ACER
Agency for the Cooperation of Energy Regulators

Annex IV

Technical Justification document for the inclusion of the border between Germany/Luxembourg and Austria in the determination of CCRs

Following its Opinion No 09/2015[1], the Agency gathered, including through public consultation PC_2016_E_02, additional information about the presence of structural congestion on the DE-AT border.

Box 1: Definition of congestions

With regard to the meaning of 'congestion', reference is made to the relevant definitions in Regulation (EC) No 714/2009 and Commission Regulation (EU) 2015/1222 ('the CACM Regulation'):

- Article 2(2)(c) of Regulation (EC) No 714/2009 defines congestion as 'a situation in which an interconnection linking national transmission networks cannot accommodate all physical flows resulting from international trade requested by market participants, because of a lack of capacity of the interconnectors and/or the national transmission systems concerned';
- Article 2(18) of the CACM Regulation defines physical congestion as 'any network situation where forecasted or realised power flows violate the thermal limits of the elements of the grid, the voltage stability or the angle stability limits of the power system'; and
- Article 2(19) of the CACM Regulation defines structural congestion as 'congestion in the transmission system that can be unambiguously defined, is predictable, is geographically stable over time and is frequently reoccurring under normal power system conditions'.

The key reasoning to demonstrate the presence of structural congestion on the DE-AT border is based on the definition of congestions in both Regulation (EC) No 714/2009 and the CACM Regulation (see Box 1).

Indeed, according to these definitions, **an interconnection linking national transmission networks has to be considered as structurally congested when it cannot accommodate all physical flows resulting from international trade requested by market participants because these trade requests would result in physical flows over network elements which are structurally (physically) congested**. Or, in other words, **an interconnection linking national transmission networks has to be considered as structurally congested when it could host the relevant flows**

[1] http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Opinions/Opinions/ACER%20Opinion%2009-2015.pdf

only at the expense of network security violations or discriminatory access on network elements which are structurally (physically) congested.

Given these definitions, this Annex first updates (Section 1) the analysis made in the Agency's Opinion No 09/2015, which demonstrated the significant impact of the DE-AT exchanges on a number of network elements in the CEE region, which are **structurally congested**.

This assessment is completed by two analyses illustrating the presence of physical congestion problems on the DE-AT border. In the first one (Section 2), the Agency shows that the maximum transfer capacity between Germany/Luxembourg and the main part of Austria would not be able to accommodate all the DE-AT commercial exchanges, should the latter effectively flow physically through the DE-AT border. In the second one (Section 3), the Agency assesses the frequency of intraday trade limitations on the DE-AT border, which demonstrates that this border cannot frequently accommodate all the requests for trade.

1. The influence of the DE-AT exchanges on a number of network elements in the CWE and CEE regions which are structurally congested

The analysis performed in support of the Agency's Opinion No 09/2015 focused on how the DE-AT exchanges influence physical flow conditions on structurally (physically) congested network elements within the congested areas as defined in the Technical report on bidding zones[2] (see Opinion No 09/2015, p. 16).

Following its publication, this analysis was questioned by some stakeholders for relying on inadequate and arbitrary sample of network models, as well as for presenting only a partial picture on how the DE-AT exchanges influence physical flow conditions on other interconnectors in Continental Europe.

To advance the analysis performed for the preparation of the Opinion No 09/2015, the Agency asked the involved regulatory authorities, i.e. Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen (BNetzA), Energetický regulační úřad (ERU), Urząd Regulacji Energetyki (URE) and Energie-Control Austria für die Regulierung der Elektrizitäts- und Erdgaswirtschaft (E-Control) for more detailed information on the Power Transfer Distribution Factor ('PTDF')[3] data, encompassing 50 randomly selected Day-Ahead Congestion Forecast Models, which represent 50 different hours within the year 2015. The Agency asked the regulatory authorities to provide the PTDF

[2] Available here: https://www.entsoe.eu/Documents/MC%20documents/140123_Technical_Report_-_Bidding_Zones_Review__Process.pdf.

[3] PTDF is in general a calculated power flow on a given network element (or group of elements) that results from an electricity exchange between two network areas. See Agency's Opinion 09/2009 (p. 25-26) for details how it is calculated.

data on how the DE-AT exchanges influence flows on interconnectors within Central Europe as well as on three transmission lines within Germany (i.e. Vieselbach–Mecklar, Wolmirstedt–Helmstedt and Remptendorf–Redwitz). These network elements were reported in the Technical report on the bidding zone review process as structural congestions and other major physical congestions[4]. It is essential to note that, at least those network elements located on the interconnections where a permanent capacity allocation procedure has been implemented, have to be considered as structurally congested (i.e. the congestion on these network elements is predictable, geographically stable over time and frequently reoccurring under normal power system conditions)[5]. Furthermore, the Agency's Opinion No 09/2009 analyses the application of congestion-related redispatching actions within Germany (p. 18), which indicates that network elements located within Germany should be considered as structurally congested. For example, the quarterly report from BNetzA provides the information that, in the first quarter of 2015, the redispatching within Germany was required in 1433 hours to address the congestion problems on the network element Remptendorf – Redwitz.[6]

The involved regulatory authorities asked the relevant TSOs to calculate these data. The TSOs, in turn, delegated the task to TSCNET Services GmbH[7] in order to ensure consistent results. The data was provided by BNetzA, ERU, URE at the end of June 2016.

The results of the extended PTDF analysis are presented in Table 1. The Table shows the average and maximum cumulative PTDF values for structurally congested interconnections and network elements as mentioned above. These are grouped into congested areas 10, 11, 12, 16, 19 and 20, as defined in the Technical report on bidding zones (see also the Agency's Opinion No 09/2015, p. 17). In addition, the average and maximum cumulative PTDF values for the western German borders (DE>NL+FR+CH) and eastern German borders (DE>PL+CZ) are also presented.

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[4] The technical report on bidding zones reports solely on physical congestions. Therefore the structural congestions reported should be understood as structural (physical) congestions.

[5] Pursuant to point 1.2 of Annex I to Regulation (EC) No 714/2009, when there is no congestion, there shall be no restriction of access to the interconnection; where this is usually the case, there need be no permanent general allocation procedure for access to a cross-border transmission service.

[6] See (p. 15): http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2015/Quartalsbericht2015.pdf;jsessionid=1A1A9B16276E61EC24FEA71D9B27D1DA?__blob=publicationFile&v=6.

[7] TSCNET Services GmbH is the service company of the TSOs which formed the Transmission System Operator Security Cooperation (TSC), i.e. 50Hertz (Germany), Amprion (Germany), APG (Austria), ČEPS (the Czech Republic), ELES (Slovenia), Energinet.dk (Denmark), HOPS (Croatia), MAVIR (Hungary), PSE (Poland), Swissgrid (Switzerland), TenneT (Germany), TenneT (The Netherlands), and TransnetBW (Germany). It coordinates the TSC's activities and renders integrated services for the TSOs and their control centres.

Table 1: Updated cumulative PTDF values for Congested Areas 10, 11, 12, 16, 19 and 20 as well as for eastern and western profiles (in percentage)

	Area 10	Area 11	Area 12	Area 16	Area 19	Area 20	DE>PL+CZ	DE>AT	DE>NL+FR+CH
Average	-11.5	15.2	17.1	8.5	6.4	26.3	**38.7**	**41.2**	**20.1**
Maximum	-16.1	21.8	22.0	12.8	10.5	30.9	44.5	46.4	22.8
Standard deviation	2.8	2.1	3.3	1.9	2.4	2.9	3.1	2.8	1.6

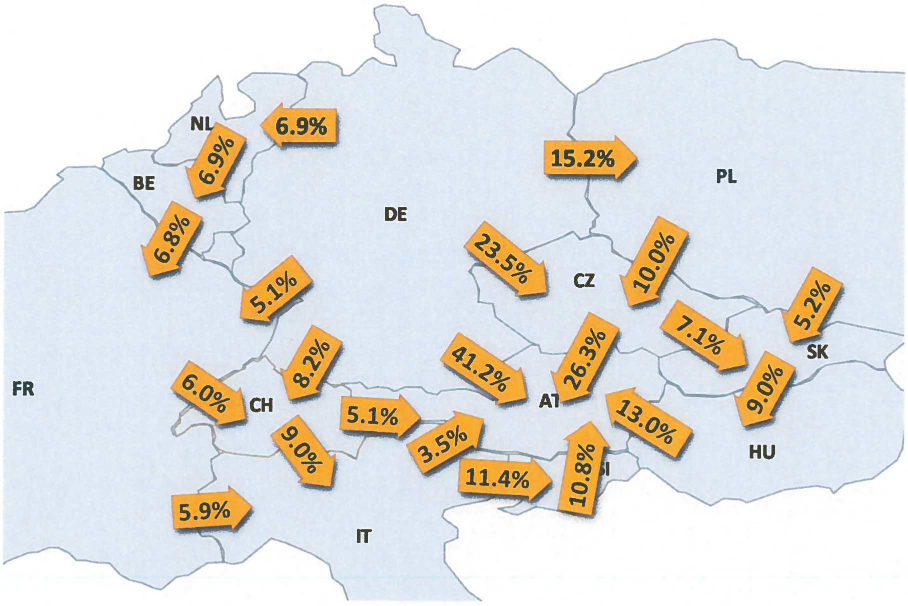
Source: URE, ERU and BNetzA (2016).

Note: Area 10: DE Internal: Vieselbach – Mecklar and Wolmirstedt – Helmstedt; Area 11: DE>PL border: Krajnik – Vierraden and Hagenwerder – Mikułowa; Area 12: DE>CZ border: Rohrsdorf – Hradec; Area 16: DE Internal: Remptendorf – Redwitz; Area 19: DE>CZ border: Etzenricht – Hradec and Etzenricht – Prestice; Area 20: CZ>AT border: Sokolnice – Bisamberg and Slavetice – Durnrohr; DE>PL+CZ: DE>PL + DE>CZ; DE>NL+FR+CH: DE>NL + DE>FR + DE>CH.

The results presented in Table 1 show that, on average, only 41.2% of the DE-AT exchanges are being physically realised through the DE-AT border, whereas 38.7% are being physically realised through the DE-PL and DE-CZ interconnections and 20.1% are being physically realised through the DE-NL, DE-FR and DE-CH interconnections. Subsequently on the Austrian side, the same flows are flowing back into Austria through the AT-CH, AT-IT, AT-SI, AT-HU and AT-CZ interconnections.

The result is also graphically presented in Figure 1 below. The Figure shows that commercial flows from Germany to Austria not only directly affect the DE-AT border, but significantly impact also other interconnections in Central Europe and three internal German network elements (albeit, only in the case of a network element Remptendorf–Redwitz, the DE-AT exchanges are aggravating the congestion, whereas on the other two the congestion is reduced by DE-AT exchanges). As those interconnections and the internal network element Remptendorf–Redwitz are considered as structurally (physically) congested, the significant impact of DE-AT exchanges on those network elements implies that the DE-AT interconnection is also structurally congested.

Figure 1: The distribution of physical flows resulting from commercial exchanges from Germany to Austria



Note 1: The sums of outgoing and incoming flows for Germany and Austria should be 100%, respectively, whereas the algebraic sums of incoming and outgoing flows for other countries should be 0.
Note 2: For some countries (i.e. FR, BE, CH, AT) the sum is not exactly 0 or 100 due to rounding effects, while for other countries (i.e. SI, HU, SK) the sum is not 0 because the incoming or outgoing flows through other borders are not presented on this figure.

These results confirm and reinforce the findings of the Opinion No 09/2015 and the conclusion that the commercial exchanges between Germany and Austria have a significant impact on the physical flow conditions on the interconnections within the CEE region, as well as within the CWE region and within Germany. On average, 58.8% of the physical flows resulting from the DE-AT exchanges are not realised through the DE-AT interconnection, but are flowing as loop flows[8] through other interconnections. In 2015 and the first half of 2016, the average commercial exchange on the DE-AT interconnection was 3189 MW, whereas the maximum of 7688 MW was reached on 10 January 2016[9]. Multiplying these exchanges by the average PTDF values results in 1234 MW (average) and 2975 MW (maximum) of loop flows flowing through the eastern DE-PL and DE-CZ interconnections and 641 MW (average) and 1545 MW (maximum) of loop flows flowing through the DE-NL, DE-FR and

[8] Loop flows are the physical flows caused by internal exchanges within a bidding zone that are flowing through other bidding zones.
[9] Source: Vulcanus (2015).

DE-CH interconnections. As shown in the Agency's Market Monitoring Report for 2015[10], pp. 167, 168, these loop flows result in a significant reduction of cross-zonal capacities on those interconnections, not only because of their volume, but also because of the uncertainty about their volumes. Because of the reliability margins to cover these uncertainties, the loss of cross-zonal capacity due to loop flows is approximately twice as high as the mere volume of loop flows (see the Market Monitoring Report for 2015, p. 167, 168 for details).

The Agency notes that the analysis based on PTDF data was performed on network models from 2015. These network models do not take into account some of the recent, current and possible future changes in the relevant network. Most notably, the following changes have often been quoted by stakeholders in their responses to public consultation PC_2016_E_02:

(a) start of the operation of the phase-shifting transformer (PST) in Mikulowa, which can be used to directly control the flows;
(b) temporary disconnection of the interconnector Vierraden-Krajnik between Poland and Germany;
(c) upcoming operation of the phase shifters at the Czech-German border;
(d) special switching of Hradec-Rohrsdorf transmission line to TenneT; and
(e) planned network investments in Germany and Austria.

The Agency would like to emphasize that these changes are not sufficient reasons to assume that the DE-AT border will not be structurally congested by the time when the decision on CRRs will effectively be implemented (i.e. by the implementation of capacity calculation methodologies pursuant to Article 20(2) of CACM Regulation which are expected to be implemented by 2018 or at the beginning of 2019 at the latest[11]). This is because:

(a) The existence of PSTs does not have a significant effect on the PTDF values in the sense that 100 MW of additional exchanges between Germany and Austria will still have largely the same impact on the physical flows on the DE-PL and DE-CZ borders[12]. Also, a PST can alter

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[10] http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER_Market_Monitoring_Report_2015.pdf

[11] See CWE and CEE MoU on the development of a common CWE and CEE CCR's day-ahead flow-based capacity calculation methodology and the merger of the CEE and CWE CCR (p. 5) https://www.entsoe.eu/Documents/MC%20documents/20160215_MoU_CWE_CEE%20TSOs%20(final%20version%20signed).pdf.

[12] The PTDF values are calculated assuming a constant phase angle of a PST. Thus, the PST has almost no effect on how the flows resulting from 100 MW of exchanges are distributed across the AC network. Nevertheless, some limited effect may be observed since a PST slightly increases the impedance of the transmission corridor (line + PST).

the physical flows on a given network element, but one cannot determine which physical flows (resulting from which exchanges) have been altered by a PST.

(b) The use of PSTs or the use of specific topological measures (e.g. special switching of Hradec-Rohrsdorf network element) to control the loop flows arising from internal exchanges should not be considered as an alternative to capacity allocation in the case of structural congestion problems. The PST devices may alter the physical flows on a congested network element, thus allowing for more exchanges; however, one still needs to determine which electricity exchanges can be increased as a result of using PSTs. If PSTs are used optimally, they have an excellent potential to increase cross-zonal capacities with the aim to maximise the social welfare. However, if PSTs are used to reduce the physical flows resulting from exchanges on the DE-AT border, but not the flows resulting from exchanges on other borders, their potential to increase cross-zonal capacities on other borders would be diminished and the social welfare would not be maximised. Such situation would not solve the existing problems of:
    (i) discrimination between electricity exchanges on different borders;
    (ii) free-riding of DE-AT electricity exchanges with regard to the use of the PST capabilities;
    (iii) loss of overall market efficiency;
    (iv) distortion of price signals as some electricity exchanges would need to pay for congestion costs while other would not.

(c) Removing the loop flows created by the DE-AT exchanges would require that the border between Germany and Austria is able to accommodate up to 7688 MW of physical flows, which is the maximum commercial exchange observed on this border up to June 2016. However, as shown in Section 2 of this Annex, the main part of Austria (which includes the vast majority of Austrian generation and load) is not able physically to import more than 3158 MW of electricity from Germany.

(d) According to the information available to the Agency, the disconnection of the interconnector Vierraden-Krajnik is temporary and cannot be considered as a permanent solution to manage congestion.

(e) The Agency cannot rely on future network development plans, whose effective implementation time is uncertain and will, most likely, deliver after the deadlines for the implementation of a coordinated capacity calculation method pursuant to Article 20(2) and Article 9(9) of CACM Regulation.

2. Assessment of the maximum transfer capacity of the DE-AT interconnection in the absence of loop flows

In response to the Agency's Opinion No 09/2015 and the public consultation on the capacity calculation regions (CCRs) Proposal, the Agency's analysis of congestion on the DE-AT interconnection has been questioned on the grounds that the DE-AT interconnection has about 11000 MW of thermal capacity and is therefore usually able, even in the absence of loop flows, to accommodate all the trade requests over this interconnection (a maximum commercial exchange of 7688 MW has been observed on the DE-AT border on 10 January 2016).

In what follows, the Agency presents an analysis of the actual maximum transfer capacity of the DE-AT interconnection taking into account the Austrian high voltage network configuration.

This analysis is based on data made publicly available by the Austrian TSO Austrian Power Grid AG (APG; www.apg.at) and by ENTSO-E.

Figure 2 below presents the Austrian high voltage network with all its interconnectors with neighbouring countries.

Figure 2: Map of the Austrian high voltage network and the location of the interconnectors

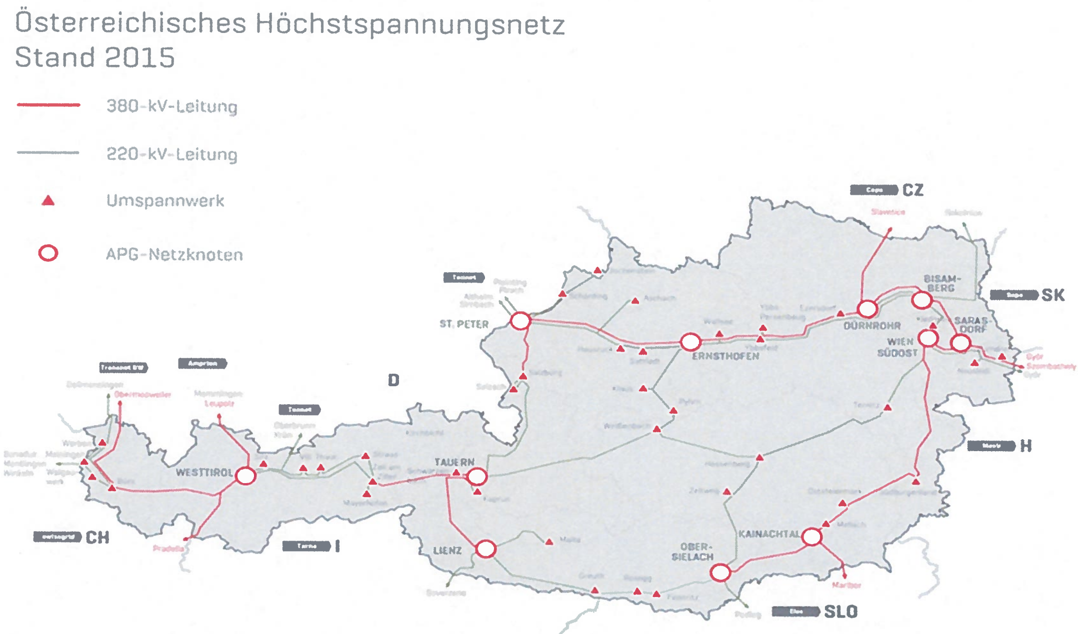


Table 2 summarises the information on interconnectors between Germany and Austria. The interconnectors below 220 kV voltage level are not included in this list since their contribution to transfer capacity is insignificant (i.e. their cumulative PTDF is below 1%).

Table 2: List of interconnectors on the DE-AT border

	Node 1	Node 2	Voltage level (kV)	Maximum active power (MW)	Source
1	St. Peter	Altheim	220	390	APG
2	St. Peter	Pirach	220	489	APG
3	St. Peter	Pleinting	220	489	APG
4	St. Peter	Simbach	220	390	APG
5	Westtirol	Leupolz	380	1496	APG
6	Westtirol	Memmingen	220	650	APG

7	Silz	Oberbrunn	220	724	ENTSO-E
8	Silz	Oberbrunn	220	724	ENTSO-E
9	Bürs	Obermooweiler	380	1300	ENTSO-E
10	Bürs	Obermooweiler	380	1300	ENTSO-E
11	Bürs	Herbertingen	220	370	ENTSO-E
12	Bürs	Dellmensingen	220	434	ENTSO-E
Total				**8755**	
Total (N-1)				**7259**	

The net transfer capacity between two network areas is calculated as the maximum electricity exchange at which the first network element affected by such exchange becomes congested (considering the N-1 criteria, i.e. in a situation of any possible contingency/outage). Assuming all the flows resulting from electricity exchanges between Germany and Austria were to be realised through the DE-AT border, the maximum electricity exchange between Germany and Austria, which does not yet cause congestion, would theoretically be 7259 MW (i.e. 8755 MW less the potential outage of the largest interconnection (i.e. 1496 MW)). Nevertheless, such calculation assumes that, at this level of electricity exchange, all the interconnectors (except the one considered out of service) would become congested. In reality, however, an electricity exchange causes different utilisation of network elements, which means that, at a certain level of electricity exchange, one of them would become congested whereas the capacity of other network elements would not be fully utilised. Furthermore, the first congestion may not appear on the interconnector, but on an internal network element.

To estimate accurately at which level of electricity exchange between Germany and Austria the first congestion would appear, a detailed analysis of the network situation involving a grid modelling would be needed. However, even without a proper grid modelling, the observation of the Austrian high voltage network configuration already allows the identification of network elements within Austria that would very likely become relevant when calculating the actual maximum transfer capacity between Germany and Austria in complete absence of loop flows. The Austrian network configuration shows that when Austria imports from Germany, the majority of imported electricity needs to flow into the main part of Austria, where the majority of load and generation is connected[13]. However the main part of Austria has a very weak connection with Germany and west Austria (West Tirol).

[13] This is, *inter alia*, evident from the PTDF data, which shows that interconnectors connected to the main part of Austria carry 80.4% of the flows resulting from DE-AT exchanges. However, this percentage should be complemented with the PTDF data for transmission lines from West Tirol to Zell, which may likely increase the percentage. When focusing only on the DE-AT interconnectors, 65% of the flows resulting from DE-AT exchanges and flowing through the DE-AT interconnection are being realised through four 220 kV

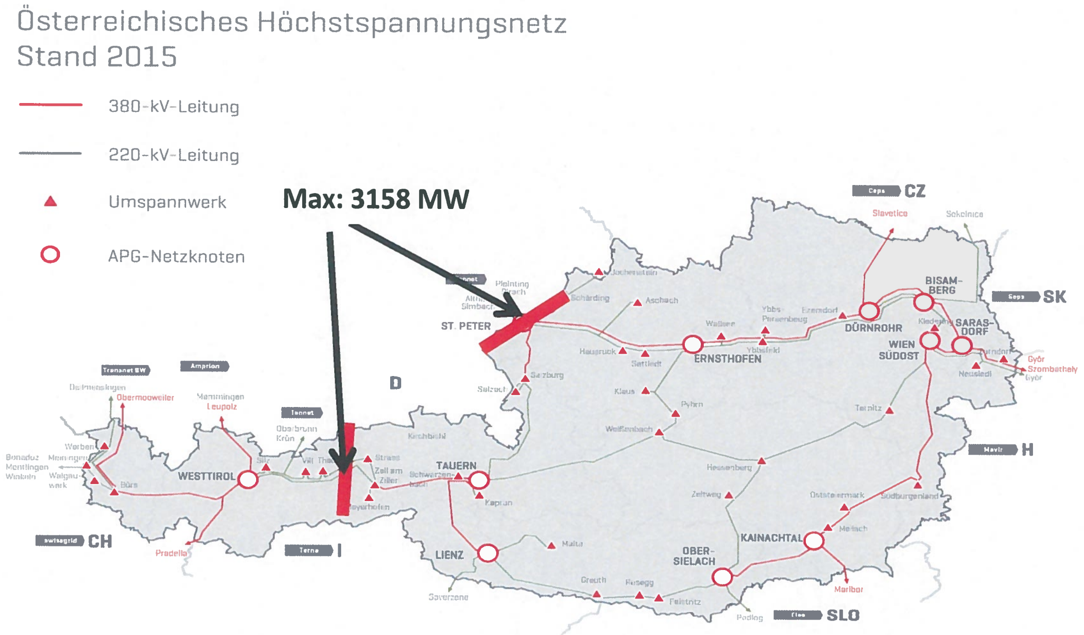
Table 3 lists the relevant interconnections and internal Austrian lines (whose location is outlined in Figure 3) that would very likely become relevant for assessing the actual maximum transfer capacity between Germany and Austria in complete absence of loop flows. These lines consist of the four 220 kV interconnector circuits connected through the St. Peter transformer station (already listed in Table 2) and four 220 kV internal circuits from the West Tirol transformer station to the Zell transformer station.

Table 3: Total transfer capacity between Germany and the main part of Austria

	Node 1	Node 2	Voltage level (kV)	Maximum active power (MW)	Source
1	St. Peter	Altheim	220	390	APG
2	St. Peter	Pirach	220	489	APG
3	St. Peter	Pleinting	220	489	APG
4	St. Peter	Simbach	220	390	APG
5	Westtirol	Zell	220	760	APG
6	Westtirol	Zell	220	760	APG
7	Strass	Thaur	220	320	APG
8	Strass	Thaur	220	320	APG
Total				**3918**	
Total (N-1)				**3158**	

Figure 3: The network elements between Germany and the main part of Austria amounting to a maximum transfer capacity between these two areas of 3158 MW

interconnectors connected to the main part of Austria (through St. Peter transformer station) even though these four interconnectors account for only 20% of capacity of all interconnectors (see Table 2). This suggests that indeed the vast majority of electricity imported from Germany flows into the main part of Austria.



The values provided in Table 3 show that, assuming a complete absence of loop flows, the main part of Austria would not be able to import more than 3158 MW (i.e. 3918 MW less the potential outage of the largest line (i.e. 760 MW)) of electricity from Germany.[14]

The Agency notes that, in 2015 and first half of 2016, the actual commercial DE-AT cross-border exchanges between Germany/ Luxembourg and Austria exceeded the value of 3158 MW 53% of the time.

3. Prohibition of trade between Germany and Austria

The DE-AT border is declared as without congestion by the involved TSOs on both sides of the border. This should imply that the trade between Germany and Austria is not limited in any way until the market closes. However, this is not the case in practice, since trade between Germany and Austria is frequently prohibited in the intraday market timeframe. The exact periods when trade between Germany and Austria is not allowed are published daily by the Austrian TSO APG[15].

[14] This is again based on the assumption that the exchange causes proportional utilisation of network elements such that all of them would become congested at the same level of exchange. An accurate estimation of the net transfer capacity on the DE-AT border would require a detailed grid modelling, able to take into account the reliability margin, the actual utilisation of network elements and the fact that a minor part of the exchanges on the DE-AT border is actually flowing into the west part of Austria.

[15] See https://www.apg.at/en/market/Markttransparenz/cross-border-exchange/REMIT

The information published by APG shows that, in the period between January 2015 and June 2016, trade between Germany and Austria in the intraday timeframe was not allowed 319 days out of 547 days (i.e. 58% of days). Hourly analysis shows that trade between Germany and Austria during the intraday timeframe was not allowed 4967 hours out of 13128 hours (i.e. 38% of hours). This indicates that, despite the fact that a significant part of the commercial flows on this border is physically flowing through neighbouring network elements and even though the border is declared by the involved TSOs as not congested, in 58% of days (or 38% of hours), there is not enough capacity on this border to accommodate all trade requests from market participants.

In the Agency's view, these above facts and findings further demonstrate that the border between Germany and Austria frequently cannot accommodate all the requests for trade over this border and should therefore be considered as structurally congested.

4. Conclusion

This Annex demonstrates that the interconnection between Germany and Austria is structurally congested because it significantly affects the structurally congested interconnections and network elements in other parts of the Central Europe.

This Annex further shows that, assuming that all DE-AT exchanges were physically to flow through the DE-AT border, 53% of the time, the maximum transfer capability between Germany and the main part of Austria would not be able physically to accommodate all the requests for DE-AT exchanges.

Finally, the presence of a structural congestion on the DE-AT border is also confirmed by the significant occurrence of intraday trade limitations on this border.

In the Agency's view, these facts and findings demonstrate that the border between Germany and Austria frequently cannot accommodate all the requests for trade over this border – or can host these flows only at the expense of network security violations or discriminatory access on other network elements and interconnections – and should therefore be considered as structurally congested.

Consequently, because of this structural congestion on the DE-AT interconnection, Regulation (EC) No 714/2009 requires that permanent capacity allocation be implemented on the border between Germany/Luxembourg and Austria.