CWE Flowbased MC Day-Ahead
APG CB Study

Version	3.0	
Date	**2016.05.18**	
Status	☐ **Draft**	☒ **Final**

Document creation and distribution

Document Owner	CWE TSOs
Function	Report for APG Critical Branches (CBs)

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1. Introduction

1.1. Background

In 2013 the Pentalateral Energy Forum (PLEF) decided to expand the CWE region by Austria as a new member. Since then APG has developed in close cooperation with the CWE-TSOs an action plan in order to be fully integrated in the operational activities.

This action plan consists of the following three steps:

1) D2CF[1] - integration
2) GSK[2] - integration
3) Full Flow Based (CB[3]).

Figure 1: Three-step of the APG integration

- D2CF-integration:

In the initial CWE Flow Based[4] calculation, performed during parallel run, the Austrian grid was included only through the DACF (Day Ahead Congestion Forecast) datasets. This changed in November 2014 with the completion of the first integration step. Since then APG is fully involved in the operational D2CF-procedures and the contractual D2CF-framework of the CWE region. Consequently on a daily basis APG's D2CF-file is merged with the D2CF-files of the other CWE-TSOs in order to create the Common Grid Model (CGM) of the CWE-region.

- GSK-integration

Similar to the D2CF-files initially Austria was also not considered in the GSK of the CWE region. In the first place in the GSK of the bidding zone DE/AT/LU solely German generation units were considered; i.e. Austrian generation units were not reflected in the PTDF calculation yet.

Therefore APG in coordination with the CWE-TSOs started to work on taking the Austrian GSK into account and actually create a German/Austrian GSK for the bidding zone DE/AT/LU, in which all relevant units are taken into account.

The process was initiated in early 2015 and a technical analysis was performed with the aim to assess the impact of the "new DE/AT GSK" on the CWE PTDFs and the Market Coupling (MC) results. The results of this technical analysis were summarized in an end report (including several annexes) and in a first step discussions with CWE NRAs were held.

In the light that with the "new DE/AT GSK" the methodology as such remained unchanged, NRAs confirmed that for the implementation no regulatory approval was required. Furthermore a market

[1] D2CF … Two Day-ahead Congestion Forecast
[2] GSK … Generation Shift Key
[3] CB … Critical Branch
[4] FB ... Flow Based

information, which was accompanied by the final report together with an explanation document, was published. The end report is available under the following link on the JAO website.
Consequently the "new DE/AT GSK" has been used in operation since the 2nd of December 2015 (for delivery date 4th of December 2015).

- Full Flow Based (CB)

With the GSK-integration of APG the first two integration steps are finalized. In that light only the final integration step – "Full Flow Based" – is pending. In this integration step the impact of APG CBs on the CWE-region is analysed in detail. Furthermore it is worth highlighting that with this integration step the CWE Day-Ahead FB method as such remains completely unchanged. Adding an APG CB to the CWE FB capacity calculation is similar to the addition of a German CB and would just mean a new CB in the common bidding zone DE/AT/LU[5].

With the completion of the final integration step APG is fully involved in the technical FB capacity calculation processes of the CWE region.

1.2. Structure of the end report

The objective of this study is to analyse in detail the impact of APG CBs on the CWE-region.
Therefore a significant number of lines in the APG grid were modelled as CBCO combination (approximately 350 CBCOs).
This study has been initiated at the beginning of 2016 and was completed by end of April 2016.
Similar to the analysis performed in the course of the second integration step (GSK-integration) the analysis is split in two principle steps:

1) FB Parameters calculations and
2) MC[6] simulations.

This sequential approach is further illustrated in Figure 2. Therefore in chapter 2 the results related to the FB parameters are illustrated whereas in chapter 3 the MC results are described in detail.

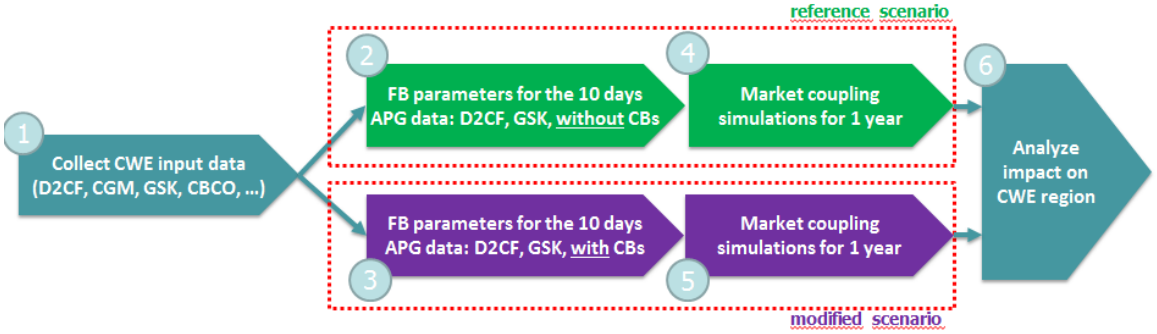

Figure 2: High-level overview of the approach to perform the impact assessment

[5] DE/AT/LU … Germany / Austria / Luxembourg
[6] MC … Market Coupling

In chapter 4 the main conclusions of this document are gathered.

1.3. Scope of the CB study (used approach)

The approach, which is used to analyse in detail the impact of APG CBs on the CWE-region is described in this chapter.
In principle the approach is based on the one presented at the CCG[7] meeting in November 2015. The slides presented regarding the standard approach for future impact assessments are attached in Annex 2.
Therefore the simulations, which were required for the CB study had been initiated right after the CCG meeting in November and the final simulations were completed by the end of April 2016. In the meantime based on discussions between the CWE project and market parties the standard approach for future impact assessments has been further developed (i.e. 12 representative days). However due to the fact that the APG CB study was initiated already at the end of 2015, the standard approach which was defined at that time (CCG in November 2015) was used to perform the APG CB study (i.e. 10 representative days).
Furthermore the stepwise approach which is used for this analysis is depicted in Figure 3.

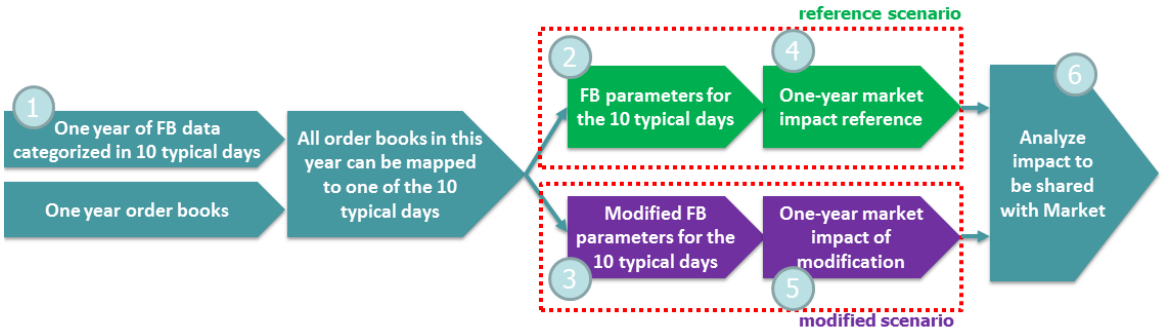

Figure 3: Overview of the approach to perform the impact assessment (presented in CCG)

In this document the current situation and future configuration are compared:

- Current situation ("**reference scenario**"): with APG D2CF, with DE/AT GSK, **no APG CBs**
- Future situation ("**modified scenario**"): with APG D2CF, with DE/AT GSK, **with APG CBs.**

Furthermore the impact of APG CBs on the CWE region is assessed based on both:

- FB Parameters calculations (difference of step 2 and 3, see Figure 3) and
- Market Coupling simulations (difference of step 4 and 5, see Figure 3).

To analyse the impact of APG CBs the dedicated study is based on the idea to cluster historical days in different categories and select for each category a representative day. This approach was also presented in the CCG meeting in November 2015.
As an illustration of the methodology, CWE TSO experts selected, via the K-MEANS algorithm, a set of 10 representative FB days (clusters). These clusters intend to resemble as many days

[7] CCG … CWE Consultative Group

possible within the period from 01/01/2014 to 07/08/2015 by analysing the shape of the FB domains.

Afterwards, the description of the 10 representative FB days (clusters) was done following the indicators which consider the wind & solar infeed in Germany as well as the minimum and maximum load in France. This process is highlighted in Figure 3 as "step 1". In Annex 2 more details on the outcomes of the assessment and each cluster are gathered. These slides were presented at the CCG in November 2015.

As conclusion these 10 days pose a good variety of the operational days of the last one and a half years and are considered as representative by CWE TSOs. Consequently CWE TSOs, as agreed during FBE Meetings, deem those 10 days to be sufficient to analyse the impact on the CWE FB parameters and the MC results due to the APG CBs.

Furthermore in Table 1 the 10 clusters including their characterization are depicted.

Cluster number	Characterization	Best reflecting BD
FB domain cluster 1[8]	Summer day with high solar, low wind and low demand	02/08/14
FB domain cluster 2	Day with low solar, average wind and average demand	06/10/14
FB domain cluster 3	Day with high solar, average wind and average demand	28/03/14
FB domain cluster 4	day with low solar, high wind and average demand	06/12/14[9]
FB domain cluster 5	No correlation with renewable infeeds	30/09/14
FB domain cluster 6	day with average solar, very high wind and average demand	24/12/14
FB domain cluster 7	Summer day with high solar and low demand	16/07/15
FB domain cluster 8	Average day	07/01/15
FB domain cluster 9	Winter day with low solar, low wind and high demand	04/02/15
FB domain cluster 10	day with high solar, average wind and low demand	30/06/14

Table 1: Overview of 10 FB domain cluster including their characterization

After gathering all input files needed (CGM, GSK, CBCO…) the FB calculations were performed for the 10 representative FB days. These calculations were done for both scenarios:

- Current situation ("**reference scenario**"): with APG D2CF, with DE/AT GSK, **no APG CBs**
- Future situation ("**modified scenario**"): with APG D2CF, with DE/AT GSK, **with APG CBs.**

The difference of the results of the FB parameter calculations of the above mentioned two situations are highlighted in chapter 2. In Figure 3 this is indicated by step 2 and step 3.

[8] In the following tables instead of the notion "FB Domain Cluster" only "Cluster" is used.

[9] Initially the 11/01/14 was the "best reflecting BD". Due to missing parallel run results some flows do not exist for 11/01/14 to calculate the FB parameters accordingly. Therefore the most similar day within this cluster is taken instead, i.e.: 06/12/2014 .

In the next step for both situations the representative FB days were “mapped” to an entire year which for MC simulations were performed. In Annex 2 for the period from 08.08.2014 to 07.08.2015 an overview of which clusters are assigned to each calendar day is depicted. In order to use as much information available from operational data (instead of parallel run data) the MC simulations were performed for the period from the 08.08.2014 – 07.08.2015. Similar to the calculation of the FB parameters these MC simulations were carried out for the following cases:

- Current situation (“**reference scenario**”): with APG D2CF, with DE/AT GSK, **no APG CBs**
- future situation (“**modified scenario**”): with APG D2CF, with DE/AT GSK, **with APG CBs.**

The difference in the MC results of these two cases are described in detail in chapter 3. This is highlighted in Figure 3 by step 4 and step 5.

2. Results of FB parameters

2.1. Introduction

Until today APG CBs have not been considered in the CWE FB calculations. Therefore APG analyses the impact of APG CBs on the CWE FB domain. The FB parameters are calculated without and with APG CBs. For evaluation it is checked, if an APG CB is higher than the 5 % threshold defined in the approval package and is limitting the presolved domain.
The presolved domain describes the FB domain that is indicated by the yellow region depicted in Figure 4. The presolved domain is defined only by the most limiting CBs, i.e all CBs that limit the FB domain (the non-redundant constraints). All CBs outside of the presolved domain are not relevant for the subsequent MC process as they pose no valid solution. Therefore the presolved domain spans the area (solution space) wherein the MC algorithm can search for the optimal solution. The redundant constraints are identified and removed by the TSOs by means of the so-called presolve. This presolve step is schematically illustrated in the two-dimensional example in Figure 4.

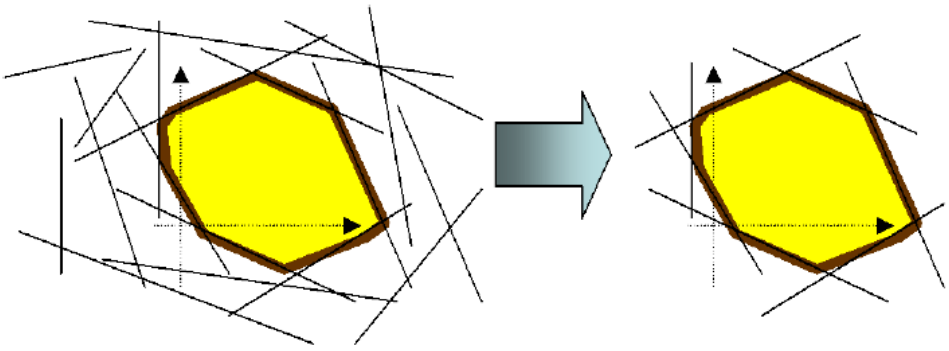

Figure 4: Presolved domain[10]

In the two-dimensional example shown above, each straight line in the graph reflects the Flow Based parameters of one Critical Branch. A line indicates for a specific Critical Branch, the boundary between allowed and non-allowed NPs.

Due to the ongoing APG integration in the CWE FB process, no FRM values haven been calculated for APG during the last FRM re-computation. Therefore the FRM values used for the calculations in this study were defined for each element by 10 % of the maximum flow (Fmax)[11]. For operation the same value will be used as starting point until a re-computation of FRM values for APG is feasible.

[10] Documentation of the CWE FB MC solution, As basis for the formal approval-request, Brussels, 1st August 2014
[11] Fmax =sqrt(3)* U*I*cos phi; with cos phi =1

2.2. General results of the FB parameter calculations

In the course of this study approximately 350 CBCO combinations within the APG grid were analysed. The calculations show, that on all 10 days the threshold of 5 % is exceeded by APG CBs. Below a summary of the calculation results is shown.

Exceedance of the 5% threshold:

- For APG CBs[12] the 5% threshold is exceeded for one hub to hub exchange (FR - DE/AT/LU)
- For the other hub to hub exchanges APG CBs do not reach the 5% threshold
- For eight days five APG CBs exceed the 5% threshold in 24 hour for 1 hub to hub exchange (FR - DE/AT/LU) (cluster 1-4 and cluster 6-10)
- For one day five CBs above 5% threshold for 15 hour for 1 hub to hub exchange (FR - DE/AT/LU) (Cluster 5)
- For one day seven CBs above 5% threshold for 4 hours for 1 hub to hub exchange (FR - DE/AT/LU) (Cluster 5, see Figure 5)
- For one day four CBs above 5% threshold for 5 hours for 1 hub to hub exchange (FR - DE/AT/LU) (Cluster 5, see Figure 5)
- For one day Seven CBs above 5% threshold for 10 hours for 1 hub to hub exchange (FR - DE/AT/LU) (Cluster 2, see Figure 6)

		Hour																							
Cluster number	**BD (best reflecting)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Cluster 1	**02.08.2014**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cluster 2	**06.10.2014**	5	5	5	5	5	5	5	7	7	7	7	7	7	7	7	7	7	5	5	5	5	5	5	5
Cluster 3	**28.03.2014**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cluster 4	**06.12.2014**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cluster 5	**30.09.2014**	5	5	5	5	5	5	5	5	7	7	7	7	4	4	4	4	4	5	5	5	5	5	5	5
Cluster 6	**24.12.2014**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cluster 7	**16.07.2015**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cluster 8	**07.01.2015**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cluster 9	**04.02.2015**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cluster 10	**30.06.2014**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 2: Number of APG CBs for which the 5% threshold is exceeded

[12] Unless otherwise deschribed, the acronym “CB” in this document inlcudes a CBCO-combination.

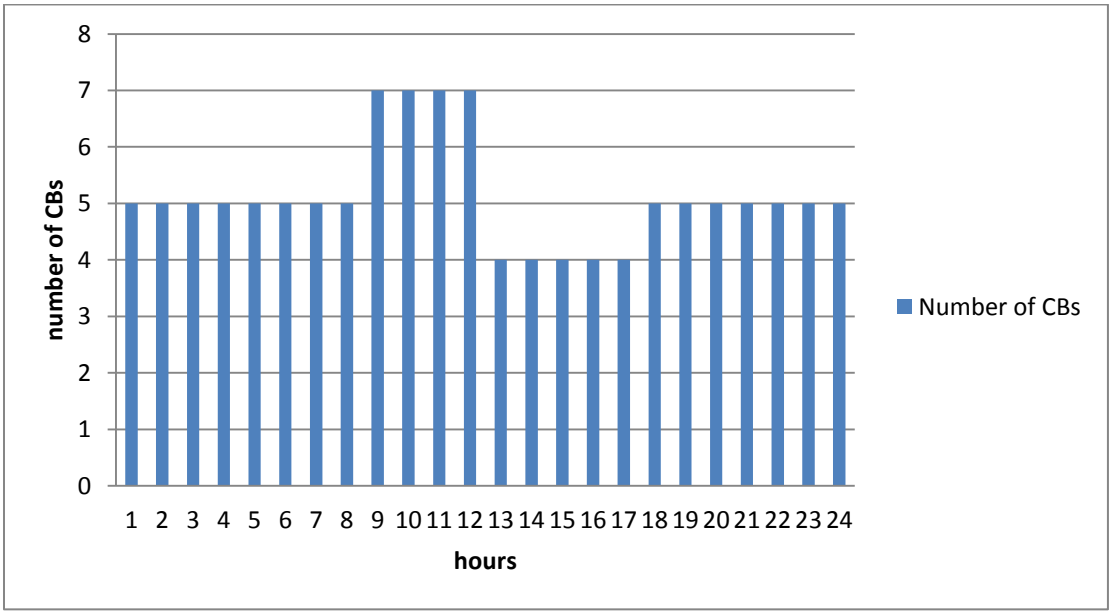

Figure 5: Cluster 5 (30.09.2014) - number of APG CBs with a threshold higher than 5 % (PTDF)

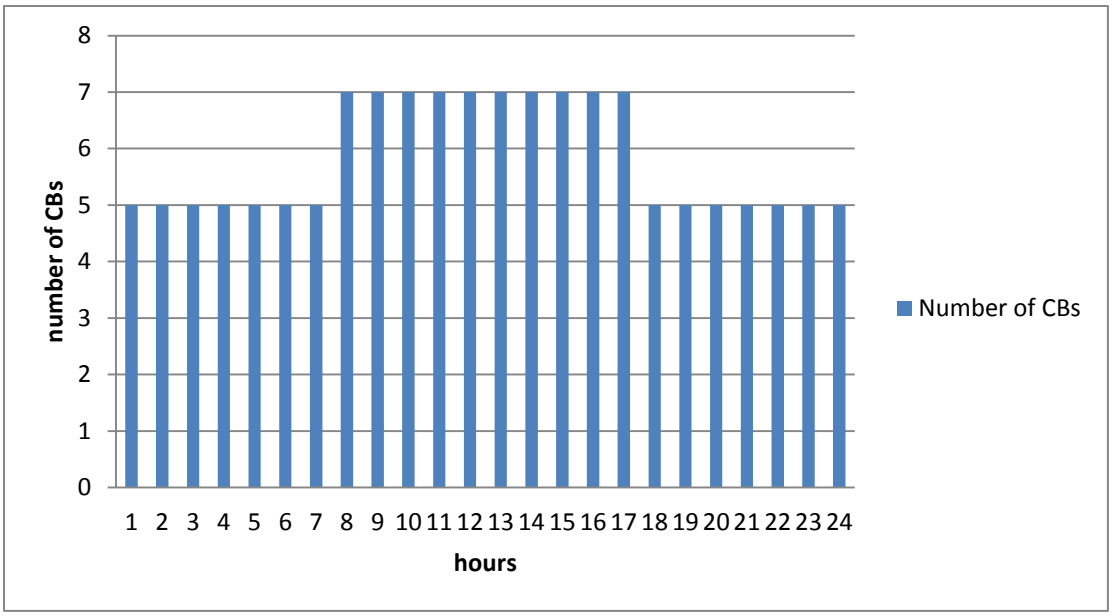

Figure 6: Cluster 2 (06.10.2014) - number of APG CBs with a threshold higher than 5 % (PTDF)

Difference in the presolved domain:

- For 9 days (cluster 1 and cluster 3-10) the FB parameters remain unchanged when APG CBs are included (APG CBs have no impact on the presolved domain).
- For one day cluster 2 (06.10.2014) for five hours of the day an APG CBCO combination is included in the presolved domain.

Table 3 gives an overview of the CBs with a PTDF ≥ 5 % which are limiting the FB domain (i.e. defining the presolved domain).

	number of CBs in presolved domain (for 24 hours)		
	without APG CBs	**with APG CBs**	**Comment**
Cluster 1	400	400	100% identical CBs - no APG CBCO combination is limiting the presolved domain
Cluster 2	360	365	One APG CBCO combination with a PFDF-value higher than 5 % is limiting the presolved FB domain in 5 hours
Cluster 3	689	689	100% identical CBs - no APG CBCO combination is limiting the presolved domain
Cluster 4	346	346	100% identical CBs - no APG CBCO combination is limiting the presolved domain
Cluster 5	396	396	100% identical CBs - no APG CBCO combination is limiting the presolved domain
Cluster 6	436	436	100% identical CBs - no APG CBCO combination is limiting the presolved domain
Cluster 7	637	637	100% identical CBs - no APG CBCO combination is limiting the presolved domain
Cluster 8	271	271	100% identical CBs - no APG CBCO combination is limiting the presolved domain
Cluster 9	477	477	100% identical CBs - no APG CBCO combination is limiting the presolved domain
Cluster 10	510	510	100% identical CBs - no APG CBCO combination is limiting the presolved domain

Table 3: Comparision of presolved domain without and with APG CBs

From Table 3 the following conclusions can be drawn:

- Only in one of the 10 days an APG CB is included in the presolved domain.
- Details on the 1 day (cluster 2 - 06.10.2014):
  For cluster 2 (06.10.2014) in five hours (hour: 8, 13, 14, 15 and 16) APG CBs with a PTDF value higher than 5 % are included in the presolved domain.

2.3. Comparison of FB domain volume and Net Positions

As cluster 2 (06.10.2014) is the only day where APG CBs are limiting the presolved domain the FB domain volume of this day is analysed in more detail. Therefore Figure 7 shows an exemplary comparison of FB Domain Volume for the day (06.10.2014).

In the interpretation of Figure 7 the following aspects have to be considered:

- on the abscissa 24 hours of the day and
- on the ordinate the GW^3 for the FB Domain Volume are depicted (GW^3 represents the three dimensional FB domain).

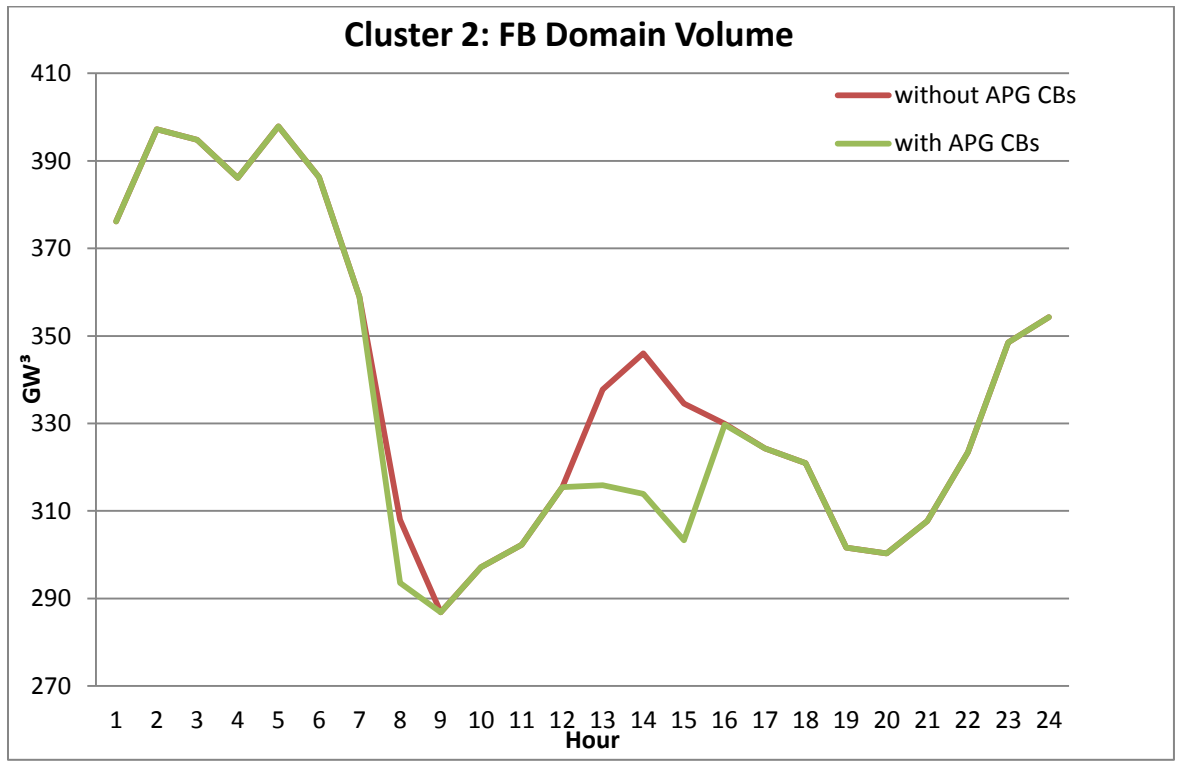

Figure 7: Cluster 2 (06.10.2014) – FB domain value without (red) and with (green) APG CBs

Figure 7 shows the FB domain value without (red) and with (green) APG CBs for cluster 2 (06.10.2014). The difference is caused by the fact, that in five hours APG CBs with a PTDF higher than 5 % are located in the presolved domain. This means that for these hours the APG CBs limit the FB domain and therefore the volume with APG CBs is lower than without APG CBs.

Figure 8 shows the minimum and maximum net positions (NPs) of the zero-balanced FB domain (with LTA inclusion) for the bidding zone DE/AT/LU.
For cluster 2 (06.10.2014) it can be concluded, that the maximum NPs are not influenced by the APG CBs. The minimum NPs are limited by the APG CBs in hour: 8, 13, 14, 15 and 16. That means that in these hours the import capacity for the bidding zone DE/AT/LU is limited by APG CBs.

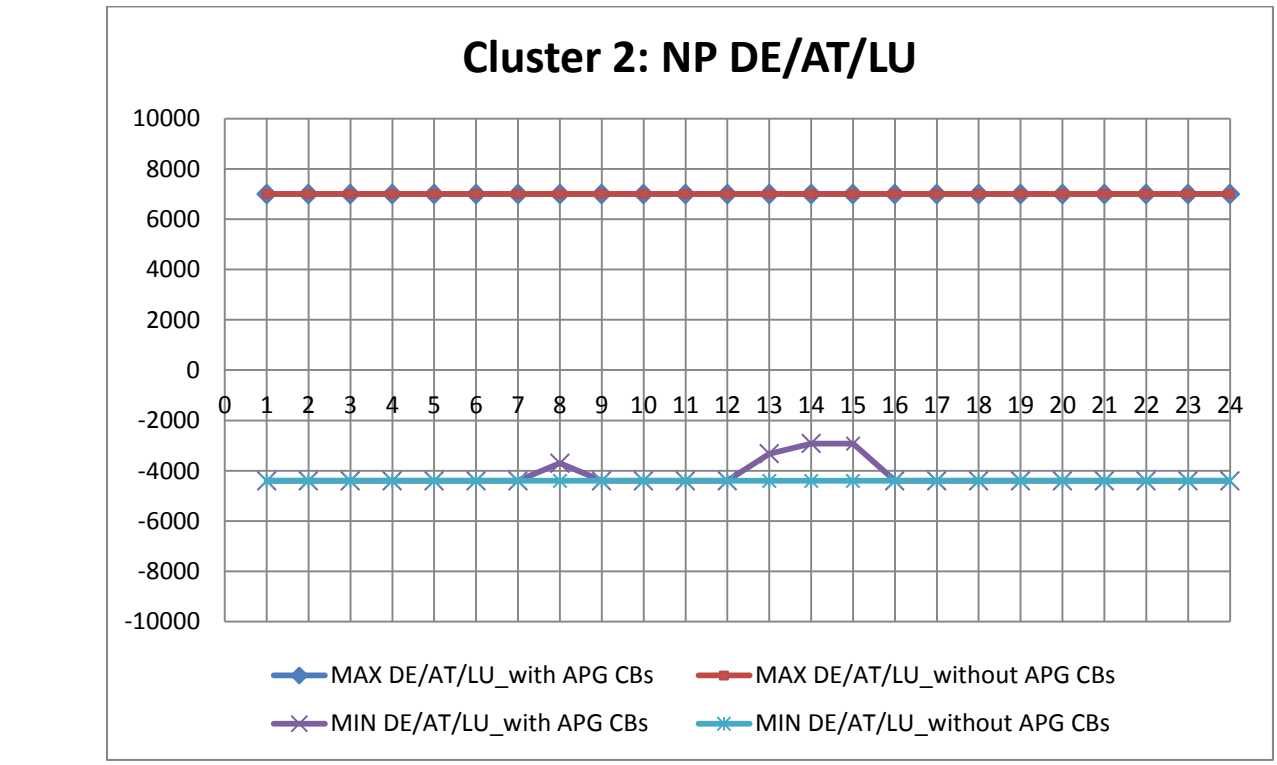

Figure 8: Cluster 2 – max net positions (NP) DE/AT/LU with and without APG CBs

Figure 9 shows the minimum and maximum NPs of the zero-balanced FB domain (with LTA inclusion) for the bidding zone FR. In this case the minimum NPs without and with APG CBs are identical. In hour: 8, 13, 14, 15 and 16 the APG CBs decrease slightly the maximum NPs of the bidding zone FR and lead to lower maximum export capability (the difference is negligible).

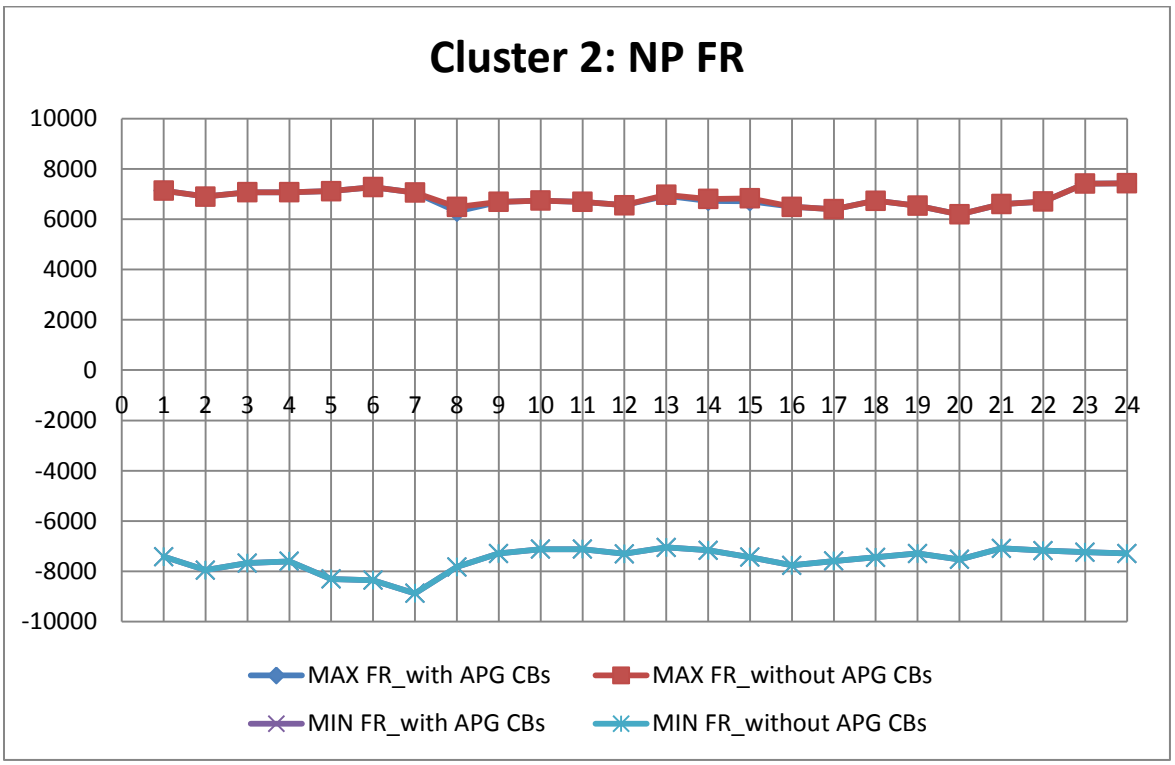

Figure 9: Cluster 2 – net positions (NP) FR with and without APG CBs

The minimum and maximum NPs of the zero-balanced FB domain (with LTA inclusion) for the bidding zone NL and BE do not differ in the cases with or without APG CBs.

3. Market Coupling results

3.1. Introduction

As stated already in chapter 1.3 for the following two cases:

- Current situation ("**reference scenario**"): with APG D2CF, with DE/AT GSK, **no APG CBs**
- Future situation ("**modified scenario**"): with APG D2CF, with DE/AT GSK, **with APG CBs.**

MC results for one year were calculated and the difference was analysed (see comparison of step 4 and step 5 in Figure 3). These MC simulations were performed on the testing environment of EPEX Spot using Euphemia 9.4 (FBI). The respective results are presented in this chapter.

In the definition process of the general impact assessment approach, data for the period of one and a half years (01/01/2014 – 07/08/2015) were analysed. Based on the available amount of data it was decided to perform MC simulation with the maximum information available in terms of operational data (instead of parallel run data). Together with the aim to perform MC simulations for one year the period from the 08.08.2014 – 07.08.2015 was chosen. For this period Table 4 provides an overview of the 10 clusters including the number of assigned days.

Cluster number	Best reflecting BD	Number of days
Cluster 1	02/08/14	*13 days*
Cluster 2	06/10/14	*28 days*
Cluster 3	28/03/14	*5 days*
Cluster 4	06/12/14	*8 days*
Cluster 5	30/09/14	*8 days*
Cluster 6	24/12/14	*7 days*
Cluster 7	16/07/15	*41 days*
Cluster 8	07/01/15	*106 days*
Cluster 9	04/02/15	*50 days*
Cluster 10	30/06/14	*90 days*
In total		***356 days***[13]

Table 4: Overview of the 10 clusters including the number of assigned days

Annex 2 gives a detailed overview which clusters are assigned to each calendar day for the period from 08.08.2014 to 07.08.2015.

[13] For the period from the 08.08.2014 – 07.08.2015 to some days no cluster could be assigned due to missing calculations from the parallel run. Consequently in the period of one year MC simulations were performed for 356 days.

3.2. MC results

All MC results which are highlighted in this chapter are also gathered in Annex 5.

In summary the FB parameters with and without APG CBs, as indicated in Table 3 of chapter 2.2, differ only in cluster 2.

Consequently based on the fact that the FB parameters for cluster 1 and cluster 3 – 10 are identical also the MC results with and without APG CBs should be identical.

Therefore the MC results of the 28 days which are assigned to cluster 2 are analysed in more detail. In Table 5 for these 28 days the results with and without APG CBs are listed.

Days of cluster 2	Number of hours with price difference [min: 0; max: 24]				Average price delta[14] of the hours were prices differ [€/MWh]				Maximum hourly price delta
	BE	DE/AT/ LU	FR	NL	BE	DE/AT/ LU	FR	NL	
01.10.14	0	0	0	0	0	0	0	0	0
02.10.14	0	0	0	0	0	0	0	0	0
04.10.14	0	0	0	0	0	0	0	0	0
05.10.14	0	0	0	0	0	0	0	0	0
06.10.14	0	0	0	0	0	0	0	0	0
07.10.14	0	0	0	0	0	0	0	0	0
08.10.14	0	0	0	0	0	0	0	0	0
10.10.14	0	0	0	0	0	0	0	0	0
03.11.14	1	1	1	1	-0,01	-0,01	-0,01	-0,01	-0,31 (BE)
13.12.14	0	0	0	0	0	0	0	0	0
31.12.14	18	2	18	16	-0,30	0,07	-0,04	0,29	- 4,63 (BE)
01.01.15	0	0	0	0	0	0	0	0	0
24.01.15	2	0	2	2	0	0	0	0	-0,15 (BE)
31.01.15	0	0	0	0	0	0	0	0	0
05.02.15	0	0	0	0	0	0	0	0	0
09.02.15	0	0	0	0	0	0	0	0	0
10.02.15	4	3	4	3	0,06	0,01	0,04	-0,02	0,76 (BE)
12.02.15	0	0	0	0	0	0	0	0	0
16.02.15	14	1	13	14	-0,03	0	-0,01	0	1,43 (NL)
18.02.15	0	0	0	0	0	0	0	0	0
19.02.15	5	0	7	5	0,02	0	0,02	0,01	0,29 (BE)
26.02.15	0	0	0	0	0	0	0	0	0
02.03.15	2	4	3	2	0,01	0	0,02	0,01	-0,79 (DE)
06.04.15	0	0	0	0	0	0	0	0	0
12.04.15	2	1	2	2	0,04	-0,01	0	0,04	1,22 (NL)
18.04.15	0	0	0	0	0	0	0	0	0
06.06.15	0	0	0	0	0	0	0	0	0
27.06.15	0	0	0	0	0	0	0	0	0

Table 5: MC results for the 28 days assigned to cluster 2[15]

[14] The delta is calculated by the difference of results with APG CBs and without APG CBs. This means (in case of positive prices) a negative delta indicates that the price with the future situation (with APG CBs) decreased compared to the current situation (without APG CBs).

In summary only in 8 of the 28 days (i.e. only in 8 days of the year) MC results with and without APG CBs differ.

Therefore based on the MC results of the 8 affected days it was further analysed which CBs were actually limiting. In that context in Table 6 the active CBCOs after MC are summarized.

	number of active CBs per day (RAM = 0)		
	without APG CBs	**with APG CBs**	**Comment**
03.11.14	4	3	With APG CBs one CWE CB is not active anymore (relieved in 1 hour); other CBs identical (also same hours)
31.12.14	5	5	Identical CBs active (with APG CBs one CB is additionally active in one hour
24.01.15	5	5	Identical CBs active (in same hours)
10.02.15	5	5	Identical CBs active (in same hours)
16.02.15	5	5	Identical CBs active (in same hours)
19.02.15	4	4	Identical CBs active (in same hours)
02.03.15	4	4	Identical CBs active (with APG CBs one CB is relieved in one hour
12.04.15	4	4	Identical CBs active (in same hours)

Table 6: Comparision of active CBs with and without APG CBs

None of the APG CBs that are included in the presolved domain become active at any time.

The following tables further highlight the MC results with the focus on prices, NPs and social welfare.

The delta (for prices, NPs and social welfare) shown in the following tables is always calculated by the difference of results with APG CBs and without APG CBs.

period	**BE**	**DE/AT/LU**	**FR**	**NL**
28 days assigned to cluster 2	0,030	0,006	0,018	0,023
1 year without 28 days	0,011	0,003	0,006	0,013
Entire year (08.08.14-07.08.15)	0,013	0,003	0,007	0,014

Table 7: Average absolute price delta with and without APG CBs [all value in €/MWh]

[15] Generally prices are depicted with two digits. To enhance readability of Table 5 zero deltas are indicated by “0” instead of “0,00”.

period	BE	DE/AT/LU	FR	NL
28 days assigned to cluster 2	2,7	1,2	5,6	2,0
1 year without 28 days	0,5	1,2	1,8	0,9
Entire year (08.08.14-07.08.15)	0,7	1,2	2,1	1,0

Table 8 Average absolute NP delta with and without APG CBs [all values in MW]

Furthermore the days assigned to cluster 2 were individually analysed in terms of total social welfare. Consequently for the 20 days were the prices are identical also the same social welfare in the CWE-region results. In Table 9 the results for the only the 8 days were the social welfare differs due to price differences are highlighted.

	Total social welfare in Mio € **in the geographical area of the Multi Regional Coupling**		
	Without APG CBs	**With APG CBs**	**delta**
03.11.2014	6.861,169	6.861,169	0,000
31.12.2014	6.842,568	6.842,580	0,012
24.01.2015	7.137,440	7.137,440	0,000
10.02.2015	7.705,549	7.705,549	0,000
16.02.2015	7.630,410	7.630,410	0,000
19.02.2015	7.340,021	7.340,021	0,000
03.02.2015	9.537,155	9.537,155	0,000
12.04.2015	7.827,117	7.827,117	0,000
		Sum of delta	**0,010**

Table 9: Social welfare analysis of the relevant days assigned to cluster 2 (all values in Mio €)

In summary there is no significant impact on social welfare results due to the addition of APG's CBs. For these eight days of cluster 2 the total social welfare increases by 10.419 €. Taking only the CWE area into account a similar increase of the CWE total social welfare of 6.579 € could be observed.

Effects unrelated to the inclusion of the APG CBs:

Mind that for cluster 2 APG CBs only impacted hours 8, 13, 14, 15 and 16 (cf. section 2.2). Consequently if discrepancies are observed for different hours, these relate to block selection effects:

- Either an impact in price for the aforementioned hours is propagated to adjacent hours through block selection effects;
- Or the effects are linked to Euphemia which may iterate slightly different and results in a slightly different block selection, resulting in price differences that are unrelated to the inclusion of the APG CBs;

Evidently the latter explanation also applies to all clusters other than cluster 2: for these clusters the APG CBs did not alter the pre-solved domain, and consequently could not possibly have affected results.

The main price discrepancies were all observed for 31.12.2014 (cf. Table 5), and main affected hours were 22, 23, and 24. As explained these hours were only impacted indirectly through block selection effects. This also accounts for the welfare impact as reported in Table 9.

4. General conclusion

For all analysed 10 clusters (business days) several APG CBCO combinations lead to a hub to hub PTDF value higher than 5 %.
For nine out of the ten analysed clusters no CB from APG with a PTDF value higher than 5 % was included in the presolved domain. Hence for these 9 clusters the input (FB parameters) for the MC simulation was 100% identical for both cases (without APG CBs and with APG CBs).
Only in one cluster (business day 06.10.2014) one CBCO combination is limiting the presolved domain.
The influence of the APG CB on the NP show that the maximum import capability of the bidding zone DE/AT/LU is decreased by the APG CB. Further the maximum export capability of the bidding zone FR is slightly decreased by the APG CB.
It can be concluded that the influence of APG CBs for the FB domain is very limited.

After performing MC simulations with and without APG CBs for the period of one year the following results could be recorded:

- for 9 out of 10 clusters the MC results are similar (for 328 out of 356 days)
- for cluster 2 the MC results partly differ:
  - for 20 of the 28 days assigned to cluster 2 the MC results are identical
  - for the remaining 8 days of cluster 2 the MC results partly differ
  - the same active constraints could be identified within all days with APG CBs
  - in the entire year no APG CBs were active
- for the 28 days on average the following absolute deltas result:

	BE	**DE/AT/LU**	**FR**	**NL**
Average price delta [€/MWh]	0,030	0,006	0,018	0,023
Average NP delta [MW]	2,7	1,2	5,6	2,0

- for the period of 1 year this results on average in the following absolute deltas:

	BE	**DE/AT/LU**	**FR**	**NL**
Average price delta [€/MWh]	0,013	0,003	0,007	0,014
Average NP delta [MW]	0,7	1,2	2,1	1,0

5. Annex

Annex 1: Glossary

Abbreviation	Full description
APG	Austrian Power Grid AG
CB	Critical Branch
CBCO	Critical Branch Critical Outage
CCG	CWE Consultative Group
CGM	Common Grid Model
CWE	Central West Europe
D2CF	Two Day Ahead Congestion Forecast
DACF	Day Ahead Congestion Forecast
DE/AT/LU	Germany / Austria / Luxembourg
FB	Flow Based
FBI	Flow Based Intuitive
GSK	Generation Shift Key
JAO	Joint Allocation Office
LTA	Long Term Allocation
MC	Market Coupling
NP	Net Position
NRA	National Regulatory Authority
PTDF	Power Transfer Distribution Factor
TSO	Transmission System Operator

Annex 2: CCG presentation on the general approach

In Annex 2 the slides from the CWE Consultative Group meeting on November 19th 2015 in Brussels are include. This annex is attached to this report in a separate document.

Annex 3: cluster assigned to each calendar day

Annex 3 indicated which clusters are assigned to each calendar day for the period MC simulations were performed for (from 08.08.2014 to 07.08.2015). This annex is attached to this report in a separate document.

Annex 4: result of FB parameters

In Annex 4 all results regarding chapter 2 are gathered. These results are attached to this report in a separate document.

Annex 5: MC results

Annex 5 covers all MC results performed in the scope of this report (chapter 3). These results consisting of prices, NP and social welfare are attached to this report in a separate document.