Report on SPAIC results for the integration of the DE-AT border into CWE Flow Based

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1 Introduction on the methodology of a SPAIC

1.1. Background

Mid of May 2017 E-Control and Bundesnetzagentur published a press release stating that both regulators agreed on a common framework for the introduction of a capacity management mechanism. According to this the border between Germany and Austria (DE-AT) shall be included in the CWE FB MC and 4.9 GW shall be the exchange capacity for Long Term Transmission Rights. The go-live date is set for 1st October 2018.
The inclusion of the border into the CWE flow based capacity calculation has also received support by the transmission system operators (TSOs) and national regulatory authorities (NRAs) of the CWE region in December 2017 and January 2018, respectively.
Flow-based experts of the DE-AT Bidding Zone Border (DE-AT BZB) project have performed, in coordination with experts from the CWE region, a SPAIC to assess the impact of the DE-AT bidding zone split introduction on the results and performance of the flow based capacity calculation in the CWE region. The results of this impact assessment are presented in this document.
It has to be highlighted that it is the first time that the CWE flow based capacity calculation is extended to another border. The standard approach used for this impact analysis is usually applied to analyse methodological or grid related changes in relation to capacity calculation. As the impact of a bidding zone split is much broader, in particular on the level of market interaction, the limitation of the assement provided in this document has to be duly taken into account.

1.2. SPAIC days and method

The study presents the result of standard process to communicate on and assess the impact of significant changes (SPAIC). A SPAIC analysis consists of a comparison of flow-based domains and market results for 12 typical "reference" days, commonly predefined by CWE TSOs, in order to estimate the impact of a change in grid topology or flow-based parameters.

In order to study the impact of the change, the following days have been analysed:

Reference date	Amount of BDs rep.	Season	Type of day
22/09/2016	39	Interseason	Weekday
01/10/2016	38	Interseason	Weekend
27/10/2016	18	Interseason	Weekday
12/11/2016	36	Winter	Weekend
21/12/2016	24	Winter	Weekday
19/01/2017	28	Winter	Weekday
23/01/2017	31	Winter	Weekday
30/03/2017	27	Interseason	Weekday
10/06/2017	37	Summer	Weekend
20/06/2017	31	Summer	Weekday
03/07/2017	30	Summer	Weekday
01/08/2017	25	Summer	Weekday

These days together represent the year from 1st September 2016 to 31st August 2017. The left column describes which days were analyzed, while the second to the left column describes the amount of business days that are represented by this reference day in the period. The second to right column explains in what season the analysed day occurred and the right column explains whether the day was a week- or a weekend day.

In line with the SPAIC approach, datasets corresponding to the criteria 2a, 2b, and 2c have been used for the impact analysis:

2 – Capacity calculation indicators – Description of datasets including main changes

- In order to calculate the capacity calculation indicators, flow-based experts created the following three datasets. For the analysis, dataset 2c was compared with 2b to see the isolated effect of the DE-AT BZB split on capacity calculation results.
- In addition, dataset 2c was compared with dataset 2a to assess the historical situation.
- The datasets are as follows and named according to the CWE reference guide (updated historical benchmark):

2a. **Dataset historical benchmark** – No modifications

2b. **Dataset updated historical benchmark** – Unrelated (approved) changes between 1st September 2016 - 1st October 2018

- Coordination of Preventive Remedial Actions (PRA) & Curative Remedial Actions (CRA) in Edges & Remedial Action Coordination Tool
- Common likely Net Position forecasting in Edges[1]
- Extended list of RAs
- Removal of French External Constraints
- Imax:
    - Dynamic line rating for Amprion
- Swissgrid D2CF instead of DACF used in CWE CGM
- LTA inclusion has changed from FAV based approach to the application of virtual branches
- FAV for Amprion lines has entirely been deleted
- Changes made to CWE grids
    - Second phaseshifter transformer in Zandvliet
    - Topological changes in APG grid
    - Additional transformer in St Peter
    - New 380 kV substation Kaprun Hauptstufe
    - Thermal rating in APG grid
    - Decomissioning Gundremmingen nuclear power plant
    - Tie line (Grafenrheinfeld – Stalldorf) TTG-TNG updated Imax
    - New tie line (Frankfurt – Kriftel) TTG – AMP

2c. **Dataset including change** – DE-AT BZB split and DE-AT related changes & unrelated changes described above

- DE-AT BZB split itself (additional CBCOs which are sensitive to the new bidding zone border between Germany and Austria, new APG GSK and therefore adaptions to the German Generation Share Key (GShK)
- Removal of German External Constraints
- Extended list of RAs including DE-AT RAs

In contrast to the operational procedure where the common grid model is merged by CORESO, the merging was done by TSCNET for all datasets.

1.3. Market Coupling Simulations

In addition to Flow Based capacity indicators, the simulation of market coupling results is an important additional part of any SPAIC. Therefore, the standard assessment foresees that the twelve typical days will be mapped against all order books of the assessment period (01/09/2016 – 31/08/2017). In parallel to capacity calculation, also market simulations have to be performed on three datasets. These simulations are run on the

[1] The introduction of edges was announced in this market message as improved reference points

dedicated simulation facility of the PCR project using the same version of the Euphemia algorithm. The order books have been prepared and provided by EPEX SPOT according to the oder book modelling approach described in 1.3.1.

1.3.1. Order Book Modelling Approach

However, the split of the German-Austrian bidding zone into two separate bidding zones constitutes a case that until now has not been investigated in any SPAIC within the CWE framework. Mapping of datasets against historical order books is not sufficient in this case, since the historic joint order book of the German-Austrian bidding zone needs to be split into two separate order books (for the German-Luxembourgian bidding zone, and for the Austrian bidding zone).

For this, historical DE and AT orders are allocated to either DE or AT separate supply and demand curves. All orders that have been submitted in 50Hz, Amprion, TNG and TTG areas are aggregated to DE supply and demand curves, whereas all orders submitted in APG area are aggregated to AT supply and demand curves.

The significant part (approximately 80% – 95%) of the historic trade between market parties in DE and AT has been traded over the counter (OTC) within the joint bidding zone, and consequently is not visible in historic EPEX order books. These trades will not be possible any more after the split. Instead, this liquidity will (at least partly) shift to the coupled day-ahead trade, i.e. to the order books of the NEMOs active in future DE and AT bidding zones. Neither the precise volume and prices of historic OTC trades between DE and AT, nor the volume of the future shift from OTC to NEMO order books are known. Therefore, modelling assumptions are required (described below) which imply a high degree of uncertainty in the market coupling simulation approach.

In order to assess the possible future shift from historic internal DE-AT OTC trade to NEMO order books, the split historic order books are altered. For the alteration, the volume of schedules between DE-TSOs and APG is taken as proxy parameter. For all hours with historic schedules from DE to AT, the volumes of these export schedules are added to the DE supply curve, and to the AT demand curve. Accordingly, for all hours with historic schedules from AT to DE, the volumes of these export schedules are added to the AT supply curve, and to the DE demand curve. All alterations are added as price-taking orders to the separate order books. Historic volumes have not always been added on a one-to-one basis (see below for a more detailed discussion of alternative alteration approaches).

1.3.2. Limitations of historic order books

Generally, any analysis that is based on historic order books is subject to different limitations. This is especially true for these market coupling simulations, since the splitting of a bidding zone will most likely lead to dynamic market reactions that cannot be estimated in advance.

Several market reactions cannot be covered by historic order books as basis for market simulations (independently of the chosen approach to split order books). Changes in supply curves can be expected e.g. because of different bidding behaviour of hydro power plants in AT (following changed price signals). Additionally, also changes in demand curves are to be expected, e.g. because of different bidding behaviour of pump storage plants.

Additionally, the alteration approach that has been applied in order to achieve separated DE and AT order books comes with more inevitable limitations. These limitations need to be clearly taken into account when analysing the simulation results that have been generated with the split order books. These limitations include, among others:

- Different OTC trading behaviour after the split, both in AT and DE. Most likely, not all historic OTC trades between DE and AT traders will switch to implicit day-ahead coupling
- Historic cross border schedules already include EPEX trading. Adding these volumes to the split order books leads to double-count.
- Historic cross border schedules also comprise intraday trading. A full shift of these volumes to day-ahead trading seems extremely unlikely.
- The consideration of OTC schedules in form of price-taking orders is an extreme approach which does not reflect price-sensitive demand/supply and "transit trades" across Austria.

Given all these different limitations of the alteration approach, any alteration approach can only be considered as an approximation of future bidding behaviour. Consequently, three scenarios have been considered for separate DE and AT order books:

- Scenario 1: Split order books are altered with 50% of historic cross border schedules. The analysis of market simulations is focused on this scenario.
- Scenario 2: Split order books without alterations (0% scenario, fringe scenario).
- Scenario 3: Split order books are altered with 100% of historic cross border schedules (additional fringe scenario).

Fringe scenarios (0% alteration, and 100% alteration of order books) have been mainly analysed for completeness. Project parties would like to put strong emphasis on the fact that these scenarios are not deemed realistic. Instead, they are only included in order to assess the sensitivity of the order book alteration approach. As is quite obvious, the 100% scenario is an extreme overestimation of the alteration approach, whereas, the 0% scenario is an extreme underestimation of the alteration approach.

However, it needs to be noted that only a modelling approach based on historic order books with limited volume combined with schedules was available. Due to the limitations and uncertainties mentioned, the results of the market coupling simulation for all scenarios provided in this SPAIC do not represent any forecast or projection of prices. To avoid the reflection of extreme scenarios, the 50% scenario has been chosen to provide market coupling simulation results for this SPAIC.

1.3.3. Comparison of simulation results against current market expectations

Even before the implementation of separate German and Austrian bidding zones, derivatives as the EEX Phelix already reflect current expectations of market parties. Conclusions with respect to the expected price levels in Germany and Austria can be drawn from the prices of different derivatives for delivery in 2019 or later. Even though Phelix AT products suffer from low liquidity, an arbitrage-free price can be deducted from Phelix DE and Phelix DE-AT products. These products allow to conclude that market parties are expecting a price difference between DE and AT of 2.50 Euro/MWh in 2019, and 3.00 Euro/MWh in 2020 (trading day was 30/04/2018).

These expectations can be compared against the price difference that results from the market coupling simulations in scenario 1, which averages at 3.52 Euro/MWh.

2 Results – FB capacity indicators

2.1. Introduction

Figure 1 to Figure 5 show the change of minimum and maximum Net Positions (NPs) of the FB domain with LTA inclusions for the dedicated CWE hubs without/with bidding zone border split between Germany and Austria. In the graphs the historical data (2a), the updated historical data (2b) – considering methodological changes that are known and approved at the time of the study – and split data (2c) of the minimum and maximum Net Position of each CWE hub are depicted.
In the interpretation of Figure 1 to Figure 5 the following aspects have to be considered:

- on the abscissa the 12 business days (BD) in an hourly resolution and
- on the ordinate the min/max net positions of each hour of the 12 BD are depicted. Please note the different scaling of each figure.

Positive Net Positions represent the export capability, the import capabilities of the CWE hubs are described through a negative netposition. Thus, the min/max netpositions represent the theoretical maxima for import and export, respectively, for a given hub. The Min/Max NP for each hub are not simultaneously feasible. Yet, these indicators provide a good visual comparison of the impact on the flow based domain.

2.2. Min/Max Net Positions (NP)

In Figure 1 min/max Net Positions for Belgium for the datasets 2a, 2b and 2c are depicted.

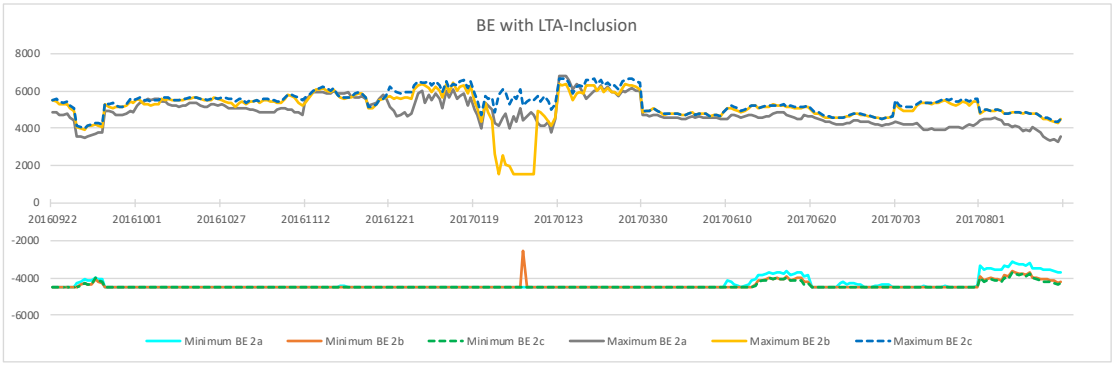


Figure 1: min/max netpositions BE for datasets s 2a/2b/2c

As shown in Figure 1 the min/max Net Positions for 2b and 2c are almost entirely above 2a, this means that in 2c higher import and export capabilities are possible compared to 2a. 2c also results in an import capability, which is always higher compared to 2b. In dataset 2c in 83,7% of the analysed hours the external constraint of Belgium is the limiting element in import direction. The cause of the behaviour on BD 20170119 for 2b could not be identified. However, as shown in Figure 1 the decline in the min netposition does not occur in 2c and is only an effect which occurred in 2b.

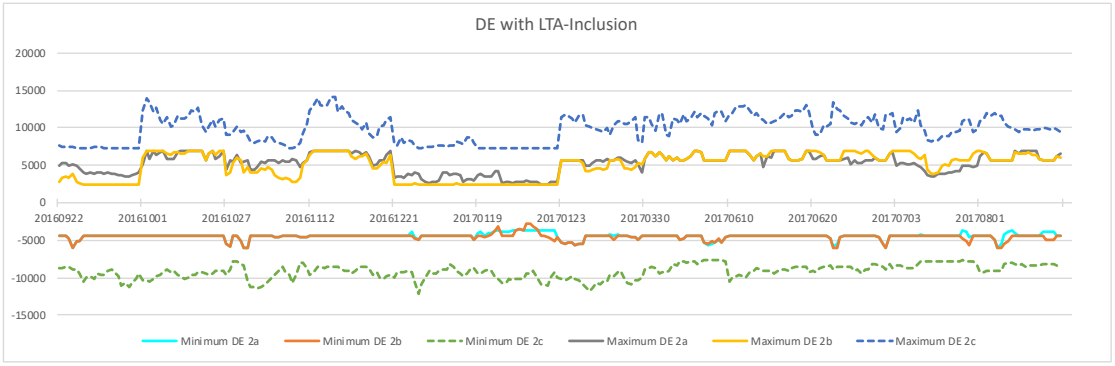


Figure 2: min/max netpositions DE for datasets s 2a/2b/2c

In Figure 2 the min/max Net Positions for DE are depicted. The minimum as well as the maximum Net Position in 2c shows a significant increase compared to the historical situation (2a), which is a direct consequence of the bidding zone border split, since there is an additional German border reflected in dataset 2c. Therefore the netpositions of the historical data (2a) and the updated historical data (2b) cannot be directly compared with the Net Positions of the data considering the bidding zone border split between Germany and Austria (2c). In the interpretation of the graphs it has to be considered, that due to the introduction of the bidding zone border split the External Constraints for Germany will be removed. The removal of the External Constraints is also reflected in the graphs of 2c.

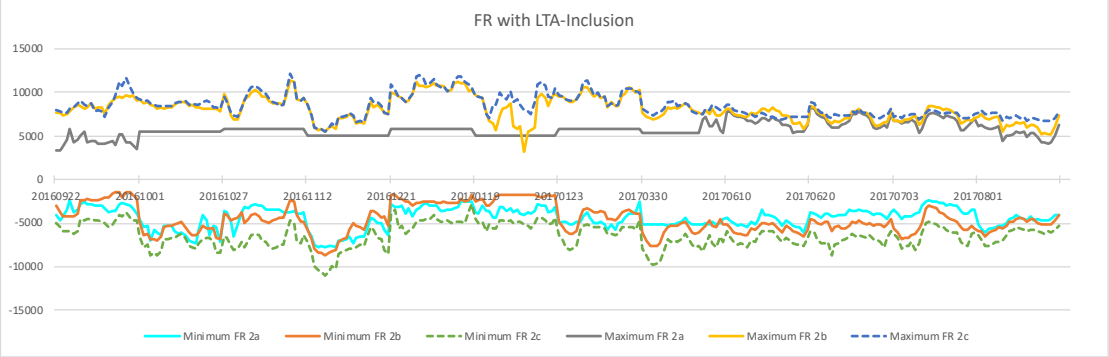


Figure 3: min/max netpositions FR for datasets 2a/2b/2c

Figure 3 demonstrates the min/max Net Positions for the French hub. It is to be noted, that the figures for 2a still reflect the French External Constraints in export direction, while in 2b and 2c the French External Constraints were removed (the application of the French external constraints was stopped on delivery day 13/04/2017, day-ahead market coupling 12/04/2017). In Figure 3 it can be seen, that 2c shows almost entirely higher import capabilities compared to both datasets 2a and 2b. In the export direction there are a few hours, in which the NPs for 2c are below the NPs for 2b.

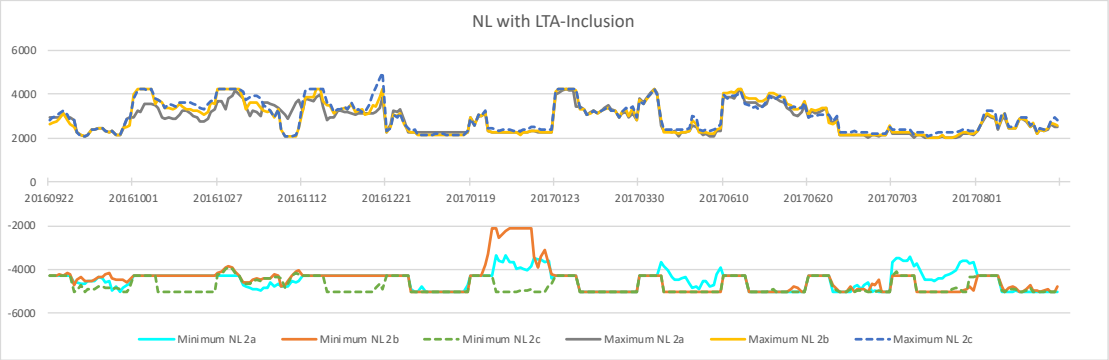


Figure 4: min/max netpositions NL for datasets 2a/2b/2c

In Figure 4 the min/max Net Positions for NL are depicted. In 46 % of the analysed hours the import netpositions remain unchanged or slightly increase due to the bidding zone border split DE-AT. For some hours on five BDs a slight reduction of import capabilities in 2c compared to 2a is observable in selected hours. All changes mentioned in the description of the datasets could have led to the decrease in import capacity. No clear trend is visible for the export capabilities. The cause of the behaviour on BD 20170119 for 2b could not be identified.

In Figure 5 the min/max Net Positions for AT are depicted.

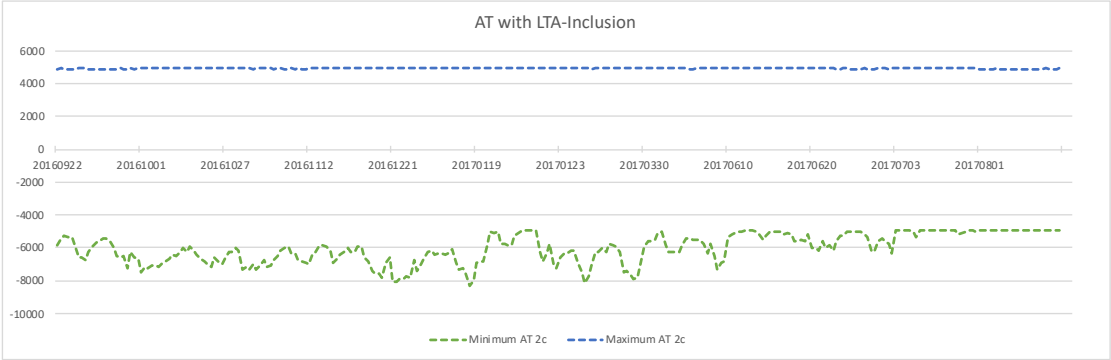


Figure 5: min/max netpositions AT for datasets 2a/2b/2c

Results for the Austrian hub cannot be shown in the same manner as there are no historical results to compare with. However, the results provide an indication of the import and export capabilities, resulting from the CWE FB process, on the border DE-AT for the situation after the bidding zone split – see graphs for 2c in Figure 5. In 73,3 % of the analysed hours the min Net Positions of AT exceed the LTA value of 4,9 GW. For the max Net Position it can be seen, that LTA inclusions were necessary and the export capability reflects basically the 4,9 GW for the analysed BDs. It has to be mentioned that in this SPAIC the values of the reference
Program (refProg) AT>DE were much lower than the LTA values for the export from Austria to Germany (refProg mainly contained imports from Germany to Austria). Therefore, the flow based model had to apply a large linear (and unrealistic) shift to reach the LTA level for this direction, with increasing inaccuracy.

2.3. Volume of the flow based domain

Figure 6 shows the volume of the flow based domain considering LTA inclusions for the datasets 2a, 2b and 2c.

In the interpretation of Figure 6 the following aspects have to be considered:

- on the abscissa the 12 business days (BD) in an hourly resolution and
- on the ordinate the GW^3 for the FB Domain volumes are depicted

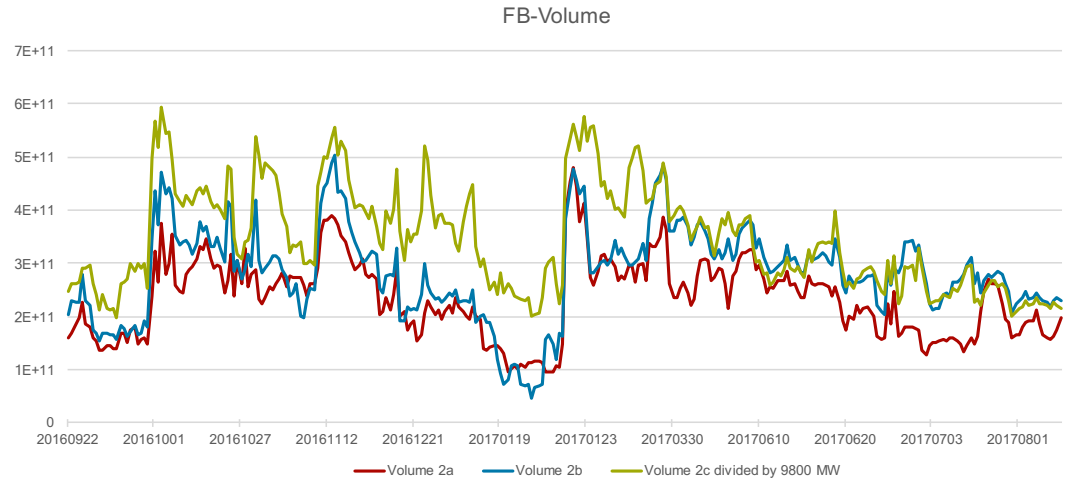


Figure 6: FB domain volume for 2a, 2b and 2c divided by 4,9 GW.

For the comparison of the FB domain volume the indicator has been adjusted
The power of the flow-based domains with and without is different due to the additional AT hub (5 hubs instead of 4).
In order to compare the FB domain volumes, the dimension of the FB domain with the separate AT hub is reduced by dividing the volume by 9800 MW.

9800 MW is the maximum observed reference exchange between DE-AT observed in the underlying data of the analysis and is therefore a worst case assumption. This means, that for most of the cases the volume of the domain with split would be even be higher than it is shown in the graph.
Based on the adjusted indicator, the volume in 2c is increased compared to 2a and 2b for a large number of hours, while in the summer days the volume in 2c is sometimes slightly below the results for 2b but still always high than 2a.

2.4. Market coupling simulations

Market coupling simulations have been performed for all three datasets (2a, 2b and 2c). For dataset 2c (the only dataset with separate DE and AT bidding zones), three different scenarios for the alteration of the separated order books have been studied. The table below shows the key results for the reference datasets 2a and 2b (no bidding zone border DE-AT for these datasets), and for the 50% scenario of dataset 2c.

2.4.1. Key Market Indicators

The following key market indicators are displayed:

- Average hourly price per CWE bidding zone (Euro/MWh). As can be expected, a separate price for the AT bidding zone can only be stated for dataset 2c. The price for the DE bidding zone refers to the joint DE-AT bidding zone in datasets 2a and 2b.
- Average hourly net position per bidding zone (MWh). Indicated is the MRC net position; net positions therefore do not sum up to zero.

SPAIC	2a		2b		2c - 50% scenario	
Bidding Zone	Price (€/MWh)	Net Position (MWh)	Price (€/MWh)	Net Position (MWh)	Price (€/MWh)	Net Position (MWh)
AT	35,63	n/a	35,51	n/a	39,42	-1657,05
BE	45,60	-840,85	45,26	-872,47	43,90	-791,05
DE	35,63	2434,74	35,51	2414,82	35,90	4353,22
FR	45,50	3075,49	45,59	3042,78	44,38	2841,77
NL	37,73	-348,21	37,82	-283,31	38,09	-235,75

The comparison of results is focused on SPAIC dataset 2b and the 50% scenario of dataset 2c (i.e. with an order book alteration of 50% of historic cross-border nominations).

For the Austrian market, the simulation leads to an average price of 39.42 Euro/MWh. This is equivalent to a price increase of 3.52 Euro/MWh compared the reference dataset with a joint DE-AT bidding zone.

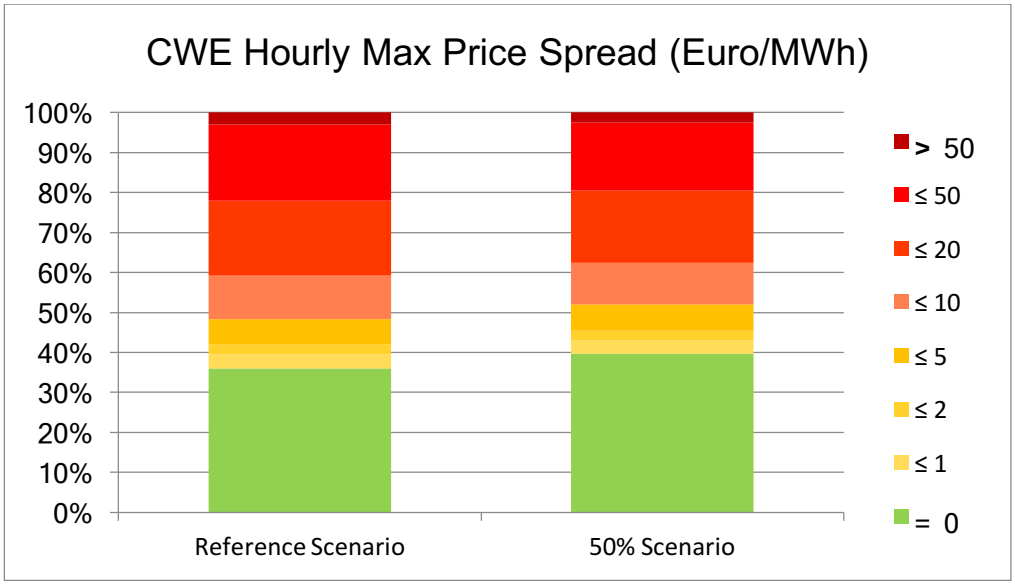
In Belgium and in France, there is a noticeable decrease of average prices (of 1.36 Euro/MWh in BE, and 1.21 Euro/MWh in FR).

Simulation results for the Netherlands and Germany show very limited price increases. Still, Germany remains the bidding zone with the lowest average price in CWE, followed by the Netherlands. The German net position is increasing significantly; partly because of the inclusion of bilateral exchanges towards Austria for the first time.

2.4.2. Price Convergence

The analysis of price convergence shows that the split of the German-Austrian bidding zone leads to higher levels of price convergence across the whole CWE region. Full price convergence in CWE is increasing, despite an additional fifth bidding zone that needs to be considered after the split. Full price convergence is increasing from 36.1% in the reference scenario without split, to 39.7% in the 50% scenario after the DE-AT split.

Additionally, also the number of hours with very high price differences between CWE bidding zones is decreasing, from 3.1% in the reference scenario without split, to 2.5% (50% scenario, with split).



2.4.3. Extreme Price Events and Welfare Indicators

The period that is assessed in this SPAIC also covers the events of the cold spell during the Winter of 2016/2017, where very high prices could be observed in all CWE bidding zones. Especially France and Belgium were suffering from very high prices. The market simulation shows that the number of hours with exceptionally high prices is decreasing with the implementation of the additional bidding zones border. The following table indicates the number of hours with prices >80 Euro/MWh per bidding zone. As can be seen, the number of high price events is decreasing in Belgium and France.

	Reference Scenario				50% scenario				
BZ	**BE**	**DE-AT**	**FR**	**NL**	**AT**	**BE**	**DE**	**FR**	**NL**
hours/year	575	128	592	104	208	487	139	500	120
percentage	6.6%	1.5%	6.8%	1.2%	2.4%	5.6%	1.6%	5.7%	1.4%

The table below indicates the changes in consumer surplus, producer surplus and total welfare between reference scenario (without DE-AT split), and the 50% scenario (with DE-AT split). Numbers indicate the total sum of all welfare changes over the whole scenario period (~ one year). As can be seen clearly, welfare in Belgium and France is increasing significantly. For Austria and Germany, a comparison of welfare is not possible with the methodology at hand, since the assessment is based on market clearing volumes. Since these volumes are already increasing with the alteration of order books, the number should not be compared between the different datasets.

	Producer Surplus	**Consumer Surplus**	**Net Welfare Effect**
FR	107 million €	119 million €	**226 million €**

BE	30 million €	65 million €	**96 million €**
NL	13 million €	- 6 million €	**7 million €**

2.4.4. Fringe Scenarios

For completeness, the below table shows the key results of the 0% scenario (no alteration of split order books), and the 100% scenario (split order books are altered with 100% of historic cross-border schedules). Both scenarios are based on dataset 2c. As can be expected, the severe overestimation of order books in the scenario 3 leads to extreme price distortions, especially for the Austrian bidding zone (the additional demand in Austria, with no alteration of the demand side, leads to numerous hours in which the market clearing price reaches the upper boundary of 3000 Euro/MWh). Even in this extreme scenario, prices in Belgium and France are decreasing in comparison to dataset 2b. It is therefore reasonable to conclude that the bidding zone split leads to price decreases in these bidding zones, independently of the exact volume of separated German and Austrian order books.

However, it needs to be noted that only a modelling approach based on historic order books with limited volume combined with schedules was available. Due to the limitations and uncertainties mentioned, the results of the market coupling simulation for all scenarios provided in this SPAIC do not represent any forecast or projection of prices. To avoid the reflection of extreme scenarios, the 50% scenario has been chosen to provide market coupling simulation results for this SPAIC.

SPAIC	2c - 100% Nominations		2c - 0% Nominations	
Bidding Zone	Price (€/MWh)	Net Position (MWh)	Price(€/MWh)	Net Position (MWh)
AT	141,28	-3468,82	37,99	235,53
BE	44,66	-782,67	43,04	- 821,43
DE	34,80	5603,03	36,53	2.793,01
FR	45,55	3113,24	43,66	2.661,82
NL	37,70	-297,32	38,24	- 205,70

3 Conclusions

The analysis performed during the "DE-AT BZB EXT SPAIC" are based on the Standard Approach for Assessing Impact of significant Changes (SPAIC) and SPAIC indicators - min/max Net Positions, FB volumes as well as the market coupling results - are described in this document. To show the impact of the influence, also compared to known and approved changes, which have been or will be implemented in parallel, a historical benchmark as well as an updated historical benchmark have been used for analysis.
The indicators gained by the flow based computations show that in general the DE-AT BZ split (2c) has on average a positive impact on the import and export possibilities in CWE. The FB domain volumes of 2a, 2b and 2c do not allow an one-to-one comparison between the volumes because the FB domain - considering the bidding zone border split – has four dimensions instead of three, without split. Based on the adjusted indicators, the volume of 2c is increased compared to 2a and 2b for all analysed business days. Alltogether, it can be concluded that more capacities can be provided to the CWE region[2] when taking into account the split of the bidding zone DE-AT.

According to the 50% scenario, average prices for Belgium and France decrease while a slight increase can be observed for the Netherlands and Germany. For Austria, an increase, similar to market expectations at the future market, is visible.

Price convergence is increasing despite an additional bidding zone. The occurrence of prices > 80 €/MWh is significantly reduced in Belgium and France.
The net welfare effects for France, Belgium and the Netherlands are positive while these indicators for Germany and Austria cannot be calculated due to the applied modelling approach for order books.

However, it needs to be noted that only a modelling approach was available, with significant limitations and uncertainties. Hence the results of the market coupling simulations for all scenarios provided in this SPAIC do not represent any forecast or projection of prices.

Nevertheless, the following observations can be drawn independently of all analysed order book scenarios:

- In Belgium and in France, a noticeable decrease of average prices can be observed.
- In terms of average prices, the effect for the Netherlands can be considered as neutral.

[2] This is by definition, due to the implementation of the congestion management between Germany and Austria, not the case for exchanges between Germany and Austria.