CWE Flowbased MC Day-Ahead
GSK Study Germany - Austria

Version	0.4	
Date	**2015 08 26**	
Status	☐ **Draft**	☒ **Final**

Document creation and distribution

Document Owner	German TSOs and APG
Function	Report for new DE/AT GSK (adaption of the DE-GSK and addition of the AT GSK)

CWE Flowbased MC Day-Ahead
GSK Study Germany - Austria

1. Introduction

An extension of CWE by integrating APG nodes in the German generation shift key (GSK) file and including an update of the German generation share key (GShK) is anticipated. This results in a new GSK for the bidding zone DE/AT.

- The purpose of the study is to include Austrian nodes in the GSK of the Austrian-German bidding zone to create better data quality /better models and to take the Austrian D2CF also into account for the BCI to be future-proof for further integration of APG and extensions in CWE.
- The changes for DE are that the GShK is now based on the generation pattern of DE/AT, instead of the DE load, which is expected especially in the future to bring benefits in terms of modelling actual power plant behavior. Since the inner-German share-key was based on a load distribution the respective TSOs recommend changing the share key to a generation based distribution to reflect the generation-pattern changes from the past.

2. The objective of this report is to analyze the impact resulting of the main changes described above. TSO Analysis

2.1. What has been done?

- 10 days have been calculated within the Private System via study mode (D-1 calculation with new GSK including Austria and new share keys between the 5 TSOs of Germany and Austria)
- Performing the operational coordination for this study similar like in the daily process amongst TSOs would result in an extremely large effort, since this would need all TSO and coordination centers to study and asses the results ex-post.
- Therefore for all analyzed scenarios (both GSK old and GSK new) the remedial actions were applied as in the parallel run.
- This is based on the assumption that in all scenarios the same critical branches (CBs) become active.

Those 10 days pose a good variety and are considered by CWE TSOs and were agreed during FBE Meetings, to be sufficient to analyze the impact on the CWE PTDF and the market coupling results due to the DE/AT GSK.

Those days represent different situations:

Date	Characteristics
Do, 26.02.2015	High Solar
Fr, 27.02.2015	High amount of hours with price convergence
Sa, 28.02.2015	
So, 01.03.2015	High Wind - Low Solar
Mo, 02.03.2015	High Wind
Di, 03.03.2015	High Wind - High Solar + non intuitive
Mi, 04.03.2015	
Do, 05.03.2015	intuitive
Fr, 06.03.2015	Low Wind + intuitive
Sa, 07.03.2015	High Solar

In the overview above one day is considered “high” or “low” if in one hour of this day the defined threshold was reached. In that context for wind and solar the following thresholds were chosen:

	High [GW / %]	Low [GW / %]	Maximum forecasted generation during the selected period [GW]
Wind	18,5 / 80%	8,1 / 35%	23,1
Solar	14,2 / 80%	6,2 / 35%	17,7

The high and low percentage refers to the maximum forecasted generation during the selected period.

The following table gives an indication on how representative the 10 selected days, compared to the timeframe from the beginning of 2014 until the end of July 2015 are. In the table below the values of the actual wind or solar generation are highlighted.

	2014 & 2015 [GW]		**10 selected days [GW]**	
	90% percentile	average	90% percentile	average
Wind	15,3	6,8	21,0	11,5
Solar	14,4	4,1	11,4	3,1

In this report the following 10 days are analyzed: 26-02-2015 – 07-03-2015.

Mind that the study does not account for all seasonal effects, as e.g. the effect of DE/AT exporting less and FR exporting more over the summer period is. This has three main reasons:

1. This effect is less obvious in the past year so that when the analysis was performed in April, it was not in scope of the study. The more extreme situation occurred after the study.
2. Export of France occurs only a minority of time over the year.
3. The FB domain is very sensitive to wind infeed in Germany and in the summer the wind infeed is usually not as high as in spring and fall. The effect of GSK, however, is most

extreme in terms of social welfare if the FB domain is very limited. Therefore, the chosen dates reflect potentially more stressed situations in which it is crucial to understand the difference.

- Comparison of DX//Run results with results by
  - application of new German share key
  - application of new German share key including Austrian nodes

In that context the following topics are addressed in the relevant chapters:

- Chapter 2.2: FB domain volume and min/max NetPos
- Chapter 3: comparison of difference between forecasted and realized tie line flows for different GSK/GShK variants

2.2. Results

Example Comparison of FB Domain Volume of one analyzed Business Day whereas

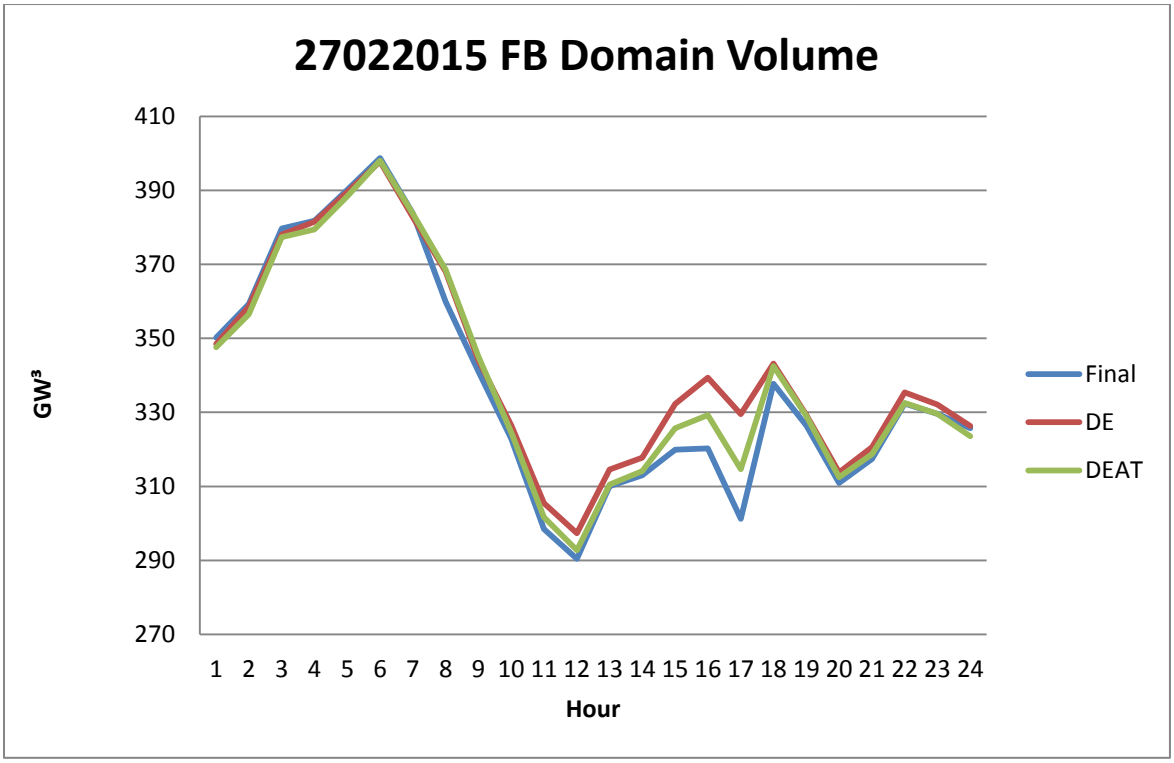
Blue = FINAL meaning DX//Run results

Red =DE meaning with new inner-German share key

Green = DEAT meaning new share key and including Austrian power plants in GSK

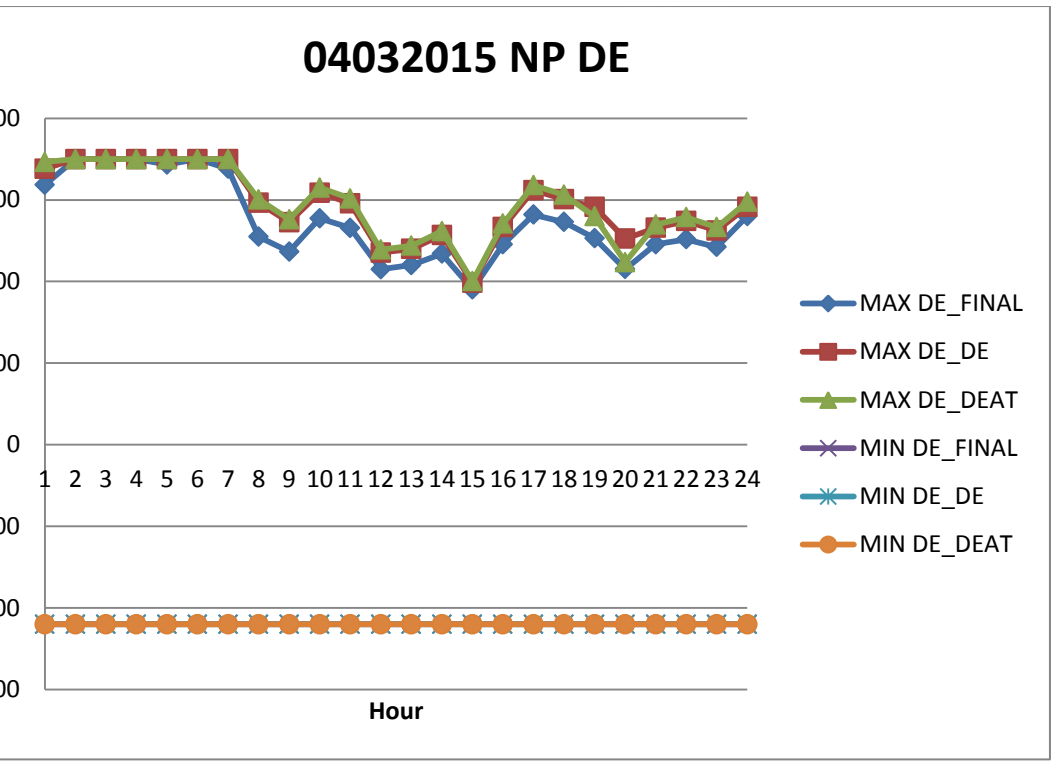
More graphs can be found in Annex 1.

- on the abscissa 24 Hours of the day are shown
- on the ordinate you have either
  - GW³ for the FB Domain Volume
  - MW for the zero-balanced FB Domain min max net position (before LTA inclusion) vertices of each hub for each hour.
  - Net position after Market Clearing (after LTA inclusion) can be found in Annex 3



Same color scheme used for the Min Max Net positions of each hub:
Example for Germany 04-03-2015;

Net positions after MC can be found in annex 3.



For the example of the 4th of March it can be concluded that with the new GSK Germany can export more and the import possibilities in the Netherlands and Belgium remain at the same level. For France the export potential remains the same whereas imports are reduced in some hours. Taking into consideration the market coupling results (see chapter 4) this practically has no impact as during the concerned hours France is actually exporting.

3. Comparison of the difference between forecasted and realized tie line flows for different GSK variants

3.1. D2CF adaption

One very important point for judging the quality of the new sharing key is to compare the forecast with the reality. Here a snapshot from reality is compared with an adapted D2CF file. For doing the comparison the D2CF file hast to be adapted to the exchange program which is represented in the snapshot. The necessary adaption of generation is depicted in the following table.

	Realized Shedules (MW)		Reference Program (MW)		Delta (MW)				
Timestamp	FR->DE	DE->NL	FR->DE	DE->NL	FR->DE	DE->NL	DE	FR	NL
26.02.2015 03:30	-3000	2435	-2500	2285	-500	150	**650**	**-500**	**-150**
26.02.2015 10:30	-3000	2447	-3000	2399	0	48	**48**	**0**	**-48**
27.02.2015 03:30	-2471	2046	-3000	2435	529	-389	**-918**	**529**	**389**
27.02.2015 10:30	-3000	2450	-3000	2447	0	3	**3**	**0**	**-3**
28.02.2015 03:30	-3000	2446	-1800	1941	-1200	505	**1705**	**-1200**	**-505**
28.02.2015 10:30	-2500	2450	-1800	1548	-700	902	**1602**	**-700**	**-902**
01.03.2015 03:30	-1200	1365	-3000	2285	1800	-920	**-2720**	**1800**	**920**
01.03.2015 10:30	-1200	1440	-3000	2385	1800	-945	**-2745**	**1800**	**945**
02.03.2015 03:30	-428	1508	-2500	1946	2072	-438	**-2510**	**2072**	**438**
02.03.2015 10:30	-1500	1469	-1912	1965	412	-496	**-908**	**412**	**496**
03.03.2015 03:30	-1200	1465	-585	1596	-615	-131	**484**	**-615**	**131**
03.03.2015 10:30	-1200	1556	-1500	1469	300	87	**-213**	**300**	**-87**
04.03.2015 03:30	-1800	1696	-1200	1465	-600	231	**831**	**-600**	**-231**
04.03.2015 10:30	-1500	1469	-1200	1556	-300	-87	**213**	**-300**	**87**
05.03.2015 03:30	-1800	1696	-1800	1696	0	0	**0**	**0**	**0**
05.03.2015 10:30	-2500	2400	-1500	1469	-1000	931	**1931**	**-1000**	**-931**
06.03.2015 03:30	-3000	2438	-1800	1469	-1200	969	**2169**	**-1200**	**-969**
06.03.2015 10:30	-3000	2436	-2500	2300	-500	136	**636**	**-500**	**-136**
07.03.2015 03:30	-2500	2388	-3000	2446	500	-58	**-558**	**500**	**58**
07.03.2015 10:30	-2500	2386	-2500	2450	0	-64	**-64**	**0**	**64**

In the first column two different timestamps are indicated.These timestamps are choosen in order to represents the historical values for off-peak (03:30) and peak (10:30). In this way the computing time can be limited. In the following two columns the exchange program of the snapshot between Germany and its neighbouring countries with interconnecting lines is mentioned. Because no BEDE Border exists at the moment, the Belgium Netposition is not influenced directly by the German Netposition. The columns 4 and 5 are displaying the exchange program which was implemented in the D2CF file initially. For finding the necessary adaption of the D2CF file the reference program of the D2CF file has to be sustracted from the one of the snapshot. The resulting shift for Germany and the adjacent CWE hubs is written in the last three columns, where a positve number means an increase of generation. For adapting the German generation three different GSKs were used. The first one was the German GSK from the FB parallel run, the second one was the German GSK including the new sharing key and the last one was the German/Austrian GSK including the new sharing key. France and the Netherlands were adapted

pro rata, which means that all injection nodes of the grid in France and the Netherlands were used equaly to adjust the Net Postion.

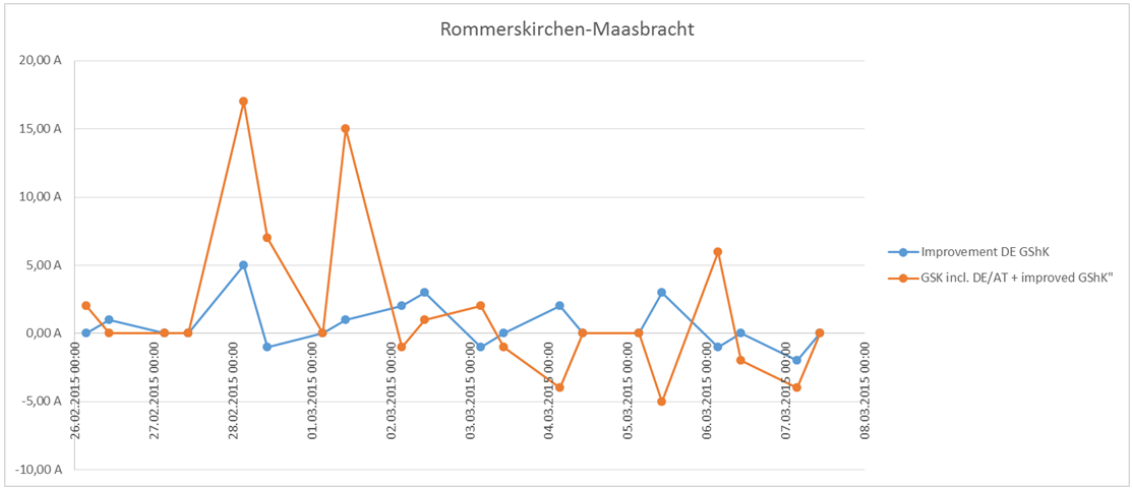
3.2. Tie-line comparison

In the following chapter all tie-lines (380 kV) between Germany-France and Germany-Netherlands were analyzed in order to monitor the effect on cross border flows.
For the German CWE tie-lines a comparison was made between the flow on the lines (in Ampere) in the snapshots and in the adapted D2CF files. On the example of the line Rommerskirchen – Maasbracht the analysis is illustrated. The complete analysis can be found in the annex 2. Note that for technical analysis the thermal limiting current is chosen in order to have a unique identification of the change, rather than a voltage dependent measure like MW.

Rommerskirchen - Maasbracht		SN-OpGSK	SN-DEGSK	SN-DEATGSK		Improvement DE GShK	GSK incl. DE/AT + improved GShK"
26.02.2015 03:30		-45,00 A	-45,00 A	-43,00 A		0,00 A	2,00 A
26.02.2015 10:30		184,00 A	183,00 A	184,00 A		1,00 A	0,00 A
27.02.2015 03:30		79,00 A	79,00 A	79,00 A		0,00 A	0,00 A
27.02.2015 10:30		-137,00 A	-137,00 A	-137,00 A		0,00 A	0,00 A
28.02.2015 03:30		-83,00 A	-78,00 A	-66,00 A		5,00 A	17,00 A
28.02.2015 10:30		-109,00 A	-110,00 A	-102,00 A		-1,00 A	7,00 A
01.03.2015 03:30						0,00 A	0,00 A
01.03.2015 10:30		73,00 A	72,00 A	58,00 A		1,00 A	15,00 A
02.03.2015 03:30		-146,00 A	-144,00 A	-147,00 A		2,00 A	-1,00 A
02.03.2015 10:30		-228,00 A	-225,00 A	-227,00 A		3,00 A	1,00 A
03.03.2015 03:30		-150,00 A	-151,00 A	-148,00 A		-1,00 A	2,00 A
03.03.2015 10:30		-15,00 A	-15,00 A	-16,00 A		0,00 A	-1,00 A
04.03.2015 03:30		290,00 A	288,00 A	294,00 A		2,00 A	-4,00 A
04.03.2015 10:30		-6,00 A	-6,00 A	-6,00 A		0,00 A	0,00 A
05.03.2015 03:30		290,00 A	290,00 A	290,00 A		0,00 A	0,00 A
05.03.2015 10:30		131,00 A	128,00 A	136,00 A		3,00 A	-5,00 A
06.03.2015 03:30		-49,00 A	-50,00 A	-43,00 A		-1,00 A	6,00 A
06.03.2015 10:30		246,00 A	246,00 A	248,00 A		0,00 A	-2,00 A
07.03.2015 03:30		-181,00 A	-183,00 A	-185,00 A		-2,00 A	-4,00 A
07.03.2015 10:30		62,00 A	62,00 A	62,00 A		0,00 A	0,00 A

This table shows the flow deviation from the snapshot and the adapted D2CF. The column “SN-OpGSK” shows the difference in Ampere between the snapshot (SN) and the D2CF adapted by the German GSK from the FB parallel run (OpGSK). The next column “SN-DEGSK” shows the snapshot flow minus the flow arising from the D2CF adapted by the German GSK with the new sharing key (DEGSK). And the column “SN-DEATGSK” is showing the result from snapshot flow minus flow from D2CF adapted by using the German / Austrian GSK (DEATGSK).
The last two columns are indicating whether there is an improvement compared to the parallel run GSK. Positive values mean improvements compared to former GSK, whereas negative values indicate deteriorations. For example the “2,00 A” in the column “Improvement DEATGSK” for 26.02.2015 03:30 means that the new DEATGSK is 2 Ampere closer to reality as the operational GSK from the FB parallel run.

The following graph is showing the evolution for all analyzed timestamps.



3.3. Overall Conclusion of the study:

- Impact on Flowbased Parameters (Capacity) is very low but average forecast quality is improving.

The respective TSOs therefore support for the following reason the changing of the German GSK including also Austrian nodes:

- next step towards full FB integration of APG in CWE capacity calculation
- Future-proof approach for flexible handling of quickly changing generation patterns and availability. (e.g. since the study started in march 2015 in Germany power plants with an infeed of ~1000 MW have been decommissioned (the new GSK gives more flexibility and is closer to reality (the generation pattern of Germany & Austria)
- improved average forecast quality of German bidding zone where Austria can take part in the central shift of net position for Basecase Improvement
- Improved modelling of generation patterns due to GSK distribution based on available generation instead of load distribution (which was developed around 2008!).
- The new combined DE/AT GSK allows for alignment of GSKs between CEE and CWE and could bring benefit for the foreseen FB CC in CEE.

4. PX Simulation results

Flow based experts asked FBvTF to perform simulation based on the selected business days, including the updated GSK/GShk
(GSK old = old DE GSK without AT; GSK new = new DE generation share key and new AT GSK)

As a result the differences of Net positions and prices for the 10 days are analyzed.

Overview

	Daily average netposition delta (GSK old - GSK new) in MW				daily average price difference after MC in €			
	BE	DE	FR	NL	BE	DE	FR	NL
20150226	15	-36	191	-170	0,897	0,069	0,029	0,884
20150227	-123	-49	197	-26	-0,608	-0,230	-0,240	-0,590
20150228	32	-1	-25	-6	0,005	-0,045	-0,029	-0,069
20150301	1	4	-28	24	0,170	0,030	0,055	0,261
20150302	46	36	14	-96	-0,400	0,131	0,043	-0,550
20150303	237	-413	-80	255	-0,223	-0,702	0,491	-0,382
20150304	13	-580	324	243	0,298	-0,140	0,903	0,913
20150305	86	-49	168	-204	0,415	-0,109	-0,131	0,285
20150306	-9	-42	-96	146	-0,188	-0,425	-0,001	-0,289
20150307	0	0	15	-15	0,011	0,000	0,022	0,089
total Average	30	-113	68	15	0,038	-0,142	0,114	0,055

Comparison of social welfare results in €:

Delivery day	Consumer surplus CWE	Producer surplus CWE	CR CWE	Consumer surplus rest	Producer surplus rest	CR Rest	Total welfare
26.02.2015	225.033,20 €	-144.380,98 €	-58.540,15 €	3.569,46 €	-2.945,49 €	-13.221,97 €	9.514,07 €
27.02.2015	-342.421,32 €	296.748,73 €	40.147,03 €	-1.362.212,89 €	1.314.251,73 €	29.747,10 €	-23.739,61 €
28.02.2015	-39.359,09 €	45.162,48 €	-3.253,19 €	-6.913,78 €	8.711,73 €	-2.185,56 €	2.162,58 €
01.03.2015	67.278,11 €	-59.105,60 €	-14.448,35 €	194.493,91 €	-128.920,13 €	-5.952,49 €	53.345,44 €
02.03.2015	32.453,28 €	-71.426,65 €	13.070,86 €	-448.722,43 €	442.633,32 €	12.325,93 €	-19.665,68 €
03.03.2015	-461.439,32 €	488.058,54 €	80.540,46 €	-65.542,43 €	76.610,41 €	34.088,16 €	152.315,81 €
04.03.2015	192.853,96 €	-154.060,97 €	131.523,30 €	-286.252,46 €	273.566,29 €	44.737,26 €	202.367,38 €
05.03.2015	-29.147,99 €	71.129,24 €	-12.563,34 €	-77.741,56 €	57.534,79 €	13.690,07 €	22.901,20 €
06.03.2015	-163.624,75 €	40.296,28 €	152.263,12 €	-493.306,90 €	362.170,38 €	-8.199,59 €	-110.401,45 €
07.03.2015	12.777,00 €	-11.021,43 €	-2.354,42 €	92.320,61 €	-88.519,31 €	-3.242,25 €	-39,81 €

The total social welfare gain is for plain **FB 320.512 €** and for **FBI 288.760 €** respectively.

Detailed analysis:

04.03.2015 Wednesday- gain of 202.000 €:

- max. Wind infeed in Germany 17,5 GW
- more German exports after MC, which lead to lower prices in non-German areas and higher prices in Germany (daily average: DE: +0,14€; FR: -0,90€; BE: -0,29€ NL:-0,91€)

06.03.2015 Friday - SW decrease of 110.000 €:

- Low Wind + intuitive
- German prices higher
- Active constraints: DE Export and inner German lines.
- Hour 11: 400MW less export of Germany→ no more full price convergence possibly due to rejected block bids / other order books-
- Active constraints on a tie-line between Amprion and Netherlands where no RA was applied, which could relief the constraint and give more convergence

Annex 3 gives more details on the market coupling results.

The following tables give an overview of the Critical Branches (CBCOs) with RAM < 200 MW (not necessarily limiting) as well as the active CBCOs after MC:

	number of CBs with RAM < 200 MW		
	GSK old	GSK new	Comment
26.02.2015	11	11	100% identical CBs RAM < 200 MW
27.02.2015	12	12	100% identical CBs RAM < 200 MW
28.02.2015	16	16	1 CB RAM < 200 MW is relieved; due to LTA inclusion 1 CB RAM < 200 MW is new (1 hour); all others are identical
01.03.2015	12	11	1 CB RAM < 200 MW is relieved; all others are identical
02.03.2015	12	14	2 CBs RAM < 200 MW are new due to LTA inclusion; all others are identical
03.03.2015	9	10	1 CB is new (1 hour); all others are identical
04.03.2015	10	10	100% identical CBs RAM < 200 MW
05.03.2015	12	12	100% identical CBs RAM < 200 MW
06.03.2015	8	8	100% identical CBs RAM < 200 MW
07.03.2015	5	5	100% identical CBs RAM < 200 MW

	number of active CBs (RAM=0)		
	GSK old	GSK new	Comment
26.02.2015	6	6	100% identical CBs are active
27.02.2015	5	3	2 CBs active for GSK old are relieved with the GSK new, all other CBs are identical
28.02.2015	5	5	100% identical CBs are active
01.03.2015	8	6	2 CBs active for GSK old are relieved with the GSK new, all other CBs identical
02.03.2015	3	3	100% identical CBs are active
03.03.2015	1	3	1 German CB active for GSK old, whereas 2 additional CBs are added for GSK new (CB from GSK old still active and the one not related to German export limit is active in an hour where the GSK old CB is already limiting)
04.03.2015	5	5	100% identical CBs are active
05.03.2015	5	3	2 CBs active for GSK old are relieved with the GSK new and shifted to max German export, all other CBs are identical
06.03.2015	2	3	1 new CB active for GSK new (only 1 hour), other CBs remain identical
07.03.2015	2	2	100% identical CB are active

As a conclusion the assumption stated in chapter 2.1 that in all scenarios basically the same CBs become active is confirmed.

5. General conclusion:

- In total with new GSK/GShK more social welfare FBI: + 289.000 € was reached.
- Grid model was more reflecting reality within all 10 days considered in this study.
- Because of seasonal effect and the number of days considered, the market coupling results cannot be extrapolated to a whole year.
- basically same active constraints could be identified within all days with new GSKs, only RAM changed on some of them an CB could become active (keep in mind that MC point also changed)

6. Next steps

- Each TSO aims to establish an individual GSK sending process to CS, that pre-merge of GSKs by Amprion becomes unnecessary and changes of sharing keys and the Austrian nodes can be used in daily process.

7. Annex

- Annex 1 shows the comparison of NP and Volume of analyzed business days
- Annex 2 shows the comparison of difference between forecasted and realized tie line flows for different GSK variants
- Annex 3 – simulation results; overview of net position, price delta and soc. welfare
- Annex 4 – details of used D2CF datasets