Study on the services needed for the Coordinated Auction Office Tool to enable the Dry-run

Verbund
November 2007
Final Report

Dry-run CA SEE

“Services needed for improvement and extension of the coordinated auction office tool for South East Europe region for enabling the Dry-run and participation of Traders”

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Verbund - Austrian Power Grid AG

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Final Report Content

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Abbreviation List

ATC Available Transfer Capacity
ATSO Albanian Transmission System Operator
APCS Power Clearing and Settlement AG
APG VERBUND-Austrian Power Grid AG, Austrian largest transmission system operator and contracting party related to the project.
BC Border Capacity or Bottleneck Capacity; maximal allowed power flow between two control areas.
BORZEN Power Market Operator in Slovenia
CAO Coordinated Auction Office
CBCs Composite Border Capacities; maximal allowed power flow between predefined profile which can include more borders between control areas.
CM Congestion Management
CONSENTEC Consulting Company based in Aachen, Germany
CSV Comma-separated values file format; file type that stores tabular data.
DrCAT Dry-run Coordinated Auction Tool; simulation software for testing the concept of a load-flow based coordinated allocation system.
Dry-run Simulation of coordinated load flow based auctions in SEE organised by SETSO TF NACMPF SG.
ECS Energy Community Secretariat
EFET European Federation of Energy Traders
EMS Serbian Transmission System and Market Operator
EPCG Electric Power Company of Montenegro, AD Niksic
ETSO European Transmission System Operators
EURELECTRIC The Union of the Electricity Industry
EKC Electricity Coordinating Center
HEP-TSO Croatian Transmission System Operator
HTSO Transmission System Operator of Greece
KfW Reconstruction Credit Institute; German government-owned development bank
MAVIR Hungarian Transmission System Operator Company
MCP Market Clearing Price
MEPSO Macedonian Transmission System Operator
MF (F-max) capacity calculation method recently presented by APCS and Consentec.
NACMPF SG Network Access Congestion Management and Power Flows Sub Group under supervision of SETSO TF, developing and simulating the effects of coordinated load flow based auctions in
SEE.

NEK  Electricity System Operator of Bulgaria
NOS BiH Independent System Operator of Bosnia and Herzegovina
OPCOM  Power Market Operator in Romania
PTDF  Power Transfer Distribution Factors; matrix to be calculated by all involved TSOs which converts within an load-flow based coordinated auction all requested cross border capacities into (estimated) physical flows.
PTRs  Physical Transmission Rights; rights possessed by auction participants to use transmission capacities for commercial exchange of a certain amount of energy between control areas.
PX  Power Exchange
SEE  South Eastern Europe
SETSO TF  Decision body of SEE TSOs related to the investigation of coordinated load flow based auctions in SEE.
TEIAS  Transmission System Operator of Turkey
TSO  Transmission System Operator
TEL  Transelectrica Romania
UIOGPF  Use It Or Get Paid For It
1. Executive Summary

By signing the contract "Services needed for improvement and extension of the coordinated auction office tool for South East Europe region for enabling the Dry-run and participation of traders" between the Energy Community and Verbund-Austrian Power Grid AG (APG), the Energy Community expresses kindly her willingness to support and foster the second phase of the so-called Dry-run for coordinated capacity allocation in the SEE region. This second phase explicitly includes the participation of the traders as well as other market participants. In order to provide a simulation close to reality of a coordinated load flow based explicit auction a testing environment had to be set up.

In this final report APG, acting in the role of the responsible project coordinator, gives an overview, first, about the efforts, which had to be done in order to provide the above mentioned testing environment, and second, about the state of the play in the second phase of the Dry-run in the year of 2007. The report is completed by the conclusions drawn by the experiences of the currently running Dry-run and the proposal of further steps and methodologies towards a third and last phase of a Dry-run.

Based on an existing simulation software for the first Dry-run in years 2006 and 2007, which had been developed in the last years by APG on its own costs and efforts, several additional functionalities were implemented. The experiences of these years, which had been made as an provider of the software and the IT infrastructure, implied the facilitation of several processes and the adaptation of the software accordingly. Several ideas about the business processes and the auction clearing algorithms, which had already been used by APG to make its own simulations in the last years, were integrated into the simulation software and made available to the market participants by easy-to-use graphical user interfaces. Beside of the extension and improvement of the functionality the simulation software was also improved in respect of usability.

But also other efforts had to be done in order to keep alive the project and the interest of the market participants. APG implemented the possibility to deal with the new and evolving methodology of capacity calculation, the so-called MF approach, into the simulation software, although it was not part of the contract. A brief description of this new method is also included in this report and due to the topicality of this issue there are still development efforts, especially in the area of standardisation of the necessary data communication.

In coordination and collaboration with Consentec, Germany, as a subcontractor, the design of concepts for the integration and implementation of a secondary market and curtailment options were elaborated. Also risk management principles and billing issues have been addressed within the project.

APG acting in the role as an consultant for the Energy Community, also made recommendations and the findings and conclusions can be found at the end of the final report.
2. Introduction

Efficient cross border trading is an essential precondition to facilitate and foster sound development of electricity markets. Especially the last years experience has shown that market based cross border allocation methods may lead to inefficient usage of interconnectors if physical conditions are not taken into consideration in an appropriate manner.

Hence, the project of investigating load flow based coordinated auctions in South-East-Europe (SEE) on the basis of a Dry-run has turned out to be a “technology driver” regarding further development of market based cross border auction proceedings, because of respecting physical situation during the allocation procedure.

Verbund-APG has developed a simulation software for the first phase of the dry-run, i.e. the Dry-run amongst SEE TSOs during the year 2006, in order to test the concept of a load-flow based coordinated allocation system in the SEE area. The concept itself has been developed by SETSO working group NACMPF. The software simulates the monthly flow based coordinated auction of available border capacities. It was the task of the TSOs to define the available border capacities on the interconnectors and the matrix for the sensitivity of load flows on the interconnecting lines (Power Transfer Distribution Factors – PTDFs). After the first phase of the Dry-run, when the TSOs fulfilled the function of the bidding parties, submission of bids is now done by traders. Based on the bids, the simulation software calculates the expected physical load flows on the lines and executes the coordinated auction according to the defined auction algorithm. The results are presented in different graphical charts. Additionally the software calculates different variants for the distribution of revenues based on the results of the auctions.

With the second phase of the Dry-run for Coordinated Auctioning in the SEE region including the traders and market participants the project has required more commitment, professional guidance and of course more resources related to manpower and finances. For transparency and cost reflecting reasons Verbund APG has applied for financial support for this second phase of the Dry-run. After extensive negotiations the Energy Community agreed to support this project by signing the contract on 3rd of July 2007.

With this final report the responsible project coordinator gives an overall description of the project, an overview of the accomplished tasks which are left open in Interim report and an assessment of the possible bottlenecks in the process. Verbund APG also would like to mention that the chapters related to Secondary Market and Curtailment are contributed by Consentec acting as a subcontractor.
3. Parties involved and responsibilities

SETSO TF

The SETSO TF composed of the SEE and the SEE neighboring TSOs is the main coordination and decision body for all activities concerning the allocation system.

NACMPF SG

NACMPF is a subgroup of SETSO TF and also composed of experts from TSOs coming from the SEE countries and the neighboring countries. NACMPF is responsible for project management and technical implementation of the Dry-run 2007. The TSOs participating in NACMPG acting as the CAO during the Dry-run on a rotating basis, i.e., each month another TSO is performing the role of the CAO in order to become familiar with all the processes necessary.

SEE TSOs

The SEE TSOs are cooperating in this project by providing expertise, taking over necessary roles in the Dry-run (e.g., being the auction office, grid calculations, placing bids during the Dry-run in 2006). Furthermore, they are playing an important role in the training of traders and/or regulators using the allocation system in the Dry-run as well as the implementation of the SEE CAO.

Consentec/APCS

Consentec is a German based consultancy body, APCS is the Austrian independent responsible party for balance group management, clearing and settlement and also offers consulting services. Both companies were contracted in the first phase on monitoring and evaluation of the result of the Dry-run 2006 and have also already been contracted for the second phase of the Dry-run. The German bank KfW have financed Consentec and APCS for providing consultant services during 2006 and 2007.

VERBUND Austrian Power Grid AG (APG)

APG as a member of SETSO TF and NACMPF SG has contributed expertise and developed the necessary tools (DrCAT) for performing the Dry-run in 2006. APG will continue being part of the project by rendering the services defined in the contract with ECS “Services needed for improvement and extension of the coordinated auction office tool for South East Europe region for enabling the Dry-run and participation of Traders”.

Traders, Power Utilities, Power Exchanges

In the Dry-run 2007 traders and power utilities, mainly members of EFET and EURELECTRIC are involved in the bidding procedures. At the training meeting organised on 1st of March 2007 in Sofia, traders and power utilities are trained by the NACMPF SG how to participate in the Dry-run, mainly how to use the DrCAT
software for bidding. About 40 participants from about 30 trading/production companies have joined in the Dry-run 2007. Also experts from SEE power exchanges BORZEN and OPCOM are monitoring the Dry-run process.

**Energy Community Secretariat (ECS)**

The Secretariat has the monitoring role related to realisation of the study. Its tasks in connection with the execution of the study are related to conducting thorough reviews of the reports (inception-interim-final), and to their background of preparing meetings of the Steering Committee. The Steering Committee is established to assess the quality of the study and confirm fulfilment of contractual obligations.

## 4. Analysis of state of play

### 4.1. Structure of the Dry-run 2006

The Dry-run for load flow based coordinated auctions was mainly a project developed by the TSOs of the SEE region and of the neighbouring countries Austria, Hungary and Italy. The TSOs have established the project within the SETSO subgroup NACMPF and elaborated the necessary technical, economic and organisational aspects. The Dry-run in SEE for 2006 was supported by the consultants Consentec, Germany and APCS, Austria which have been financed by KfW from Germany.

Further the SEE TSOs acted as traders during the simulation of monthly load flow based coordinated auctions by submitting bids to the Auction Office, i.e. the electronic auction portal (see Figure 1).

![Figure 1: Structure of the Dry-run in 2006](image)

In order to increase knowledge and to gain experience each participating TSO fulfilled the tasks of the CAO for at least one monthly coordinated auction round. In the first phase of Dry-run in 2006 the following SEE TSOs participated actively (see
also Figure 2): ATSO (Albania), NOS BiH (Bosnia-Herzegovina), NEK (Bulgaria), HTSO (Greece), MEPSO (FYR of Macedonia), TEL (Romania), EPCG (Montenegro), EMS (Serbia), TEIAS - not modelled (Turkey).

Figure 2: Map of participating TSOs within the first Dry-run phase during 2006

The NACMPF SG member-companies from countries participating in the Dry-run simulated the work of a Coordinated Auctioning Office (CAO), based on a rotation principle, in the following order:

<table>
<thead>
<tr>
<th>Time Schedule</th>
<th>TSO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Jan-Mar 2006:</td>
<td>EKC</td>
</tr>
<tr>
<td>2 Feb-Apr 2006:</td>
<td>EMS</td>
</tr>
<tr>
<td>3 Mar-May 2006:</td>
<td>NEK</td>
</tr>
<tr>
<td>4 Apr-Jun 2006:</td>
<td>EPCG</td>
</tr>
<tr>
<td>5 May-Jul 2006:</td>
<td>HTSO</td>
</tr>
<tr>
<td>6 Jun-Aug 2006:</td>
<td>NOS BiH</td>
</tr>
<tr>
<td>7 Jul-Sep 2006:</td>
<td>ATSO</td>
</tr>
<tr>
<td>8 Aug-Oct 2006:</td>
<td>TEIAS</td>
</tr>
<tr>
<td>9 Sep-Nov 2006:</td>
<td>MEPSO</td>
</tr>
<tr>
<td>10 Oct-Dec 2006:</td>
<td>TEL</td>
</tr>
</tbody>
</table>

Table 1: List of TSOs performed the role of the CAO during 2006

The time schedule for the auction embraced roughly five stages:

(1) Preparation:
Administrative procedures like information on time schedules, or requests to send network models etc.

(2) Calculation of input data:
Merging and verifying of network models
Computation of PTDF matrix representing the physical network
Calculation and evaluation of border limits – the so-called Border Capacity or Bottleneck Capacity (BC) for each border pair in both directions

(3) Bidding phase
During a certain time window the other TSOs had the opportunity to send bids to the auction platform

(4) Calculation of auction results
Clearing process done by the Dry-run simulation software according to the mathematical algorithm

(5) Publication of results and analyses of revenue allocation schemes
Every round has been analysed by the TSO acting as Auction Office and the report has been published on the ETSO Homepage www.etso-net.org.

4.2. Used tools for the Dry-run 2006 – DrCAT

In autumn 2005 APG (VERBUND Austrian Power Grid AG) as a co-convenor of NACM SG decided to enable the Dry-run by developing a web based auction portal (DrCAT - Dry-run Coordinated Auction Tool; http://www.DrCAT.at; see also Figure 3). All costs of development, hosting and operation were borne by APG.

That tool is used to calculate the outcome of a load flow based coordinated auctions for transmission rights in electricity networks. The input data for the calculation comprise zones that act as sources and sinks for electricity transport, the interconnections between these zones, and bids. A bid consists of a source zone, a destination zone, a bid price and a bid volume. The output data provide information about which bids are accepted including respective prices and volumes. Furthermore, the flows and congestion are displayed as well as different allocation schemes for payments to TSOs can be calculated.

The tool embraces a database and an optimisation kernel based on a commercial third party software. Input information are stored in a MySQL-database. The optimisation algorithm is solved by a standard commercial optimisation solver and the output data are written back to the database. In general, there are two optimisation cases – with and without netting. Netting means that counter flows are taken into account, flows in opposite directions cancel out. Hence, the available capacity for the auction increases. The optimizations with and without netting are conducted by using different PTDF matrices.

The simulation software DrCAT addresses, particularly, the participators of the Dry-run coordinated auctions initiated by SETSO NACMPF SG for the SEE region.
4.3. Tasks of the Dry-run 2006

During the Dry-run in 2006 the basic principles and mechanism of load flow based coordinated auctions have been investigated. As mentioned above the Dry-run in 2006 was supported by Consentec and APCS which was financed by KfW.

The major tasks of that Dry-run in 2006 were:

- to investigate the “Basic principles and mechanisms of Coordinated Auctioning”,
- to investigate the basics necessary to define “Auction Rules”,
- to analyse the “Financial Flows”,
- to define the necessary “Information Flow”,
- to analyse the “Economic benefits” of load flow based coordinated auctioning,
- to develop a proposal of an “Multilateral agreement between TSOs”,
- to define the “Software specification” and
- to develop “ Transitional solutions” of auction proceedings.

4.4. Structure of the Dry-run 2007

For the second phase of the SEE Dry-run the structure has been changed. Traders and market participants are invited to be involved into the Dry-run. Especially with the participation of the traders in the Dry-run, this project is expected to deliver added
value to the market development in the SEE region, in terms of preparing the necessary preconditions for the establishment of the Auction Office for 2009¹.

The structure of the Dry-run 2007 is shown in Figure 4. The difference compared to the Dry-run 2006 is that the whole process is closely related to real operations. I.e. traders who are willing to join the Dry-run in 2007 are replacing the TSOs as market actors. Also the time frames of the auction rounds have been improved; i.e. in 2006 only monthly auctions were simulated and in 2007 also the processes and necessary tools of performing daily auctions have been developed. The additional functions, not necessary for the Dry-run like Risk-Management, Billing, Secondary Trading and Scheduling – in order to take full advantage of the load flow based coordinated auction concept – have to be investigated.

![Figure 4: Structure of the Dry-run for 2007](image)

The main additional functions needed for performing that Dry-run are:

- Adaptation of Dry-Run software (improvement of daily allocation process) for integration of Traders in Dry-run.
- Development of combined border concept (shall be able to be stored separately and provide the opportunity to upload combined BCs together with line capacities).
- Development of automatic e-mail communication with traders (automatic submission of test results).
- Development and discussion of partial netting possibilities (i.e. treatment of options and obligation at the same time in order to increase the system usage). If traders agree to mandatory bids then these bids could be used for

¹ Date according to the conclusions of the 11th Athens Forum; date has been already postponed from 2008 to 2009 in the meantime.
netting in the auction algorithm and in this way increase the available capacities.

- Development of interfaces with capacity-coordination and PTDF-calculation tool in order to speed up the process for daily auctions
- Implementation of different bid types (blockbids) and investigation of fill or kill options for these blockbids on the results of the auctions (Fill or kill option: the bidder should determine whether he needs the full blockbid or whether he is content with a part of the bid in case that the full blockbid cannot be operated in the auction).
- Implementation of different products (base, peak, and other freely definable products).
- Design of Secondary Market concept, Risk Management concept, and Billing concept together with consultant.
- Investigation of curtailment options and possibilities together with consultant
- Documentation (Dry-run software manual).
- Optimizing processes and systems (for traders and for SEE TSOs) based on consultants’ input.

All these additional requirements stemming from the design of the second phase of the Dry Run result in the necessity to adapt and upgrade the simulation software DrCAT in order to perform the simulation and to document and discuss the results. The additional work concerns mainly the programming of the new functions. There is also some additional work necessary on the side of the consultants who should of course monitor also the correct function and reliability of the simulation software. The following shows the parties who have fulfilled the auction office role during the second phase of the Dry-run in 2007.

<table>
<thead>
<tr>
<th>2nd phase of the Dry-run SEE</th>
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<tbody>
<tr>
<td>11 Feb-Apr 2007:</td>
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<tr>
<td>12 Mar-May 2007:</td>
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<td>13 Apr-Jun 2007:</td>
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<td>14 May-Jul 2007:</td>
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<tr>
<td>15 Jun-Aug 2007:</td>
</tr>
<tr>
<td>16 Jul-Sep 2007:</td>
</tr>
<tr>
<td>17 Aug-Oct 2007:</td>
</tr>
<tr>
<td>18 Sep-Nov 2007:</td>
</tr>
</tbody>
</table>

Table 2: List of TSOs performed the role of the CAO during 2006
5. Final state of development within the project

5.1. Issues solved in the final phase of the Dry-run

For the second phase of the SEE Dry-run of coordinated flow based auctions the structure has been changed compared to first simulation round during 2006 (see chapter 4). Beside TSOs also Traders have been invited to join the Dry-run process in order to get more reliable market data and information based on Traders inputs (i.e. market price differences in terms of capacity bids for Dry-run simulations). Especially their participation can deliver added value to the market development in the SEE region, in terms of preparing the necessary preconditions for the establishment of the Auction Office for 2009.

The important goal of the second phase of the Dry-run was to investigate and create all necessary functions necessary for a simulation of real-time operation. The first step was the involvement of traders who took over the role of the bidding parties, and the next step was the implementation of daily auctions. Additionally further concepts and functions had to be developed and integrated into the simulation software.

The simulation software DrCAT has turned out as an essential tool for the development of the coordinated auction system in SEE. The results derived from the process are used to develop and define the final concept of the coordinated allocation system and for the implementation of the CAO. The results can also used to define the functional specification of the final IT-solution for the CAO. The technical findings and results - extracted from the simulation and documented by the consultants - have been made available regularly in a transparent way to all involved parties of the Dry-run via the webpage www.DrCAT.at.

5.2. List of work packages

Within this chapter, additional functions and improvements made on the Dry-run simulation software are explained in details. All these additional requirements stemming from the design of the second phase of the Dry-run result in the necessity to adapt and upgrade the simulation software DrCAT in order to be able to perform the simulation and to document and discuss the results.

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2 Date according to the conclusions of the 11th Athens Forum; date has been already postponed from 2008 to 2009 in the meantime.
<table>
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<tr>
<th>Work pack. no.</th>
<th>Work package title</th>
<th>Type of activity</th>
<th>Lead. partic. no.</th>
<th>Lead. partic. short names</th>
<th>Person-hours</th>
<th>Start month</th>
<th>End month</th>
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<td>Adaptation of Dry-run software for inclusion of traders</td>
<td>RTD 2</td>
<td>HW, TS, MV</td>
<td></td>
<td>450</td>
<td>Jun 07</td>
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<tr>
<td>WP2</td>
<td>Development of combined border concept</td>
<td>RTD 2</td>
<td>CT, HW</td>
<td></td>
<td>285</td>
<td>Jun 07</td>
<td>Aug 07</td>
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<td>WP3</td>
<td>Development of automatic email communication with traders</td>
<td>RTD 2</td>
<td>HW, TS, MV</td>
<td></td>
<td>120</td>
<td>Sep 07</td>
<td>Nov 07</td>
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<td>WP4</td>
<td>Development of partial netting possibilities</td>
<td>RTD 2</td>
<td>HW, TS, MV</td>
<td></td>
<td>240</td>
<td>Oct 07</td>
<td>Nov 07</td>
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<td>Development of interfaces with capacity-coordination and PTDF-calculation tool</td>
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<td>CT, HW</td>
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<td>Nov 07</td>
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<td>RTD 4</td>
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<td>Sep 07</td>
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<td>WP7</td>
<td>Implementation of different products</td>
<td>RTD 3</td>
<td>CT, HW, TS, MV</td>
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<td>Sep 07</td>
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<td>Design of concepts for secondary market, risk management and billing</td>
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<td>Nov 07</td>
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Table 3: work package list
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<th>Milestone name</th>
<th>Work pack. involved</th>
<th>Expected date</th>
<th>Achievement</th>
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<td>Adaptation of Dry-run software for inclusion of traders</td>
<td>WP1</td>
<td>Nov 07</td>
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<td>2</td>
<td>Development of combined border concept</td>
<td>WP2</td>
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<td>100%</td>
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<td>3</td>
<td>Development of automatic email communication with traders</td>
<td>WP3</td>
<td>Nov 07</td>
<td>100%</td>
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<tr>
<td>4</td>
<td>Development of partial netting possibilities</td>
<td>WP4</td>
<td>Nov 07</td>
<td>100%</td>
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<tr>
<td>5</td>
<td>Development of interfaces with capacity-coordination and PTDF-calculation tool</td>
<td>WP5</td>
<td>Nov 07</td>
<td>100%</td>
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<tr>
<td>6</td>
<td>Implementation of different bid types</td>
<td>WP6</td>
<td>Sep 07</td>
<td>100%</td>
</tr>
<tr>
<td>7</td>
<td>Implementation of different products</td>
<td>WP7</td>
<td>Sep 07</td>
<td>100%</td>
</tr>
<tr>
<td>8</td>
<td>Design of concepts for secondary market, risk management and billing</td>
<td>WP8</td>
<td>Nov 07</td>
<td>100%</td>
</tr>
<tr>
<td>9</td>
<td>Investigation of curtailment options</td>
<td>WP9</td>
<td>Nov 07</td>
<td>100%</td>
</tr>
<tr>
<td>10</td>
<td>Documentation</td>
<td>WP10</td>
<td>Nov 07</td>
<td>100%</td>
</tr>
<tr>
<td>11</td>
<td>Optimizing processes and systems</td>
<td>WP11</td>
<td>Nov 07</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 4: achievement status table

<table>
<thead>
<tr>
<th>Leading participants short names</th>
<th>Full name</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW</td>
<td>Hannes Wornig</td>
</tr>
<tr>
<td>TS</td>
<td>Tim Schreier</td>
</tr>
<tr>
<td>MV</td>
<td>Milan Vukasovic</td>
</tr>
<tr>
<td>CT</td>
<td>Christian Todem</td>
</tr>
<tr>
<td>CO</td>
<td>Consultant</td>
</tr>
</tbody>
</table>

Table 5: members of the project team

<table>
<thead>
<tr>
<th>Type of activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTD</td>
</tr>
<tr>
<td>Research and technological development</td>
</tr>
<tr>
<td>DEM</td>
</tr>
<tr>
<td>Demonstration</td>
</tr>
<tr>
<td>TRA</td>
</tr>
<tr>
<td>Training</td>
</tr>
<tr>
<td>MGT</td>
</tr>
<tr>
<td>Management of consortium</td>
</tr>
<tr>
<td>OTHER</td>
</tr>
<tr>
<td>Other specific activities</td>
</tr>
</tbody>
</table>

Table 6: types of activites
6. Development of Work Packages

6.1. Adaptation of Dry-run software for inclusion of traders

The work package 1 comprises all adaptations which have been done for the inclusion of the traders which have not been specified explicitly in the other work packages. This work is constantly done on behalf of new inputs of the market participants and new developments and evolving tendencies in the SEE region.

The following list shows the main and biggest efforts which have been done to include the traders and to give them (as well as the TSOs) a comfortable platform for testing coordinated load flow based auctions:

- A new design was created and the platform was adapted according to the new design requirements.
- Unused or ineffective input and database fields were removed.
- Common wording was introduced and implemented consistently through the platform.
- Import and export functions were improved in order to make the data interchange with other software products easier, especially in regard to localization issues.
- Most of the displayed lists were extended with more pre-selection and sorting possibilities.
- The validation of every input field was reengineered in order to provide a better usability.
- The bid and block bid input form built completely new in order to meet the trader’s needs (see Figure 5).
- Most of the result graphics were improved. New result graphics were added.
- Beside the already implemented “Bid Statistics”, a new menu item was introduced called “Bid analysis”. This analysis gives a more precise description and aggregation of the auction results. The example displayed in figure 2 shows all accepted and rejected bids for the monthly product M0708 (August 2007) in the bidding direction from TEL to MEPSO using the calculation method “without netting”. From the drop-down menu “View” (Figure 6), it is also possible for the auction office to get detailed information on products and block products, bid submission, block bid submission, combined product results and bid acceptance overview.
- Due to the above described changes manifold modifications had to be done on the database tier and the database itself.
Figure 5: Graphical user interface for the bid and block-bid input form (WP1)

Figure 6: Graphical user interface for the bid analysis with tables and graphics (WP1)
6.2. Development of combined border concept

According to the work package 2, the DrCAT test system enables the auction office to define combined lines which can be used to represent Composite Border Capacities (CBCs) between two previously agreed interfaces.

Basic border-wise BCs can be supplemented with a number of combined lines which will represent additional binding constraints in the clearing process. Using this approach, security of entire interconnection will be increased since unforeseen loop-flows will be limited.

The auction office can create new CBCs or edit existing ones. Figure 7 – clipping 2 shows CBC for the total import of Greece, Albania and Macedonia, created with the intention to limit flows over the technical profile (Serbia-Albania + Serbia-Macedonia + Montenegro-Albania + Bulgaria-Greece).

Additionally, a detailed description of the defined CBC can be inserted as it is shown in Figure 7 – clipping 3.

![Figure 7: Graphical user interface for creating/editing combined lines (WP2)](image-url)
Whereas the combined lines which respect the technical profiles were formerly defined as part of an auction, the new version enables the user to define the different combined lines on a system-wide level and to put them into action as part of the auction definition with one click (see Figure 8).

**Figure 8:** Graphical user interface for inserting combined lines defined on a system-wide level into newly-created auction (WP2)

In order to ease the input of the combined line capacities, their input was integrated into the capacity input mask. Hence the user is able to manually enter/edit and upload the line capacity values (using .CSV file) as well as values of combined lines in one step at one location (see Figure 9).

**Figure 9:** Graphical user interface for input of the capacities of the combined lines in the capacity menu (WP2)
6.3. Development of automatic email communication with traders

The email communication module provides an interface for the auction office to send the auction results to various user groups.

The user groups are bidders, TSOs, auction office and administrators. The recipients can be selected manually in general (Figure 10).

With bidders being the role selection, there is an additional automatic selection: the communication module can choose only bidders that took part in the current auction, only active bidders that took part in any auction so far or all bidders registered to the system.

As a next step the email content can be defined. So far, there are two possible types of emails designed for bidders:

The first email content type provides each bidder with full information about the auction. At first, general information about offered products and technical details are given. The next sets of tables comprise of a summary about which trader received how much capacity in total and an overview for each border listing the capacities of all the products requested as well as accepted and the respective prices. Each product is linked to a list of all bids submitted by the bidder. The next set of tables provides detailed information for the block products submitted by the bidder and is...
build up in the same way. This email type concludes with a set of tables that
summarizes both types of bids and shows the bidders share of the entire market
demand for capacity.

The second type of email provides the bidder only with personal data. The first set of
tables lists the bidder’s requested and accepted capacities as well as the respective
product prices for each border and product. Each product is followed with a detailed
list of submitted bids. Another similar set of tables follows listing the bidder’s personal
results for the block products.

There are also two types of email prepared to send out to Transmission System
Operators (TSOs):

The first and comprehensive content type comprises of a general overview about the
closed auction and a list for each border of aggregated requested and accepted
volume and rate of acceptance. This mail type concludes with a revenue distribution
among all TSOs according to each implemented distribution method.

The second type of mail provides just the revenue distribution.

For auction office members the email content comprises of a general description of
the closed auction, which is followed as for the TSOs by a list of aggregated
requested and accepted volumes for each border, the total bid value for each product
and rate of acceptance. This mail type concludes with a revenue distribution among
all TSOs according to each implemented distribution method.

The administrators email content represents a list of all in the auction participating
bidders.

After confirming the dialog by pressing send, the emails are generated and sent to
the specified users with the help of a free licence third party email server.

6.4. Development of partial netting possibilities

Taking also firm bids into account, i.e bids which implicate an obligation to use the
allocated capacity if accepted (rights-with-obligations), allows for the consideration of
netting in the auction clearing procedure.

Partial netting has a positive influence on the total volume of allocated power in a
flow-based coordinated auction mechanism. Due to the fact that capacity obligations
are used for netting purposes (traders must nominate the obtained capacity), energy
transactions that have a source-sink pair in commercial “non-interesting” direction will
produce additional transfer capacity on critical bottlenecks.
As it is shown in Figure 11, market participants are able to adjust their bidding behaviour in the current auction and to freely choose bid type: obligation (if checkbox is selected) or option (default setting). With this possibility offered to market participants, auction office has clear information to which extent it can rely on submitted bid from a market participant.

Partial netting lead to higher social welfare: overall higher level of accepted bid power on the regional level, better utilization of transmission network and lower auction clearing prices.

For the implementation of partial netting, special advanced features of electricity markets have to be developed such as coordinated redispatching measures and the relevant compensation schemes. If a trader does not fulfil its declared obligation, TSOs must then assess the extent to which the nominations of traders are in excess of the critical border capacity and decide, on some basis, how to change foreseen regional generation patterns. Furthermore, adequate compensation schemes should be elaborated. Due to the above-mentioned obstacles for its implementation in reality, it seems that partial netting is not advisable so far.

6.5. Development of interfaces with capacity-coordination and PTDF calculation tool

In accordance with working package 5 an interface was created which simplifies the generation of a CSV file out of an XLS file. The format of this file is compliant with the input format for the PTDFs of the DrCAT test system. After the calculation of the
PTDF matrix was done, using commonly agreed software tools, the MS™ Excel sheet has to be filled with the calculated Power Transfer Distribution Factors (PTDFs). It is also necessary to enter predefined trading product code, as shown in Figure 12 (H01 – hourly product for 00:00 to 01:00, M01 – monthly product for January). To start the generation of the CSV file, the user has to click on the button “XLS to CSV” located in the top left corner of the MS™ Excel sheet (see Figure 12).

![Figure 12: Screenshot for XLS to CSV conversion interface (WP5)](image)

The macro, which has been originally developed in Visual Basic, will immediately be executed and the CSV file for DrCAT test system will be created with the default filename YYMMDD.csv in the same directory where the working excel file is located (see Figure 13).

![Figure 13: Screenshot of the CSV after the conversion procedure is completed (WP5).](image)

As additional work, although not part of work package 5, adaptations are made on defining additional constraints for Fmax-based approach of the capacity calculation procedure (Figure 14). The user is able to define:

- critical internal lines in (n-0) case with available capacity in forward and reverse directions as well as corresponding PTDF column which shows influence of each possible trading direction pair on internal line in question;
- critical internal lines and tie-lines in (n-1) case with corresponding critical contingency and available capacity in forward and reverse directions as well
as corresponding PTDF column which shows influence of the each possible trading direction pair on internal or tie-line in question.

Figure 14: Graphical user interface for defining additional constraints in (n-0) and (n-1) cases for Fmax-based approach of the capacity calculation procedure (WP5).

6.6. Implementation of different bid types

The simulation software DrCAT offers the conduction of auctions that accept a variety of different bid types. Supported bid types are the standard divisible bid for a single product, an indivisible bid for a single product, a linked bid and a block bid.

The **standard bid** is a request for transmission capacity with a user defined volume (in MW) and price (in €/MWh). The bid’s volume is seen as a maximum capacity that the bidder is demanding. In case of congestion, the volume of the last accepted bid (marginal bid) is curtailed and so it receives capacity only up to the ATC.

The time frame of transmission capacity is indicated by the bid’s product (see below). Last but not least, a source zone and a sink zone are specified with the bid submission.

An **indivisible bid** is similar to a standard bid with an additional “fill-or-kill” attribute indicating that the bidder would like to be awarded the full capacity request or nothing.
This bid type is not subject to curtailments. As a consequence, indivisible bids can cause paradoxically rejected divisible bids (rejected although submitted with a price higher than the MCP). Our conclusion is that indivisible bids have to be handled with care in order to avoid situation of gambling. So, as a recommendation indivisible bids shall be limited in its amount.

Additionally the option of linked bids was investigated. Linked bids are multiple, indivisible bids placed for different products but on the same source – sink zone combination. Prices and volumes of the bids do not have to be equal. Bids that are linked are either accepted all together completely or none of them (Figure 16). Our conclusion is that linked bids do not offer any advantages to the traders and therefore is not recommended to be used for real.
A block bid as a standard bid is a request for the transmission of electricity from a specific source zone to a specific sink zone submitted by one trader (Figure 17).

The difference between both types of bids is that a block bid is a request for an equal volume of capacity in multiple consecutive products (either hourly, daily, monthly or yearly). It is also a type of “fill or kill” / “all or nothing” which indicates that either the complete volume in all demanded products is accepted or nothing. Block bids can bring value added for market participants, in particular with daily auctions, because of the possibility to harmonise such block products with standardised products traded at power exchanges. Because of missing of power exchanges and lacking of liquid markets in most of SEE countries so far, block bids are not of utmost importance. Nevertheless so called user defined block bids, i.e. blocks can be defined by each user on its own according to personal needs, can be an valuable asset\(^3\). These user-defined block bids are not scope of this work.

![Figure 17: Graphical user interface for defining and editing block products (WP 6)](image)

\(^3\) With so called user defined block bids each user would have the possibility to create blocks according to the needs of his technical units. I.e. min. production times and ramp rates etc. can be taking into account.
A trader places a block bid by selecting the block product and submitting the requested power as well as the price he is willing to pay in €/MWh. A conversion to €/MW is done automatically (Figure 18).

A block bid is accepted when the utility resulting from its execution is larger than the sum of utility of each of the single product bids displaced by the block bid. The utility of a bid is equal to its volume times its requested capacity.

### 6.7. Implementation of different products

According to the work package 7 the simulation software DrCAT enables to define new products, like base, peak, off-peak etc., and to update and delete the existing ones (see Figure 19). Beside the already known features to handle the administration of products, the input of a “simple” product was facilitated by changing the definition of a product. This resulted in removing the definition of weekdays and hours for a product and in adding an additional field, the type of the product, i.e. hourly, daily, monthly, yearly. Hence it is possible to create even more flexible products.

In conjunction with the re-definition of the product the implementation of block products is the biggest improvement in regard of products. Block products can
consist of any combination of “simple” products (see Figure 19) and thus they are as flexible as the “simple” products.

Figure 19: Graphical user interface for the administration of “simple” products and block products (WP7)

The implementation of the different products and bid types had the biggest impact on the auction algorithm. The database structure had to be completely reengineered as well as the auction algorithm and market clearing price determination.

6.8. Design of concepts for secondary market, risk management and billing

6.8.1. Secondary Market concepts

The following paragraph was under investigation by Consentec and the final paper received from consultants is appended in full.

Wholesale market players have evolving traded electricity portfolios to manage. Sometimes they buy capacity rights on a yearly basis, which they do not need during certain seasons. At other times they only need the capacity rights they buy daily or monthly during peak hours; thus they may like to sell on their rights in a deep and liquid market for certain off-peak periods. Meanwhile other players, with contrasting portfolios of power sales and purchases, may find themselves naturally on the buying side in some of those same seasons or off-peak periods, in their own efforts to optimise their portfolios. Moreover, customer portfolios as well as market price
expectations evolve over time, giving rise to additional needs for reselling or buying transmission rights, ideally at random point of time.

Secondary markets for transmission capacity are intended to fill the gap between the medium/long term and the day-ahead allocation stages. In the first place, they serve to provide the above mentioned hedging and optimisation opportunities. This requires the option to break up longer term transmission rights into shorter time periods (e.g. to sell only a few hours of a transmission right that originally has been allocated as a monthly band).

At several European borders such kind of secondary markets are already in place. Some TSOs (who operate these markets) report a rather low utilisation of these platforms. However, before concluding that secondary markets are unattractive by principle, one should take into consideration that it might be the particular market design as well as the interface to the day-ahead allocation that could prevent current secondary markets from being widely accepted as a valuable risk hedging instrument. As secondary markets constitute the link between the allocation of forward and day-ahead transmission rights, their design is crucial for the consistency of the entire congestion method in general and the suitability of forward rights as hedging instruments in particular. We reflect this in our proposal for a secondary markets concept which is on the one hand very easy and on the other hand very flexible to combine the objectives of desirable liquidity and hedging possibilities.

### 6.8.2. Secondary Market: Fragmentation

The secondary market shall help market participants to adjust their time profile of transmission rights to their commodity portfolio. To allow this, there must be a possibility to sell only parts of a transmission right in terms of volume (i.e. only a part of the capacity amount) and in terms of time periods (i.e. for instance only one month out of a yearly transmission right). Concerning the fragmentation of time periods a compromise between flexibility and liquidity should be found. A completely free fragmentation might miss this target; for example, it would be hardly possible to find on the 10th of February a counterpart for an offer to sell an hourly transmission right for the 18th of November, 10.00-11.00h. However, on the 16th of November, the same trade is much more realistic.

A reasonable compromise would be to disaggregate forward transmission right immediately after each primary allocation into the granularity of the subsequent allocation stage. Concretely, this means that

- after each yearly auction, the allocated yearly rights would be disaggregated into 12 monthly rights of the same amount, and
- after each monthly auction, the allocated monthly rights would be disaggregated into hourly rights for all 24 hours of all days of the respective month.

Coming back to the above example, on the 10th of February transmission rights until the end of February would be tradable as hourly products, whereas transmission rights for later months would be tradable as monthly bands only (Figure 20).
Depending on regional circumstances it may be desired to further disaggregate transmission rights at an earlier point of time. This may allow market participants to earlier match their portfolios, but may be a risk for the liquidity of the secondary market. Therefore, such steps should be carefully investigated. Eventually, a fragmentation into a limited number of standard products (e.g. peak/off-peak) could be preferable to allowing an arbitrary fragmentation into hourly rights at an early point of time.

6.8.3. Secondary market: Involvement of the auction office

With respect to the secondary market, the auction office would have two functions:

The auction office must keep track of who owns which forward transmission rights. This is a prerequisite for checking the validity of the nominations prior to the day-ahead allocation. For this purpose the auction office needs to maintain a registry of transmission rights ownership. Buyers and sellers of transmission rights in the secondary market must notify the auction office of each transfer (i.e. submit data about the buyer, the seller, the maturity period and amount transferred). However, the auction office would not require price information nor would it need to organise the secondary market. Also, the buyers and sellers in the secondary market would not require a confirmation by the auction office, because the ownership transfer would not change the total amount of allocated transmission rights and thus their potential physical impact on the network.

Flow-based capacity allocations allow the market to determine how to share capacity between different borders. But to avoid misallocations of capacity that cannot be corrected for long time periods (e.g. between a yearly capacity auction and a
monthly capacity auction for December) and allow secondary markets to continuously adapt capacity prices to their expected value at the day-ahead auction\(^4\), a flow-based secondary market is important. We recommend to include a flow-based capacity concept in the secondary market, because only such a concept allows to continuously adapt the ratio of the volumes of transmission rights between the different borders. In order to include the flow-based concept the auction office should offer a means to convert transmission rights between different directions (i.e. source/sink pairs). This must be done by the auction office because it needs to keep track of the technical impact (i.e. the power flows) resulting from the potential nomination of transmission rights (Figure 21).

Figure 21: Principle of secondary trade between different transmission directions

Practically, this would mean that the auction office would post conversion ratios between the transmission directions, taking into account their flow impact on the relevant network constraints. The conversion ratios would be determined on the basis of the flow-based capacity model that had been used in the latest allocation round for the given maturity period.

For example, a conversion ratio between AÆB and CÆD of 1:2 would mean that a transmission right of 10 MW from A to B could be converted into 20 MW from C to D (because taking back the 10 MW AÆB out of the market would relieve the critical network elements such that another 20 MW could be transmitted from C to D without breaching security limits).\(^5\)

\(^4\) Having a well functioning secondary market, a transmission right is very similar to a financial option which can be bought and sold at stock exchanges. For such financial options the described behaviour of continuously reflecting evolving expectations about the prices of the underlying product is typical and reflected in the exchange prices.

\(^5\) It depends on the flow factors (PTDF) if the conversion ratio is greater or less than 1. In the example in the text we assume that transmission from C to D has a lower PTDF on the critical network constraints than transmission from A to B. Therefore, the conversion leads to an increase of the total amount of transmission rights. If the PTDF of CÆD was greater than that of AÆB, the total amount would decrease, i.e. the trader would receive less MW in direction CÆD than he owns in direction AÆB.
The market participants could use this facility in the following way (Figure 22): Suppose the owner of a transmission right of 10 MW from A to B (trader 1) wants to sell his right. He becomes aware of another market participant (trader 2) who wants to buy a transmission right from C to D. Now trader 1 can request the auction office to convert the required amount of his transmission right A→B into C→D, thereby changing the amount of MW according to the posted ratio.\(^6\) After the auction office has confirmed (and registered) the conversion, trader 1, now owning a transmission right C→D of 20 MW, can sell to trader 2.

Trader 1 might want to execute this sequence of conversion and selling to trader 2 even if there was an alternative buyer (trader 3) who wanted to buy a transmission right A→B, depending on which counterpart offers the better price. “Better” here means that the price ratio must exceed the reciprocal conversion ratio: If trader 2 offers 10 €/MW for C→D, trader 3 must offer more than 20 €/MW in order to become more attractive for the seller.\(^7\)

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\(^6\) In practice, the final conversion ratio could depend on the amount of MW to be converted. This is because the ratio is computed for the total set of transmission rights that are “in the market” at the time of computation. Through the conversion, the binding network constraint(s) according to the flow-based capacity model might change (i.e. physical congestion is shifted to a different network element). This issue could be resolved by allowing traders to enter the amount of MW that they wish to convert via an electronic interface and offer them, for a limited time, a firm conversion ratio based on that amount.

\(^7\) After each registered conversion, the auction office would update all conversion ratios in case the binding constraints according to the flow-based capacity model have changed (cf. footnote 6). This way the conversion ratios (indicating the price ratios for the secondary market) continuously reflect the (evolving) location of congestion in the grid.
a) secondary trade for single transmission direction

Trader 1  Trader 2  Auction Office

 owns capacity A→B

 want to buy capacity A→B

 ready to sell capacity A→B

 price negotiation

 transaction

 information on ownership transfer

 information on ownership transfer

 registry update

b) secondary trade between different transmission directions

Trader 1  Trader 2  Auction Office

 owns capacity A→B

 want to buy capacity C→D

 want to convert x MW A→B to C→D

 replace x MW A→B by y MW C→D

 ready to sell capacity C→D

 price negotiation

 transaction

 information on ownership transfer

 information on ownership transfer

 registry update

Figure 22: Process of secondary trade for single direction (a) and between different directions by means of conversion through the auction office (b)
As a consequence of the secondary market design described above, the market would be as simple as possible if trade takes place within identical transmission directions (Figure 22). At the same time, the total amount of transmission rights allocated for a given direction would remain adjustable by the market throughout the phase of secondary trading (Figure 22). This way the distribution of transmission rights can follow the evolving market valuation. Moreover, eventual inefficient results of the primary allocation (i.e. the yearly/monthly auctions) can be adjusted. And last but not least the liquidity of the secondary market would significantly increase because through the flow-based conversion facility there would be one secondary market for the entire region instead of one per border.

6.8.4. Secondary market: Flow-based capacity model and recomputation issues

As described above, we recommend that the auction office offers a possibility to convert transmission rights between different directions on the basis of the flow-based capacity model. This raises the question, which model exactly to be used at a given point of time.

In order to find a solution to this question, one should take into consideration

- that the flow-based capacity model may be updated prior to each auction round, reflecting the TSOs’ increased certainty about future network conditions; and
- that prior to each auction round the already allocated transmission rights are taken into account as causing (potential or certain) flows that need to be deducted from the total allocable capacity.

This means that although different capacity models are applied for the same maturity period (e.g. one hour of a particular day) throughout the course of the year, all transmission rights allocated for a given period are always compatible with the capacity model that has been used for the latest allocation round for that period.9

Consequently, the flow-based conversion of transmission rights for a given maturity period should be based on the flow-based capacity model that has been applied at the latest allocation round for the respective maturity period.10 This concept respects that the TSOs' knowledge on network constraints evolves over time, but that, for

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8 In the monthly auction the already allocated yearly transmission rights constitute options, such that they have a potential impact on the flows, which can be considered through worst case assessment. In the day-ahead auction, yearly and monthly transmission rights have been firmly nominated (or given back to the auction), such that their impact in terms of flows can be computed as a certain input.

9 For example, after the monthly allocation for March, all transmission rights for March are compatible with the capacity model used for the monthly March auction. Transmission rights that had been allocated in the previous yearly auction have been segmented into months, and the March segment of these rights has been considered for the determination of the allocable March capacity, using the March capacity model.

10 For example, after the monthly auction for March the hourly transmission rights for March hours are based on the capacity model applied for the monthly auction for March, while at the same time secondary trading for monthly transmission rights from April to December is performed on the basis of the capacity model used for the last yearly auction.
instance, the latest capacity update for a certain month does not apply to other months thereafter.

6.8.5. Secondary market: Interface to day-ahead-allocation

As discussed above, it depends on the properties of the involved national electricity markets if long and medium term PTRs serve rather as physical or financial hedging instruments. Owing to the diversity of national market development across Europe, the allocation of forward PTRs should ideally be designed such that both purposes can be accommodated. One important aspect in this context is the interface between secondary markets and day-ahead allocation.

Prior to the day-ahead allocation (e.g. one hour before) owners of long and medium term PTRs must firmly nominate to which extent they will use their rights in the 24 hours of the next day. Unused capacity will be reallocated through the day-ahead auction, thereby avoiding that capacity is wasted. To achieve not only a physical, but also a financial hedging functionality we recommend that in this case the owners of the long/medium term PTR receive a compensation amounting to the day-ahead clearing price for the respective transmission direction (use-it-or-get-paid-for-it, UIOGPFI). This underlines the financial hedging function of the PTRs, where the PTR price should at any time – primary allocation, secondary market and return to the auction office – reflect the expected day-ahead capacity price.

6.8.6. Risk Management and Billing

The SEE market has been developing quite fast over the last years. Nevertheless, especially SEE trading companies for electricity haven’t reached the level of Western European companies in the electricity sector yet in terms of sales volumes, credit worthiness, contractual behaviour etc. The opening of the SEE electricity markets to all market participants can pose a threat to local trading entities who are less competitive compares to Western European companies.

Therefore the success of the CAO depends also on comprehensive risk management principles, i.e. the CAO needs guarantees for the payment of its participating traders.

In principle the CAO faces the following kind of risks:

- Payments risk (risk that trader/auction winner does not pay for transmission rights acquired)

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11 Note that in contrast to the reduction of capacity (be it by allocation of inverse day-ahead capacity or by curtailment), the compensation of not nominated yearly/monthly transmission rights at the day-ahead clearing price does not constitute a commercial risk for the TSOs, because they simply pass on a share of their day-ahead income to the previous owners of the not nominated rights and keep only the share relating to the newly issued capacity.

12 When setting up the details of the CM method, one may consider to let the UIOGPFI compensation slightly differ from the day-ahead clearing price. This could be used to steer the liquidity of the secondary and day-ahead capacity markets. For example, setting the compensation slightly below the day-ahead clearing price would increase the attractiveness and liquidity of the secondary market at the expense of reduced capacity volumes to be (re)allocated in the day-ahead stage.
- Timing risk (payments cannot be settled as per contract terms due to delays in banking/payments system or other uncertainties)
- Collateral risk (risk that collateral is not available or of a lesser value than previously determined)
- Currency risk (exchange rate risk, inflation risk)

One possibility to reduce the fallout risk is to provide well rated companies with higher credit limits. These credit limits determine the available trading volumes for each individual market participant, i.e. it limits the ability to place bids in the auction system. Therefore the market participants (i.e. companies) have to provide the CAO with officially approved rating certificates.

Additionally bank guarantees or promissory notes can serve as collaterals as well. It has to be also carefully watched that banks which issuing that instruments have certain requested ratings.

Such principle/instruments is/are necessary to guarantee the solvency of the CAO for fulfilling the financial duties toward its shareholders (TSOs using the flow based coordinated auction mechanism). Nevertheless it could be seen as discriminatory because of limiting trading possibilities especially for poorly – or even not – rated (local) trading companies compared to well established (foreign) companies. Further, if the rating of a market participant is decreasing below a required rating limit, the relevant participant shall be obliged to inform the CAO immediately. Furthermore the market participant has to secure its exposure through a different risk management instrument offered by the CAO.

An additional risk management instrument can be a so called deposit account (at the account of the CAO and/or at an account of a bank chosen by the CAO). Using a deposit account a market participant can only trade according the amount provided on it. The CAO therefore needs to install electronic communication with the relevant accounts in order to perform online checking of the limits. Those limits have to be taken into consideration during the daily auction procedures (i.e. the bids placed by the market participant must not exceed its limit provided at the deposit).

In order to avoid the currency risk, the only accepted currency for risk management instruments as well as for the entire payment should be EUR.

A possibility to overcome the above mentioned principle of potential discrimination of poorly or even non rated trading companies could be the appointment of a risk management institution. Within the concept business plan, provided by APG, Terna together with EBRD for the 9th Athens Forum, such a risk management institution (risk management office, RMO) is described. Such an RMO comprises the possibility to enhance the credit limits for poorly rated (local) trading entities at the Auction Office. The RMO could provide a guarantee mechanism which is designed to cover a certain share of a participant’s collateral requirements. Therefore such a mechanism could provide equal opportunities to all market participants and could bring more confidence into regional trading. Details about such an option can be found in the mentioned business plan.
Also of utmost importance in relation to risk management principles and instruments used by the CAO is the accurate billing, i.e. the timing of issuing the invoices.

So, the invoicing of yearly and monthly auctions have to be done in such a manner that non paid capacities can be re-auctioned at the next auction time frame (e.g. non paid yearly capacities can be re-auctioned during the following monthly auction).

**Figure 23: Billing principles of yearly, monthly and daily allocated capacities**

So, in order to enable the aforesaid it is recommended that the CAO invoices capacities allocated in the course of yearly auctions in twelve equal amounts. The amount of January and February should be invoiced at the same time, directly after the publication of yearly auction results. The other months should be invoiced month by month (e.g. amount for March in January). So, if an auction participant is not paying its yearly allocated capacity for the relevant month, the capacity could be re-auctioned in the course of the following monthly auction (Figure 23, see Top).

For monthly auctions it is recommended that the CAO invoices the relevant monthly auction before the beginning of the month, for which the auction has been taken place. So, if an auction participant is not paying its monthly allocated capacity for the relevant month, the capacity could be re-auctioned in the course of the daily auctions during that month (Figure 23, see middle).
For daily auction a deposit account should be used. By using that measure the receivables of the daily auctions are covered. Hence, it is a convenient procedure to issue the invoice in the following month for the entire last month (Figure 23, see bottom).

### 6.9. Investigation of curtailment options

The following paragraph was under investigation by Consentec and the final paper received from consultants is appended in full.

Delivery obligations for electricity as a commodity are defined throughout the industry as “firm”, allowing only for clearly defined exceptions in cases of objectively determined and narrow “force majeure” circumstances or events. In order to achieve true competition between domestic and foreign suppliers, the terms on which cross-border transmission rights are granted would need to match those for power supply in this respect. However, experience shows that the insurance of system security which is indispensable for TSOs occasionally requires to limit cross-border power exchange on short notice to a level below the transmission capacity that has already been allocated beforehand.

This is especially relevant for medium and long term transmission rights (e.g. monthly and yearly capacities) where it is less evident than in the day-ahead timeframe that TSOs can guarantee a certain amount of physical capacity that is only subject to force majeure reduction. For example, the coordination of network maintenance activities or reactions to unforeseen plant unavailability require to adjust the allowed physical cross-border exchange in the course of the year. While this technical background is generally undoubted, it is not clear how to deal with this issue commercially in the context of capacity allocation.

In order to be able to effectively limit cross-border exchanges, TSOs on most continental European borders reserve the right to curtail already allocated capacities. The conditions for such curtailment differ between borders. Whereas EU Regulation 1228/2003 introduces the necessity to compensate the capacity owners in case of capacity curtailment, for the time being there is no consensus about the height of compensation prices.

Therefore, compensation prices are one open issue that has to be addressed in a curtailment concept. Other open issues are the decision which rights are curtailed and the interdependence with other measures with similar effect.

#### 6.9.1. Interdependence with other possible measures

In general a necessary network relief is achieved by enforcing a plant dispatch that is (in total) more expensive than the one that would have been the market result without the need to relief the network. Typically this means an increase of generation in a high price area and a decrease of generation in a low price area. Different measures will result in such a shift in plant dispatch:
A curtailment of already allocated capacities will make it impossible for the capacity holders to carry out a power transfer they might need to fulfill their already concluded energy trades. Therefore they will have to buy energy in the high-price-area and sell energy in the low-price area (or sell it to other countries). This will lead to the necessary generation shift, but makes it also obvious that market participants whose capacity is subject to curtailment measures should have the possibility to square their positions on the day-ahead market. Curtailment therefore is (except from emergency measures) only acceptable if it takes place prior to day-ahead allocation and (where power exchanges exist) gate closure of day-ahead markets:

A cross-border redispatch means a node specific increase of generation on one side and an also node specific decrease of the same amount of power on the other side of a congested and possibly overloaded bottleneck. Plant owners are compensated on the basis of actual costs or bid prices.

Countertrading means the conclusion of a trade to relief the network. This could be achieved buying energy on the sink side of a congested and possibly overloaded border and selling it on the source side. This would require the TSOs, however, to act as market participants on energy markets and therefore seems to be unfavourable. Therefore, Consentec would recommend to primarily consider an alternative possibility to carry out countertrading by buying back capacity for the possibly overloaded transmission direction on the secondary market. This will not directly mean a generation shift between the countries on both sides of the congested border but will give a TSO the possibility to reduce the capacity that was given to the market. It is therefore obvious that such countertrading must take place prior to the nomination of long term capacity rights.

The congestion management guidelines amending regulation 1228/2003 make clear that before curtailment is applied, possibilities for countertrading and cross-border Redispatch should be exhausted. This makes it necessary to compare the methods to come to a manageable approach for application in practice.

Comparing cross-border redispatch with curtailment and countertrading it is obvious that the nodal approach of redispatch can lead to a possibly higher effectiveness in load flow control and adjusting the flow on a certain network element than zonal approaches are able to. One, however, has to consider that redispatch requires the original plant dispatch to have taken place before. This means that the decision about nodal adjustments of generated power is only possible when the involved TSOs information about the planned grid usage on plant-by-plant basis. This information is typically only available after submission of D-1 schedules and therefore after D-1 allocation and gate closure of day-ahead markets which is a point in time where a curtailment (except from emergency measures) of allocated (and at this time also nominated) long term rights does not seem to be a realistic option any more. Thus, cross-border redispatch can only happen after curtailment and therefore might only be a substitute for curtailment where it can be assured that enough redispatch capacity is available to make curtailment unnecessary at all. On the other hand resources for an effective redispatch (controllable power generation at nodes that have a high influence on the congested bottlenecks) are limited and have to be used if network relief becomes necessary after D-1 allocation and therefore after the latest time where curtailment should be applied. In such emergency situations, where an
exactly predictable network relief is needed, the technical effectiveness of cross-border redispatch may be highly desirable or necessary. As a consequence we do not recommend to generally substitute countertrading and curtailment with cross-border redispatch. We also do not consider a complete transition to cross-border redispatch commercially efficient in any cases from the economic point of view. As a consequence of the short activation times and possibly unfavourable pricing, economic costs for cross-border redispatch could be higher than for countertrading or curtailment. Depending on the specific situation, however, it could make sense to partially substitute curtailment measures with cross-border redispatch. But this needs a careful technical and economical assessment for the specific case and requires an appropriate regulatory incentive scheme.

For the comparison of countertrading with curtailment it has to be considered that countertrading is only possible until the secondary market for a given maturity period ends (e.g. evening of D-2) whereas curtailment is possible in this time period but also after the nomination of long term rights (morning of D-1) until the start of the day-ahead capacity allocation. However, there are significant differences in the information available between these two periods. During the period where also countertrading is possible the necessity for curtailment cannot be clearly decided because of relevant uncertainties. On the one hand at this time the TSOs do not know which parts of the allocated capacity will really be used. Therefore a curtailment at this time could turn out to be dispensable afterwards. On the other hand, as no common grid model for the maturity period of a transmission right is prepared between yearly and monthly or monthly and day-ahead auction, no up-to-date grid model is available to decide on the necessary amount of capacity curtailment. After nomination of long-term rights, though, there is a significant gain on information. First, at this time updated capacity models which are prepared in the evening of D-2 are available. Therefore amounts of necessary capacity curtailments can be calculated on a reliable basis. Second, the nomination of long term rights makes it possible to take account of the actual usage of allocated yearly and monthly capacity when deciding on curtailments.

This leads to our recommendation to apply curtailment only in the period after the nomination of long term transmission rights and before day-ahead allocation. If a TSOs feels the need to enforce a network relief in the time frame between allocation and nomination of long term rights – for instance because of a foreseeable line outage unknown at allocation time – we propose to achieve this relief via countertrading, i.e. buying back capacity on the secondary market. This will avoid in-advance capacity curtailments with inevitable discussions about fair compensation payments and should therefore be more favourable and smoother from market participants point of view. TSOs, however, should be prevented from using secondary markets for transmission rights to gain additional revenues. Therefore regulatory supervision for TSOs’ countertrading activities – possibly combined with the additional rule that capacity bought back by a TSO once must not be resold on the secondary market before the next allocation step for the same maturity period again – will be necessary.

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13 In theory, this could be possible if a TSO would buy back capacity at low prices and sell this capacity later at higher prices.
6.9.2. Determination of transmission rights to curtail

The question which transmission rights should be curtailed is very simple with bilateral auctions but much more complex for a multilateral coordinated flow-based allocation of transmission rights. This is because, as mentioned before, each exchange influences every border, thus a required network relief cannot be achieved only by curtailment of one exchange program. Instead, there exist a lot of alternative curtailment possibilities comprising not only one, but different borders and the decision among them is an optimisation problem for which the objective function has to be defined.

Different methods are currently under discussion, among them a least volume curtailment and a limitation of curtailments to the border where capacity had to be reduced.

We, however, are strictly in favour of an objective function that minimises the loss of economic welfare in the region due to an inevitable curtailment. The loss of economic welfare is given by the sum of the values (compensation prices) of curtailed rights. Therefore, the minimisation of loss of economic welfare is at the same time also a minimisation of compensation costs for curtailing TSOs.

We consider this curtailment method the only one which fits without distortions in the concept of flow-based allocation not only of day-ahead, but also of long term transmission rights. Allocation and curtailment are linked inevitably because the effectiveness and efficiency of an allocation method cannot be judged without including the conditions for curtailment. Therefore it is important, that allocation and curtailment are based on the same principles. Maximisation of economic welfare, however, is undoubtedly the basic principle behind allocation. Thus, it should also be used for curtailment.

This means that, given the same prices are applied (cf. section 4.3), the result in terms of allocated rights should not differ between a situation where the capacity is limited at allocation time and one where more capacity is sold at allocation time and has to be curtailed afterwards. The possibility for market based capacity shifting between borders is widely considered as one of the most important advantages of
flow-based allocation of transmission rights. In our opinion, the importance of shifting capacities to the borders where they are needed does not lose importance in cases of curtailment.

The proposed objective function does not include any additional algorithmic challenges compared to the original allocation problem. Especially, curtailment can be decided unambiguously and objectively for any number of congested bottlenecks at one time.

For every applied curtailment method is has to be sure that no misleading incentives are given. This especially tackles the point of distribution of curtailment costs. One of the important advantages of the proposed approach to decide on curtailment is the possibility to use the same key for distribution of curtailment costs as it is applied to the distribution of auction revenues. This is logical because the network modelling and objective functions are more or less identical and at the same time it avoids any incentives for shifting between allocated capacity and curtailment. If such incentives existed this could lead on the one hand to a sub-optimal allocation result in terms of economic welfare, on the other hand there could be the possibility for some TSOs to maximise their revenues on the cost of others.

6.9.3. Compensation prices

The need for compensation payments in case of curtailment is given in EU regulation 1228/2003 and the congestion management guidelines. Nevertheless, these guidelines do not precisely specify the pricing of compensation payments.14

Currently, at most borders owners of curtailed rights are compensated with the original auction price, at some borders an additional compensation of e. g. 10% of this price is applied.

Given the idea behind PTRs to enable long term hedging functionality for market participants and thus fulfill an important prerequisite to foster competition we, however, clearly are in favour of a compensation with the day-ahead price of curtailed rights but also see problems in explicit auctions of transmission rights only to realise this approach.

Therefore, in the following, we first discuss the principal advantages of a day-ahead-price compensation but afterwards also consider potential drawbacks and alternative approaches.

From an economic perspective, there are a number of reasons why the valuation of capacity reductions by the current (i.e. day-ahead) price should be preferred to a valuation based on the original auction price:

14 Article 2.13 of the CM Guidelines states that „no consequential losses shall be taken into account“. While this clearly excludes claims that reach beyond the mere capacity payments (e.g. problems due to the need to supply the customers without the import/export capacity), we would consider it a too narrow interpretation to conclude that this only allows to pay back the original auction price.
The expected value of payments is equal for both variants: Since the forward allocation prices reflect the market participants’ expectation of the average spot price differential in the allocated period, the day-ahead price may be higher or lower than the original auction price. What remains is the risk exposure to the volatility of the prices: While a payment based on the original auction price assigns this risk to the owners of the transmission rights, a payment according to the day-ahead auction price assigns it to the TSOs.

We find it difficult to argue why the capacity owners should bear this risk. In most cases it will be impossible to make them responsible for the unforeseen capacity reduction (neither collectively nor a single one). This justifies a socialisation of the risk, which is possible for the TSOs through the network tariffs. In fact, this could be interpreted as a utilisation of congestion income (from yearly and monthly allocation) to guarantee capacity availability according to article 6(6.)(a) of Regulation 1228/2003 because the capacity is financially firm. Under the assumption of functioning competition, the cost savings on the market participants’ side (through reduced risk management efforts) would be passed on to the consumers. What remains is the benefit of true cross-border competition since importers would no longer have a higher risk of non-fulfilment of their supply obligations than domestic competitors.

Compensation according to the day-ahead capacity price ensures that all transmission rights for a given delivery period are equivalent on the secondary market. In contrast, payments based on the original auction price constitute a distortion of the secondary market.

Consider the situation that, for instance, forward transmission rights for the 12th of March 2007 need to be curtailed prior to the day-ahead auction on 11 March. Some of these rights origin from the yearly auction for 2007 (that took place at the end of 2006), while others have been allocated at the monthly auction for March (that took place in February 2007). Most likely their original auction prices (in €/MW/d) are different, firstly because of the different times of the original auctions and secondly because the expected average value of capacity for all days of March will differ from the average of all days of the year. If compensation for curtailment was based on the original auction price, there would exist rights for the same day but with different compensation entitlements. On the secondary market, consequently, transmission rights for the same day would have different values, depending on their “allocation history”. Such complication (which might affect the attractiveness of secondary trading) is avoided when compensations for all rights are based on the day-ahead auction price.

Consider a scenario with two interconnected countries A and B and expected average yearly market prices of 30 €/MWh and 40 €/MWh, respectively. A trader buys power in country A and sells it as a yearly band to a consumer in country B. We assume perfect competition in the yearly transmission capacity auction, hence the trader has to pay 40 - 30 = 10 €/MWh for the transmission rights. He may nevertheless make a profit, e.g. because he achieves a selling price of 41 €/MWh (because the consumer assumes this a fair price), leaving a profit of 1 €/MWh (41 - 10 - 30 = 1) for the trader.

Now consider that for one day the capacity needs to be reduced on the day-ahead such that the trader is forced to buy on the spot market in B (instead of importing
from A) in order to fulfil his contractual obligations in relation to the consumer. On that day the spot price in B differs from the originally expected 40 €/MWh, firstly because of the reduction of transmission capacity (having an increasing effect) and secondly because of seasonal variation around the yearly average. Analogous effects occur in country A. As a result, two cases are possible:

The price difference between A and B may be higher than the originally expected 10 €/MWh, e.g. spot prices are 25 €/MWh in A and 60 €/MWh in B. Due to the lack of transmission capacity, the trader now can only locally sell his power contracted in A, making a loss of 5 €/MWh (25 - 30 = -5). In order to supply his customer in B, he needs to purchase for the local spot price of 60 €/MWh while still receiving just 41 €/MWh from his yearly supply contract, thus making an additional loss of 19 €/MWh. Moreover, he paid 10 €/MWh at the yearly capacity auction. We assume that the day-ahead auction price, as the yearly one, matches the market price differential, which is now 35 €/MWh. With compensation at day-ahead auction price, the trader receives a compensation of 35 €/MWh, leaving him with a total result of (25 - 30) + (41 - 60) - 10 + 35 = 1 €/MWh: He is hedged against losses from having to supply to/from the local markets.

The price difference between A and B may also be lower than the originally expected 10 €/MWh, e.g. prices are 29 €/MWh in A and 35 €/MWh in B. Again, the trader is forced to act locally in both A and B, but this time the low price in B allows for a positive contribution. Under equivalent assumptions the day-ahead transmission capacity price is now 6 €/MWh; i.e. the trader receives a compensation below the original auction price. The total result for the trader is (29 - 30) + (41 - 35) - 10 + 6 = 1 €/MWh – identical to the first case and to the case without capacity reduction. In essence, the example shows that only through compensation by the day-ahead price PTRs fulfil their intended purpose as a financial hedge against short term price volatility.

- A market participant giving up his transmission right (be it through curtailment or voluntarily through bidding for capacity in the opposite direction) receives a fair payment.

Within an implicit capacity auctions or explicit capacity auctions where (at least besides transmission rights) transmission obligations are sold, we recommend to achieve this compensation with day-ahead prices by substituting curtailment where necessary with the declaration of inverse capacities on the day ahead\(^\text{15}\). With market coupling, inverse capacity will lead to cross-border exchange from high price to the low price areas in order to satisfy the flow constraints.

With explicit auctioning, market participants are invited to bid for transmission against the prevailing exchange direction. Since this may be from expected high price to low price areas, negative bid prices would have to be allowed.

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\(^{15}\) Curtailment may still be necessary as a fallback solution for cases where the day-ahead allocation of inverse capacity fails, e.g. due to a lack of appropriate offers.
Figure 25: Option to allocate inverse day-ahead transmission capacity as substitute for curtailment – schematic example (single border)

In combination with the flow-based capacity model, this would mean that for those borders or network elements where the expected flows resulting from the nomination of forward transmission rights exceed the border capacity or max. flow, respectively, negative capacity values would be declared. (Note that in a single auction round both inverse [i.e. negative] and positive capacities may occur, meaning that some congested border(s) need(s) to be relieved while at the same time other borders can sustain further flow.)

As mentioned, the suggested concept of optional inverse day-ahead capacity works both with implicit and explicit auctions.\textsuperscript{16} In both cases the day-ahead allocation may\textsuperscript{17} yield negative revenues for the auction office which should be socialised via the network tariffs\textsuperscript{18}.

Of course a compensation at the day-ahead capacity price does not necessarily require the concept of inverse day-ahead capacity, but could also be realised by means of curtailment.

\textsuperscript{16} Taking into account the liquidity of PX spot markets (which are considered a prerequisite for the introduction of implicit auctions anyway) one could assume that under an implicit auctioning regime the realisation of relieving flows through inverse capacity is somewhat more reliable than in an explicit auction framework, where the AO relies on market participants explicitly bidding in the relieving direction.

\textsuperscript{17} Total day-ahead revenues may also stay positive, namely in the case where the allocation of negative flows on overloaded borders is overcompensated by positive contributions from the other borders in the region.

\textsuperscript{18} The possibility to carry out curtailment in special cases is necessary to ensure security of supply at any time and sensible from an economic point of view as otherwise long term capacities generally, i. e. for the vast majority of time, had to be restricted unnecessarily by much higher margins. Given this technical and economic background we consider it inevitable that TSOs can socialise curtailment costs and do not have to bear return risks because of a compensation scheme that is intended to foster competition from which, at least on the long run, society should benefit.
However, the eventual allocation of inverse capacities has some advantages:

The reduction of capacity is not a separate mechanism, but smoothly integrated into a congestion management stage that exists anyway, namely the day-ahead allocation, merely by extending the allowed range of capacity values (and prices). This would presumably increase the general acceptance of short term capacity reduction by market participants. As a consequence, it might become easier for TSOs to decide on a reduction of capacity in cases where otherwise a network overload is probable. This could contribute to an increase of security of supply.

As discussed, with curtailment after allocation with a flow-based capacity model it would be difficult to objectively define which rights to curtail to which extent. Effectively, TSOs need a relief of flows, and PTRs between different pairs of countries affect the relevant flows to different extents. Through the clearing mechanism of the day-ahead allocation, the most economic adjustments of exchanges are detected in an automatic, objective and transparent way.

In contrast to curtailment, the day-ahead allocation of inverse capacity allows that not necessarily capacity is taken away (according to a prescribed key) from those who have obtained yearly or monthly rights. Rather, the method focuses on the required physical effect, namely the reduction of the total flow impact of all ultimately allocated transmission rights. It is the market that determines who will perform the flow relief through obtaining transmission obligations for inverse capacity.

The fact that a “correction” of year and month capacity assessment by means of inverse day-ahead capacity would be a normal and accepted mechanism and would simplify the discussion about an aspect that particularly traders have been concerned about for a long time: the share of capacity between the different allocation stages. The higher the capacity allocated yearly and monthly, the more frequently inverse day-ahead capacity will occur. However, this does neither mean that total capacity would necessarily increase nor that extensive application of inverse capacity would be recommendable. But the present situation – where capacity reduction (through curtailment) is usually considered a “last resort” that should be avoided if possible – could be replaced by a sensible discussion about the optimal share of capacity across timescales, taking into account economic, commercial, regulatory and, last but not least, network security perspectives.

Thus, we recommend curtailment compensation at day-ahead-prices in general and substituting conventional curtailment with declaration of inverse capacity in detail. There is, however, one important drawback with this concept for explicit capacity auctions where only transmission rights are sold: If a curtailment is necessary normally no capacity for this transmission direction is sold in the day-ahead auction. Therefore, no valid day-ahead capacity price is available and can be used for compensation payments. One might think of different remedies to this problem, although, in our opinion, they also have significant problems:

Not having a day-ahead price for the hour where curtailment occurs, one could take for example the moving average of the day-ahead capacity prices for this respective hour of the last e. g. five days. The problem with this approach is that one cannot say generally that this average price is in any way a better estimation of the fair value of
curtailed capacity then the original auction price. For instance, average price differences and capacity prices between two countries could be lower than in the yearly average due to seasonal characteristics, but after an unforeseeable outage and the necessary curtailments price spikes might occur that will influence the fair value of transmission capacity but not at all be reflected in the moving average price.\(^{19}\)

Another possibility could be to ensure the possibility to sell a defined share of the total capacity in the day-ahead auction in any case. Especially this would mean that curtailment was needed also in the case where allocated yearly and monthly capacity does not exceed the total capacity but does not allow to sell the defined minimum amount of capacity in the day-ahead auction. Besides the question if this was acceptable for traders one definitely would end up with a day-ahead capacity price with this approach. However, we foresee the danger of gaming possibilities for market participants whose long term rights were subject to curtailment. This can be illustrated with a small example (only one hour is considered, therefore a transmission right of 1 MWh means a right to use 1 MW of capacity for 1 hour). A market participant might have bought a long term transmission right from A to B for 100 MWh at a price of 10€/MWh. For the maturity period of this right he also has bought energy in A at a price of 40€/MWh and at the same time sold in B at a price of 50€/MWh. Now the total capacity is curtailed to 90 MW. To be able to sell capacity in the day-ahead auction the long term right is curtailed to 80 MWh and 10 MWh are sold day-ahead. Let's assume that due to the curtailment the energy price in A does not change but goes up to 60€/MWh in B. Thus, the fair day-ahead price for the capacity would be 20€/MWh. If this will be the outcome of the day-ahead auction the market participant for one hour gets a compensation payment of 20MWh x 20 €/MWh = 400€. He needs this payment exactly to buy 20 MWh of energy in B at a price of 60€/MWh while being forced to sell the same amount of energy in A at 40€/MWh. Thus, a compensation with day-ahead prices that really reflect market price differences seems to be a fair compensation pricing. But consider a scenario where this market participant also takes part in the day-ahead auction and, by bidding e. g. 40 €/MWh, wins the available 10 MWh of transmission rights and at the same time pushes the compensation price to 40€/MWh. This market participant will now receive a compensation payment of 20 MWh x 40€/MWh = 800€, while at the same time he has to pay 10 MWh x 40€/MWH = 400€ for the newly acquired rights and has to buy additional 10 MWh of energy in B at a price of 60€/MWh while only being able to sell 10 MWh in A at 40€/MWH\(^{20}\) (200€). In other words, in this scenario the market participant could by his own bidding behaviour achieve a situation where the curtailment compensations (800€) exceed his actual costs (600€). This does not seem to be acceptable.

As a consequence, it is evident that a compensation with day-ahead capacity prices might be sensible and desirable, but impossible for an explicit auction of transmission rights only.

\(^{19}\) Of course, they are also not reflected in the original auction price, but what is relevant here that there is neither certainty nor sufficient probability that the moving average price is a better estimate for the effective value of curtailed capacity than the original auction price is.

\(^{20}\) As there is no direct link between prices of transmission rights and energy prices in explicit auctions, energy prices can remain the same compared to the scenario considered before.
We would, however, not recommend, to completely switch to a compensation scheme based on original auction prices because this will, as explained before, also break up the compatibility between fragmented yearly and monthly rights on the secondary market and could be an important drawback for liquidity of secondary markets. Instead, we propose a compensation with the original auction price of the monthly auction for a given maturity period. This will mean a compensation with the original auction price and, as such, an application of the currently used compensation scheme for monthly rights, but a compensation with a price different from the original auction price for curtailed yearly rights. Besides the effect, that with this compensation scheme an identical valuation of yearly and monthly rights on the secondary market is ensured, it also seems to be a sensible assumption that the monthly price is a better estimator for the fair price of curtailed capacity than the original spot price of the yearly auction because of two causes. First, it reflects seasonal effects like time dependencies of price differences between markets. Second, some of the possible causes for curtailments, like long-term outages of lines, might be known at the time of monthly allocation and therefore might already be reflected in the resulting auction prices.

### 6.10. Documentation

The document which describes Dry-run simulation software from traders point of view could be find in ANNEX 1.

### 6.11. Optimizing processes and systems

The working package 11 comprises all work to be done to the new requirements regarding responsiveness and manageability of the system. Especially the new products had a great impact on the database structure, the auction algorithm and the market clearing price determination.

Partly the database structure had to be adapted completely in order to keep track with the changing requirements. Additionally the complexity of the auction algorithm increased and caused time problems because of the new bid and product types. These time problems had to be evaluated and to be solved by optimising the mathematical programming of the algorithm.
7. Conclusions

The following conclusions are based on the work according to the contract, as well as on APG’s experience in the other regions in Europe.

7.1. Auction Design

7.1.1. Auction Algorithm

The principle to be adopted for solving the allocation problem, is the use of the overall economic welfare as the objective (function). I.e. the willingness to pay of the traders and the technical restriction as defined by the TSOs determine the market clearing prices for capacities. The last fully accepted or partially accepted bid sets the market clearing price in case of a congestion. A market clearing price is also set, if the requested capacity is exactly the available capacity.

7.1.2. Divisible Bids

Divisible bids are the standard bid format within a flow based coordinated auction scheme. I.e. by using divisible bids the requested amount of interconnection capacity can be curtailed and the price determination can be done in the above mentioned manner.

7.1.3. Indivisible Bids

Indivisible bids, especially in conjunction with block bids, can lead to inconsistencies in the determination (i.e. calculating) of the market clearing prices, because due to the indivisibility the merit order is no longer the main principle of capacity allocation in the objective function. This issue can be solved with further constraints in the mathematical model, resulting in a very resource-consuming calculation. Furthermore, indivisibilities enable the execution of market power, especially the blocking of capacity with low risk, respectively effort, and additionally do not emphasise the maximum use of available capacities. Our conclusion is that indivisible bids have to be handled with care in order to avoid situations of gambling. So, as a recommendation indivisible bids shall be limited in its maximum bid amount.

7.1.4. Linked Bids

Linked bids can be seen as a linkage of different bids to obtain a bidding path (i.e. source - sink zone combination) or to obtain a timely profile (i.e. block bid). Regarding a coordinated explicit flow based auction a bidding path through linked bids is no longer useful nor necessary. A timely linkage of different bids with the same source - sink combination is not advisable in conjunction with block bids, because block bids fulfil the same requirements at a lower risk, especially if freely user-defined (not system-wide defined) block bids come into action. Our conclusion is that linked bids do not offer any advantages to the traders and therefore linked bids are not recommended to be used for the real run of flow based coordinated auctions.
7.1.5. Block Bids

Block bids can bring value added for market participants, in particular with daily auctions, because of the possibility to harmonise such block products with standardised products traded at power exchanges. Because of missing power exchanges and lacking of liquid markets in most of SEE countries so far, block bids are not of utmost importance. Nevertheless so called user defined block bids, i.e. blocks which can be defined by each user on its own according to personal needs, can be an valuable asset\(^\text{21}\). These user-defined block bids are not scope of this work.

The recommendations are expressing the expert opinion of APG. For a final software also consultation with market participants is advisable, as in-depth consultation with market participants was not part of the contract.

7.2. General recommendations

As a general recommendation for the 3\(^{rd}\) phase, for fostering the regional development in SEE, APG proposes the following, based on the experience made in other regions. The list of the topics is starting with the highest priority first.

- mutual agreement of involved TSOs regarding the location (hosting country) of the CAO
- development and agreement on a common business plan
- development and agreement on company agreements (articles of association and syndicate agreement if necessary)
- employment of a managing director of the CAO (who can act as a project manager during the start up phase)
- starting of staff recruiting procedure for the CAO
- agreement on auction income sharing keys
- setting up of the IT infrastructure

Additionally APG recommends to look for financial support for the CAO project to cover the costs and efforts of the above mentioned technical, organisational and legal issues. For example, the current technical and organisational support of the consultants Consentec and APCS within NACMPF has been a main facilitator of the entire project. Additionally, above mentioned legal issues have to be solved during 2008. Therefore a legal support is advisable as well.

For simulation purposes for the 3\(^{rd}\) phase APG already announced to offer the simulation software DrCAT on its own costs and efforts during 2008. That test software is a very flexible tool, as it can be adapted in a very short time period once the scope of the modelled geographic area is known. Also, results and experience gained from the usage of the simulation software DrCAT test software can be used for the preparation of SEE CAO IT tendering procedure.

\(^{21}\) With so called user defined block bids each user would have the possibility to create blocks according to the needs of his technical units. I.e. min. production times and ramp rates etc. can be taking into account.
7.3. Participation of traders

As already mentioned during the report, traders participated at the Dry-run 2007. The submission of bids is performed by traders, starting from April 2007\textsuperscript{22}.

The experience made so far, in terms of participation of traders, is that during the Dry-run simulations in 2007 more and more traders lost their interest in submitting necessary market information (in terms of capacity price differential bids). The number of actively participating traders per month can be seen in Figure 26.

![Figure 26: Number of traders that took part in the monthly and daily auctions (Dry-run 2007)](image)

So far we interpret the decrease of interest in that way, because traders have no information about the intended start of the real operation of the SEE CAO.

7.4. MF approach

The following graphics and short explanations show the recently by consultants (i.e. APCS and Consentec) presented new capacity calculation method, called MF (or Fmax) approach. That method has been presented by the above mentioned consultants during their contribution in SEE for the CAO development process (financed by KfW for supporting the SETSO NACMPF SG during the Dry-run phase 2007).

Because of that, additional method adaptations within the simulation software DrCAT were necessary for supporting the entire development. That implementation of the so called MF approach was not part of that contract; nevertheless APG has installed it on its own costs and effort.

\textsuperscript{22} The contract between ECS and Verbund APG started beginning of July 2007. Nevertheless APG offered the Dry-run toll on its own cost earlier in order to have a seamless continuation of the entire process.
Usually, using the BC approach, for each interconnection only one value of capacity per direction has to be calculated. i.e. all existing tie lines are aggregated to one fictive interconnection (see Figure 27, left picture).

The main difference of the MF approach, compared to the BC approach, is that the network can be represented in a higher granularity. Depending on the decision and responsibility of the involved TSOs also internal elements, as well as critical conditions (represented by the n-1 security criteria), can be taken into account (see Figure 27, right picture).

**Figure 27: Border-wise BC approach and Fmax-based approach**

Hence, with the implementation of MF approach, it is possible to define potentially critical branches (internal lines and/or tie-lines) in (n-0) and/or (n-1) cases. With the definition of each critical branch by the relevant TSO, also the respective topology change has to taken into account (ideally automatically by an capacity calculation tool in a centralized or decentralized manner\(^{23}\)). The MF approach overcomes a number of drawbacks of the BC approach, especially with respect to the dependency of assumptions and approximations related to the base case model and the relatively rough representation of network constraints due to the aggregation to one figure per border (flow gates) determined by the BC approach itself. It means that a higher level of network security can be achieved with the implementation of MF approach and TSOs as well as market participants will have clear and transparent information.

APCS and Consentec are preparing a detailed explanatory document related to the MF approach (as a part of their support for the SETSO NACMPF SG during the Dry-run phase 2007, financed by KfW), which is intended to be a public document.

\(^{23}\) The mentioned capacity calculation tool for the MF approach is not part of that contract.
7.5. Auction income sharing

Compared to the currently applied method of bilateral cross border congestion management in the course of allocations, where usually all auction income is shared mostly on a 50:50 base between both TSOs, flow based coordinated auctions will require complex and regional coordinated schemes for sharing the entire auction income in a fair, transparent and non discriminatory manner.

So far, Consentec as one of the consultants during the Dry-run project within the year 2006 has elaborated several methods on how to share the regional congestion income. The analysis shows that no “first best solution” exists. Results, i.e. auction income shares calculated for a single TSO, can vary largely depending on the key applied.

Nevertheless, we recommend not to install a single auction income sharing key because of the above mentioned findings. For us, a weighted usage of several key is advisable. In particular we recommend the usage of auction income sharing keys which respect the offered capacities by TSOs, like the so called “absolute flow” key. Additionally we recommend to take into account the market value of congestion, i.e. price-signal based auction income sharing keys should also be used.

The exact definition and weighting of the different keys was not part of that study and is in the responsibility of the participating TSOs who set up the CAO.
8. ANNEX 1: Traders’ Manual: Dry-run Coordinated Auction Tool (DrCAT)

Traders’ manual of the “Dry-run Coordinated Auction Tool (DrCAT)” is an integrative part of this final report and can be found as a separate document.