European Network of
Transmission System Operators
for Electricity

Technical Report

Bidding Zones Review Process

2 January 2014

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Table of Contents

1.	**Introduction**	5
1.1.	Motivation and general background	5
1.2.	The current bidding zone configuration	5
1.3.	CACM NC requirements and envisaged process	6
1.4.	Structure of the Technical Report	7
2.	**Present congestions and their future evolution**	8
2.1.	General background information on capacity calculation methodologies	8
2.2.	Methodology and general descriptions	8
2.3.	Congested areas in 2011 and 2012 and their future evolution	10
2.4.	Day ahead market price analysis	20
3.	**Power flows not resulting from capacity allocation**	22
3.1.	Methodology and general descriptions	22
3.1.1.	Real-Time Unscheduled Flows (RTUF) indicator	23
3.1.2.	PTDF flow indicator	23
3.1.3.	Day Ahead Unscheduled Flows (DAUF) indicator	24
3.2.	Data sources	25
3.2.1.	Vulcanus database	25
3.2.2.	Computation of the PTDF matrix	26
3.2.3.	DACF computation	27
3.3.	Analysis of the indicators	27
3.3.1.	Results of the Real-Time Unscheduled Flows (RTUF) Indicator for the years 2011 and 2012 on a bidding zone basis	28
3.3.2.	Results of the PTDF Flow indicator for the years 2011 and 2012 on a bidding zone basis	32
3.3.3.	Results of the Day Ahead Unscheduled Flows (DAUF) indicator for the years 2011 and 2012 on a bidding zone basis	36
3.3.4.	Comparison of indicators and conclusion	39
3.3.5.	Further individual analysis	44
4.	**Congestion incomes and firmness costs**	**48**
4.1.	Interpretation and survey set-up	48
4.1.1.	Congestion incomes	48
4.1.2.	Financial firmness costs	48
4.1.3.	Physical firmness costs and internal congestion cost	48
4.2.	Results	50
4.2.1.	Congestions incomes	50
4.2.2.	Financial firmness costs	52
4.2.3.	Physical firmness costs and internal redispatch costs	53
5.	**Final Summary**	57

Annex 1: Abbreviations 58
Annex 2: Bidding zone connections 60
Annex 3: Net Transfer Capacity between bidding zones 61
Annex 4: Monthly average graphs for non-allocated flow indicators 62
Annex 4.1. Individual border monthly averages RTUF indicator 62
Annex 4.2.: Individual border monthly averages PTDF indicator 79
Annex 4.3: Individual border monthly averages DAUF evolution 88
Annex 5: Statistical data related to the indicators 100
Annex 5.1.: Statistical data related to the RTUF indicator 100
Annex 5.2.: Statistical data related to the PTDF indicator 103
Annex 5.3.: Statistical data related to the DAUF indicator 106

List of Figures

Figure 1: Current bidding zone configuration 6
Figure 2: Activities in the bidding zone Review Process 7
Figure 3: Congestions in different planning / operational stages 9
Figure 4: Critical/Congested network element clusters: planning phase (D-1 and D-2 in 2011 and 2012) 10
Figure 5: Congestion clusters: operational phase (real-time) 11
Figure 6: Network developments at the northern Italian borders 15
Figure 7: Day ahead market price analysis (percentages represent time shares) 20
Figure 8: Day ahead market price analysis before and after CZ-SK-HU market coupling 21
Figure 9: Average realized scheduled exchanges & measured physical flows 29
Figure 10: Average Real-Time Unscheduled Flows (RTUF) for the years 2011 and 2012 (in MW) 30
Figure 11: Example time split arrow 31
Figure 12: Time split arrows RTUF 2011 & 2012 (in MW) 32
Figure 13: Average flows induced by all cross-border exchanges & measured physical flows for the years 2011 and 2012 (in MW) 33
Figure 14: Average PTDF Flow deviation (PTDFF) for the years 2011 and 2012 (in MW) 34
Figure 15: Time split arrows PTDF 2011 & 2012 (in MW) 35
Figure 16: Average day ahead scheduled exchanges & day ahead calculated flows 37
Figure 17: Average Day Ahead Unscheduled Flows (DAUF) for the second half of 2012 (in MW) 38
Figure 18: Time split arrows (DAUF) for the second half of 2012 (in MW) 39
Figure 19: RTUF flow indicator for second half of 2012 (average values in MW) 40
Figure 20: PTDF flow deviation indicator for second half of 2012 (average values in MW) 40
Figure 21: Comparison of the particular indicators of unscheduled flows (second half of 2012) 41
Figure 22: Comparison of indicators for the CWE and CEE regions with an additional border between DE/LU and AT for the second half of 2012 44

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 23: Values of the RTUF indicator for the CEE region with control area resolution for the years 2011 and 2012 45
Figure 24: Analysis of CEE region with control area resolution envisaged for the bidding zone study 47
Figure 26: Congestion incomes per bidding zone 50
Figure 27: Total financial firmness costs 53
Figure 28: Physical firmness and internal redispatch costs 54
Figure 29: Current bidding zone borders: control area resolution 60
Figure 30: Current bidding zone borders: country resolution 60
Figure 31: Net Transfer Capacity between bidding zones 61

List of Tables

Table 1: Names of the flows and indicators 22
Table 2: CGM and intervals used 26
Table 3: Advantages and limitations of the RTUF indicator 28
Table 4: Advantages and limitations of the PTDF flow indicator 33
Table 5: Advantages and limitations of the DAUF indicator 36
Table 6: Overview of physical flows, scheduled flows and RTUF 46
Table 7: TSO congestion management incomes 2011 and 2012 [in Mil. EUR] 51
Table 8: Statistical data related to the RTUF indicator 100
Table 9: Statistical data related to the RTUF indicator for a positive flow direction 101
Table 10: Statistical data related to the RTUF indicator for a negative flow direction 102
Table 11: Statistical data related to the PTDF indicator 103
Table 12: Statistical data related to the PTDF indicator for a positive flow direction 104
Table 13: Statistical data related to the PTDF indicator for a negative flow direction 105
Table 14: Statistical data related to the DAUF indicator 106
Table 15: Statistical data related to the DAUF indicator for a positive flow direction 107
Table 16: Statistical data related to the DAUF indicator for a negative flow direction 108

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

1. Introduction

1.1. Motivation and general background

The current and target model for the European Electricity Market is based on a zonal approach (i.e. bidding zones with one wholesale electricity price). Consequently, the current European market contains several bidding zones, usually based on a historical context corresponding to a member state. However there are some exceptions, i.e. multiple bidding zones may exist within one member state, or several member states may constitute one bidding zone (please see section 1.2. for further details).
The Network Code on Capacity Allocation and Congestion Management (CACM NC) drafted by ENTSO-E and submitted to ACER on September 27th 2012 addresses the definition and configuration of Bidding Zones in Articles 37 to 40.
The present report represents the first step of this bidding zone review process: according to Article 40 of the CACM NC, and in order to decide whether it is appropriate to proceed with the review of the configuration, the involved TSOs are tasked with delivering a Technical Report containing several analyses aimed at identifying the appropriateness and the robustness of the current bidding zone structure.

1.2. The current bidding zone configuration

A bidding zone is the largest geographical area within which Market Participants are able to exchange energy without Capacity Allocation. In other words, it is assumed that there are no major congestions resulting from transactions within bidding zones. This implies that within bidding zones such exchanges should be possible without any constraints. Exchanges between bidding zones may be constrained when cross-zonal capacities are insufficient to facilitate them. This leads to the question of where such cross-zonal capacities should be and how the geographical boundaries of the associated bidding zones should be determined in relation to electrical borders.
As stated in Article 37(4) (c) of the CACM NC, the involved system operators performing the assessment of the bidding zone configuration shall both assess the current bidding zone configuration and alternative bidding zone configurations.
The current bidding zone configuration is described in Figure 1, where each colour represents a different bidding zone.
From this figure it can be seen that currently Germany, Luxembourg and Austria represent a single bidding zone and therefore this bidding zone comprises three member states and several TSOs.
With the exemption of the Belgian, the Austrian-German-Luxembourg, the Hungarian, the Slovenian and the Slovakian bidding zones neighbouring bidding zones are all electrically connected to each other. Annex 2 contains a diagram illustrating these bidding zone connections. The net transfer capacity between bidding zones is also illustrated in Annex 3.
Furthermore, the current legal framework (Regulation (EC) 714/2009 and the associated Congestion Management Guidelines) imposes an obligation to account for the impact of commercial transactions between the member states on the neighbouring power systems.
"In cases where commercial exchanges between two countries (TSOs) are expected to affect physical flow conditions in any third-country (TSO) significantly, congestion-management methods shall be coordinated between all the TSOs so affected through a common congestion-management procedure."
Reporting therefore concerns not only bidding zone borders but also where necessary member state borders or even smaller areas (TSO control areas).

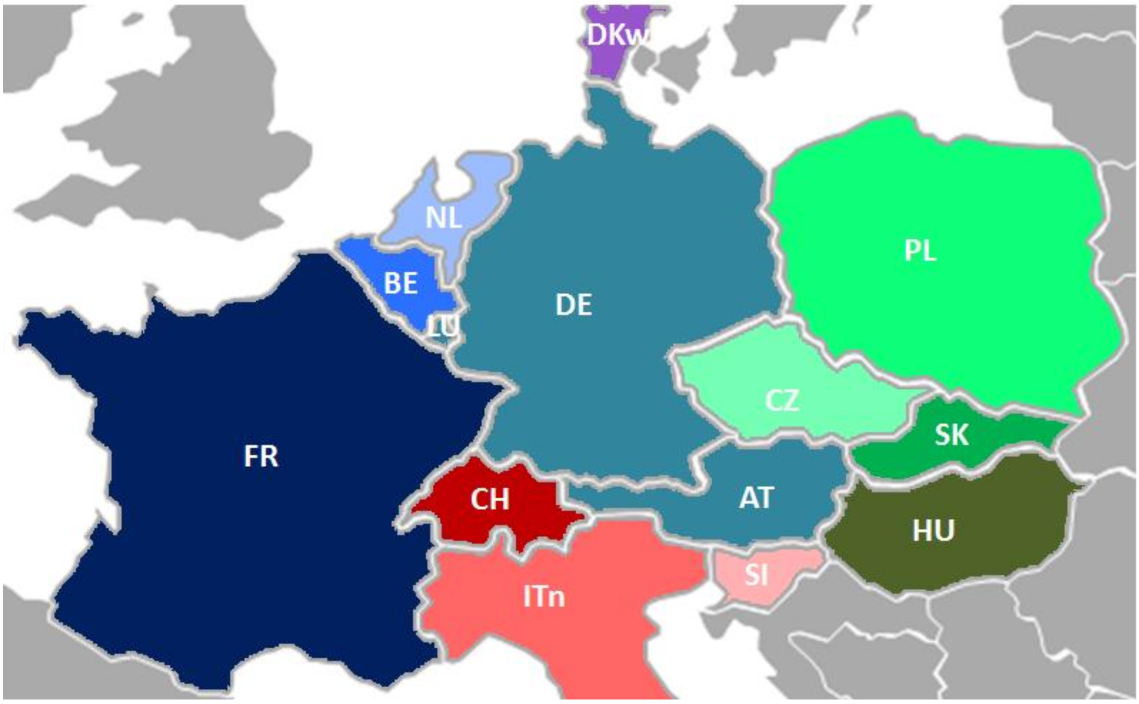


Figure 1: Current bidding zone configuration (countries with identical colors represent one zone)

1.3. CACM NC requirements and envisaged process

The CACM NC, drafted by ENTSO-E and submitted to ACER on September 27th 2012, addresses the topic of the bidding zone structure in its second chapter.

In Article 37 a process for reviewing the bidding zone configuration is described in terms of:

- entities entitled to launch a bidding zone structure review;
- perimeters and limitations of such analyses;
- obligations for the Nominated Electricity Market Operators and other Market Participants; and
- core properties of the process.

In Article 38 the criteria for assessing the efficiency of alternative bidding zone configurations are defined in terms of the network security, overall market efficiency, stability and robustness of bidding zones.

Article 39 of the CACM NC requires an efficiency assessment of the current bidding zone configuration every two years. This process (illustrated in Figure 2) shall consist of:

- a biennial Technical Report prepared, according to Article 40 of the CACM NC by all TSOs and sent to all National Regulatory Authorities (NRA); and
- an evaluation of market structure and possible market power issues prepared by all National Regulatory Authorities on the basis of the biennial Technical Report.

Based on these reports, all National Regulatory Authorities may consequently request the launch of a process for reviewing the bidding zone configuration.

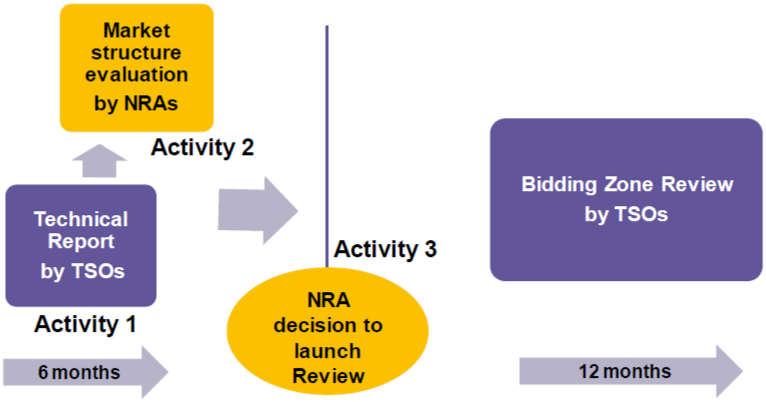


Figure 2: Activities in the Bidding Zone Review Process

A bidding zone review process based on a legally binding CACM NC could be initiated upon completion of the EU Comitology process for the CACM NC. However, in a letter dated August 30th 2012, ACER and NRAs invited ENTSO-E "to start an early implementation of the process for reviewing the bidding zones as foreseen in the nearly finalised CACM NC". Therefore, the present Technical Report has been issued prior to the Comitology process and the entry into force of the CACM NC.

This Technical Report is based on the provisions contained in the September 27th 2012 version of the CACM NC and on the "Terms of Reference for the early implementation of the CACM NC concerning a bidding zone review in CWE (Belgium, France, Germany, Luxembourg, the Netherlands), Denmark-West, CEE (Austria, Czech Republic, Germany, Hungary, Poland, Slovenia, Slovakia), Switzerland, and Italy". These Terms of Reference were presented to the Florence Forum in November 2012.

Any future amendments made to the CACM NC (e.g. during the Comitology process) are not considered in this report but will have to be taken into account in future bidding zone reviews.

1.4. Structure of the Technical Report

The present Technical Report is subdivided into four main sections:

- Present congestions and their future evolution (Chapter 2)
  According to Articles 40.1.a and 40.1.b of the CACM NC, an analysis of the relevant congestions in 2011 and 2012 and their expected evolution due to investments in networks or due to significant changes in generation or consumption patterns is shown.

- Power flows not resulting from capacity allocation (Chapter 3)
  According to Article 40.1.c of the CACM NC, an analysis of the share of power flows that do not result from the Capacity Allocation mechanism is shown for each Capacity Calculation Region where appropriate.

- Congestion incomes and firmness costs (Chapter 4)
  According to Article 40.1.d of the CACM NC, a summary of Congestion Incomes and Firmness Costs incurred in 2011 and 2012 is shown.

- Final summary and main findings (Chapter 5)
  An overview of the main evidences from the first three sections is presented and the main conclusions are highlighted.

2. Present congestions and their future evolution

The CACM NC requires a publication of structural congestions and major physical congestions, including their location and frequency. It also envisages an analysis of the expected evolution or removal of these congestions due to investments or changes in the generation or consumption pattern. This chapter seeks to address these requirements by first providing general background information on Capacity Calculation in section 2.1 and methodological descriptions in section 2.2. In section 2.3, congested areas in 2011 and 2012 and their future evolution patterns are represented. Section 2.4 concludes this section with a Day Ahead Market Price analysis. This analysis identifies times during which prices converged and hence congestions were not relevant for the market or during which the price difference pointed in a particular direction.

2.1. General background information on capacity calculation methodologies

TSOs manage congestions inter alia within their capacity calculation processes. Therefore, despite the fact that capacity calculation methodologies are not explicitly required by the CACM NC for this Technical Report, a brief introduction to this topic is provided.

Cross-border transmission capacity assessment is a security analysis (e.g. a contingency analysis) performed by the Transmission System Operator(s) as a part of their capacity calculation and operational planning processes in order to provide the available transmission capacity to market participants that is compatible with the secure operation of the interconnected electrical system, taking into account all technical limitations (constraints) of the grid.

The currently applied EU wide approach for cross-zonal capacity assessment is the so called NTC approach[1]. This methodology (originally designed for two isolated systems) has been further improved and modified by TSOs to reflect local specifics and the physical reality of the transmission grid (e.g. mutual interdependencies among different cross-zonal borders).

2.2. Methodology and General Descriptions

For the purpose of this report congestions have been investigated for different timeframes. According to this time criterion, different types of congestions are observed for the following three processes:

- **D-2 Cross-border capacity calculation**
- **D-1 Short-term operational planning** by TSOs (after DA gate closure time until real-time)
- Remaining security violations in **real-time system operation** by TSOs

All three processes are briefly described below.

D-2 Cross-border capacity calculation:

Within this process TSOs calculate cross-zonal capacities, which are offered to market participants (for a given timeframe). The objective of this security assessment is to obtain the maximum possible transmission capacity for a given time frame and a certain cross-zonal interface (including so called technical profiles, which encompass several bidding zone borders) that is compatible with individual TSO security standards. All grid elements[2] have finite capabilities defined by their design and construction. Therefore, these grid elements are, besides other technical aspects, the limiting factors when assessing cross-border transmission capacity. For the purpose of this Technical Report, such limiting elements are called **critical network elements**. Before available capacities are provided to the

[1] https://www.entsoe.eu/publications/market-reports/ntc-values/
[2] lines, transformers, breakers etc.

market, they are also subject to mutual harmonization and coordination between neighbouring TSOs. A limited cross-border capacity does not necessarily decrease social welfare, as it might be the case that the markets may not need more cross-border exchange capacity than they have been provided with.

Short-term operational planning by TSOs
During this process (from day ahead towards intraday operational planning) TSOs use updated available data for short-term forecasts (e.g. DACF[3]). In particular, information resulting from the previous processes (cross-border as well as internal transactions), information about RES, updated load forecasts and unforeseen events are taken into account. Grid security violations which occur during these processes are caused by deviations from forecasts and they may be a consequence of improper market design (e.g. market based dispatch of power plants, too many capacities offered to and used by the market, loop flows etc.). Other reasons include unexpected changes in the grid topology or the generation or load pattern. During this phase **congested network elements** are identified. These processes also serve as a basis for identifying possible remedial measures to prevent or mitigate the forecasted security violations in these congested network elements.

Real-time system operation by TSOs
In this process, congestions on grid elements caused by unscheduled flows and unexpected (unplanned) events are identified. The aim of all previous congestion management procedures is to avoid congestions at this stage. In contrast to the previous stages, they represent a more immanent physical risk. Therefore, these physical congestions are treated as **security violations**.

Figure 3 illustrates this evolution of congestions occurring at different points in time. It also indicates the data source that is used as an input for each activity (e.g. D2CF Files[4], DACF Files and Snapshots[5] / Flow Data). Congestions across all three timeframes depicted in Figure 3 have been investigated and analysed to identify congested areas within the relevant region in this Technical Report.

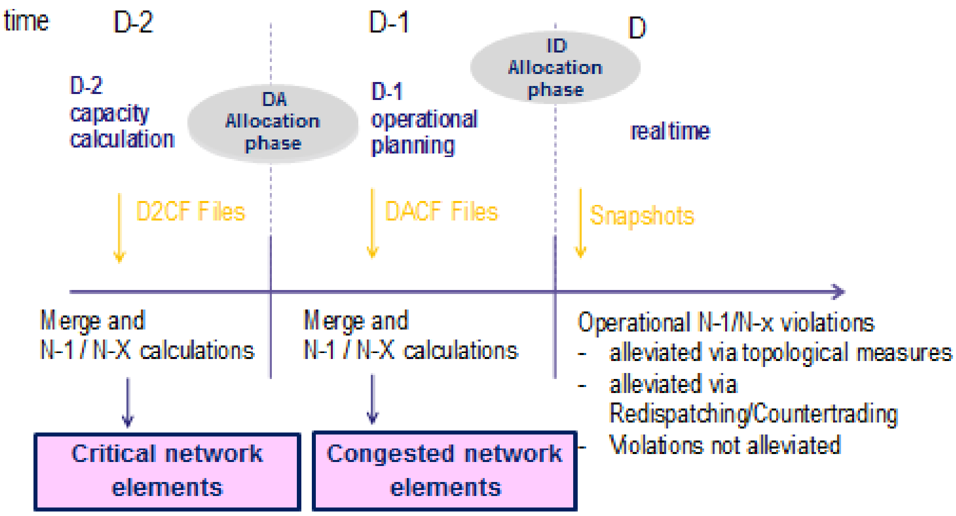


Figure 3: Congestions in different planning / operational stages

[3] Day Ahead Congestion Forecast
[4] Congestion Forecasts 2 days prior to real time
[5] Snapshots of the grid topology close to real time

2.3. Congested areas in 2011 and 2012 and their future evolution

Congestions and congested areas can be identified based on available information and data related to the processes described in section 2.2. Such information may encompass results of calculations, recorded real-time data or a track record of measures related to remedial actions. With the help of expert knowledge, critical and frequently congested network elements were aggregated into areas in which congestions appear. These areas do not represent all congested network elements that have been identified by the participating TSOs for the years 2011 and 2012. Only the most significant clusters are represented.

TSOs follow different data gathering and data storing policies. Furthermore, the regional initiatives employ not entirely homogeneous approaches to capacity calculation (from bilateral NTCs to technical profiles). In this context, clustering the information into comparable congested areas represents a cautious approach that considers the limited comparability of the available data.

For the purpose of this Technical Report, clusters of critical network elements in the D-2 capacity calculation phase and congested network elements in the D-1 operational planning phase have been combined. Both are represented in Figure 4. The presented congestion areas provide only a subset of the network elements in which congestion occurred in the years 2011 and 2012.

Several TSOs which are within the scope of this Bidding Zone Review are part of the TSO Security Cooperation (TSC). New projects for Mid- and Long Term Operational Planning as well as an improved coordination for Short Term Operational Planning Procedures such as DACF and IDCF aim at a further improvement of the grid situation and of the security of supply throughout the European interconnected electricity system.

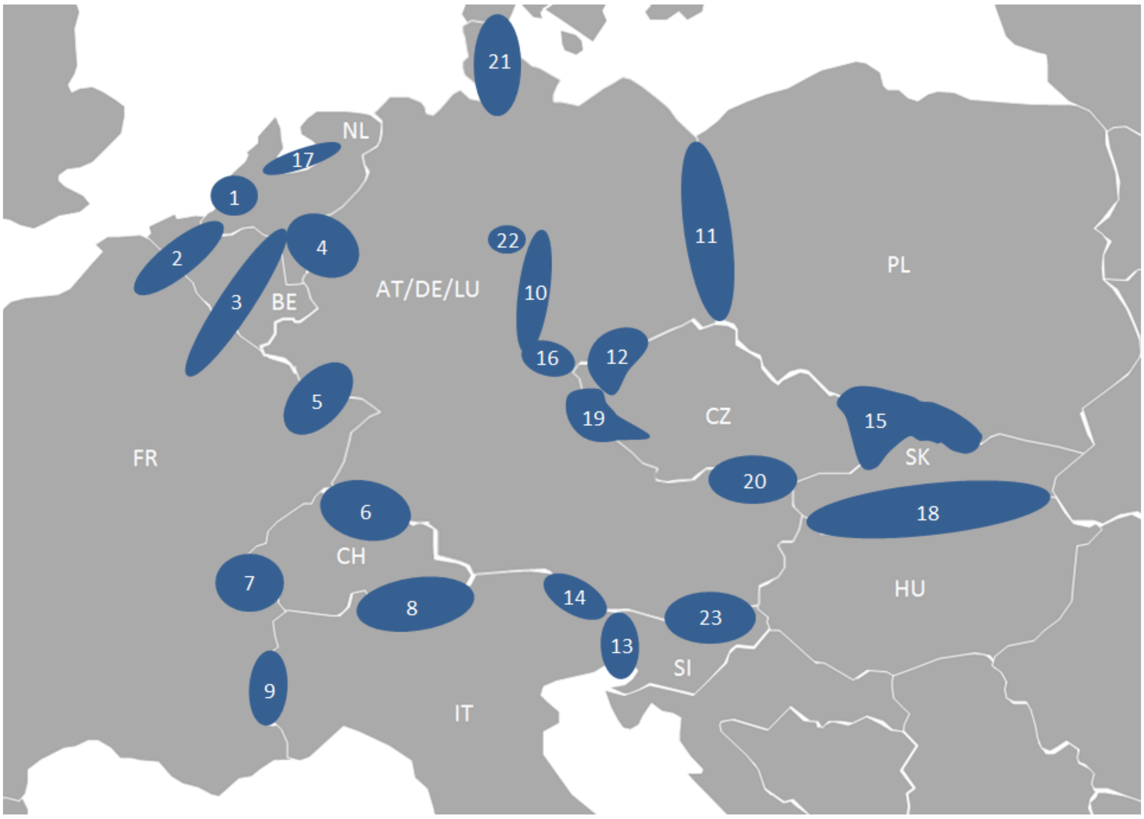


Figure 4: Critical/Congested network element clusters: Planning phase (D-1 and D-2 in 2011 and 2012)

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 5 represents congestions which have been identified in the real-time phase.

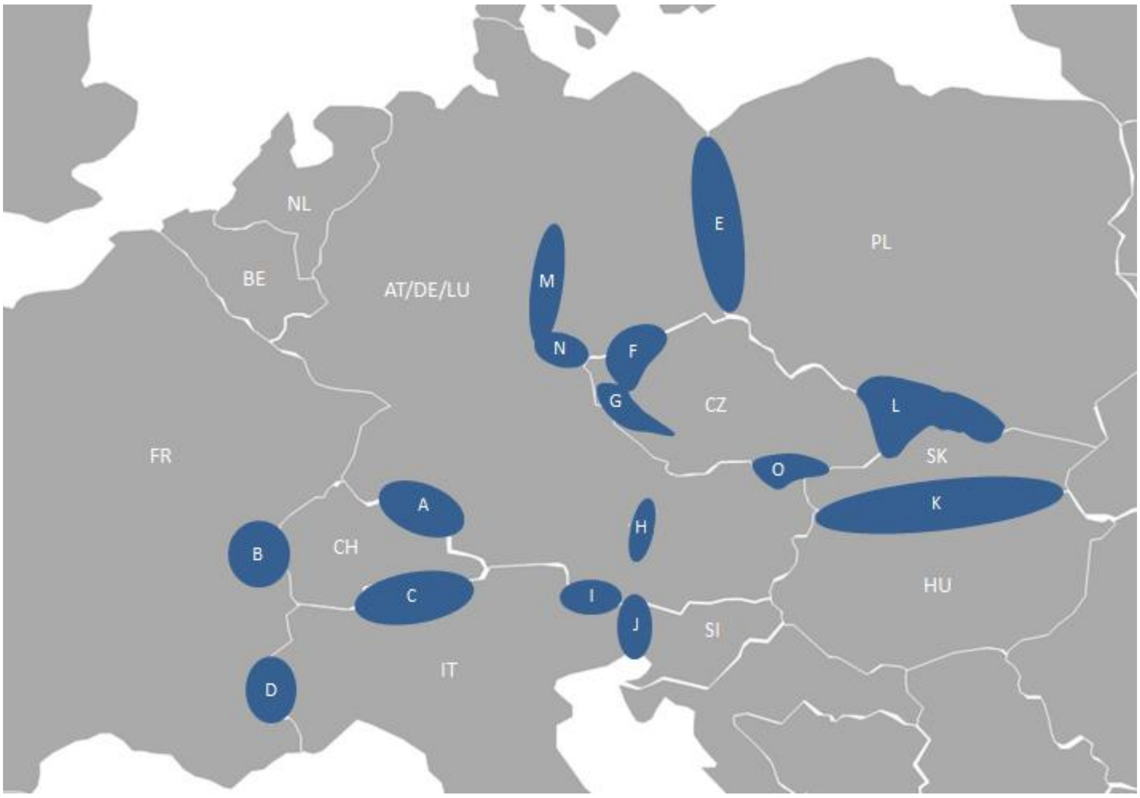


Figure 5: Congestion clusters: Operational phase (real-time)

Compared to congestions in the planning phase congestions in the operational phase last for a significantly shorter duration. Each of the congested areas illustrated in Figure 4 and Figure 5 are briefly described below.

Congested Area No. 1 [TenneT NL]

Due to the connection of new power plants before the completion of necessary grid reinforcements in the region of Maasvlakte congestion management was needed. In case of potential congestion in the planning phase, bids were collected and awarded to avoid actual congestions in the operational phase. With the completion of the reinforcement projects in 2013 the matter has been resolved.

Congested Area No. 2 [TenneT NL, Elia, Rte]

This cluster expands from the Netherlands (Borssele region), crosses the north trunk of the Belgian grid (via Zandvliet - Avelgem) and continues south-bound towards France (to the Avelin region). Some years, the cluster also spreads out within France and parallel to the Belgian border, between Areas 2 and 3.

This area limits the French-Belgium capacity about 15% of the time.

The main reason for this congestion is the 800-1000 MW expected unscheduled flow that partially crosses this cluster (together with cluster 3). It does so both in the north (1.2 GW max., 100 MW min.) and south direction (1.7 GW max., 100 MW min.). The forecasted direction changes depending on various patterns. The most important of these are related to Renewable Energy Sources (RES), generation expected profiles (wind, sun) and RES-related constraints (temperature and availability of water for power plant cooling in certain areas). Unplanned outages play a much less important role. It is important to note that the main drivers for this congestion are in almost all cases located outside of the cluster itself.

There are no congestions in the operational phase; these disappear during the real-time phase due to enhanced regional coordination, accompanied by several non-costly topological measures and (to a much lesser extent) redispatch.
By 2016, the congestion reported and already anticipated for the planning stage is expected to decrease due to the set up in of an additional phase shifter transformer Zandvliet (Belgium-Netherlands Border). The relieving impact of this project on any planned congestion will be particularly significant. Additionally, the Stevin Project[6] will further reinforce the network in the Belgian north during this same period. Reinforcement is also planned on the French grid between 2016 and 2018; the Avelin-Gavrelle line will be rebuilt as a double circuit line[7].
By 2018, the congestions reported and anticipated for the planning stage will also decrease due to the completion of the following projects: as part of the general Project Brabo[8] in Belgium, an investment is expected on the Doel-Zandvliet axis by upgrading an existing 150 kV circuit to 380 kV which will alleviate constraints on the existing network, and a DC link between Belgium and the United Kingdom (Nemo Link ®)[9] will be commissioned and built.
Congestions on the Dutch side during the D-2 planning phase (currently mainly during scheduled maintenance) will be reduced with the completion of the Zuid-West 380 project, which is expected by 2019.
In 2023, the congestions reported and anticipated for the planning phase will be further reduced by an upgrade and capacity reinforcement of the Belgian Avelgem-Doel[10] line in order to accommodate increased physical flows on the grid.

Congested Area No. 3 [TenneT NL, Elia, Rte]
This cluster extends from the Netherlands (Eindhoven region), crosses the central-south trunk of the Belgian grid (via Van-Eyck - Gramme) and follows south-bound towards France (Lonny – Aubange area). It continues within France (via Moulaine) towards Lonny-Vesle.
This area limits the French-Belgium capacity about 20% of the time.

[6] The Stevin project addresses several major needs. It enables Belgian offshore wind power to be brought inland and transmitted to the domestic market. It is necessary in order to create a further interconnection with the Belgian grid via a subsea connection to the United Kingdom. This expansion of the 380 kV grid will significantly improve the electricity supply for the West Flanders region, and make further economic development possible in the strategically important growth area in and around the port of Zeebrugge. It enables the connection of additional decentralised electricity generation (wind, solar and other forms of sustainable energy) in the coastal region. A strong 380 kV backbone between the coast and the inland parts of the country, which Stevin will provide, is therefore necessary. For more information on this project please consult: http://www.elia.be/en/projects/grid-projects/stevin

[7] Overview of the planned grid development by RTE: http://www.rte-france.com/uploads/Mediatheque_docs/vie_systeme/annuelles/Schema_developpement/Schema_decennal_2012_V2.pdf

[8] The Brabo Project will shore up the high-voltage grid and will consolidate security of supply for both the port of Antwerp and Belgium as a whole. This latter project is two-fold. On the right bank of the River Scheldt, in the Berendrecht-Zandvliet-Lillo district of Antwerp, a new 380 kV line will be built between the high-voltage substations at Zandvliet (near BASF) and Lillo (near the Liefkenshoek Tunnel). This will cross the River Scheldt to Liefkenshoek. On the left bank of the River Scheldt, the existing 150 kV line between Liefkenshoek and the Mercator high-voltage substation will be modernised and upgraded to 380 kV. For more information on this project please consult: http://www.elia.be/en/projects/grid-projects/brabo

[9] Nemo Link® is the name of a project to lay high voltage electricity cables under the sea, improving the link between UK and European electricity generation for consumers in the UK and across the continent. It is a joint project between National Grid Nemo Link Limited, a subsidiary company of the UK's National Grid PLC, and the Belgian Elia Group. The project will give both countries improved reliability and access to electricity and sustainable generation. Nemo Link® will consist of subsea and underground cables connected to a converter station and an electricity substation in each country, which will allow electricity to flow in either direction. The proposed site for the converter station and electricity substation in the UK is an eight hectare piece of land, formerly occupied by the Richborough Power Station, which now forms part of the Richborough Energy Park proposals. A similar converter station and substation is proposed in Zeebrugge, Belgium. For more information on this project please consult: http://www.nemo-link.com

[10] TYNDP Projects 380.73+74.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

The main reason for this congestion is the 800-1000 MW expected unscheduled flow that partially crosses this area (together with Area 2). Please see the epigraph of Area 2 for an explanation of the causes involved. Again, it is important to note that the main drivers for this congestion are in almost all cases located outside of the cluster itself. As in Area 2, there are no congestions in the operational phase. All the congestions that are registered during the planning phase effectively disappear thanks to enhanced regional coordination accompanied by topological measures and (to a lesser extent) redispatch.

During 2016, the congestion reported and already anticipated for the planning stages is expected to decrease due to the reinforcement of the Belgian north-south axis (Gramme)[11]. Reinforcement is also planned on the French grid between 2016 and 2018. The Lonny-Vesle line will be rebuilt as a double circuit line[12].

During 2018, the congestion reported and already anticipated by Elia for the planning stage is also expected to decrease significantly due to the commissioning of an additional DC link with Germany (Alegro)[13].

Congested Area No. 4 [TenneT NL, Amprion]

The lines indicated by cluster 4 were identified during the D2CF- and the DACF- processes. The occurrence of congestion in this area is dependent on the amount of wind energy in the German grid.

However, due to a functioning congestion management system there are no congestions in the operational phase at the DE-NL border.

In order to ensure a future reduction of congestions for this area, there are two new connections planned. The first one is the new connection from Doetinchem to Niederrhein[14]. The second one is a new connection between Germany and Belgium (Alegro)[13] which will also reduce the congestions at the German-Netherlands border. Planning and coordination have been regionally enhanced by the creation of SSC.

Congested Area No. 5 [Amprion, Rte]

The critical elements on the French-German border and internal elements of the French grid close to the border limit the capacity. The lines are crucial elements for exchanges in the CWE MC area between two large import/export bidding zones. The lines indicated by the cluster have been identified during the D2CF- and DACF- processes.

The lines are not congested during the operational phase due to coordinated capacity calculation in the CWE area and the use of non-costly topological measures.

[11] The reinforcement of the Gramme-Zutendaal-Van Eyck line (region Genk-Kinrooi-Maaseik) will increase the transport capacity of the Belgian network in order to guaranty security of supply and energy exchanges with the neighbouring countries (via the Netherlands). This project contains a reinforcement and adaptation of the existing 380 kV and 150 kV network between the existing substation at Van Eyck, the future substation at André Dumont and the existing substation at Langerlo. The project starts in March 2013 and has scheduled completion by 2015. For more information on this project please consult: http://www.elia.be/en/projects/grid-projects/~/media/files/Elia/Projects/Other/130517_Elia-Van-Eyck.pdf (in Dutch only).

[12] Overview of the planned grid development by RTE: http://www.rte-france.com/uploads/Mediatheque_docs/vie_systeme/annuelles/Schema_developpement/Schema_decennal_2012_V2.pdf

[13] The high-voltage electricity systems around the German city of Aachenand Liège in Belgium are relatively well developed and close to each other but they are not yet directly connected. Therefore, the two transmission system operators (TSO) in these areas, Elia (Belgium) and Amprion (Germany) have decided to lay an underground direct-current link between their transmission systems. The whole route for this link, which will be known as ALEGrO (standing for the Aachen-Liège Electric Grid Overlay) and will use direct-current technology, will be laid underground. The works are expected to start in mid 2016 and to take around two years to complete, from constructing the converter stations to laying cables along the entire route. The commissioning of the interconnection is anticipated in late 2018. For more information on this project please consult: http://www.elia.be/en/projects/grid-projects/alegro/alegro-content and http://www.amprion.net/netzausbau/alegro-hintergrund

[14] TYNDP Project of pan European significance No. 103, http://www.amprion.net/netzausbau/wesel-niederlande-hintergrund

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Planning and coordination have been regionally enhanced by the creation of CORESO and SSC.
Due to a functioning capacity management system at the German-French border there are no congestions during real-time.
Rte and Amprion are observing and investigating the situation at the French-German border together. With the decommissioning of French nuclear power plants (Fessenheim for example), the flow pattern will change in the area. Furthermore, a reinforcement of the grid in the Alsace region is expected[15]. The new line that is going to be built between Germany and Belgium (Alegro)[13] will also help to further reduce the congestions at the German-French border.

Congested Areas in the North (No. 6 and A) and West (No. 7 and B) of Switzerland [Rte, Swissgrid, TransnetBW, Amprion]

Imports and high north-south transit flows due to price differences and the demand situation in Switzerland and Italy are causing congestions in northern Switzerland.
The grid in northern Switzerland is highly meshed and the appearance of congestions is dependent on maintenance activities in the area of the bidding zone border. Maintenance activities can lead to a decrease in the available cross-border capacity, especially in the planning phase.
Therefore, the occurrence of congestions in this area is influenced by national and also regional characteristics.
The main reason for the congestions on the Swiss-French border is the high export situation from France. This is often dependent on weather conditions, as France has a high level of production, but less demand in case of early but warm winters. In general, the congested areas in the planning phase correspond to those in the operational phase. Nevertheless, the ratio of security violations occurrences compared with those in the planning phase is rather small (ten times lower than forecasted). Moreover, Swissgrid pursues a comparatively strict policy with regard to reporting (n-1) situations. Every element overloaded in the (n-1) case above 100% is reported as a security violation, even when sufficient remedial actions are available.
Since numerous grid reinforcements are planned during the next ten years, the high north-south transit situation and the following congestions might be relieved in particular areas. In any case, this depends on the generation and demand situation within Switzerland and in adjacent countries, along with the general development of IEM flows.
Furthermore, construction and extension of the transmission grid in the Bodensee area is being investigated by APG, Swissgrid, TransnetBW, Amprion and also the VUEN[16]. Further investigation of the area will take place as part of the activities of ENTSO-E.

Congested Area No. 8, 9, 13, 14, D, C, I and J – Northern Italian Borders [Terna, APG, Swissgrid, Rte]

With Italy being an importing country, the situation at the northern Italian borders is generally characterized by high import flows from France, Switzerland, Austria and Slovenia. The situation can be also influenced by specific outages in all the related countries.
In general, the congested areas at the northern Italian borders are more or less the same in the planning phase as the ones in the operational phase. Nevertheless, the ratio of security violation occurrences compared with the ones in the planning phase is rather small.
The Italian-French border (cluster 9 and D) is rarely congested. Furthermore, a thermal capacity increase of the whole 380kV connection Albertville - La Coche - La Praz - Villarodin - Venaus - Piossasco was completed in 2013, and this border will be also enhanced in the future thanks to the new HVDC link Grand'Ile-Piossasco (2019). In addition, further internal developments are expected on both the Italian and French sides.
The Italian-Swiss border (cluster 8, C) is generally the most congested of the northern Italian borders (anyhow the occurrence of congestions, both in the planning and in operational phases, is not high).

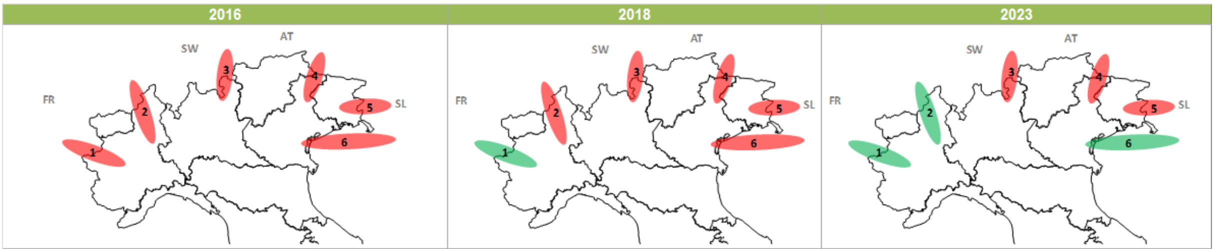
[15] http://www.rtefrance.com/uploads/Mediatheque_docs/vie_systeme/annuelles/Schema_developpement/Schema_decennal_2012_V2.pdf
[16] TYNDP project number 90.136

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Swissgrid applies a specific policy regarding the operational limits of their lines, which does not allow any temporary overloading on Swiss lines. This means, that every element being overloaded in the (n-1) case above 100% is reported as a security violation, even though remedial actions are available to solve the problem. Furthermore, unscheduled flows in the area CH-DE-FR-IT affect this border. The Italian-Swiss border is the only northern Italian border that has no PST installed, while all the other borders (IT-FR; IT-AT; IT-SI) are controlled by this machinery. Therefore, the possibility of controlling the power flows on the Swiss border is lower compared to the other borders. A new HVDC link (Pallanzeno – Airolo) and internal reinforcements are under investigation to enhance the interconnection between Italy and Switzerland.

The Italian-Austrian border (cluster 14, I) showed congestions in 2011 and 2012 on the sole connection both in the planning and operational phases mainly due to high production in Carinthia, but these congestions were quickly and easily resolved by a dedicated topological remedial action. In order to solve these congestions a PST was installed in Lienz on the existing 220 kV line in the second part of 2012, and in 2013 a new 150 kV connection was put in operation. Additionally, a new 220 kV link between Italy and Austria (Curon – Nodrio) is under investigation to enhance the interconnection in the north of Italy, and the reconstruction of the existing 220 kV Soverzene-Lienz line as 380 kV line on an optimized route is anticipated.

The Italian-Slovenian border (cluster 13, J) sometimes showed congestions on the 220 kV interconnection in (n-1)-security, but there is a special protection scheme operating on this border designed to solve these congestions. Additionally, on both the 380 kV and 220 kV interconnections, PSTs are installed in order to manage the flows at the border. In the future, a new double circuit 400 kV OHL between Okroglo(SI) and Udine(IT) with PST in Okroglo is anticipated. Furthermore, a New HVDC link between Italy and Slovenia (Salgareda – Divacca) border is under investigation to enhance the interconnection between these countries.



2016	2018	2023
1 IT-FR Piossasco – Gande'lle 2 IT-SW HVDC Pallanzeno - Airolo 3 IT- AT: Curon - Nauders 4 IT-AT: Veneto Region - Lienz 5 IT-SI: Udine – Okroglo 6 IT-SI: Salgareda - Slovenia	2 IT-SW HVDC Pallanzeno - Airolo 3 IT- AT: Curon - Nauders 4 IT-AT: Veneto Region - Lienz 5 IT-SI: Udine – Okroglo 6 IT-SI: Salgareda - Slovenia	3 IT- AT: Curon - Nauders 4 IT-AT: Veneto Region - Lienz 5 IT-SI: Udine – Okroglo

Figure 6: Network developments at the northern Italian borders

Congested Area No. 10 and M [50Hertz-TenneT East-West]

The cluster comprises the 380 kV Mecklar - Vieselbach and Helmstedt – Wolmirstedt lines directed from west to east (inner German lines). The cluster has no relevance for D-2 cross-border capacity calculation. D-1 congestions (DACF process) are healed in D-1 or by remedial actions in the operational phase. The remaining congestion ((n-1)-violations) in the operational phase occurred in single hours (real-time). The cluster is mainly historical, especially with regard to the line Helmstedt - Wolmirstedt, due to the construction of a new 380 kV line in the north of Helmstedt - Wolmirstedt (the line between Krümmel and Görries). The new line was commissioned in December 2012, supporting power transmission between the east and west of Germany.

Congested Area No. 11 and E [PSE, 50Hertz]
The observed congestions are similar in the planning and operational phases. In the planning phase necessary analyses are based first on individual estimations in capacity calculation and on the common TSC approach in the day ahead process. As preparation for the operational phase, bilateral or multilateral remedial actions may be needed to fulfil the security criteria for the profile between PSE and 50Hertz.
The relevant, highly congested tie-lines are: 220 kV Krajnik - Vierraden (both circuits) and 380 kV Hagenwerder-Mikułowa, the internal 400 kV Mikułowa – Czarna line and the 400/220 kV transformers in Mikułowa. Other congested lines are the 220 kV Mikułowa - Świebodzice line (both circuits), the 220 kV Mikułowa - Cieplice, line and the AT2 400 MVA autotransformer in Krajnik.
The congestions listed above are caused by high physical flows from 50Hertz to PSE. These flows are correlated with periods of high generation in the 50 Hertz area. In the planning stage, the transmission capacity offered to the market is limited as unscheduled flows have to be taken into account. Unscheduled flows, composed of loop and transit flows, are influenced by various factors including volatile injections and commercial schedules from northern to southern parts of Europe.
The congestions in the operational phase are eliminated by remedial actions (including bilateral and multilateral actions).
The installation of phase shifters is planned in the coming years on all four tie-lines between PSE and 50Hertz to reduce the profile load. In addition, a new interconnector, a 400 kV double circuit line between Eisenhüttenstadt and Plewiska (TYNDP project 58.140), is planned to be built.

Congested Area No. 12 and F [CEPS, 50Hertz]
In D-2 (capacity calculation stage) all elements (especially the cross border lines) that are relevant for cross-border capacity calculation are monitored (contingency list according to ENTSO-E Operational Handbook). NTC values at the CEPS-50Hertz border are determined in close coordination with the CEPS-TenneT-D profile. In addition, the impact of the CEPS-PSE border is taken into account in case of topology changes. The mutual interdependencies between the CEPS-TenneT-D and CEPS-50Hertz profiles via the CEPS grid (subst. Hradec u Kadane, etc.) are important and the level of unscheduled flows at the CEPS-50Hertz border has to be considered when the NTC between CEPS and 50Hertz is assessed.
From CEPS's side, elements monitored in D-2 appeared in the D-1 stage as well, with various occurrences. Congestions are managed on the CEPS side by reducing NTCs (in the direction of CEPS) for day ahead and intraday market time frames.
The assumed reason for congestions (common for all stages) on the CEPS side is the high level of physical resp. unscheduled flows from the 50Hertz area to the CEPS area over this border in cases of high transit (resp. loop) flows from north(west) to south(east).
From CEPS' side, the same elements monitored in D-2 and D-1 appeared in this stage, with various occurrences. Congestions are usually relieved by internal, bilateral or multilateral remedial actions. In some limited cases (in 2011) however, remedial actions were either not available or exhausted, leading to (n-1)-violations.
A phase shifting transformer at the CEPS-50Hertz cross-border connection is envisaged by 2016.

Congested Area No. 15 and L [CEPS, PSE, SEPS]
The CEPS-SEPS profile consists of three 400 kV lines and two 200 kV lines. This is the strongest CEPS cross-border profile. However, there is a strong mutual interdependency with CEPS-PSE, and the respective SEPS-PSE profiles. Highly congested tie-lines are the 220 kV Liskovec- Povazska Bystrica line and the 400 kV Nosovice-Varin line.
The CEPS-PSE profile consists of two 400 kV lines and two 200kV lines. There is a high interdependency with the PSE-SEPS profile. Highly congested tie-lines are the 220 kV Kopanina - Liskovec and Bujaków – Liskovec, congested tie-lines are the 400 kV Wielopole - Nosovice, Krosno and the Iskrzynia – Lemieszany.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

From the perspective of CEPS, PSE and SEPS the assumed reason for congestion is unscheduled flows and loop flows from Germany's resp. common AT/DE/LU bidding zone. As the generation is located in the northern part and load centers are located in southern parts unscheduled flows cross PSE-50 Hertz profile, flow through Polish power system and further to CEPS grid. These flows are modulated with PSE exchanges. The most critical situation occurs when the load centre is in the Balkan peninsula and or if the PSE-SEPS profile is out of operation due to maintenance. In this case, CEPS-PSE and CEPS-SEPS profiles are further congested.

The description of the congestions applies for both the planning phase and the operational phase.

A reduction of unscheduled flows due to the common AT/DE/LU bidding zone is envisaged by installing Phase Shifting Transformers (PST) at the CEPS-50Hertz border. The greatest effect should be achieved by installing PST on PSE-50Hertz border. The installation of phase shifters on all four tie-lines between PSE and 50Hertz is planned in the coming years.

Congested Area No. 16 and N [50Hertz-TenneT North-South]
This cluster comprises the 380 kV lines Remptendorf - Redwitz and partially Mecklar - Vieselbach (inner German lines). The Remptendorf - Redwitz line is considered in D-2 capacity calculation ('monitored branch'), but the line is not an active constraint (no D-2 congestion limiting cross-border capacity). D-1 congestions (DACF process) are healed in D-1 or by remedial actions in the operational phase. Remaining congestion ((n-1)-violations) in the operational phase occurred in single hours (real-time). The transmission corridor has been strengthened by replacing the line cables between Remptendorf - Redwitz in December 2012 (increasing the transmission capacity by 300 MW). In addition, the construction of a new 380 kV Vieselbach - Redwitz line (TYNDP project 45.193) is expected to be finished by 2016.

Congested Area No. 17 [TenneT NL]
This cluster reflects the internal Ens – Lelystad line. Potential congestions regularly appear in the planning phase. Potential congestion arises in cases of high cross-border flows at the Dutch – German border. Overload can be mitigated by remedial actions using PST steps. This bottle neck has been identified in the recently published Quality and Capacity Plan for the Netherlands, where it is discussed in more detail. Reinforcement has been planned.

Congested Area No. 18 and K [Mavir, Seps]
In a narrow sense, this congestion area consists of the existing two tie-lines between Slovakia and Hungary. On the other hand, there is high interdependency among the lines of the so called CEE profile. This profile consists of the tie-lines between Czech Republic and Austria, Slovakia and Hungary and, Slovakia and Ukraine. The loading of this profile highly depends on loop and transit flows in the CEE region.
The area is congested up to 3-8 % of the time, but the market demand is continuously higher than the available network capacity.
From MAVIR's and SEPS's perspective (based on their expert knowledge), the reason for the congestion is on one hand the large and volatile RES feed from the northern part of Germany and the high level of import position in the southern CEE area (APG and MAVIR). On the other hand, the loop and transit flows result in much higher actual north-to-south flows than the scheduled levels. This causes the uncertainty in the network capacity determination and thus the restriction of the market activities.
Congestions in the operational phase are handled with curative topological remedial actions.
There are new network investments planned on the SK-HU border (a double circuit Gabcikovo - Gonyu 400 kV tie-line[17] and double circuit Rimavska Sobota - Sajoivanka 400 kV tie-line equipped

[17] TYNDP 2012 project number: 48

only by one circuit) by 2018. The expected effect is that the Győr - Gabcikovo tie-line will be critical much less frequently.
Additional network investment is planned in connection with the SK-HU border (a double circuit Velke Kapusany - Kisvarda 400 kV tie-line[18]).

Congested Area No. 19 and G [CEPS, TenneT-D]
In D-2 (capacity calculation stage) all elements (especially the cross-border lines) that are relevant for cross-border capacity calculation are monitored (contingency list according to ENTSO-E Operational Handbook). NTC values at the CEPS-TenneT-D border are determined in close coordination with the CEPS-50Hertz profile. Additionally, the impact of the CEPS-APG border is taken into account by CEPS in case of topology changes. Due to mutual interdependencies between the CEPS-TenneT-D and CEPS-50Hertz profiles via the CEPS grid (subst. Hradec u Kadane etc.) the level of unscheduled flows at the CEPS-50Hertz border has to be taken into account from CEPS' point of view when the NTC between CEPS and TenneT-D is assessed.
D-1 Congestions (DACF process) are healed in D-1 or by remedial actions in the operational phase. From CEPS' side, some of the elements monitored in D-2 appeared in this stage, with various occurrences. From CEPS' point of view the high transit flows in northwest-southeast and southeast-west directions have a non-negligible impact.
There are no relevant congestions in the operational phase (no (n-1)-violations in real-time) in the TenneT-D control area. From CEPS' side, some of the elements monitored in D-2 and D-1 appeared in this stage, with various occurrences.
A phase shifting transformer at the CEPS-50Hertz cross-border connection is envisaged by 2016.

Congested Area No. 20 and O [CEPS, APG, SEPS]
The interface which causes the congestions in planning phase consists of two parallel 400kV lines (380 kV line Slavetice - Dürnrohr) and two parallel 200kV lines (Sokolnice - Bisamberg). In D-2 (capacity calculation stage) all elements (especially the cross border lines) which are relevant for cross-border capacity calculation are monitored (contingency list according to ENTSO-E Operational Handbook). From CEPS' side the impact of the border CEPS-TenneT-D and CEPS-SEPS is also taken into account in case of topology changes. Further the level of unscheduled flows on CEPS-APG border has to be considered when the NTC between CEPS and APG is assessed.
From CEPS' side, monitored elements in D-2 appeared at the D-1 stage as well, with various occurrences. And congestions are attempted to be relieved by reducing NTCs for day ahead and intraday market time frames.The assumed reason for congestion (common for all stages) on CEPS side is the high level of physical resp. unscheduled flows in north to south directions due to high production in the north of Europe and high load in the south (Hungary, Balkan, Austria, Italy). This becomes stronger in case of topological changes (e.g. maintenance).
From CEPS' side, the same monitored elements in D-2 and D-1 appeared as well as congestions in the operational phase, with various occurrences. Congestions are usually relieved by internal or bilateral remedial actions.
From APG side there was no congestion in real time in 2011 and 2012. Only very rarely (n-1)-load of about 103% occurred.
For the future evolution of the area there is an expected aggravation due to further renewables in the north of Europe.
For the development planning in the operational phase is therefore an increase of capacity due to thermal rating of cross border lines Slavetice - Dürnrohr planned for 2014 (probably not applicable for D-2). With the planned 380 kV line St.Peter - Germany this congestion should be solved in D-1 and real-time, as from APG's point of view. Furthermore, after the installation of Phase Shifting Transformer on CEPS-50Hertz border a reduction of unscheduled flows over this border is expected.

[18] TYNDP 2012 project number: 54

Congested Area No. 21 Denmark West - Germany [EnDK / TenneT-D]
In D-2 (capacity calculation stage) all elements that are relevant for cross-border capacity calculation are monitored (contingency list according to ENTSO-E Operational Handbook). D-1 congestions (DACF process) are healed in D-1 or by remedial actions in the operational phase. The installation of the new PST at Kassoe has improved the situation in D-1 and real-time. There are no relevant congestions in the operational phase (no (n-1)-violations in real-time). In terms of future evolutions, by 2016 a new 380 kV Dollern - Hamburg/Nord line will be built[19]. By 2018, the following will be constructed:

- a 380kV line Audorf - Flensburg – Kassoe[20]
- a DC-connection Brunsbüttel/Wilster/district Segeberg – Großgartach/Goldshöfe/Grafenrheinfeld[21]
- a 380 kV line Hamburg/Nord – Audorf[22]
- a 380 kV line Dollern – Landesbergen[23]

Furthermore, by 2023 a new 380 kV line Brunsbüttel - Süderdonn - Heide - Husum - Niebül – Denmark is planned[24].

Congested Area No. 22 Lehrte - Mehrum in 2012 [TenneT-D]
The Lehrte-Mehrum line has no D-2 congestion (not relevant for cross-border capacity calculation). Reported congestions in the D-1 timeframe for the 220kV-line between Lehrte and Mehrum are caused by local generation/load patterns. Moreover, load flows between the east and west on the 380 kV line between Wolmirstedt and Wahle influence the load flow situation in this region. There are no relevant congestions in the operational phase (no (n-1)-violations in real-time). In terms of future evolutions, a new 380 kV Wahle-Mecklar line is planned[25].

Congested Area No. 23 [APG, ELES]
With regard to the 220 kV line Obersielach – Podlog in the D-2 phase congestions are solved with few restrictions of trading (daily capacity) and special switching for Sokolnice – Bisamberg. In 2011 & 2012 no cross border redispatch was needed. This profile is not highly congested and the assumed reason of congestion is mostly generation/load situation near the border line and import of Balkan and Italian Area. There was no congestion in the planning phase in 2011 and 2012.

Congested Area No. H [APG] only 2012 / 220 kV Salzburg - Tauern
Exclusively in 2012, there was a long unplanned outage of the Salzburg-Tauern line due to an emergency (avalanche, snow slide).
The 220 kV line was out of operation for 6% of the time in 2012 due to an emergency (avalanche).
Regarding the future evolution of the area a 380 kV Salzburg line from St. Peter to Tauern is planned for 2019.

[19] TYNDP project 44.147 / present status: design & permitting phase
[20] TYNDP project 39.144 / present status: planning phase
[21] TYNDP project 43.A88 / present status: planning - district Segeberg - Goldshöfe under consideration
[22] TYNDP project 44.148 / present status: design & permitting phase
[23] TYNDP project 44.A157 / present status: planning phase
[24] TYNDP project 43.A90 / present status: planning
[25] TYNDP project 44.157 / present status: design & permitting

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

2.4. Day ahead market price analysis

This section seeks to identify the relevant direction for the market from a commercial point of view. The relevant direction is identified by comparing the day ahead electricity market prices in the neighbouring zones for each of the 17 544 hours in 2011 and 2012. The flow was defined by the "low price to high price" principle, which means that if in a certain hour the price in "A" was lower than the price in "B" the direction was "A"→"B". On the map, the present bidding zone structure is represented with different colours (Figure 7). The percentages show the proportion of the hours for each direction. Comparing for example Belgium to France in 5% of the timestamps, the Belgian prices were lower than the French prices. Therefore, the direction was from Belgium to France. It was in the opposite direction in 7% and in 88% the prices were equal, so the commercially relevant direction cannot be identified. Where only two numbers are presented the correlation between the prices was less than 1%.

Due to the fact that the French day ahead market prices were produced with an accuracy of three decimals during 2011 and 2012 (as opposed to the two decimal accuracy level of the rest of the CWE areas) the standard 0.005 EUR threshold has been applied. This means price differences under 0.005 EUR are treated as equal. As of early 2013, all CWE prices (France included) have a two decimal precision.

The German, Austrian and Luxembourgian bidding zone has two electricity exchanges (EEX and EXAA (AT)) with different gate closure times. To have a consistent picture, EEX data was used for the previously mentioned bidding zone, as the traded volume on EEX is significantly higher and this exchange is used as a benchmark among traders.

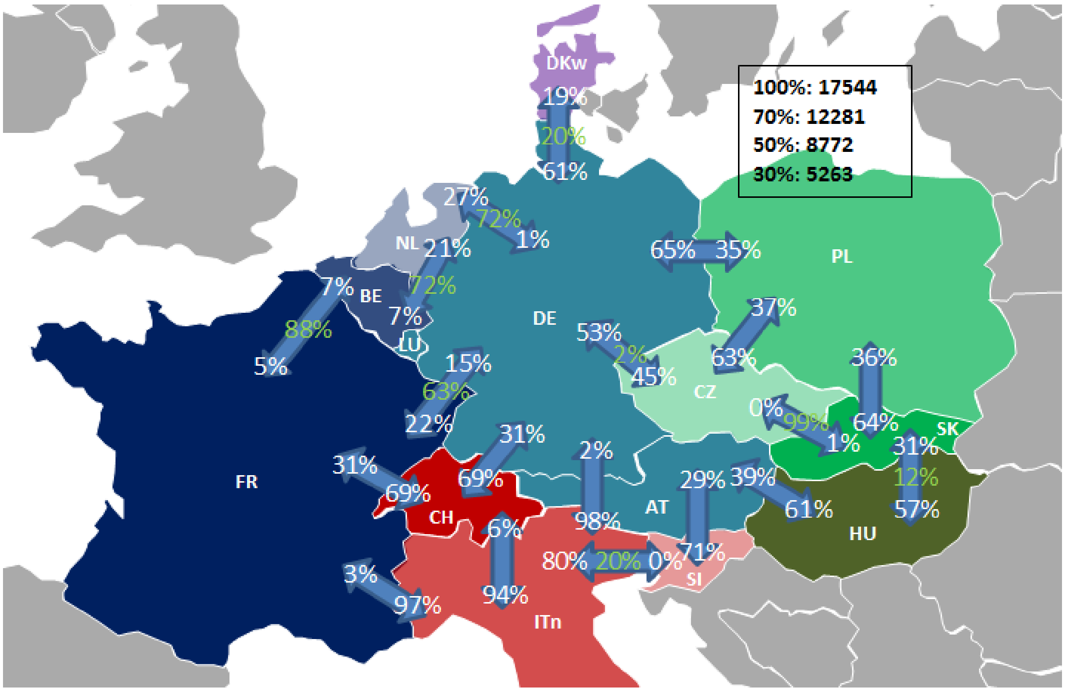


Figure 7: Day ahead market price analysis (percentages represent time shares)

Since the Hungarian day-ahead electricity market joined (11.09.2012) the already coupled Slovak-Czech market during the analysed period and it had significant impact on the prices, it is essential to distinguish the period before and after the trilateral market coupling (cf. Figure 8).

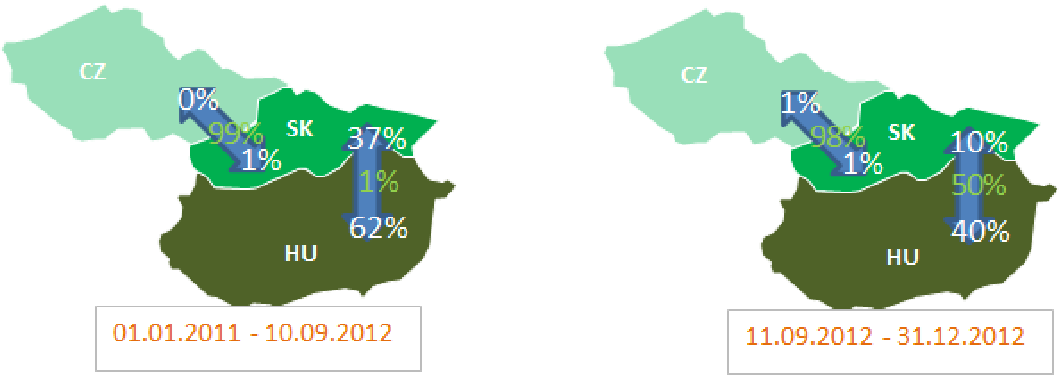


Figure 8: Day ahead market price analysis before and after CZ-SK-HU market coupling

3. Power flows not resulting from capacity allocation

Within this chapter, an assessment of flows not resulting from capacity allocation is carried out based on three different approaches. Each approach uses different indicators to calculate the power flows not resulting from capacity allocation.
In section 3.1 the calculation methodologies and general descriptions are provided. Section 3.2 gives an overview of the data used. In the first part of section 3.3, the assessment is then performed on a bidding zone level as explicitly required by the draft CACM NC. Existing bidding zones may include more than one control area (e.g. even in different member states). This means that bidding zone borders may consist of borders of more than one TSO or member state. Therefore an additional chapter is introduced in section 3.3.5, in which the indicators of flows not resulting from capacity allocation are calculated both at member state level (according to EU regulation 714/2009[26]) and at control area level.

3.1. Methodology and general descriptions

This chapter provides a description of the three indicators that are used within this report and how these are calculated. For the purpose of this Technical Report all three indicators seek to identify “Power Flows not resulting from Capacity Allocation”. All of them are calculated as the difference between an “allocated flow” and a “physical flow”. However, for each indicator different interpretations of “allocated flows” and “physical flows” are assumed. In Table 1, an overview of the names of the three indicators and their corresponding non-allocated flows is provided:

Table 1: Names of the flows and indicators

Name of the indicator	Name of the non-allocated flow	Allocated flows	Physical flows
Real-Time Unscheduled Flows (RTUF) Indicator	Real-Time Unscheduled Flows (RTUF)	Realized Scheduled Exchange (SE)	Measured Physical Flows (PF)
PTDF Flow Indicator	PTDF Flow deviations (PTDFF)	Flows induced by all cross border exchanges (CF)	Measured Physical Flows (PF)
Day Ahead Unscheduled Flows (DAUF) Indicator	Day Ahead Unscheduled Flows (DAUF)	Day Ahead Scheduled Exchange (DASE)	Day ahead calculated Flows (DACF)

The subsequent sections (3.1.1 until 3.1.2) describe the indicators in further detail.

[26] Regulation (EC) No 714/2009 requires that in cases where commercial exchanges between two countries (TSOs) are expected to affect physical flow conditions in any third-country (TSO) significantly, congestion-management methods shall be coordinated between all the TSOs so affected through a common congestion-management procedure.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

3.1.1. Real-Time Unscheduled Flows (RTUF) Indicator

The basic idea behind this indicator is to compare hourly measurements of physical cross-border flows and scheduled exchanges (matched nominations) over chosen bidding zone borders. This approach should provide a general indication of the difference between the world of trade and the world of physics.

For each hour (h), Real-Time Unscheduled Flows $RTUF_b$(h) can be calculated from measured cross-border physical flows PF_b(h) and scheduled exchanges SE_b(h) as follows:

$$\mathbf{RTUF_b\ (h) = PF_b\ (h) - SE_b\ (h)}$$

- Physical flow PF_b(h): measured cross-border physical flow over given bidding zone border (b).
- Scheduled exchange SE_b(h): realized commercial exchange based on matched nominations from all time horizons (year ahead to intraday and including remedial and balancing actions, if any) over given bidding zone border (b).

3.1.2. PTDF Flow Indicator

This indicator is based on the capacity allocation flow-based model of the internal electricity market in Europe, assuming that:
- Transactions within each bidding zone are not limited (copper-plate)
- Transactions between all bidding zones are limited through capacity calculation and allocation.

Flows not resulting from capacity allocation are computed as the difference between the measured physical flow and the computed flows at the bidding zone borders from the net positions of each bidding zone for each hour of the year.

The equation is as follows:

$$\mathbf{PTDF\ Flow\ deviation_{\,b}\ (h) = PF_b\ (h) - CF_b\ (h)}$$

- PTDF Flow deviation b (h): share of power flow not resulting from capacity allocation on a bidding zone border (b).
- PF_b (h): Measured cross-border physical flow over given bidding zone border (b).
- CF_b (h): calculated flow induced by all cross-border commercial exchanges between all European bidding zones.

In order to compare the measured cross-border physical flows PF_b (h) and calculated flows CF_b (h), the net position per bidding zone will have to be transformed into cross-border flows resulting from capacity allocation. This transformation takes into account the electric properties and constraints of the transmission grid from a common grid model.
The indicator calculates PTDF Flow deviations by comparing the cross-border flows that are the result of the capacity allocation process and the measured physical flows on cross-border tie-lines.
The indicator does neither evaluate who is responsible for the PTDF Flow deviations nor if the identified PTDF Flow deviations induce constraints.

$$CF_h = \left(\sum_{l=1}^{L=number\ of\ BZ\ border} \begin{bmatrix} 1 & \cdots & k \\ \vdots & \ddots & \vdots \\ L & \cdots & . \end{bmatrix} \cdot \begin{bmatrix} 1 \\ \vdots \\ k \end{bmatrix} \right)$$

Sum of the flows created by all exchanges between bidding zones in the synchronous area at all bidding zone borders

PTDF matrix (resolution per bidding zone)

Net positions of the relevant bidding zones

For each hour the flows resulting from capacity allocation will be computed using a power transfer distribution factor (PTDF) matrix and the net positions of the relevant bidding zones from the synchronous area.
The measured hourly physical flow minus the above vector CF_b (h) will be the indicator for each hour.

3.1.3. Day Ahead Unscheduled Flows (DAUF) Indicator

The goal of this indicator is to determine expected flows that do not result from capacity allocation mechanisms at the day ahead planning stage. It takes into account the NTC based capacity allocation mechanism as it is the only mechanism that has been used in the whole area covered by the study in 2011 and 2012.
Day Ahead Scheduled Exchanges (DASE) represent all cross-border transactions concluded by market participants from the long term and day ahead perspectives as the outcome of cross-border capacity allocation mechanisms.
The Day Ahead Congestion Forecast (DACF) procedure is described in the ENTSO-E RG CE Operation Handbook – Policy 4: Coordinated Operational Planning. The DACF data sets are generated after the gate closure of the Day Ahead Cross-Border Market. The results of DACF calculations identify expected power flows, which are the outcome of all transactions concluded by market participants within each bidding zone and between all bidding zones from the long term and day ahead perspectives.
These forecasted flows on particular cross-border lines are aggregated per bidding zone border.
An hourly comparison of the results of DACF calculations and DASE per bidding zone border determines the expected DAUF. These DAUFs are the result of transactions that cause cross-zonal flows and at the same time are not subject to and therefore are not controlled by cross-border capacity allocation mechanisms.

Expected flow that does not result from capacity allocation mechanisms at the day ahead planning stage (DAUF) for bidding zone border (b) and hour (h) is calculated as follows:

$$\mathbf{DAUF_b(h) = DACF_b(h) - DASE_b(h)}$$

- $DACF_b$(h) – sum of expected power flows on tie-lines of the bidding zone border (b) as result of the DACF model (h) calculation.
- $DASE_b$(h) – matched nominations for long term and day ahead transactions for the bidding zone border (b) and hour (h) as a result of all cross-border transactions concluded by market participants.

3.2. Data Sources

This chapter provides a description of the data used for the calculation of the three indicators used in this Technical Report. The data sources are the "Vulcanus" Database, PTDF calculation and DACF calculation.

3.2.1. Vulcanus Database

Vulcanus is a web IT platform used by TSOs to store and visualize matched data on control area[27] and control block level[28], amongst others Day Ahead Control Programs and schedules, Intraday Control Programs and schedules, Realized Control Programs and schedules, and Measured Physical Flow. The data suppliers (who collect data from the relevant TSOs) are Amprion for the northern part of Continental Europe, Swissgrid for the southern part of Continental Europe and REE. Data on measured physical flows, net positions and scheduled exchanges was taken from the Vulcanus database.
Data is stored primarily in hourly resolution; however for some TSOs data is also available in ¼ hour resolution.

Measured Physical Flow
These values represent the metered aggregated load flows at the border between two control blocks. They are uploaded approximately at the end of the following week.

Scheduled exchanges

- Day Ahead Scheduled Exchanges (DASE):
  These values represent the planned bilateral exchange of each block for the following day. The day ahead scheduled exchanges include the long term and day ahead matched cross-border nominations.
- Realized Scheduled Exchanges (SE):
  These values are the realized schedules of the bilateral exchange of each block. The realized schedules represent the day ahead schedules with additional intra-day modifications. The Realized Scheduled Exchanges take into account the long term nominations, day ahead nominations, ID nominations and potential remedial actions, and may include balancing exchanges. They are updated as soon as the inadvertent deviation accounting is completed (approximately at the end of the following week).

Control Programs (Net Position)
Realized control programs (net positions) are the sum of the realized scheduled exchanges of each block. The realized control program takes into account the long term nominations, day ahead exchanges, ID exchanges and potential remedial actions, and may include balancing exchanges.

[27] A CONTROL AREA is a coherent part of the UCTE INTERCONNECTED SYSTEM (usually coincident with the territory of a company, a country or a geographical area, physically demarcated by the position of points for measurement of the interchanged power and energy to the remaining interconnected network), operated by a single TSO, with physical loads and controllable generation units connected within the CONTROL AREA. A CONTROL AREA may be a coherent part of a CONTROL BLOCK that has its own subordinate control in the hierarchy of SECONDARY CONTROL. Source: Continental Europe Operation Handbook

[28] A CONTROL BLOCK comprises one or more CONTROL AREAS, working together in the SECONDARY CONTROL function with respect to the other CONTROL BLOCKS of the SYNCHRONOUS AREA it belongs to.
Source: Continental Europe Operation Handbook

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

3.2.2. Computation of the PTDF matrix

A power transfer distribution factor (PTDF) is an influence (sensitivity) factor in the modification of the generation or load on the active power flow of a given element of the grid (or a zone). The PTDF matrix is based on a DC load flow approach. More detailed information on the CWE flow based initiative is available on the CASC website[29].

The PTDF matrix for all the relevant bidding zone borders is currently unavailable, but it will be known on an hourly basis when the flow-based capacity calculation and allocation mechanism becomes widespread in Europe. The PTDF matrix (resolution per bidding zone) has been computed from a common reference grid model (CGM) and a generation shift key (GSK).

ENTSO-E RGCE (Network Model and Forecast Tool WG) provides two scenarios for CGM: one for the winter and another for the summer. The files that have been used are from 2012 and 2013.

Table 2: CGM and intervals used

Interval	CGM
1/1/2011 → 31/3/2011	Winter 2012
1/4/2011 → 31/10/2011	Summer 2012
1/11/2011 → 31/03/2012	Winter 2012
1/4/2012 → 31/10/2012	Summer 2012
1/11/2012 → 31/12/2012	Winter 2013

Only three files are used because of the data availability for 2011. For 2011, 2012 file is used (see Table 2).

It is not possible to perfectly represent the grid topology as some aspects will not be taken into account with this approach (e.g. maintenances, modification of topology, new lines, generation and load pattern, load variation). Different rules are used in Europe for the determination of GSK (e.g. merit order, linear GSK). For the indicator the computation of the GSK has to be standardized in order to ensure the comparability of the PTDFs.

For this Technical Report, a GSK with a pro-rata of all generation units connected to the grid model has been chosen. Non-linear phenomena, e.g. maximal power, are not taken into account. For example, a bidding zone produces 2000 MW and a power plant in the bidding zone produces 100 MW. If the bidding zone production is increased by 30 MW, the power plant production will be increased by 1.5 MW (100/2000x30=1.5).
The generation of a bidding zone is increased by 100 MW. If the load of an L line increases by 5 MW, the PTDF of the bidding zone on the L line will be 0.05. This computation is made for each tie-line and each bidding zone.

The PTDF matrix is computed on the bidding zone level but in the Vulcanus data base the resolution can be different. The net position for the Austrian-German-Luxembourg bidding zone is not directly available. The Vulcanus database provides (among many others) one net position for Germany-Luxembourg-Denmark West and another net position for Austria. For the computation of the matrix, the generation units are increased for all four areas at the same time. It is also not possible to compute the allocated flows between the Austrian-German-Luxembourg bidding zone and the Denmark West bidding zone.

[29] For more information on the flow based approach, CWE FBMC reports are available on CASC website. http://www.casc.eu/en/Resource-center/CWE-Flow-Based-MC/Documentation

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

The shape of the PTDF matrix is the following for k bidding zones and n borders:

$$\begin{array}{c} \\ Border\ AB \\ Border\ AC \\ \dots \\ \dots \\ Border\ n \end{array} \begin{array}{c} \begin{array}{ccc} BZ\ A & BZ\ B & \qquad\qquad BZ\ k \end{array} \\ \begin{bmatrix} PTDF_{\ BZ\ A\ on\ borderAB} & & PTDF_{\ BZ\ k\ on\ borderAB} \\ PTDF_{\ BZ\ A\ on\ borderAC} & & PTDF_{\ BZ\ k\ on\ borderAC} \\ & & \\ & & \\ PTDF_{\ BZ\ A\ on\ border\ n} & & PTDF_{\ BZ\ k\ on\ border\ n} \end{bmatrix} \end{array}$$

3.2.3. DACF computation

The DACF (Day Ahead Congestion Forecast) procedure is established for short-term load flow forecast and security analyses.
Each TSO collects the forecast data for the agreed timestamps (production schedules from the power plant operators, grid topology, import/export programs etc.). According to the ENTSO-E Operational Handbook (Policy 4) there are six mandatory data sets for each day (3:30, 7:30, 10:30, 12:30, 17:30, 19:30) for 2011 and 2012. After having collected the complete load flow data sets for all TSOs, these data sets are merged into models covering the whole area of Continental Europe. These models are used to improve the operational planning process and identify if – and in case of security violations to what extent – remedial actions are needed. The first version of the mandatory models is used to calculate the DACF indicator. These models are available for the second half of 2012 because of the data storage rules of the common platform for merging all TSO data sets.
Due to the conditions mentioned above, the DAUF Indicator values are calculated for the second half of 2012 and six mandatory DACF models per day. Instead of 1104 (184 days * six mandatory models), 1103 values per border are calculated, because one model is missing (19.30 on 05.09.2012).

3.3. Analysis of the indicators

Schedules are a TSO tool for planning system operation after market closure and before real time. Schedules are agreed plans from generation and consumption units as well as internal and external commercial exchanges and exchanges between TSOs. Schedules provide the necessary information for the TSO to operate and balance the system, as well as carry out security analysis. All Schedules in a scheduling area should sum up to zero within a time period to keep the system in balance. If no faults occur both consumption and production will be equal to the prognosis. This enables the TSO to balance its system in real-time with a minimum level of reserves for balancing, compared to the extensive level of reserves necessary if no schedules are available[30].

In this sense, the **Load Frequency Control** (although the LFC works on the control area level) **ensures that the sum of all differences between commercial and physical flows over all borders of a bidding zone and the respective control area is very close to zero**. From the bidding zone perspective, control system differences between schedules and physical flow at one border net off differences at other borders (netting effect).

In the ideal case of two isolated systems with a single AC interconnection the physical flow will also always be equal to the schedule. However, in a meshed network and when looking at individual borders of a bidding zone, differences between schedules and physical flows can be observed. In case differences between cross-border schedules and measured cross-border physical flows occur the

[30] Source: Supporting Document for the Network Code on Operational Planning and Scheduling, Chapter 5.7, Page: 44

resulting flow is called a Real-Time Unscheduled Flow which covers loop and transit flows, among others.
In the following, the calculation of this indicator and two other complementary indicators (described above) is carried out for each bidding zone border.

3.3.1. Results of the Real-Time Unscheduled Flows (RTUF) Indicator for the years 2011 and 2012 on a bidding zone basis

The advantages and limitations of the RTUF indicator are shown in Table 3. This is followed by a graphical representation of the indicator for both years 2011 and 2012. The values of each border for 2011, 2012 and the combined values of both years are given in Table 8, Table 9 and Table 10 respectively. These tables can be found in Annex 5.1 of this document.

Table 3: Advantages and limitations of the RTUF indicator

Advantages	Limitations
Verifiable data from an agreed TSO database, which is available for the whole investigated period	Measured physical flows include both market and non-market transactions (internal, bilateral, multilateral redispatch, primary and secondary reserve power), with some transactions not being scheduled (e.g. primary and secondary reserve)
Simplicity of the approach (no CGM used). No major modification of data is necessary.	Degree of freedom for nomination paths/ calculation of scheduled exchanges for similar source/sink combinations affects the calculated unscheduled flows (bilateral exchange calculation approach from net positions in market coupling for example in CWE)
	Allows for assessment on the cross border profile level, not particular network elements. The influence of (scheduled) transactions on third borders on physical flows is unknown, but its share could be considerable
	Different capacity allocation mechanisms impact scheduled exchanges/nominated capacities in different regions (e.g. market coupling in the CWE region and explicit capacity allocation in CEE).

Figure 9 shows the average values of the realized scheduled exchanges (blue arrows) and the measured physical flows (green arrows) for the years 2011 and 2012 (in MW).

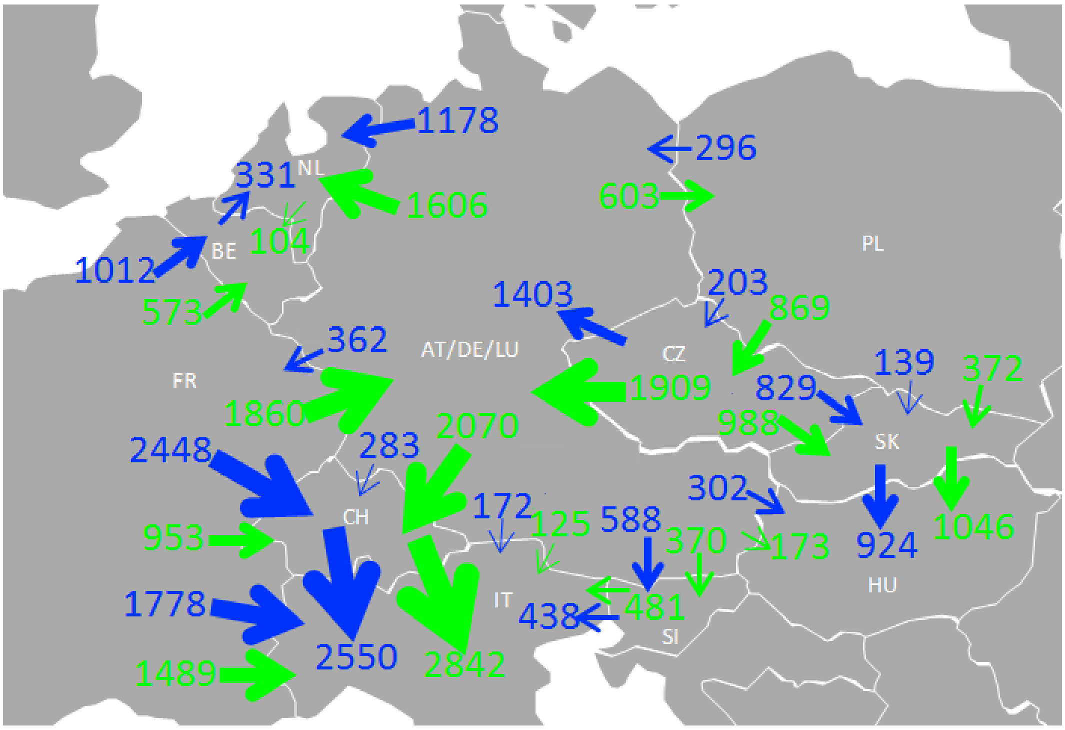


Figure 9: Average Realized Scheduled Exchanges (blue) & Measured Physical Flows (green) for the years 2011 and 2012 (both in MW)

The values in Figure 9 should be read in the following way: at the Belgian-French border for example, the average physical flow is 573 MW from France to Belgium for 2011 - 2012. On the same border, the average realized scheduled exchange is 1012 MW from France to Belgium.

Figure 10 shows the average values of the Real-Time Unscheduled Flows (RTUF) for the years 2011 and 2012 (in MW). For the calculation methodology see Chapter 3.1.1.

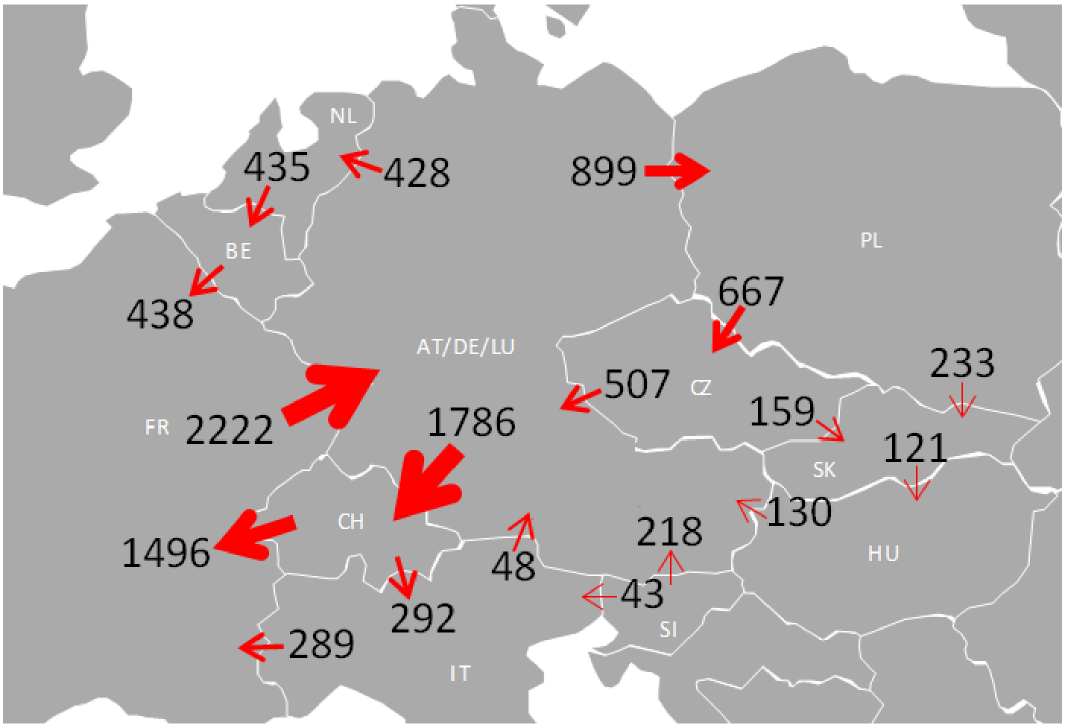


Figure 10: Average Real-Time Unscheduled Flows (RTUF) for the years 2011 and 2012 (in MW)

The values in Figure 10 should be read in the following way: at the Belgium-Netherlands border for example the RTUF flow is 435 MW from the Netherlands to Belgium.

Time Split Arrows SE-PF (2011&2012)

The Time Split Arrows shown in Figure 12 are based on the values of Figure 10, which were split according to their flow direction.

As an example, the values in Figure 11 are explained for given RTUF between bidding zones A and B.

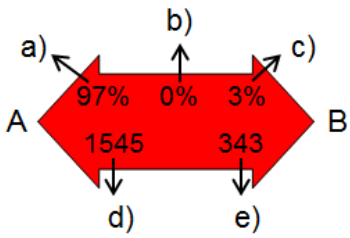


Figure 11: Example Time Split Arrow

a) Number of hours in which the calculated unscheduled flow is directed from bidding zone B to A divided by total number of hours.
Example: In 97% of the hours the direction of the flow is from B to A.

b) Number of hours in which the calculated unscheduled flow is zero divided by total number of hours.
Example: In 0% (<1%) of the hours there is no unscheduled flow.

c) Number of hours where the calculated unscheduled flow is directed from zone A to B divided by total number of hours.
Example: In 3% of the hours the direction of the flow is from A to B.

d) Average value of the calculated unscheduled flow indicator from B to A [MWh/h]

e) Average value of the calculated unscheduled flow indicator from A to B [MWh/h]

The Time Split Arrows for the Real-Time Unscheduled Flows (RTUF) Indicator are shown in Figure 12.

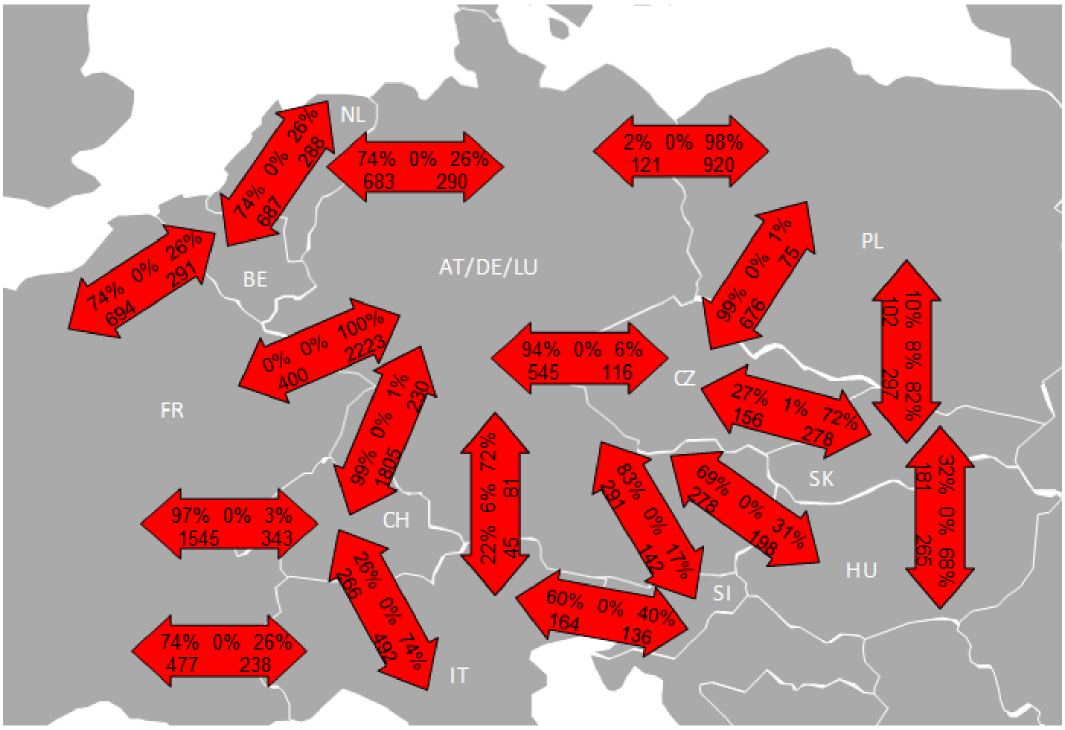


Figure 12: Time Split Arrows RTUF 2011 & 2012 (in MW)

The values in Figure 12 should be read in the following way: at the Italy-Switzerland border for example

- 26% of the time, the RTUF flow is from Italy to Switzerland and the average value in this direction is 266 MW
- 74% of the time, the RTUF flow is from Switzerland to Italy and the average value in this direction is 492 MW

3.3.2. Results of the PTDF Flow Indicator for the years 2011 and 2012 on a bidding zone basis

The advantages and limitations of the PTDF Flow indicator are shown in Table 4. This is followed by a graphical representation of the indicator for the combination of the years 2011 and 2012.
The values of each border for 2011, 2012 and the combined values of the years 2011 and 2012 are given in Table 11, Table 12 and Table 13 respectively. These tables can be found in Annex 5.2 of this document.

Table 4: Advantages and limitations of the PTDF flow indicator

Advantages	Limitations
Loop flows are considered as a subset of unscheduled flows (as other indicators also include transit flows)	Only three CGM files are used (does not take into account maintenances, modification of topology, new lines, generation and load pattern, variation of the load)
The physics of the flows are taken into account by translating commercial exchanges into physical flows between bidding zones.	Assumptions on pro-rata GSK do not consider merit order and/or cross border portfolio optimization; no maximum generation per generator is considered when applying pro-rata GSK
	Data availability of net position (for aggregation of countries see also subsection 3.2.2)
	Measured physical flows include both market and non-market transactions (internal, bilateral, multilateral redispatch, primary and secondary reserve power) with some transactions not being scheduled (e.g. primary and secondary reserve).

Figure 13 shows the average values of the flows induced by all cross-border exchanges (blue arrows) and the measured physical flows (green arrows) for the years 2011 and 2012 (in MW).

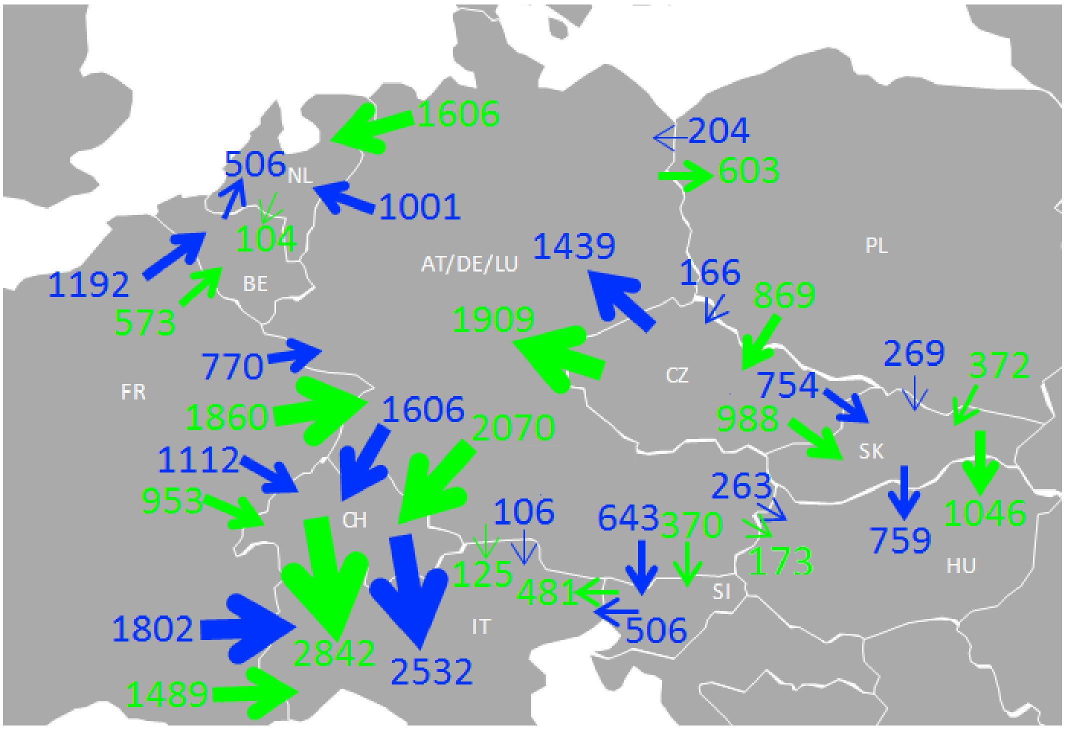


Figure 13: Average flows induced by all cross-border exchanges (blue) & Measured Physical Flows (green) for the years 2011 and 2012 (in MW)

The values in
Figure 13 should be read in the following way: at the Belgian-French border for example the average physical flow is 573 MW from France to Belgium for the years 2011-2012. On the same border, the calculated flow induced by all cross-border exchanges is 1192 MW from France to Belgium.
Figure 14 shows the average values of the PTDF Flow deviation for the years 2011 and 2012 (in MW). For the calculation methodology see subsection 3.1.2.

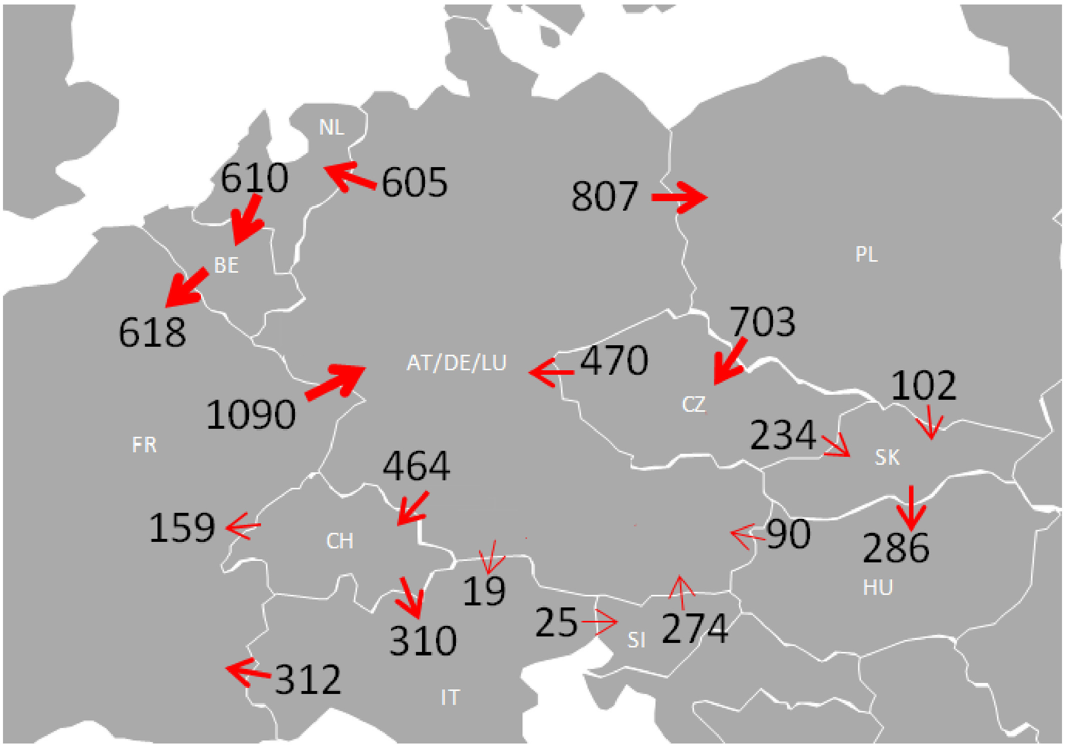


Figure 14: Average PTDF Flow deviation (PTDFF) for the years 2011 and 2012 (in MW)

The values in Figure 14 should be read in the following way: at the Belgium-Netherlands border for example the PTDF Flow deviation is 610 MW from the Netherlands to Belgium.
The Time Split Arrows for the PTDF indicator are shown in Figure 15. An explanation for these arrows and how to read them can be found in subsection3.3.1.

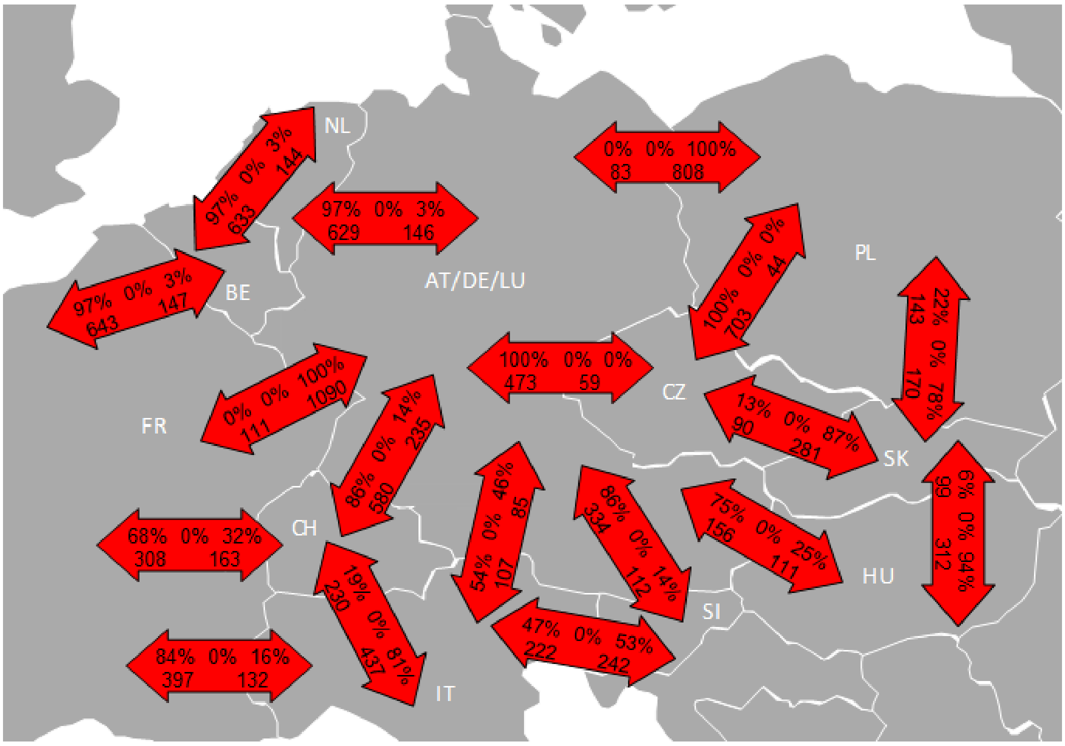


Figure 15: Time Split Arrows PTDF 2011 & 2012 (in MW)

The values in Figure 15 should be read in the following way: at the Italy-Switzerland border for example,

- 19% of the time, the PTDF Flow deviation is from Italy to Switzerland and the average value in this direction is 230 MW
- 81% of the time, the PTDF Flow deviation is from Switzerland to Italy and the average value in this direction is 437 MW

3.3.3. Results of the Day Ahead Unscheduled Flows (DAUF) Indicator for the years 2011 and 2012 on a bidding zone basis

The advantages and limitations of the DAUF indicator are shown in Table 5. This is followed by a graphical representation of the indicator for the second half of 2012. The values of each border for the second half of 2012 are given in Table 14, Table 15 and Table 16. These tables can be found in the Annex 5.3 of this document.

Table 5: Advantages and limitations of the DAUF indicator

Advantages	Limitations
DAUF presents expected day ahead unscheduled flows without non-market based transactions, such as cross-border remedial and balancing measures taken by TSOs, and only internal remedial actions may be included in the single DACF models depending on specific TSO system operation security policy	No intraday market transactions are included in DASF. A comparison of intraday plus DASF with Intraday Congestion Forecast (IDCF) calculation would be better because they take into account all cross-zonal transactions, but unfortunately IDCF files are not available for the whole period of analysis and whole area covered by the study
DASE is verifiable data from an agreed TSO database which is available for the second half of 2012. It represents all cross-border transactions concluded by market participants from the long term and day ahead perspectives as the outcome of cross-border capacity allocation mechanism	Internal remedial actions are planned according to local (unharmonized) TSO security policies
DACF procedure established in Operation Handbook for short term security analyses. Models are created in the framework of coordinating regional initiatives, using the common platform. They cover the whole area of Continental Europe.	Planned physical flow depends on DACF assumptions and is only available for Q3 and Q4/2012 for six hours per day
	Degree of freedom for nomination paths/ calculation of scheduled exchanges for similar source/sink combinations affects calculated unscheduled flows (bilateral exchange calculation approach from net positions in market coupling, for example in CWE)
	Different capacity allocation mechanisms affect scheduled exchanges/nominated capacities in different regions (e.g. market coupling in the CWE region and explicit capacity allocation in CEE).

Figure 16 shows the average values of day ahead scheduled exchanges (blue arrows) and day ahead calculated flows (green arrows) for the 2^{nd} half of 2012 (in MW).

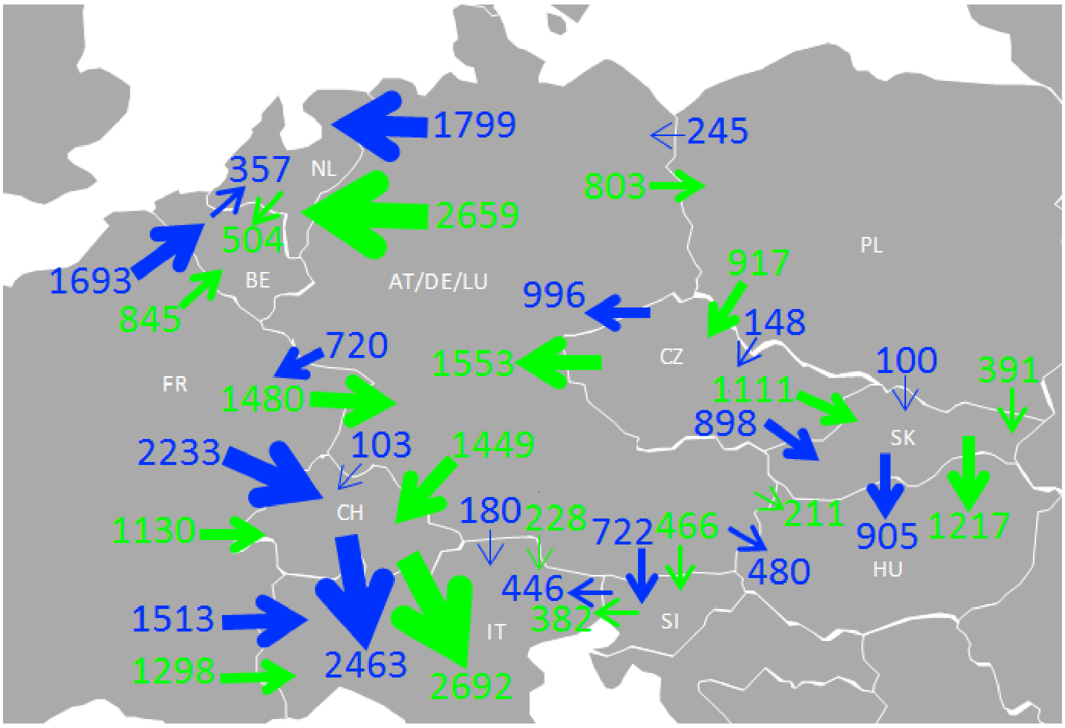


Figure 16: Average Day Ahead Scheduled Exchanges (blue) & Day Ahead Calculated Flows (green) for the second half of 2012 (in MW)

The values in Figure 16 should be read in the following way: at the Belgian-French border for example the average DACF is 845 MW from France to Belgium. On the same border, the average DASE is 1693 MW from France to Belgium.

Figure 17 shows the average values of the DAUF for the 2nd half of 2012 (in MW). For the calculation methodology see subsection 3.1.3.

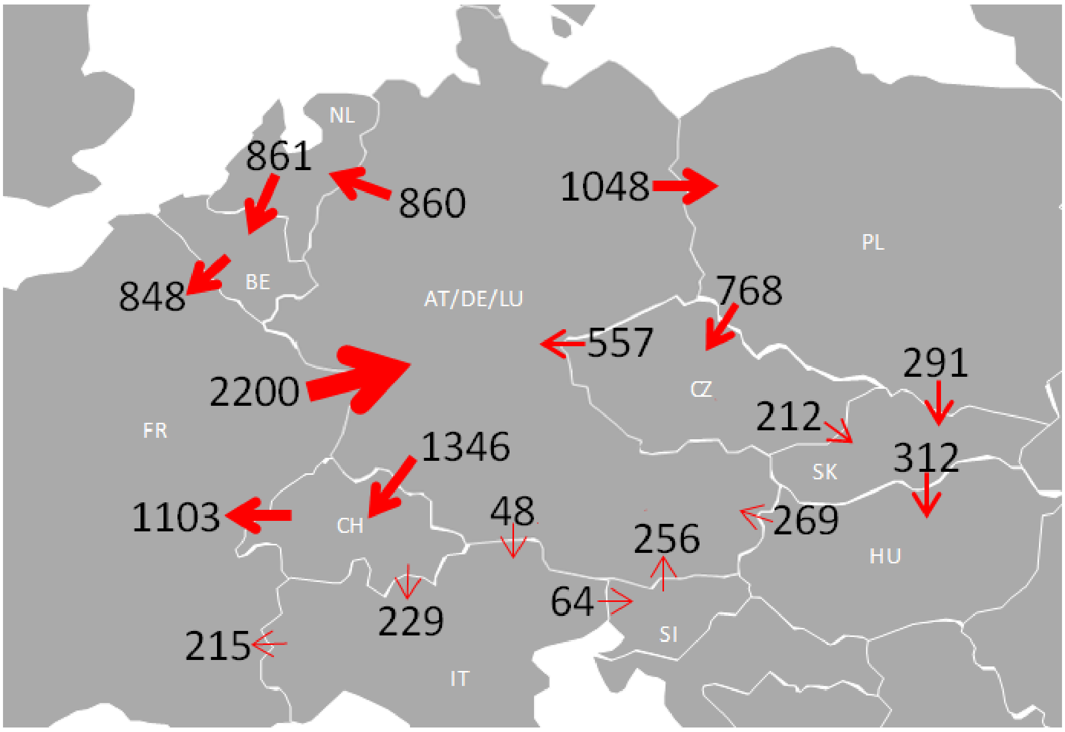


Figure 17: Average Day Ahead Unscheduled Flows (DAUF) for the second half of 2012 (in MW)

The values in Figure 17 should be read in the following way: at the Belgium-Netherlands border for example the DAUF is 861 MW from the Netherlands to Belgium.

The time split arrows for the DAUF-Indicator are shown in Figure 18. An explanation for these arrows and how to read them can be found in subsection3.3.1.

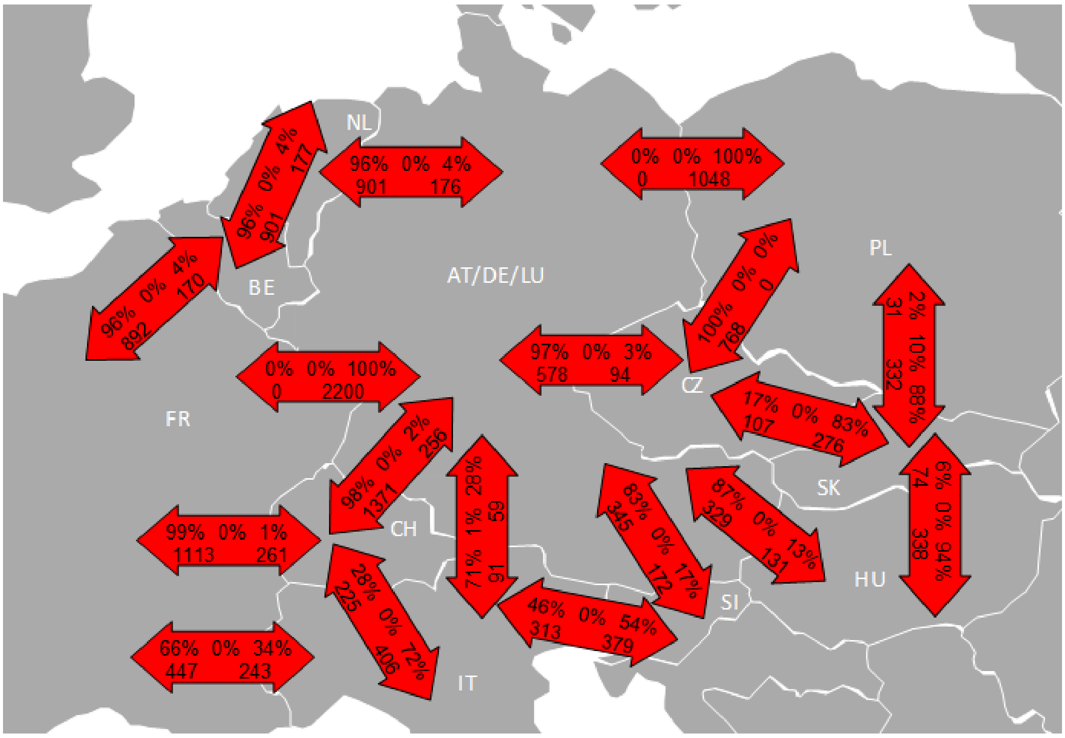


Figure 18: Time Split Arrows (DAUF) for the second half of 2012 (in MW)

The values in Figure 18 should be read in the following way: at the Italy-Switzerland border for example:

- 28% of the time, the DAUF is from Italy to Switzerland and the average value in this direction is 225 MW
- 72% of the time, the DAUF is from Switzerland to Italy and the average value in this direction is 406 MW.

3.3.4. Comparison of indicators and conclusion

In the following a comparative description of the calculated non-allocated flow is given for all the indicators. Furthermore, the main conclusions regarding the non-allocated flow are presented.
Considering that the DAUF indicator in subsection 3.3.3 has been calculated based on data for the second half of 2012 and for six timestamps per day, the RTUF and PTDFF indicators have also been recalculated for the same timestamps in order to facilitate a comparative assessment:

- Recalculated average Measured Physical Flows (green) and Realised Scheduled Exchanges (blue) are illustrated in Figure 19 (relevant for the RTUF indicator)
- Recalculated average Measured Physical Flows (green) and flows induced by all cross-border exchanges (blue) are illustrated in Figure 20 (relevant for the PTDF indicator)

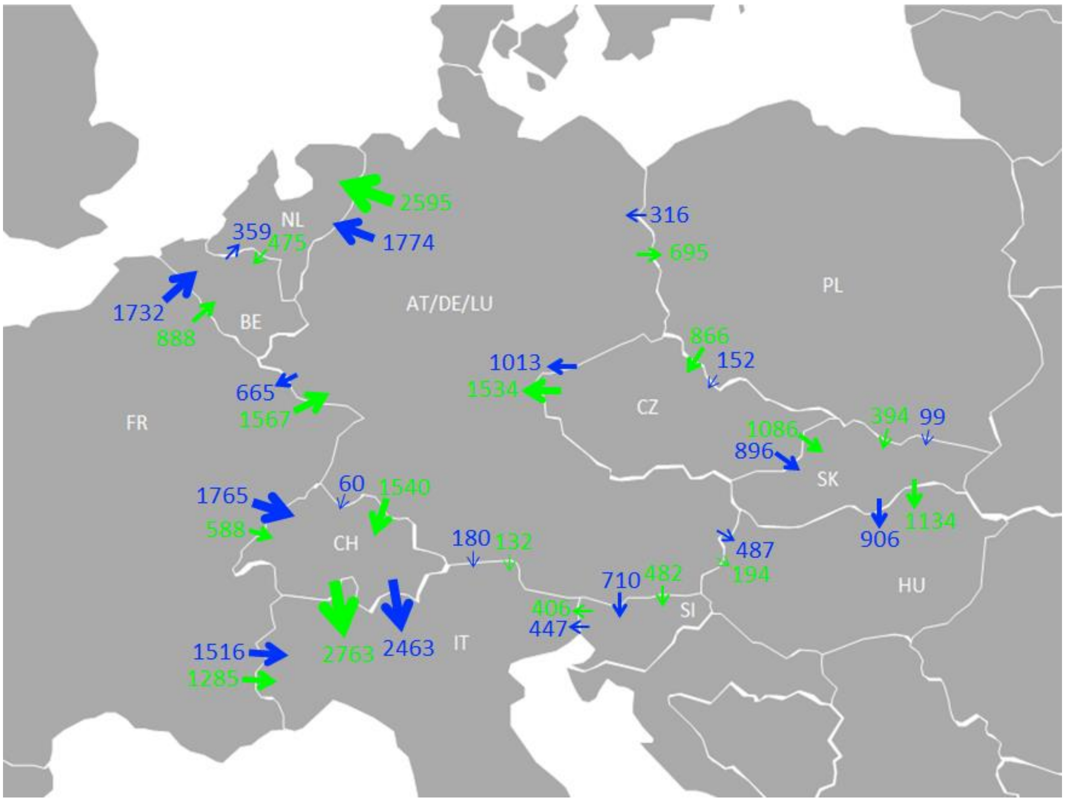


Figure 19: RTUF flow indicator for second half of 2012 (average values in MW)

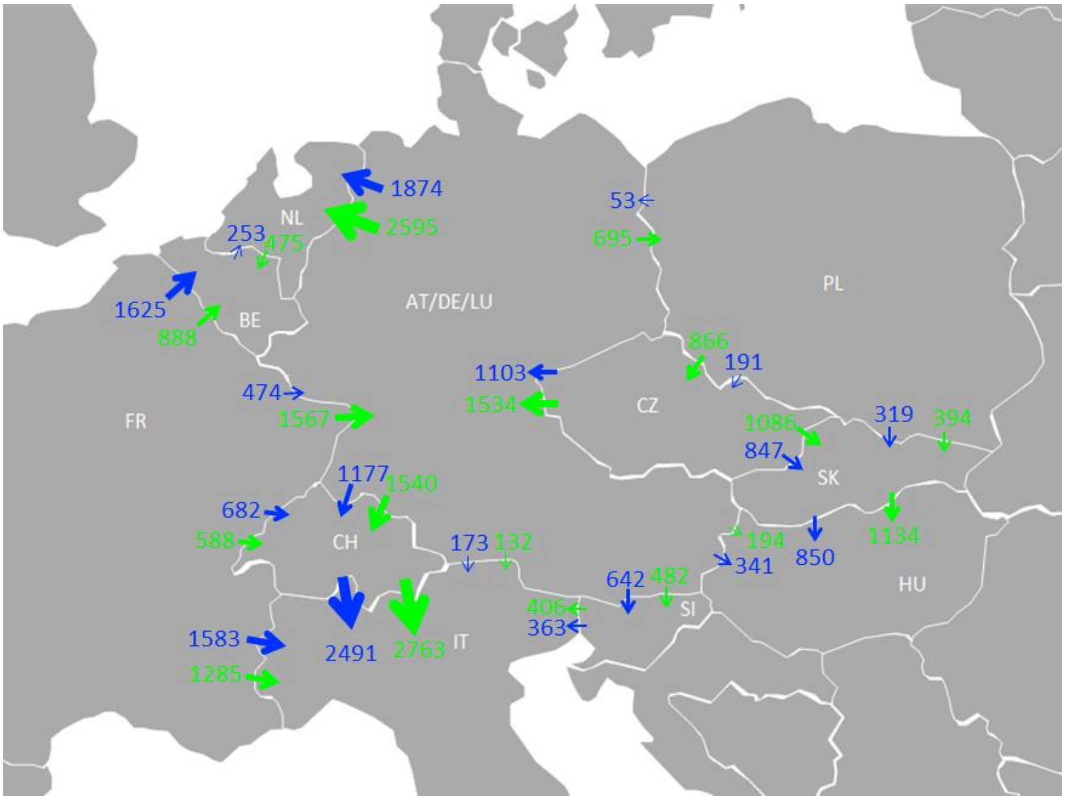


Figure 20: PTDF flow deviation indicator for second half of 2012 (average values in MW)

The focus of the following analysis is on the second half of 2012 based on the average values. This is because the data needed for the calculation of the DAUF-Indicator is only available from July 2012 onwards. The nature of the statements below is true for the years 2011 and 2012 as well; only the magnitude of the different flows might be different. In Figure 21, the values for the calculated non-allocated flows for all three indicators are shown for the second half of 2012.

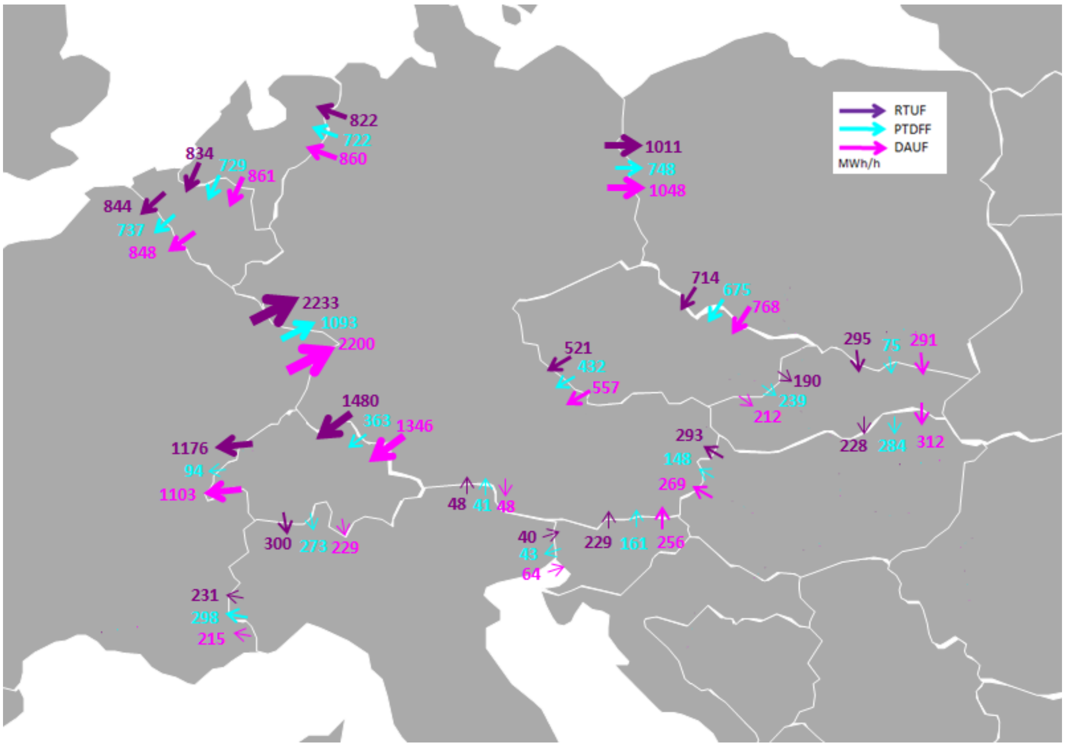


Figure 21: Comparison of the particular indicators of unscheduled flows (second half of 2012)

- The three indicators do not represent exactly the same kind of flows. This is for example due to the fact that the RTUF Indicator and the DAUF Indicator compute non-allocated flows for two different points in time.
- For all three indicators the highest values of non-allocated flows occur at the border from the French- to the AT/DE/LU bidding zone. At this border the physical flow and the allocated flows point in opposite directions for the RTUF and DAUF indicators. Only the calculated allocated flows of the PTDF Indicator point in the same direction as the physical flow.
- For the RTUF and the DAUF Indicator the second highest values of non-allocated flows can be found at the border of the AT/DE/LU and CH bidding zones. At this border the physical flow and the allocated flows point in the same direction for all three indicators.
- For the RTUF and the DAUF-Indicator the non-allocated flows at the border between the bidding zones of Switzerland and France have roughly the same magnitude as at the bidding zone border of AT/DE/LU and Switzerland. In contrast, the PTDF Flow deviations at this border are much smaller.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

- For all three indicators high values of non-allocated flows can be observed at the AT/DE/LU- and Polish bidding zone border. At this border the physical flow and the allocated flows point in the opposite direction.

- The biggest absolute differences of non-allocated flows calculated by the PTDF- and RTUF-Indicator can be observed at the AT/DE/LU-CH and FR-CH borders. On the contrary, the borders between AT/DE/LU-NL, NL-BE and BE-FR show almost identical values for all three indicators, but the PTDF-Indicator is smaller than the RTUF- and DAUF-Indicator. The situation is the opposite (i.e. PTDF-Indicator smaller than RTUF- and DAUF-Indicators) at the borders between SK-CZ, SK-HU and FR-IT.

- For nine out of the 18 bidding zone borders (PL → CZ, PL→ SK, SK → HU, CZ→ DE/AT/LU, DE→ PL, DE/AT/LU → CH, CH→ IT, NL→ BE, BE→ FR) the geographical orientation of non-allocated flows is from north to south. This implies that electricity is flowing from these generation centres located in the northern part of continental Europe to the above listed southern parts with their load centres.

- The non-allocated flows at the
  - AT/DE/LU to Netherlands bidding zone,
  - Netherland to Belgium bidding zone,
  - Belgian to French bidding zone and
  - Poland to Czech Republic bidding zone

  borders have roughly the same magnitude for all three indicators.

- The non-allocated flows at the border of the CZ to AT/DE/LU bidding zone have roughly the same magnitude and direction for all three indicators. More detailed results for individual borders are provided in the individual analyses of part 3.3.5.

- The non-allocated flows at the
  - Swiss to Italian bidding zone,
  - Italian to French bidding zone,
  - Slovenian to AT/DE/LU bidding zone,
  - Hungary to AT/DE/LU bidding zone,
  - Czech Republic to Slovakia bidding zone and
  - Slovakia to Hungarian bidding zone

  borders have roughly the same magnitude for all three indicators.

- The smallest non-allocated flows for all indicators can be observed at the borders between AT/DE/LU and the Italian bidding zone, as well as between the borders of the Italian and Slovenian bidding zone.

- The results of all three indicators provide average non allocated flows that are generally in the same direction for all bidding zone borders. Only at the border of the AT/DE/LU bidding zone to the Italian bidding zone and the Italian-Slovenian border, where the level of non-allocated flows is very low, a different direction of the non-allocated flows can be observed among the three indicators.

- Besides the direction of the non-allocated flows, the computed values provide information about the magnitude of these flows. The magnitude of the non-allocated flows is similar for the RTUF and the DAUF Indicators. The PTDF indicator usually has the lowest value (except in some special cases) when compared to the other indicators. This is because, contrary to the RTUF and DAUF

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

indicators, the calculated allocated flows in the PTDF indicator take into account the impact of all exchanges at all borders.
For 14 out of 18 borders (exceptions are Czech Republic to Slovakia, Slovakia to Hungary and Italy to France), the non-allocated flows calculated with the PTDF Indicator are smaller in relation to the non-allocated flows calculated with both other indicators (RTUF- and DAUF-Indicator). In one case (the border between Switzerland and Italy) the non-allocated flow of the PTDF Indicator is larger than the DAUF Indicator

- In terms of identifying sources, sinks and the causation of non-allocated flows:
  - The calculated non-allocated flows at bidding zone borders do not per se allow for general conclusions on concrete sources, sinks or causes of these flows. However, there may be intuitive explanations on the zonal level:
    - long distance transmission of intermittent generation that is not appropriately participating in the market and does not obtain sufficient market incentives to schedule or balance its injections
    - lack of mapping or insufficient mapping of internal transactions at bidding zone borders
    - generation units and consumption units close to a bidding zone border may cause physical flows which are completely independent from flows allocated via the market
    - market party choices of nomination paths for cross-border transactions and the calculation approach for bilateral scheduled exchanges in market coupling affect the size of the unscheduled flows for the RTUF and DAUF indicators
    - the RTUF and PTDF indicators inter alia comprise non-market based transactions (and they might not be scheduled), which affect physical flows and therefore the size of unscheduled flows as calculated for these indicators
  - In order to assess concrete sources, sinks and cause, a more detailed analysis would have to take place. Such an analysis must involve more detailed grid models and load-flow analyses.
  - The non-allocated flows computed by the three indicators represent flows that can potentially create constraints, both at a bidding zone border or inside a bidding zone. Furthermore, a high or low average value of non-allocated flows does not necessarily indicate a constraint; however, non-allocated flows have to be taken into account in the capacity calculation process as an uncertainty (both loading/relieving) as they have an impact (both decreasing/increasing) on the capacity available to the market.
  - The analyses of the previous sections have been focused on average values. Annexes 4 and 5 of this document contain further information (e.g. minimum, maximum values and monthly developments).

The above analysis refers to bidding zones. However the picture is different when looking at member state level or even control area level. This topic is addressed in the next section for the CEE region.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

3.3.5. Further individual analysis

In this subchapter special attention is given to borders between bidding zones, in particular member states which consist of more than one control area. Therefore, a higher granularity than the "Bidding-Zone-Granularity" (which is used in the previous chapters) is used here[31].

a) Comparison of the results of the three indicators with an additional border between the DE/Lux and AT bidding zone and therefore also separate net positions for Germany/Luxembourg and Austria

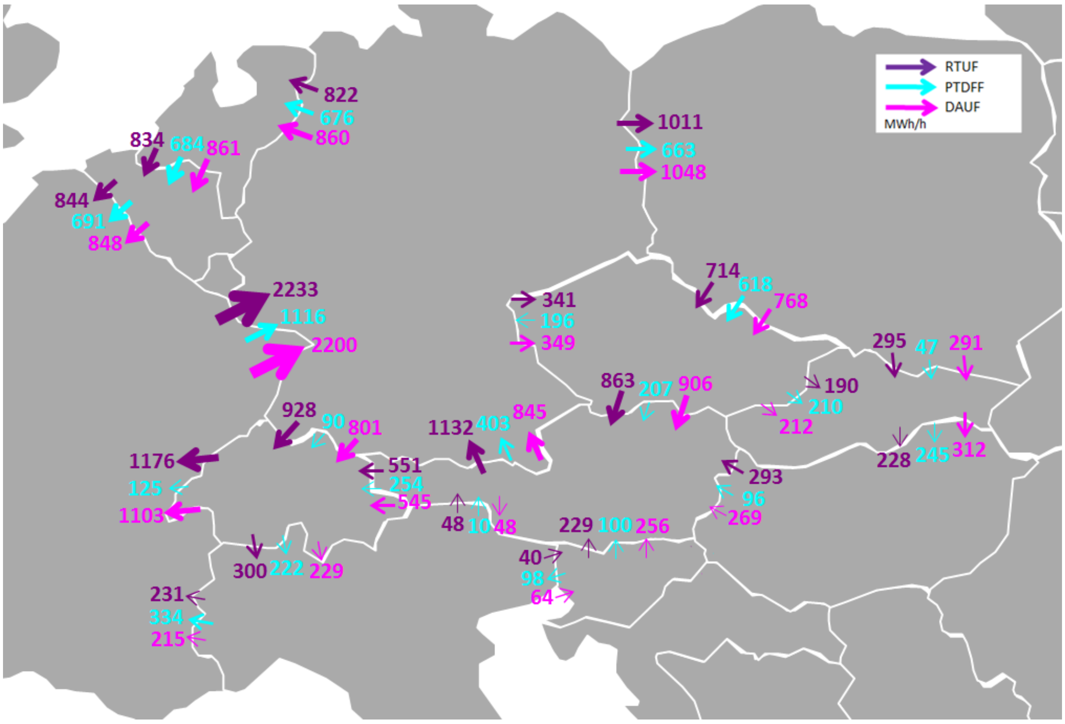


Figure 22: Comparison of indicators for the CWE and CEE regions with an additional border between DE/LU and AT for the second half of 2012

The above figure shows a comparison of the three indicators (average half-year values) using member state granularity (i.e. for borders between EU member states except Luxembourg). However, it must be noted that the data basis for the PTDF indicator was changed by introducing separate net positions for Germany/Luxembourg[32] and Austria, in contrast to the PTDF indicator presented in Figure 21 where an aggregated net position for the AT/DE/LU bidding zone[32] was used. Hence, there are differences in the values of the PTDF indicators for all borders compared to Figure 21.
Within the CWE region the highest values are observed at the FR-DE border for all three indicators. In the CEE region the highest values can be observed for the RTUF indicator at the DE-AT border followed by the DE-PL border.
The directions of indicators observed on half-year averages shown in Figure 22 are generally the same, meaning that for all three indicators the unscheduled flows point in the same direction[33].

[31] only schedules between control block AT and control block DE are publically available – therefore analyses for any other internal interface are not possible.
[32] including Denmark West
[33] Exceptions: IT-AT (the DAUF indicator is opposite to the others), IT-SI and CZ-DE (the direction of PTDF indicator is in opposition to the remaining indicators)

A more detailed representation of monthly flows is represented in Annex 4.

b) Analysis of CEE region using control area resolution

The differences between the indicators, namely between the NTC type indicators (RTUF and DAUF) and the PTDF indicator are of particular interest. The PTDF indicator is calculated based on net positions and PTDF factors. Such factors will also be used in practically implemented market coupling arrangements[34]. Flow Based Capacity Calculation (FBCC) and Allocation (FBA) is expected to be the cornerstone of the future integrated market in Europe and should be able to significantly reduce the amount of non-allocated flows.
However, the order of magnitude of improvement differs significantly[35]. It is particularly interesting to note the very specific case of the CZ-DE/LU border where the directions of the PTDF indicator and the NTC-type indicators (RTUF and DAUF) are opposite.
This is due to a strong netting effect at this border. This netting effect becomes visible when the CZ-DE/Lux border is split according to its different physical characteristics[36]. Therefore, the RTUF indicator is calculated using a control area granularity. This is shown for the CEE region in
Figure 23.

Figure 23 depicts Scheduled Exchanges, Physical Flows and Real-Time Unscheduled Flows (RTUF indicator) throughout the CEE member states, shown with control zone resolution.

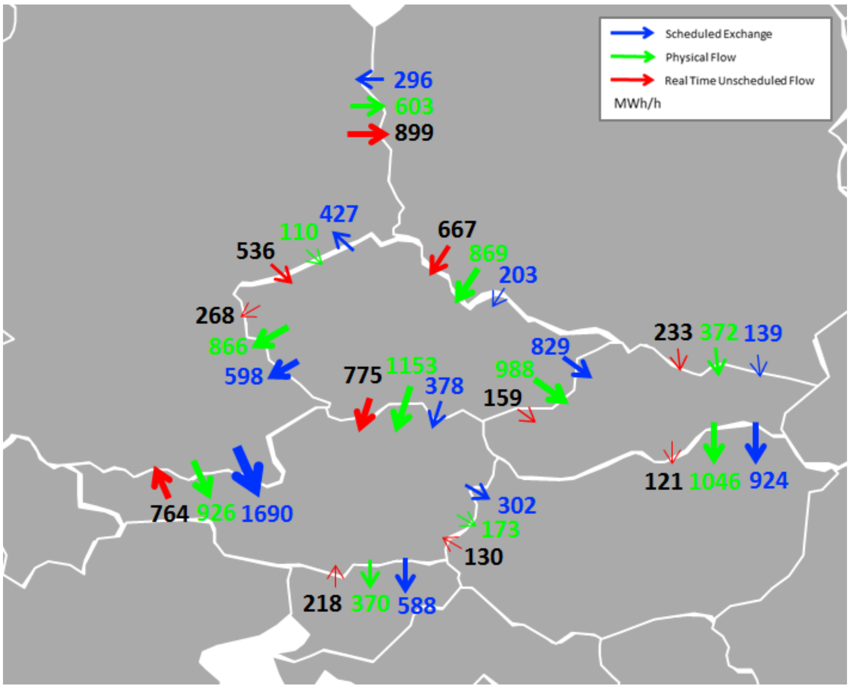


Figure 23: Values of the RTUF indicator for the CEE region with control area resolution for the years 2011 and 2012

[34] Practically implemented flow based market coupling schemes will use more sophisticated PTDF factors, e.g. in the CWE flow based market coupling

[35] For example the biggest improvement (low rations between PTDF and NTC indicators) is observed at the DE-CH (10%), CH-FR (11%, while even in cases of two borders the PTDF indicator suggests higher values of unscheduled flows: SK-HU (107%), and CZ-SK (110%) borders.

[36] TenneT-D-CEPS (dominant power flow from CZ to DE) and 50Hz-CEPS (dominant power flow from DE to CZ)

The data used for this analysis has been extracted from Vulcanus, from internal and publically available TSO data available to CEPS, TenneT-D and 50Hertz. The netting effect between CZ and DE mentioned in the previous paragraph becomes evident.
The efficiency of the future FB mechanism is dependent on several factors (e.g. architecture of bidding zones, appropriateness of the parameters and scenarios used, coordination of grid topology measures, coordination of remedial actions etc.). Of these factors the bidding zone configuration is the focus of this report and also the subsequent Bidding Zone Study.

The magnitude of the non-allocated flows at the DE South/LU (Tennet-D) to AT, DE/LU North (50 Hertz) to Poland, Poland to CZ and CZ to DE/LU North (50 Hertz) borders are the highest in the CEE area for the RTUF indicator. Scheduled flows at the border between DE/LU to AT are about 83% higher than physical flows on that border. Table 6 below provides an overview of the other borders in the region with regard to this analysis. As a comparison, the same analysis for the CZ-SK border shows only a very small deviation between scheduled exchanges and physical flows, confirming the historically strong interconnection between these two zones (one common state in the past).

Table 6: Overview of physical flows, scheduled exchanges and RTUF for the years 2011 and 2012 (in MW)

			physical flow	scheduled exchanges	RTUF	RTUF / physical flow*
DE/LUX South (TenneT-D)	→	AT	926	1690	764	83%
CZ	→	DE/LUX South (TenneT-D)	866	598	268	31%
CZ	→	DE/LUX North (50 Hertz)	-110	427	537	488%
DE/LUX North (50 Hertz)	→	PL	603	-296	899	149%
PL	→	CZ	869	203	666	77%
PL	→	SK	372	139	233	63%
SK	→	HU	1046	924	121	12%
AT	→	HU	173	302	128	74%
AT	→	SL	370	588	218	59%
SK	→	CZ	988	829	159	16%

* absolute positive value

The above analysis raises the question of whether and how the impact of non-allocated flows on market efficiency and network security should be assessed. In this context, the impact of intermittent long distance transmission and its sources and sinks (transits[37] and loop flows[38]) needs particular consideration (cf. Figure 24). These questions and whether a bidding zone configuration can alleviate any relevant issues will form a core part of the Bidding Zone Study in 2014. Several TSOs have already carried out studies related to this subject[39]. These studies will be duly considered.

[37] An energy flow that occurs in a country, that is neither the source nor the sink of the energy flow. The energy flow arrives in the grid over one or more borders and leaves the country over one or more borders

[38] The part of the physical flow on a border between two control areas observed even without any transaction, i.e. flows over control areas caused by origin and destination within one control area.

[39] CEPS/PSE/SEPS/MAVIR study:
http://www.ceps.cz/ENG/Media/Tiskove-zpravy/Documents/120326_Position_of_CEPS_MAVIR_PSEO_SEPS-Bidding_Zones_Definition.pdf
APG study:
http://www.apg.at/de/Global/Pages/~/media/C50DB68C7337445C8077FC843B0DECD5.pdf

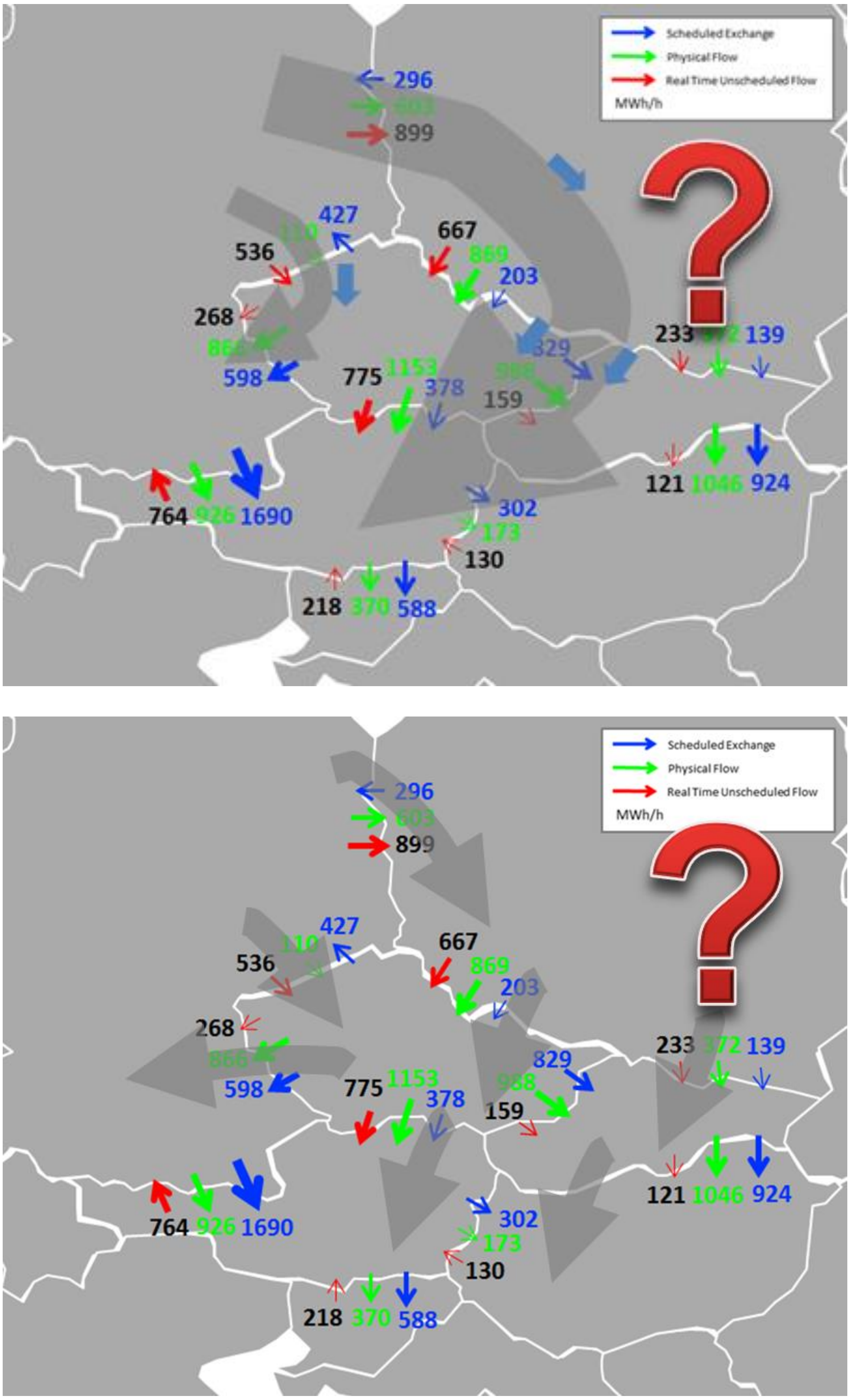


Figure 24: Analysis of CEE region with control area resolution envisaged for the bidding zone study

The flow sources and sinks and directions of Figure 24 are indicative and will be core subjects of the further analysis.

4. Congestion incomes and firmness costs

As stated in the introduction and in the CACM NC, the Technical Report shall include congestion incomes and firmness costs. Generally speaking, these parameters have relevance with regard to bidding zones as they indicate to some extent internal and cross-border congestions. However, additional clarification is required regarding the exact cost types that are to be considered. In the following section, a discussion of the parameters and the performed survey is therefore given before the actual results are presented. In section 4.1 a brief description of the TSO internal survey-setup is provided. Section 4.2 contains the results and section 4.3 draws some general conclusions.

4.1. Interpretation and survey set-up

For the purpose of this Technical Report TSOs have surveyed their congestion incomes, financial firmness costs and physical firmness costs.

4.1.1. Congestion incomes

- Interpretation:
  Congestion incomes refer to the revenues received as a result of capacity allocation[40]

- Survey set-up:
  The total yearly incomes were acquired on a country level for 2011 and 2012. The incomes were gathered on a country and on a border level for those borders where capacity allocation mechanisms exist. In the case of Italy, the income originating from the internal Italian bidding zones is not taken into account.

4.1.2. Financial firmness costs

- Interpretation
  Firmness means arrangements guaranteeing that capacity rights remain unchanged or are compensated when capacity reduction occurs. If there is curtailment of assigned capacity rights, compensation costs are paid. These costs are classified as financial firmness expenses, which include the reimbursement of the original price, compensation of the original price augmented with a specified percentage or compensation in the form of market-spread. Different compensation cases and rules are defined in the European regions.

- Survey set-up:
  Each TSO delivered the set of financial firmness rules that are applicable in its area. More precisely, the different compensation cases and the associated compensation rules were supplied, differentiating for example a “force majeure” case. The related financial firmness costs were delivered on a TSO level for 2011 and 2012.

4.1.3. Physical firmness costs and internal congestion cost

- Interpretation:
  Firmness means arrangements to guarantee that capacity rights remain unchanged or the holders of originally obtained transmission rights are compensated. Physical firmness costs are related to arrangements that guarantee unchanged capacity rights. However, all measures that maintain

[40] see CACM NC

system stability could be considered as measures that guarantee unchanged capacity rights. Therefore the following classification has been applied in order to narrow down the scope of the investigation

- Physical firmness measures
  - Only measures that alleviate congestion are considered as physical firmness measures. The control of power flows is achieved by circuit switching or by changing the generation and/or load pattern.
  - Measures that are related to system stability such as the activation of market-wide reserve capacities or emergency load shedding have not been considered.

- Physical firmness costs
  - Physical firmness costs are related to the physical firmness measures described above.
  - As redispatch measures are taken to accommodate a secure flow resulting from all transactions in a bidding zone, it is not possible to make a clear distinction between measures taken for the firmness of cross border capacity or internal capacity. Therefore all redispatch costs are included in the figures for physical firmness. 'Physical firmness', as represented in the graphs and numbers in this chapter 4, should therefore be read as 'Physical firmness and internal redispatch measures'.
  - Only costs that are direct payments to other actors or the market are considered as physical firmness costs. This includes for example re-dispatch or counter-trading costs.
  - Costs that are not clearly allocated as they are distributed over the system (losses) or are not linked to one event (amortization, wearing) have not been considered.

In conclusion, only costs that are caused by changing the generation and/or load pattern are considered as physical firmness costs or internal redispatch. These costs indicate congestions that remain after the market-based capacity allocation process.

- Survey set-up:
  Each TSO indicated the costs for 2011 and 2012. Cost categories for internal redispatch, cross-border redispatch and counter trading were given. Additional types of physical firmness costs could be added by the TSOs if applicable.

4.2. Results

In general all TSOs were able to provide the data requested. However, the resulting data set made it apparent that drawing hard conclusions regarding the adequacy of the bidding zone configuration based on these numbers is treacherous as explained in the relevant sections.

4.2.1. Congestions incomes

The numbers on congestion income were found to be relatively reliable and comparable. Figure 25 provides the congestion incomes per bidding zone.

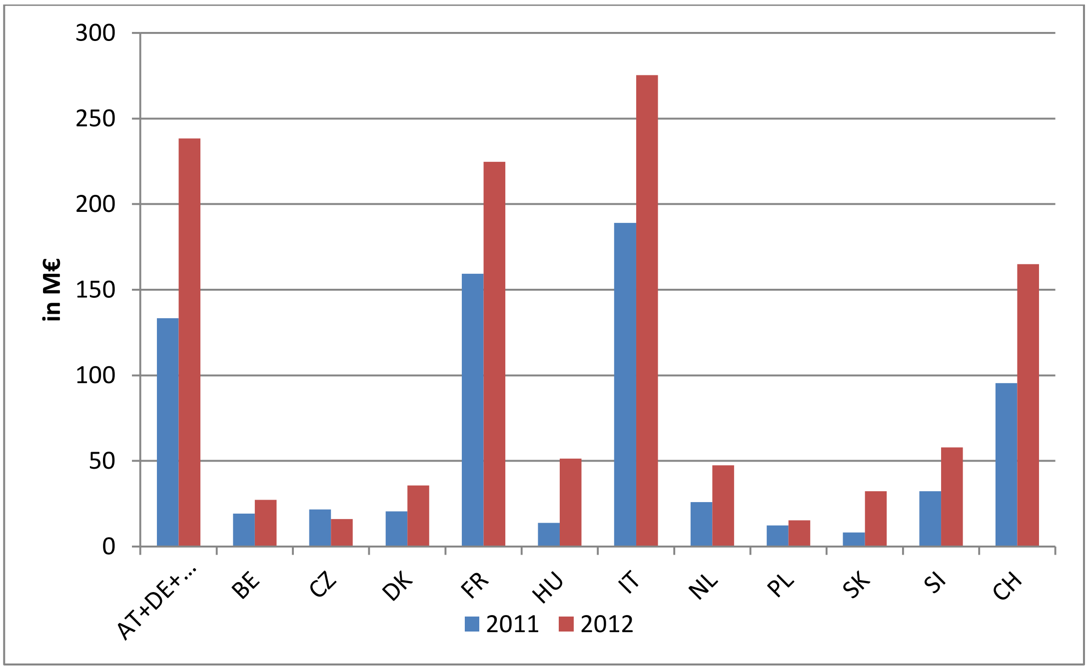


Figure 25: Congestion incomes per bidding zone

Apart from the Czech Republic, all bidding zones experienced higher congestion incomes in 2012 than in 2011. This is primarily driven by a larger price differential between the implicitly coupled markets. The competitiveness of various generation types (coal versus gas and renewable versus fossil fuels) in the wholesale markets has become more distinct. This has increased price spreads and therefore congestion incomes.

Per border

Looking at the different borders in each of the bidding zones the picture is more differentiated, as can be seen in Table 7 below.

Table 7: TSO congestion management incomes 2011 and 2012 [in Mil. EUR]

2011																
TSO	Country		AT	BE	CZ	DK	FR	DE	HU	IT	LU	NL	PL	SK	SI	CH
APG	Austria	AT			4,69				8,05	10,11					6,03	7,62
Elia	Belgium	BE					2,07					16,12				
CEPS	Czech Republic	CZ	4,69					12,58					3,95	0,45		
Energinet	Denmark	DK				3,85		15,94								
RTE	France	FR		2,03				29,65		107,93						0,07
TSO of Amprion +50 HertzT +Tennet +TransnetBW +VKW Netz	Germany	DE			12,48	16,79	28,31					9,81	6,50			24,06
Mavir	Hungary	HU	8,05											5,83		
Terna	Italia	IT	10,11				104,90								26,28	63,69
CREOS	Luxembourg	LU														
Tennet	Netherlands	NL		17,20				7,30								
PSE Operator	Poland	PL			4,00			6,31						1,85		
SEPS	Slovak Republic	SK			0,45				5,83				1,78			
ELES	Slovenia	SI	6,03							26,28						
Swissgrid	Switzerland	CH	7,62					25,20		44,74						
Total			**36,49**	**19,23**	**21,62**	**20,63**	**135,28**	**96,98**	**13,88**	**189,06**	**0,00**	**25,93**	**12,23**	**8,12**	**32,31**	**95,44**

2012			TSO's congestion management revenues on border with:													
TSO	Country		AT	BE	CZ	DK	FR	DE	HU	IT	LU	NL	PL	SK	SI	CH
Verbund APG	Austria	AT			3,19				24,22	17,42					25,30	12,52
Elia	Belgium	BE					12,86					15,85				
CEPS	Czech Republic	CZ	3,19					8,00					3,08	1,73		
Energinet.dk	Denmark	DK				4,63		31,95								
RTE	France	FR		12,14				47,88		146,78						15,16
TSO of TransnetBW +Amprion +50 Hertz +TenneT TSO GmbH	Germany	DE			8,03	31,08	48,30					31,62	8,70			25,20
Mavir	Hungary	HU	24,22											27,20		
Terna	Italia	IT	17,42				148,44								32,59	112,10
CREOS	Luxembourg	LU														
TenneT TSO B.V.	Netherlands	NL		15,14				34,17								
PSE S.A.	Poland	PL			3,08			8,69						3,45		
SEPS	Slovak Republic	SK			1,73				27,20				3,47			
ELES	Slovenia	SI	25,30							32,59						
Swissgrid	Switzerland	CH	12,52				15,17	24,98		78,67						
Total			**82,65**	**27,28**	**16,03**	**35,72**	**224,77**	**155,66**	**51,42**	**275,45**	**0,00**	**47,47**	**15,25**	**32,38**	**57,89**	**164,98**

Increases larger than 100% between 2011 and 2012 were witnessed at the following borders: AT – HU; AT – SI; BE – FR; CZ – SK; DE – DK; DE – NL; HU – SK and FR – CH.
Congestion incomes decreased at the following borders: CZ – AT; BE – NL; CZ – DE; CZ – PL and CH – DE.
As it can be seen from Table 7, congestion incomes are most often shared 50/50 by the neighbouring TSOs, but it also happens that the auction income share per border is different. Differences can furthermore be explained by the different processes and agreements that are valid for the border in question (e.g. one TSO ensures the physical firmness of capacity and the other one performs curtailment and pays back 100% compensation from its own congestion management revenue) or by different accounting policies.

4.2.2. Financial firmness costs

As financial firmness costs are relatively well defined, TSOs did not encounter difficulties in reporting them. The comparability however is affected by the differences in the detailed auction rules:

- CEE Auction rules: Compensation is paid if there is a curtailment of allocated Physical Transmission Rights (PTRs) or a curtailment of nominated PTRs. The compensation is based on the original auction price. There is no compensation in the case of force majeure.

- CWE Auction rules[41]: In this region, there is market-coupling in place but the financial firmness rules depend on the borders and the origin of the reduction (safety of the power system or force majeure). The reimbursed price can be based on the reason for the reduction, the marginal price of auctions with compensation or the capped day ahead spot spread[42].

- CSE Auction rules[43]: In case of curtailment, the original auction price is paid back (reimbursement). The only exception is the FR-IT border, at which 110% of the original auction price is paid as compensation. Before the nomination deadline, the curtailments can be performed for a certain number of hours per year (up to 35 equivalent days). If this limit per border is reached, the capacity has to be physically firm.

Financial firmness costs for 2011 and 2012 are shown in Figure 27. For some bidding zones, substantial financial firmness costs were experienced.

[41] http://www.casc.eu/en/News--Events/News/CWE-Auction-Rules-v22
[42] for more detailed information, please refer to the CWE auction rules V2.2.
[43] one set of auction rules within CWE for 2012.

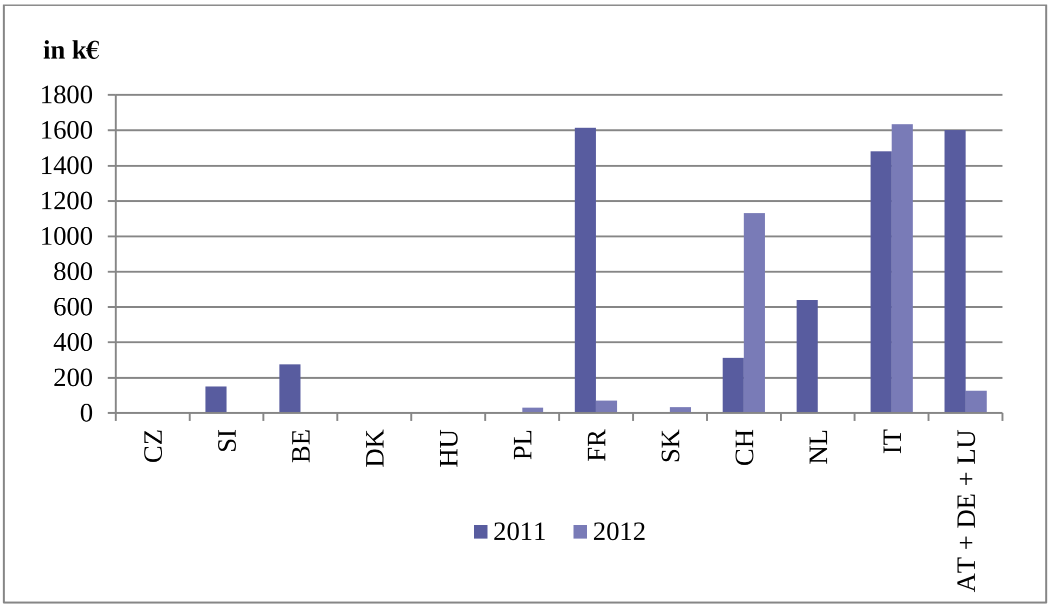


Figure 26: Total financial firmness costs

The financial firmness costs experienced by TSOs are incidental. In the first week of February 2011, for instance, an incident was recorded in the CWE region. This accounts for all the costs in this year in Belgium and the Netherlands, and for some in France and Germany. Due to this incidental character no conclusions on trends or tendency can be drawn based on the numbers for 2011 and 2012.
Typically the order of magnitude is significantly smaller than the physical firmness costs discussed below.

4.2.3. Physical firmness costs and internal redispatch costs[44]

The costs shown in Figure 28 represent the sum of the costs for 'cross-border redispatch measures', 'countertrading' and 'internal redispatch measures'.

It has to be noted that the comparison of the physical firmness costs can only be indicative. There are substantial differences between the different countries.
Among other points, this relates to:

- the categorization of measures as physical firmness measures
- the interdependency to other grid management measures (e.g. congestion management, voltage control, balancing)
- the trigger for the measures (e.g. local vs. regional congestion)
- the monitoring of measures and related costs
- regulatory, system dispatch and market arrangements for the determination of redispatch costs
- the availability of power plants and the respective cost structure and availability of alternatives to the TSOs (e.g. topology measures)

A direct comparison is therefore hardly applicable. For this reason, the redispatch costs and measures are described for each bidding zone separately in the following.

[44] Two types of data were collected with regard to physical firmness and internal redispatch: volumes and costs. The volume data was not sufficiently robust to be shown here.

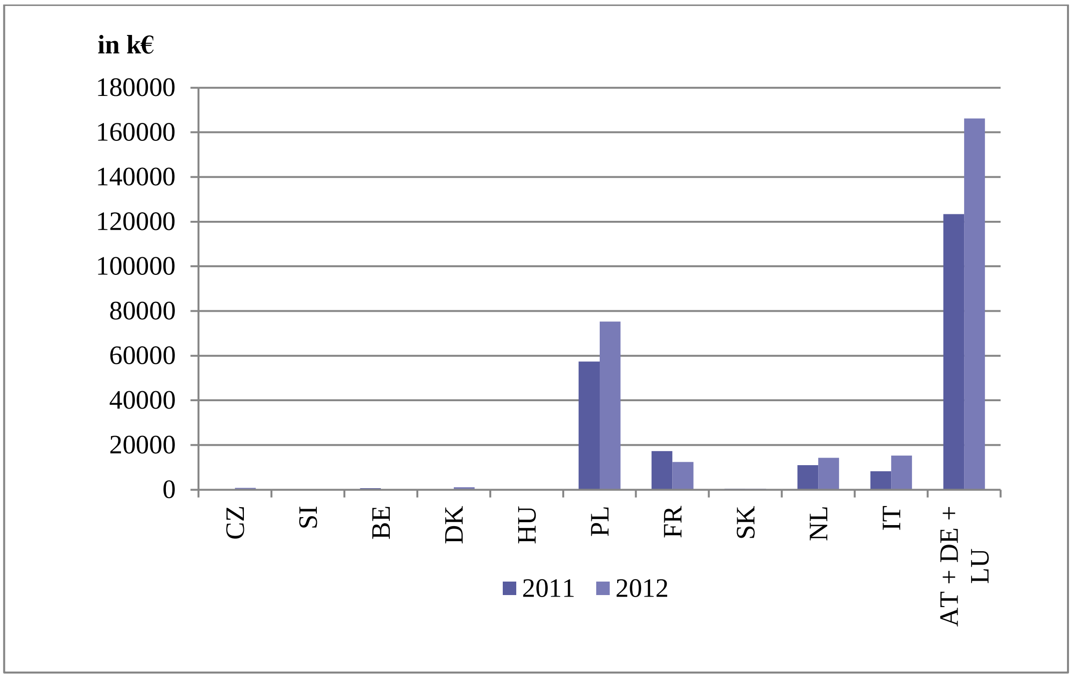


Figure 27: Physical firmness and internal redispatch costs

- <u>Austria/Germany/Luxembourg</u>
  The Austrian-German-Luxembourgian bidding zone experienced total physical firmness costs of 123448 k€ in 2011 and 166182 k€ in 2012. The numbers summarize all costly remedial actions for the management of transmission congestions within the bidding zone and at its borders. Different forms of internal and cross-border redispatching and countertrading were applied. The main driver is the congestion between Remptendorf (50Hertz) and Redwitz (TenneT). A new line is currently under construction and is planned to be finished in 2015.

- <u>Belgium</u>
  The physical firmness costs in Belgium consisted of internal redispatch amounted to 660 k€ and 144 k€ in 2011 and 2012 respectively (since there was no cross- border redispatch during the studied period). This is to be considered in combination with the absence of any reported clusters of congestion in the area during real-time operations (which justifies the limited magnitude of these figures).

- <u>Czech Republic</u>
  CEPS faced 23 k€ and 62 k€ internal redispatch costs in 2011 and 2012 respectively. On cross border redispatch measures CEPS had to spend 44 k€ and 800 k€ in 2011 and 2012 respectively.

- <u>Denmark</u>
  In 2011 ENDK faced 318 k€ physical firmness costs and in 2012 these costs were 1170 k€. The figures for both years include a positive contribution from countertrading.

- <u>France</u>
  Rte faced 18072 k€ physical firmness costs in 2011 and 11832 k€ in 2012 mainly due to internal structural congestion (in Brittany and the south east). Redispatch costs for voltage control are not included in these numbers.

- Hungary
  Hungary experienced no physical firmness costs in the years 2011 and 2012.

- Italy
  TERNA had 8274 k€ physical firmness costs in 2011 and 15.241 k€ in 2012. In addition, TERNA reported 19115 k€ and 43386 k€ costs respectively for local congestion in the internal grid.

- The Netherlands
  In the Netherlands, TenneT experienced high physical firmness costs because of internal congestion not related to cross-border capacity. Due to the connection of new power plants before the completion of necessary grid reinforcements in the Maasvlakte region, congestion management was needed. These costs accounted for 85% and 57% respectively of the reported physical firmness costs of 10976 k€ and 14230 k€ in 2011 and 2012. In 2013, the grid reinforcement for the area concerned was completed.

- Poland
  PSE reported costs of 57319 k€ for 2011 and 75227 k€ in 2012 for physical firmness costs and internal redispatch costs. Poland has a central dispatch system. PSE conducts an integrated balancing and congestion management process. In this process, the influence of neighbouring systems is taken into account. Therefore, internal congestion management costs include the cost of preventive measures concerning cross-border flows. These actions are performed in an integrated process. The reported internal redispatch costs encompass all costs borne by TSO resulting from system balancing and congestion management, including the costs of measures that are not relevant with regard to a bidding zone design.
  Because of the reporting of all costs as mentioned earlier internal redispatch costs are relatively high (56882 k€ in 2011 and 74038 k€ in 2012). On the other hand, cross-border redispatching costs and countertrading costs are relatively low (437 k€ in 2011 and 1189 k€ in 2012).

- Slovakia
  SEPS experienced physical firmness costs of 364 k€ in 2011 and 397 k€ in 2012.

- Slovenia
  ELES experienced no physical firmness costs in 2011 and 2012.

- Switzerland
  Due to differences in the commercial redispatching arrangements, Swissgrid reported physical volumes for firmness for both years. Internal redispatch volumes were 1989 MWh for 2011 and 2870 MWh for 2012. Cross-border redispatch measures for these years were 29510 MWh and 86287 MWh.

4.3. Conclusions

The difference in reported numbers, notably on physical firmness, cannot be interpreted as a difference in robustness of the various grids per se. Reported costs of firmness vary widely across the bidding zones. This variation can come from a variation in the level of control over dispatching by the TSO in the various countries, variation in robustness of the grid within the bidding zone and the differences in redispatch options as well as the monitoring obligations.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Also specific (temporary) situations within a country can have substantial impact on firmness costs, notably internal redispatch in a given period.

The following conclusions must therefore be considered to be of a general and indicative nature.
Congestion incomes have increased in 2012. This indicates a decreasing potential for enlarging bidding zones. However, congestion incomes vary considerably from year to year. This variation primarily stems from different fuel mixes and the varying competitiveness of the generation assets at both sides of each border resulting from fluctuations in fuel prices (among other factors). For a bidding zone review this means that no conclusions can be based on this indicator solely.

Physical firmness costs differ largely between countries. In most countries, they are zero or close to zero. Relevant costs are only shown for PL, FR and DE/AT/LU. The highest costs are seen for the DE/AT/LU zone. For all countries, an increase can be witnessed.

Financial firmness costs are of a magnitude lower than physical firmness costs. Their relevance is therefore limited. In 2011, the financial firmness costs were generally higher than in 2012. For example, in DE/AT/LU or FR there were nearly no costs in 2012 but relatively high costs in 2011. The highest amount of financial firmness costs on the whole period 2011-2012 can be seen for Italy. This phenomenon can be explained as a consequence of the different approaches of capacity calculation and allocation methodologies which are applied at the Northern Italian border (top-down approach). In general financial firmness costs are driven by infrequent events therefore changes cannot be interpreted as a trend.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

5. Final Summary

In this Technical Report

- Present congestions and their main evolution;
- Power flows not resulting from capacity allocation; and
- Congestion incomes and firmness costs

have been analysed.

The present congestions have been represented graphically and descriptions have been provided. These descriptions include outlooks on their future evolution.

Three indicators have been developed for the power flows not resulting from capacity allocation. They have been applied to the bidding zone borders of the area under investigation. A complementary analysis has been provided for the CEE region.

Congestion incomes and firmness costs have been supplied by all TSOs. The Report contains overviews of the collected information.

In terms of the underlying data, both internal TSO information and externally available data has been used. For upcoming Technical Reports further alignment of the collected data will be a core requirement to further enhance the reliability and comparability of the analyses.

This Technical Report does not contain any explicit recommendation as to whether a bidding zone review should be launched. In their letter dated August 30th 2012, ACER and NRAs invited ENTSO-E "to start an early implementation of the process for reviewing the bidding zones as foreseen in the nearly finalized Network Code on CACM". Therefore, the bidding zone review process specified in the CACM NC will be pursued by ENTSO-E.

The outcomes of the Technical Report analyses will be used as an input into this analysis of the current bidding zone configuration and potential alternative scenarios. The bidding zone review study may further encompass Load Flow Analyses, Market Studies, and Statistical and Regression Analyses.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Annex 1: Abbreviations

ACER	Agency for the Cooperation of Energy Regulators
AT	Austria
ATC	Available Transfer Capacity
BE	Belgium
CACM	Capacity Allocation and Congestion Management
CASC	Capacity Allocating Service Company
CEE	Central and Eastern Europe
CGM	Common reference Grid Model
CH	Switzerland
CSE	Continental South East
CWE	Central Western Europe
CWE MC	CWE Market Coupling
CZ	Czech Republic
D-1	One day prior to real time
D-2	Two days prior to real time
D2CF	Congestion Forecasts two Days prior to real time
DA	Day Ahead
DACF	Day Ahead Congestion Forecast
DC	Direct Current
DE	Germany
DEAT	Germany and Austria
DK	Denmark
EEX	European Energy Exchange
ENTSO-E	European Network of Transmission System Operators for Electricity
FBA	Flow Based Allocation
FR	France
GSK	Generation Shift Key
HU	Hungary
HVDC	High-Voltage Direct Current
IDCF	Intra Day Congestion Forecast
IEM flows	Internal Electricity Market flows
IT	Italy
LFC	Load Frequency Control
LU	Luxembourg
NC	Network Code
NL	Netherlands
NRA	National Regulatory Authorities
NTC	Net Transfer Capacity
OHL	Overhead Line
PL	Poland
PST	Phase Shifting Transformers
PTDF	Power Transfer Distribution Factor

PTR	Physical Transmission Rights
RES	Renewable Energy Sources
SI	Slovenia
SK	Slovakia
TSC	TSO Security Cooperation
TSO	Transmission System Operator
VUEN	Vorarlberger Übertragungsnetze

Annex 2: Bidding zone connections

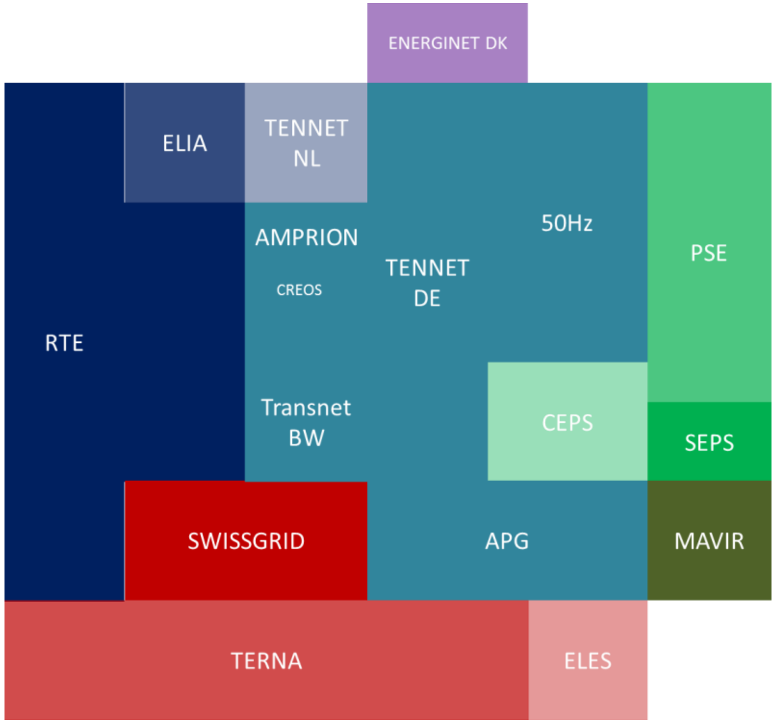


Figure 28: Current bidding zone borders: Control area resolution

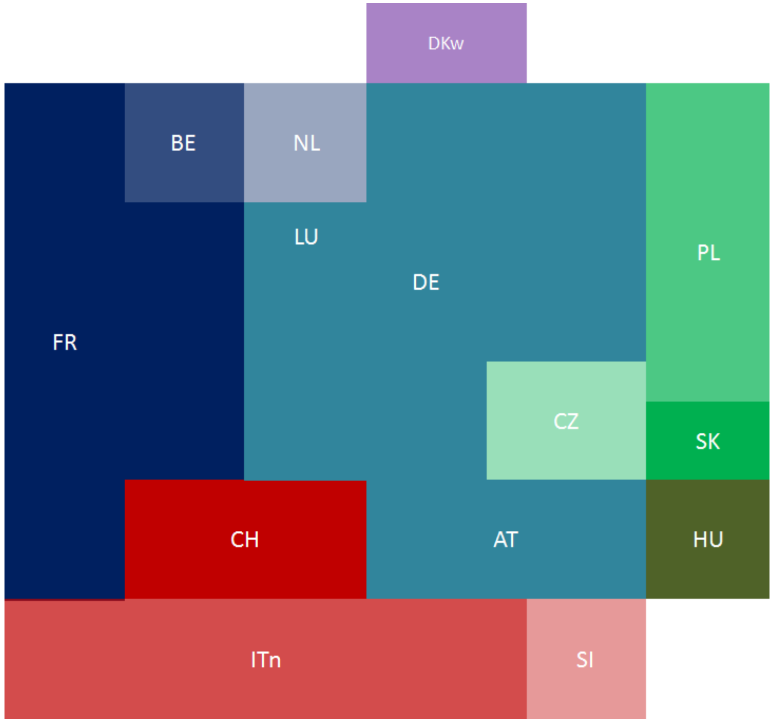


Figure 29: Current bidding zone borders: Country resolution

Annex 3: Net Transfer Capacity between bidding zones

Figure 6.1:
Illustration of Net Transfer Capacities in Europe (summer 2010/11)

Figure 30: Net Transfer Capacity between bidding zones

(Source: TYNDP 2012)

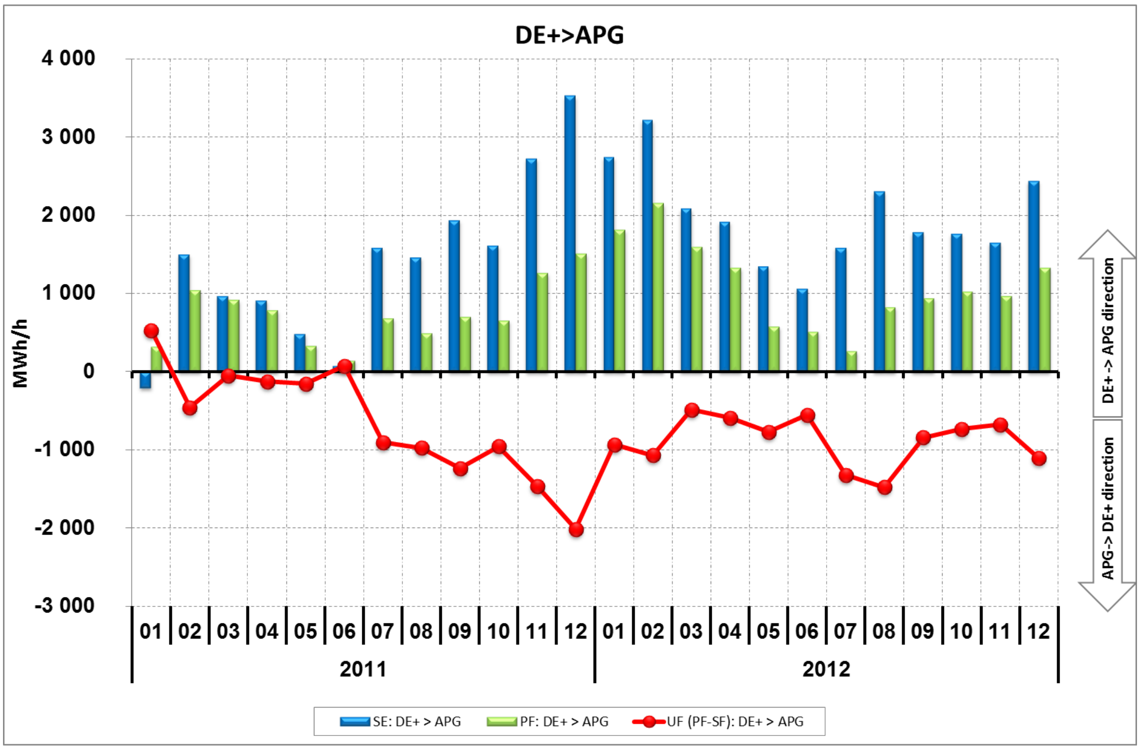
Annex 4: Monthly average graphs for non-allocated flow indicators

Annex 4.1. Individual border monthly averages RTUF indicator

The indicator shows the part of these transactions which physically flows through the neighboring systems.

Germany-Austria

The figure below shows the evolution of monthly average values of Realised Scheduled Exchanges, Measured Physical Flows and Unscheduled Flows (RTUF) for the border between DE and AT. This border is the one that exchanges by far the highest volume of energy. Scheduled exchanges exceeding 4 000 – 5 000 MWh/h are not rare. One can clearly see that commercial transactions DE→AT are in most time stamps higher than the Physical Power Flows on this border

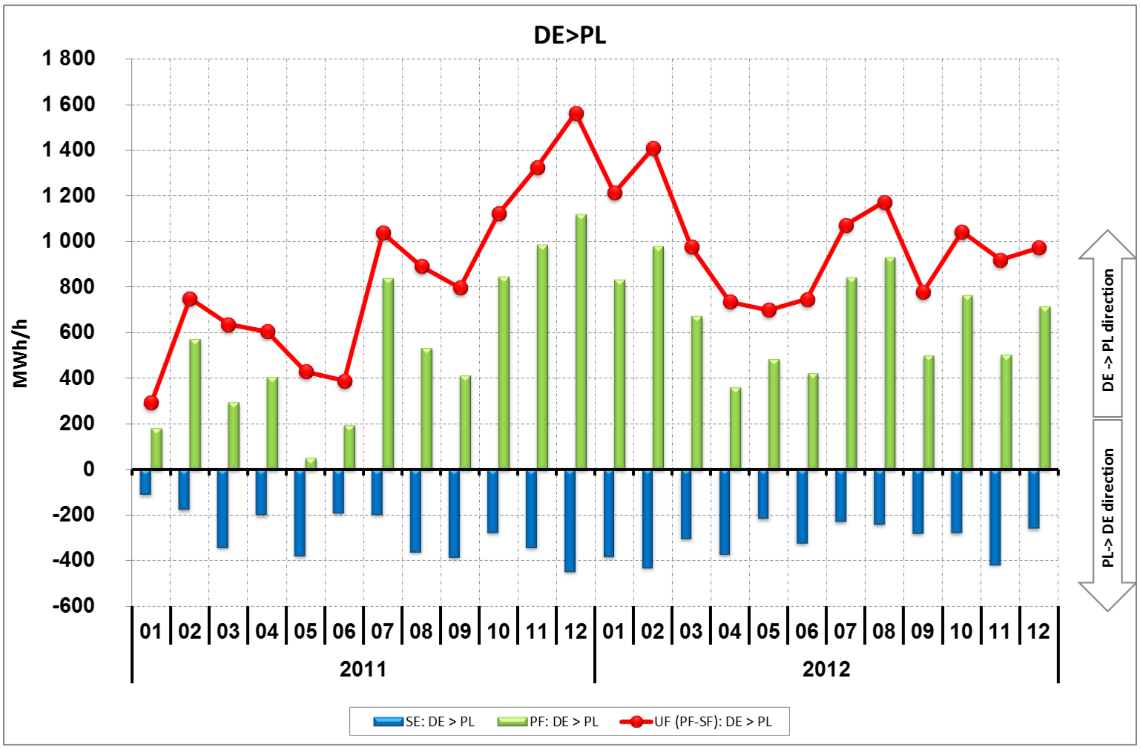


ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Germany-Poland

The Figure below shows the evolution of monthly averages values of Realised Scheduled Exchanges, Measured Physical Flows and Unscheduled Flows (RTUF) for the border between Germany and Poland. One can clearly see that the direction of the physical flow is usually in the opposite direction to the commercial schedules (schedules: PL→DE, flow: DE→PL).

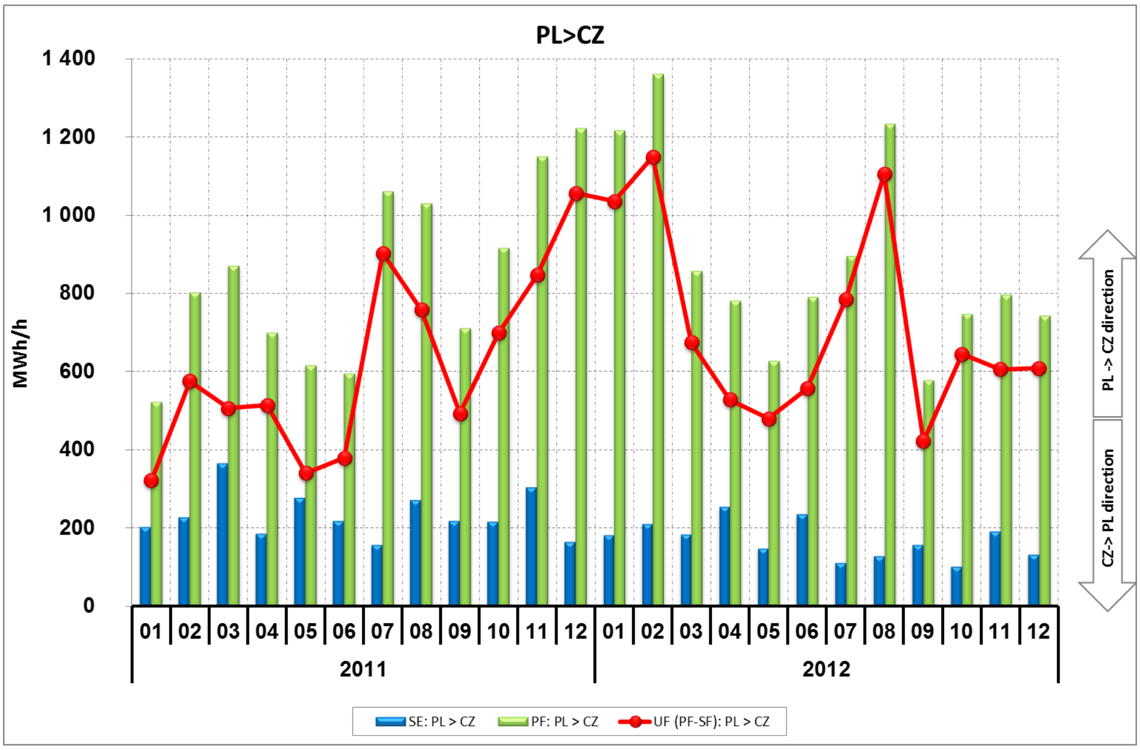
During the whole analysed period (January 2011 – December 2012) the measured physical flows on the DE-PL border were much higher and had the opposite direction than the Realised Scheduled Exchanges between these countries. There was a permanent and high level of monthly averages unscheduled flows: 750 – 1 600 MWh/h in the period July 2011 – December 2012.



Poland-Czech Republic

The figure below shows the evolution of monthly averages values of Realised Scheduled Exchanges, Measured Physical Flows and Unscheduled Flows (RTUF) for the border between Poland and the Czech Republic. The level of Unscheduled Flows on the PL-CZ border is only slightly lower than on the DE-PL border and ranges between 300 – 1 200 MWh/h. The pattern of Unscheduled Flows is similar to that on the DE-PL border.

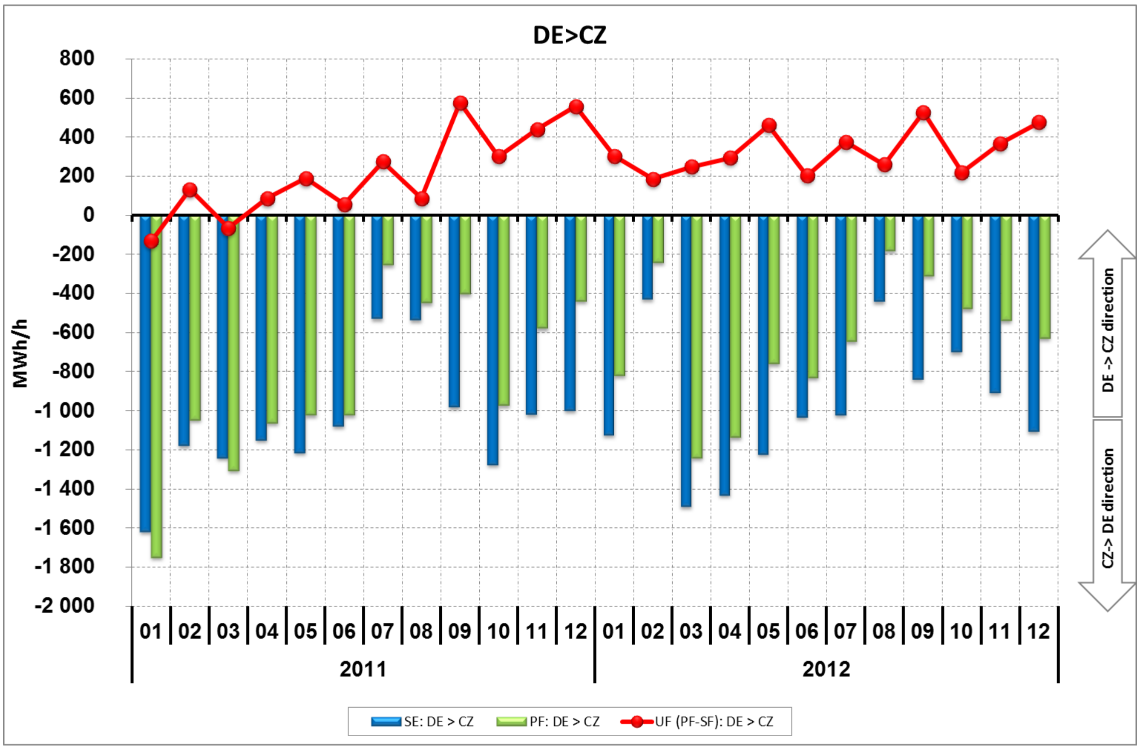
During the whole analysed period (January 2011 – December 2012) the measured physical flows on the PL-CZ border were much higher than the Realised Scheduled Exchanges between these countries. This was quite similar to the situation on the DE-PL border, except that on the PL-CZ border the direction of scheduling was usually the same as the direction of flow.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

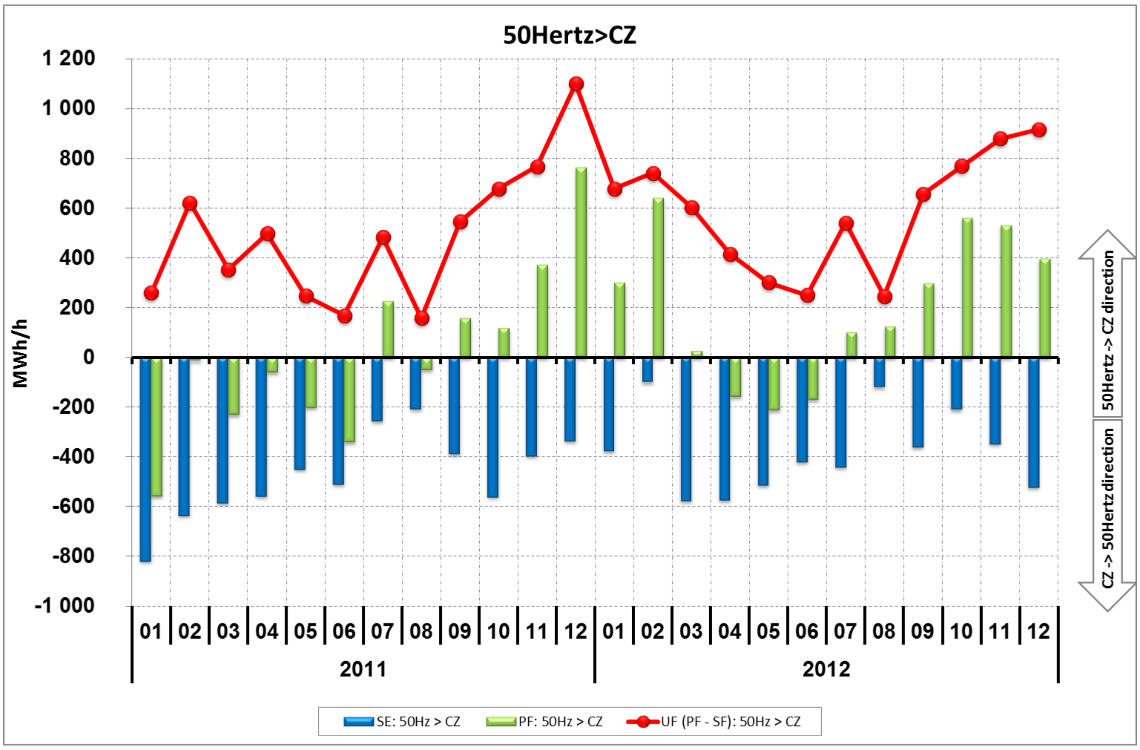
Czech Republic – Germany

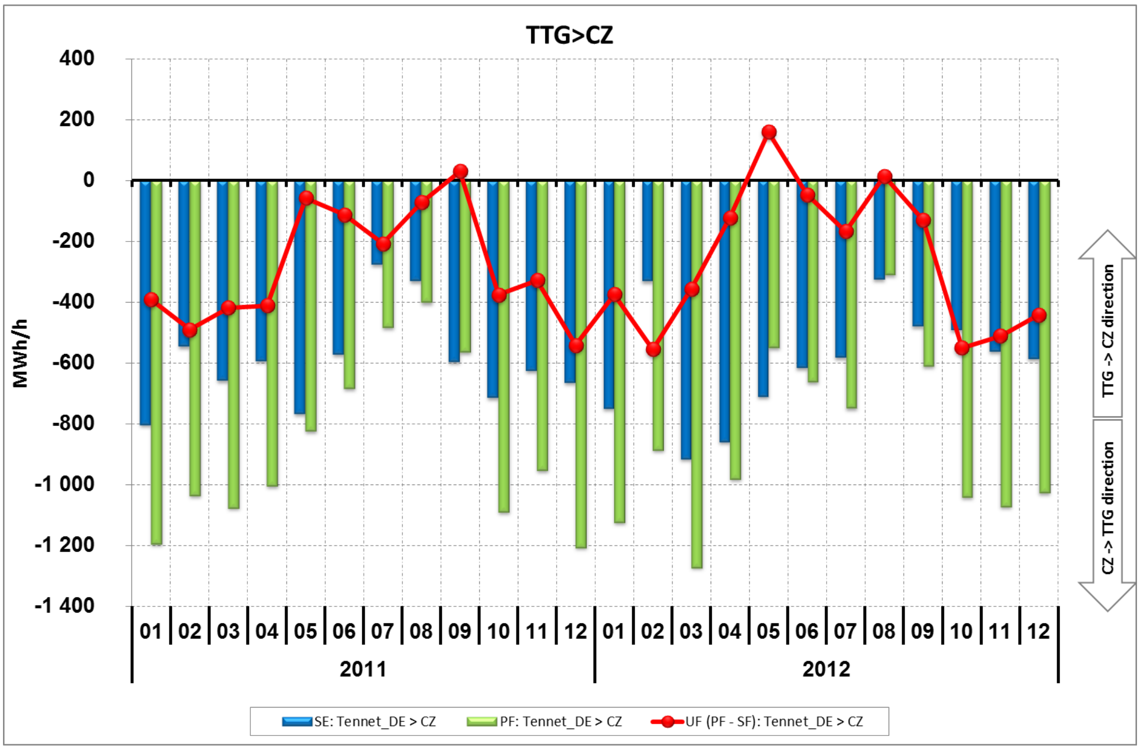
In the figure below, the evolution of monthly averages values of Realised Schedules, Measured Load Flows and Unscheduled Flows (RTUF) for the whole border between the Czech Republic and Germany is shown.



At first sight, unscheduled flows do not seem too high for this border. In Vulcanus, the interconnections ČEPS-50Hertz and ČEPS-TenneT-D (TenneT Germany) are aggregated as one common profile. However, in the case of this border, the loading of both interconnections is structurally different, as one conducts power flows in the direction usually from 50Hertz to ČEPS (DE→CZ) and the other one from ČEPS to TenneT-D (CZ→DE), therefore the aggregated nature of the Vulcanus database introducing a strong netting effect.

On one set of interconnecting lines the power flows usually in the direction from 50Hertz to ČEPS (from DE to the CZ) and the other one from ČEPS to TenneT-D (from the CZ to DE). Hence, a separate assessment for the cross-border profile between ČEPS and 50Hertz had to be done. The Figures below show the evolution of monthly averages values of Realised Schedules, Measured Load Flows and Unscheduled Flows for the border between the CZ and DE for each set of interconnection lines separately. For a better understanding of the phenomenon of unscheduled power flows in this area, it was split into two parts: (i) DE (50 Hertz)→CZ and (ii) DE (TenneT-D)→CZ.

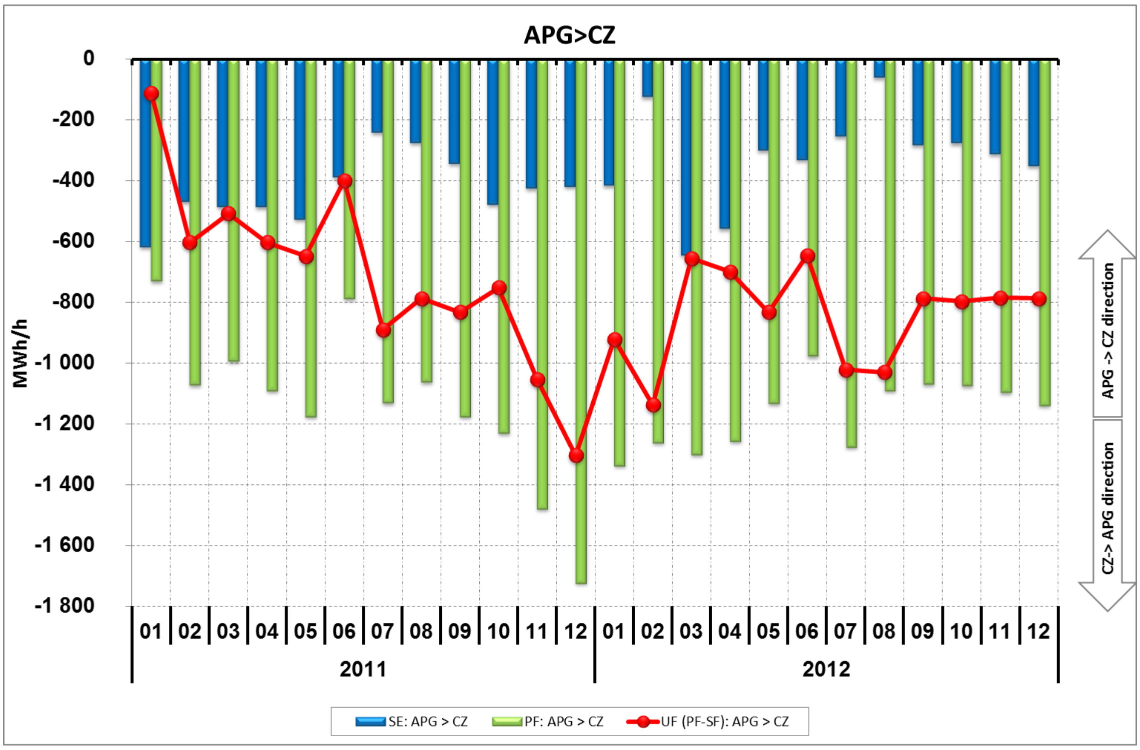

50Hertz>CZ
MWh/h
1 200
1 000
800
600
400
200
0
-200
-400
-600
-800
-1 000
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
50Hertz -> CZ direction
CZ -> 50Hertz direction
SE: 50Hz > CZ
PF: 50Hz > CZ
UF (PF - SF): 50Hz > CZ


TTG>CZ
MWh/h
400
200
0
-200
-400
-600
-800
-1 000
-1 200
-1 400
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
TTG -> CZ direction
CZ -> TTG direction
SE: Tennet_DE > CZ
PF: Tennet_DE > CZ
UF (PF - SF): Tennet_DE > CZ

Czech Republic – Austria

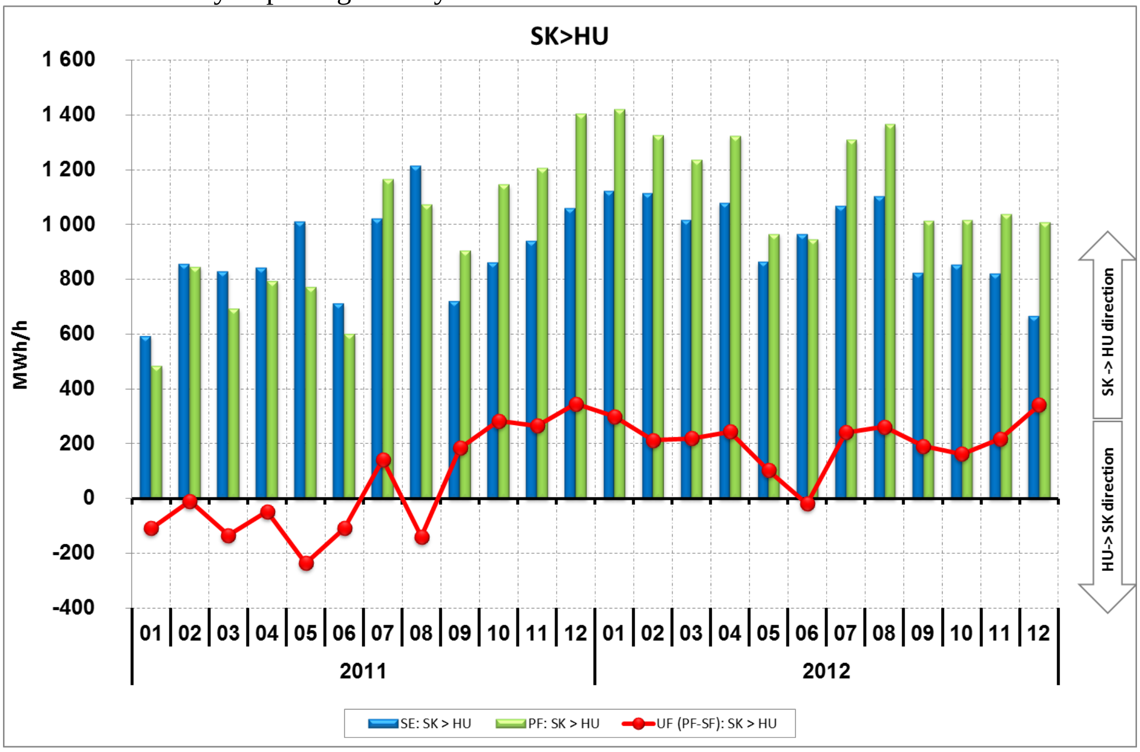
The Figure below shows the evolution of monthly averages values of Realised Scheduled Exchanges, Measured Physical Flows and Unscheduled Flows (RTUF) for the border between the Czech Republic and Austria. The level of Unscheduled Flows on the AT-CZ border is in range between 100 – 1 300 MWh/h.

During the whole analysed period (January 2011 – December 2012) the measured physical flows on the AT-CZ border were much higher than the Realised Scheduled Exchanges between these countries. There was a permanent and high level of monthly average unscheduled flows: 750 – 1 300 MWh/h in the period July 2011 – December 2012.



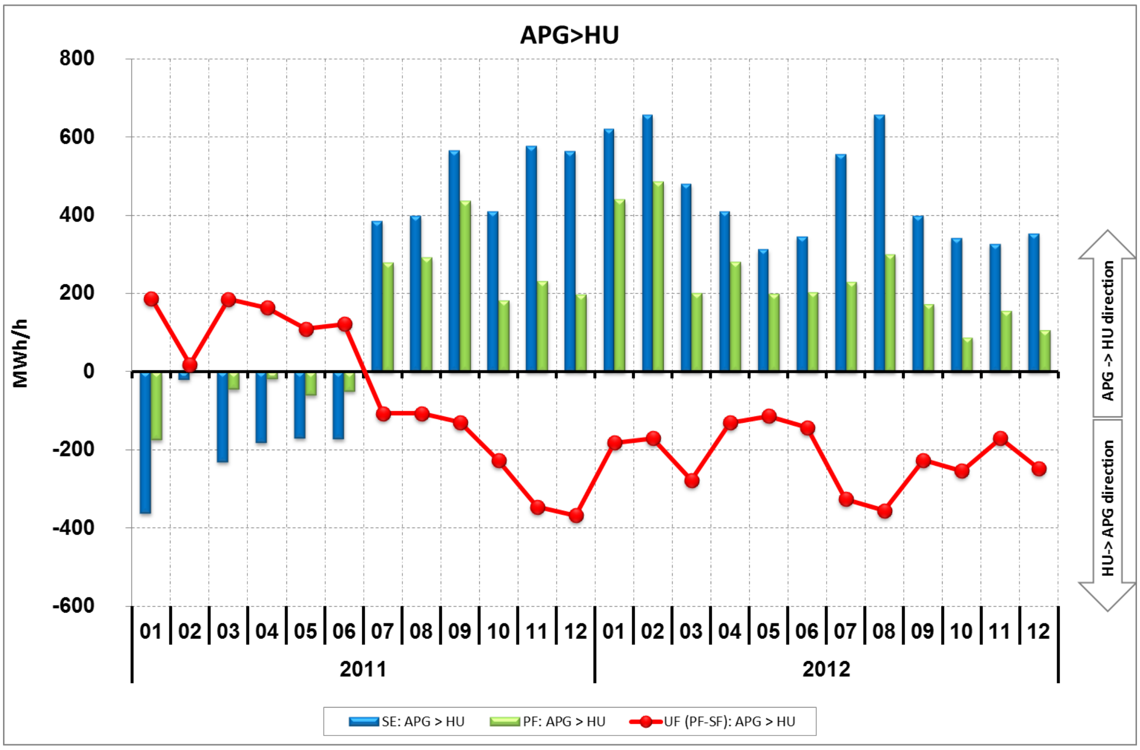
Slovakia-Hungary

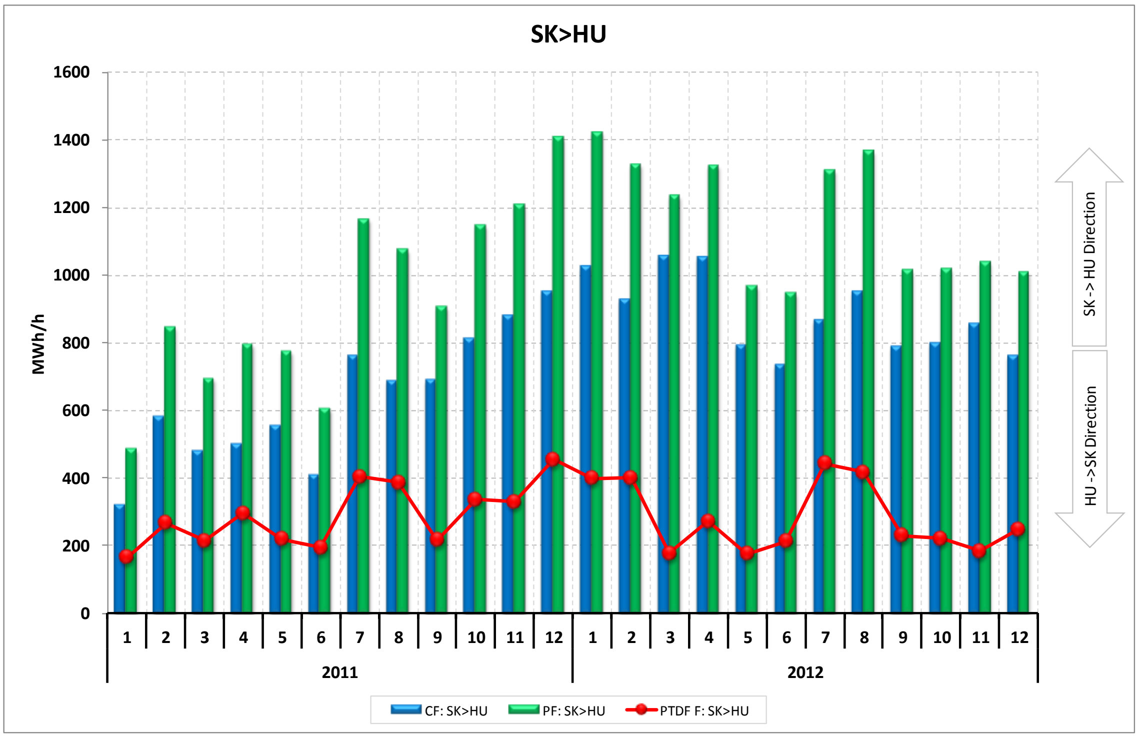
The Figure below shows the evolution of monthly average values of Realised Scheduled Exchanges, Measured Physical Flows and Unscheduled Flows for the border between Slovakia and Hungary. Even if this profile is not the most affected border, one can see a dominant unscheduled flow – with minor exceptions – in the direction SK→HU in the second half of 2011 and the whole 2012. During this period of time the average values of unscheduled power flows reach 200 - 300 MWh/h, which is less compared to levels reached on the most affected borders. Irrespective of their comparatively moderate magnitude these unscheduled flows have been the cause for operational remedial actions taken by some TSOs in the concerned area (e.g. changes of the network topology by SEPS that have a negative impact on operational security level and loses in the system). However, the SK-HU profile is the major import direction for Hungary and as such is very important for ensuring a reliable power supply for this structurally importing country.

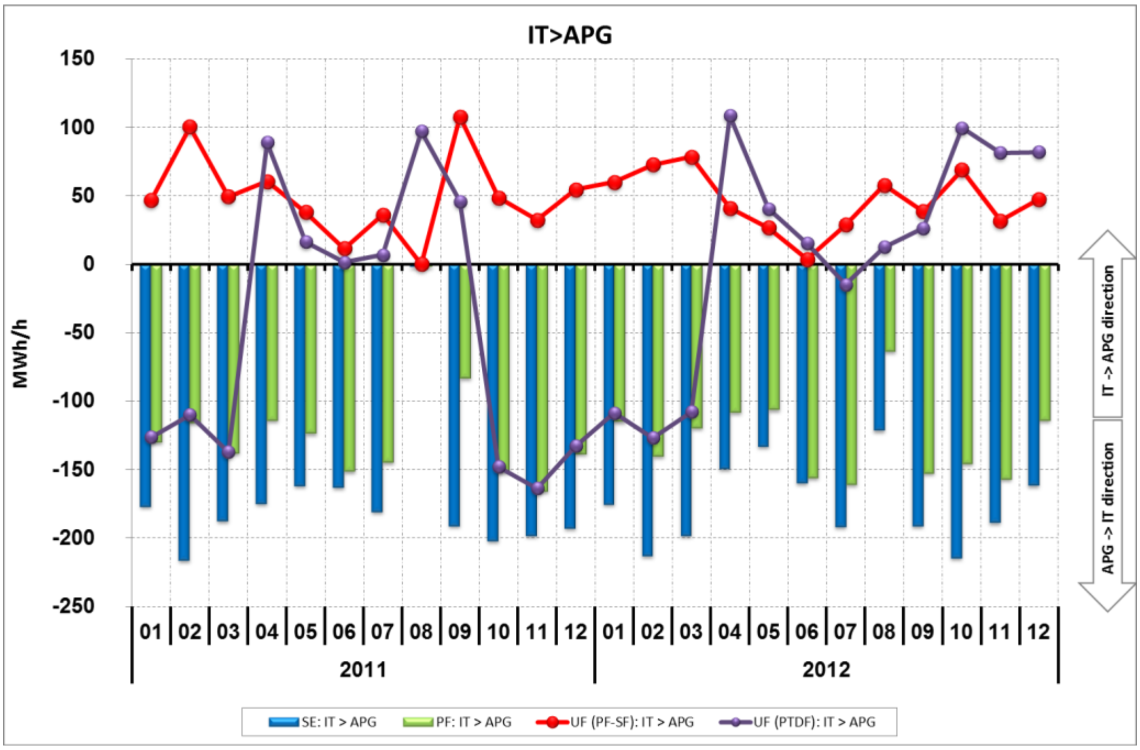


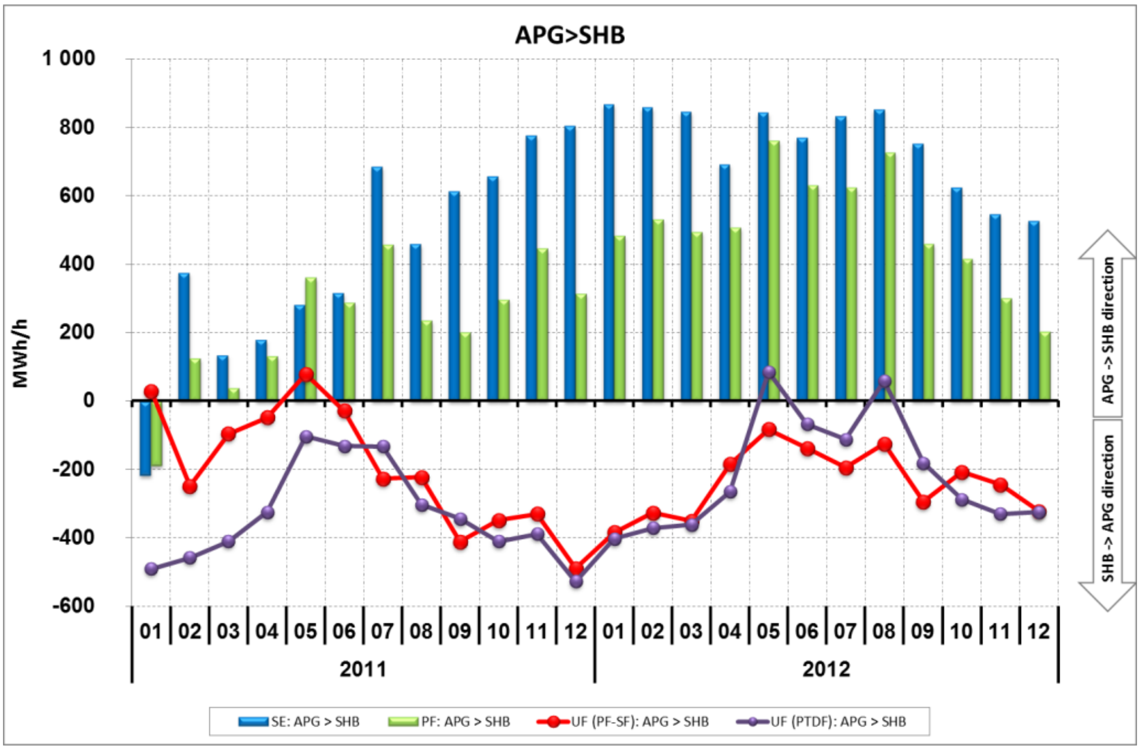
Austria-Hungary

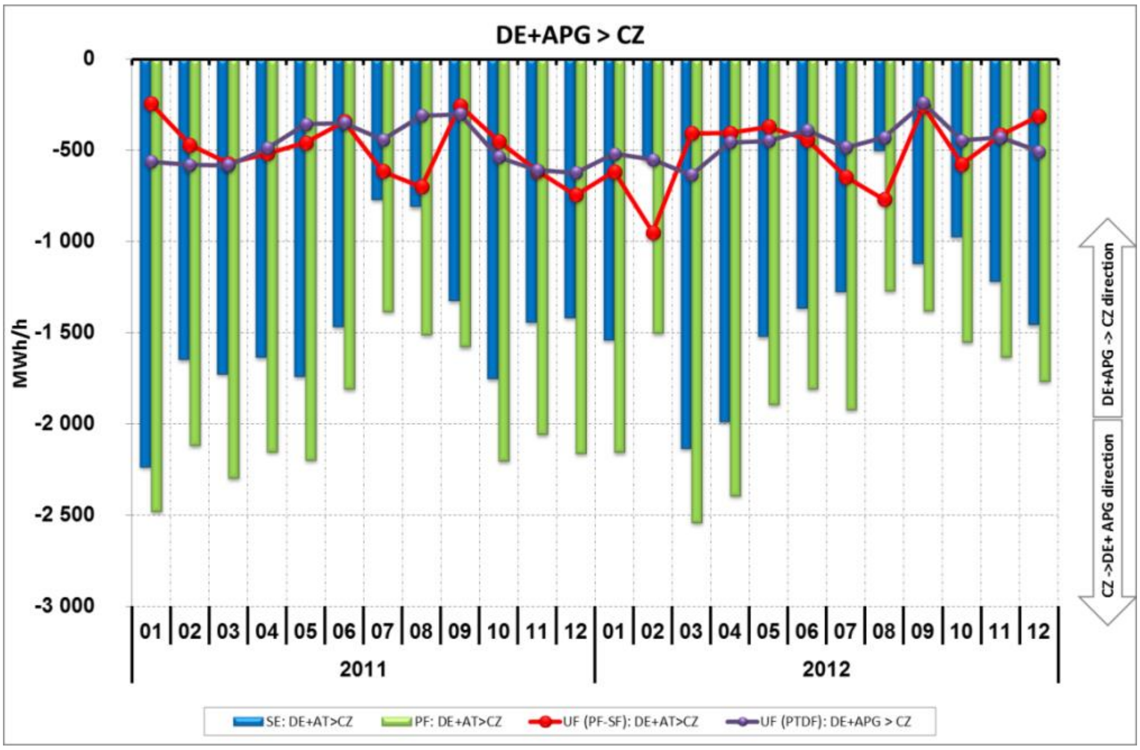
The Figure below shows the evolution of monthly average values of Realised Scheduled Exchanges, Measured Physical Flows and Unscheduled Flows for the border between Austria and Hungary. One can see that in the first half of 2011 the direction of Unscheduled Flows was AT→HU and remained at the level between (0, 200 MWh/h). From that time, in the second half of 2011 and the whole 2012, the monthly average level of unscheduled flows was much higher, in the direction HU→AT, sometimes reaching almost 400 MWh/h.

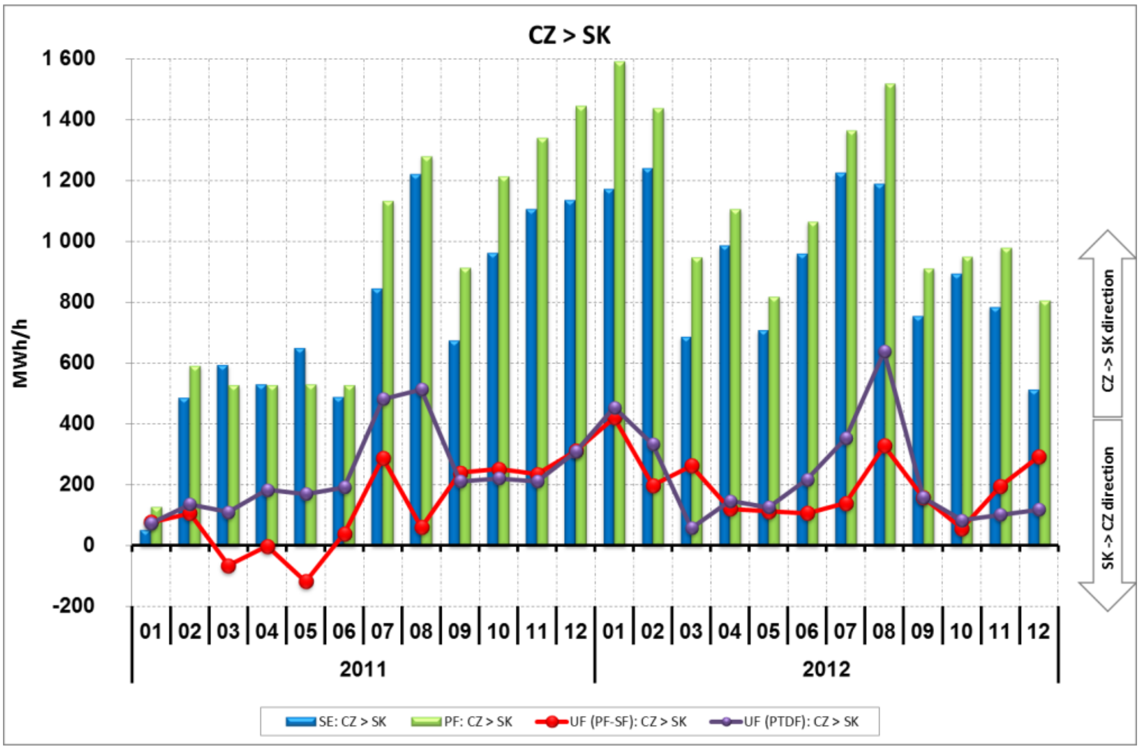


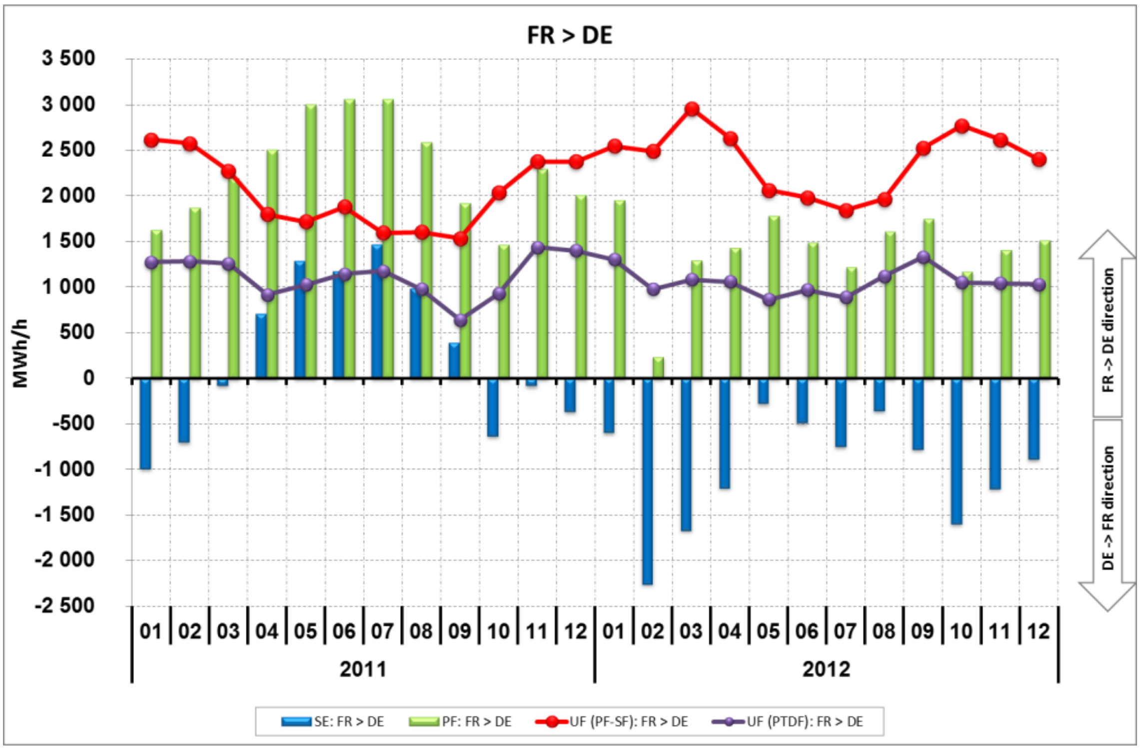

SK>HU
1600
1400
1200
1000
800
600
400
200
0
MWh/h
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
SK -> HU Direction
HU -> SK Direction
CF: SK>HU
PF: SK>HU
PTDF F: SK>HU

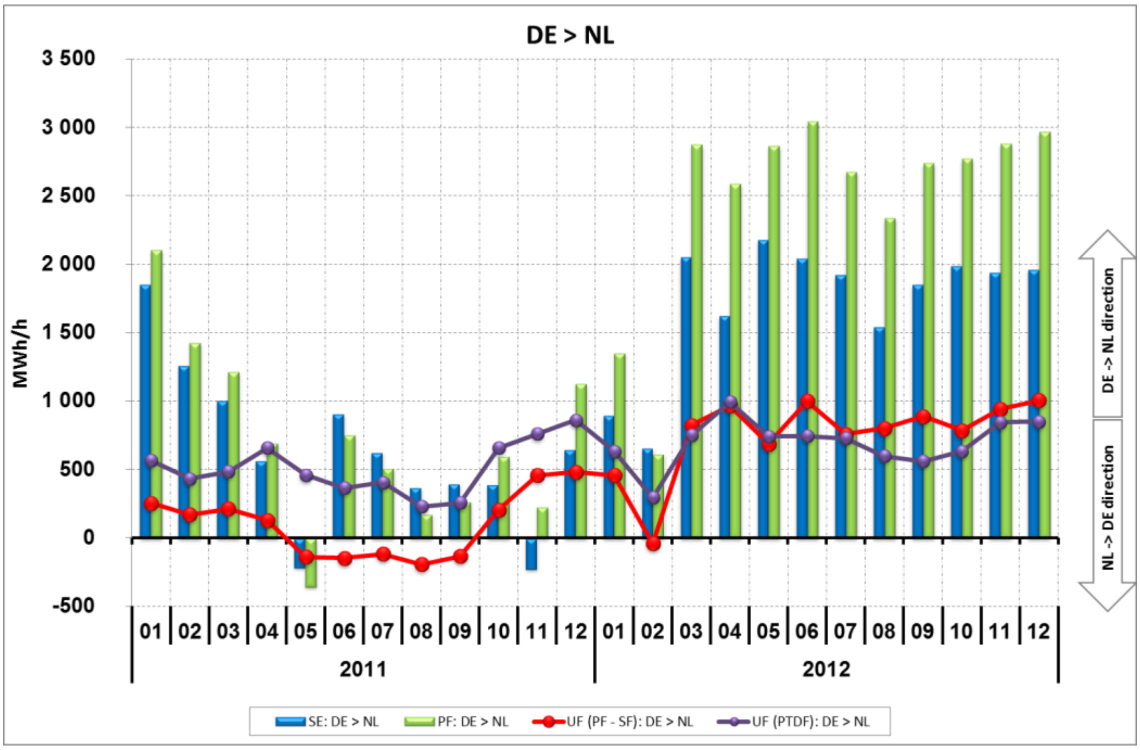

IT>APG
150
100
50
0
-50
-100
-150
-200
-250
MWh/h
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
IT -> APG direction
APG -> IT direction
SE: IT > APG
PF: IT > APG
UF (PF-SF): IT > APG
UF (PTDF): IT > APG

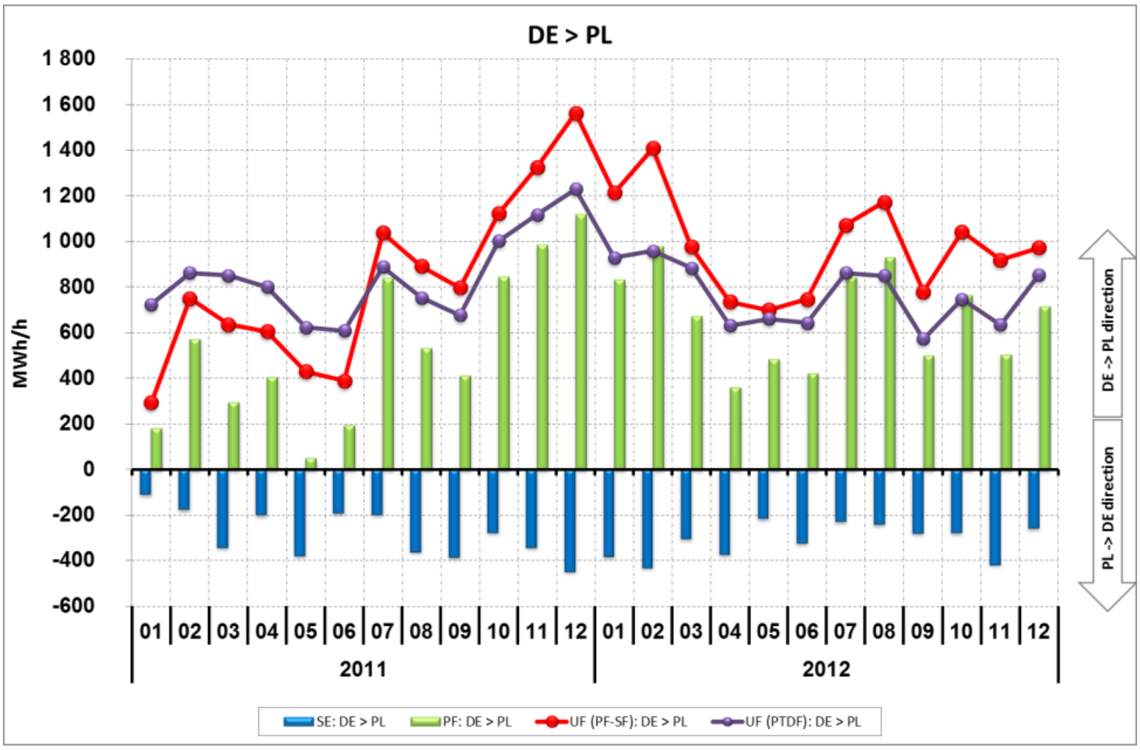

APG>SHB
MWh/h
1 000
800
600
400
200
0
-200
-400
-600
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
APG -> SHB direction
SHB -> APG direction
SE: APG > SHB
PF: APG > SHB
UF (PF-SF): APG > SHB
UF (PTDF): APG > SHB

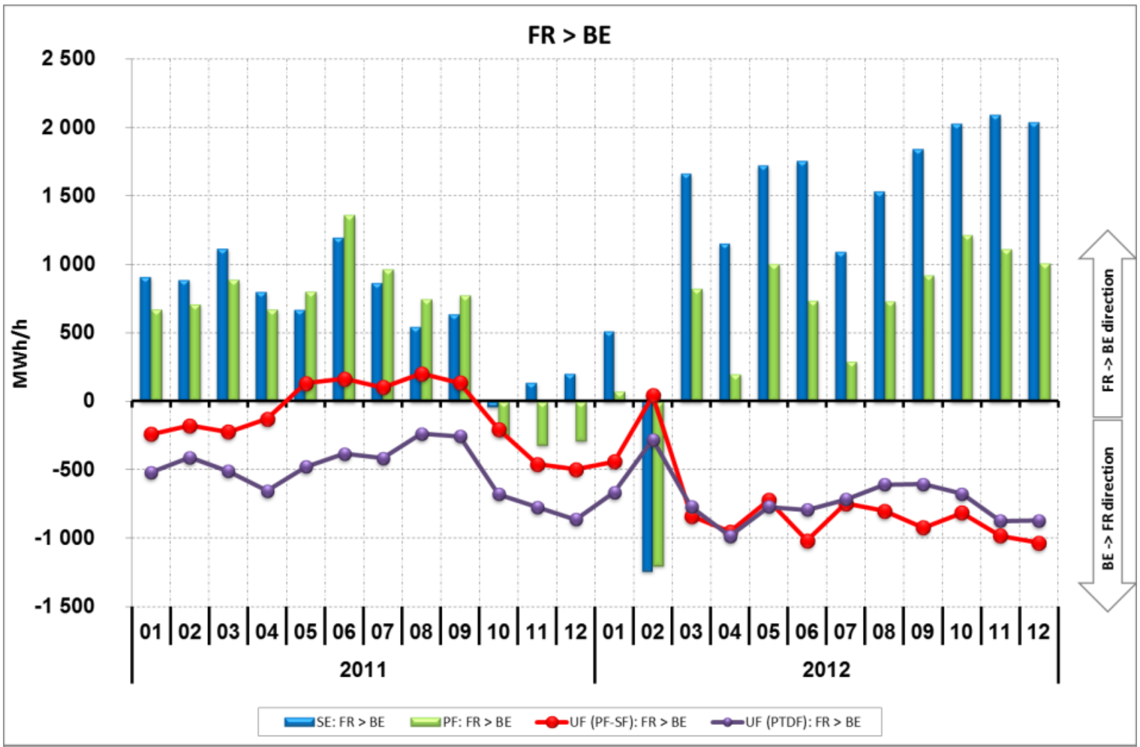

DE+APG > CZ
MWh/h
0
-500
-1 000
-1 500
-2 000
-2 500
-3 000
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
DE+APG -> CZ direction
CZ ->DE+ APG direction
SE: DE+AT>CZ
PF: DE+AT>CZ
UF (PF-SF): DE+AT>CZ
UF (PTDF): DE+APG > CZ

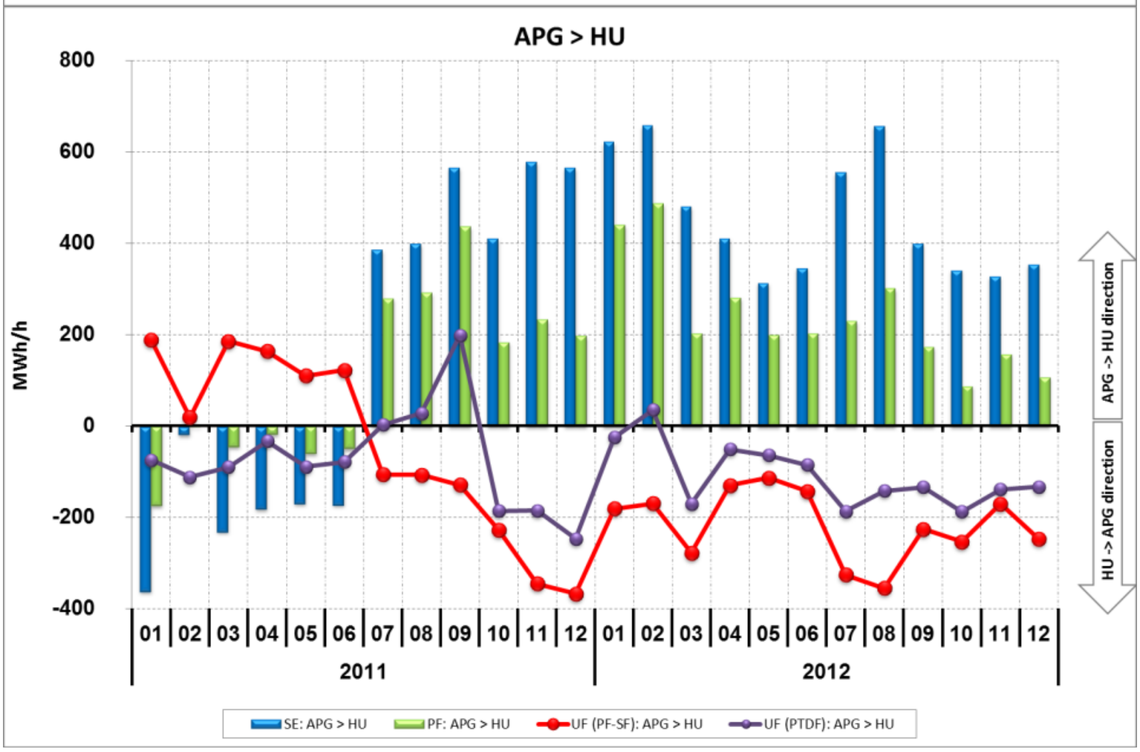

CZ > SK
MWh/h
1 600
1 400
1 200
1 000
800
600
400
200
0
-200
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
CZ -> SK direction
SK -> CZ direction
SE: CZ > SK
PF: CZ > SK
UF (PF-SF): CZ > SK
UF (PTDF): CZ > SK

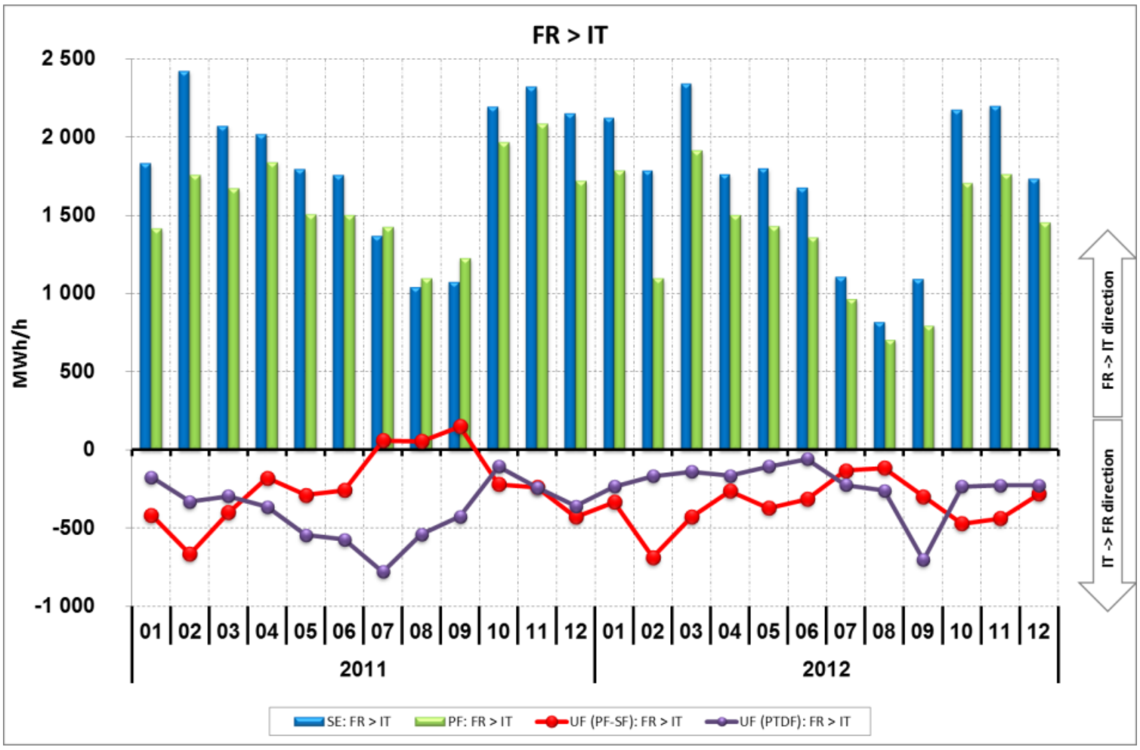

FR > DE
MWh/h
3 500
3 000
2 500
2 000
1 500
1 000
500
0
-500
-1 000
-1 500
-2 000
-2 500
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
FR -> DE direction
DE -> FR direction
SE: FR > DE
PF: FR > DE
UF (PF-SF): FR > DE
UF (PTDF): FR > DE

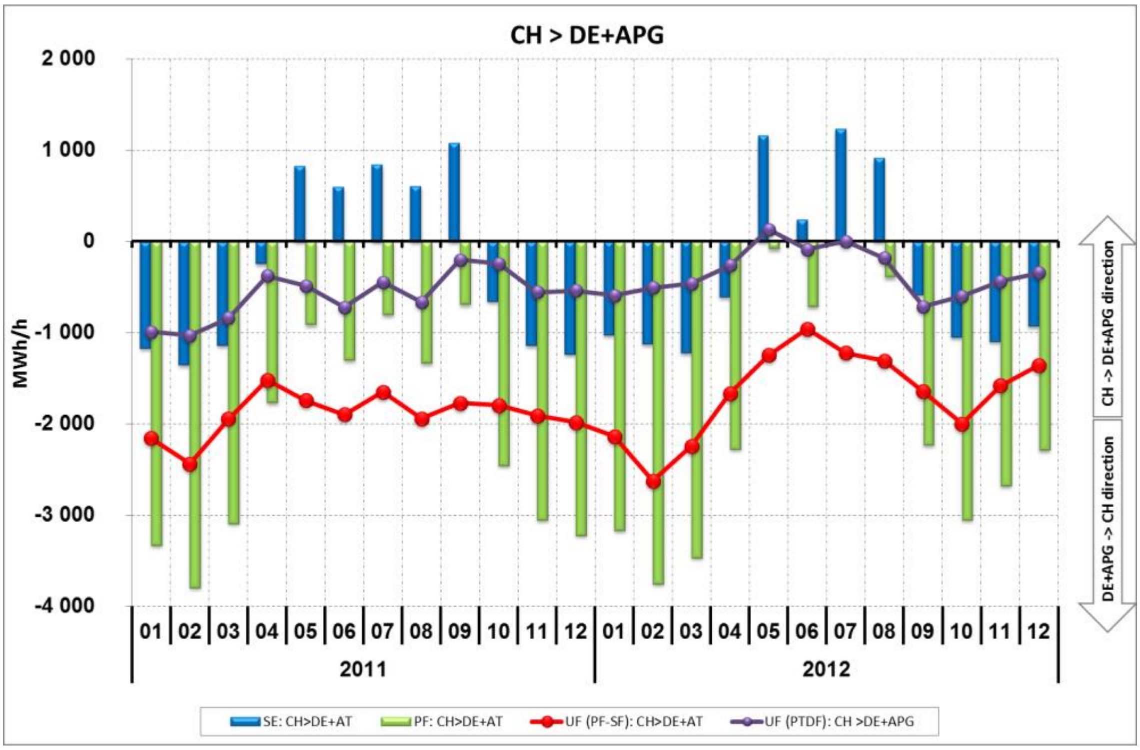

DE > NL
MWh/h
3 500
3 000
2 500
2 000
1 500
1 000
500
0
-500
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
DE -> NL direction
NL -> DE direction
SE: DE > NL
PF: DE > NL
UF (PF - SF): DE > NL
UF (PTDF): DE > NL

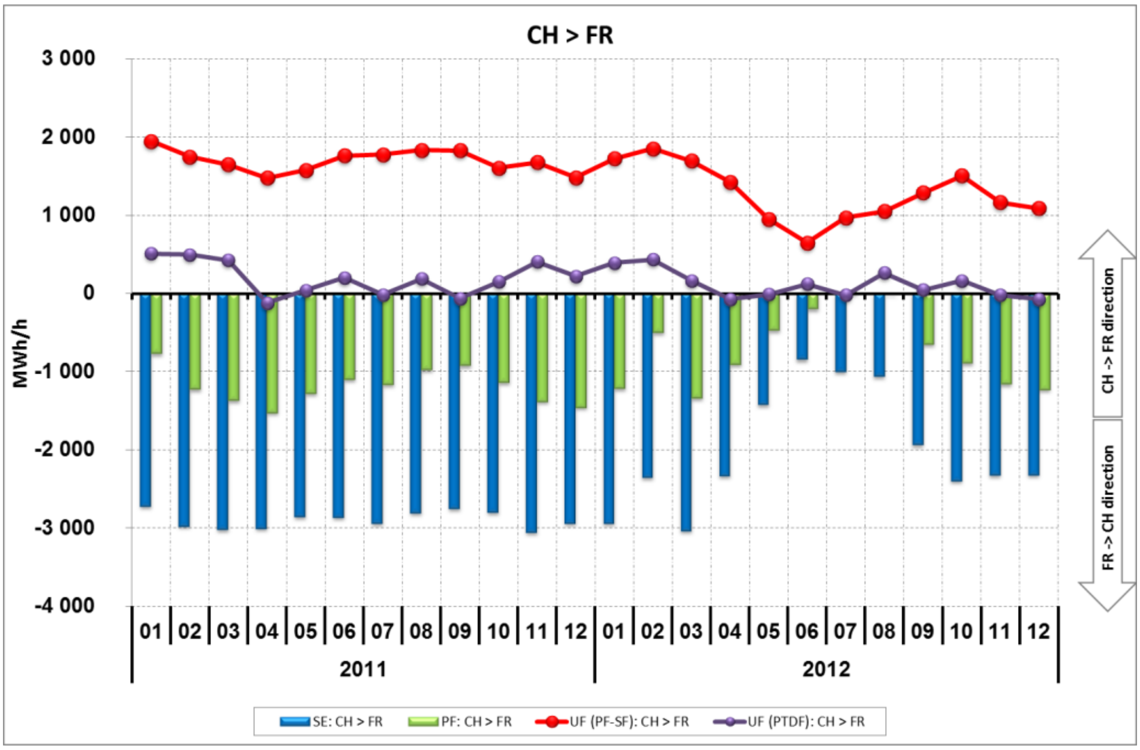

DE > PL
MWh/h
1 800
1 600
1 400
1 200
1 000
800
600
400
200
0
-200
-400
-600
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
DE -> PL direction
PL -> DE direction
SE: DE > PL
PF: DE > PL
UF (PF-SF): DE > PL
UF (PTDF): DE > PL

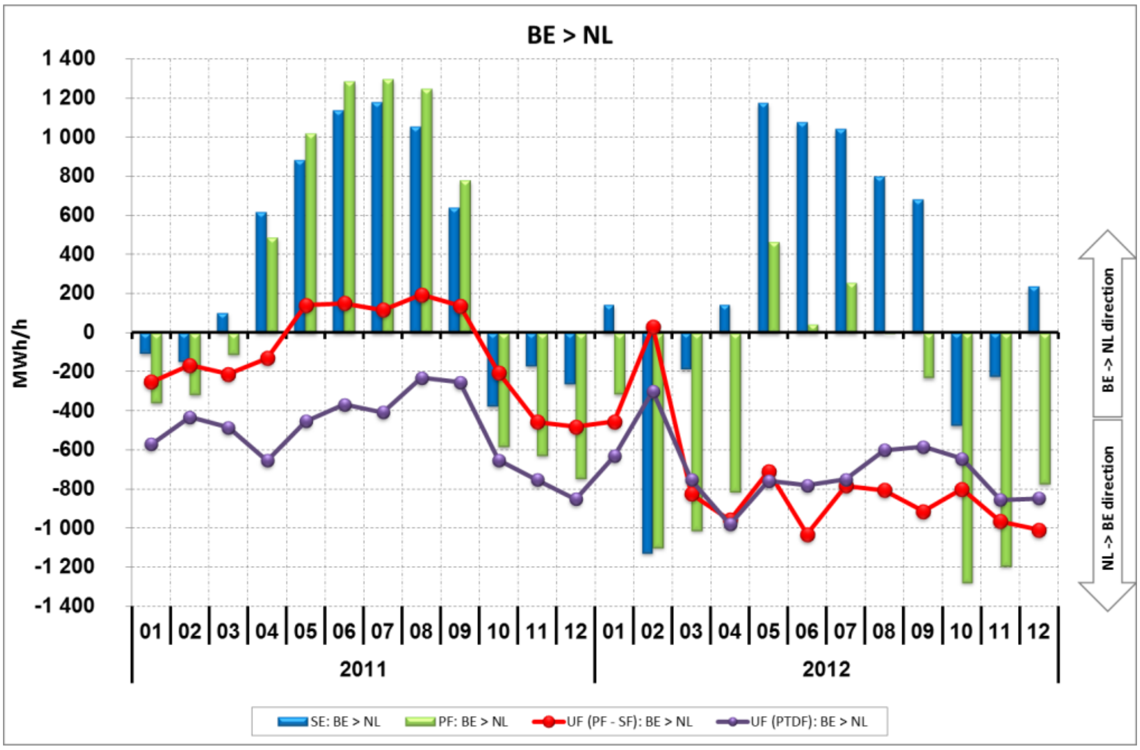

FR > BE
2 500
2 000
1 500
1 000
500
0
-500
-1 000
-1 500
MWh/h
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
FR -> BE direction
BE -> FR direction
SE: FR > BE
PF: FR > BE
UF (PF-SF): FR > BE
UF (PTDF): FR > BE

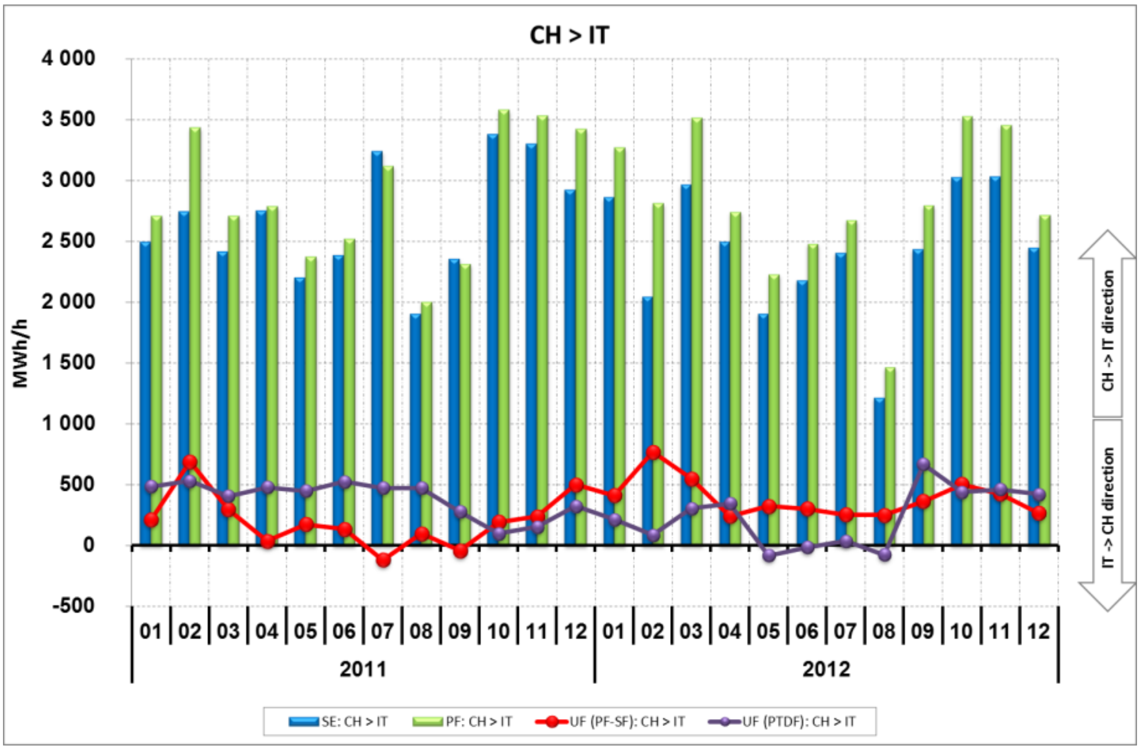

APG > HU
800
600
400
200
0
-200
-400
MWh/h
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
APG -> HU direction
HU -> APG direction
SE: APG > HU
PF: APG > HU
UF (PF-SF): APG > HU
UF (PTDF): APG > HU

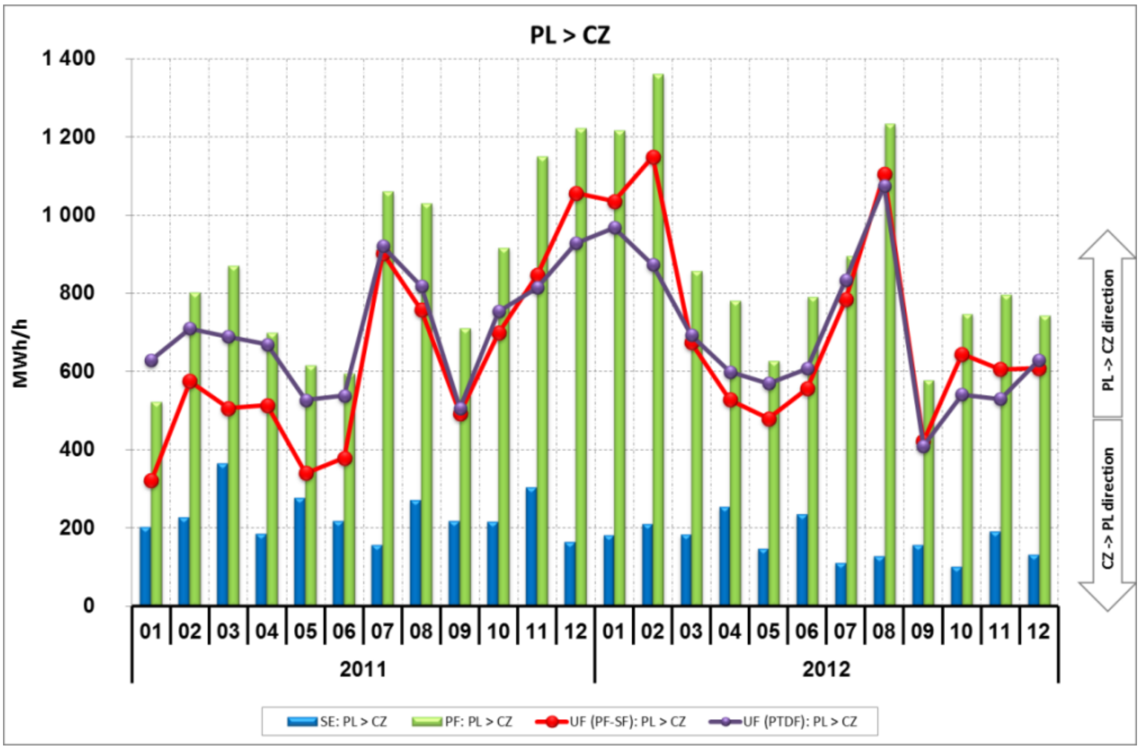

FR > IT
MWh/h
2 500
2 000
1 500
1 000
500
0
-500
-1 000
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
FR -> IT direction
IT -> FR direction
SE: FR > IT
PF: FR > IT
UF (PF-SF): FR > IT
UF (PTDF): FR > IT

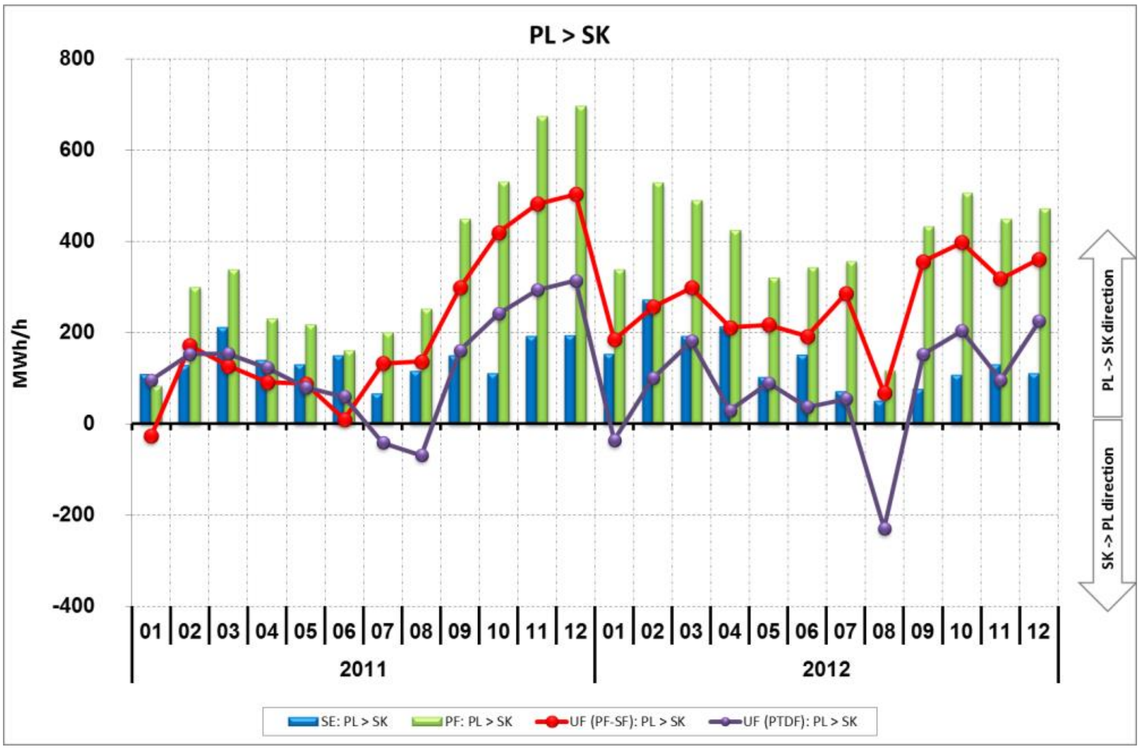

CH > DE+APG
MWh/h
2 000
1 000
0
-1 000
-2 000
-3 000
-4 000
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
CH -> DE+APG direction
DE+APG -> CH direction
SE: CH>DE+AT
PF: CH>DE+AT
UF (PF-SF): CH>DE+AT
UF (PTDF): CH >DE+APG

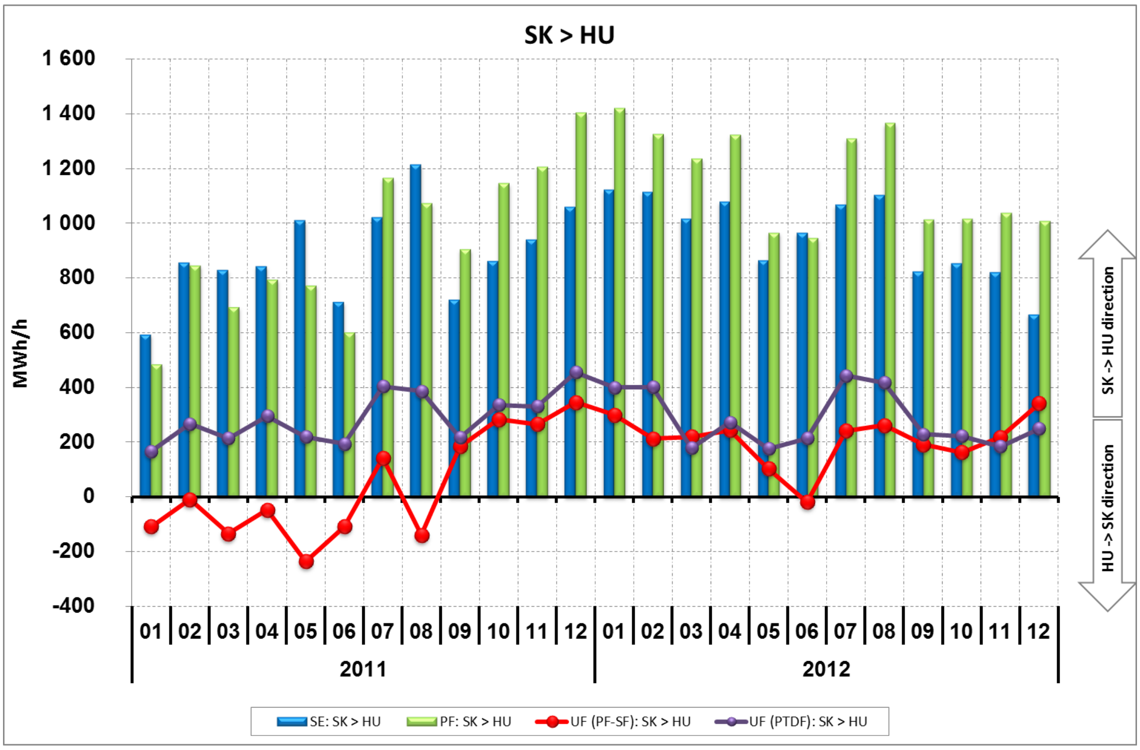

CH > FR
MWh/h
3 000
2 000
1 000
0
-1 000
-2 000
-3 000
-4 000
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
CH -> FR direction
FR -> CH direction
SE: CH > FR
PF: CH > FR
UF (PF-SF): CH > FR
UF (PTDF): CH > FR


BE > NL
MWh/h
1 400
1 200
1 000
800
600
400
200
0
-200
-400
-600
-800
-1 000
-1 200
-1 400
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
BE -> NL direction
NL -> BE direction
SE: BE > NL
PF: BE > NL
UF (PF - SF): BE > NL
UF (PTDF): BE > NL

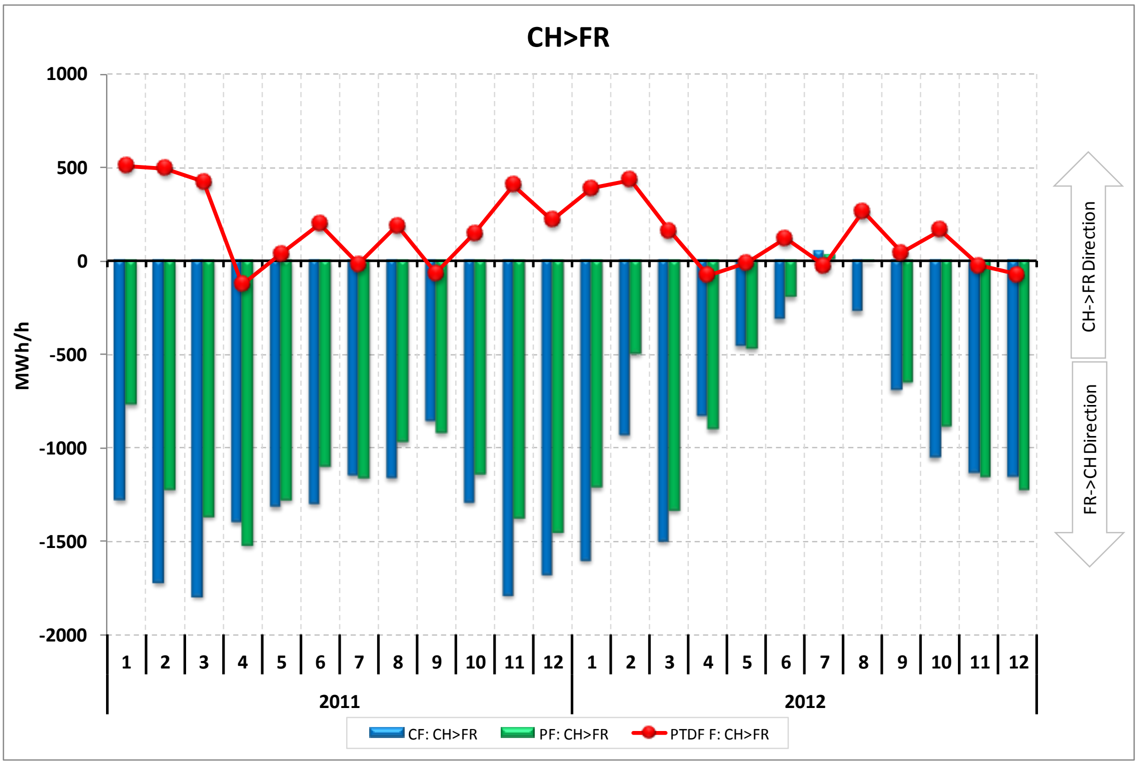

CH > IT
MWh/h
4 000
3 500
3 000
2 500
2 000
1 500
1 000
500
0
-500
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
CH -> IT direction
IT -> CH direction
SE: CH > IT
PF: CH > IT
UF (PF-SF): CH > IT
UF (PTDF): CH > IT

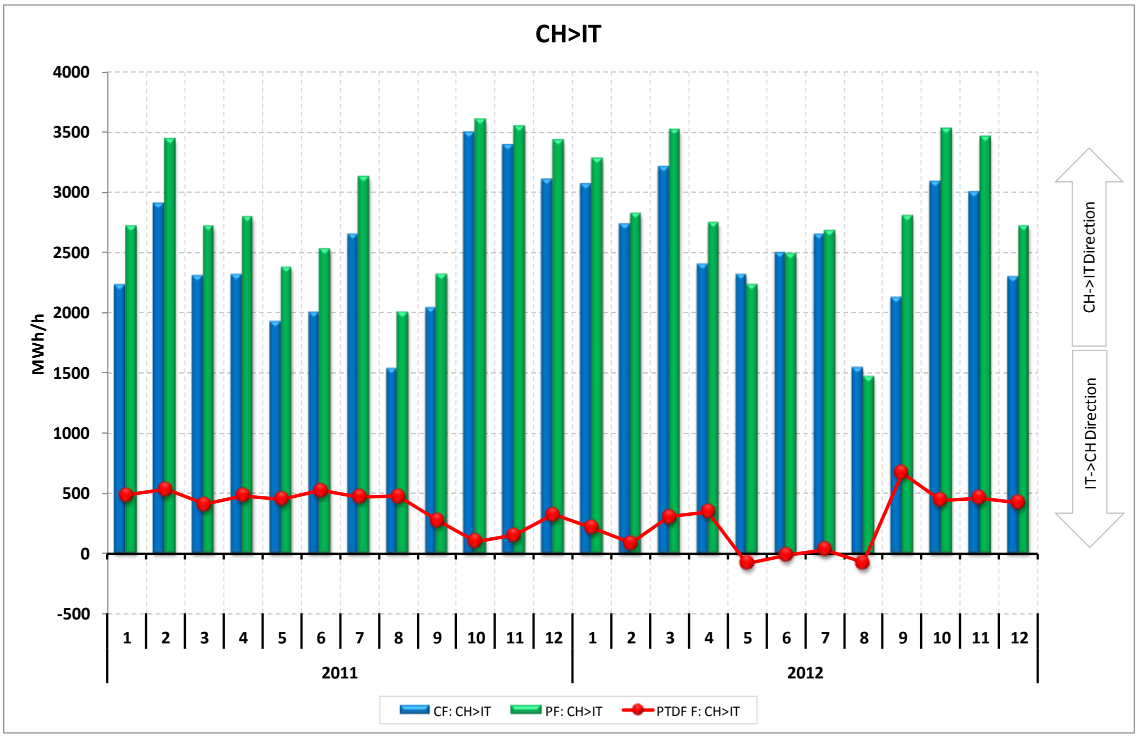

PL > CZ
MWh/h
1 400
1 200
1 000
800
600
400
200
0
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
PL -> CZ direction
CZ -> PL direction
SE: PL > CZ
PF: PL > CZ
UF (PF-SF): PL > CZ
UF (PTDF): PL > CZ


PL > SK
800
600
400
200
0
-200
-400
MWh/h
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
PL -> SK direction
SK -> PL direction
SE: PL > SK
PF: PL > SK
UF (PF-SF): PL > SK
UF (PTDF): PL > SK

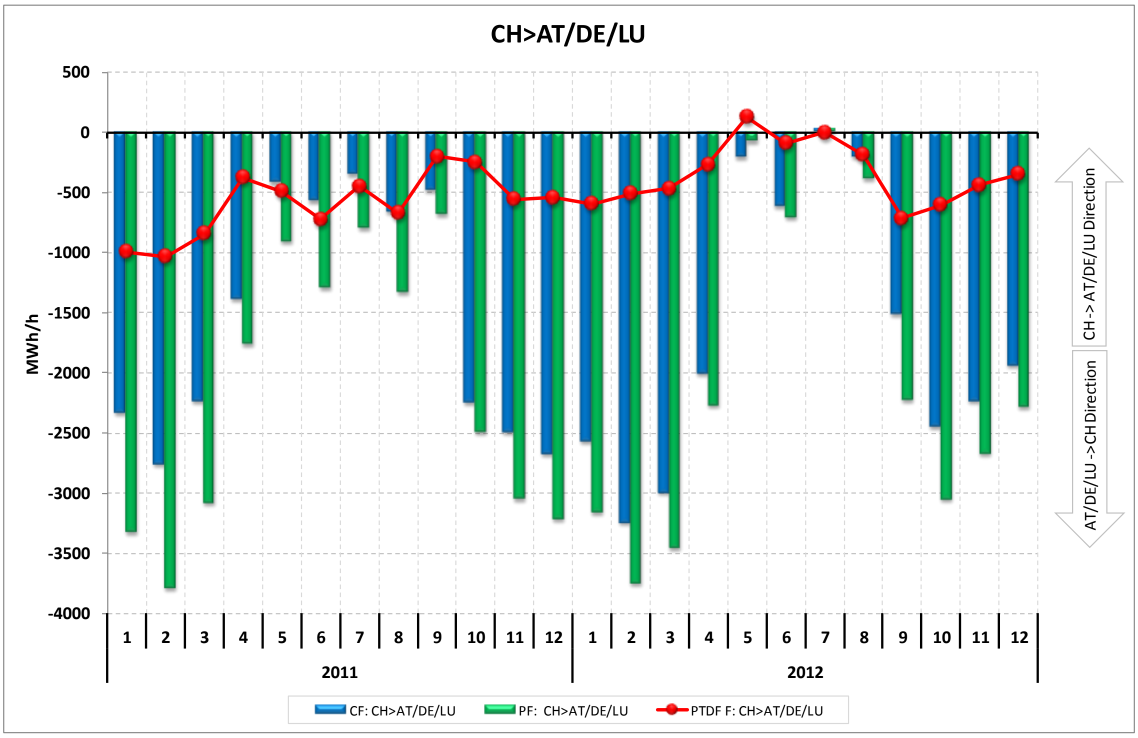

SK > HU
1 600
1 400
1 200
1 000
800
600
400
200
0
-200
-400
MWh/h
01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
2011
2012
SK -> HU direction
HU -> SK direction
SE: SK > HU
PF: SK > HU
UF (PF-SF): SK > HU
UF (PTDF): SK > HU

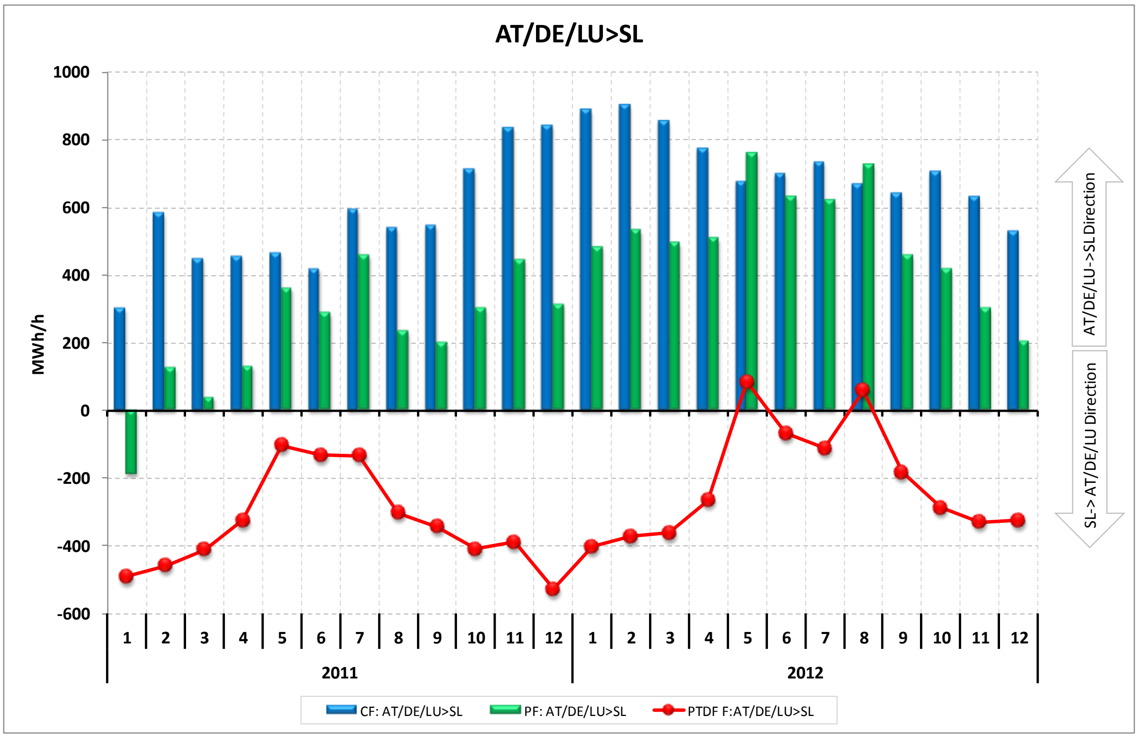
Annex 4.2.: Individual border monthly averages PTDF indicator

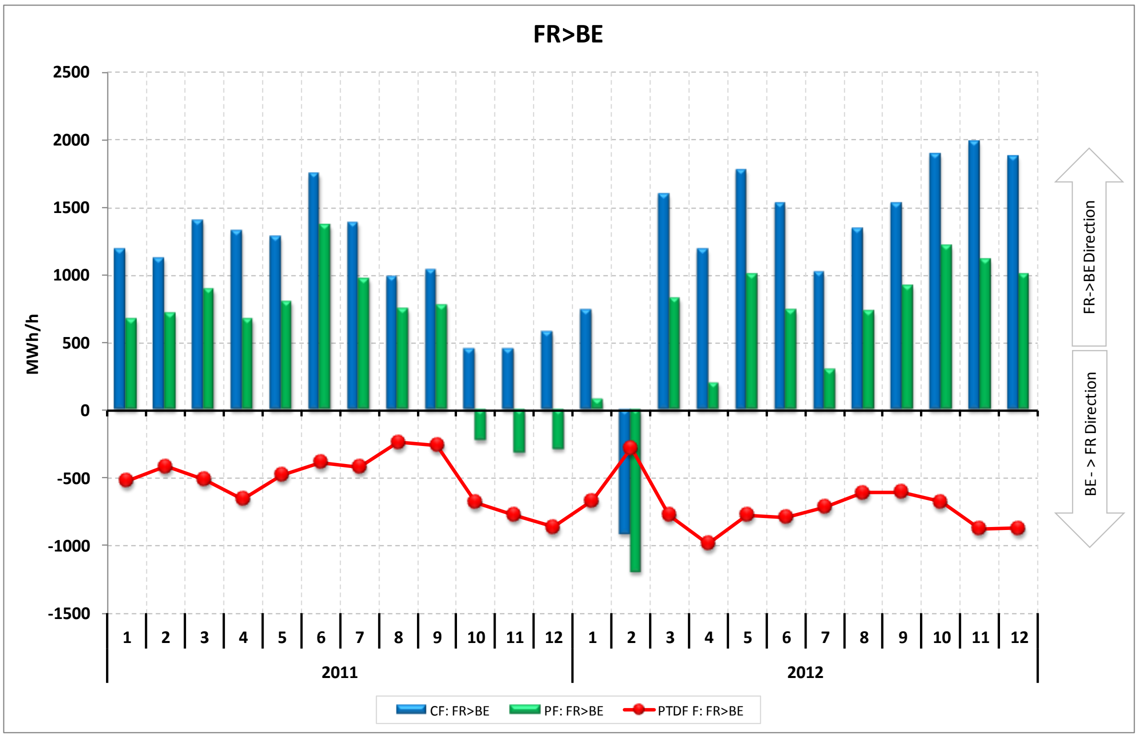


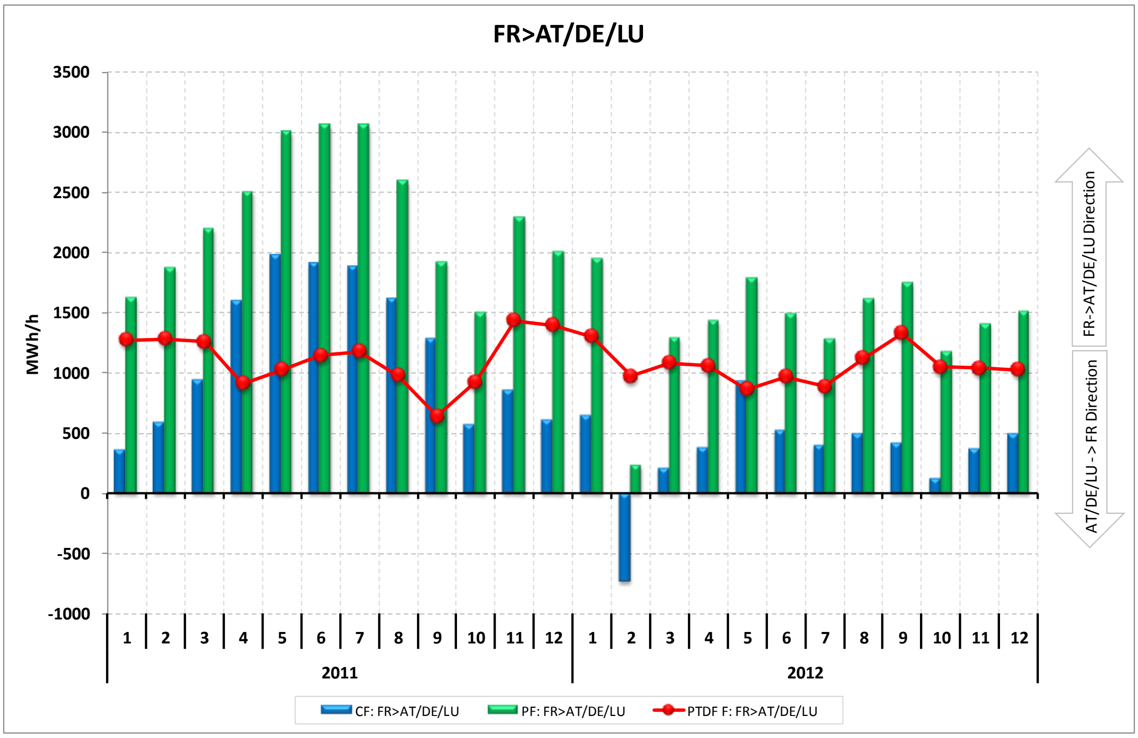


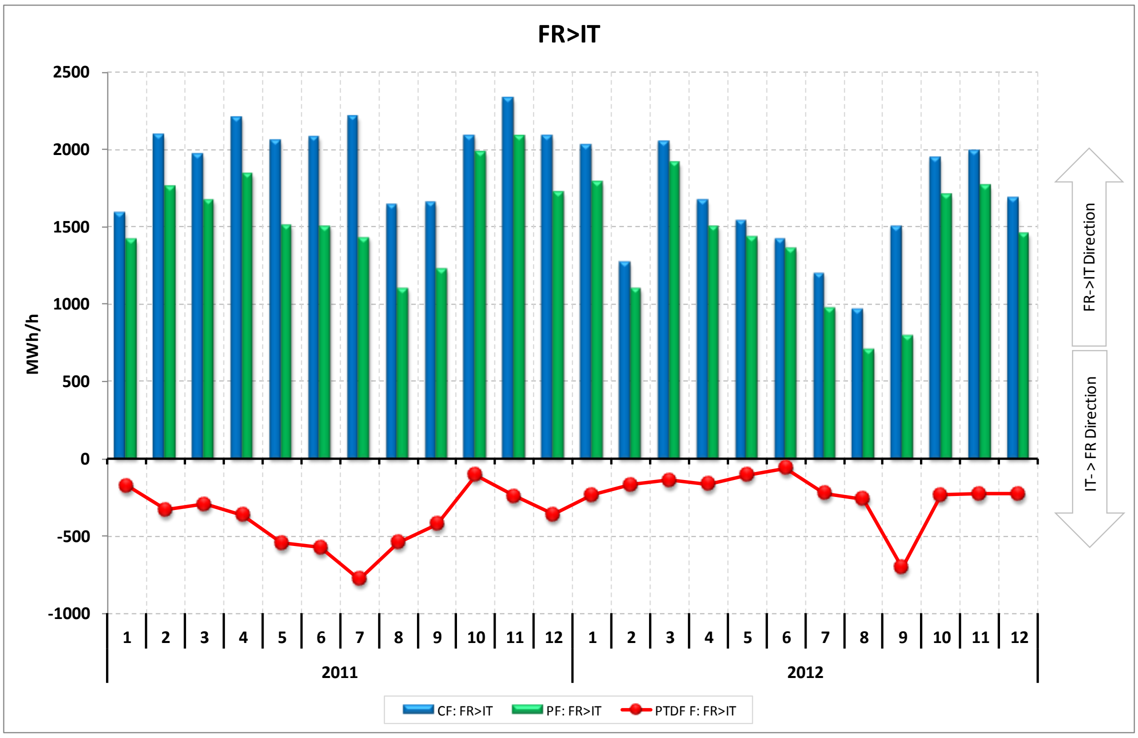
ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

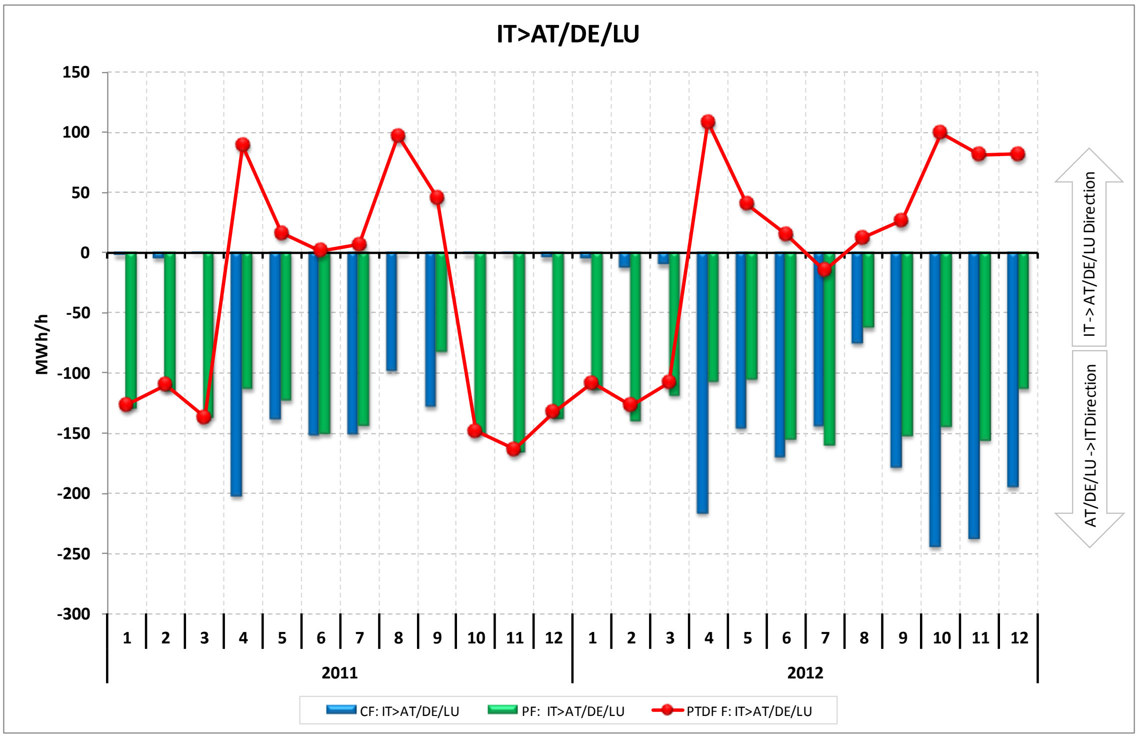

CH>AT/DE/LU
MWh/h
500
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
CH-> AT/DE/LU Direction
AT/DE/LU ->CH Direction
CF: CH>AT/DE/LU
PF: CH>AT/DE/LU
PTDF F: CH>AT/DE/LU

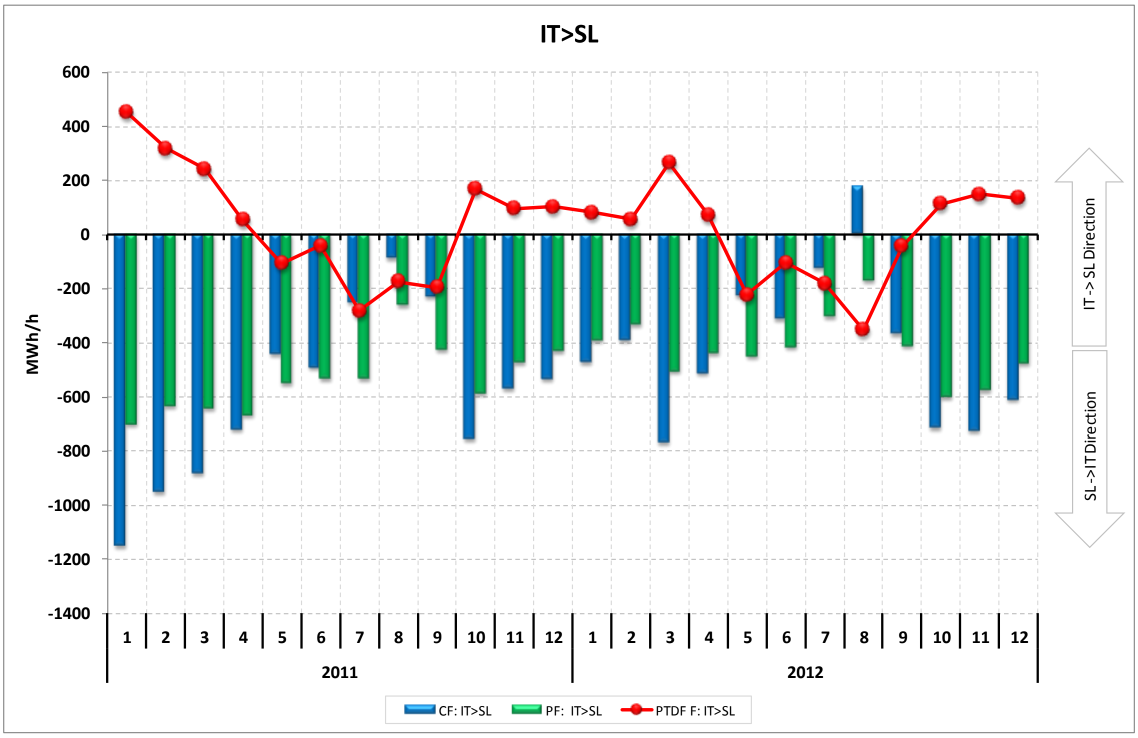

AT/DE/LU>SL
MWh/h
1000
800
600
400
200
0
-200
-400
-600
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
AT/DE/LU->SL Direction
SL-> AT/DE/LU Direction
CF: AT/DE/LU>SL
PF: AT/DE/LU>SL
PTDF F:AT/DE/LU>SL

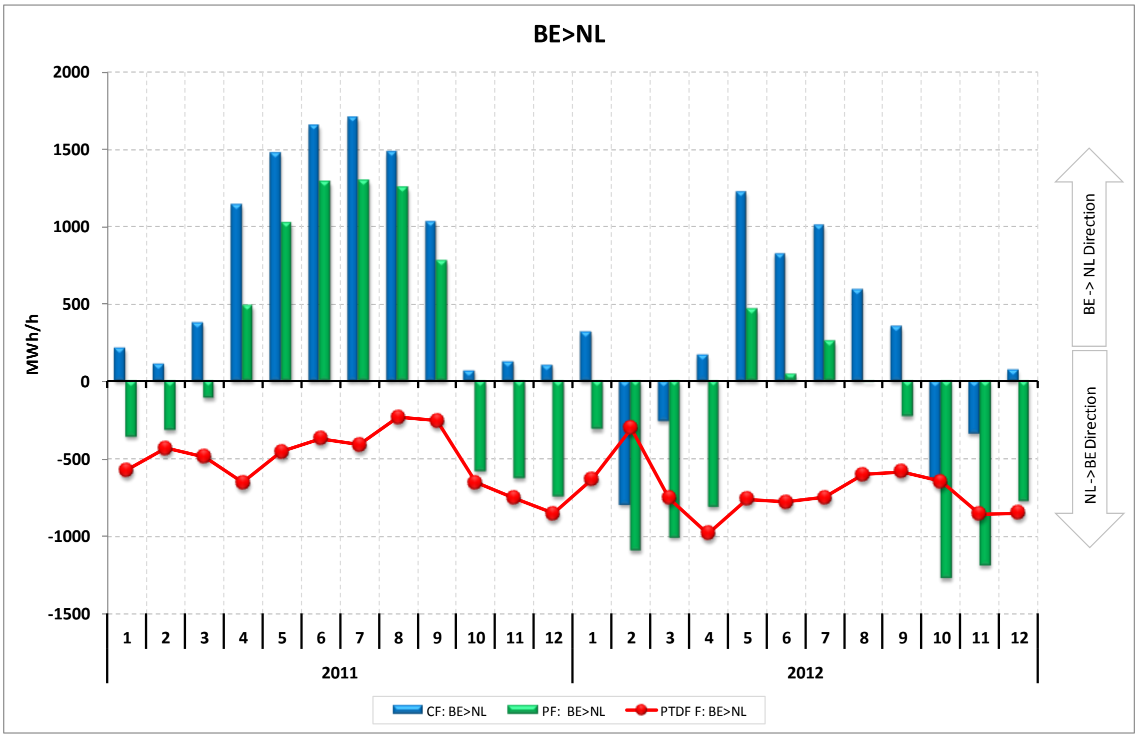

FR>BE
MWh/h
2500
2000
1500
1000
500
0
-500
-1000
-1500
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
FR->BE Direction
BE - > FR Direction
CF: FR>BE
PF: FR>BE
PTDF F: FR>BE


FR>AT/DE/LU
MWh/h
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
FR->AT/DE/LU Direction
AT/DE/LU - > FR Direction
CF: FR>AT/DE/LU
PF: FR>AT/DE/LU
PTDF F: FR>AT/DE/LU

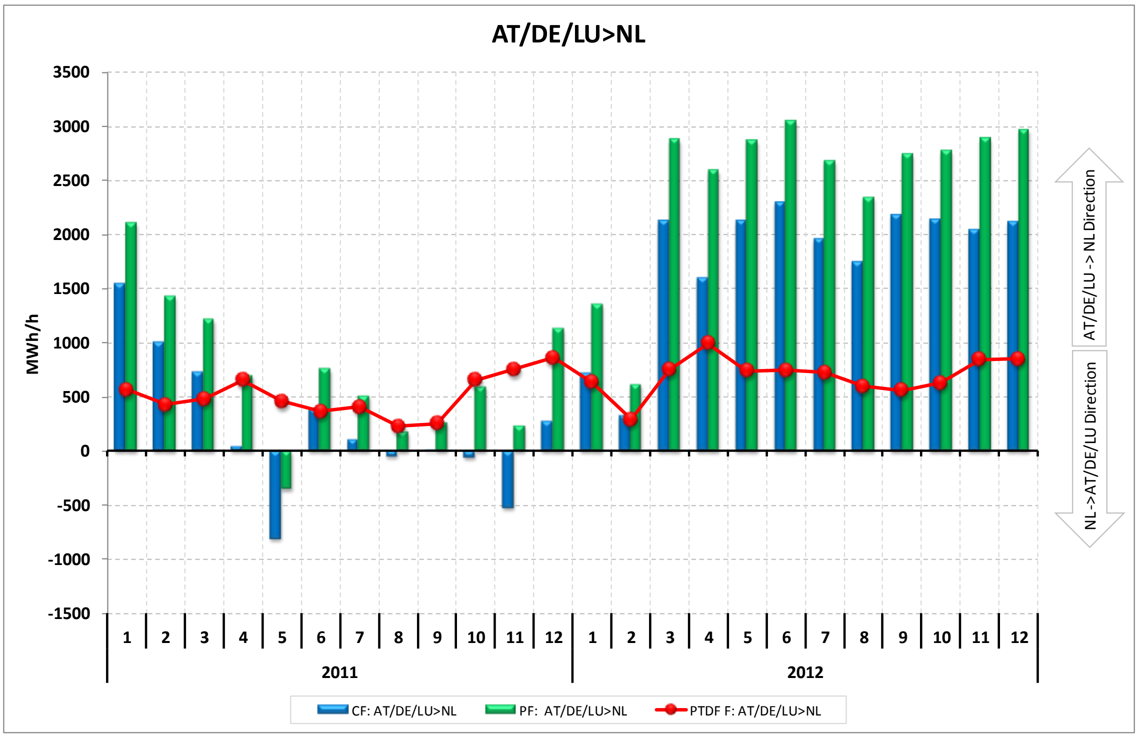

FR>IT
MWh/h
2500
2000
1500
1000
500
0
-500
-1000
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
FR->IT Direction
IT-> FR Direction
CF: FR>IT
PF: FR>IT
PTDF F: FR>IT

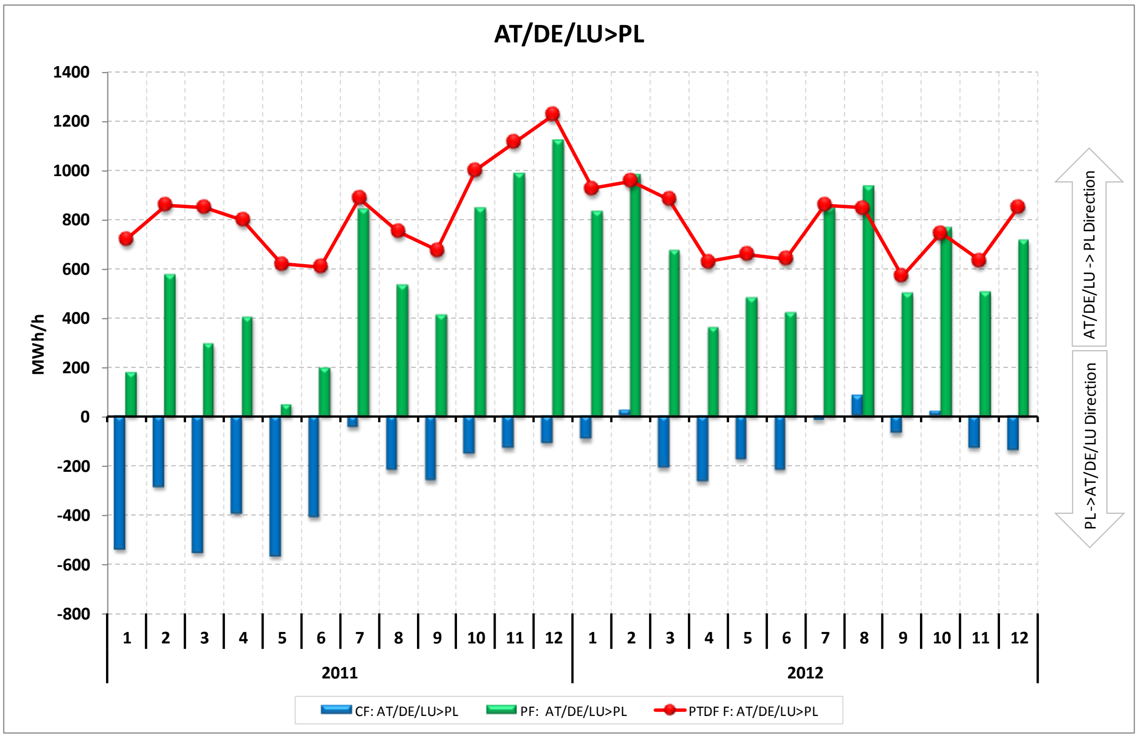

IT>AT/DE/LU
MWh/h
150
100
50
0
-50
-100
-150
-200
-250
-300
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
IT->AT/DE/LU Direction
AT/DE/LU->IT Direction
CF: IT>AT/DE/LU
PF: IT>AT/DE/LU
PTDF F: IT>AT/DE/LU

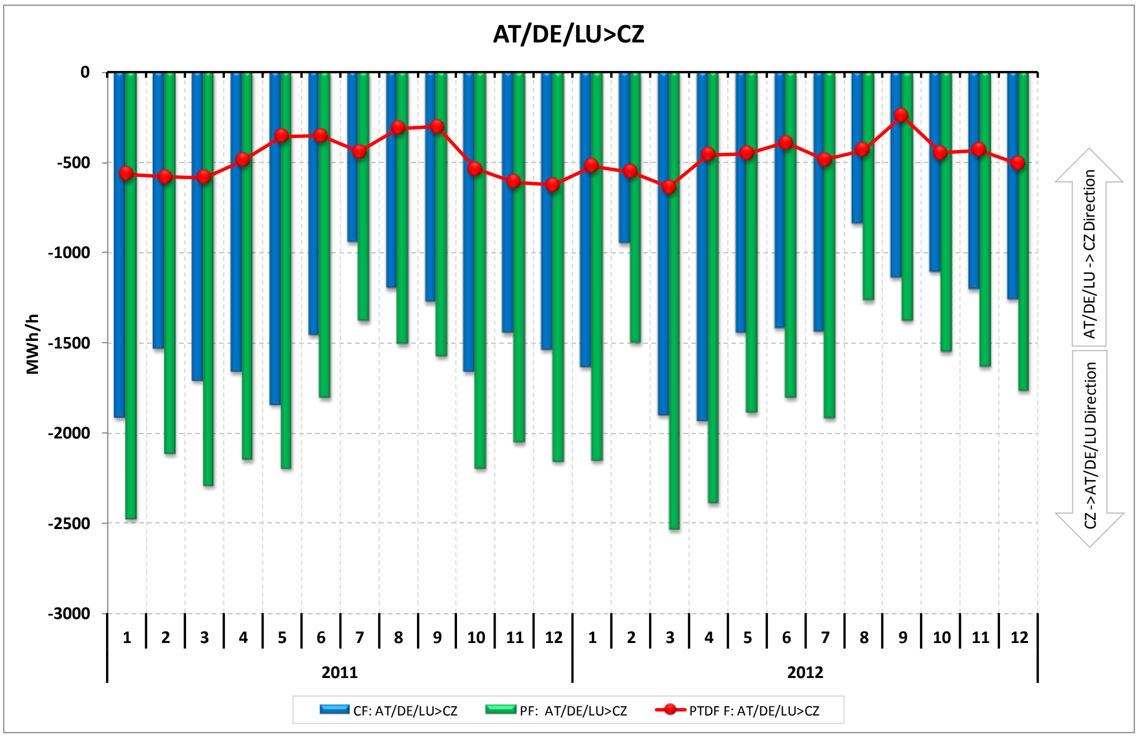


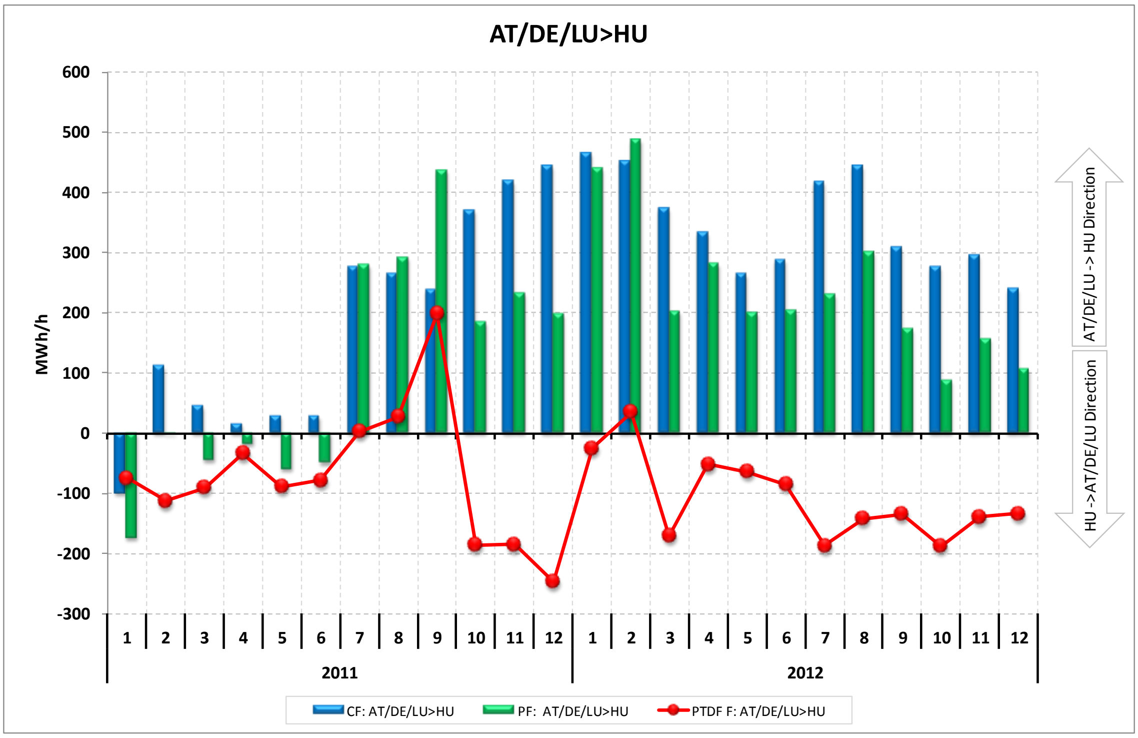


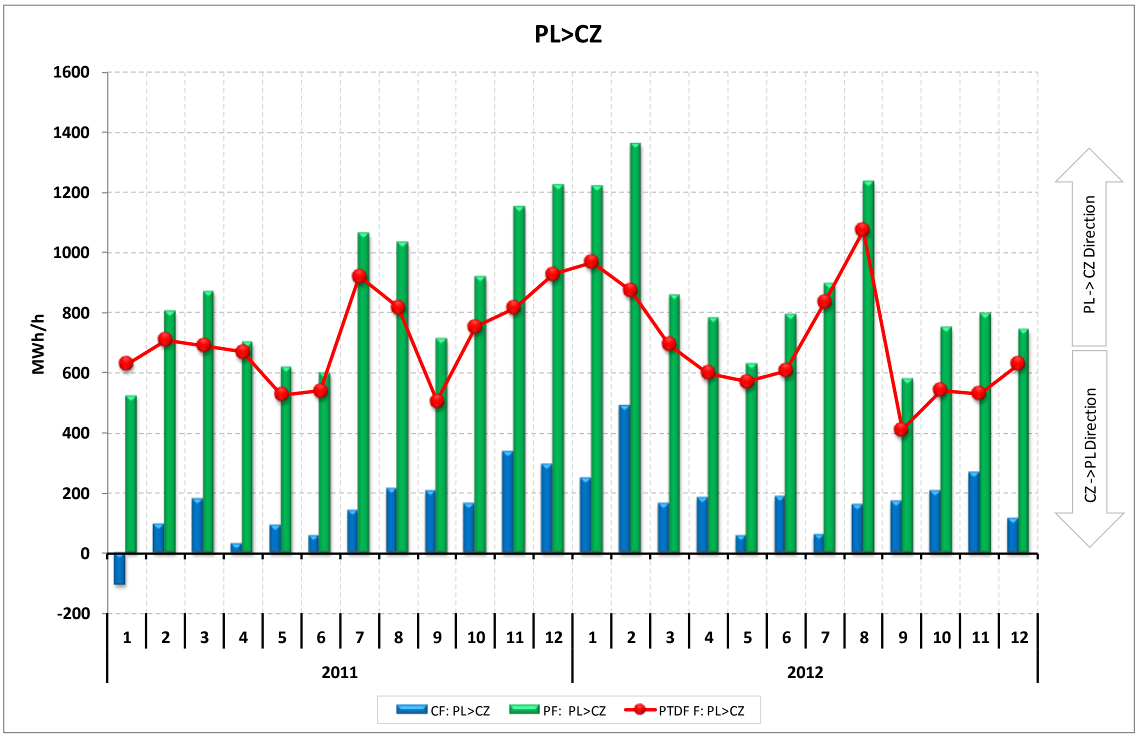
ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu


AT/DE/LU>NL
MWh/h
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
-1500
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
AT/DE/LU -> NL Direction
NL->AT/DE/LU Direction
CF: AT/DE/LU>NL
PF: AT/DE/LU>NL
PTDF F: AT/DE/LU>NL

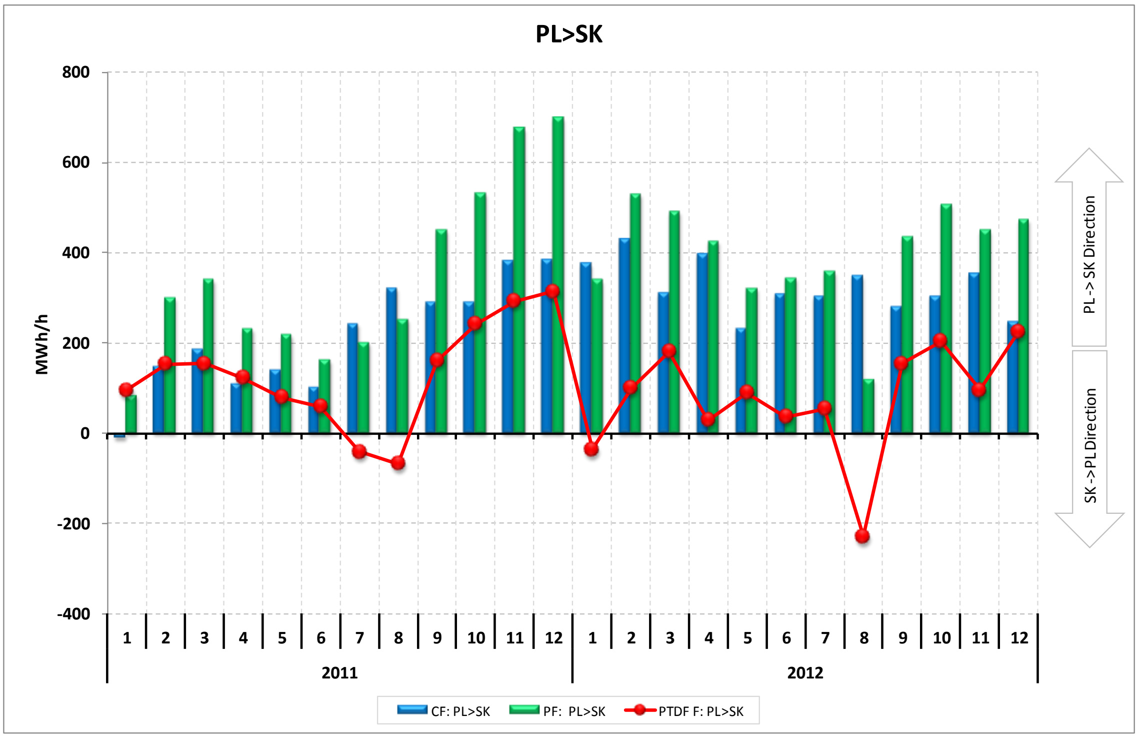

AT/DE/LU>PL
MWh/h
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
AT/DE/LU -> PL Direction
PL->AT/DE/LU Direction
CF: AT/DE/LU>PL
PF: AT/DE/LU>PL
PTDF F: AT/DE/LU>PL


AT/DE/LU>CZ
MWh/h
0
-500
-1000
-1500
-2000
-2500
-3000
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
AT/DE/LU -> CZ Direction
CZ ->AT/DE/LU Direction
CF: AT/DE/LU>CZ
PF: AT/DE/LU>CZ
PTDF F: AT/DE/LU>CZ

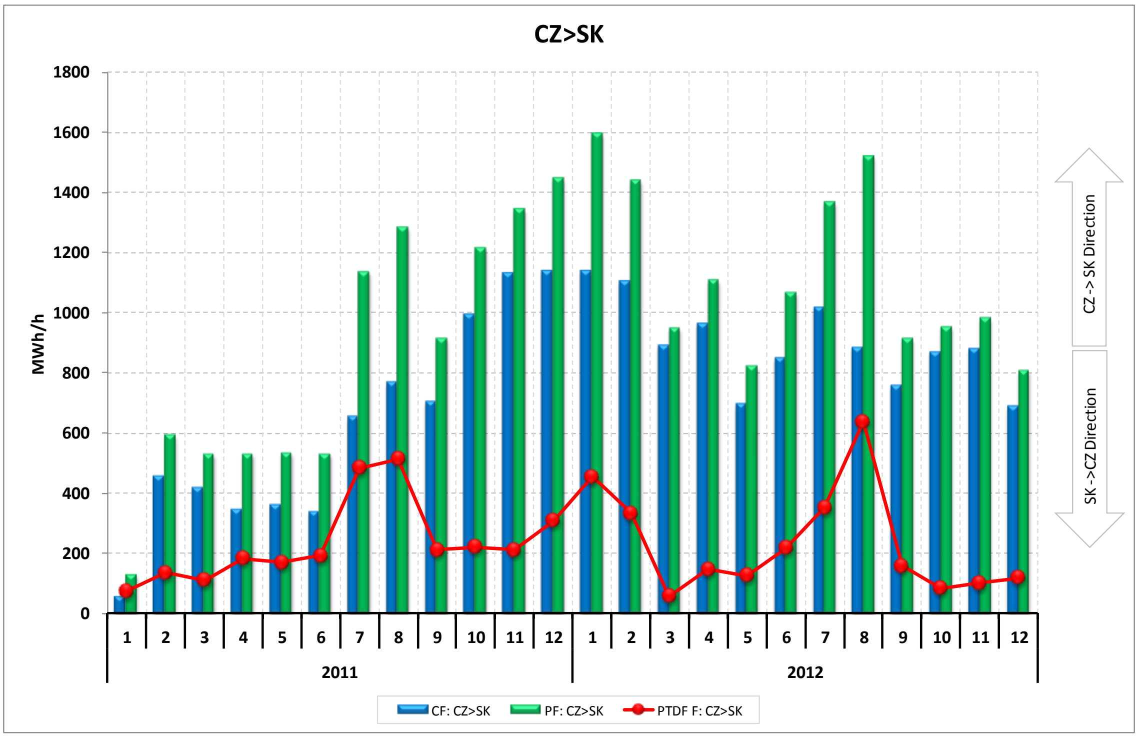

AT/DE/LU>HU
MWh/h
600
500
400
300
200
100
0
-100
-200
-300
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
AT/DE/LU -> HU Direction
HU ->AT/DE/LU Direction
CF: AT/DE/LU>HU
PF: AT/DE/LU>HU
PTDF F: AT/DE/LU>HU



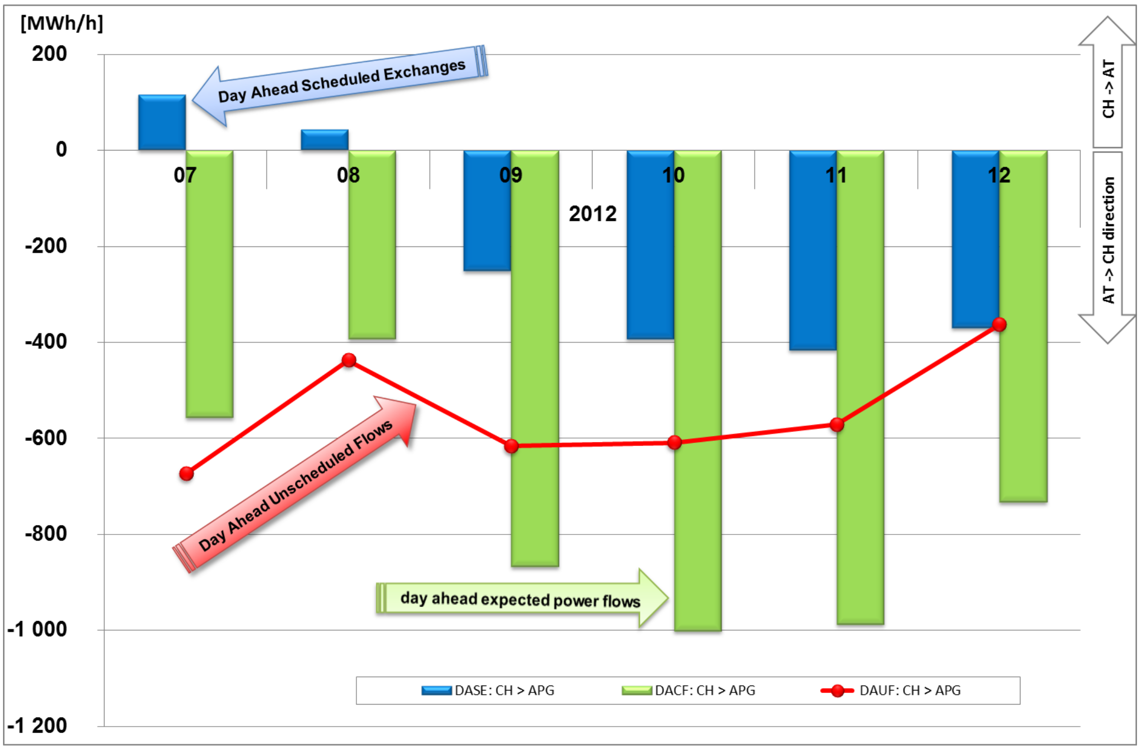
PL>CZ
MWh/h
PL-> CZ Direction
CZ->PL Direction
2011
2012
CF: PL>CZ
PF: PL>CZ
PTDF F: PL>CZ

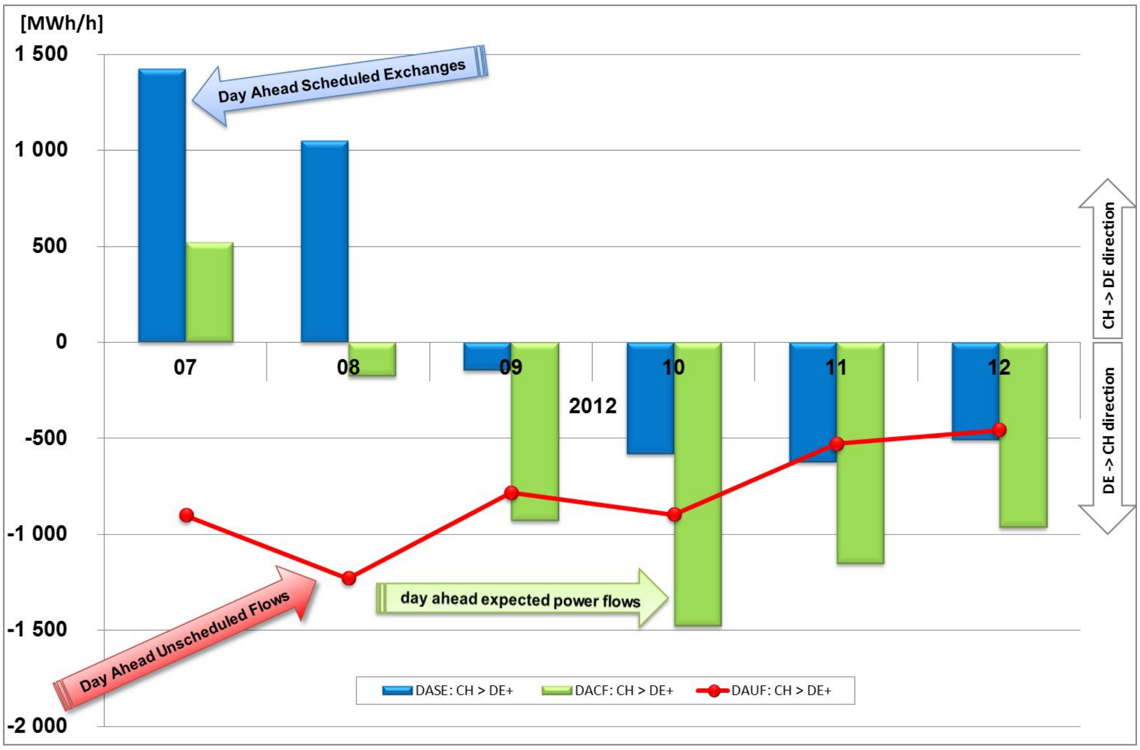


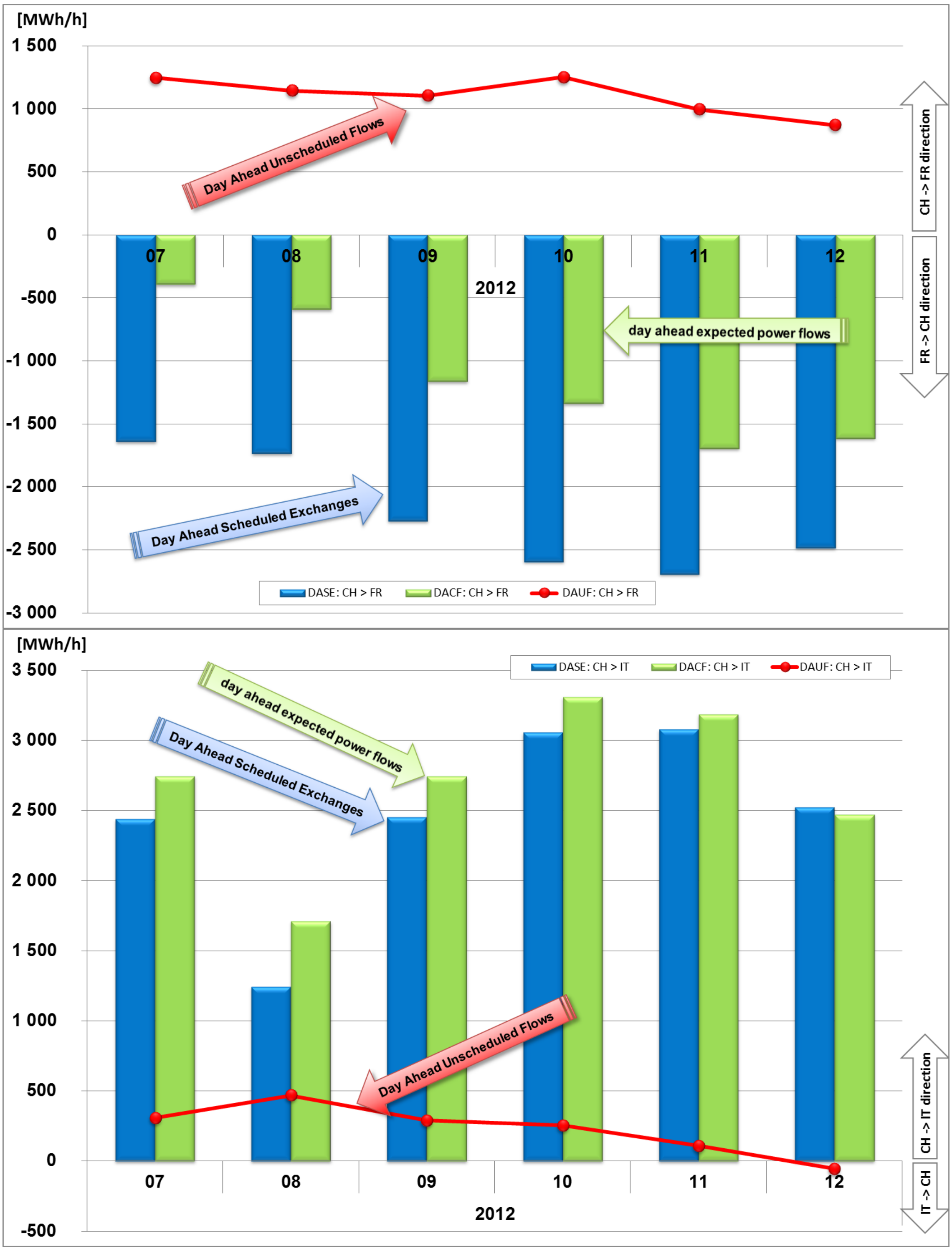
PL>SK
MWh/h
PL-> SK Direction
SK->PL Direction
2011
2012
CF: PL>SK
PF: PL>SK
PTDF F: PL>SK

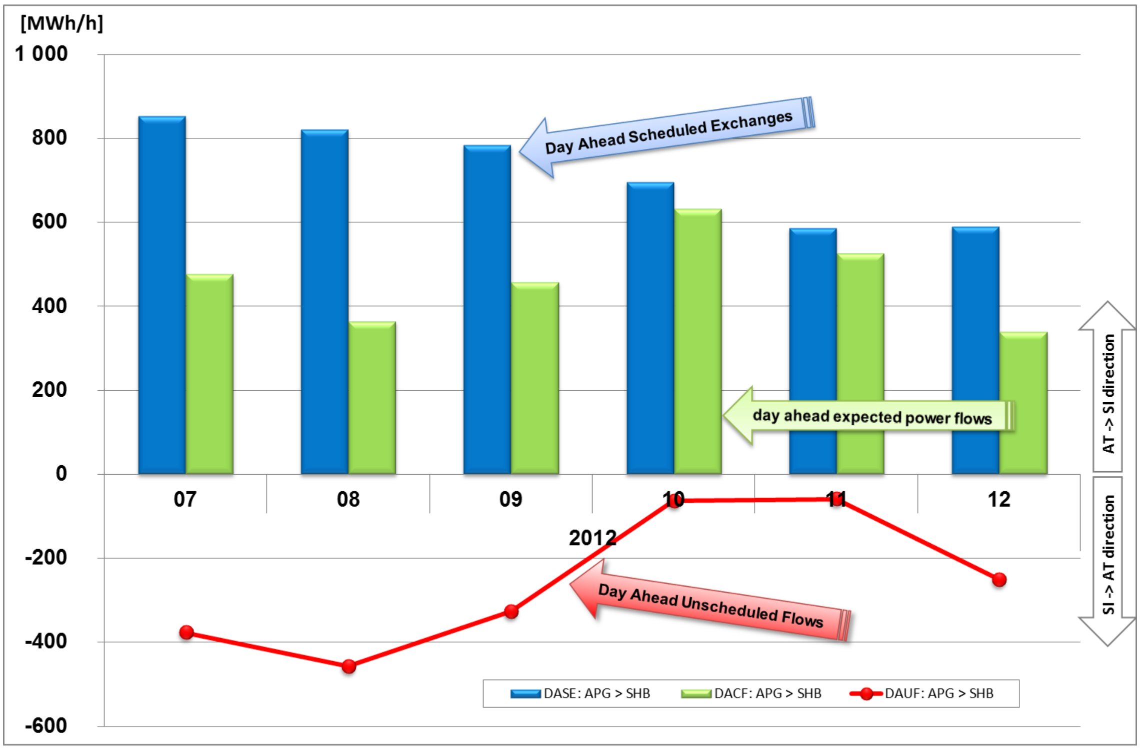

CZ>SK
MWh/h
1800
1600
1400
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
2011
2012
CZ -> SK Direction
SK ->CZ Direction
CF: CZ>SK
PF: CZ>SK
PTDF F: CZ>SK

Annex 4.3: Individual border monthly averages DAUF evolution

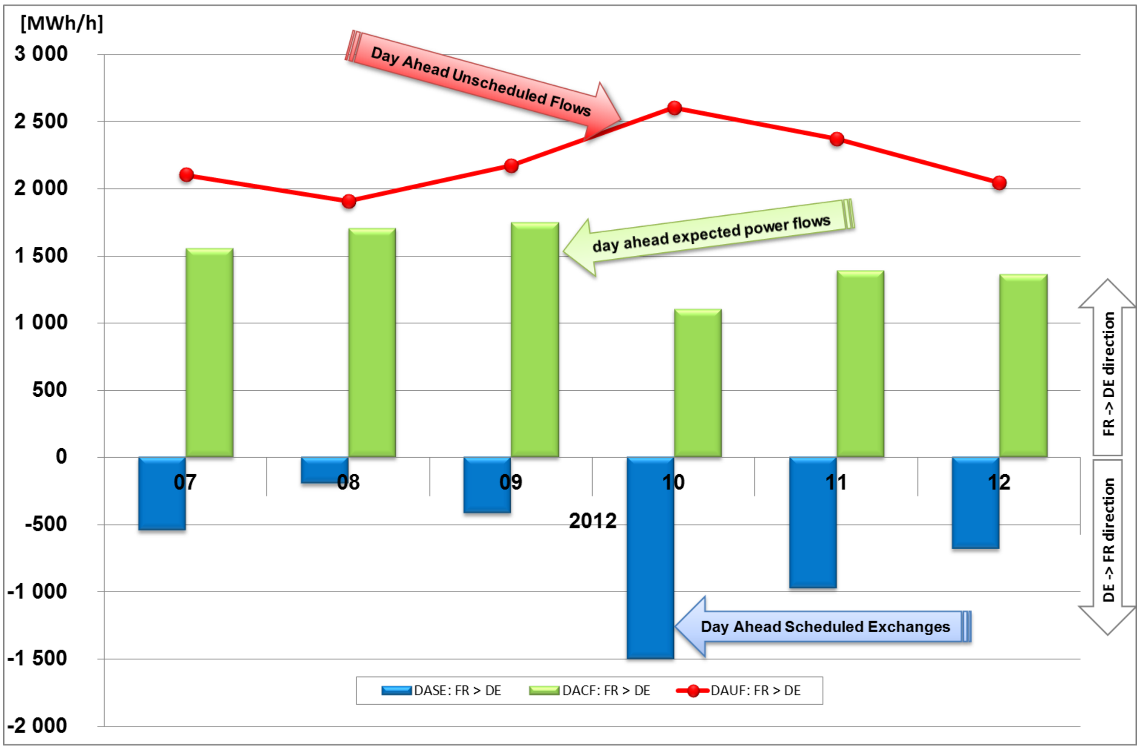




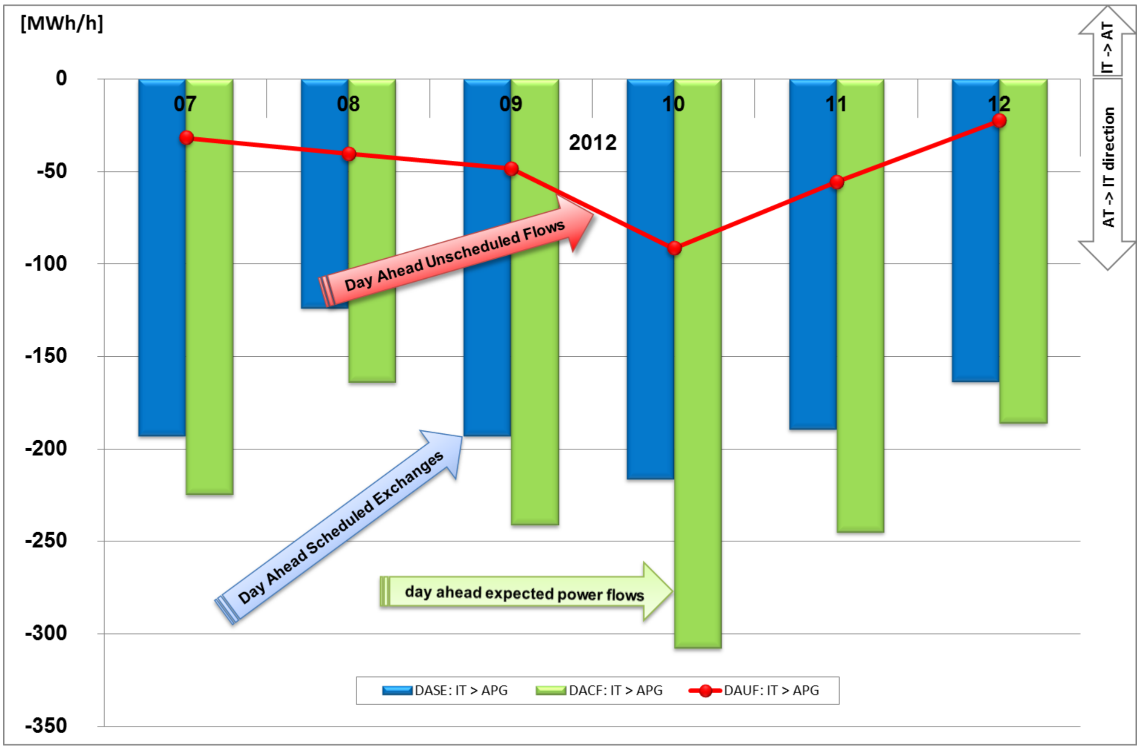

[MWh/h]
1 500
1 000
500
0
-500
-1 000
-1 500
-2 000
-2 500
-3 000
Day Ahead Unscheduled Flows
day ahead expected power flows
Day Ahead Scheduled Exchanges
07
08
09
10
11
12
2012
CH -> FR direction
FR -> CH direction
DASE: CH > FR
DACF: CH > FR
DAUF: CH > FR
[MWh/h]
3 500
3 000
2 500
2 000
1 500
1 000
500
0
-500
DASE: CH > IT
DACF: CH > IT
DAUF: CH > IT
day ahead expected power flows
Day Ahead Scheduled Exchanges
Day Ahead Unscheduled Flows
07
08
09
10
11
12
2012
CH -> IT direction
IT -> CH

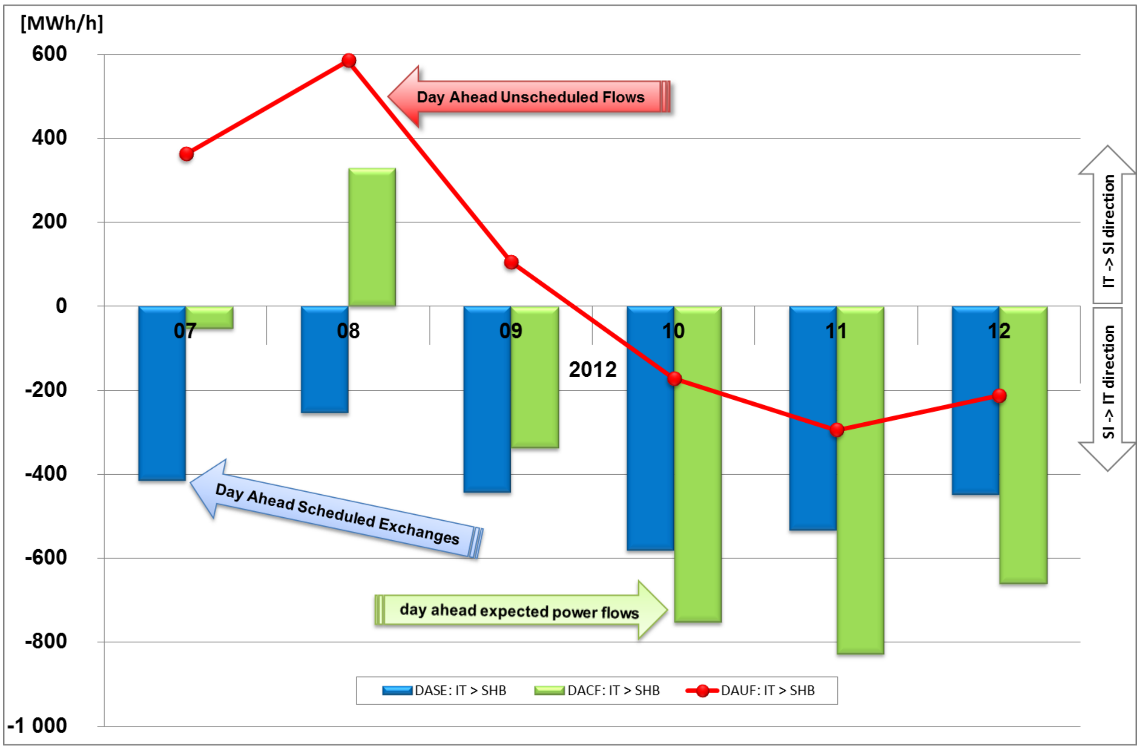

[MWh/h]
1 000
800
600
400
200
0
-200
-400
-600
07
08
09
10
11
12
2012
Day Ahead Scheduled Exchanges
day ahead expected power flows
Day Ahead Unscheduled Flows
AT -> SI direction
SI -> AT direction
DASE: APG > SHB
DACF: APG > SHB
DAUF: APG > SHB


[MWh/h]
2 500
2 000
1 500
1 000
500
0
-500
-1 000
-1 500
07
08
09
10
11
12
2012
Day Ahead Scheduled Exchanges
day ahead expected power flows
Day Ahead Unscheduled Flows
FR -> BE direction
BE -> FR direction
DASE: FR > BE
DACF: FR > BE
DAUF: FR > BE

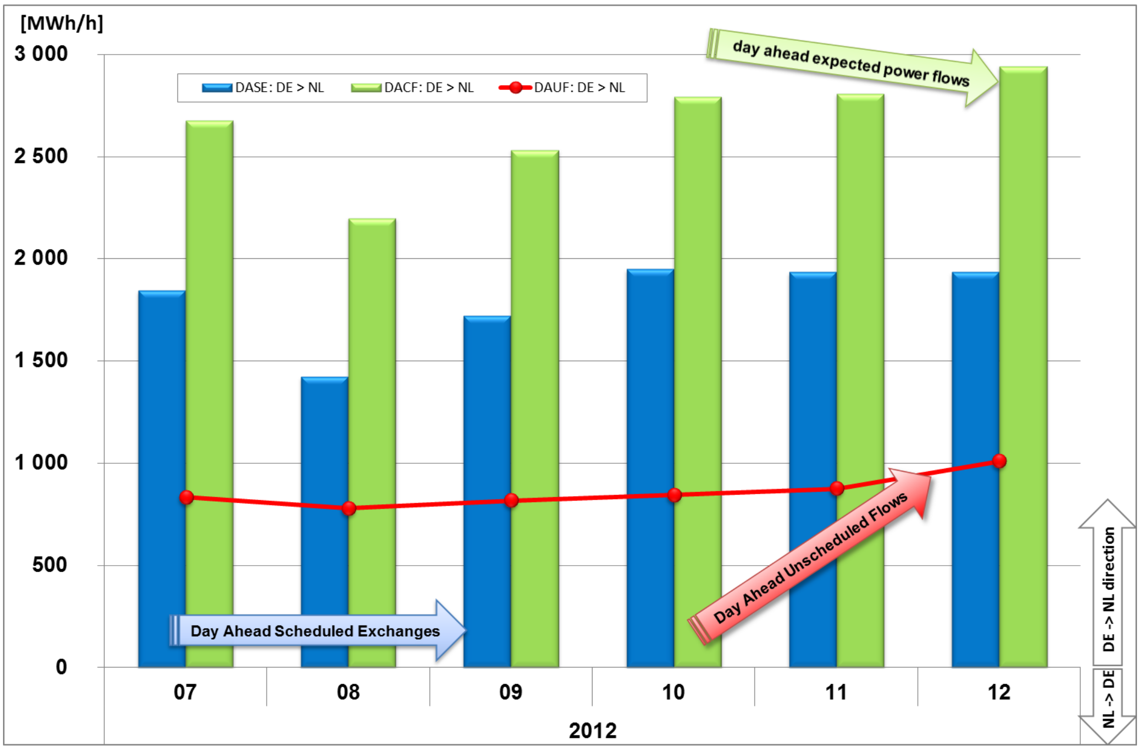

[MWh/h]
3 000
2 500
2 000
1 500
1 000
500
0
-500
-1 000
-1 500
-2 000
Day Ahead Unscheduled Flows
day ahead expected power flows
Day Ahead Scheduled Exchanges
07
08
09
10
11
12
2012
FR -> DE direction
DE -> FR direction
DASE: FR > DE
DACF: FR > DE
DAUF: FR > DE

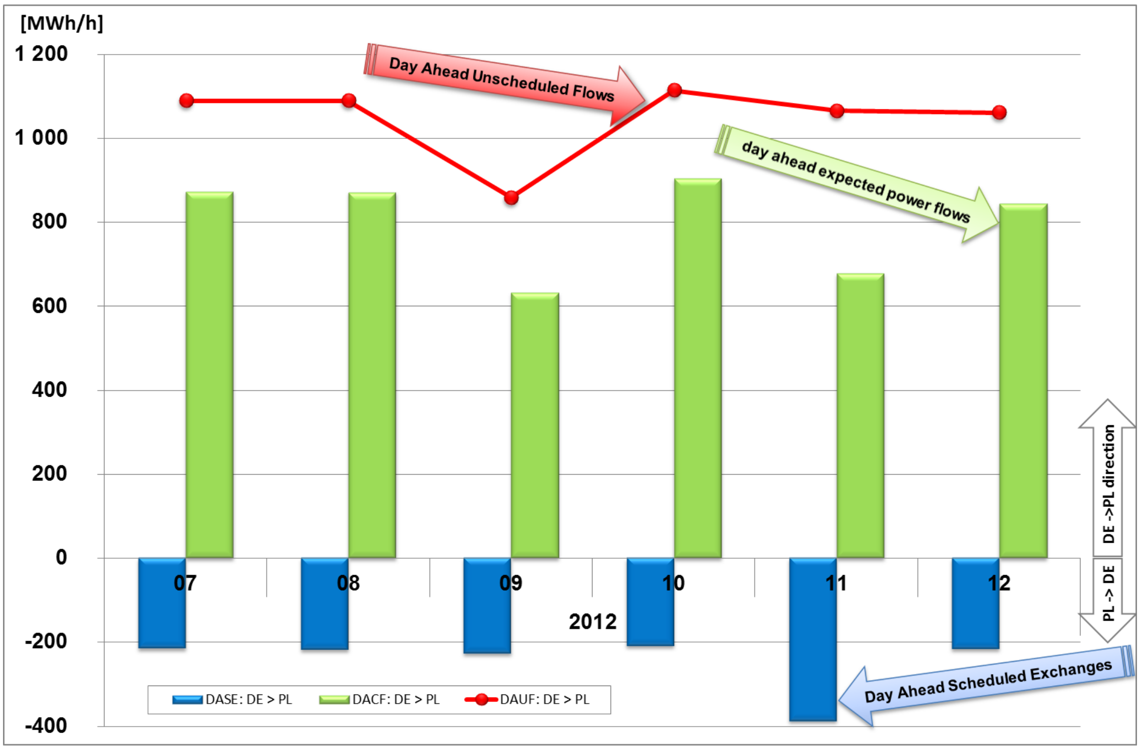

[MWh/h]
2 500
2 000
1 500
1 000
500
0
-500
-1 000
Day Ahead Scheduled Exchanges
day ahead expected power flows
Day Ahead Unscheduled Flows
07
08
09
10
11
12
2012
FR -> IT direction
IT -> FR direction
DASE: FR > IT
DACF: FR > IT
DAUF: FR > IT

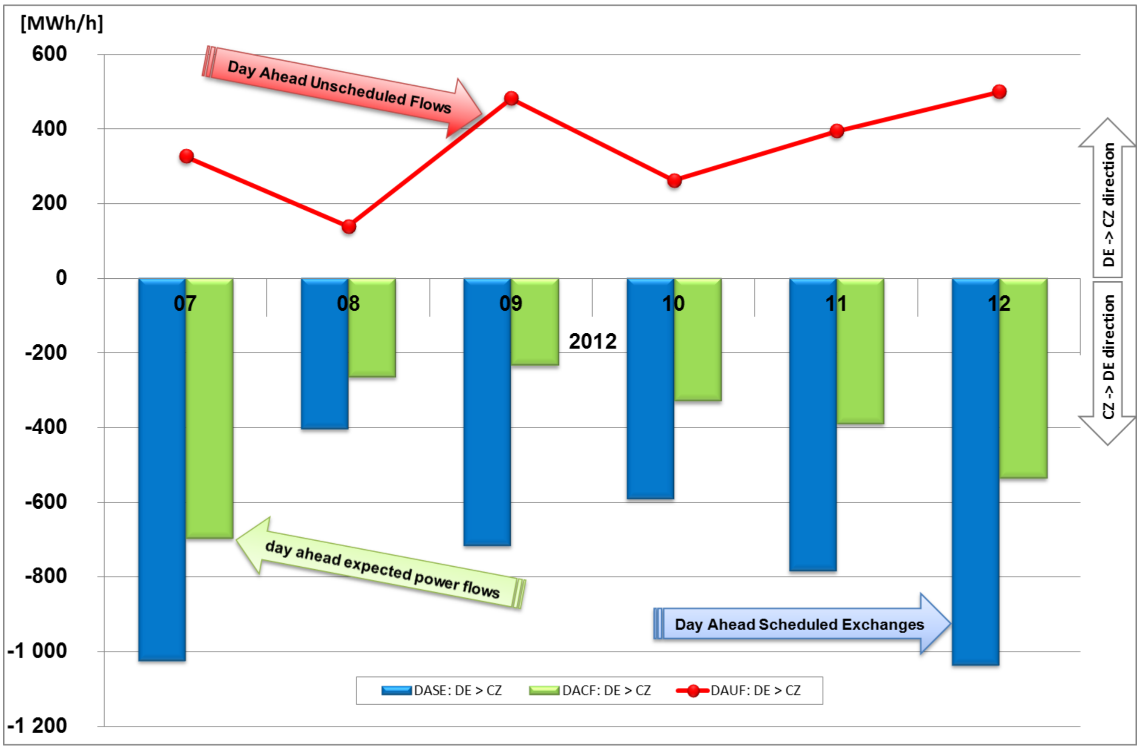

[MWh/h]
0
-50
-100
-150
-200
-250
-300
-350
07
08
09
10
11
12
2012
Day Ahead Unscheduled Flows
Day Ahead Scheduled Exchanges
day ahead expected power flows
IT -> AT
AT -> IT direction
DASE: IT > APG
DACF: IT > APG
DAUF: IT > APG


[MWh/h]
600
400
200
0
-200
-400
-600
-800
-1 000
07
08
09
10
11
12
2012
Day Ahead Unscheduled Flows
Day Ahead Scheduled Exchanges
day ahead expected power flows
IT -> SI direction
SI -> IT direction
DASE: IT > SHB
DACF: IT > SHB
DAUF: IT > SHB

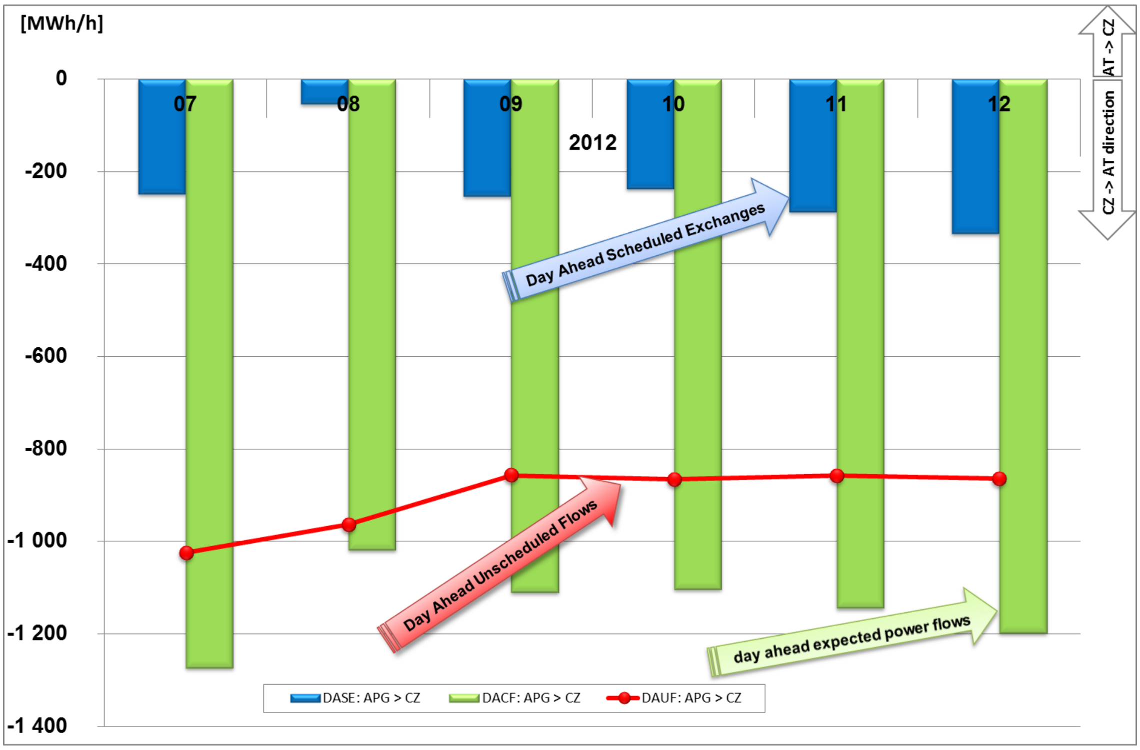

[MWh/h]
1 500
1 000
500
0
-500
-1 000
-1 500
DASE: BE > NL
DACF: BE > NL
DAUF: BE > NL
Day Ahead Scheduled Exchanges
Day Ahead Unscheduled Flows
day ahead expected power flows
07
08
09
10
11
12
2012
BE -> NL direction
NL -> BE direction

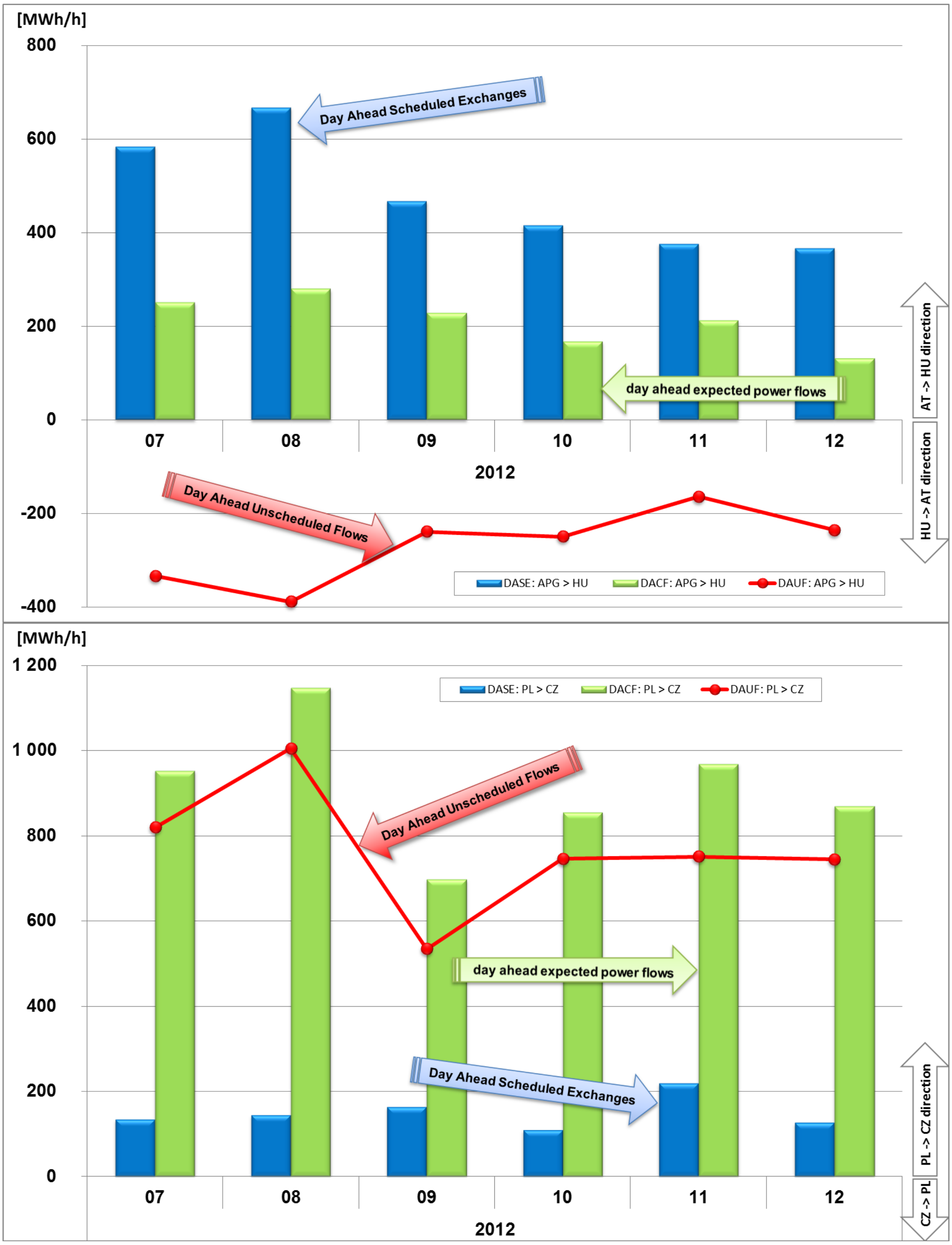

[MWh/h]
3 000
2 500
2 000
1 500
1 000
500
0
DASE: DE > NL
DACF: DE > NL
DAUF: DE > NL
day ahead expected power flows
Day Ahead Unscheduled Flows
Day Ahead Scheduled Exchanges
07
08
09
10
11
12
2012
DE -> NL direction
NL -> DE

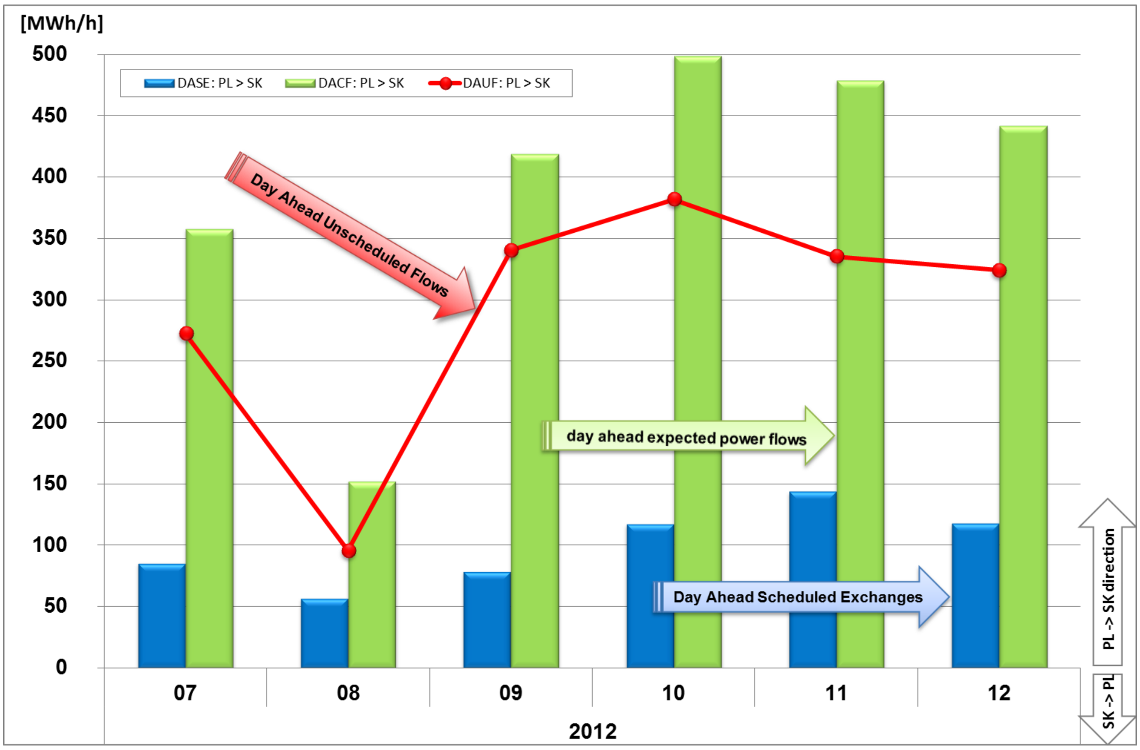

[MWh/h]
1 200
1 000
800
600
400
200
0
-200
-400
07
08
09
10
11
12
2012
Day Ahead Unscheduled Flows
day ahead expected power flows
Day Ahead Scheduled Exchanges
DE ->PL direction
PL -> DE
DASE: DE > PL
DACF: DE > PL
DAUF: DE > PL

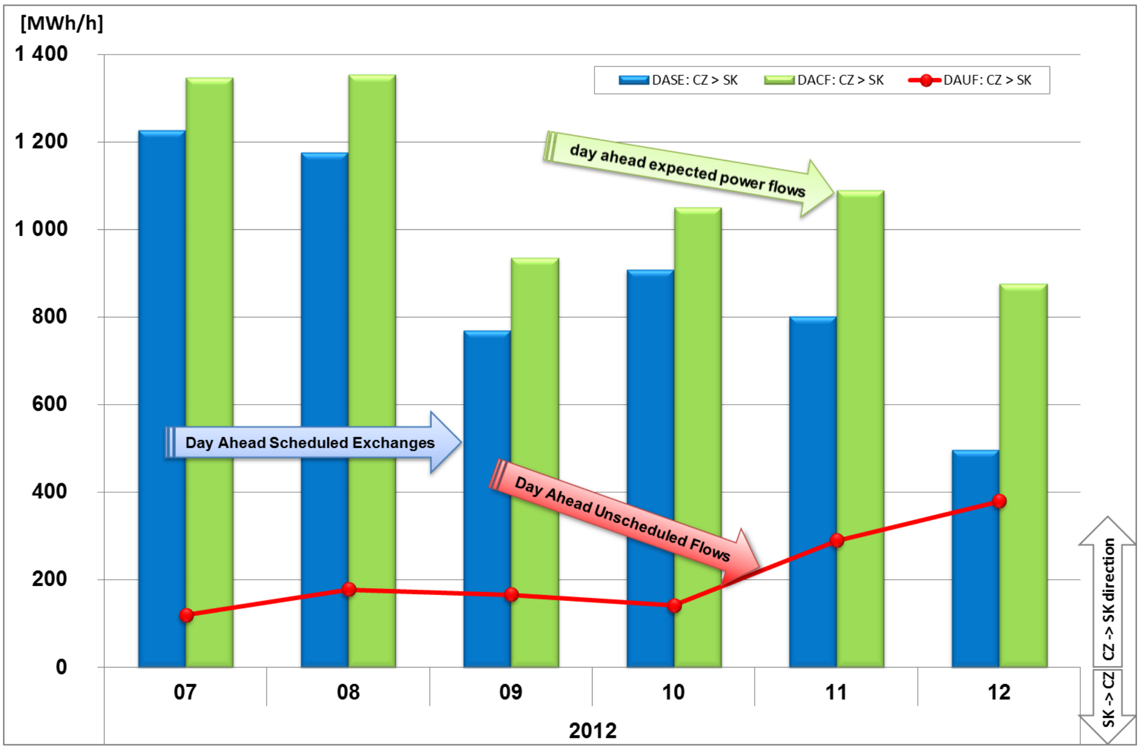

[MWh/h]
600
400
200
0
-200
-400
-600
-800
-1 000
-1 200
07
08
09
10
11
12
2012
Day Ahead Unscheduled Flows
day ahead expected power flows
Day Ahead Scheduled Exchanges
DE -> CZ direction
CZ -> DE direction
DASE: DE > CZ
DACF: DE > CZ
DAUF: DE > CZ


[MWh/h]
2 500
2 000
1 500
1 000
500
0
-500
-1 000
-1 500
07
08
09
10
11
12
2012
Day Ahead Scheduled Exchanges
day ahead expected power flows
Day Ahead Unscheduled Flows
DE -> AT direction
AT -> DE direction
DASE: DE+ > APG
DACF: DE+ > APG
DAUF: DE+ > APG

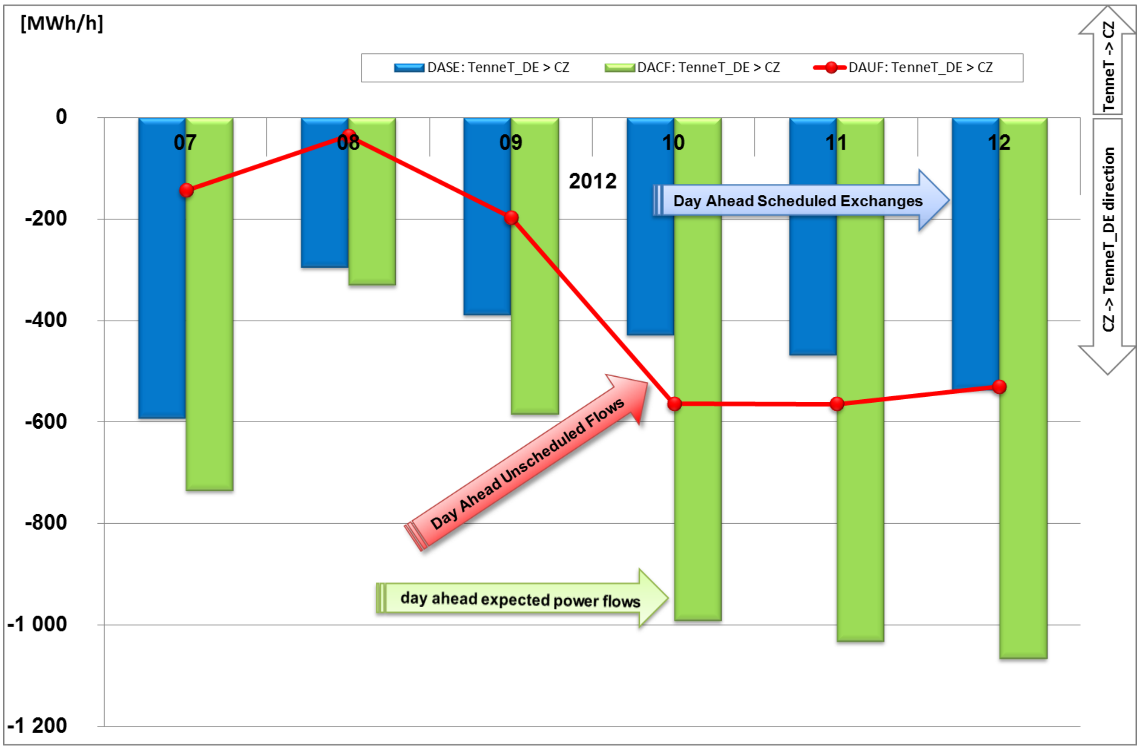

[MWh/h]
0
-200
-400
-600
-800
-1 000
-1 200
-1 400
07
08
09
10
11
12
2012
Day Ahead Scheduled Exchanges
Day Ahead Unscheduled Flows
day ahead expected power flows
AT -> CZ
CZ -> AT direction
DASE: APG > CZ
DACF: APG > CZ
DAUF: APG > CZ


[MWh/h]
800
600
400
200
0
-200
-400
Day Ahead Scheduled Exchanges
day ahead expected power flows
Day Ahead Unscheduled Flows
07
08
09
10
11
12
2012
AT -> HU direction
HU -> AT direction
DASE: APG > HU
DACF: APG > HU
DAUF: APG > HU
[MWh/h]
1 200
1 000
800
600
400
200
0
DASE: PL > CZ
DACF: PL > CZ
DAUF: PL > CZ
Day Ahead Unscheduled Flows
day ahead expected power flows
Day Ahead Scheduled Exchanges
07
08
09
10
11
12
2012
PL -> CZ direction
CZ -> PL

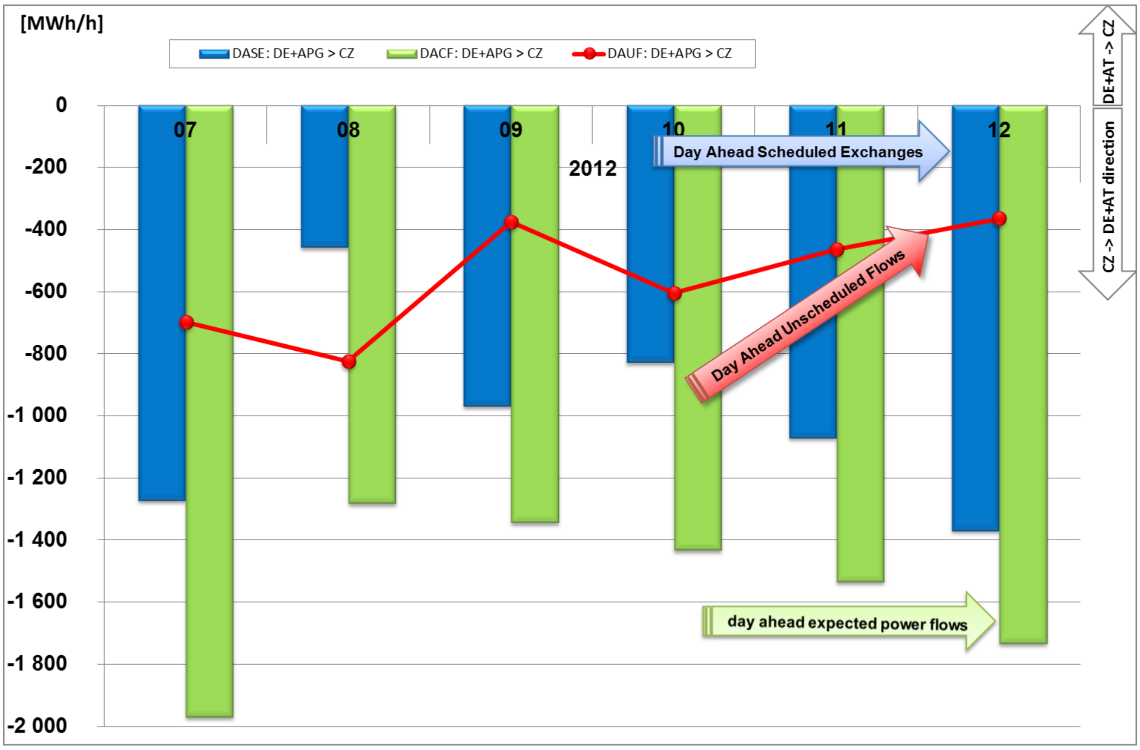

[MWh/h]
500
450
400
350
300
250
200
150
100
50
0
DASE: PL > SK
DACF: PL > SK
DAUF: PL > SK
Day Ahead Unscheduled Flows
day ahead expected power flows
Day Ahead Scheduled Exchanges
07
08
09
10
11
12
2012
PL -> SK direction
SK -> PL


[MWh/h]
1 400
1 200
1 000
800
600
400
200
0
DASE: CZ > SK
DACF: CZ > SK
DAUF: CZ > SK
day ahead expected power flows
Day Ahead Scheduled Exchanges
Day Ahead Unscheduled Flows
07
08
09
10
11
12
2012
CZ -> SK direction
SK -> CZ


[MWh/h]
1 400
1 200
1 000
800
600
400
200
0
DASE: SK > HU
DACF: SK > HU
DAUF: SK > HU
Day Ahead Scheduled Exchanges
Day Ahead Unscheduled Flows
day ahead expected power flows
SK -> HU direction
HU -> SK
07
08
09
10
11
12
2012


[MWh/h]
DASE: TenneT_DE > CZ
DACF: TenneT_DE > CZ
DAUF: TenneT_DE > CZ
0
-200
-400
-600
-800
-1 000
-1 200
07
08
09
10
11
12
2012
Day Ahead Scheduled Exchanges
Day Ahead Unscheduled Flows
day ahead expected power flows
TenneT -> CZ
CZ -> TenneT_DE direction


[MWh/h]
1 200
1 000
800
600
400
200
0
-200
-400
-600
DASE: 50Hertz > CZ
DACF: 50Hertz > CZ
DAUF: 50Hertz > CZ
Day Ahead Unscheduled Flows
day ahead expected power flows
Day Ahead Scheduled Exchanges
07
08
09
10
11
12
2012
50Hertz_DE -> CZ direction
CZ -> 50Hertz_DE direction


[MWh/h]
DASE: DE+APG > CZ
DACF: DE+APG > CZ
DAUF: DE+APG > CZ
0
-200
-400
-600
-800
-1 000
-1 200
-1 400
-1 600
-1 800
-2 000
07
08
09
10
11
12
2012
Day Ahead Scheduled Exchanges
Day Ahead Unscheduled Flows
day ahead expected power flows
DE+AT -> CZ
CZ -> DE+AT direction

Annex 5: Statistical data related to the indicators

Annex 5.1.: Statistical data related to the RTUF indicator

Table 8: Statistical data related to the RTUF indicator

All		max [MW]	min [MW]	10% percentile [MW]	90% percentile [MW]	average [MW]	median [MW]	sum [GWh]	time [h]	time [%]
CH > APG	PF	617	-2067	-1344	-226	-747	-719	-13110	17544	100%
	SF	1086	-900	-483	128	-214	-275	-3746	17544	100%
	UF	641	-1709	-957	-152	-534	-518	-9364	17544	100%
CH > DE+	PF	2161	-4357	-2825	360	-1322	-1433	-23201	17544	100%
	SF	4000	-1508	-1056	1540	-70	-500	-1224	17544	100%
	UF	1008	-3448	-2058	-462	-1253	-1256	-21977	17544	100%
CH > FR	PF	1901	-2751	-1790	15	-953	-1038	-16716	17544	100%
	SF	1100	-3600	-3200	-942	-2448	-2893	-42954	17544	100%
	UF	3252	-1284	700	2219	1496	1561	26238	17544	100%
CH > IT	PF	5143	-1176	1474	4092	2842	2935	49857	17544	100%
	SF	4240	-482	1370	3710	2550	2548	44734	17544	100%
	UF	1855	-1721	-282	883	292	282	5123	17544	100%
APG > SHB	PF	1245	-806	-45	766	370	392	6485	17544	100%
	SF	952	-890	57	950	588	673	10308	17544	100%
	UF	956	-941	-516	80	-218	-224	-3824	17544	100%
FR > BE	PF	3169	-2592	-704	1715	573	660	10060	17544	100%
	SF	3601	-1985	-385	2421	1012	1068	17748	17544	100%
	UF	1240	-2492	-1296	316	-438	-384	-7688	17544	100%
FR > DE	PF	4809	-1318	404	3342	1860	1860	32630	17544	100%
	SF	2819	-3651	-2600	1815	-362	-347	-6345	17544	100%
	UF	4562	-934	1215	3313	2222	2182	38975	17544	100%
FR > IT	PF	3235	-1273	643	2300	1489	1508	26131	17544	100%
	SF	2956	-969	1027	2647	1778	2033	31193	17544	100%
	UF	1287	-1727	-861	257	-289	-276	-5062	17544	100%
IT > APG	PF	211	-285	-212	0	-125	-141	-2185	17544	100%
	SF	99	-221	-221	-72	-172	-201	-3023	17544	100%
	UF	333	-234	-39	151	48	44	838	17544	100%
IT > SHB	PF	442	-1430	-751	-184	-481	-499	-8446	17544	100%
	SF	229	-775	-598	-203	-438	-460	-7688	17544	100%
	UF	796	-1198	-284	194	-43	-41	-759	17544	100%
BE > NL	PF	2478	-2838	-1544	1372	-104	-124	-1829	17544	100%
	SF	1455	-1459	-1157	1401	331	490	5798	17544	100%
	UF	1313	-2388	-1286	312	-435	-383	-7628	17544	100%
DE > NL	PF	4898	-2897	-606	3402	1606	1839	28172	17544	100%
	SF	2510	-2459	-734	2445	1178	1534	20667	17544	100%
	UF	2447	-1305	-319	1271	428	378	7504	17544	100%
DE > PL	PF	2030	-1354	-26	1245	603	603	10581	17544	100%
	SF	805	-1240	-647	0	-296	-295	-5198	17544	100%
	UF	2690	-681	297	1500	899	893	15779	17544	100%
DE > CZ	PF	1512	-2971	-1586	75	-756	-760	-13265	17544	100%
	SF	1067	-2700	-1774	-193	-1025	-1069	-17979	17544	100%
	UF	1815	-1071	-264	818	269	257	4714	17544	100%
DE+ > APG	PF	3700	-1546	-199	2049	926	919	16247	17544	100%
	SF	6209	-2916	-109	3483	1690	1694	29646	17544	100%
	UF	2291	-4182	-1903	365	-764	-764	-13399	17544	100%
APG > CZ	PF	196	-2435	-1660	-664	-1153	-1144	-20228	17544	100%
	SF	712	-800	-692	-46	-378	-396	-6626	17544	100%
	UF	572	-2546	-1341	-220	-775	-769	-13602	17544	100%
APG > HU	PF	959	-634	-131	478	173	174	3027	17544	100%
	SF	810	-800	-327	790	302	392	5303	17544	100%
	UF	720	-922	-469	247	-130	-151	-2276	17544	100%
PL > CZ	PF	2424	-266	339	1389	869	865	15250	17544	100%
	SF	770	-405	0	539	203	162	3554	17544	100%
	UF	2474	-353	223	1146	667	634	11696	17544	100%
PL > SK	PF	1184	-335	0	680	372	380	6523	17544	100%
	SF	600	-200	0	370	139	98	2443	17544	100%
	UF	910	-459	0	506	233	232	4080	17544	100%
CZ > SK	PF	2510	-552	278	1616	988	1027	17326	17544	100%
	SF	1896	-870	253	1386	829	858	14544	17544	100%
	UF	1317	-659	-175	495	159	157	2782	17544	100%
SK > HU	PF	2041	-191	539	1507	1046	1073	18343	17544	100%
	SF	1300	-526	500	1200	924	993	16217	17544	100%
	UF	1115	-701	-232	462	121	129	2126	17544	100%
CEPS > 50HzT	PF	1604	-1938	-756	491	-110	-82	-1928	17544	100%
	SF	1353	-695	40	765	427	451	7484	17544	100%
	UF	734	-2393	-1092	-38	-536	-504	-9412	17544	100%
CEPS > TTG	PF	2038	-456	338	1347	866	895	15192	17544	100%
	SF	1609	-951	88	1087	598	614	10495	17544	100%
	UF	1647	-1115	-187	720	268	272	4697	17544	100%
DE+APG > CZ	PF	2886	-3372	-1493	719	-397	-412	-6962	17544	100%
	SF	1779	-3406	-2404	-292	-1403	-1465	-24606	17544	100%
	UF	5830	-4438	-937	2877	1006	1059	17643	17544	100%
CH > DE+APG	PF	2684	-5543	-4003	37	-2070	-2195	-36311	17544	100%
	SF	5046	-1842	-1440	1634	-283	-806	-4970	17544	100%
	UF	916	-4156	-2785	-832	-1786	-1764	-31341	17544	100%

Table 9: Statistical data related to the RTUF indicator for a positive flow direction

+		max [MW]	min [MW]	10% percentile [MW]	90% percentile [MW]	average [MW]	median [MW]	sum [GWh]	time [h]	time [%]
CH > APG	PF	617	1	20	339	151	116	80	531	3%
	SF	1086	1	26	484	215	163	644	2991	17%
	UF	641	1	19	382	157	113	106	673	4%
CH > DE+	PF	2161	1	83	1105	535	456	1591	2977	17%
	SF	4000	1	173	2158	1085	961	7241	6673	38%
	UF	1008	1	54	605	290	253	170	587	3%
CH > FR	PF	1901	1	50	936	405	300	738	1824	10%
	SF	1100	1	68	1100	513	456	315	614	3%
	UF	3252	1	815	2225	1545	1578	26396	17082	97%
CH > IT	PF	5143	5	1483	4093	2849	2938	49871	17504	100%
	SF	4240	3	1370	3710	2555	2550	44741	17512	100%
	UF	1855	1	96	971	492	441	6352	12914	74%
APG > SHB	PF	1245	1	121	786	450	443	6911	15346	87%
	SF	952	1	261	950	668	721	10718	16049	91%
	UF	956	1	18	317	142	105	420	2966	17%
FR > BE	PF	3169	1	218	1843	997	936	13006	13041	74%
	SF	3601	1	322	2495	1355	1302	19714	14544	83%
	UF	1240	1	43	602	291	247	1322	4540	26%
FR > DE	PF	4809	1	564	3362	1954	1931	32887	16833	96%
	SF	2819	1	262	2000	1258	1320	9718	7727	44%
	UF	4562	49	1217	3314	2223	2182	38978	17535	100%
FR > IT	PF	3235	1	681	2303	1511	1518	26196	17338	99%
	SF	2956	1	1028	2650	1792	2034	31235	17431	99%
	UF	1287	1	35	501	238	194	1098	4615	26%
IT > APG	PF	211	1	7	85	48	42	33	698	4%
	SF	99	4	11	99	53	54	1	11	0%
	UF	333	1	15	176	81	67	1014	12583	72%
IT > SHB	PF	442	1	14	214	99	75	52	531	3%
	SF	229	1	17	176	87	67	14	157	1%
	UF	796	1	18	302	136	102	960	7061	40%
BE > NL	PF	2478	1	153	1664	875	837	7162	8184	47%
	SF	1455	1	221	1401	930	1074	10511	11300	64%
	UF	1313	1	47	591	288	246	1305	4523	26%
DE > NL	PF	4898	1	567	3497	2118	2173	30789	14535	83%
	SF	2510	1	513	2449	1651	1809	23733	14376	82%
	UF	2447	1	120	1383	683	597	8836	12944	74%
DE > PL	PF	2030	1	177	1275	706	679	11025	15624	89%
	SF	805	1	5	276	112	77	118	1046	6%
	UF	2690	2	340	1505	920	906	15821	17190	98%
DE > CZ	PF	1512	1	43	666	315	260	681	2158	12%
	SF	1067	1	29	511	234	183	215	920	5%
	UF	1815	1	89	889	452	402	5853	12944	74%
DE+ > APG	PF	3700	1	265	2132	1161	1098	17291	14894	85%
	SF	6209	1	531	3574	1993	1897	30982	15543	89%
	UF	2291	1	70	1102	498	390	1674	3361	19%
APG > CZ	PF	196	12	16	193	96	99	1	15	0%
	SF	712	1	19	294	134	102	176	1315	7%
	UF	572	1	27	392	177	139	124	697	4%
APG > HU	PF	959	1	54	506	269	250	3589	13333	76%
	SF	810	1	126	800	499	540	6581	13183	75%
	UF	720	1	31	424	198	167	1081	5454	31%
PL > CZ	PF	2424	2	351	1390	875	869	15259	17434	99%
	SF	770	1	38	565	276	247	3657	13227	75%
	UF	2474	1	242	1150	676	639	11712	17322	99%
PL > SK	PF	1184	1	151	697	419	412	6549	15622	89%
	SF	600	1	25	406	198	175	2470	12451	71%
	UF	910	1	78	528	297	285	4257	14332	82%
CZ > SK	PF	2510	1	355	1621	1024	1049	17409	17009	97%
	SF	1896	1	341	1395	874	882	14700	16820	96%
	UF	1317	1	55	538	278	252	3532	12704	72%
SK > HU	PF	2041	2	541	1507	1047	1074	18344	17523	100%
	SF	1300	1	500	1200	931	996	16231	17432	99%
	UF	1115	1	53	518	265	236	3149	11879	68%
CEPS > 50HzT	PF	1604	0	55	657	329	287	2514	7642	44%
	SF	1353	1	166	770	479	480	7691	16062	92%
	UF	734	0	18	312	137	105	194	1415	8%
CEPS > TTG	PF	2038	0	365	1350	880	903	15225	17302	99%
	SF	1609	1	191	1097	647	646	10648	16455	94%
	UF	1647	0	87	772	403	369	5493	13647	78%
DE+APG > CZ	PF	2886	1	80	1234	576	458	3239	5621	32%
	SF	1779	1	44	724	321	237	283	881	5%
	UF	5830	1	344	3077	1647	1543	21688	13166	75%
CH > DE+APG	PF	2684	1	73	1226	572	465	1056	1845	11%
	SF	5046	1	209	2428	1226	1075	7391	6029	34%
	UF	916	4	48	456	230	195	36	157	1%

Table 10: Statistical data related to the RTUF indicator for a negative flow direction

-		max	min	10% percentile	90% percentile	average	median	sum	time	time
		[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[GWh]	[h]	[%]
CH > APG	PF	-1	-2067	-1354	-277	-776	-737	-13190	17007	97%
	SF	-1	-900	-483	-92	-302	-296	-4390	14527	83%
	UF	-1	-1709	-965	-201	-562	-533	-9470	16863	96%
CH > DE+	PF	-1	-4357	-2904	-377	-1702	-1749	-24792	14564	83%
	SF	-1	-1508	-1110	-279	-779	-842	-8465	10868	62%
	UF	-2	-3448	-2069	-562	-1306	-1280	-22147	16956	97%
CH > FR	PF	-1	-2751	-1821	-352	-1110	-1121	-17454	15719	90%
	SF	-2	-3600	-3200	-1270	-2556	-2916	-43269	16929	96%
	UF	-3	-1284	-793	-45	-343	-252	-158	462	3%
CH > IT	PF	-2	-1176	-877	-41	-347	-243	-14	40	0%
	SF	-3	-482	-411	-59	-222	-202	-7	32	0%
	UF	-1	-1721	-559	-37	-266	-209	-1228	4615	26%
APG > SHB	PF	-1	-806	-436	-23	-195	-151	-426	2187	12%
	SF	-1	-890	-582	-38	-275	-231	-410	1491	8%
	UF	-1	-941	-536	-67	-291	-276	-4244	14565	83%
FR > BE	PF	-1	-2592	-1417	-91	-655	-541	-2946	4496	26%
	SF	-1	-1985	-1579	-84	-656	-481	-1966	2998	17%
	UF	-1	-2492	-1413	-123	-694	-605	-9010	12986	74%
FR > DE	PF	-1	-1318	-804	-53	-364	-295	-257	707	4%
	SF	-1	-3651	-2923	-335	-1637	-1635	-16062	9810	56%
	UF	-38	-934	-839	-126	-400	-266	-4	9	0%
FR > IT	PF	-5	-1273	-686	-39	-317	-256	-65	206	1%
	SF	-2	-969	-857	-75	-374	-306	-42	112	1%
	UF	-1	-1727	-940	-89	-477	-429	-6161	12913	74%
IT > APG	PF	-1	-285	-216	-63	-146	-152	-2219	15157	86%
	SF	-1	-221	-221	-89	-183	-201	-3024	16565	94%
	UF	-1	-234	-105	-6	-45	-33	-176	3943	22%
IT > SHB	PF	-1	-1430	-754	-223	-500	-507	-8499	17003	97%
	SF	-2	-775	-600	-231	-443	-460	-7701	17387	99%
	UF	-1	-1198	-348	-25	-164	-133	-1719	10450	60%
BE > NL	PF	-1	-2838	-1795	-196	-961	-915	-8991	9358	53%
	SF	-1	-1459	-1401	-130	-755	-742	-4712	6239	36%
	UF	-1	-2388	-1396	-119	-687	-598	-8932	13011	74%
DE > NL	PF	-1	-2897	-1819	-143	-871	-739	-2618	3007	17%
	SF	-1	-2459	-2050	-149	-968	-844	-3065	3167	18%
	UF	-1	-1305	-598	-44	-290	-251	-1331	4591	26%
DE > PL	PF	-1	-1354	-497	-31	-232	-185	-443	1913	11%
	SF	-1	-1240	-680	-80	-374	-361	-5315	14229	81%
	UF	-1	-681	-252	-19	-121	-94	-42	351	2%
DE > CZ	PF	-1	-2971	-1635	-232	-907	-861	-13946	15383	88%
	SF	-1	-2700	-1788	-350	-1095	-1114	-18194	16620	95%
	UF	-1	-1071	-545	-33	-249	-198	-1139	4583	26%
DE+ > APG	PF	-1	-1546	-867	-49	-394	-321	-1044	2649	15%
	SF	-1	-2916	-1476	-89	-668	-540	-1336	2000	11%
	UF	-1	-4182	-2013	-223	-1063	-977	-15073	14174	81%
APG > CZ	PF	-9	-2435	-1660	-666	-1154	-1144	-20229	17529	100%
	SF	-1	-800	-700	-141	-419	-420	-6803	16219	92%
	UF	-1	-2546	-1351	-299	-815	-794	-13725	16844	96%
APG > HU	PF	-1	-634	-290	-17	-134	-108	-562	4194	24%
	SF	-1	-800	-597	-44	-294	-260	-1278	4352	25%
	UF	-1	-922	-512	-62	-278	-263	-3357	12067	69%
PL > CZ	PF	-1	-266	-217	-16	-84	-61	-9	106	1%
	SF	-1	-405	-178	-7	-68	-45	-103	1506	9%
	UF	-1	-353	-172	-8	-75	-50	-16	219	1%
PL > SK	PF	-1	-335	-116	-10	-56	-45	-26	461	3%
	SF	-1	-200	-80	-10	-41	-34	-28	681	4%
	UF	-1	-459	-232	-15	-102	-75	-178	1742	10%
CZ > SK	PF	-1	-552	-330	-18	-156	-133	-83	532	3%
	SF	-1	-870	-475	-31	-216	-179	-156	722	4%
	UF	-1	-659	-325	-23	-156	-131	-750	4812	27%
SK > HU	PF	-2	-191	-117	-8	-55	-26	-1	21	0%
	SF	-2	-526	-280	-28	-133	-102	-15	110	1%
	UF	-1	-701	-379	-26	-181	-155	-1023	5648	32%
CEPS > 50HzT	PF	0	-1938	-967	-70	-449	-362	-4442	9900	56%
	SF	-1	-695	-293	-20	-141	-116	-207	1473	8%
	UF	0	-2393	-1119	-142	-596	-545	-9606	16128	92%
CEPS > TTG	PF	-1	-456	-294	-19	-136	-104	-33	242	1%
	SF	-1	-951	-295	-18	-140	-111	-152	1084	6%
	UF	0	-1115	-442	-28	-204	-166	-796	3897	22%
DE+APG > CZ	PF	-1	-3372	-1694	-158	-856	-759	-10201	11916	68%
	SF	-1	-3406	-2420	-486	-1494	-1518	-24889	16663	95%
	UF	-1	-4438	-2004	-129	-926	-734	-4045	4370	25%
CH > DE+APG	PF	-1	-5543	-4060	-569	-2380	-2461	-37367	15697	89%
	SF	-1	-1842	-1530	-368	-1074	-1226	-12361	11512	66%
	UF	-1	-4156	-2790	-871	-1805	-1772	-31377	17385	99%

Annex 5.2.: Statistical data related to the PTDF indicator

Table 11: Statistical data related to the PTDF indicator

All		max	min	10% percentile	90% percentile	average	median	sum	time	time
		[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[GWh]	[h]	[%]
CH > FR	PF	1901	-2751	-1790	15	-953	-1039	-16716	17544	100.00%
	CF	1192	-2931	-1950	-164	-1112	-1180	-19513	17544	100.00%
	PTDF F	1185	-839	-203	565	159	140	2797	17544	100.00%
CH > IT	PF	5143	-1176	1474	4093	2842	2935	49857	17544	100.00%
	CF	4718	-913	1245	3785	2532	2545	44427	17544	100.00%
	PTDF F	1889	-1009	-178	754	310	334	5430	17544	100.00%
CH > AT/DE/LU	PF	617	-3031	-1344	-226	-747	-719	-13110	17544	100.00%
	CF	724	-1944	-1023	-37	-572	-620	-10035	17544	100.00%
	PTDF F	733	-1111	-493	108	-175	-155	-3075	17544	100.00%
AT/DE/LU > SL	PF	1245	-1105	-45	766	370	392	6485	17544	100.00%
	CF	1204	-168	361	922	643	654	11287	17544	100.00%
	PTDF F	623	-1736	-586	39	-274	-275	-4803	17544	100.00%
FR > BE	PF	3442	-2592	-704	1715	573	659	10060	17544	100.00%
	CF	4569	-2700	40	2292	1192	1261	20908	17544	100.00%
	PTDF F	752	-1923	-1024	-199	-618	-627	-10848	17544	100.00%
FR > AT/DE/LU	PF	4809	-1318	403	3342	1860	1860	32630	17544	100.00%
	CF	3008	-2389	-559	2152	770	745	13507	17544	100.00%
	PTDF F	2261	-111	660	1508	1090	1091	19123	17544	100.00%
FR > IT	PF	3235	-1273	643	2301	1489	1508	26131	17544	100.00%
	CF	3255	-716	964	2558	1802	1858	31607	17544	100.00%
	PTDF F	733	-1855	-718	75	-312	-303	-5476	17544	100.00%
IT > AT/DE/LU	PF	211	-320	-212	0	-125	-141	-2185	17544	100.00%
	CF	70	-461	-250	-1	-106	-100	-1859	17544	100.00%
	PTDF F	331	-279	-175	131	-19	-12	-326	17544	100.00%
IT > SL	PF	442	-1803	-751	-184	-481	-499	-8446	17544	100.00%
	CF	686	-2071	-1012	-8	-506	-507	-8881	17544	100.00%
	PTDF F	1329	-749	-356	392	25	27	435	17544	100.00%
BE > NL	PF	2478	-2838	-1544	1372	-104	-124	-1829	17544	100.00%
	CF	2907	-2417	-811	1805	506	505	8874	17544	100.00%
	PTDF F	655	-2403	-1008	-201	-610	-614	-10703	17544	100.00%
AT/DE/LU > NL	PF	6311	-2897	-606	3402	1606	1838	28172	17544	100.00%
	CF	5528	-3232	-1104	2719	1001	1210	17563	17544	100.00%
	PTDF F	2300	-734	189	1014	605	603	10609	17544	100.00%
AT/DE/LU > PL	PF	2030	-1354	-26	1245	603	603	10581	17544	100.00%
	CF	719	-1346	-660	217	-204	-186	-3575	17544	100.00%
	PTDF F	1824	-160	455	1168	807	803	14156	17544	100.00%
AT/DE/LU > CZ	PF	1512	-2971	-1586	75	-756	-760	-13265	17544	100.00%
	CF	1020	-2738	-1316	16	-663	-672	-11629	17544	100.00%
	PTDF F	1060	-1253	-494	327	-93	-105	-1637	17544	100.00%
AT/DE/LU > HU	PF	959	-634	-131	478	173	174	3027	17544	100.00%
	CF	747	-480	-36	510	263	292	4613	17544	100.00%
	PTDF F	642	-558	-271	100	-90	-101	-1586	17544	100.00%
PL > CZ	PF	2424	-266	339	1389	869	865	15250	17544	100.00%
	CF	1027	-636	-178	527	166	164	2921	17544	100.00%
	PTDF F	2203	-108	396	1033	703	684	12329	17544	100.00%
PL > SK	PF	1184	-335	0	680	372	380	6523	17544	100.00%
	CF	725	-299	41	490	269	275	4726	17544	100.00%
	PTDF F	738	-498	-109	302	102	117	1797	17544	100.00%
CZ > SK	PF	2510	-552	278	1616	988	1027	17326	17544	100.00%
	CF	1669	-499	202	1227	754	796	13228	17544	100.00%
	PTDF F	1384	-585	-28	538	234	204	4097	17544	100.00%
SK > HU	PF	2041	-191	539	1507	1046	1073	18343	17544	100.00%
	CF	1443	-266	390	1089	759	790	13322	17544	100.00%
	PTDF F	976	-461	57	526	286	281	5021	17544	100.00%

Table 12: Statistical data related to the PTDF indicator for a positive flow direction

+		max	min	10% percentile	90% percentile	average	median	sum	time	time
		[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[GWh]	[h]	[%]
CH > FR	PF	1901	1	50	936	405	300	738	1824	10.40%
	CF	1192	0	40	666	298	225	349	1173	6.69%
	PTDF F	1185	0	54	635	308	265	3700	12004	68.42%
CH > IT	PF	5143	5	1483	4093	2849	2938	49871	17502	99.76%
	CF	4718	2	1253	3786	2538	2549	44436	17509	99.80%
	PTDF F	1889	0	107	788	437	416	6203	14180	80.83%
CH > AT/DE/LU	PF	617	1	20	339	151	116	80	531	3.03%
	CF	724	0	19	331	155	122	229	1482	8.45%
	PTDF F	733	0	17	252	115	88	476	4150	23.65%
AT/DE/LU > SL	PF	1245	1	121	786	450	443	6911	15346	87.47%
	CF	1204	0	368	923	646	655	11291	17482	99.65%
	PTDF F	623	0	15	242	112	88	266	2370	13.51%
FR > BE	PF	3442	1	218	1843	997	936	13006	13039	74.32%
	CF	4569	0	414	2335	1375	1361	21886	15916	90.72%
	PTDF F	752	0	15	346	147	110	80	544	3.10%
FR > AT/DE/LU	PF	4809	1	564	3362	1954	1931	32887	16831	95.94%
	CF	3008	0	224	2247	1236	1198	15851	12829	73.12%
	PTDF F	2261	9	661	1508	1090	1091	19123	17542	99.99%
FR > IT	PF	3235	1	681	2304	1511	1518	26196	17336	98.81%
	CF	3255	3	983	2559	1814	1862	31626	17436	99.38%
	PTDF F	733	0	18	285	132	105	373	2824	16.10%
IT > AT/DE/LU	PF	211	1	7	85	48	42	33	698	3.98%
	CF	70	0	1	12	6	4	10	1629	9.29%
	PTDF F	331	0	11	175	85	74	688	8083	46.07%
IT > SL	PF	442	1	14	214	99	75	52	531	3.03%
	CF	686	0	20	363	159	123	268	1686	9.61%
	PTDF F	1329	0	44	473	242	218	2258	9343	53.25%
BE > NL	PF	2478	1	153	1664	875	837	7162	8183	46.64%
	CF	2907	0	204	1941	1060	1021	12405	11700	66.69%
	PTDF F	655	0	16	345	144	103	75	516	2.94%
AT/DE/LU > NL	PF	6311	1	568	3498	2119	2173	30789	14533	82.84%
	CF	5528	1	432	2860	1665	1671	21946	13181	75.13%
	PTDF F	2300	0	234	1021	629	616	10689	16997	96.88%
AT/DE/LU > PL	PF	2030	1	177	1275	706	679	11025	15623	89.05%
	CF	719	0	30	376	184	157	943	5131	29.25%
	PTDF F	1824	4	456	1169	808	803	14157	17530	99.92%
AT/DE/LU > CZ	PF	1512	1	43	666	315	260	681	2158	12.30%
	CF	1020	0	28	457	207	168	386	1863	10.62%
	PTDF F	1060	0	33	494	232	192	1540	6623	37.75%
AT/DE/LU > HU	PF	959	1	54	506	269	250	3589	13333	76.00%
	CF	747	0	95	517	318	327	4875	15331	87.39%
	PTDF F	642	0	12	252	111	78	479	4311	24.57%
PL > CZ	PF	2424	2	351	1390	875	869	15259	17433	99.37%
	CF	1027	0	54	572	297	276	3684	12389	70.62%
	PTDF F	2203	0	397	1033	703	684	12330	17530	99.92%
PL > SK	PF	1184	1	151	697	419	412	6549	15621	89.04%
	CF	725	0	97	495	294	290	4816	16365	93.28%
	PTDF F	738	0	39	320	170	156	2339	13747	78.36%
CZ > SK	PF	2510	1	355	1621	1024	1049	17409	17008	96.94%
	CF	1669	0	288	1234	790	815	13329	16880	96.22%
	PTDF F	1384	0	64	560	281	237	4298	15318	87.31%
SK > HU	PF	2041	2	541	1507	1047	1074	18344	17521	99.87%
	CF	1443	0	397	1089	763	791	13329	17464	99.54%
	PTDF F	976	0	112	534	312	293	5130	16438	93.70%

Table 13: Statistical data related to the PTDF indicator for a negative flow direction

-		max	min	10% percentile	90% percentile	average	median	sum	time	time
		[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[GWh]	[h]	[%]
CH > FR	PF	-1	-2751	-1821	-352	-1111	-1122	-17454	15717	89.59%
	CF	0	-2931	-1976	-398	-1213	-1228	-19862	16370	93.31%
	PTDF F	0	-839	-329	-25	-163	-137	-903	5539	31.57%
CH > IT	PF	-2	-1176	-877	-41	-347	-243	-14	40	0.23%
	CF	-15	-913	-584	-37	-269	-201	-9	34	0.19%
	PTDF F	0	-1009	-495	-31	-230	-189	-773	3363	19.17%
CH > AT/DE/LU	PF	-1	-3031	-1354	-276	-776	-737	-13190	17005	96.93%
	CF	0	-1944	-1033	-176	-639	-669	-10264	16061	91.55%
	PTDF F	0	-1111	-537	-47	-265	-229	-3551	13393	76.34%
AT/DE/LU > SL	PF	-1	-1105	-437	-23	-195	-151	-426	2185	12.45%
	CF	-4	-168	-111	-8	-53	-34	-3	61	0.35%
	PTDF F	0	-1736	-600	-80	-334	-322	-5068	15173	86.49%
FR > BE	PF	-1	-2592	-1417	-91	-655	-541	-2946	4496	25.63%
	CF	-1	-2700	-1407	-69	-601	-420	-977	1627	9.27%
	PTDF F	0	-1923	-1029	-247	-643	-640	-10928	16999	96.89%
FR > AT/DE/LU	PF	-1	-1318	-804	-53	-364	-295	-257	707	4.03%
	CF	0	-2389	-1000	-86	-497	-429	-2344	4714	26.87%
	PTDF F	-111	-111	-111	-111	-111	-111	0	1	0.01%
FR > IT	PF	-5	-1273	-686	-39	-317	-256	-65	206	1.17%
	CF	-1	-716	-402	-13	-174	-139	-19	107	0.61%
	PTDF F	0	-1855	-751	-87	-397	-369	-5850	14719	83.90%
IT > AT/DE/LU	PF	-1	-320	-216	-63	-146	-152	-2219	15155	86.38%
	CF	0	-461	-256	-6	-117	-116	-1869	15914	90.71%
	PTDF F	0	-279	-206	-16	-107	-108	-1014	9460	53.92%
IT > SL	PF	-1	-1803	-754	-223	-500	-507	-8499	17001	96.90%
	CF	0	-2071	-1031	-129	-577	-560	-9149	15857	90.38%
	PTDF F	0	-749	-448	-36	-222	-197	-1823	8200	46.74%
BE > NL	PF	-1	-2838	-1795	-196	-961	-915	-8991	9357	53.33%
	CF	-1	-2417	-1190	-109	-604	-540	-3531	5843	33.30%
	PTDF F	-1	-2403	-1013	-242	-633	-626	-10777	17027	97.05%
AT/DE/LU > NL	PF	-1	-2897	-1819	-143	-871	-739	-2618	3007	17.14%
	CF	0	-3232	-2046	-151	-1005	-896	-4383	4362	24.86%
	PTDF F	0	-734	-335	-23	-146	-99	-80	546	3.11%
AT/DE/LU > PL	PF	-1	-1354	-497	-31	-232	-186	-443	1912	10.90%
	CF	0	-1346	-737	-68	-364	-315	-4518	12412	70.75%
	PTDF F	-2	-160	-147	-6	-83	-92	-1	13	0.07%
AT/DE/LU > CZ	PF	-1	-2971	-1636	-232	-907	-861	-13946	15381	87.67%
	CF	0	-2738	-1344	-201	-766	-747	-12015	15680	89.38%
	PTDF F	0	-1253	-572	-54	-291	-253	-3176	10920	62.24%
AT/DE/LU > HU	PF	-1	-634	-290	-17	-134	-108	-562	4192	23.89%
	CF	0	-480	-251	-17	-118	-100	-262	2212	12.61%
	PTDF F	0	-558	-293	-35	-156	-144	-2064	13232	75.42%
PL > CZ	PF	-1	-266	-218	-16	-85	-59	-9	105	0.60%
	CF	0	-636	-304	-23	-148	-125	-763	5154	29.38%
	PTDF F	-1	-108	-99	-13	-44	-41	-1	13	0.07%
PL > SK	PF	-1	-335	-116	-10	-56	-46	-26	460	2.62%
	CF	0	-299	-157	-11	-76	-61	-90	1178	6.71%
	PTDF F	0	-498	-355	-13	-143	-92	-542	3796	21.64%
CZ > SK	PF	-1	-552	-330	-19	-156	-133	-83	531	3.03%
	CF	-1	-499	-329	-18	-152	-134	-101	663	3.78%
	PTDF F	0	-585	-189	-12	-90	-74	-201	2225	12.68%
SK > HU	PF	-2	-191	-117	-8	-55	-26	-1	21	0.12%
	CF	-2	-266	-204	-9	-86	-64	-7	79	0.45%
	PTDF F	0	-461	-204	-13	-99	-80	-110	1105	6.30%

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Annex 5.3.: Statistical data related to the DAUF indicator

Table 14: Statistical data related to the DAUF indicator

All		max	min	10% percentile	90% percentile	average	median	sum	time	time
		[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[GW]	[h]	[%]
CH > FR	DACF	1 212	-3 252	-2 056	-182	-1 130	-1 135	-1 246	1 103	100,00%
	DASF	-144	-3 200	-3 123	-1 188	-2 233	-2 337	-2 463	1 103	100,00%
	DAUF	2 771	-1 015	500	1 737	1 103	1 096	1 217	1 103	100,00%
CH > IT	DACF	4 833	-230	1 238	3 899	2 692	2 763	2 970	1 103	100,00%
	DASF	4 240	241	1 220	3 859	2 463	2 470	2 717	1 103	100,00%
	DAUF	1 392	-945	-256	682	229	238	253	1 103	100,00%
CH > AT/DE/LU	DACF	2 320	-4 025	-3 019	355	-1 449	-1 620	-1 598	1 103	100,00%
	DASF	4 471	-1 625	-1 424	1 972	-103	-575	-113	1 103	100,00%
	DAUF	887	-3 708	-2 149	-556	-1 346	-1 338	-1 484	1 103	100,00%
AT/DE/LU > SI	DACF	1 120	-326	186	733	466	468	514	1 103	100,00%
	DASF	952	-583	391	951	722	795	797	1 103	100,00%
	DAUF	790	-844	-578	110	-256	-281	-282	1 103	100,00%
FR > BE	DACF	3 082	-1 905	-274	2 021	845	840	932	1 103	100,00%
	DASF	3 199	-792	577	2 601	1 693	1 803	1 867	1 103	100,00%
	DAUF	532	-2 369	-1 533	-238	-848	-823	-935	1 103	100,00%
FR > AT/DE/LU	DACF	4 212	-500	452	2 614	1 480	1 417	1 632	1 103	100,00%
	DASF	1 800	-3 001	-2 622	1 541	-720	-850	-794	1 103	100,00%
	DAUF	4 266	129	1 053	3 279	2 200	2 231	2 427	1 103	100,00%
FR > IT	DACF	2 913	-288	516	2 201	1 298	1 231	1 431	1 103	100,00%
	DASF	2 658	-617	863	2 652	1 513	1 104	1 669	1 103	100,00%
	DAUF	863	-1 561	-759	311	-215	-208	-238	1 103	100,00%
IT > AT/DE/LU	DACF	102	-568	-366	-79	-228	-239	-251	1 103	100,00%
	DASF	0	-221	-221	-72	-180	-196	-198	1 103	100,00%
	DAUF	308	-347	-159	62	-48	-52	-53	1 103	100,00%
IT > SI	DACF	944	-1 652	-1 071	296	-382	-404	-421	1 103	100,00%
	DASF	23	-630	-630	-203	-446	-455	-492	1 103	100,00%
	DAUF	1 232	-1 022	-485	612	64	63	71	1 103	100,00%
BE > NL	DACF	1 644	-3 278	-1 931	735	-504	-346	-556	1 103	100,00%
	DASF	1 451	-1 451	-927	1 401	357	469	394	1 103	100,00%
	DAUF	516	-2 374	-1 539	-257	-861	-841	-949	1 103	100,00%
AT/DE/LU > NL	DACF	4 491	-1 205	1 488	3 684	2 659	2 786	2 933	1 103	100,00%
	DASF	2 485	-2 453	744	2 459	1 799	1 978	1 984	1 103	100,00%
	DAUF	2 360	-521	253	1 536	860	842	948	1 103	100,00%
AT/DE/LU > PL	DACF	2 285	-334	285	1 318	803	798	886	1 103	100,00%
	DASF	25	-967	-630	0	-245	-195	-270	1 103	100,00%
	DAUF	2 285	59	631	1 492	1 048	1 033	1 156	1 103	100,00%
AT/DE/LU > CZ	DACF	-148	-3 281	-2 213	-931	-1 553	-1 522	-1 713	1 103	100,00%
	DASF	923	-3 017	-1 893	-64	-996	-988	-1 098	1 103	100,00%
	DAUF	309	-1 437	-976	-133	-557	-541	-614	1 103	100,00%
AT/DE/LU > HU	DACF	811	-461	-21	446	211	219	233	1 103	100,00%
	DASF	800	-602	48	800	480	560	530	1 103	100,00%
	DAUF	530	-846	-558	33	-269	-277	-297	1 103	100,00%
PL > CZ	DACF	1 976	45	459	1 367	917	907	1 011	1 103	100,00%
	DASF	700	-55	0	419	148	75	163	1 103	100,00%
	DAUF	1 838	7	408	1 143	768	744	848	1 103	100,00%
PL > SK	DACF	986	-48	0	637	391	411	431	1 103	100,00%
	DASF	550	-20	0	285	100	50	110	1 103	100,00%
	DAUF	761	-106	0	516	291	297	321	1 103	100,00%
CZ > SK	DACF	1 882	-363	649	1 567	1 111	1 137	1 225	1 103	100,00%
	DASF	1 732	-596	360	1 397	898	933	991	1 103	100,00%
	DAUF	1 079	-517	-62	467	212	216	234	1 103	100,00%
SK > HU	DACF	1 950	145	799	1 567	1 217	1 249	1 343	1 103	100,00%
	DASF	1 300	-118	444	1 200	905	1 000	998	1 103	100,00%
	DAUF	1 021	-268	49	596	312	304	344	1 103	100,00%
CH > AT	DACF	738	-1 767	-1 282	-165	-755	-787	-833	1 103	100,00%
	DASF	1 035	-547	-515	223	-211	-314	-232	1 103	100,00%
	DAUF	502	-1 412	-960	-137	-545	-549	-601	1 103	100,00%
CH > DE/LU	DACF	1 617	-2 458	-1 802	667	-693	-857	-765	1 103	100,00%
	DASF	3 495	-1 078	-936	1 755	108	-311	119	1 103	100,00%
	DAUF	393	-2 823	-1 441	-176	-801	-773	-884	1 103	100,00%
DE/LU > AT	DACF	2 966	-819	107	2 025	1 055	1 036	1 164	1 103	100,00%
	DASF	5 368	-1 380	491	3 343	1 900	1 889	2 096	1 103	100,00%
	DAUF	1 650	-2 850	-1 880	195	-845	-873	-932	1 103	100,00%
AT > CZ	DACF	-137	-2 110	-1 575	-736	-1 142	-1 134	-1 259	1 103	100,00%
	DASF	424	-800	-492	45	-235	-249	-260	1 103	100,00%
	DAUF	119	-1 928	-1 344	-485	-906	-915	-1 000	1 103	100,00%
DE/LU > CZ	DACF	1 118	-1 935	-957	102	-411	-393	-453	1 103	100,00%
	DASF	847	-2 252	-1 450	-50	-760	-771	-839	1 103	100,00%
	DAUF	1 496	-859	-106	824	349	330	385	1 103	100,00%
DE/LU North > CZ (TTG > CEPS)	DACF	407	-1 634	-1 237	-262	-791	-853	-872	1 103	100,00%
	DASF	372	-1 300	-891	-17	-452	-457	-498	1 103	100,00%
	DAUF	981	-1 383	-799	143	-339	-352	-374	1 103	100,00%
DE/LU South > CZ (50Hertz > CEPS)	DACF	1 900	-635	-144	929	380	359	419	1 103	100,00%
	DASF	414	-1 108	-623	31	-309	-303	-341	1 103	100,00%
	DAUF	1 979	-556	95	1 258	689	692	759	1 103	100,00%

Table 15: Statistical data related to the DAUF indicator for a positive flow direction

+		max	min	10% percentile	90% percentile	average	median	sum	time	time
		[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[GW]	[h]	[%]
CH > FR	DACF	1 212	3	50	572	290	243	22	75	6,80%
	DASF	-	-	-	-	-	-	-	-	-
	DAUF	2 771	1	513	1 737	1 113	1 098	1 219	1 095	99,27%
CH > IT	DACF	4 833	147	1 239	3 899	2 695	2 763	2 970	1 102	99,91%
	DASF	4 240	241	1 220	3 859	2 463	2 470	2 717	1 103	100,00%
	DAUF	1 392	2	89	757	406	364	322	795	72,08%
CH > AT/DE/LU	DACF	2 320	7	105	1 363	655	556	108	165	14,96%
	DASF	4 471	13	234	2 604	1 361	1 291	585	430	38,98%
	DAUF	887	18	25	666	256	159	4	17	1,54%
AT/DE/LU > SI	DACF	1 120	3	225	738	485	475	518	1 069	96,92%
	DASF	952	3	434	952	746	798	802	1 075	97,46%
	DAUF	790	1	21	389	172	137	33	190	17,23%
FR > BE	DACF	3 082	0	236	2 112	1 108	1 026	1 019	920	83,41%
	DASF	3 199	5	673	2 601	1 747	1 835	1 874	1 073	97,28%
	DAUF	532	0	19	382	170	118	8	46	4,17%
FR > AT/DE/LU	DACF	4 212	13	500	2 629	1 521	1 437	1 637	1 076	97,55%
	DASF	1 800	5	199	1 800	1 028	1 008	374	364	33,00%
	DAUF	4 266	129	1 053	3 279	2 200	2 231	2 427	1 103	100,00%
FR > IT	DACF	2 913	2	569	2 209	1 324	1 242	1 434	1 083	98,19%
	DASF	2 658	100	863	2 652	1 523	1 104	1 670	1 097	99,46%
	DAUF	863	1	32	502	243	210	90	370	33,54%
IT > AT/DE/LU	DACF	102	1	3	66	29	22	1	24	2,18%
	DASF	-	-	-	-	-	-	-	-	-
	DAUF	308	1	12	115	59	48	18	304	27,56%
IT > SI	DACF	944	2	39	592	277	225	80	289	26,20%
	DASF	23	23	23	23	23	23	0	1	0,09%
	DAUF	1 232	1	79	704	379	359	228	601	54,49%
BE > NL	DACF	1 644	1	65	1 054	530	473	206	389	35,27%
	DASF	1 451	1	182	1 401	850	929	638	750	68,00%
	DAUF	516	3	31	383	177	150	7	41	3,72%
AT/DE/LU > NL	DACF	4 491	27	1 602	3 697	2 709	2 801	2 942	1 086	98,46%
	DASF	2 485	21	1 067	2 459	1 898	1 982	2 012	1 060	96,10%
	DAUF	2 360	11	317	1 549	901	861	956	1 061	96,19%
AT/DE/LU > PL	DACF	2 285	7	328	1 325	823	803	889	1 080	97,91%
	DASF	25	5	10	25	19	23	0	4	0,36%
	DAUF	2 285	59	631	1 492	1 048	1 033	1 156	1 103	100,00%
AT/DE/LU > CZ	DACF	-	-	-	-	-	-	-	-	-
	DASF	923	3	31	560	253	203	23	92	8,34%
	DAUF	309	2	13	167	94	86	3	35	3,17%
AT/DE/LU > HU	DACF	811	1	63	454	255	244	247	970	87,94%
	DASF	800	1	197	800	542	585	548	1 011	91,66%
	DAUF	530	1	11	279	131	109	19	143	12,96%
PL > CZ	DACF	1 976	45	459	1 367	917	907	1 011	1 103	100,00%
	DASF	700	1	35	495	227	200	164	722	65,46%
	DAUF	1 838	7	408	1 143	768	744	848	1 103	100,00%
PL > SK	DACF	986	16	238	646	439	430	431	983	89,12%
	DASF	550	2	32	317	165	138	110	668	60,56%
	DAUF	761	1	143	528	332	325	322	969	87,85%
CZ > SK	DACF	1 882	44	650	1 567	1 113	1 138	1 225	1 101	99,82%
	DASF	1 732	13	411	1 398	920	941	994	1 081	98,01%
	DAUF	1 079	1	71	493	276	254	254	920	83,41%
SK > HU	DACF	1 950	145	799	1 567	1 217	1 249	1 343	1 103	100,00%
	DASF	1 300	18	465	1 200	913	1 000	999	1 094	99,18%
	DAUF	1 021	1	90	605	338	317	349	1 034	93,74%
CH > AT	DACF	738	2	32	459	214	169	12	57	5,17%
	DASF	1 035	2	40	566	257	192	64	250	22,67%
	DAUF	502	2	30	360	177	151	7	42	3,81%
CH > DE/LU	DACF	1 617	11	97	1 186	604	549	163	270	24,48%
	DASF	3 495	3	195	2 203	1 158	1 069	556	480	43,52%
	DAUF	393	7	31	281	140	126	6	46	4,17%
DE/LU > AT	DACF	2 966	2	321	2 052	1 160	1 097	1 187	1 023	92,75%
	DASF	5 368	13	697	3 372	2 010	1 961	2 115	1 052	95,38%
	DAUF	1 650	5	50	786	374	299	62	167	15,14%
AT > CZ	DACF	-	-	-	-	-	-	-	-	-
	DASF	424	4	20	266	116	88	17	151	13,69%
	DAUF	119	12	24	109	67	70	0	3	0,27%
DE/LU > CZ	DACF	1 118	0	19	385	187	131	34	184	16,68%
	DASF	847	1	25	469	174	120	16	93	8,43%
	DAUF	1 496	0	99	849	456	413	419	919	83,32%
DE/LU North > CZ (TTG > CEPS)	DACF	407	7	13	256	114	96	3	23	2,09%
	DASF	372	3	14	279	121	99	11	94	8,52%
	DAUF	981	0	23	473	215	161	42	197	17,86%
DE/LU South > CZ (50Hertz > CEPS)	DACF	1 900	3	102	1 007	510	461	460	902	81,78%
	DASF	414	2	19	242	108	83	15	138	12,51%
	DAUF	1 979	4	225	1 275	738	724	768	1 041	94,38%

Table 16: Statistical data related to the DAUF indicator for a negative flow direction

-		max	min	10% percentile	90% percentile	average	median	sum	time	time
		[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[GW]	[h]	[%]
CH > FR	DACF	-2	-3 252	-2 092	-361	-1 233	-1 216	-1 268	1 028	93,20%
	DASF	-144	-3 200	-3 123	-1 188	-2 233	-2 337	-2 463	1 103	100,00%
	DAUF	-25	-1 015	-614	-53	-261	-116	-2	8	0,73%
CH > IT	DACF	-230	-230	-230	-230	-230	-230	0	1	0,09%
	DASF	-	-	-	-	-	-	-	-	-
	DAUF	-2	-945	-510	-24	-225	-169	-69	308	27,92%
CH > AT/DE/LU	DACF	-5	-4 025	-3 082	-431	-1 819	-1 881	-1 706	938	85,04%
	DASF	-16	-1 625	-1 510	-333	-1 038	-1 160	-699	673	61,02%
	DAUF	-21	-3 708	-2 156	-593	-1 371	-1 356	-1 489	1 086	98,46%
AT/DE/LU > SI	DACF	-7	-326	-239	-18	-117	-97	-4	34	3,08%
	DASF	-3	-583	-499	-24	-179	-111	-5	28	2,54%
	DAUF	-2	-844	-593	-90	-345	-346	-315	913	82,77%
FR > BE	DACF	0	-1 905	-959	-79	-478	-389	-88	183	16,59%
	DASF	-13	-792	-500	-27	-244	-177	-7	30	2,72%
	DAUF	-2	-2 369	-1 543	-322	-892	-847	-943	1 057	95,83%
FR > AT/DE/LU	DACF	-26	-500	-309	-59	-172	-159	-5	27	2,45%
	DASF	-4	-3 001	-3 000	-279	-1 581	-1 500	-1 169	739	67,00%
	DAUF	-	-	-	-	-	-	-	-	-
FR > IT	DACF	-4	-288	-284	-29	-132	-91	-3	20	1,81%
	DASF	-77	-617	-471	-112	-257	-188	-2	6	0,54%
	DAUF	-1	-1 561	-862	-76	-447	-394	-327	733	66,46%
IT > AT/DE/LU	DACF	0	-568	-368	-97	-237	-244	-252	1 065	96,55%
	DASF	-14	-221	-221	-72	-182	-196	-198	1 089	98,73%
	DAUF	0	-347	-170	-20	-91	-79	-71	785	71,17%
IT > SI	DACF	-2	-1 652	-1 114	-113	-616	-602	-502	814	73,80%
	DASF	-4	-630	-630	-203	-447	-455	-492	1 102	99,91%
	DAUF	0	-1 022	-600	-60	-313	-285	-157	502	45,51%
BE > NL	DACF	-2	-3 278	-2 119	-167	-1 067	-968	-762	714	64,73%
	DASF	-1	-1 451	-1 310	-129	-691	-653	-244	353	32,00%
	DAUF	-2	-2 374	-1 548	-323	-901	-859	-957	1 062	96,28%
AT/DE/LU > NL	DACF	-136	-1 205	-998	-225	-532	-432	-9	17	1,54%
	DASF	-3	-2 453	-1 273	-43	-644	-560	-28	43	3,90%
	DAUF	-2	-521	-376	-15	-176	-129	-7	42	3,81%
AT/DE/LU > PL	DACF	-1	-334	-323	-17	-142	-99	-3	23	2,09%
	DASF	-4	-967	-665	-66	-345	-306	-270	783	70,99%
	DAUF	-	-	-	-	-	-	-	-	-
AT/DE/LU > CZ	DACF	-148	-3 281	-2 213	-931	-1 553	-1 522	-1 713	1 103	100,00%
	DASF	-13	-3 017	-1 908	-311	-1 109	-1 071	-1 122	1 011	91,66%
	DAUF	-3	-1 437	-986	-175	-578	-556	-618	1 068	96,83%
AT/DE/LU > HU	DACF	0	-461	-224	-9	-107	-69	-14	133	12,06%
	DASF	-1	-602	-402	-16	-196	-184	-18	92	8,34%
	DAUF	-2	-846	-574	-91	-329	-322	-316	960	87,04%
PL > CZ	DACF	-	-	-	-	-	-	-	-	-
	DASF	-2	-55	-30	-5	-16	-14	0	20	1,81%
	DAUF	-	-	-	-	-	-	-	-	-
PL > SK	DACF	-29	-48	-47	-32	-40	-43	0	3	0,27%
	DASF	-2	-20	-18	-4	-11	-10	0	3	0,27%
	DAUF	-2	-106	-75	-5	-31	-15	-1	17	1,54%
CZ > SK	DACF	-19	-363	-328	-53	-191	-191	0	2	0,18%
	DASF	-8	-596	-330	-24	-168	-124	-4	21	1,90%
	DAUF	-2	-517	-227	-18	-107	-77	-20	183	16,59%
SK > HU	DACF	-	-	-	-	-	-	-	-	-
	DASF	-8	-118	-118	-11	-59	-50	-1	9	0,82%
	DAUF	-2	-268	-147	-12	-74	-66	-5	69	6,26%
CH > AT	DACF	-1	-1 767	-1 292	-293	-808	-820	-845	1 046	94,83%
	DASF	-3	-547	-515	-111	-349	-391	-297	851	77,15%
	DAUF	-3	-1 412	-971	-190	-573	-563	-608	1 061	96,19%
CH > DE/LU	DACF	-10	-2 458	-1 884	-310	-1 114	-1 119	-928	833	75,52%
	DASF	-8	-1 078	-996	-272	-701	-766	-437	623	56,48%
	DAUF	-2	-2 823	-1 460	-250	-842	-807	-890	1 057	95,83%
DE/LU > AT	DACF	-4	-819	-666	-39	-291	-245	-23	80	7,25%
	DASF	-6	-1 380	-798	-33	-369	-275	-19	51	4,62%
	DAUF	-5	-2 850	-1 936	-268	-1 063	-1 015	-995	936	84,86%
AT > CZ	DACF	-137	-2 110	-1 575	-736	-1 142	-1 134	-1 259	1 103	100,00%
	DASF	-2	-800	-505	-81	-291	-280	-277	951	86,22%
	DAUF	-73	-1 928	-1 345	-488	-909	-915	-1 000	1 100	99,73%
DE/LU > CZ	DACF	-3	-1 935	-1 037	-124	-531	-476	-488	919	83,32%
	DASF	-5	-2 252	-1 480	-229	-846	-826	-855	1 010	91,57%
	DAUF	-2	-859	-385	-32	-183	-135	-34	184	16,68%
DE/LU North > CZ (TTG > CEPS)	DACF	-7	-1 634	-1 245	-301	-810	-863	-875	1 080	97,91%
	DASF	-2	-1 300	-903	-133	-506	-501	-510	1 008	91,39%
	DAUF	-1	-1 383	-834	-114	-459	-422	-416	906	82,14%
DE/LU South > CZ (50Hertz > CEPS)	DACF	-5	-635	-423	-36	-204	-171	-41	201	18,22%
	DASF	-1	-1 108	-636	-106	-368	-343	-356	965	87,49%
	DAUF	-3	-556	-261	-33	-145	-133	-9	62	5,62%