2.4 FFC sensitivities

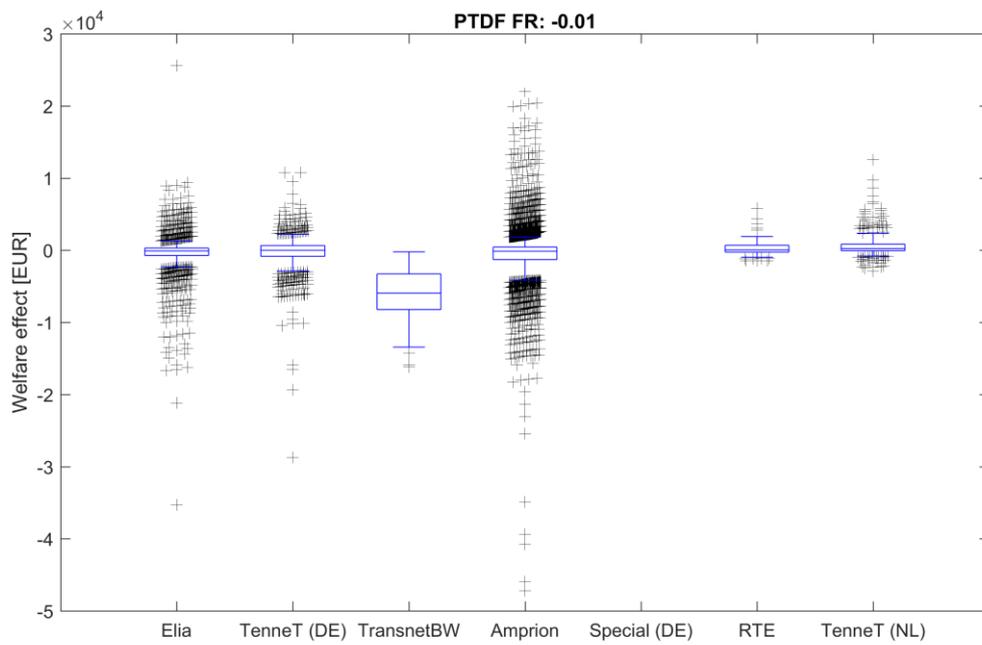
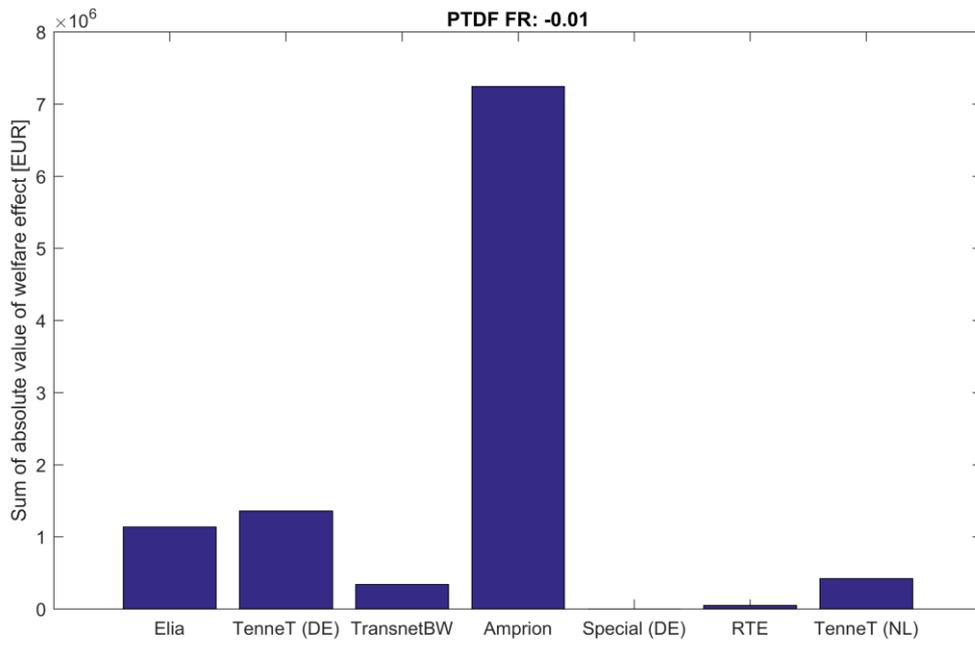


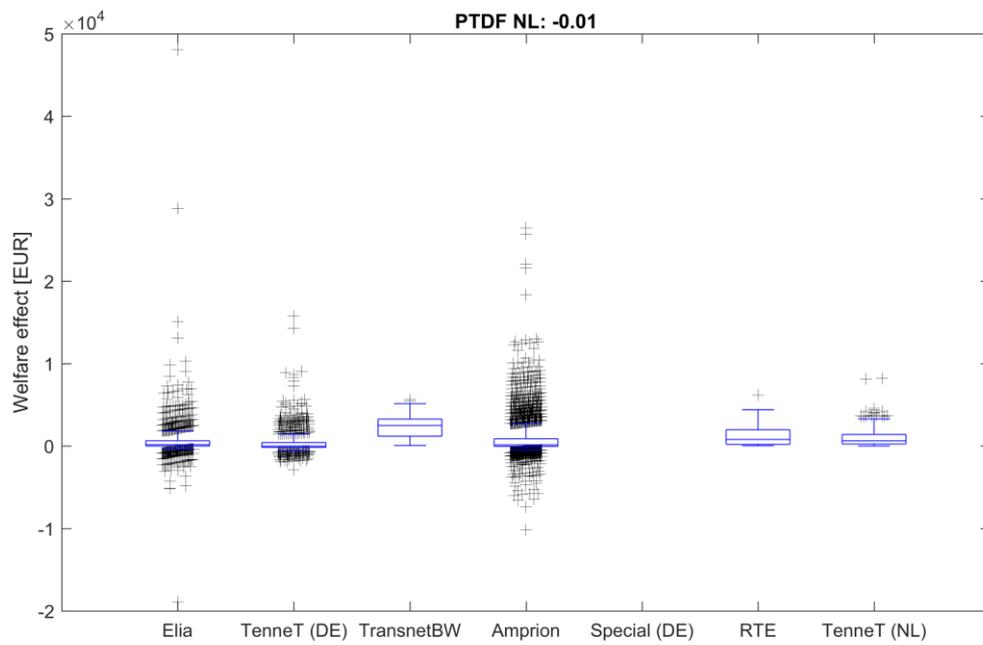
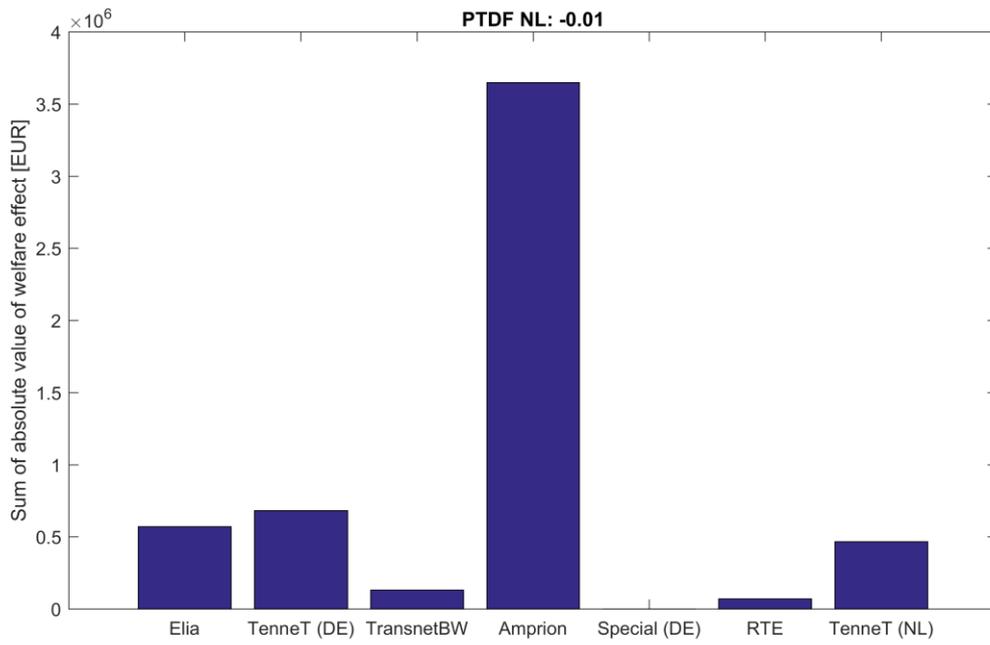








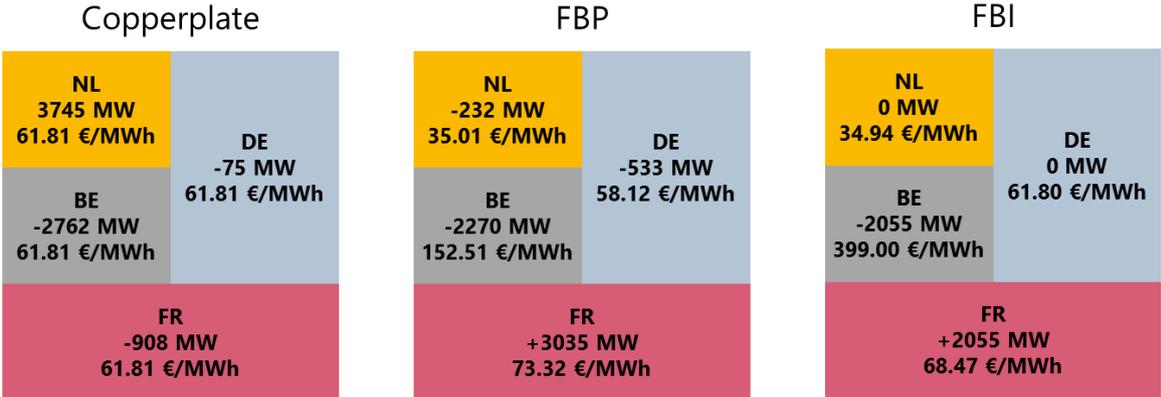






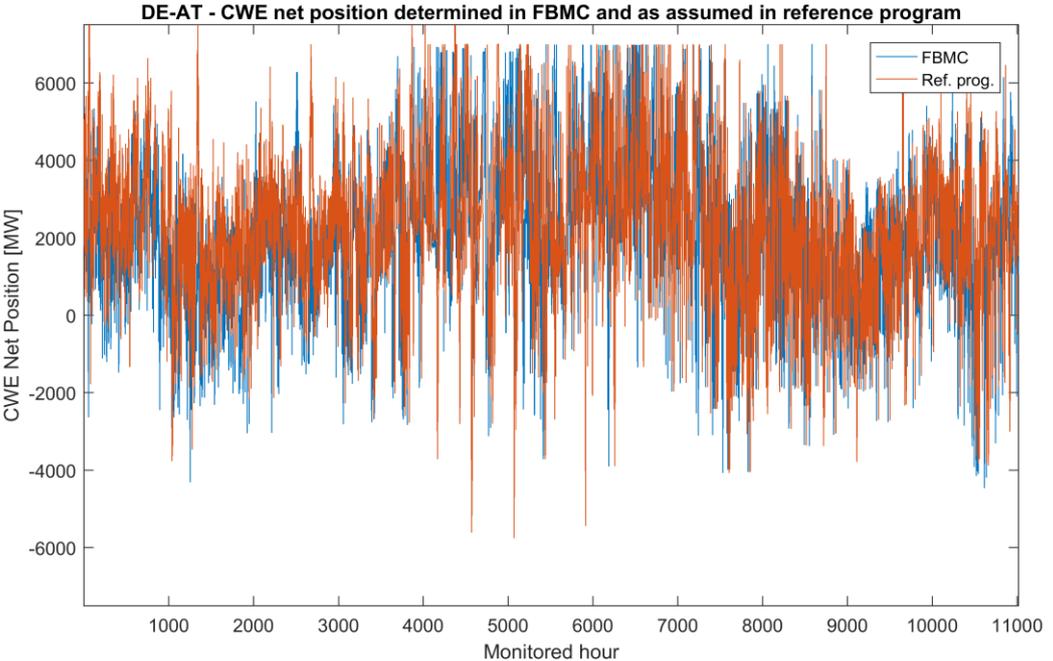
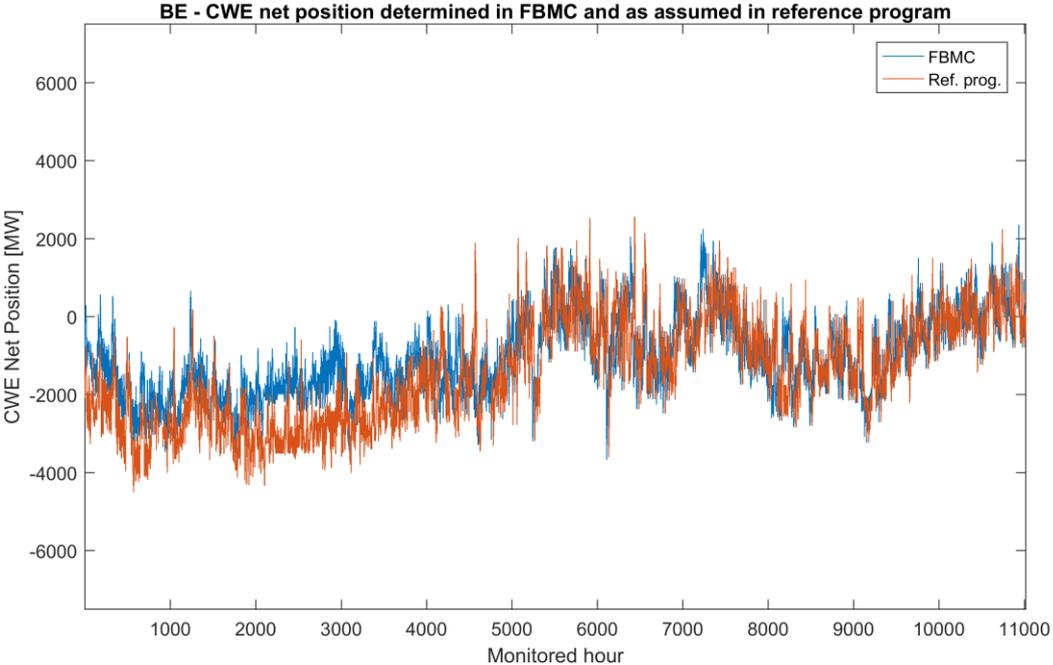
# Discussion of selected case

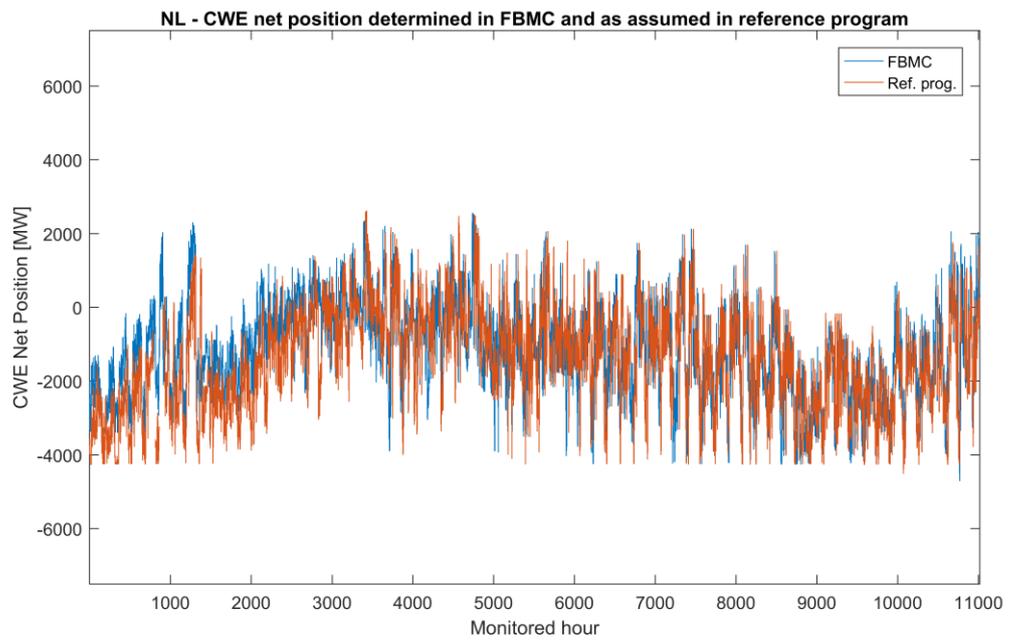
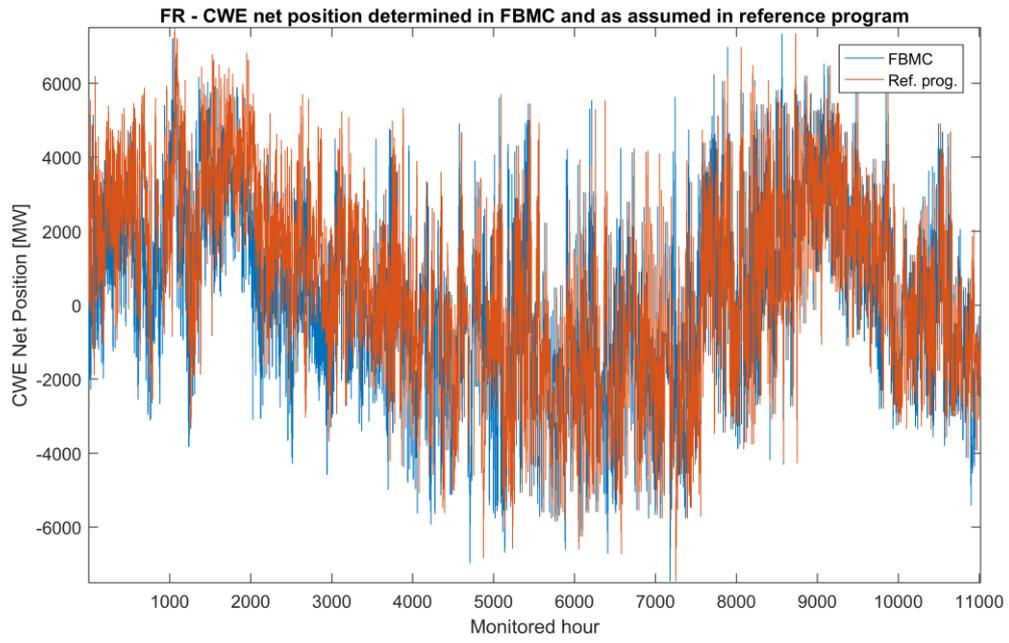
Oct. 16<sup>th</sup>, 2015, 8:00 h (Hour of maximum price spread of FBI vs. FBP)

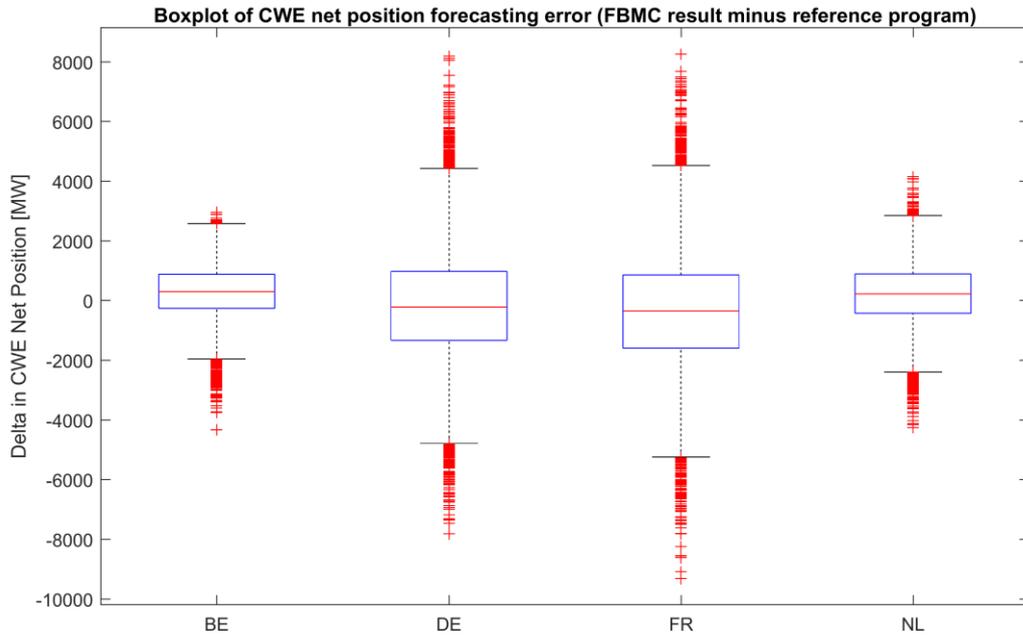


### A.3 Modelling accuracies

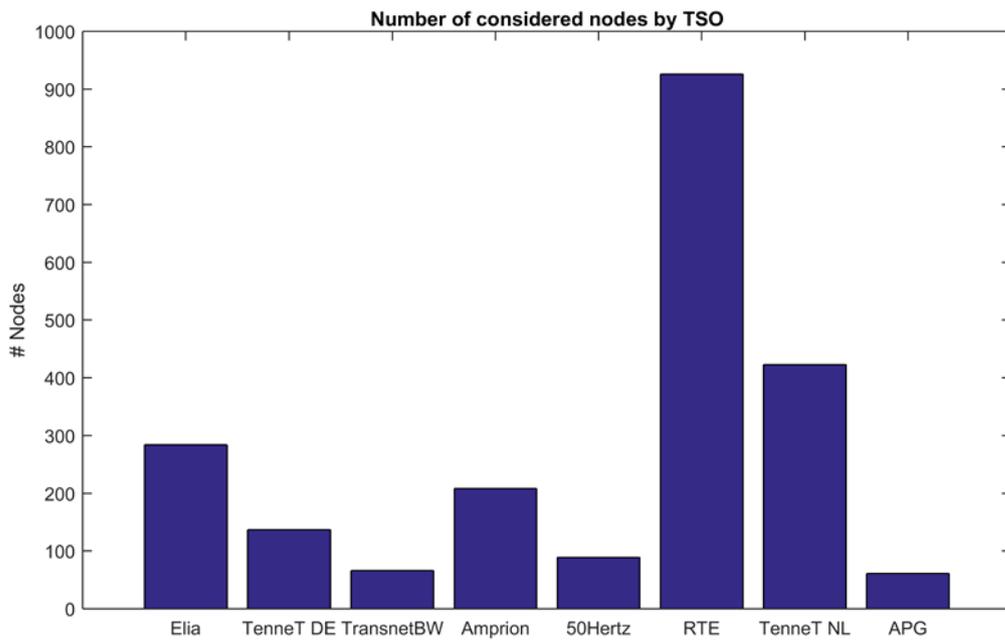
#### A.3.1 Bidding zone positions

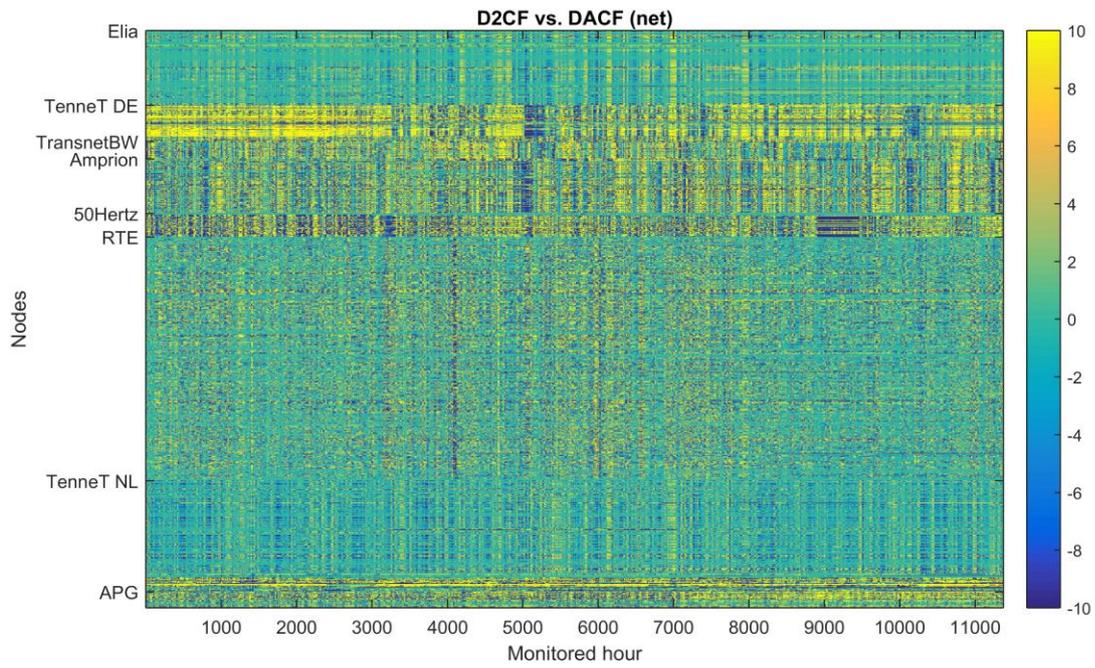
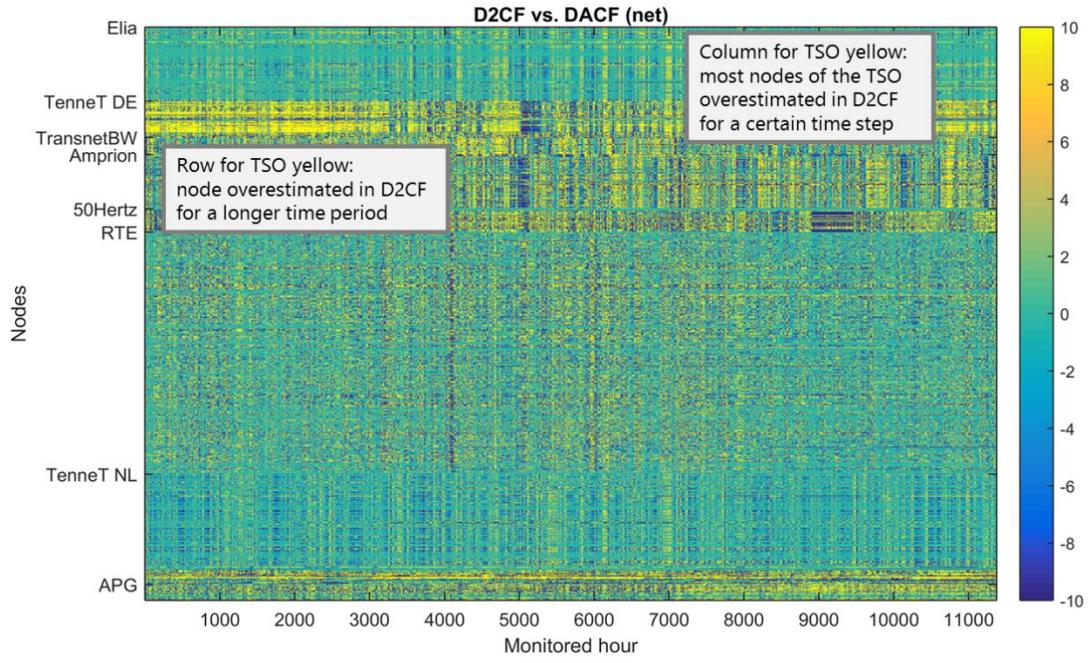


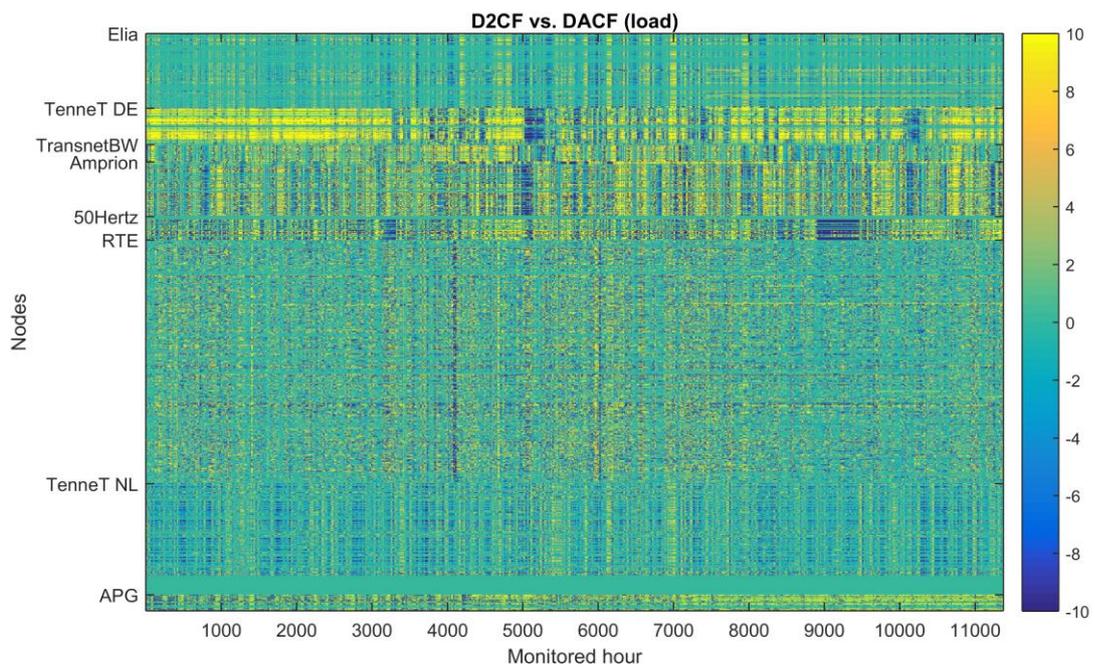
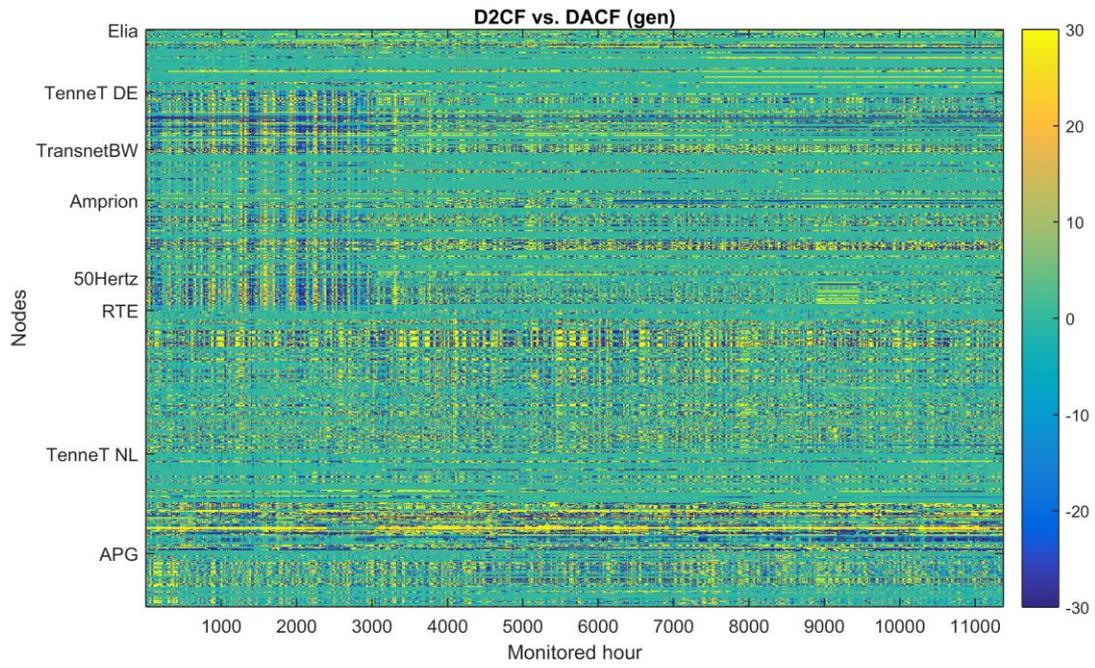


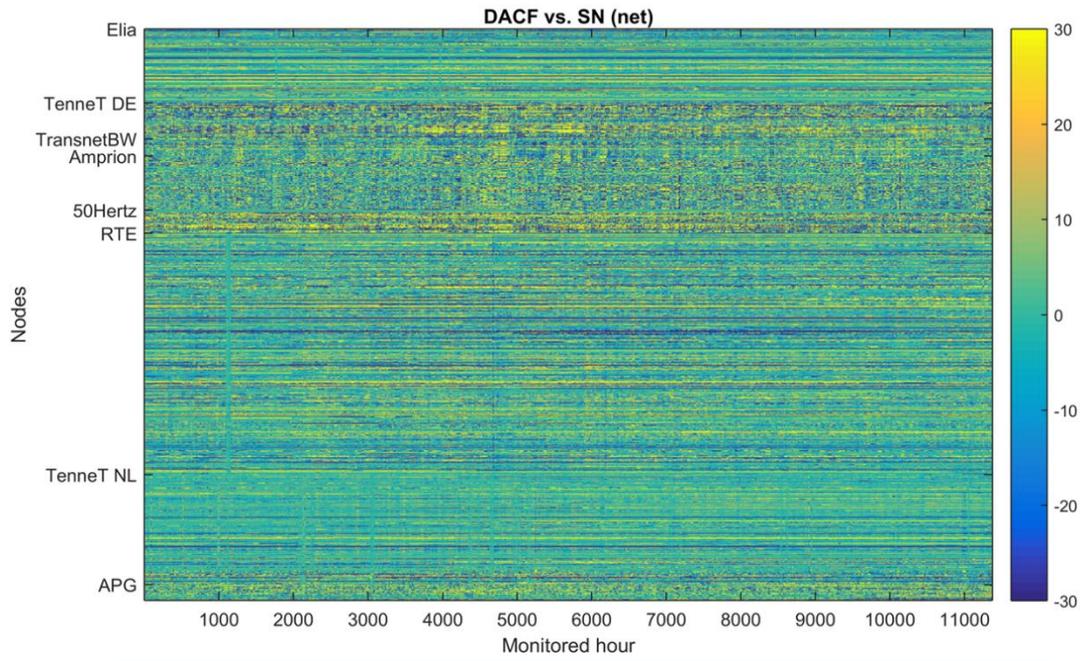


### A.3.2 Nodal positions

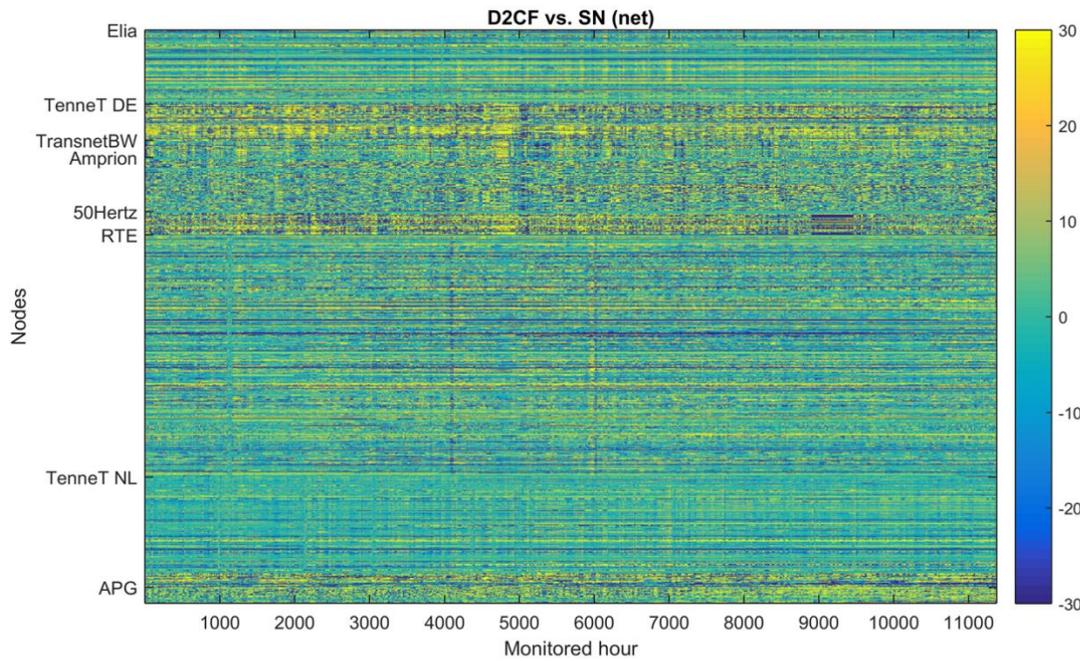




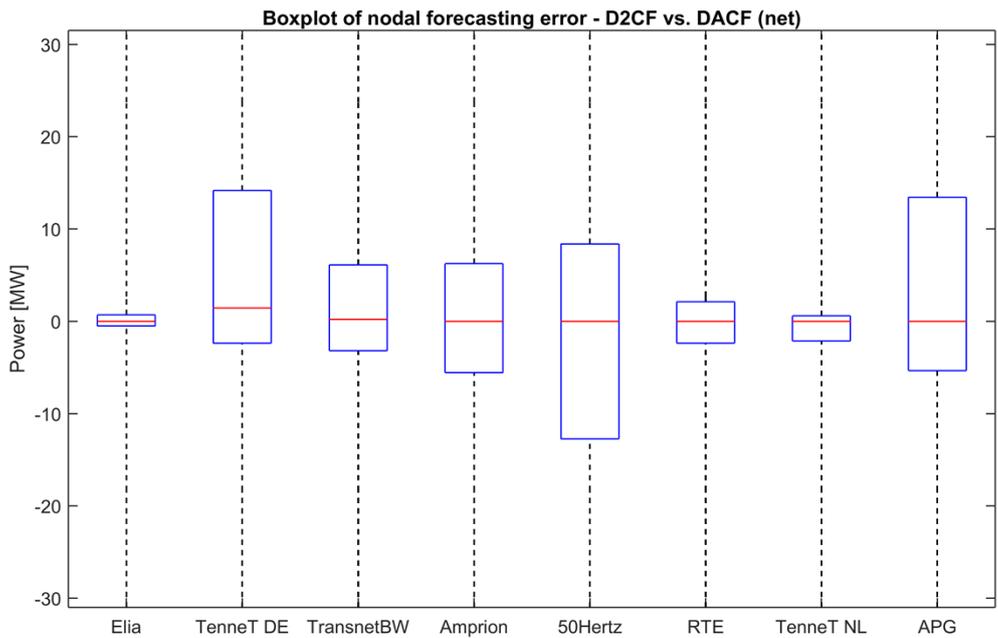
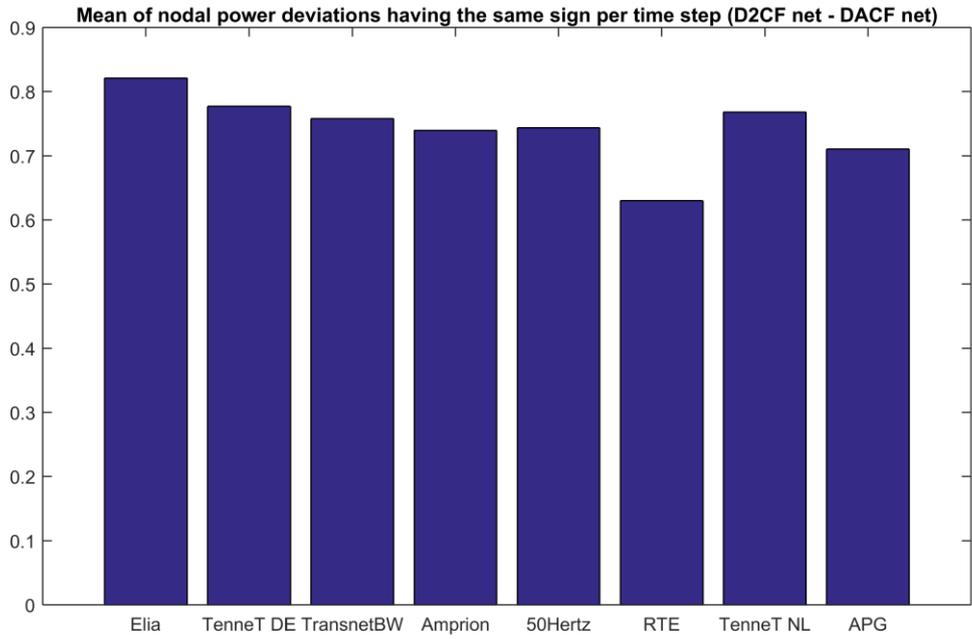




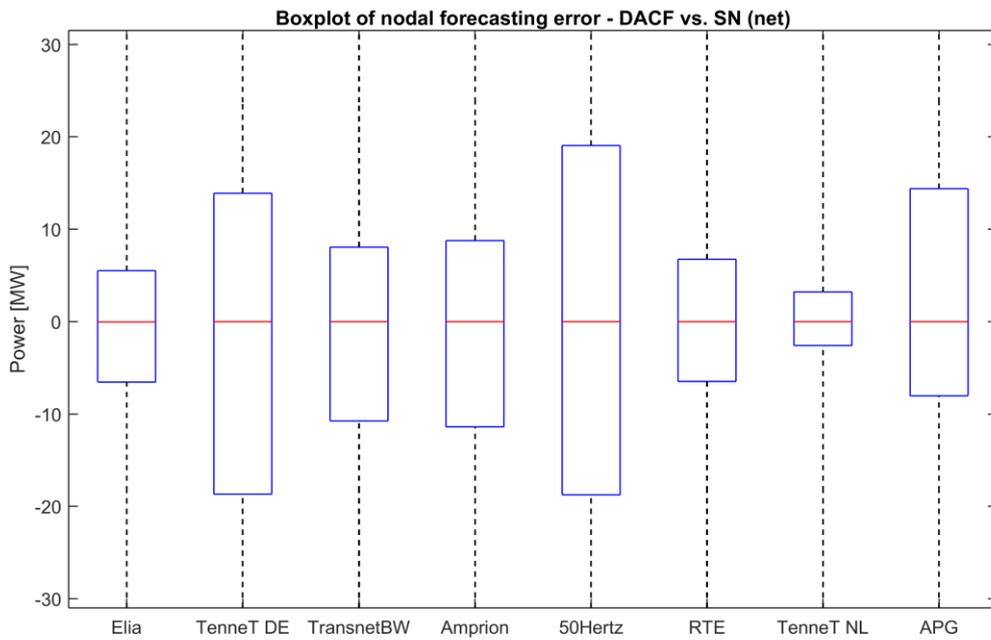
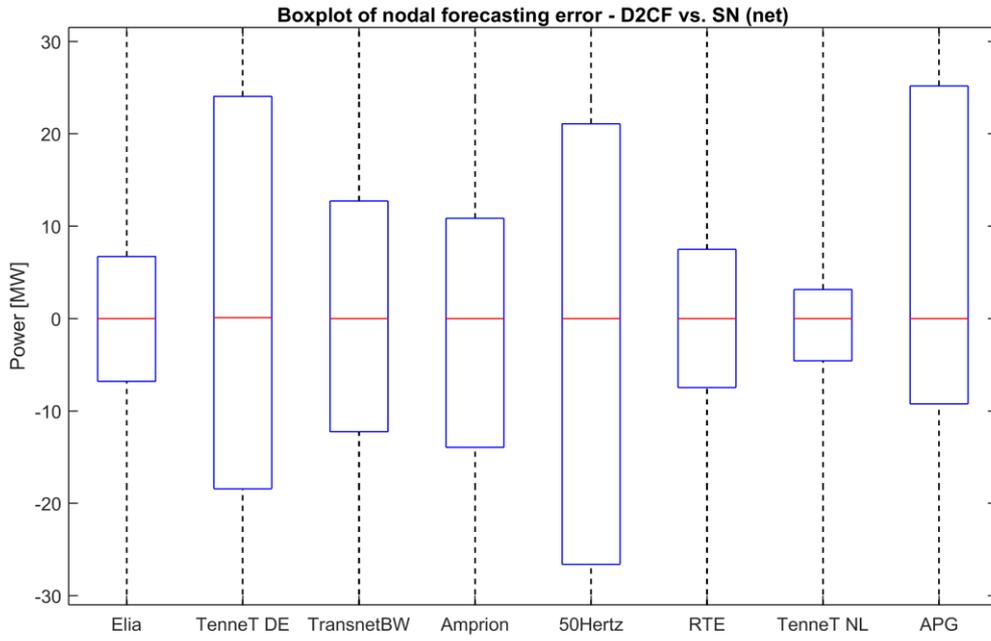
 Comparison with snapshots not reliable for all TSOs since node codes are modelled differently in load flow tools and state estimation

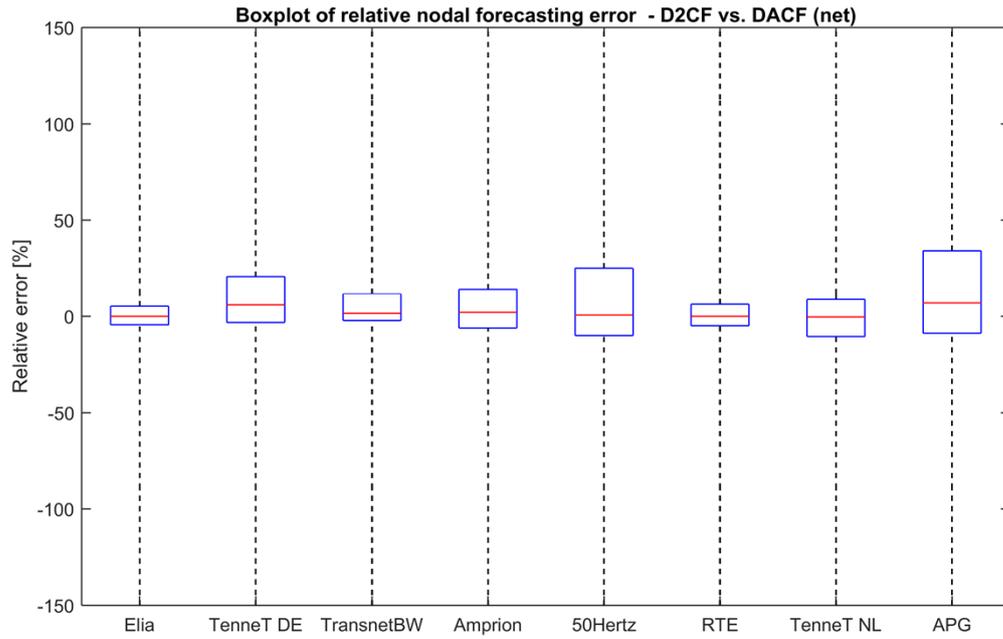


 Comparison with snapshots not reliable for all TSOs since node codes are modelled differently in load flow tools and state estimation

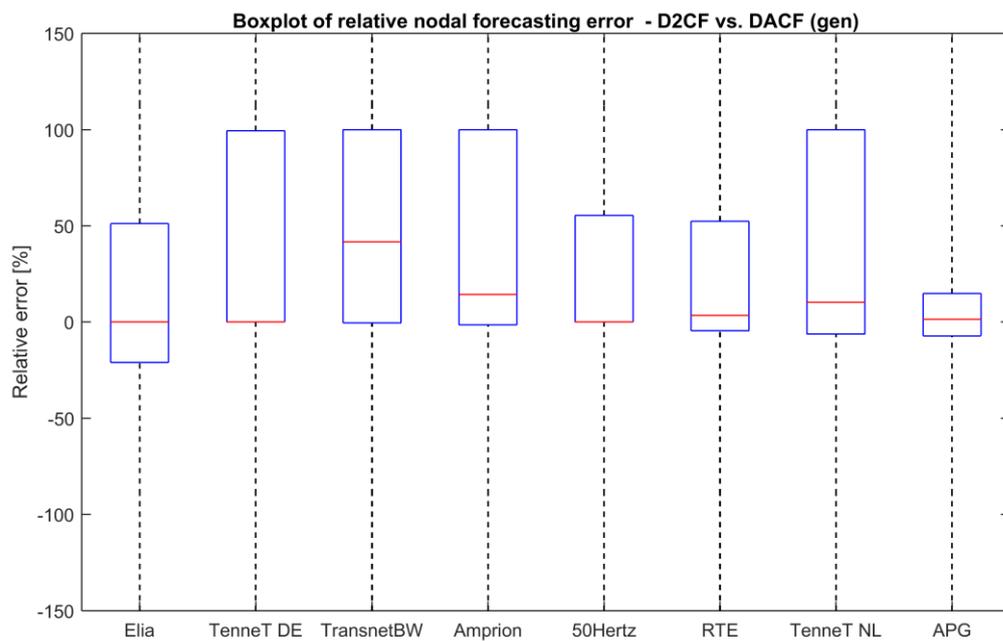


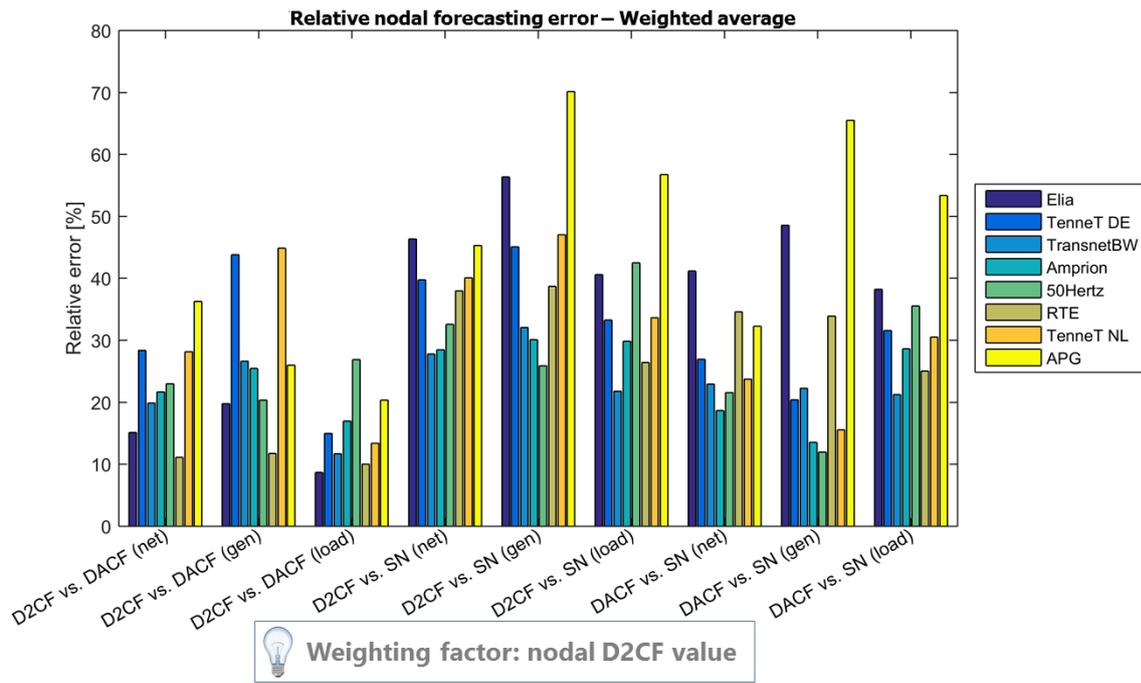
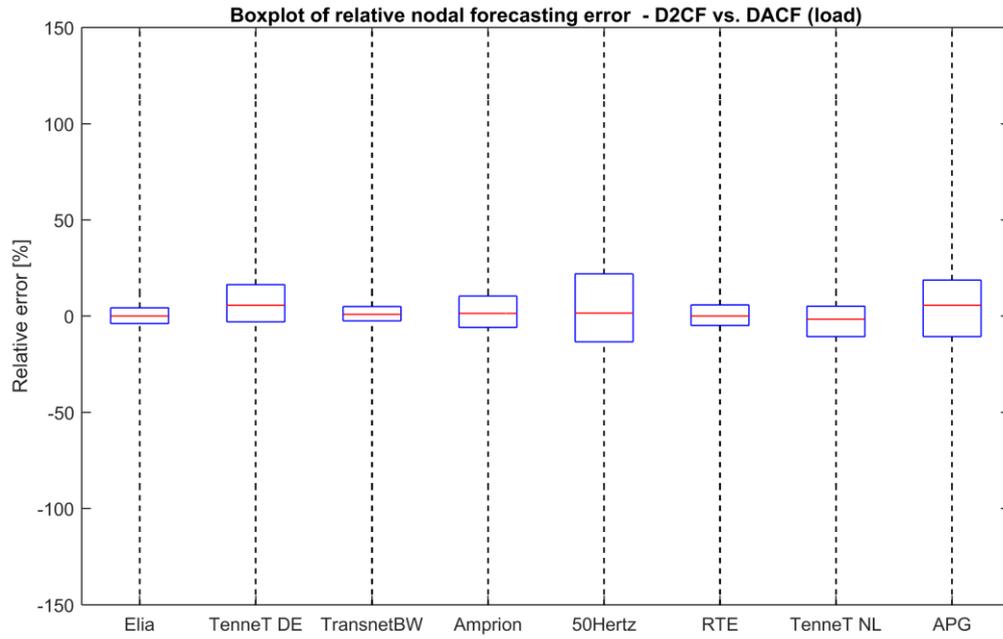
 **Nodal forecasting error =  
Nodal position in D2CF minus nodal position in DACF**

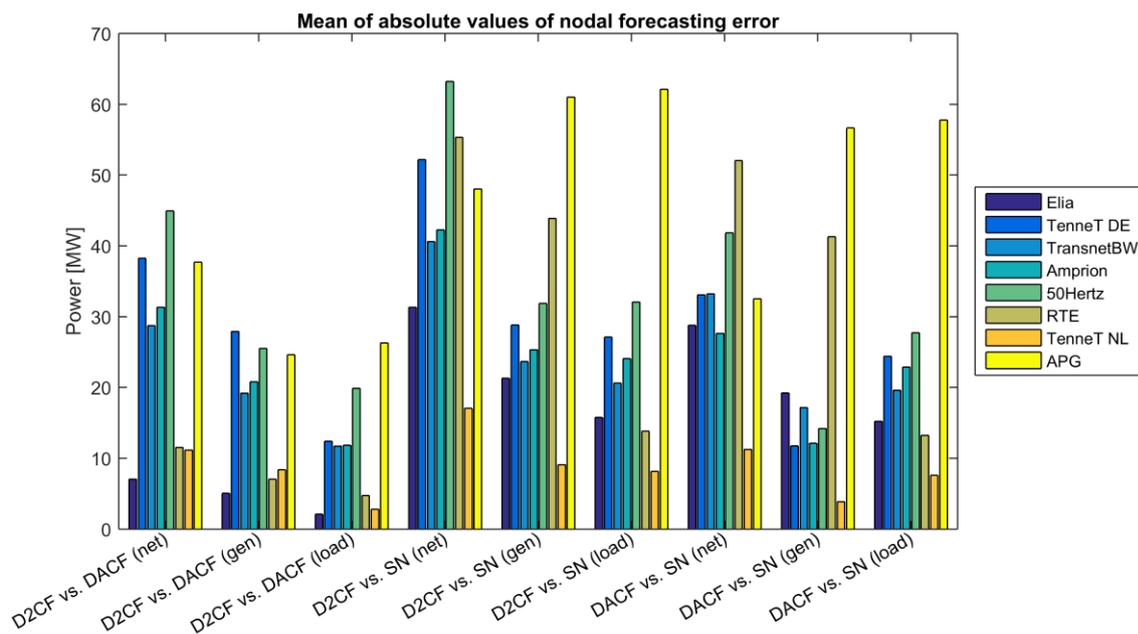
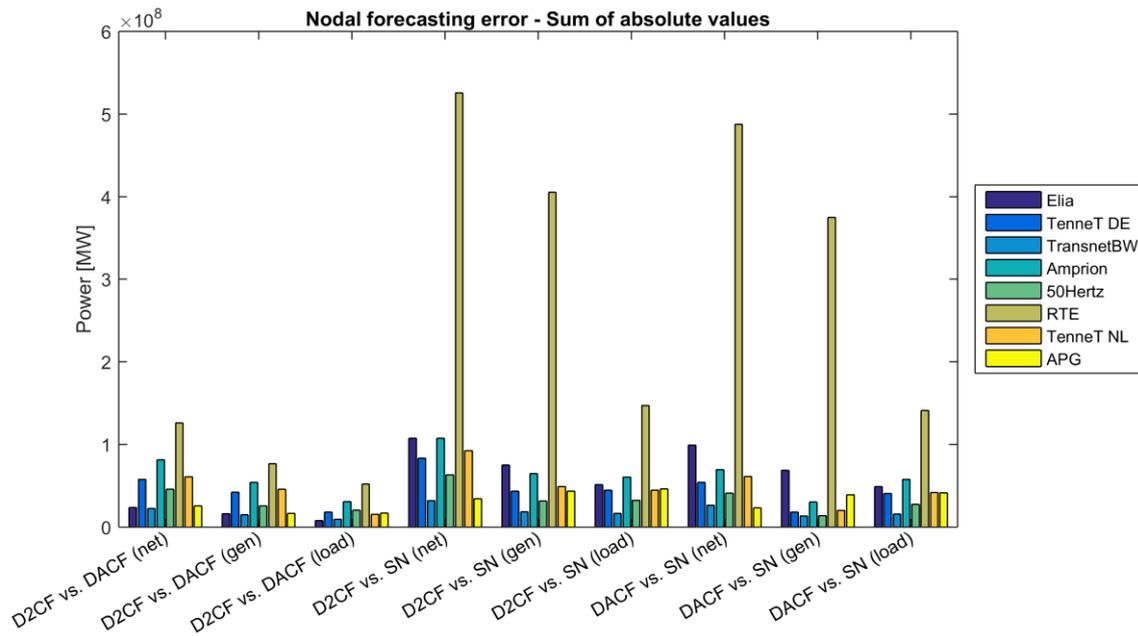


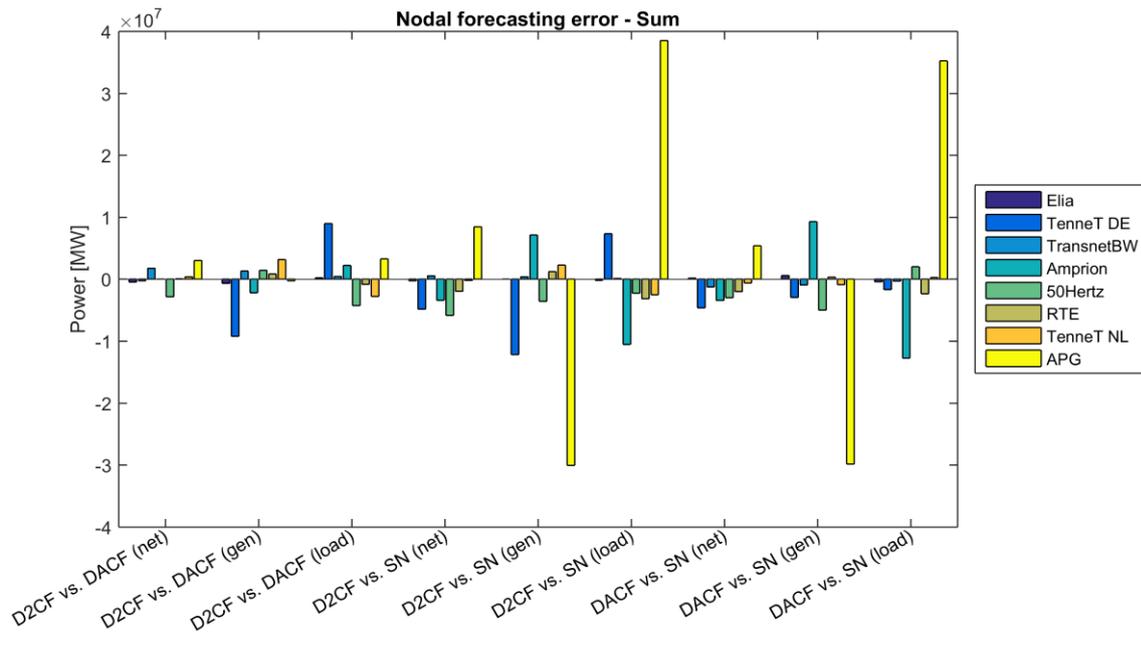


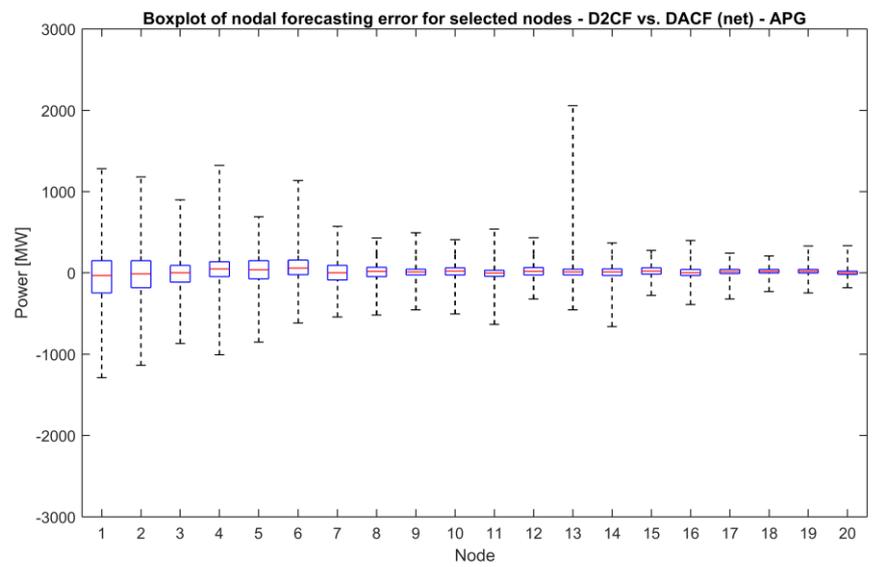
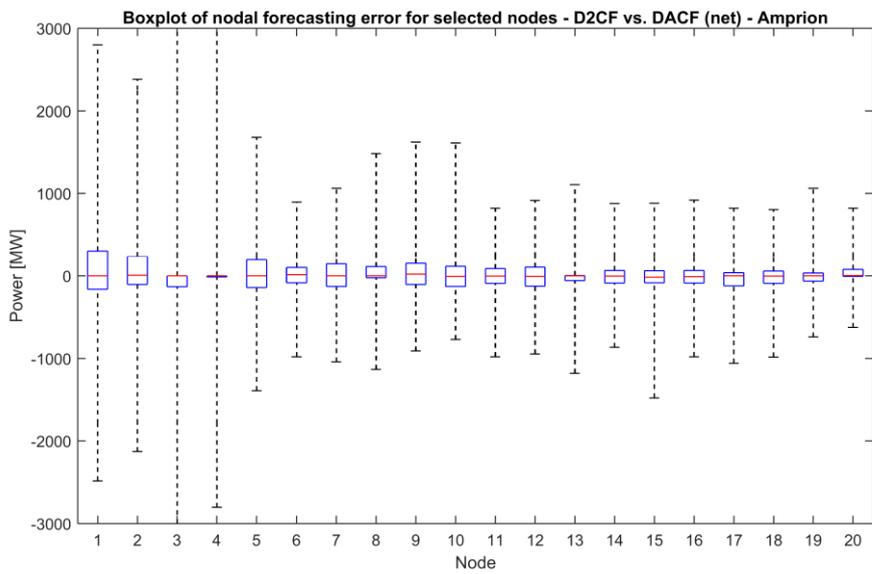
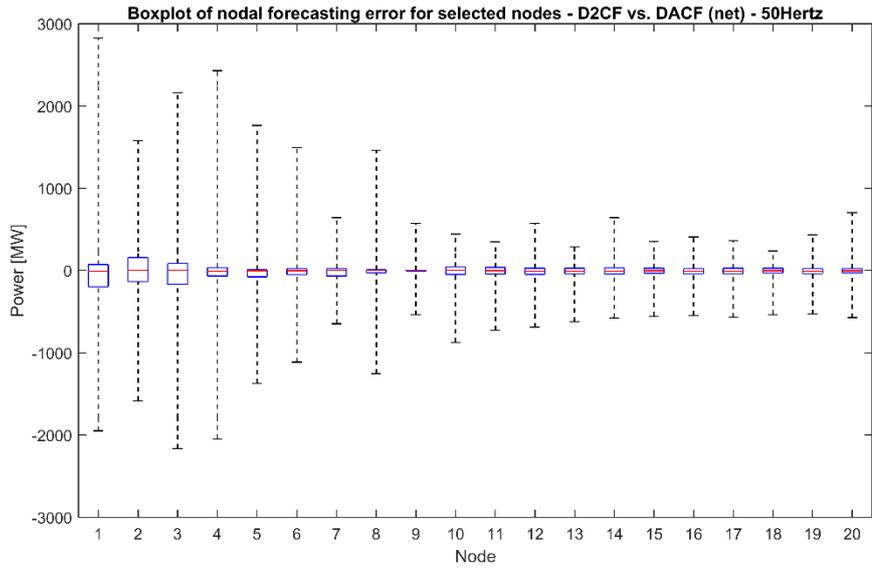
 **Relative error with D2CF values as base**  
**Values with D2CF=0 not counted (division by zero)**

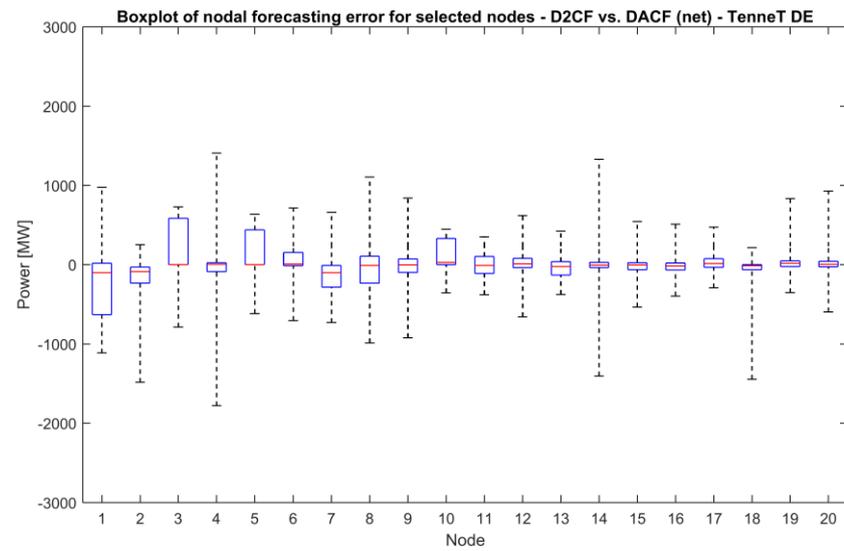
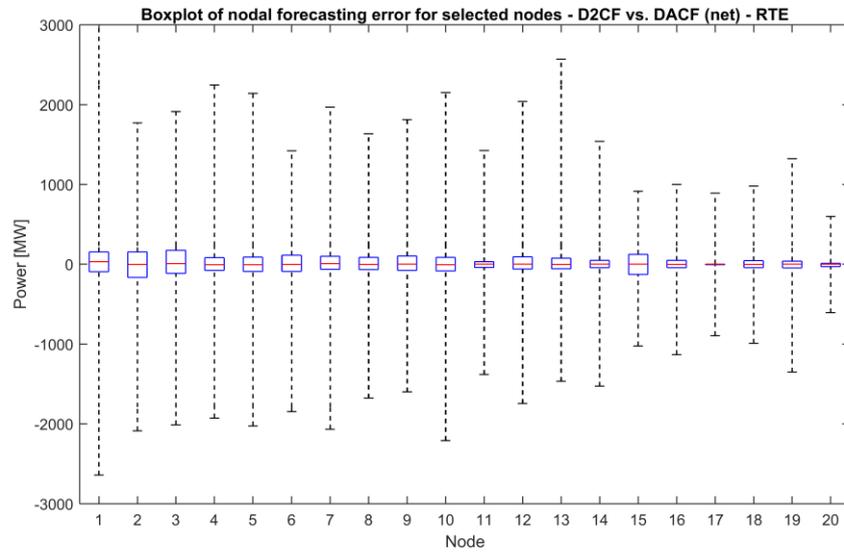
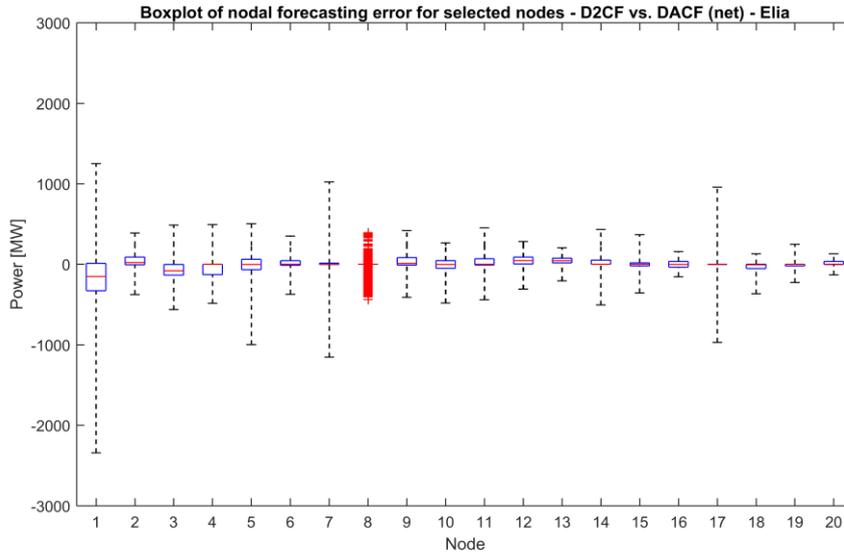


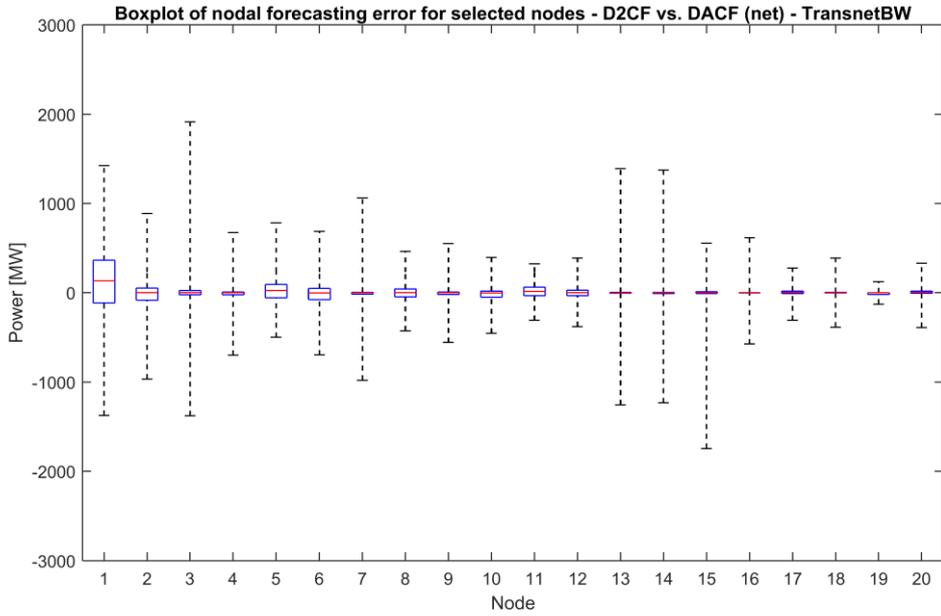
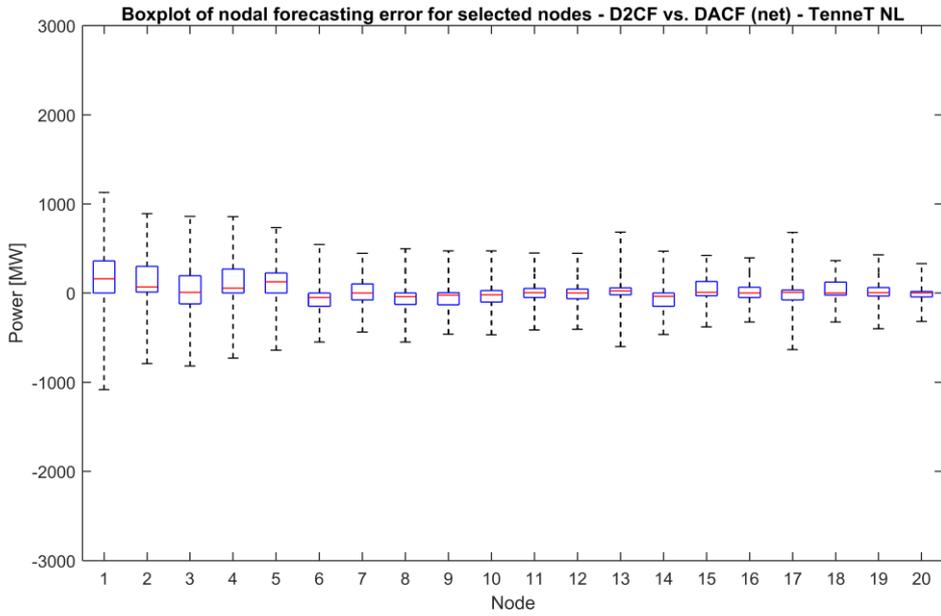


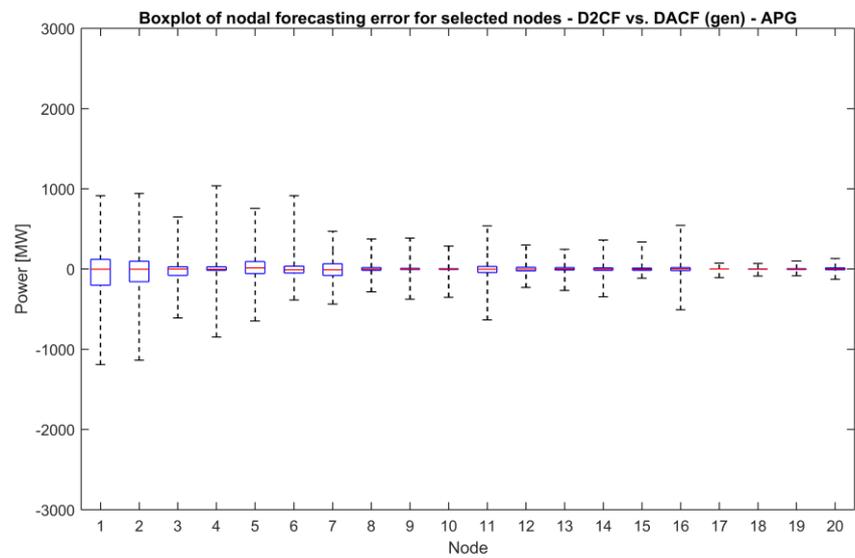
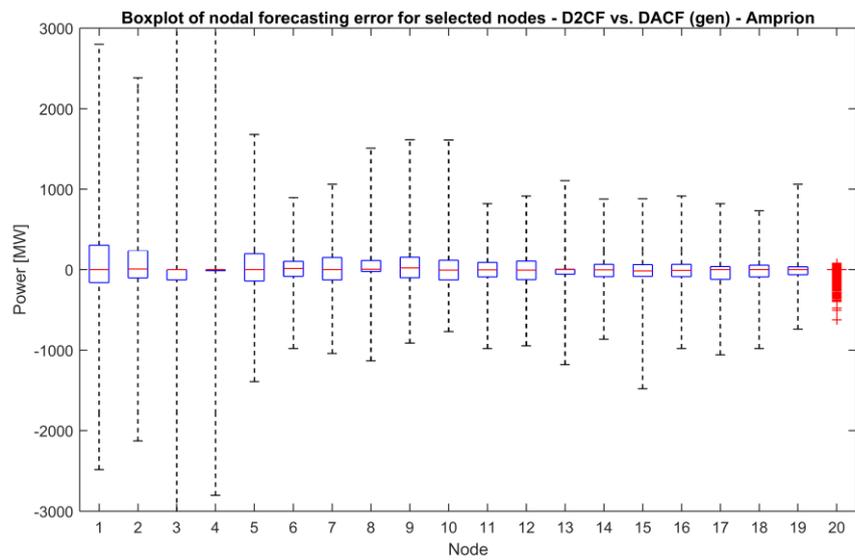
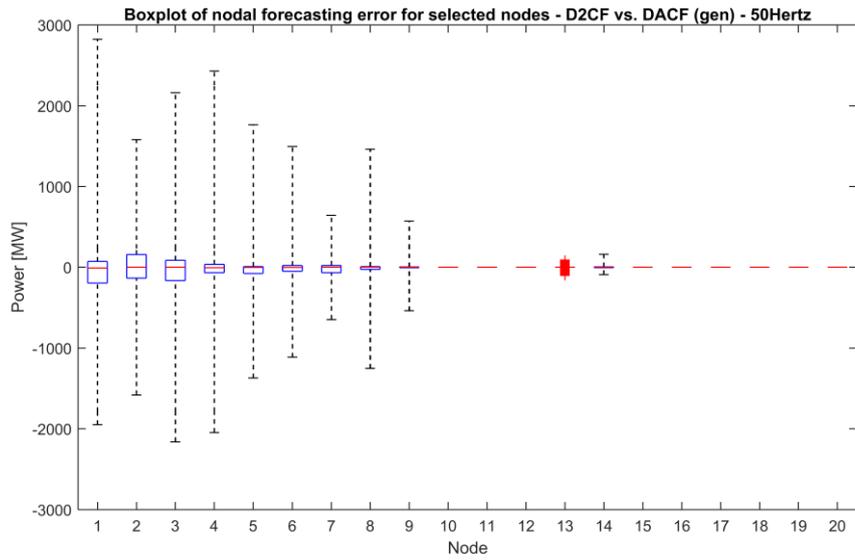


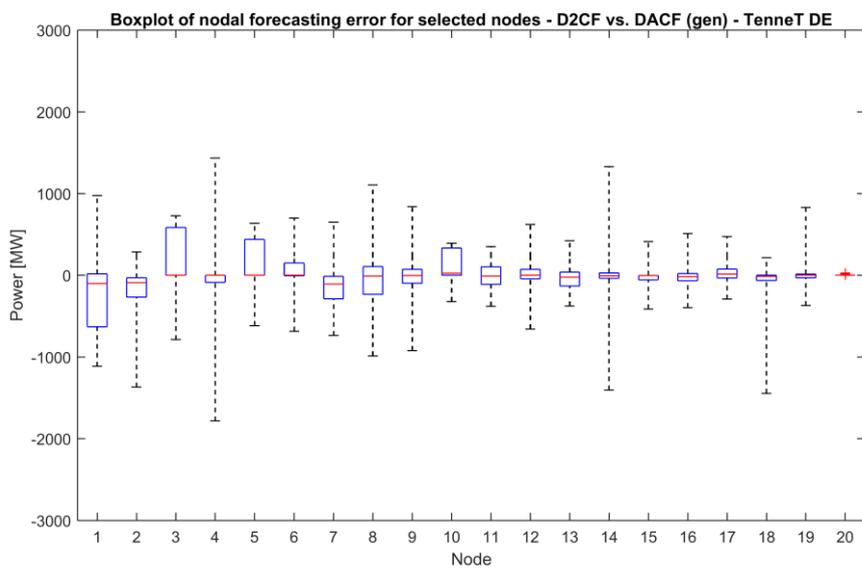
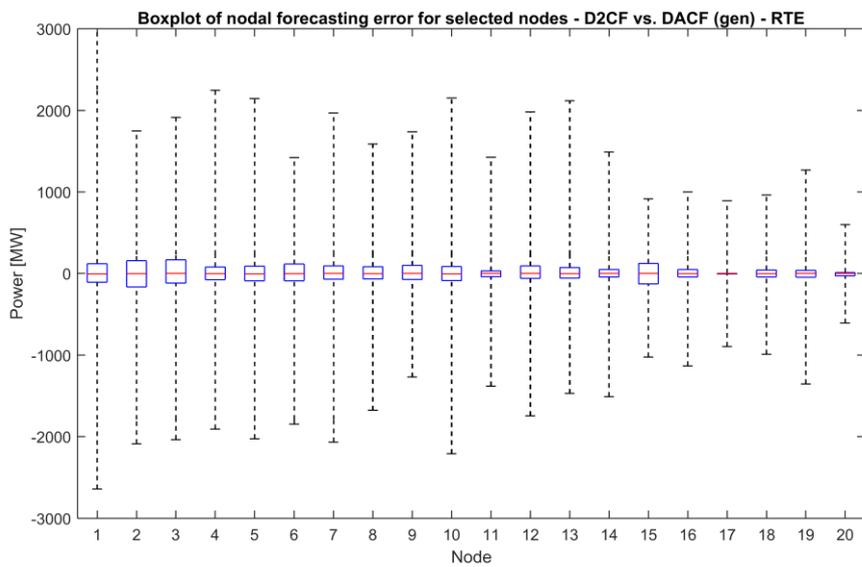
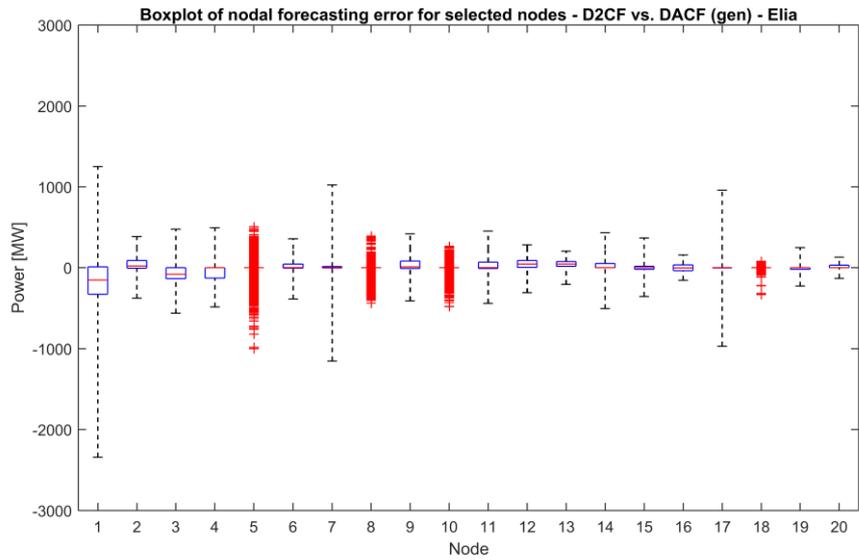


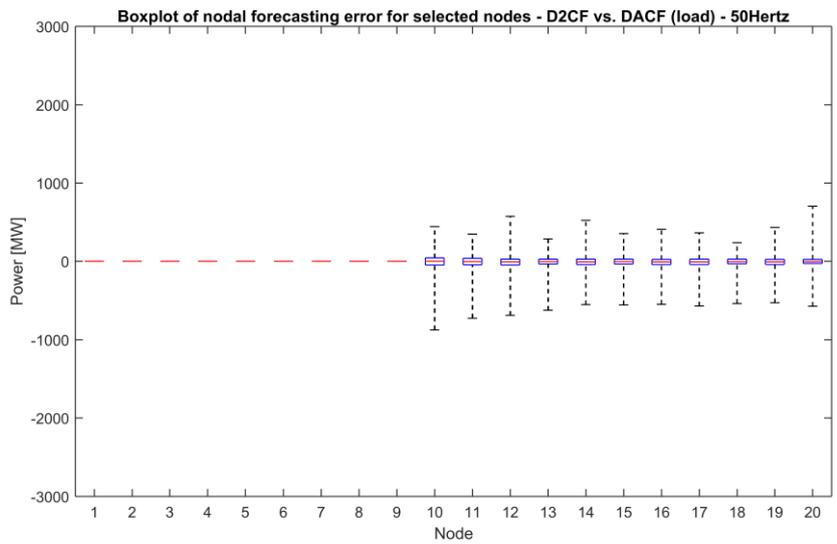
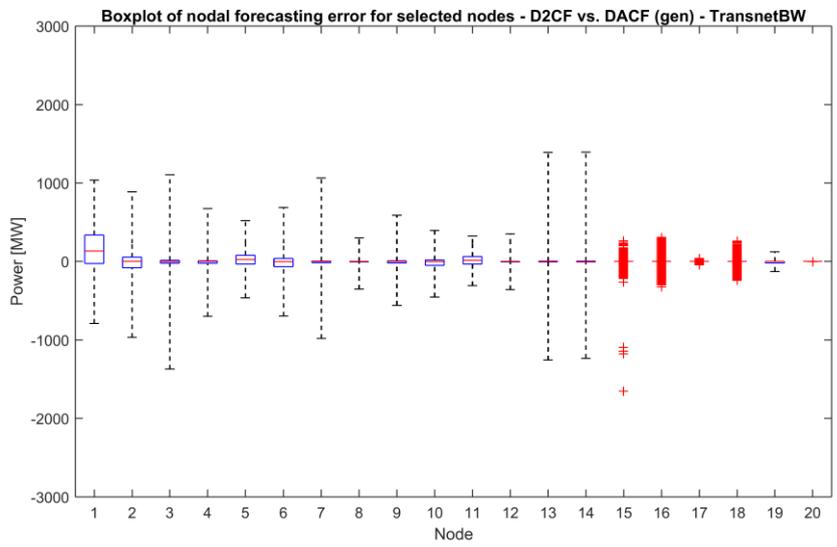
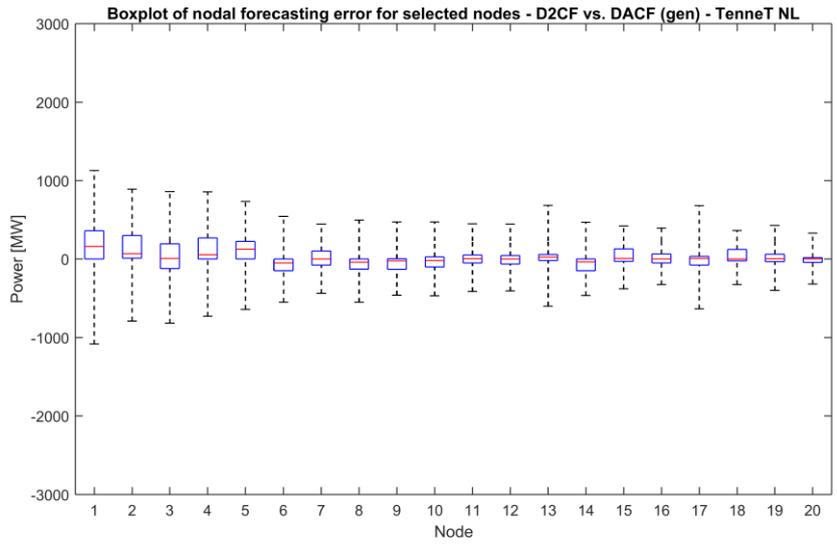


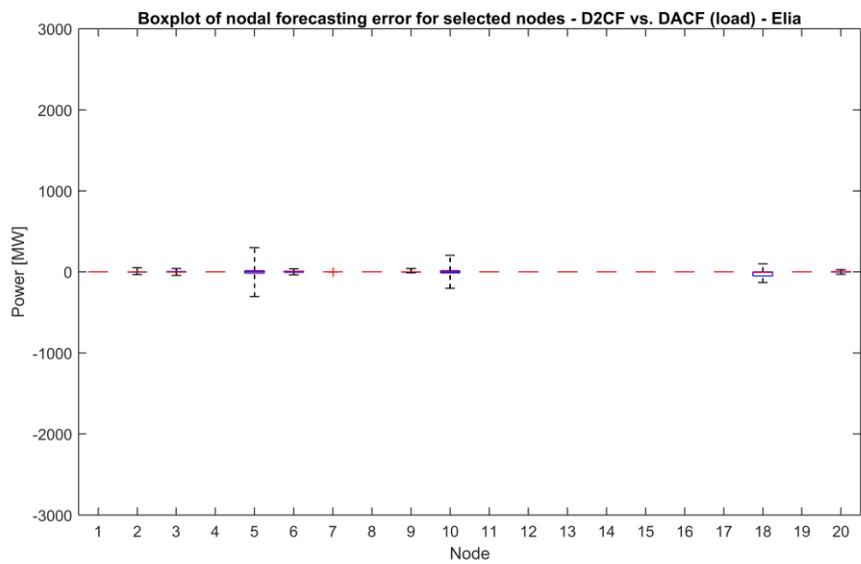
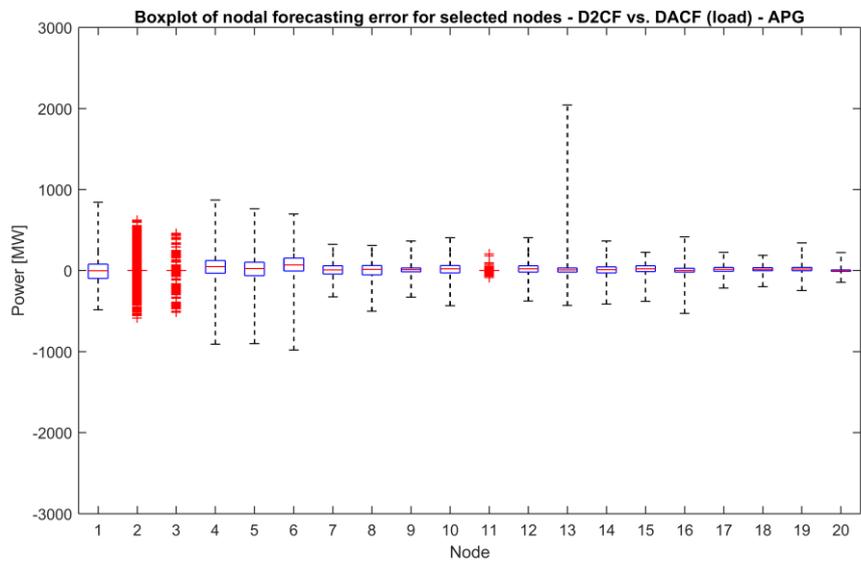
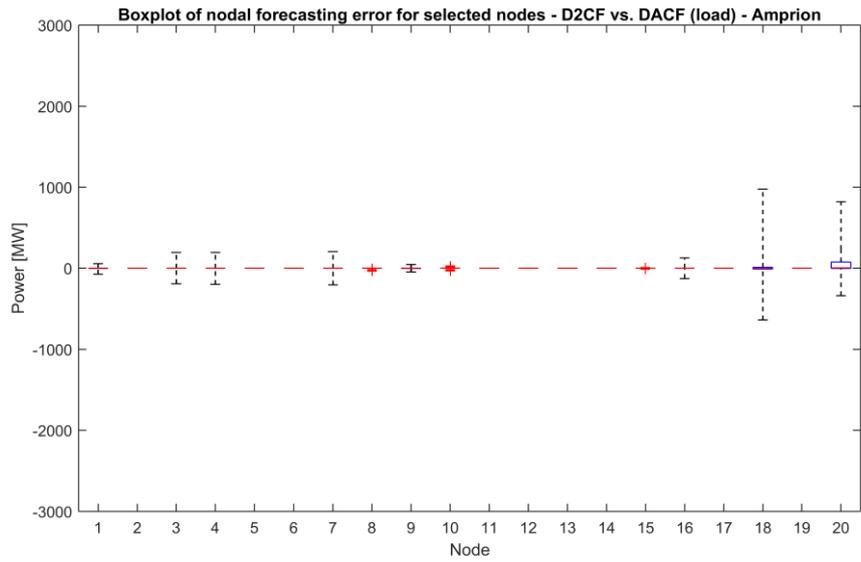


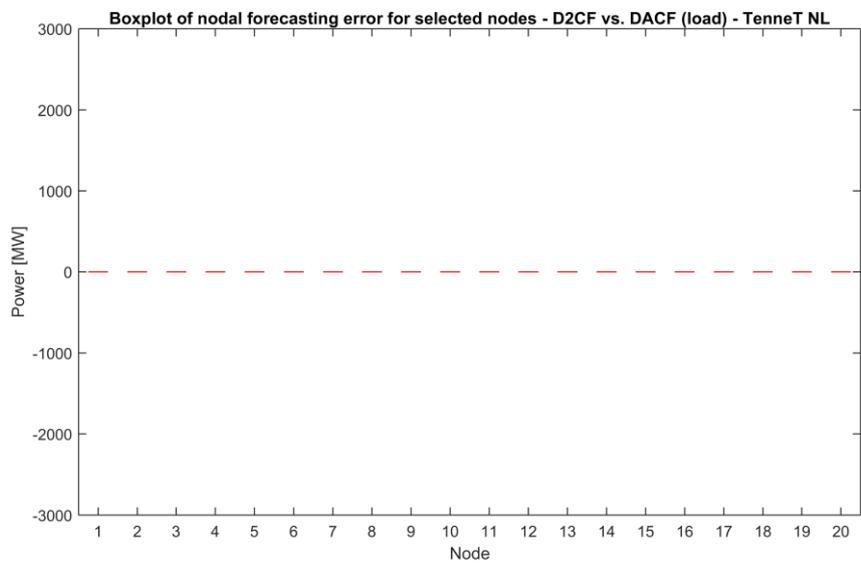
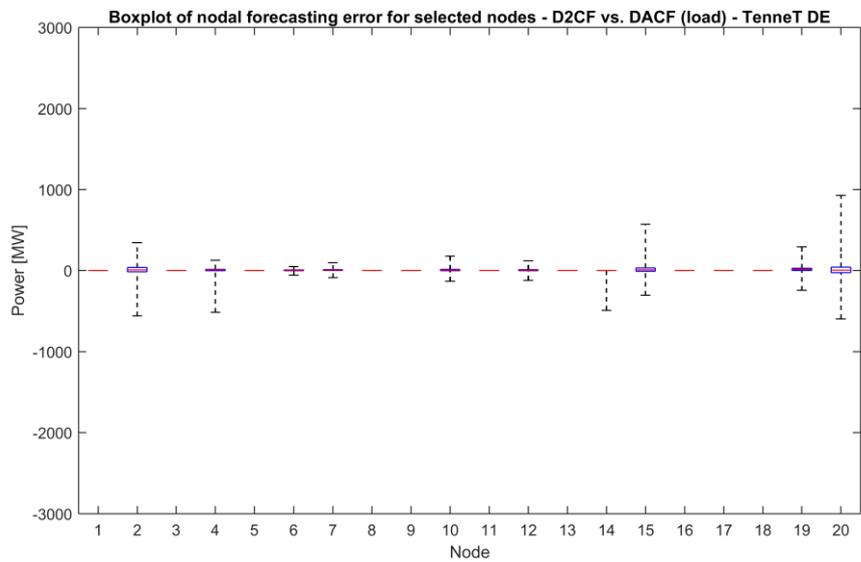
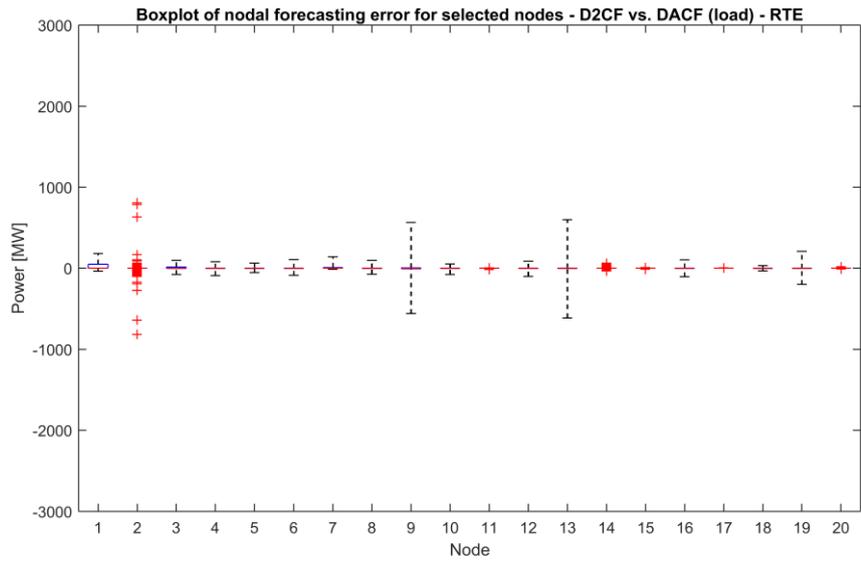


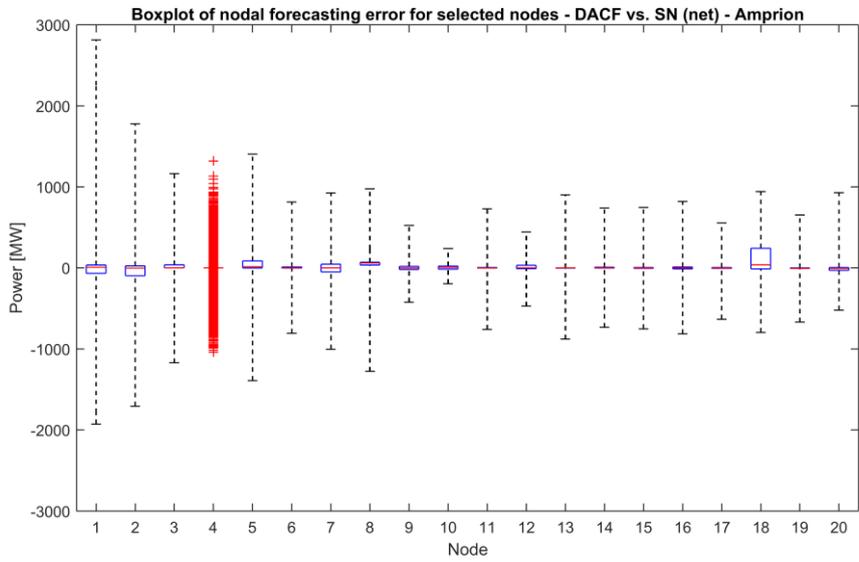
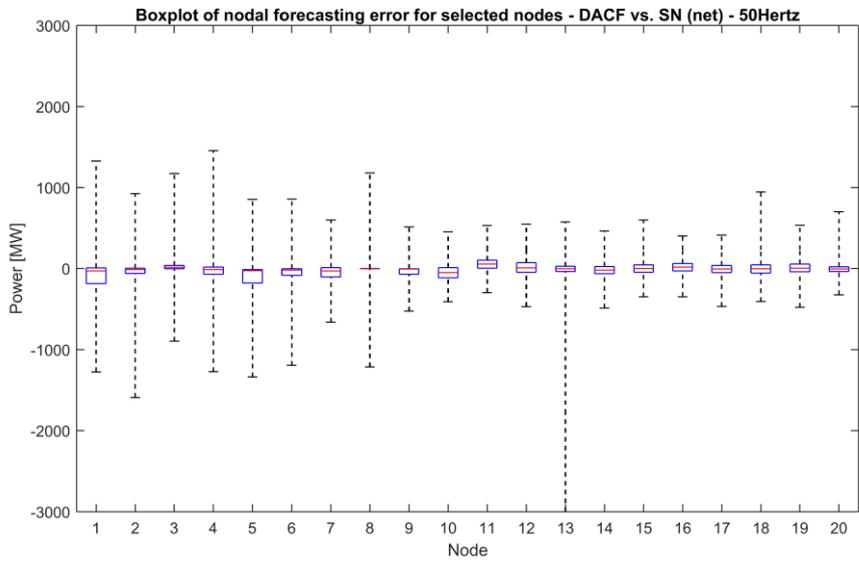
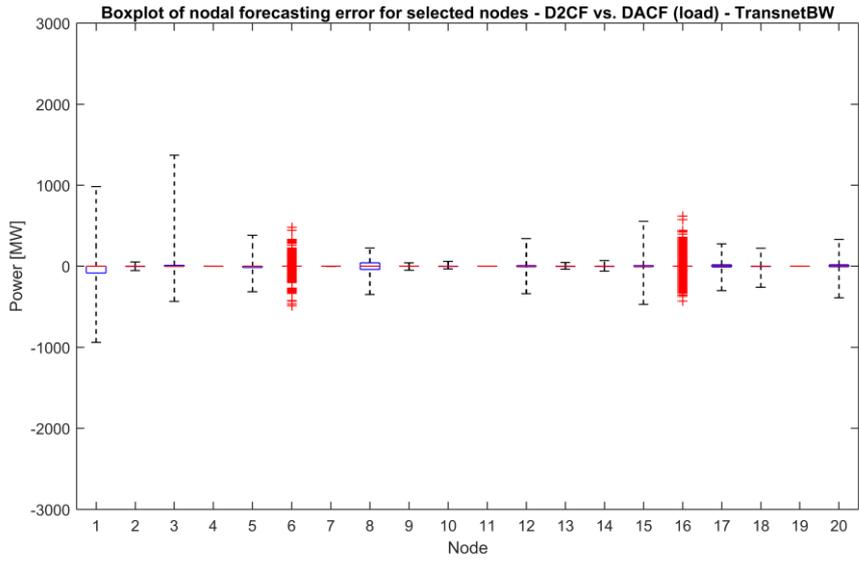


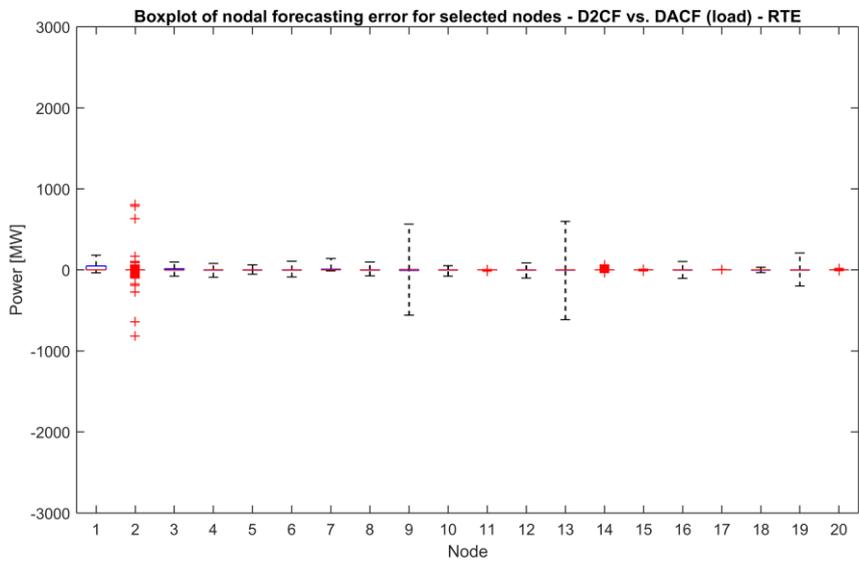
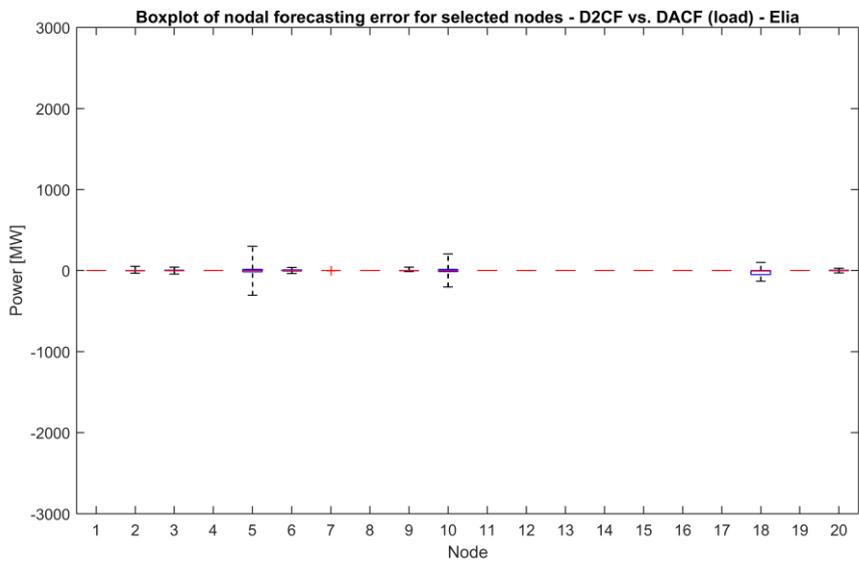
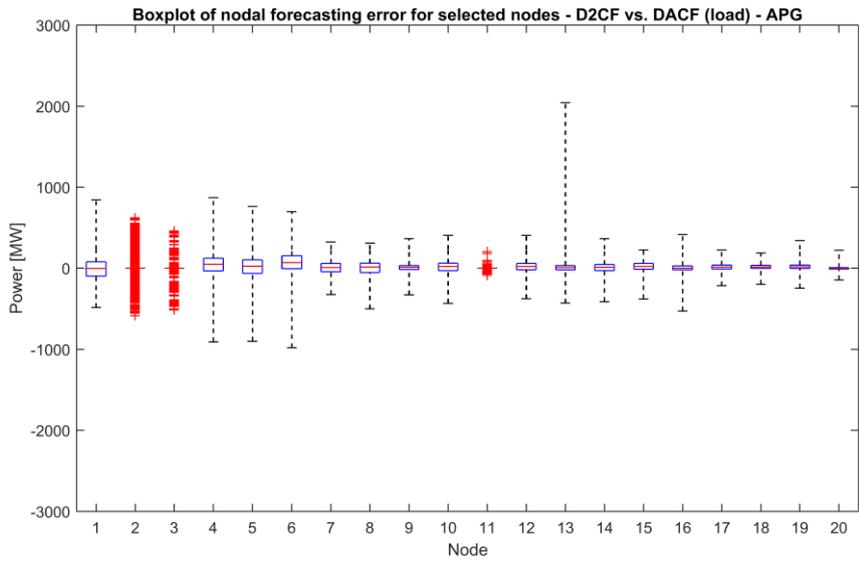


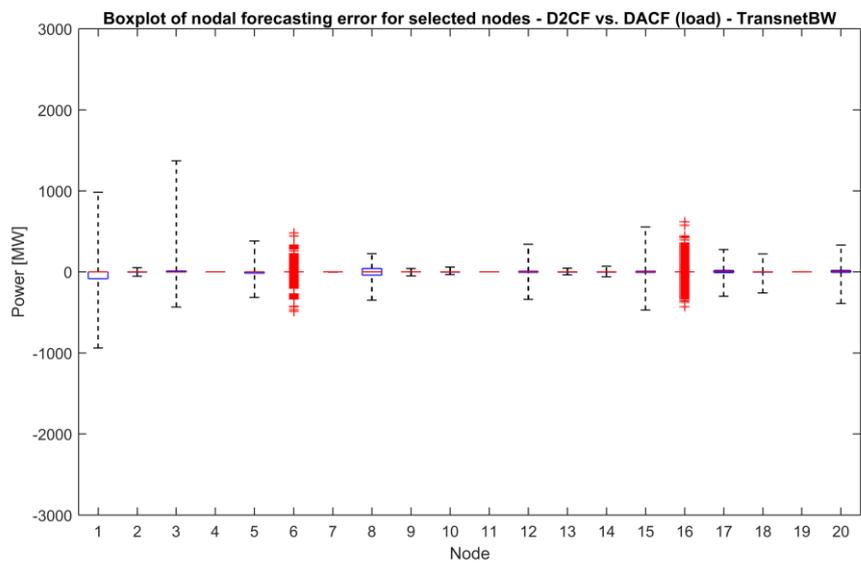
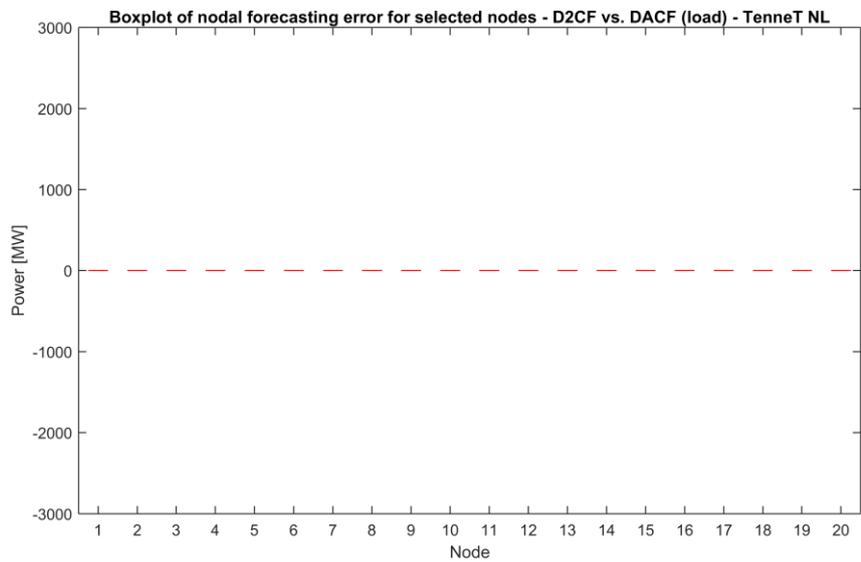
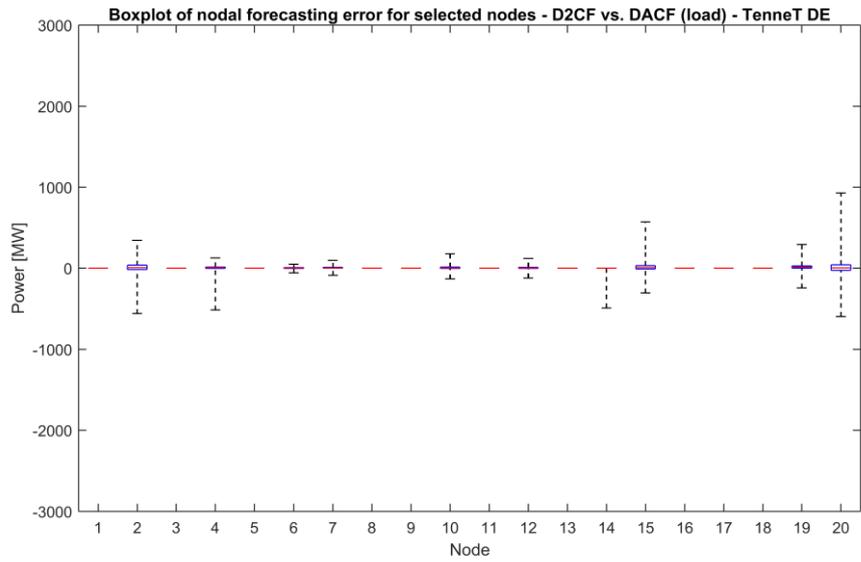


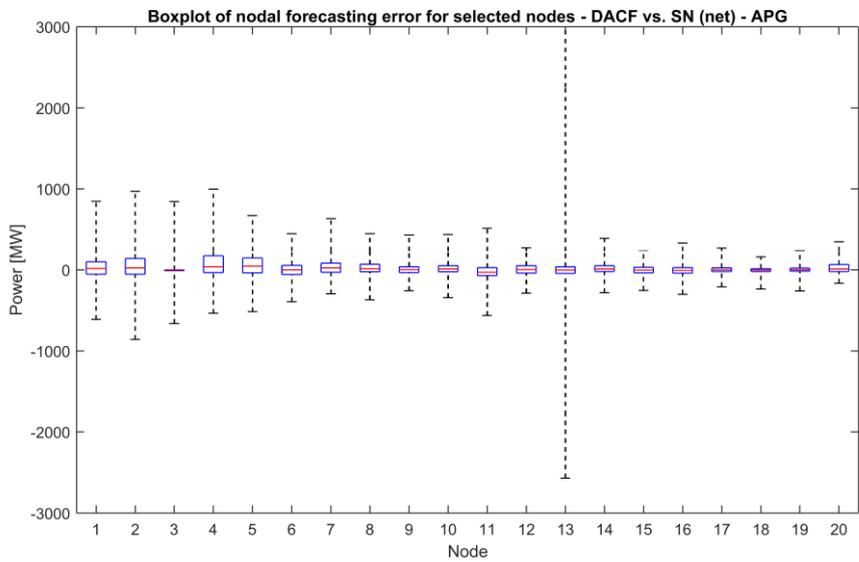
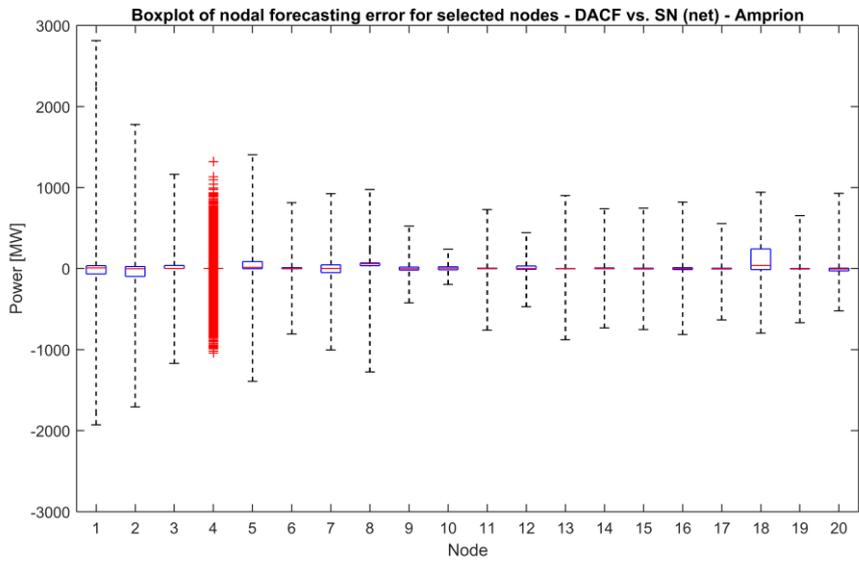
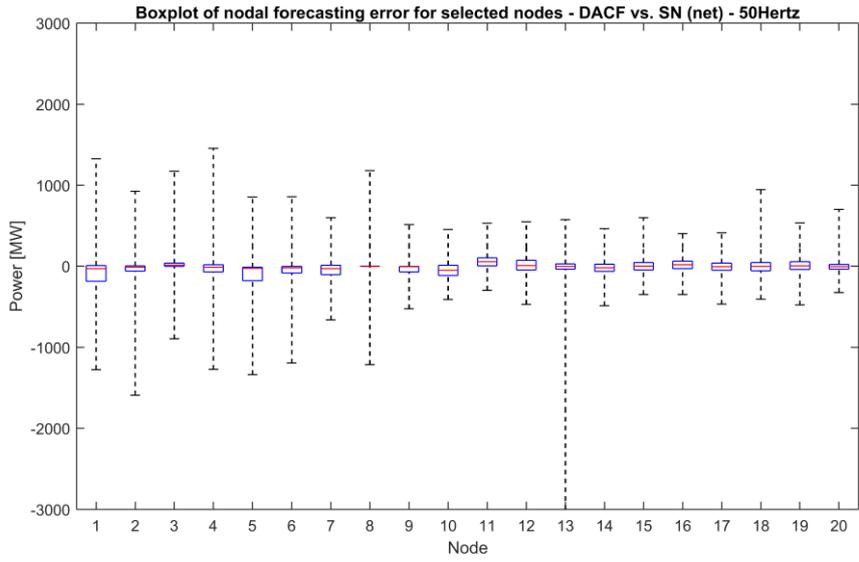


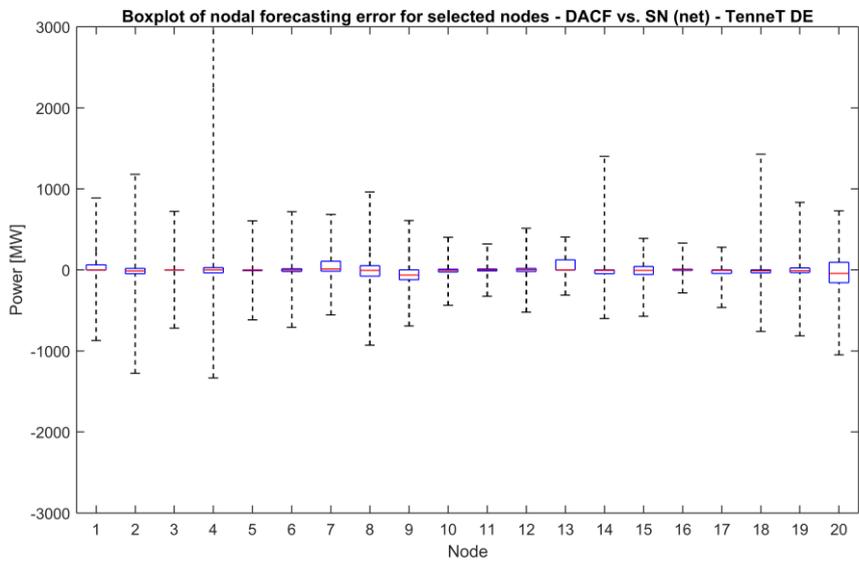
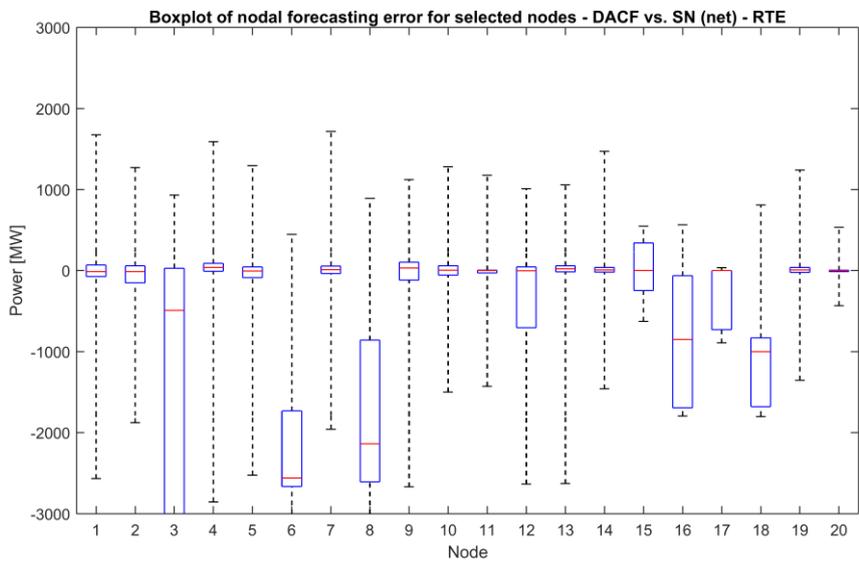
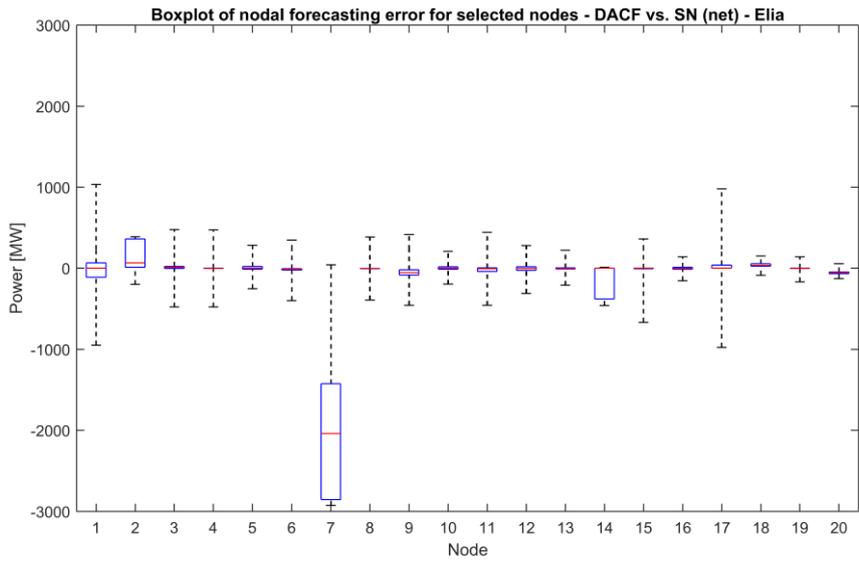


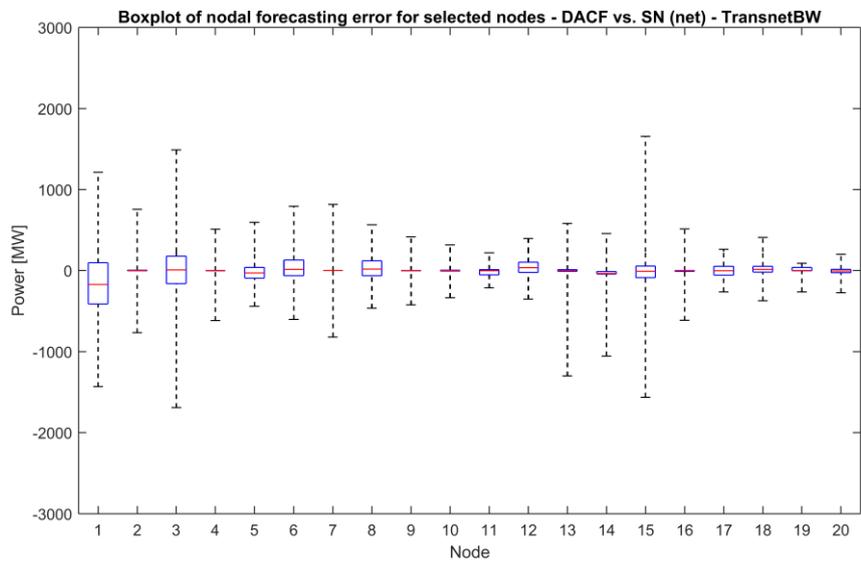
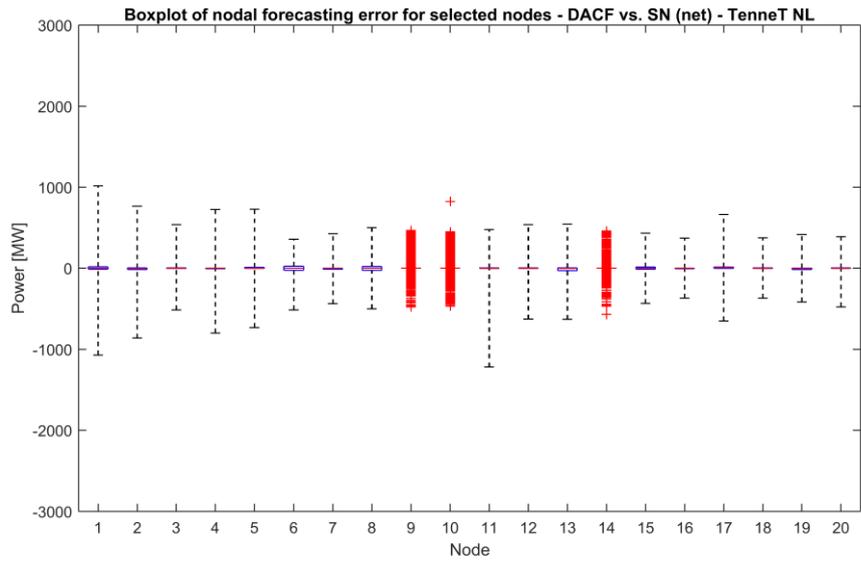




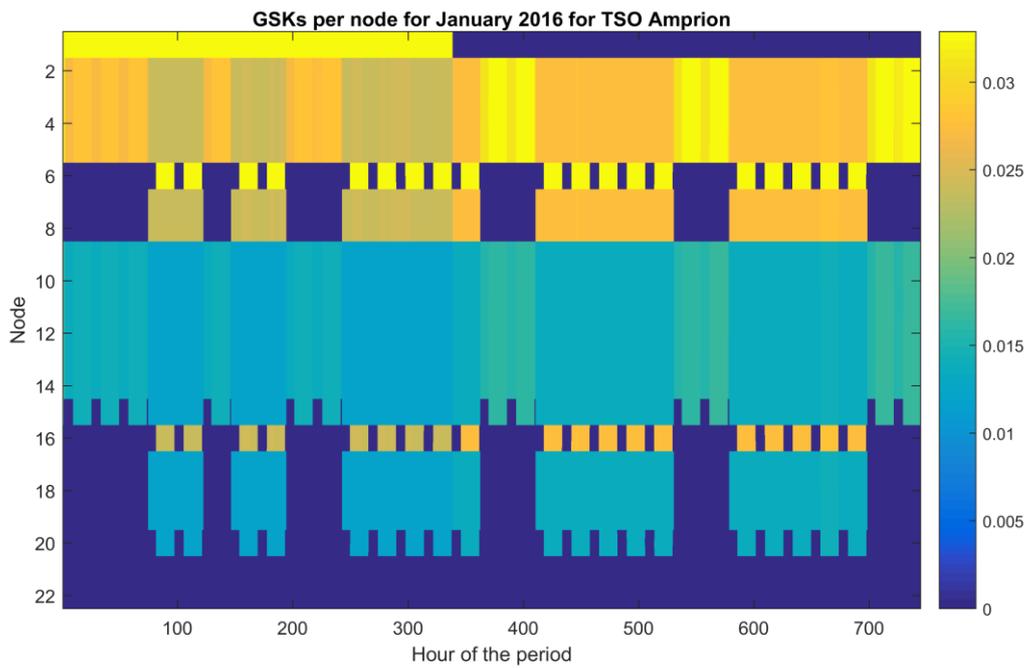
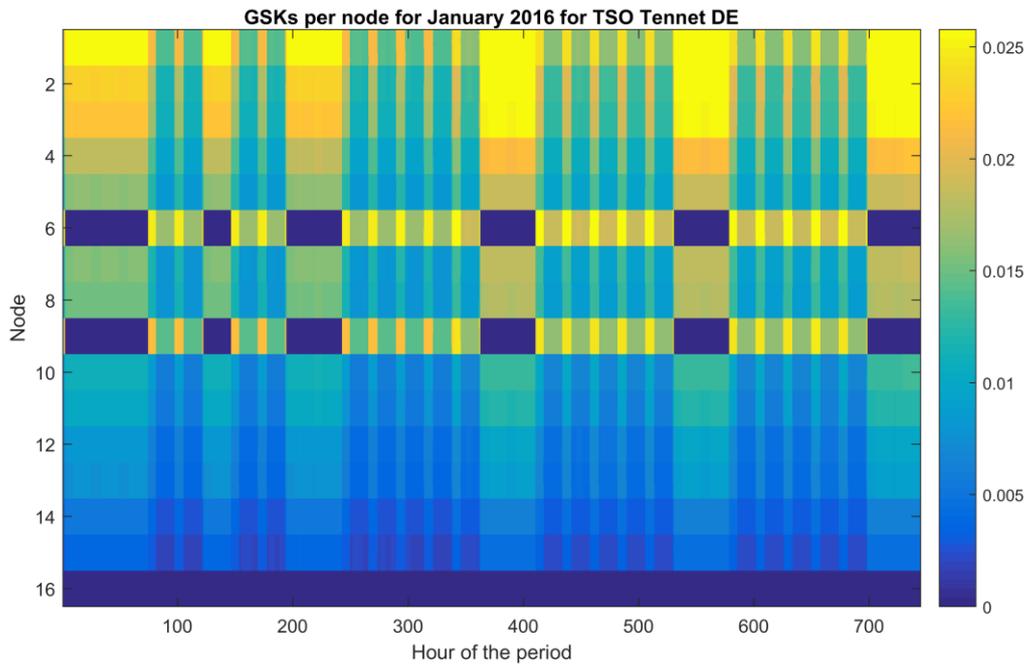


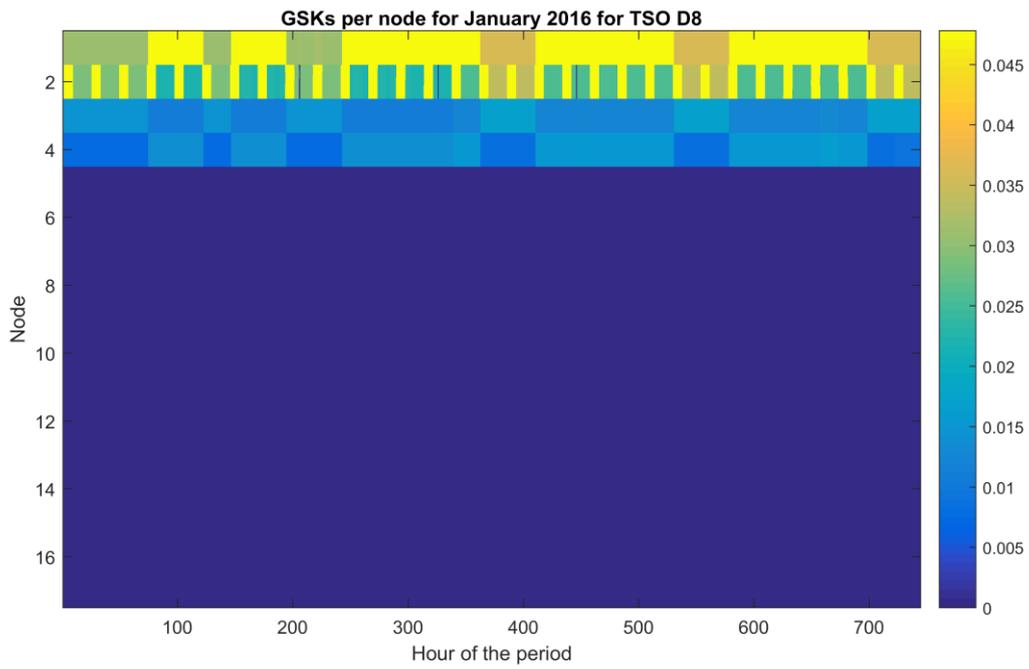
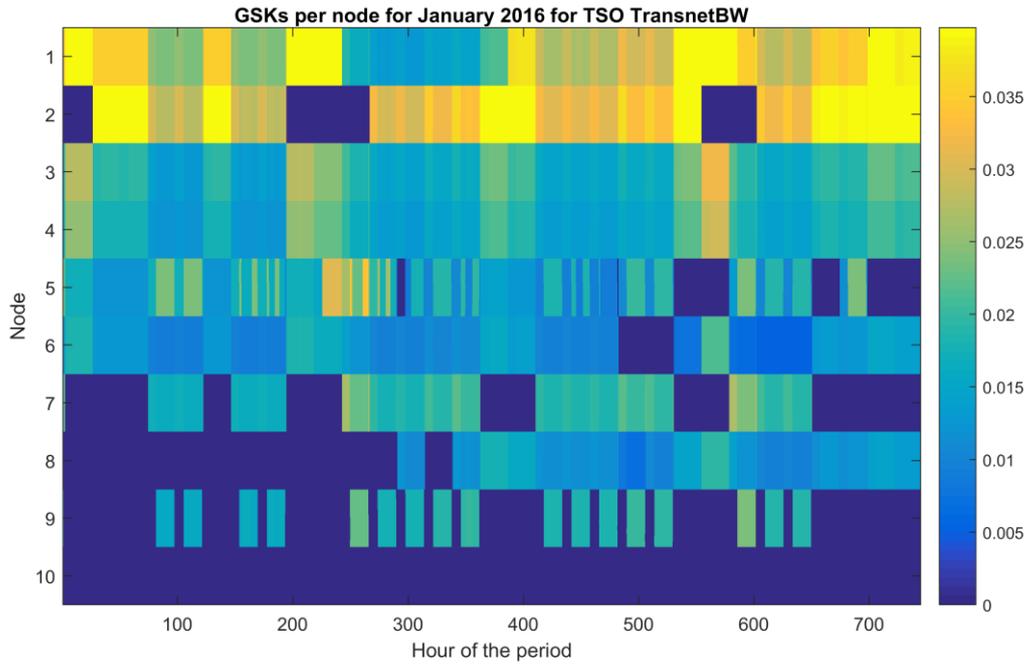


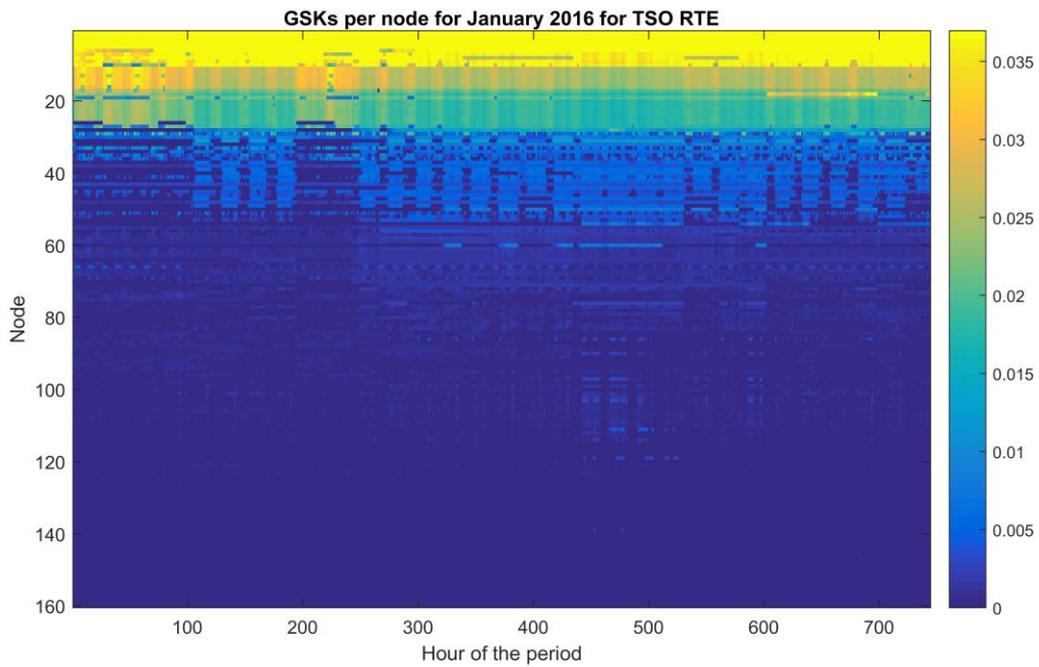
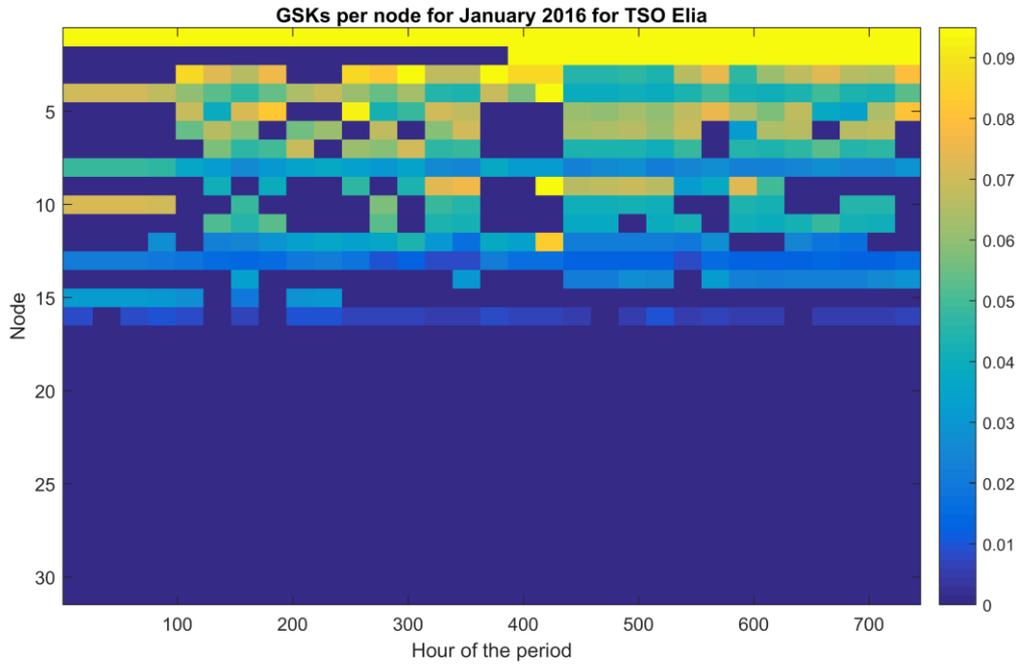


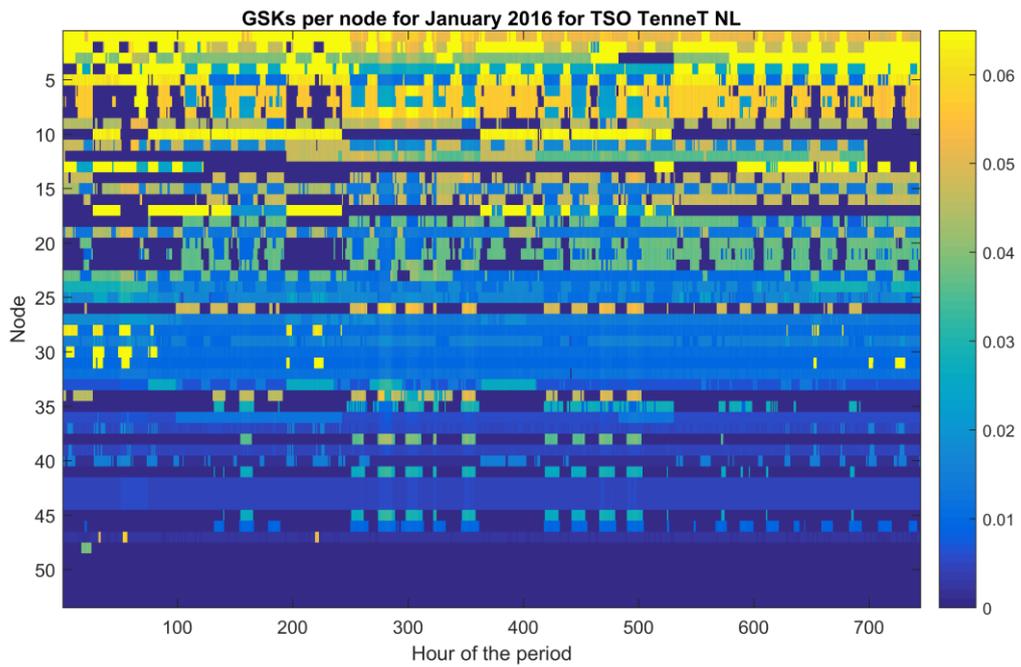
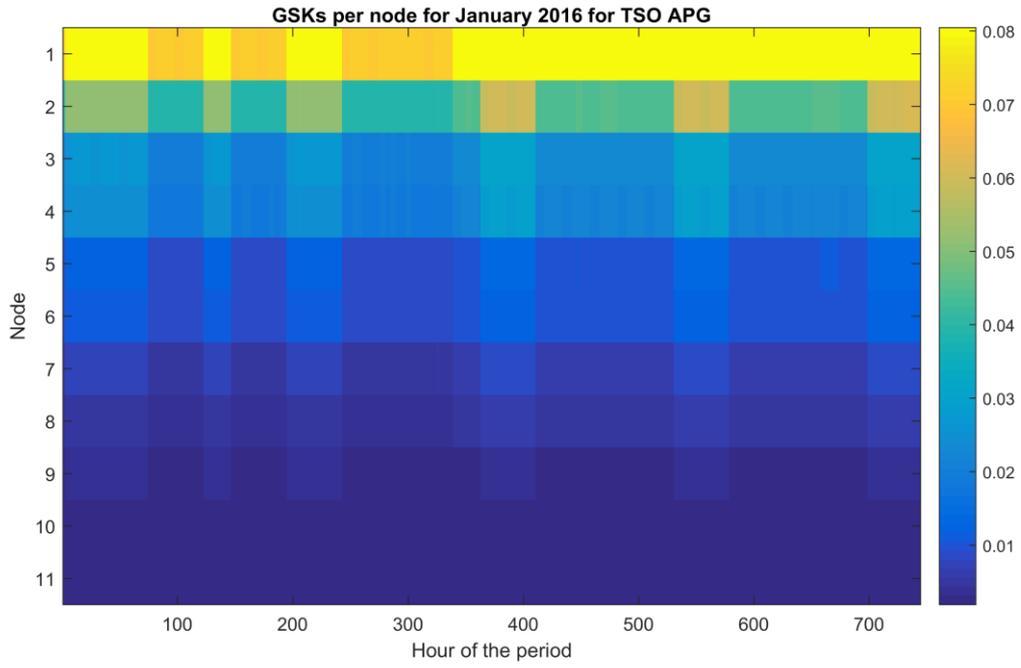


### A.3.3 GSKs

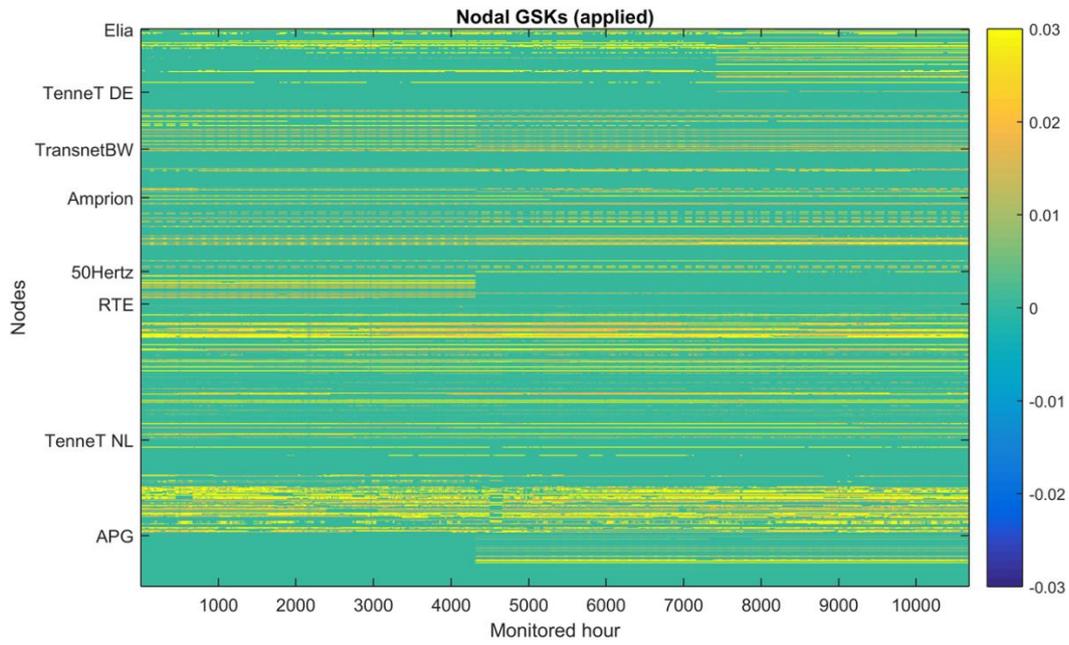






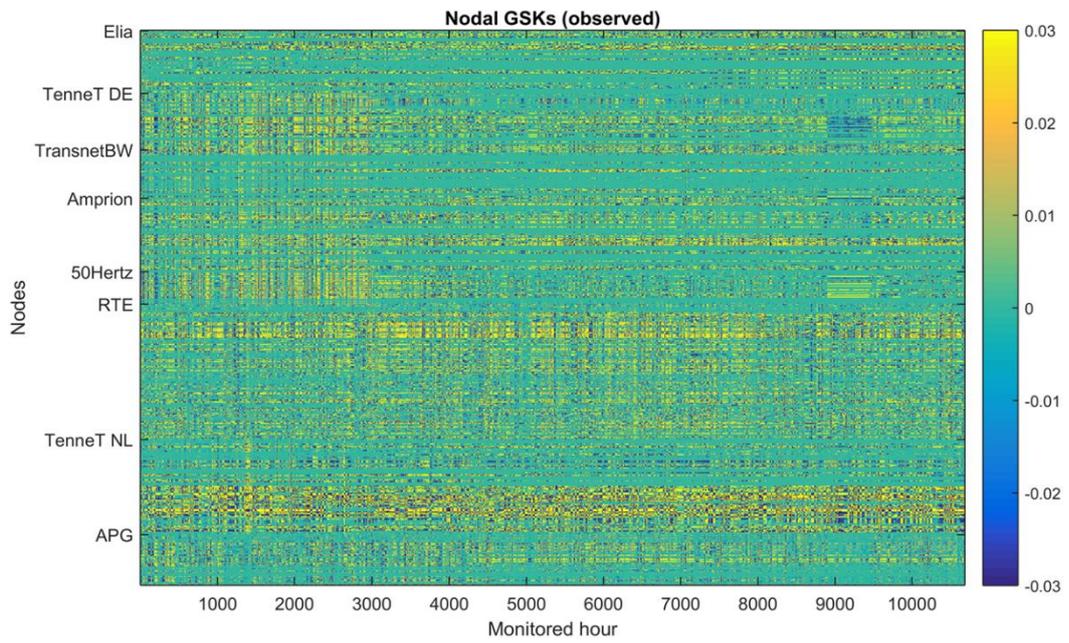


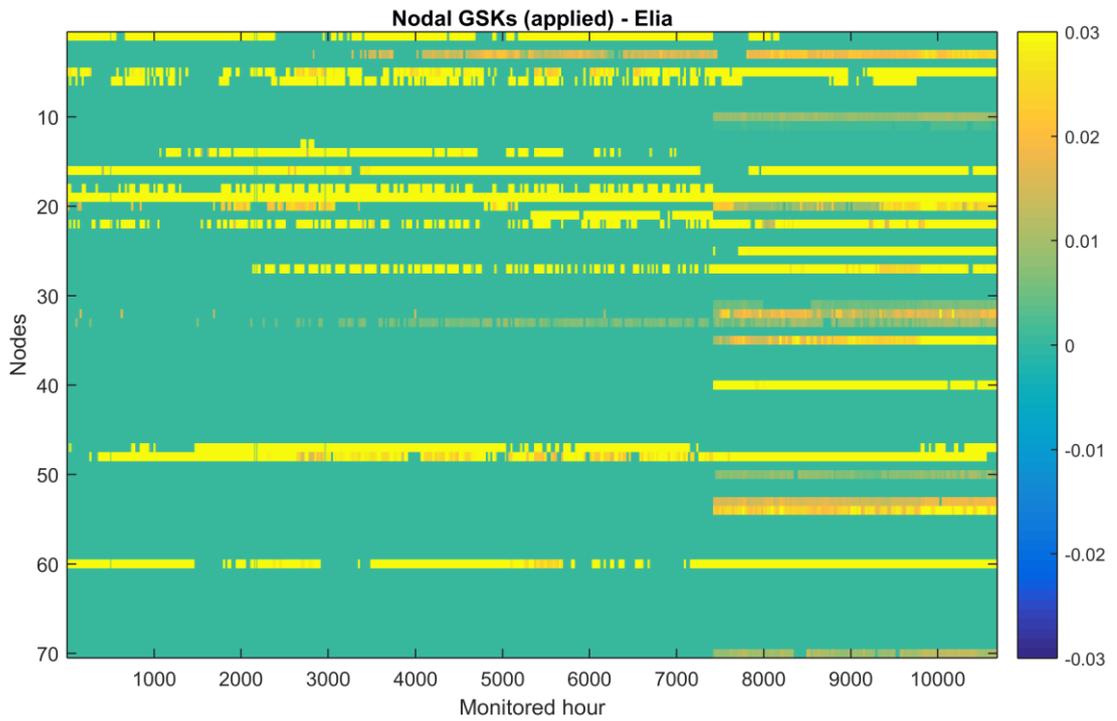
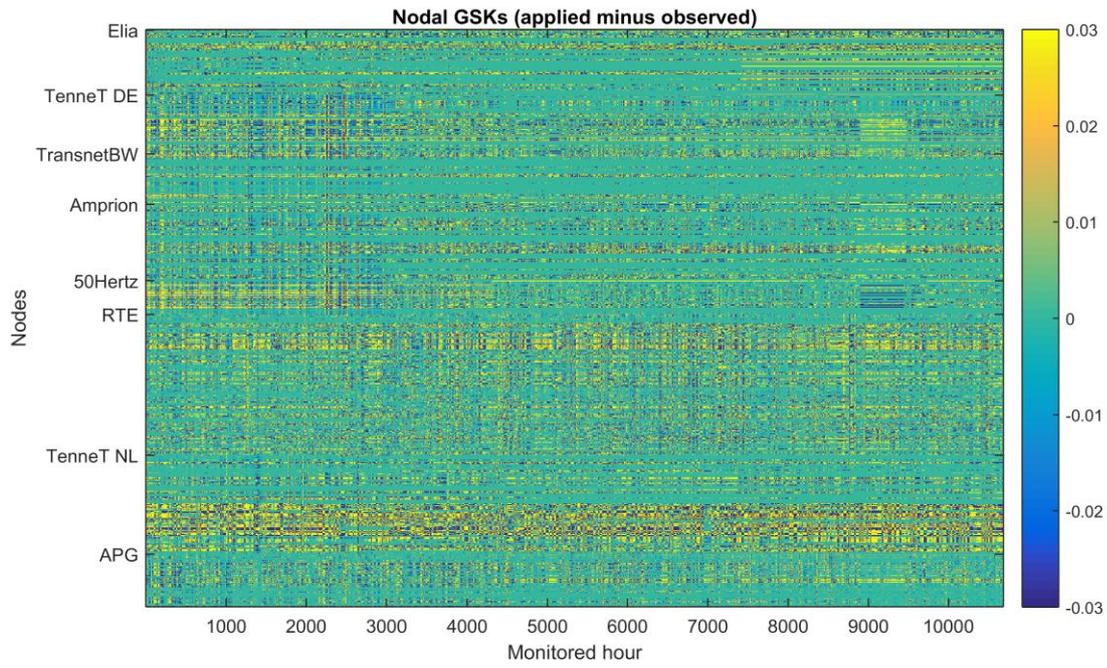
 **GSK applied: GSK determined by TSOs and used in FBMC algorithm**

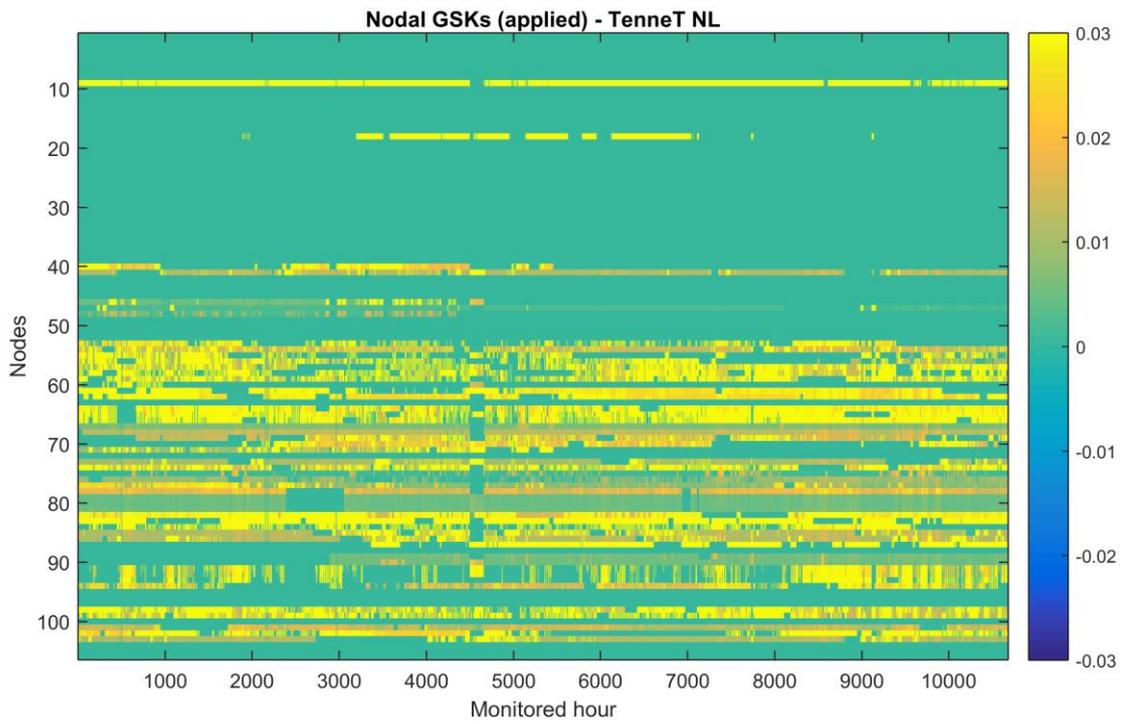
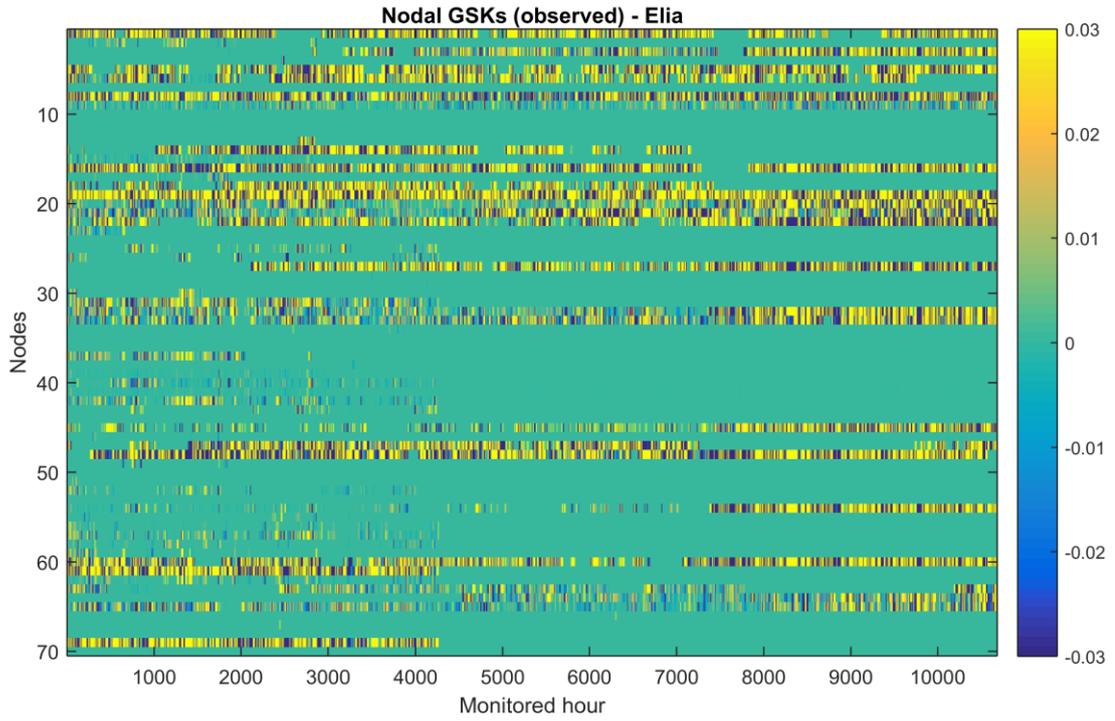


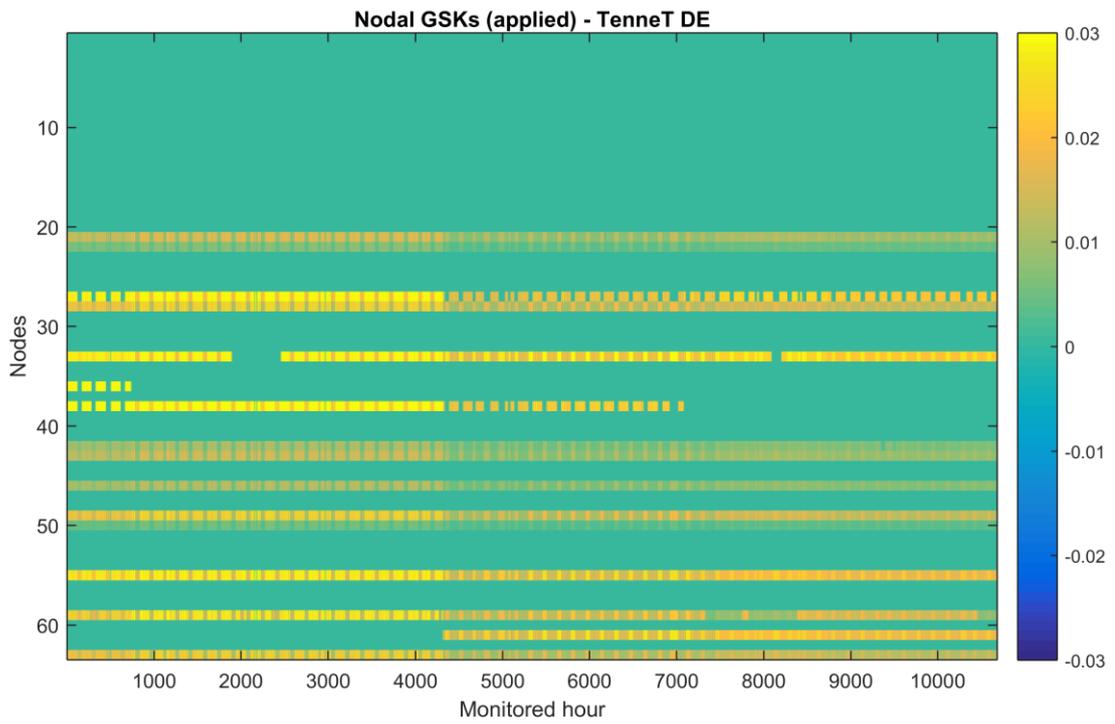
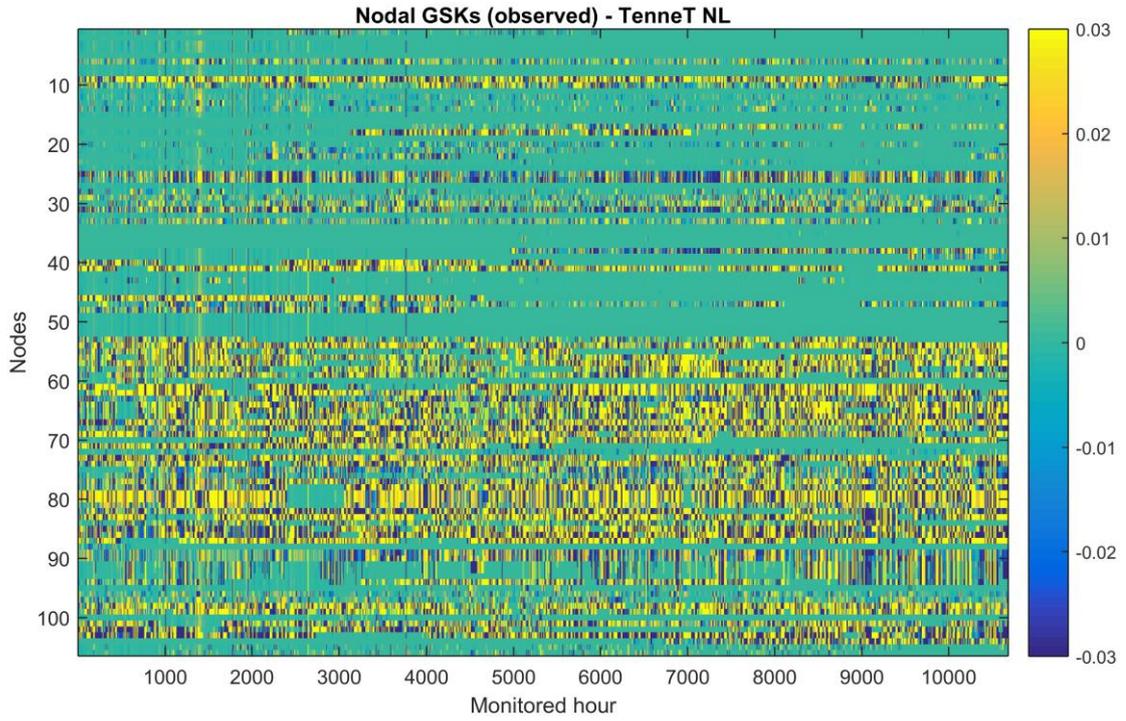
 **Observed GSK for each node computed by:**  

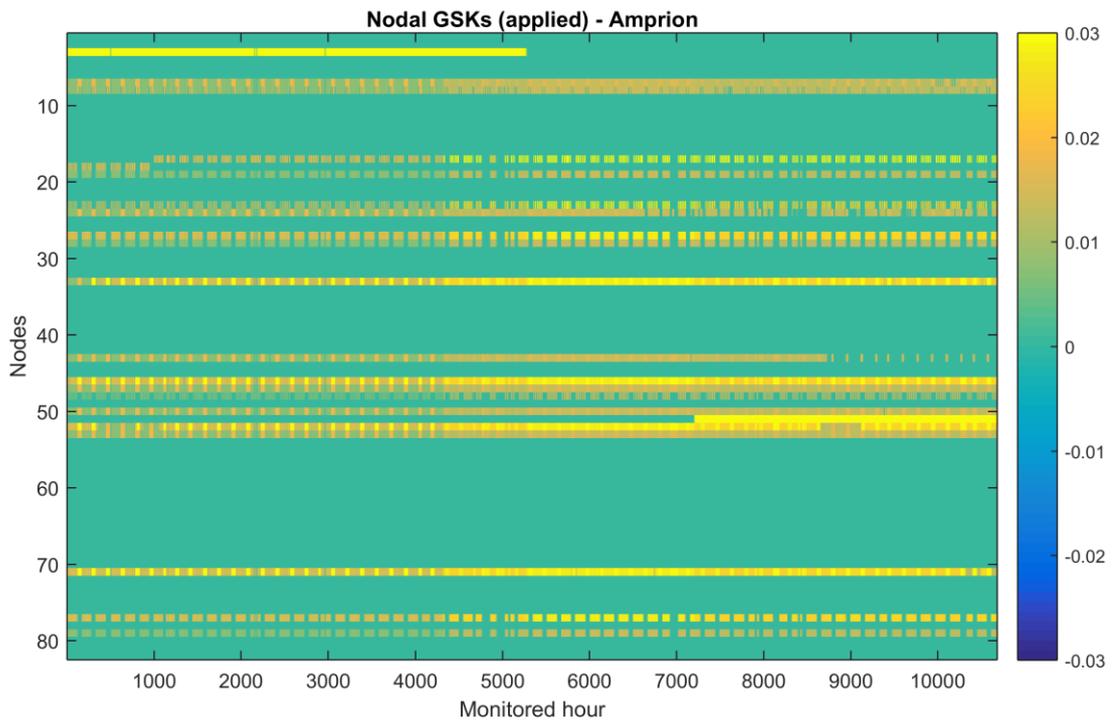
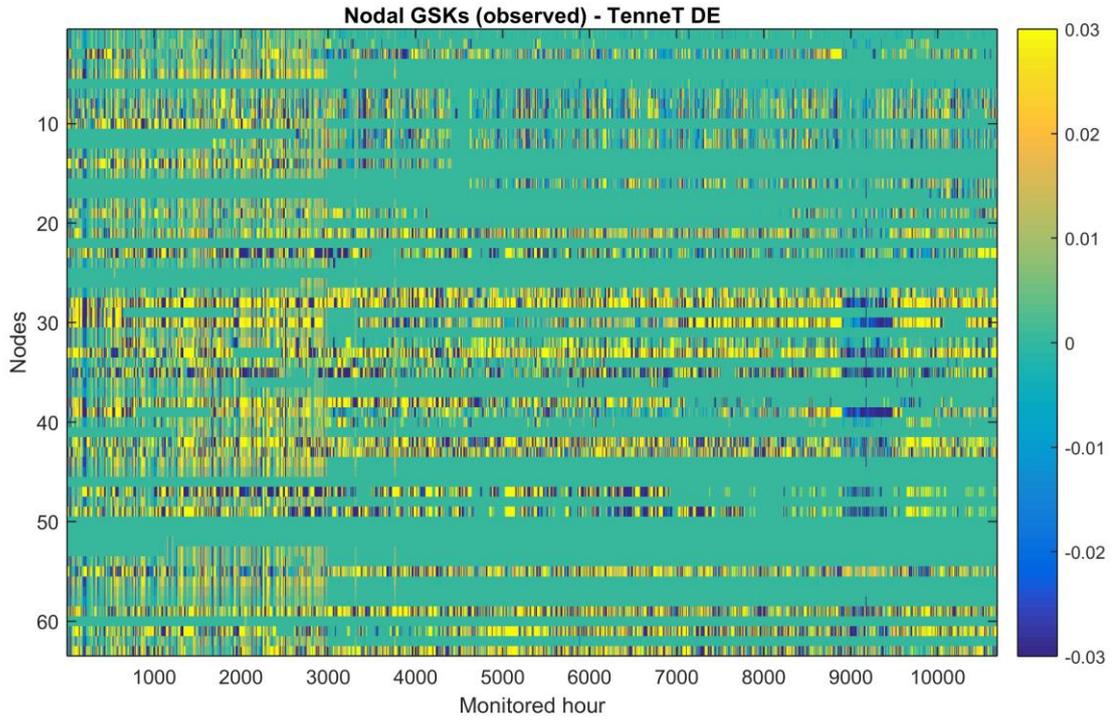
$$\frac{\text{(nodal gen. position in D2CF - nodal gen. position in DACF)}}{\text{(change of zones aggregated gen. position between D2CF and DACF)}}$$

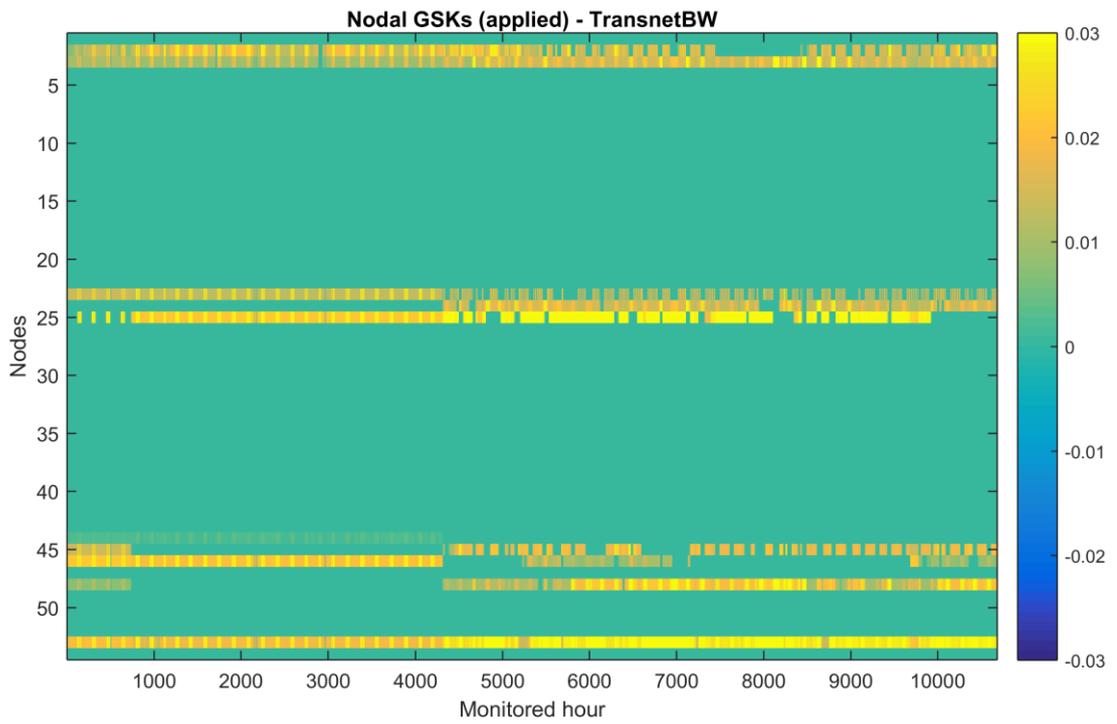
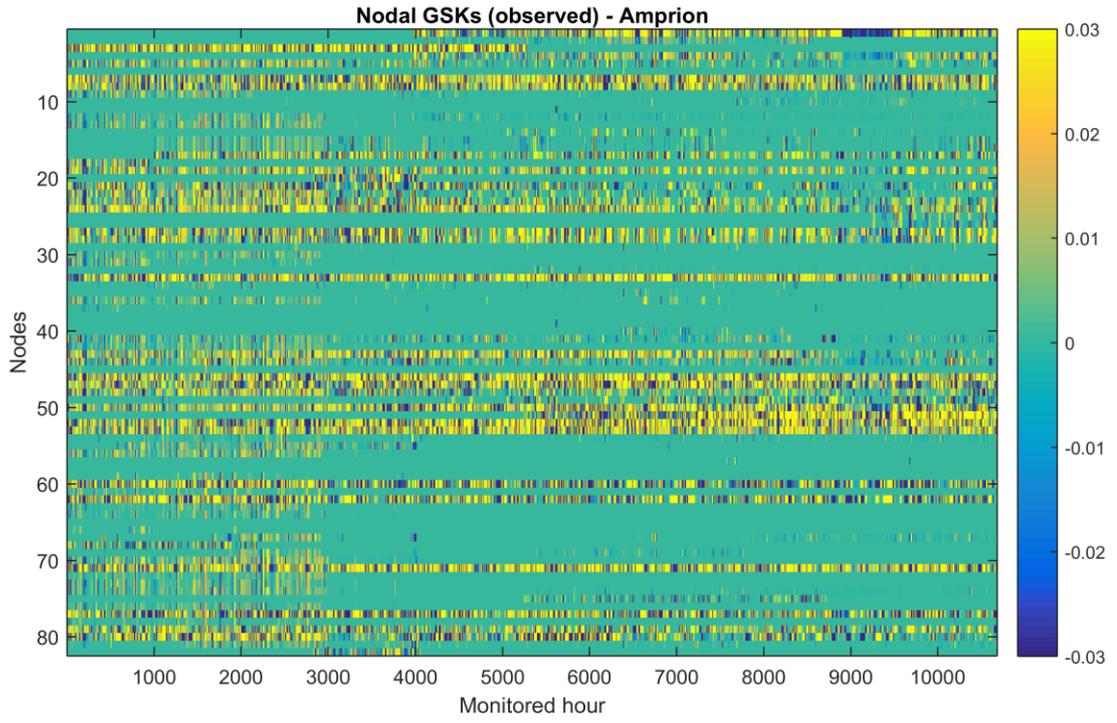


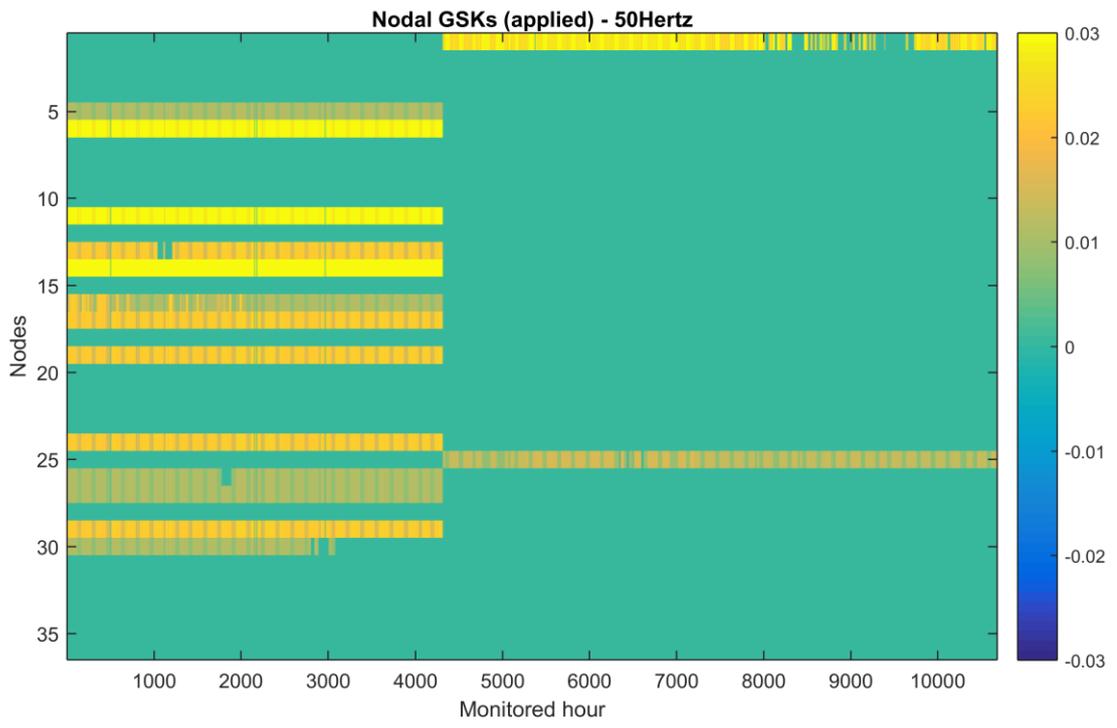
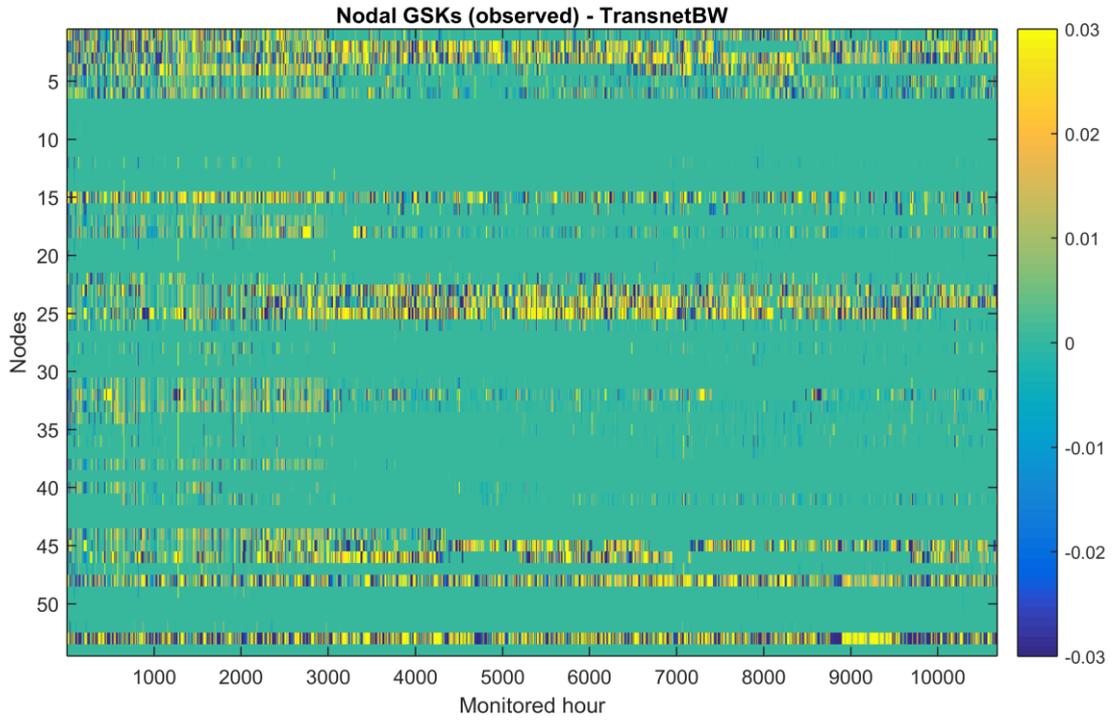


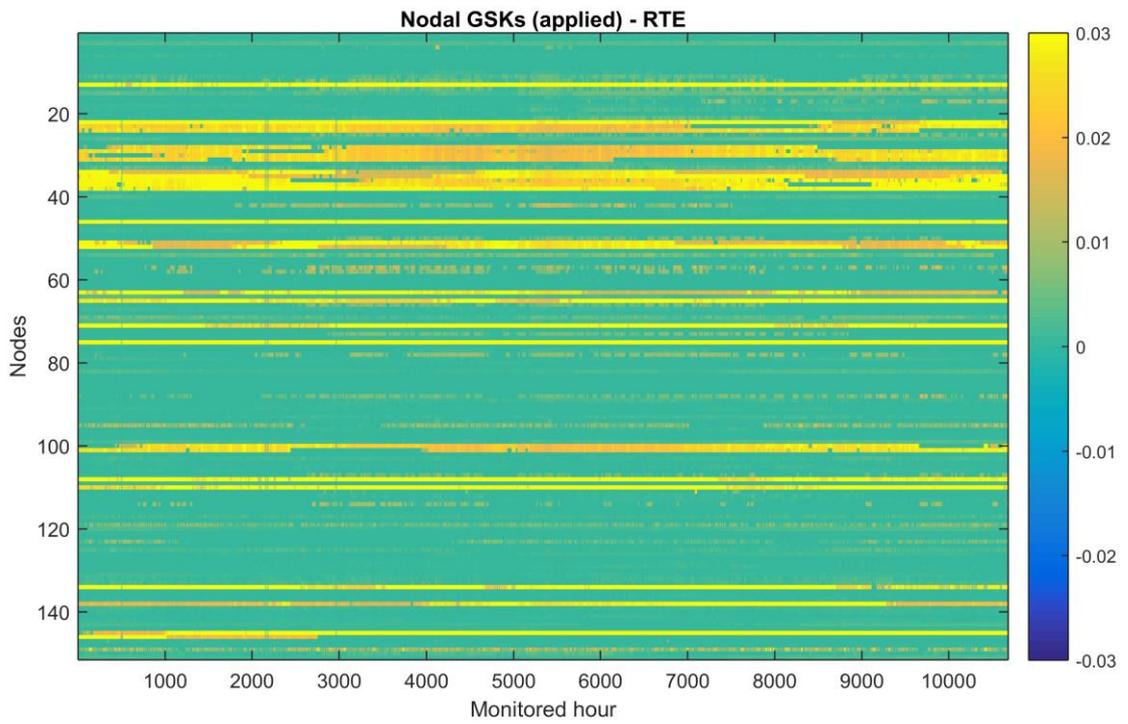
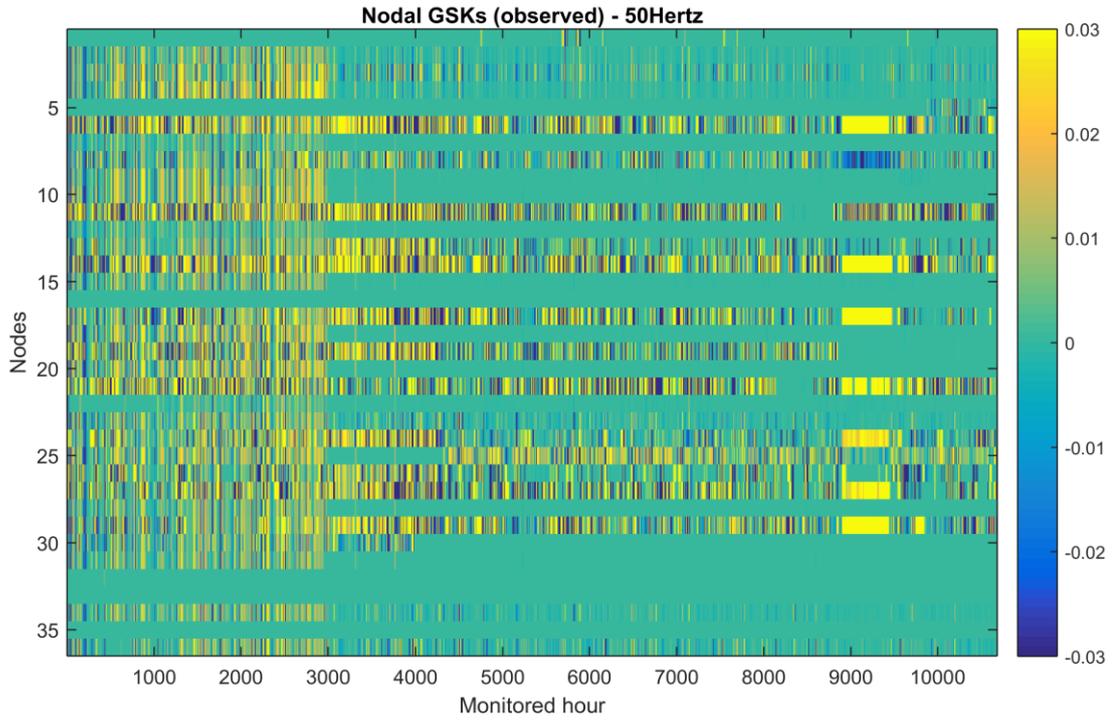


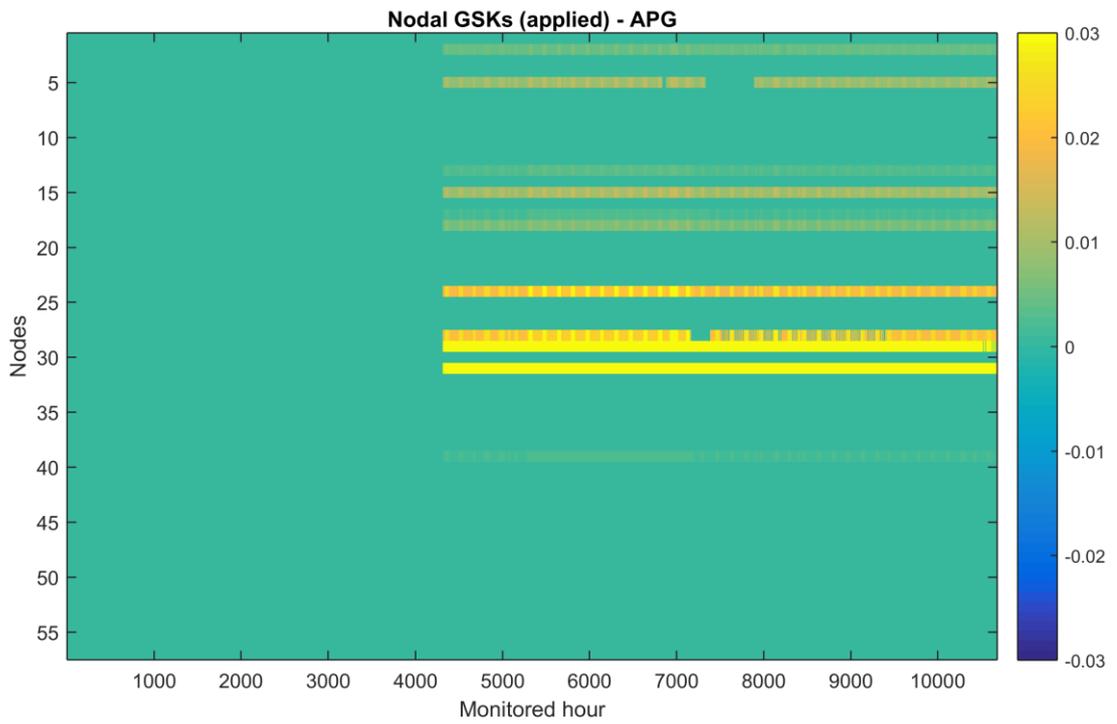
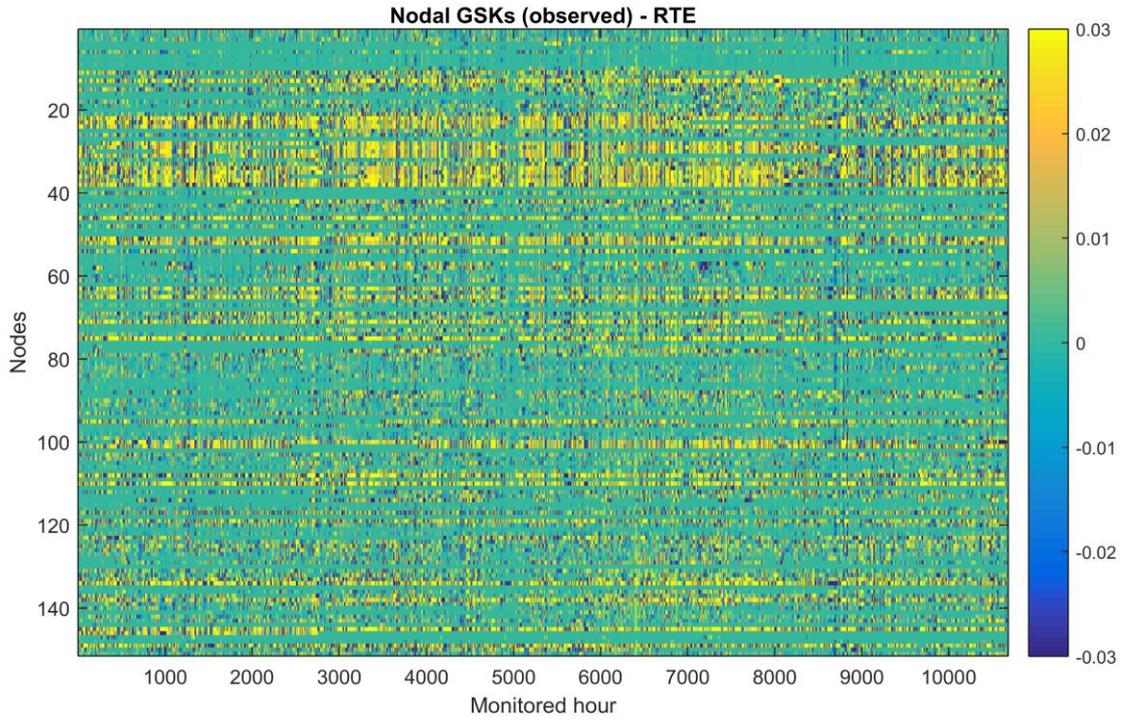


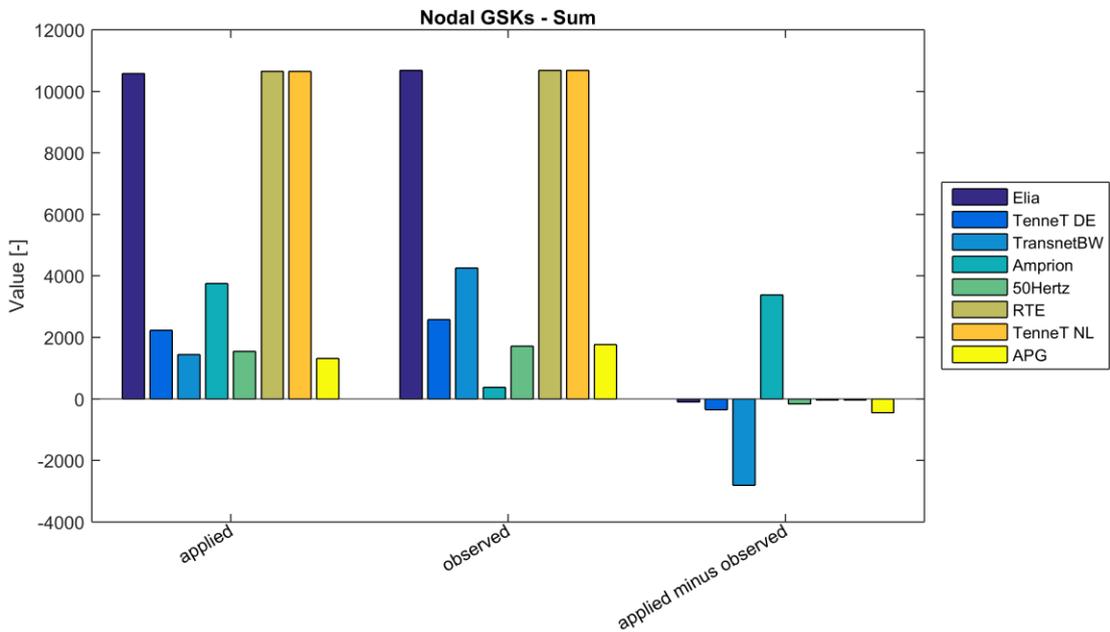
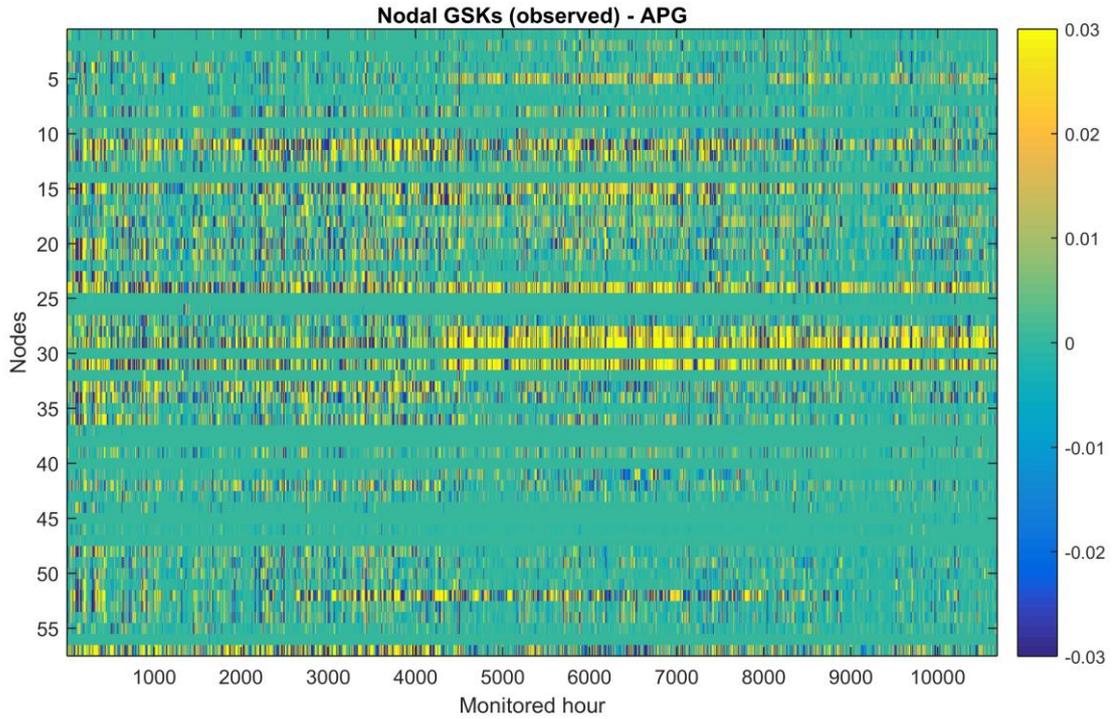




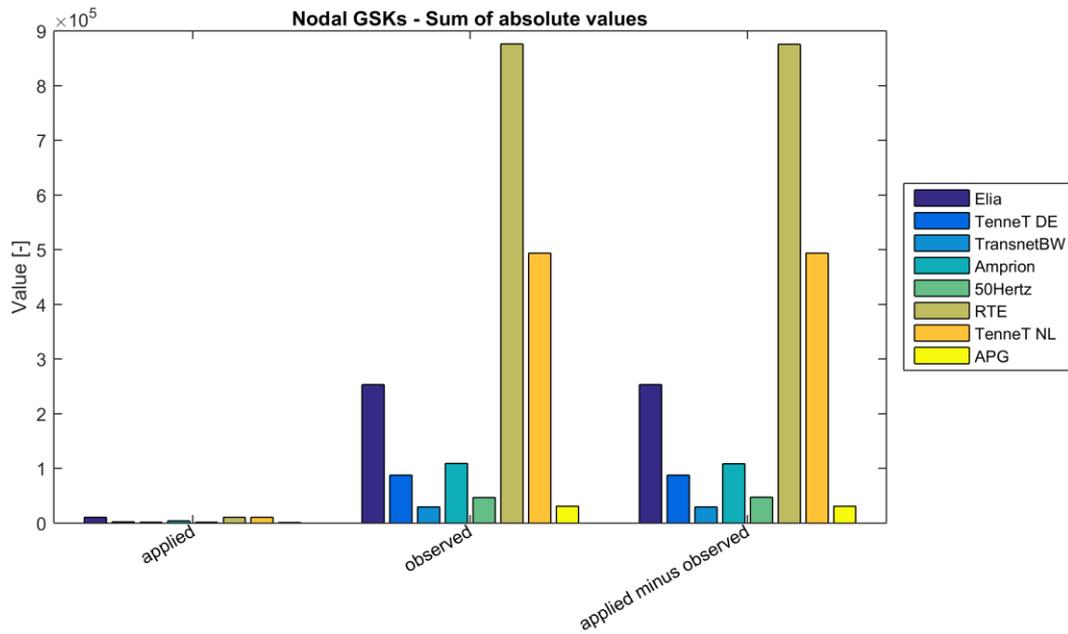




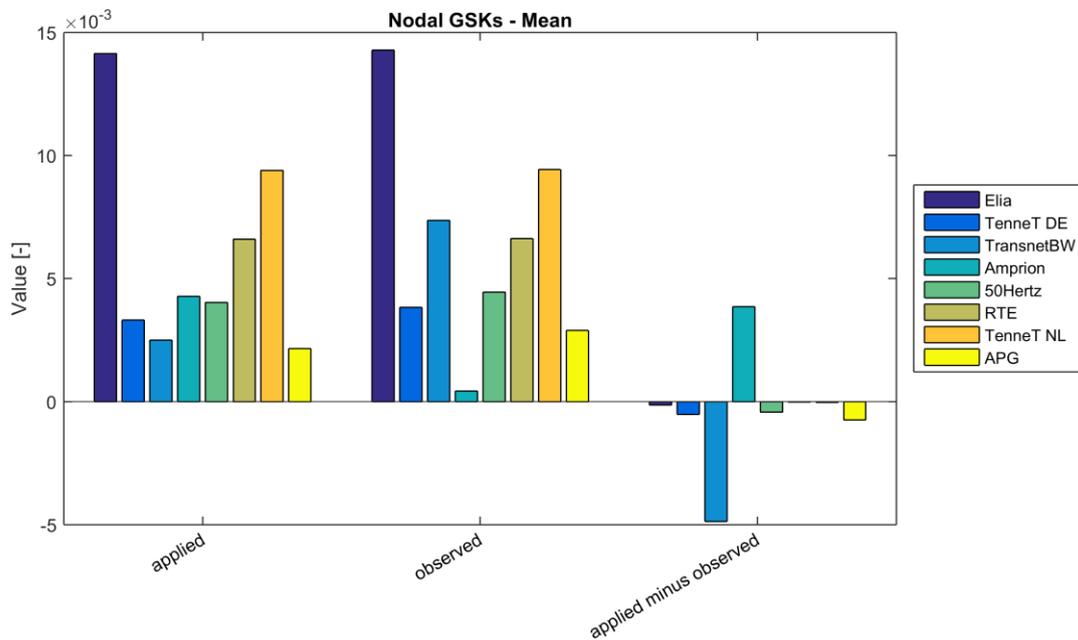


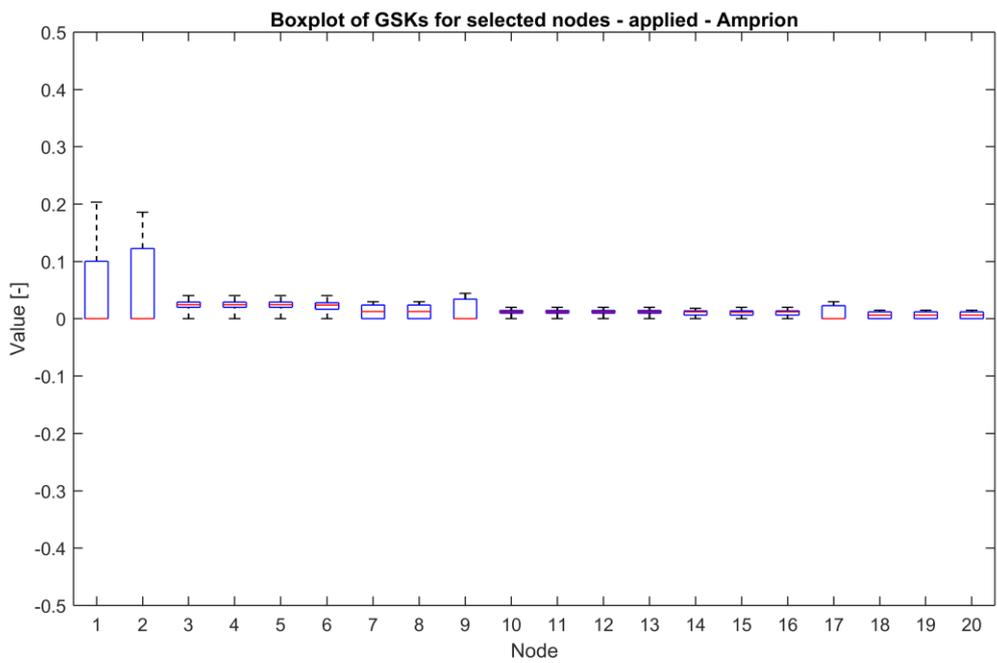
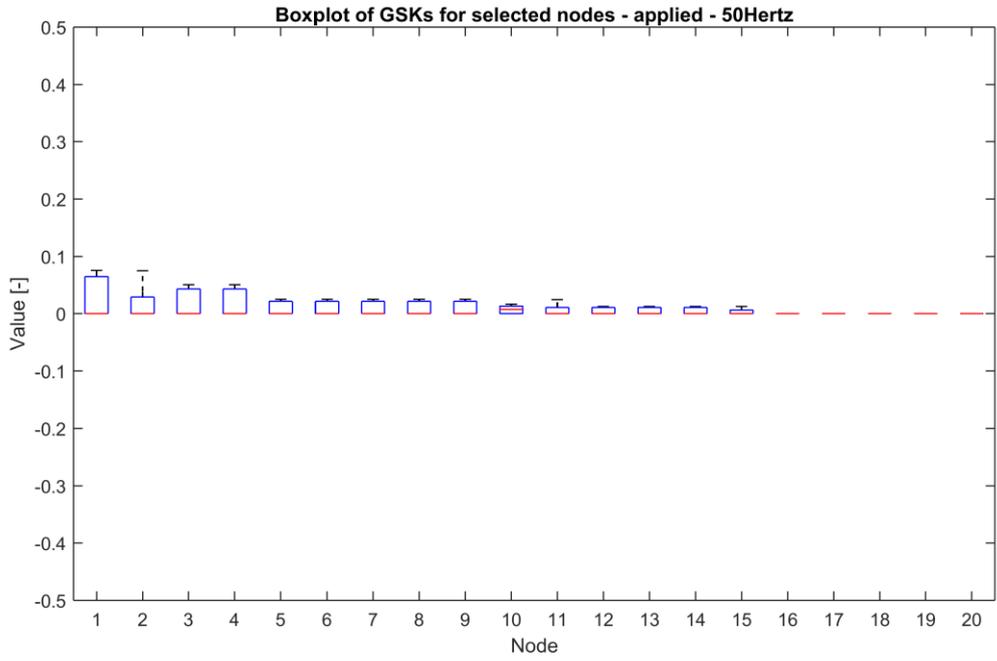


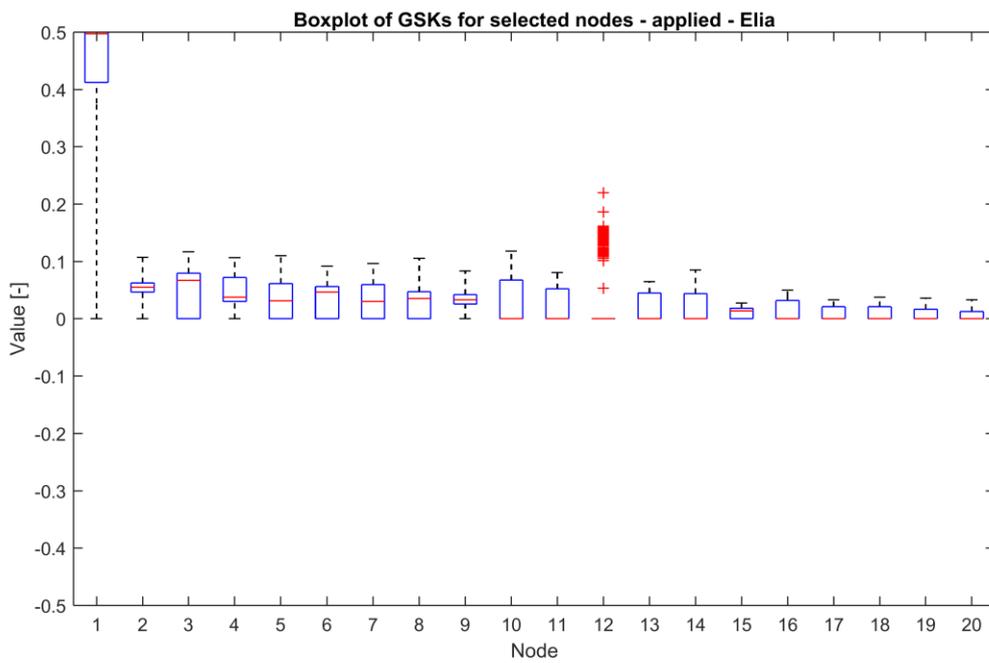
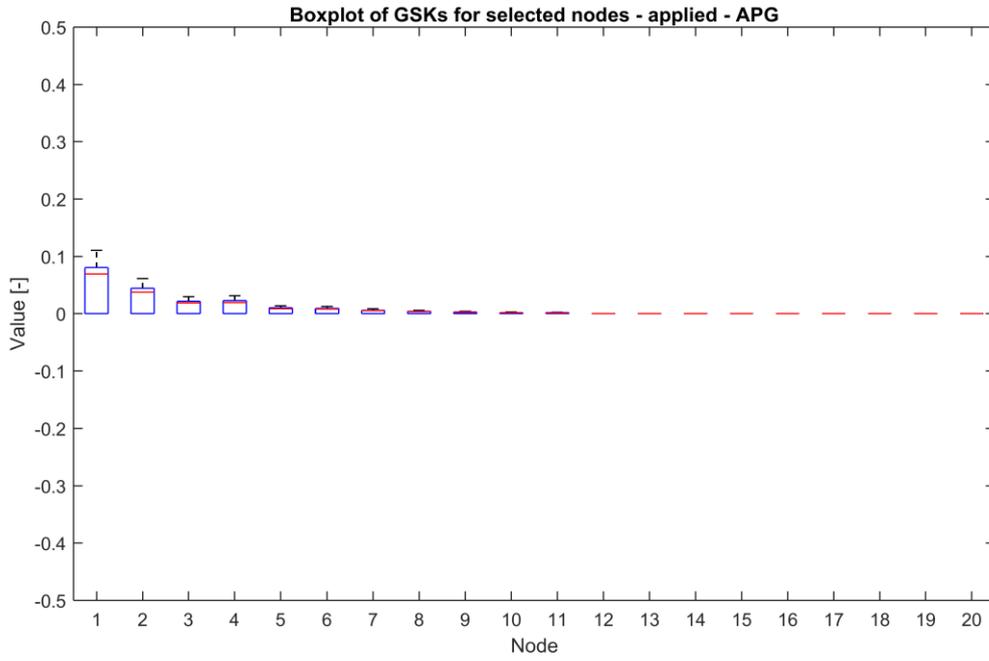
Note on this figure: the nodal GSKs within each bidding zone sum up to 1 for each time step. The total sum is the sum over all considered time steps (~ 11.000 hours in the monitoring period). For the bidding zone DE/AT/LU the distribution of the GSK share in the different TSO areas can be observed in the graph, once for applied, once for observed GSKs. In particular the difference in GSK share for observed vs. applied GSKs between Amprion and TransnetBW is prominent

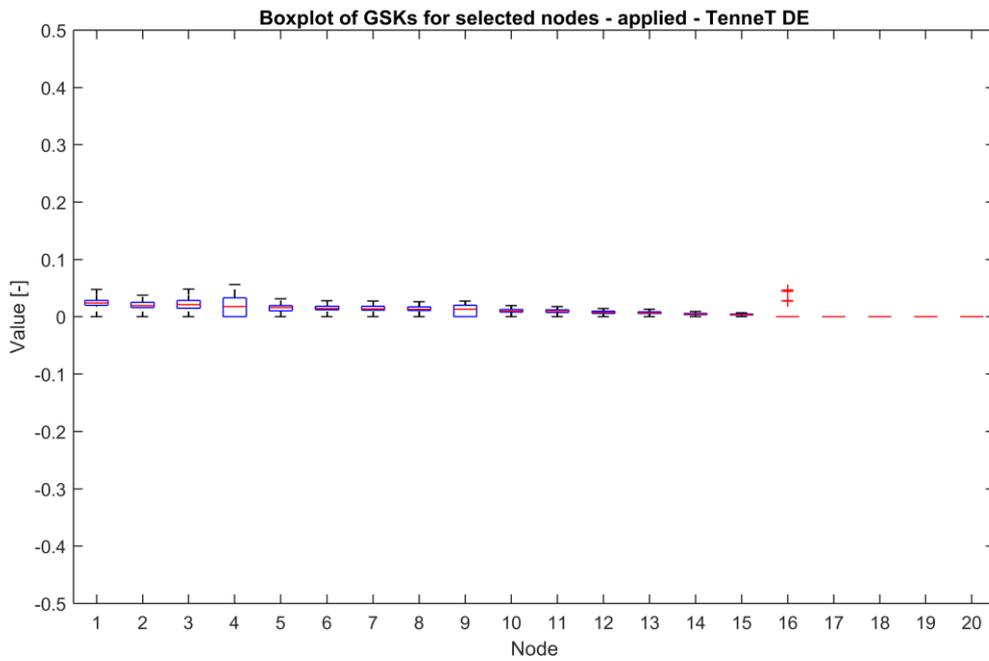
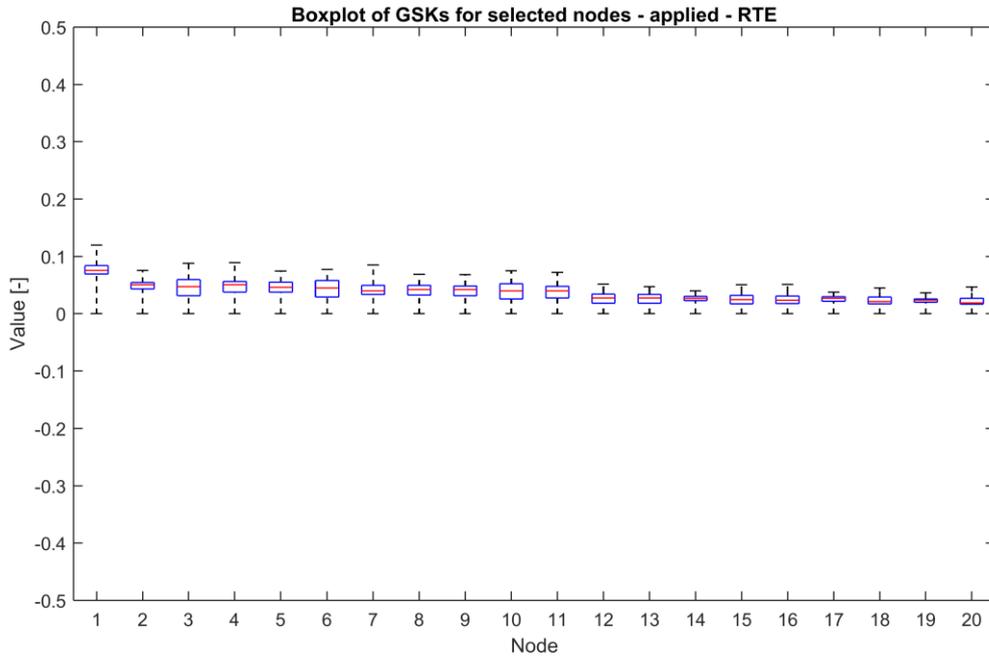


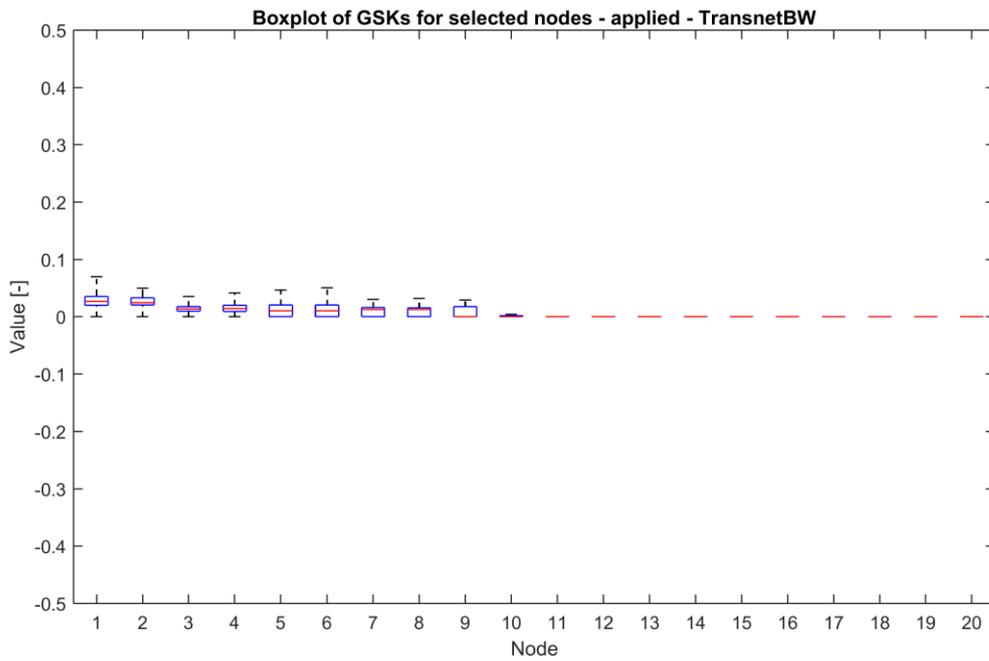
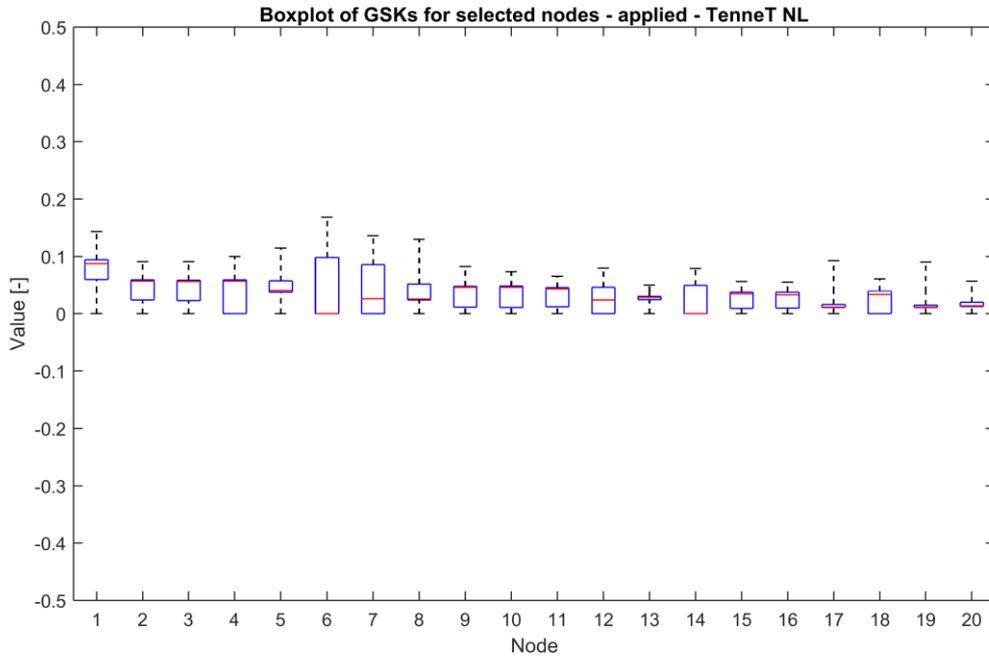
Note on this figure: For interpretation of the sum of the absolute values of the GSKs it should be noted that the number of nodes per TSO differs significantly. In the RTE area there are the most nodes for which the observed GSKs (sometimes positive, sometimes negative, but here the absolute value is relevant) are summed up.

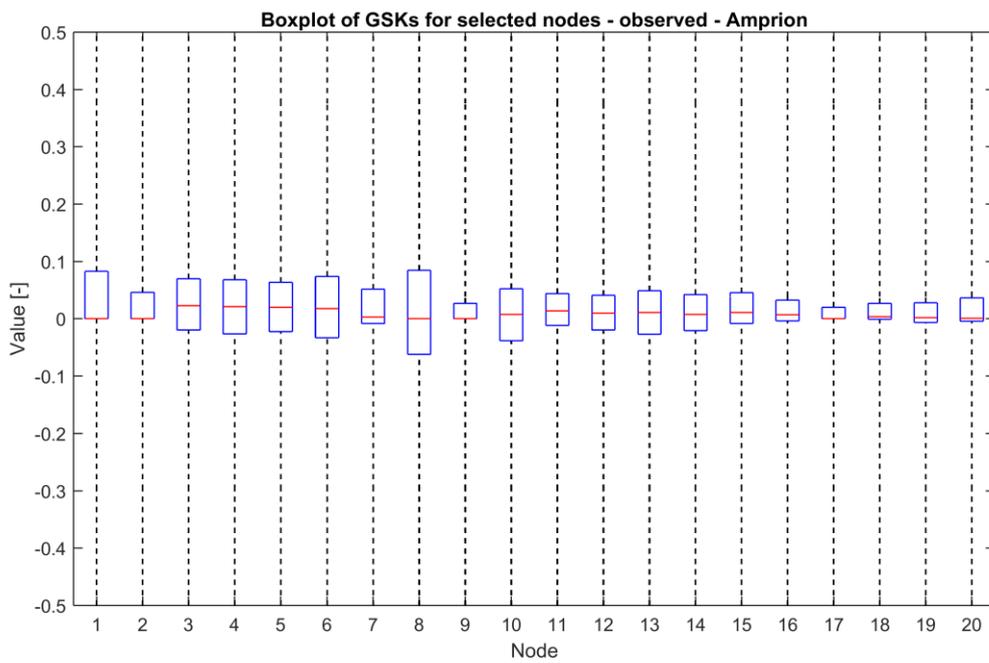
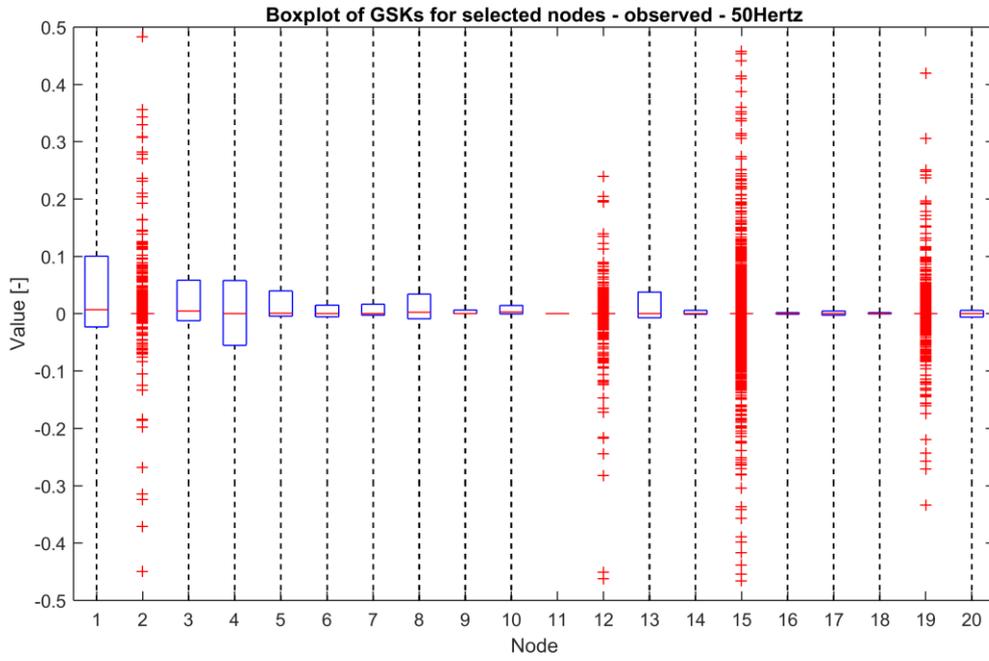


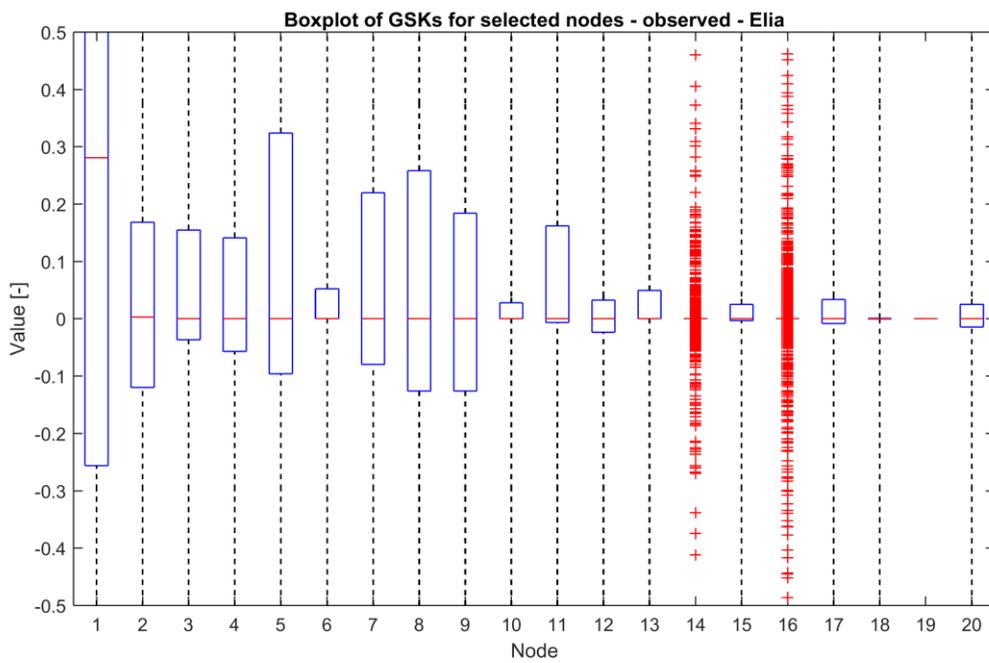
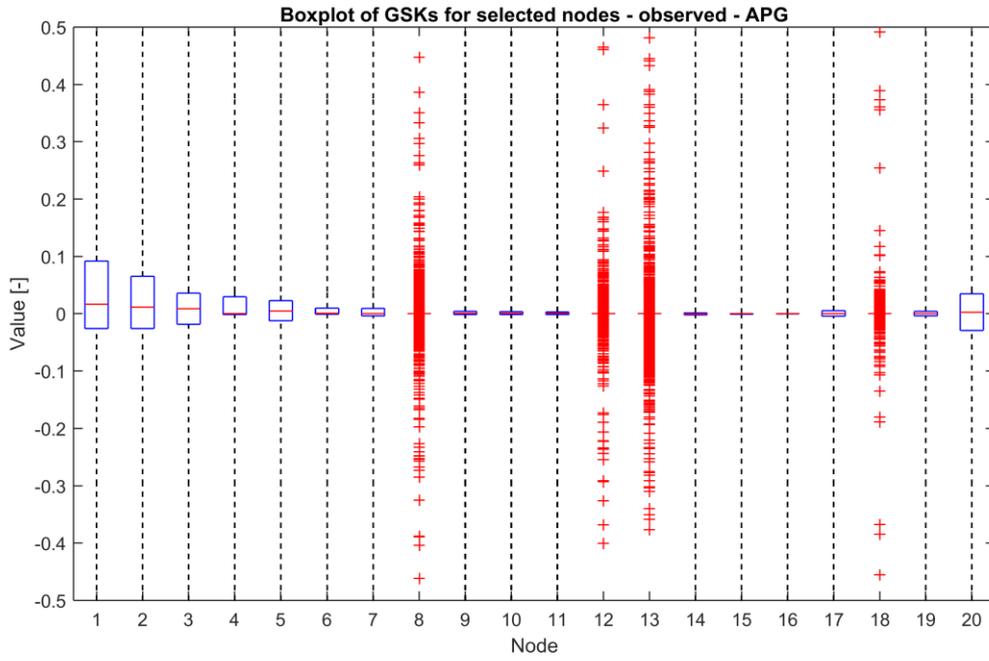


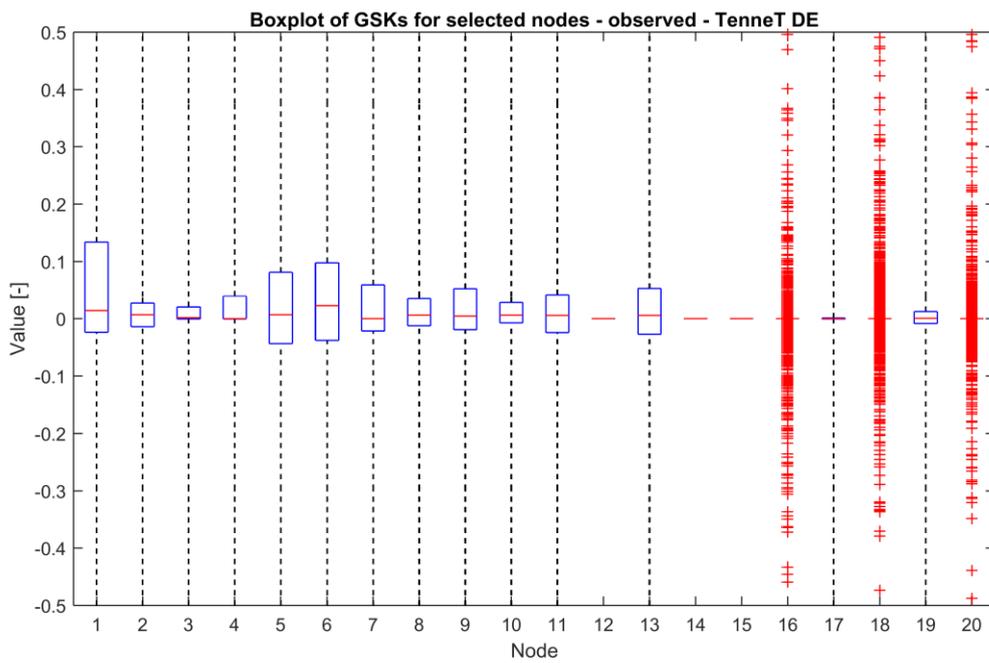
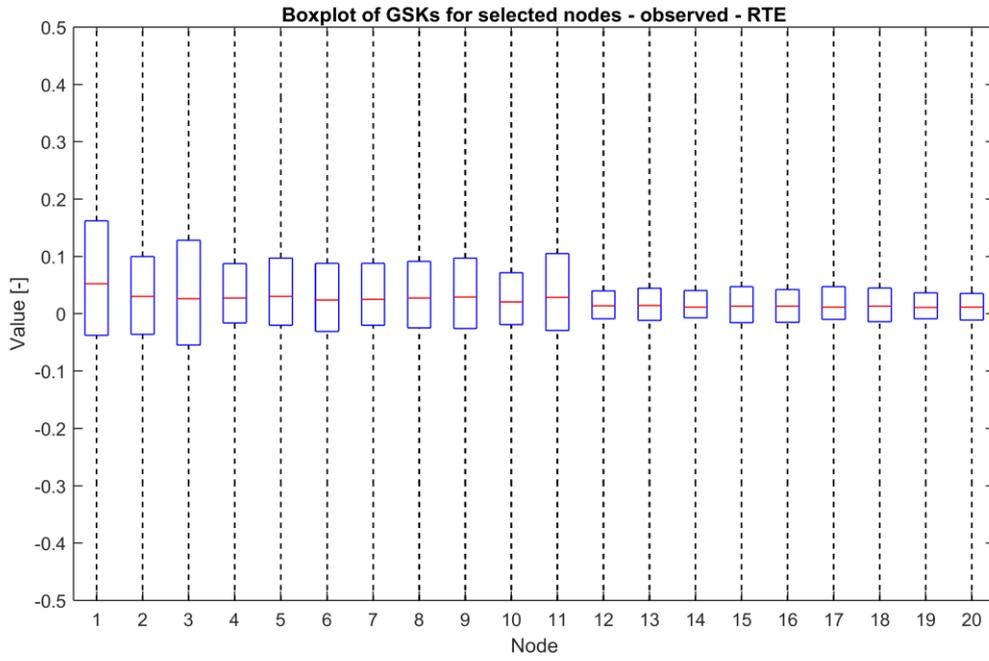


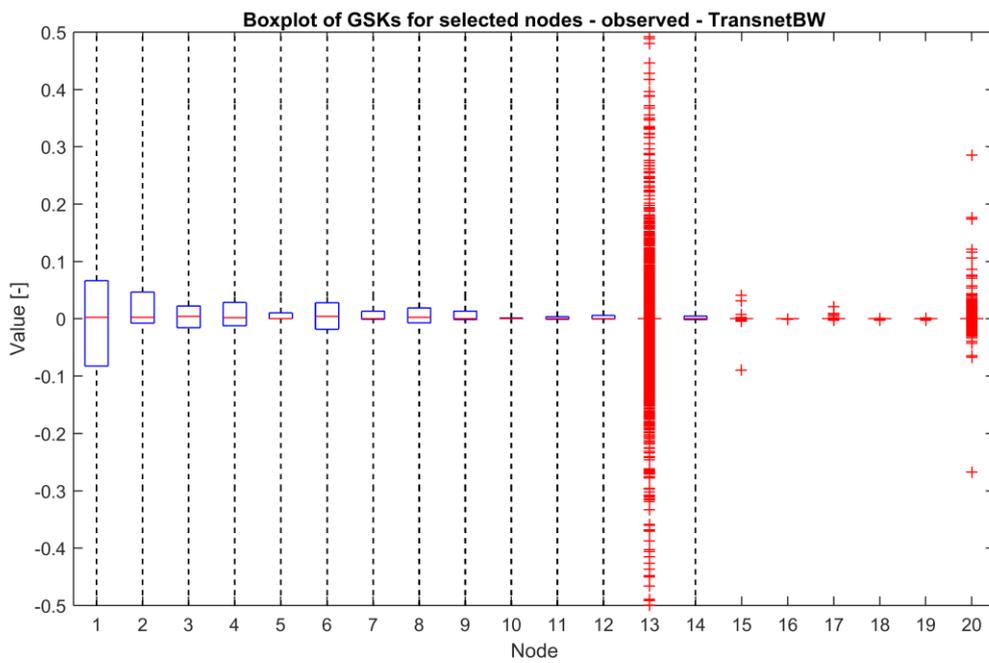
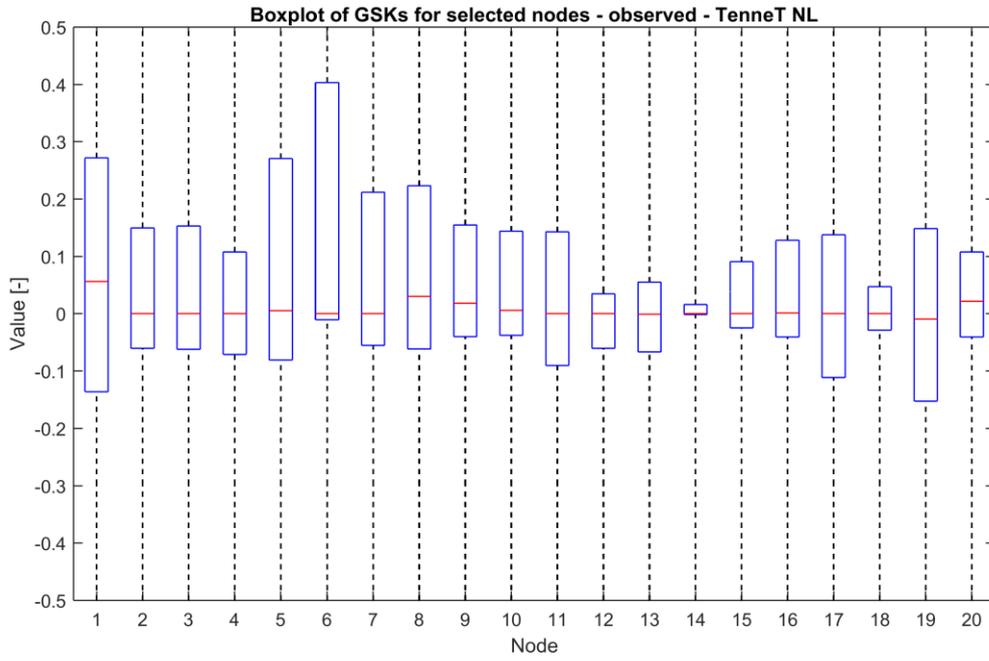


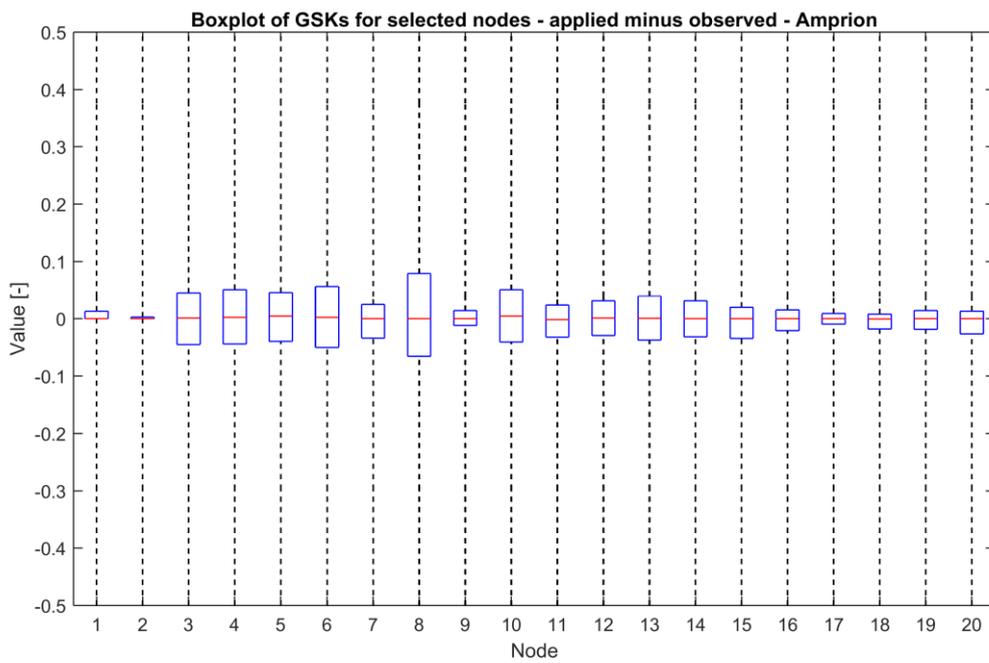
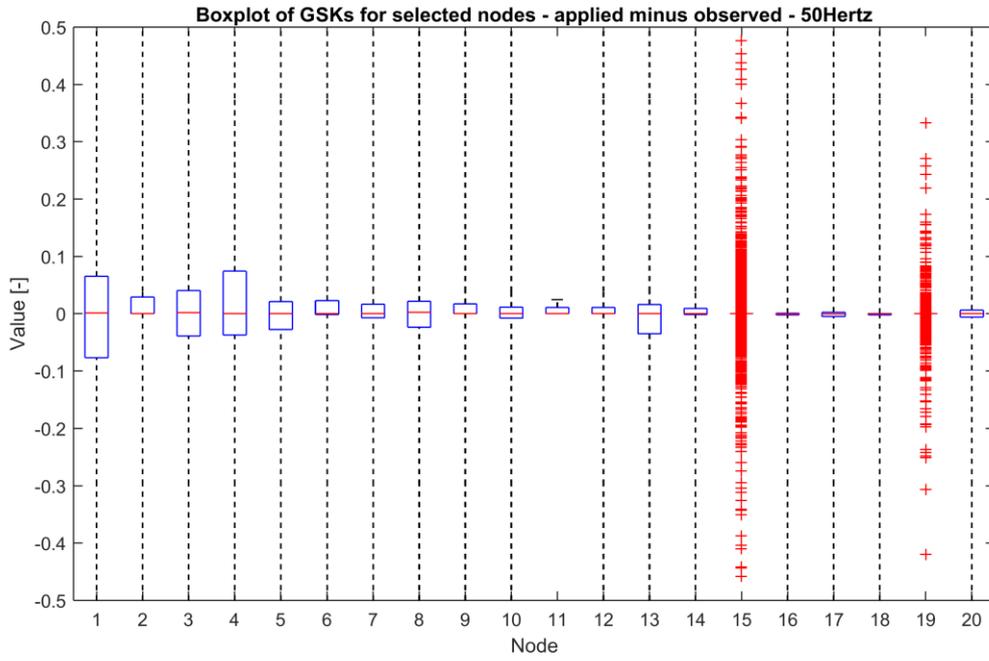


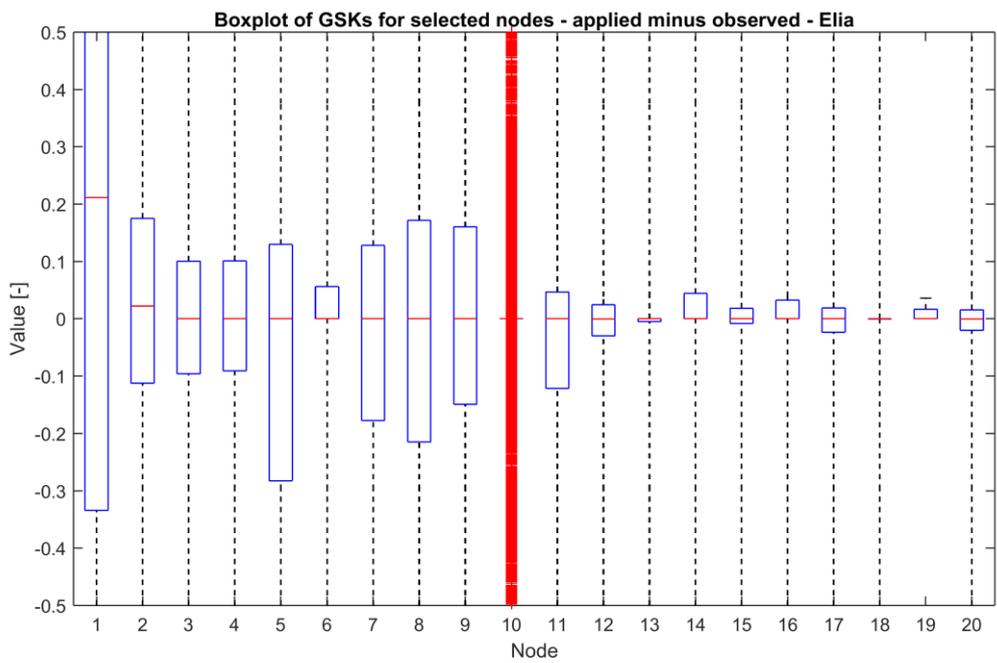
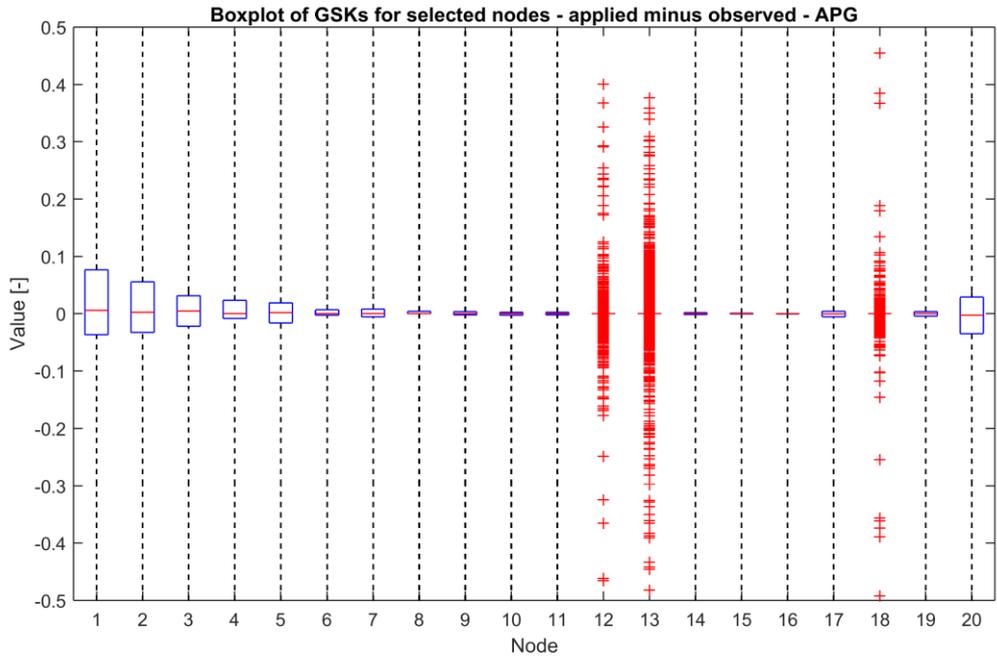


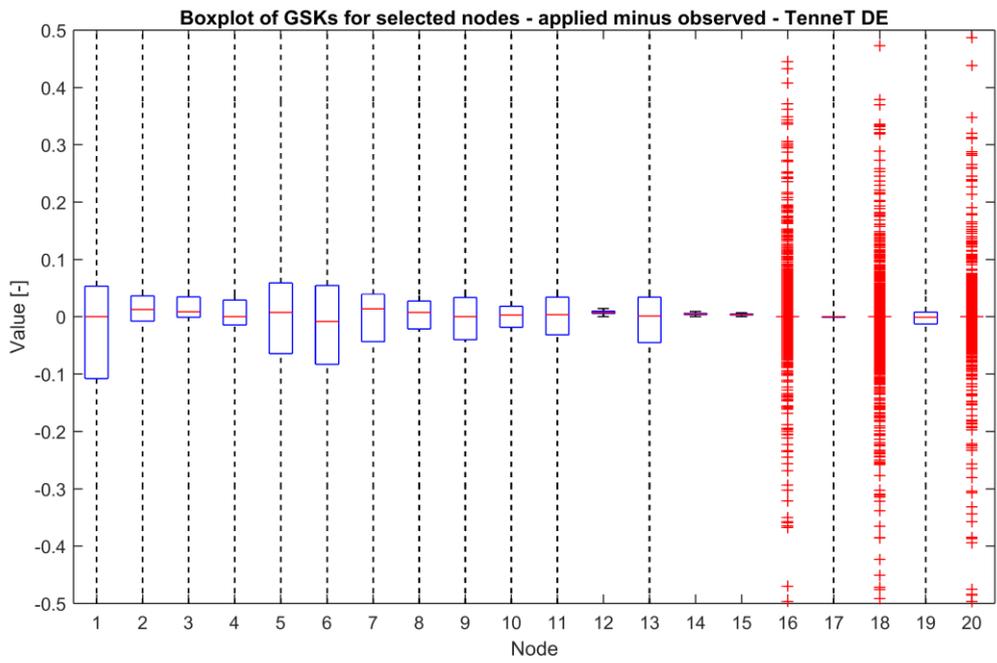
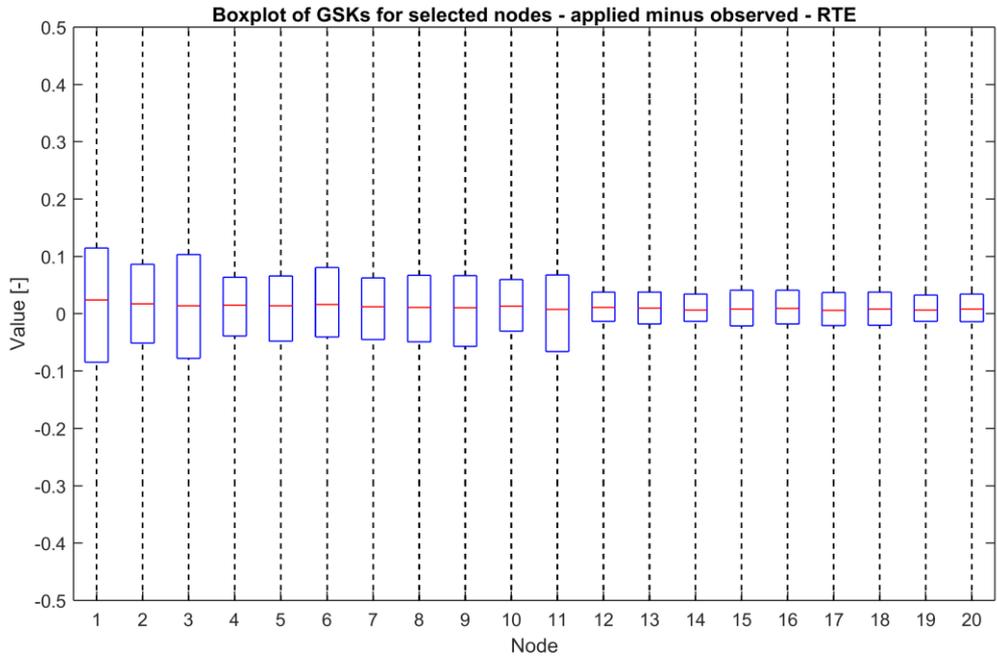


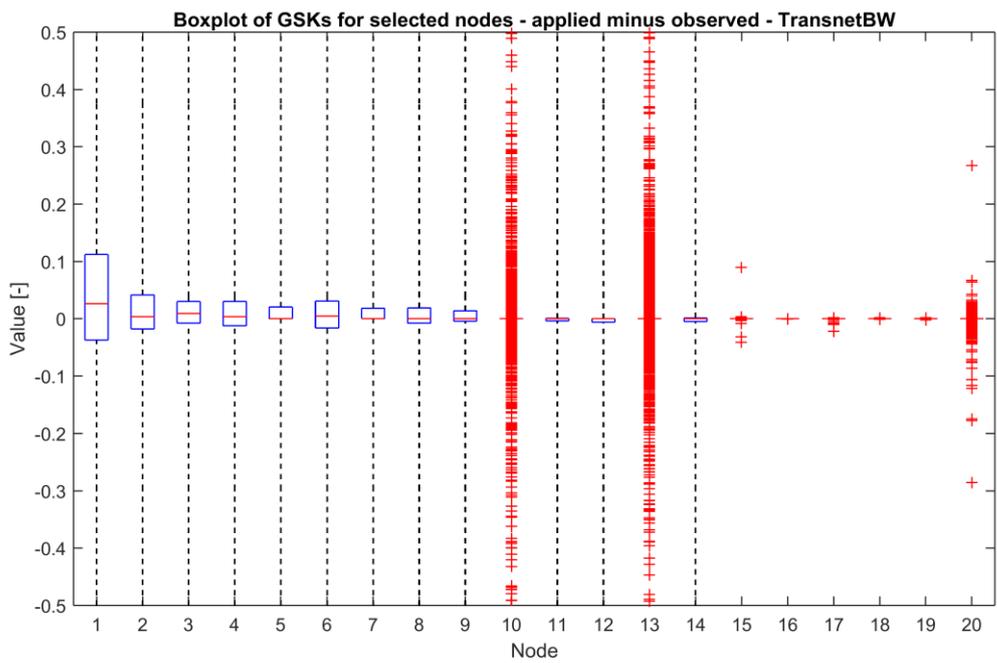
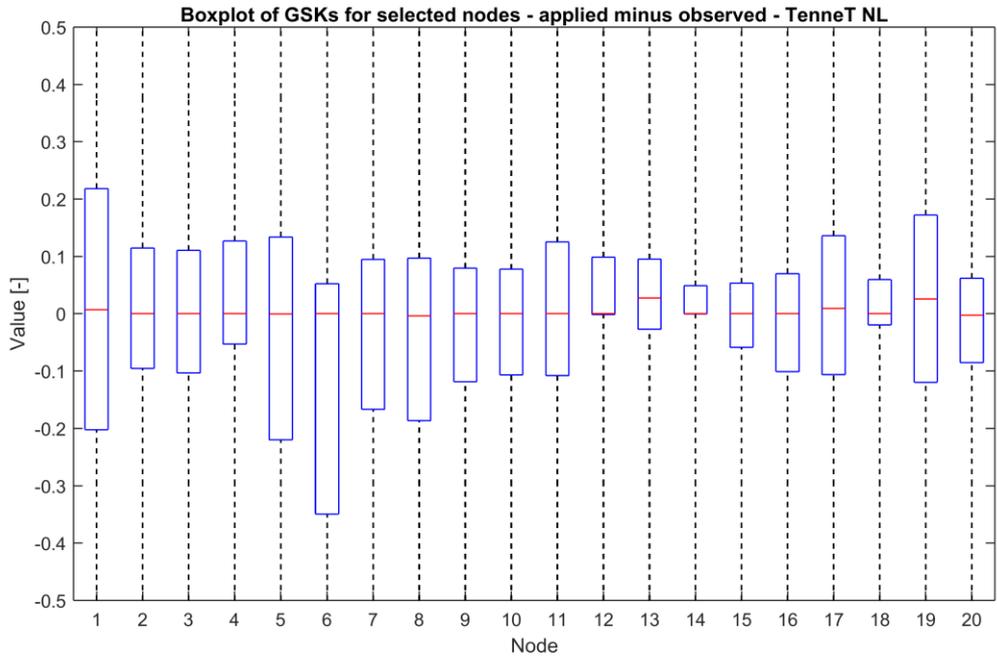




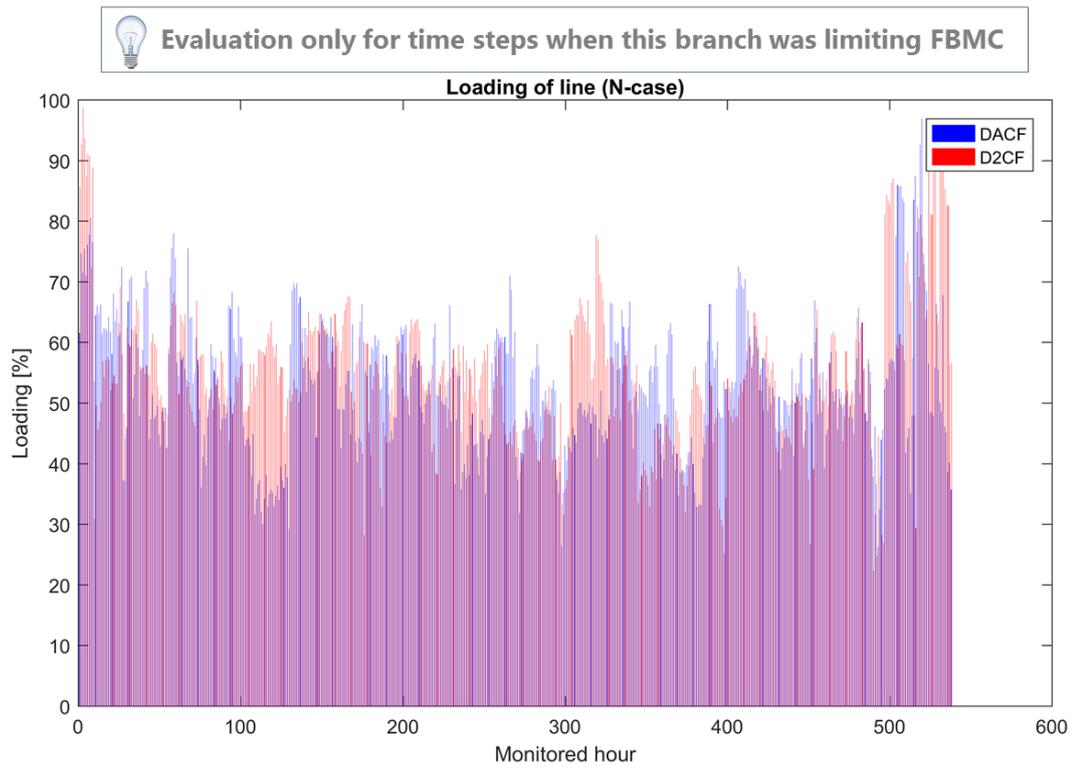




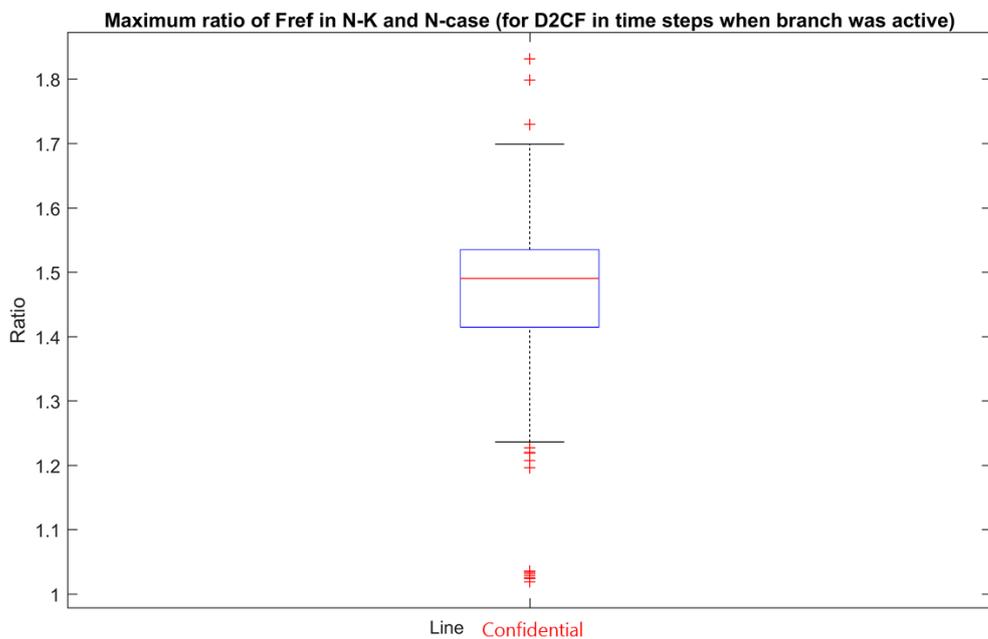




### Most frequently active branch

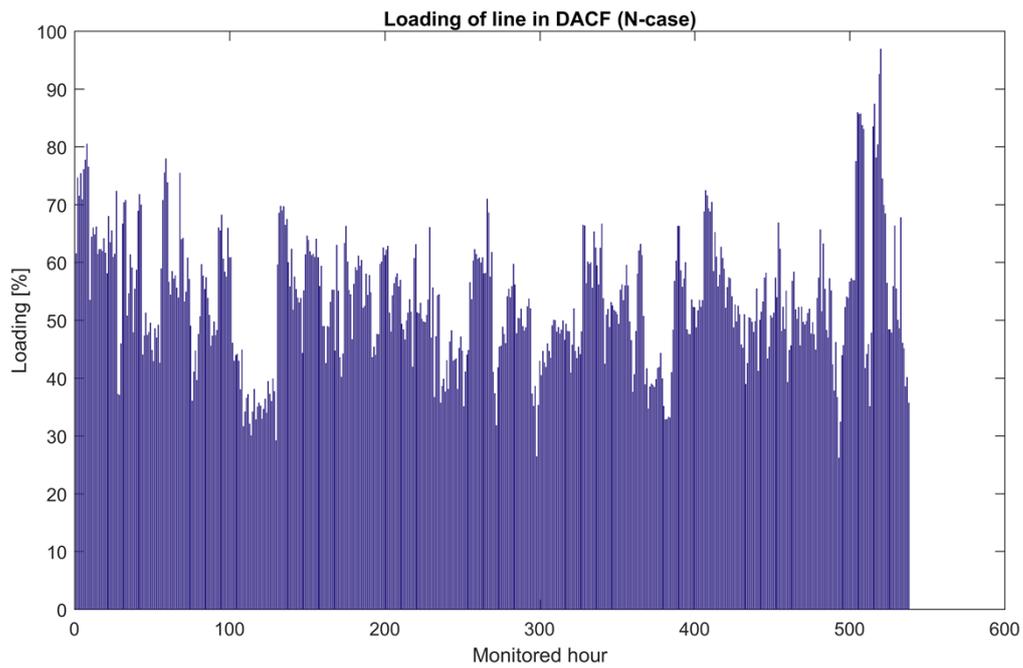


### Most frequently active branch



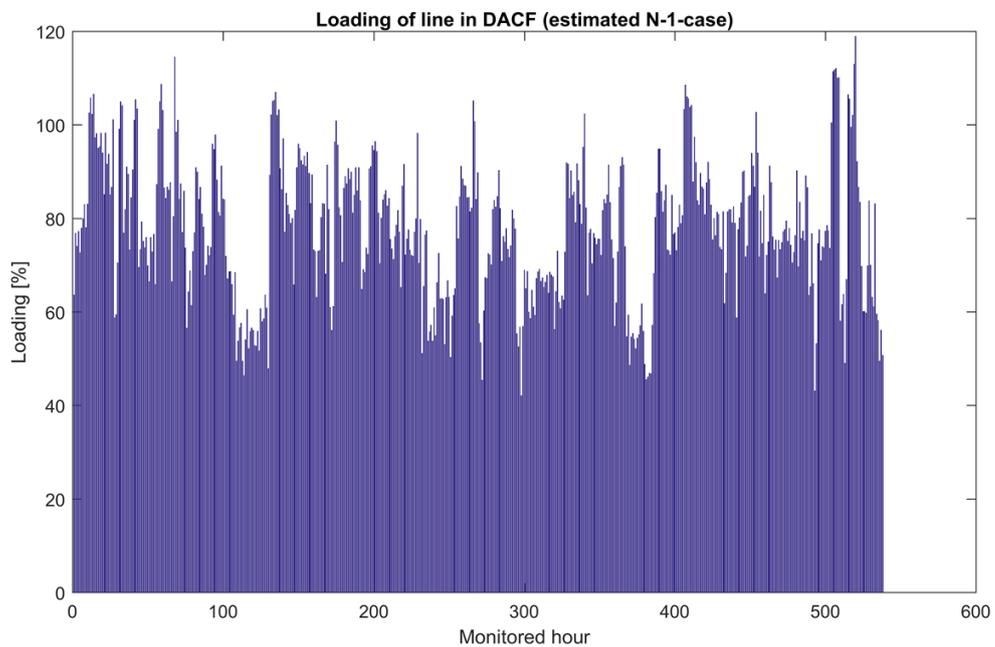
Note on this figure: it can be observed that line loadings in the N-k case are in more than 50% of the observations between 40% and 55% higher than the line loading in the N-case. Outliers range from almost 0% increase of N-k loading compared to the N-case loading (ratio=1) to more than 80% (ratio = 1.8)

## Most frequently active branch

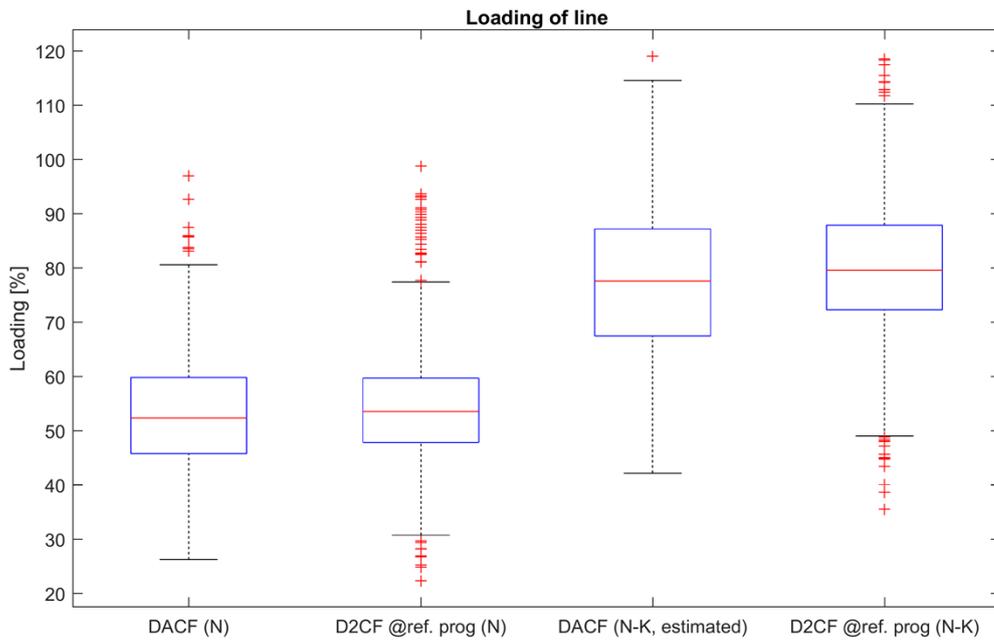


## Most frequently active branch

 **Flow in N-1 case estimated by scaling DACF flow in N-case with the maximum Fref-ratio between N-K-case and N-case in D2CF in time step**



## Most frequently active branch



## Most frequently active branch

