Towards a common co-ordinated regional congestion management method in Europe

Study commissioned by the

European Commission

Directorate-General Energy and Transport

Final report

12 October 2007

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Contents

Abbreviations

ABC	Available border capacity
AO	Auction Office
ATC	Available transfer capacity
BC	Border capacity (i.e. maximum total flow allowed on a group of network elements)
CM	Congestion management
CWE	Central Western European region, identical with North-West Europe (i.e. Belgium, France, Germany, Luxemburg and The Netherlands) according to the congestion management Guidelines
ERGEG	European regulators' group for electricity and gas
EU	European Union
FTR	Financial transmission right
IEM	Internal Electricity Market
MF	Maximum flow (allowed on an individual network element)
NRA	National Regulatory Authority
NTC	Net transfer capacity
OTC	Over the counter (energy trade not involving a power exchange)
PLEF	Pentalateral energy forum, comprising governments, NRAs, TSOs, PXs and the Market Parties Platform
PTR	Physical transmission right
PX	Power Exchange
TSO	Transmission System Operator
UIOGPFI	Use it or get paid for it

1 Introduction

1.1 Background and purpose of the study

Since the beginning of the liberalisation of the electricity markets in the EU the occurrence of congestion in the transmission networks has been seen as an obstacle for the realisation of the envisaged Internal Electricity Market (IEM). Besides efforts to promote the mitigation of congestion through network extension, the efficient management of access to scarce transmission capacity, so-called congestion management (CM), has been in the central focus of EU energy policy for years. After a phase of parallelism of pan-European discussions on optimal solutions for CM on the one hand and mostly border-wise practical implementations of CM methods on the other hand, the recent adoption of a regional approach marked a significant change. Developments since then have been mainly put forward in the context of the regions established through the Congestion Management Guidelines amending Regulation (EC) No. 1228/2003 [1, 2]. While the regional approach shall allow for faster progress through the respectively reduced geographical scope, the ultimate goal still remains the pan-European IEM.

On this backdrop, the European Commission (DG TREN) has commissioned a study with the purpose to develop an outline of a common co-ordinated congestion management method which fulfils the requirements of Regulation 1228/2003 and the Congestion Management Guidelines. The analyses were focussed on two aspects:

- to identify issues and propose solutions concerning the implementation of regionally coordinated CM methods and procedures; and
- to analyse how inter-regional coordination and compatibility between the existing regional CM approaches can be ensured or improved.

Geographically, the focus of the study has been on the Central European regions and those interconnections with other regions where current initiatives and basic developments can be observed and analysed: Central West (and its connections to the Northern region), Central East and to less extent Central South. We also took into account ongoing development in South Eastern Europe. The most important projects and initiatives are briefly described in the following.

1.2 Status quo of regional congestion management initiatives

Establishment and work of Regional Electricity Initiatives

For each region established in section 3.2 of the Congestion Management (CM) Guidelines [2] the Electricity Regional Initiatives have been set up beginning in April / May 2006 and in several cases reached very rapidly considerable discussion level, proposals and implementation plans, which have been extensively documented by ERGEG.[1] This process is building the basis for several of the following concrete developments and proposals.

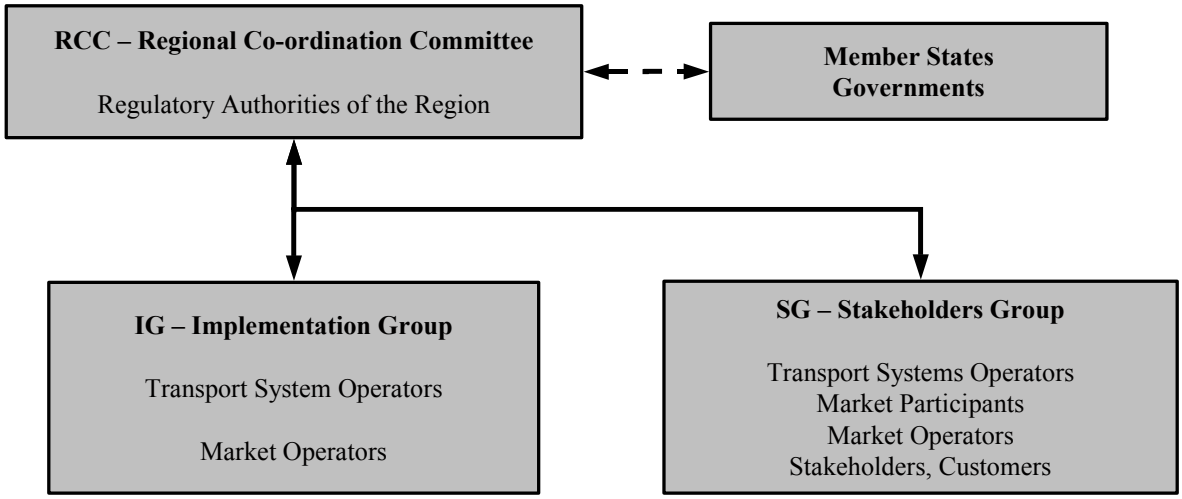

Fig. 1.1: Structure of ERGEG Regional Initiatives

Trilateral Market Coupling (TLC)

Belpex launched the Day Ahead Market for electricity in Belgium in co-operation with the Dutch and French energy exchanges APX and Powernext and the Belgian, Dutch and French electricity transmission system operators Elia, TenneT and RTE in November 2006, including day-ahead market coupling (**Trilateral Market Coupling** – TLC): The daily capacity on the Belgian–French and the Belgian–Dutch interconnections is allocated by means of market

[1] http://www.ergeg.org/portal/page/portal/ERGEG_HOME/ERGEG_RI/ERI

coupling of Belpex, APX and Powernext. The trilateral market coupling is designed to enable different power exchanges to be coupled in a manner, which does not require them to make any change to their market rules. The three power exchanges continue to exist as legally separate markets. There is neither a single order book nor a common clearing and settlement facility.

Central Western Europe (CWE) / Pentalateral Energy Forum (PLEF)

In the scope of the ERGEG Regional Initiatives, the Central Western forum was set up. One milestone of the work in the CWE Regional Initiative was the action plan published by the CWE regulators on 12 February 2007 [16]. It requested – among other issues – a study with a view to implementing a flow-based market coupling mechanism in Central West Europe. TSOs in CWE were asked to provide an implementation study on flow-based market coupling and an orientation study on an appropriate load-flow consideration with implicit auctions.

On 6 June 2007, the governments, regulators, TSOs, power exchanges and market parties of the CWE region signed a Memorandum of Understanding (MoU). The MoU aims at the analysis, design and implementation of a flow-based market coupling in CWE with January 2009 as target date and the achievement of further development in the field of security of supply. As a particular element different to other European regions, the Ministries of the countries taking part in the PLEF (Belgium, France, Germany, Luxemburg, the Netherlands) committed themselves to review and support the process regularly and to resolve upcoming issues especially as regards legal or regulatory obstacles.

- In detail, the flow-based market coupling the signatories of the CWE MoU are aiming at a harmonisation of power exchanges gate closure times and coherence with ongoing projects in relation to neighbouring countries or countries (i.e. the NorNed connection between the Netherlands and Norway and the market coupling project between Germany and Denmark).

Concerning the geographical perimeter of the coupled area, involved parties recognise that in view of the NorNed project and the intended market coupling project between Germany and Denmark, the development ideally should allow for a seamless cooperation between these projects or should even allow all market coupling models to be brought together in one over-

all solution. Therefore interaction and co-ordination with other involved parties that are not part of the CWE region is envisaged.

Cable Link Norway-Netherlands (NorNed)

The regulatory approval of the NorNed sub-sea cable link between Norway and the Netherlands, granted in 2004, required that the capacity be implicitly auctioned by employing market coupling between the power exchanges APX and NordPool Spot. In 2004 the TSOs TenneT and Statnett and the exchanges NordPool and APX agreed to implement market coupling across NorNed.

On this backdrop, the TSOs Statnett, TenneT, Elia and RTE and the exchanges NordPool, APX, Belpex and Powernext presented plans to develop a '**Multi-Market Coupling**' (MMC) to be implemented in 2007. MMC was intended to provide an integrated solution for the combined TLC and Nordic regions[2]

Exchanges and the TSOs in the two regions have established a joint steering committee and project structure to take forward the development of MMC, including any interim arrangements. Recently, the introduction of an interim solution has become more likely as the harmonisation efforts between the TLC and Nord Pool market areas and rules are facing delays.

Current development is aiming at the integration or co-ordination of the NorNed project with the CWE flow-based market coupling and its extension or coordination to the Nordic region.Market Coupling Denmark-Germany

The European Energy Exchange AG, Nord Pool Spot AS, Energinet.dk, Vattenfall Europe Transmission GmbH and E.ON Netz GmbH adopted a Memorandum of Understanding con-

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[2] Developing a common multi market coupling (MMC) solution: Integration of the Nordic and TLC regions via NorNed and creation of a platform suitable for wider European integration, Paper by Statnett, TenneT, Elia, RTE, Nord Pool Spot, APX, Belpex and Powernext, 20 June 2006, www.ergeg.org

cerning **market coupling between Denmark and Germany** in November 2006.[3] The aim was to introduce an implicit auction for daily cross-border capacity allocation for both interconnectors between Denmark and Germany (i.e. the AC connection between E.ON Netz and Jutland as well as the KONTEK DC interconnector). This should connect the Nordic market where implicit auctions are already implemented and the German market.

Similar to the MMC approach, the market coupling solution between Denmark and Germany is planned to be flexible with respect to further developments. This includes compatibility considerations with the NorNed cable project, the progress of market coupling in the Central Western Europe region as well as possibilities for later integration of cross-border intraday trading and balancing markets.

The involved parties set up in April 2007 an implementation project coordinating six task groups (business process description, budget calculation, IT specification, company foundation, contractual framework and communication). Operation was originally announced to start in the 4th quarter of 2007.[4]

Recent announcements state that the project has been delayed and is not to start before 2008. Development is now aiming at the integration or co-ordination of the project between Germany and Denmark with the CWE flow-based market coupling and its extension or coordination to the Nordic region.

Co-ordinated Explicit Auction in Central Eastern Europe

In the Central Eastern European (CEE) region the TSOs CEPS, ELES, E.ON Netz, MAVIR, PSE-Operator, SEPS, Vattenfall Europe Transmission and Verbund-APG intend to introduce

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[3] Joint press release from Energinet.dk, European Energy Exchange AG, E.ON Netz GmbH, Nord Pool Spot AS, Vattenfall Europe Transmission GmbH, e. g. http://www.eex.de/index.php?session=7ad8ed58c904f303bc98ea500ea10ce4&page=12#link6

[4] http://www.eex.com/en/Press%20Room/Press%20Release/press/14082, 07-05-2007

co-ordinated flow-based explicit auctions in 2008.[5] In terms of geographical scope as well as the methodical/procedural background (flow-based capacity model, scheduling etc.) this would constitute a significant extension of the presently applied co-ordinated auction between Germany, Poland, Slovakia and the Czech Republic.

Dry Run for Explicit Auction in South Eastern Europe

In the South-east European (SEE) region the SETSO TF (South-east European Transmission System Operators Task Force) and its subgroup NACMPF (Network Access, Congestion Management and Power Flows) inside ETSO are working on the development of suitable mechanisms for transmission capacity allocation. Like in CEE, the development leads towards co-ordinated flow-based explicit auctions. While an implementation date has not been agreed yet, the TSOs perform a monthly "dry run" to test and develop the foreseen approach. The results are available to the public[6] and the participation of network users in the dry run is planned for the near future.

Open Market Coupling (OMC)

In the framework of the European discussion on the improved and market based allocation of cross border capacities the concept of **'Open Market Coupling'** (OMC) has been developed and introduced by the German Power Exchange EEX in the first round of the Mini Fora. The concept envisages a combination of explicit and implicit auctions when allocating the transmission capacity between liquid European markets. According to the concept a central Auction Office shall be established or an existing Auction Office's functions are extended. The Auction Office bids at all participating power exchanges, enters in the rights of use of allocated capacity and manages the electricity cross border trade. The German Study Group on

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[5] Preparation of the Coordinated Physical Transmission Right (PTR) Allocation Scheme for the CEE – Region, Presentation at the 3rd IG-Meeting, 29 September 2006

[6] http://www.drcat.at

Congestion Management commissioned three studies on this concept, dealing with the examination of legal, technical and economic aspects.[7] The studies attest the legal and technical feasibility of OMC and demonstrate its economic efficiency and positive welfare effects. Their results are now being absorbed by the development towards flow-based market coupling in the CWE region.

1.3 Our approach

The aforementioned initiatives and projects (which to a large extent were kick-started by the regionalisation of the discussion from the Florence Forum to the different Mini-Fora and, subsequently, the Regional Initiative) gave the basis for our first and initial analysis. We consider the starting of the regional discussions as extremely helpful and find important approaches in the discussions being held in the Regional Initiatives and the different projects under development.

However, it has to be stated that interregional co-ordination is very difficult to be reached on the basis of bi- or multi-lateral projects. Some of the practical problems in the different projects may have conceptual roots and could be due to the lacking inter-regional coherence. We therefore sketched the current projects and initiatives, developed basic concepts of how to interact between the different European regions and how to aim for a *common* regional congestion management method applicable in the framework of the Directives, the Regulation and the Guidelines. With this compilation as a basis, we designed a questionnaire in order to compile stakeholders' assessment of current status quo, priority needs, possible solutions and further proposal. In order to consider all market participants' appraisements, also of those not located in one of the regions in focus, all European TSOs and Regulators that expressed their willingness to support the study as well as ETSO, ERGEG, EFET and EuroPEX were integrated in the survey.

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[7] http://www.bundesnetzagentur.de/enid/Special_topics/Open_Market_Coupling_32p.html

After evaluating the reactions to this questionnaire we held repeated and intense discussion with representatives of all groups of stakeholders mentioned above. On this basis and on the grounds of our own analysis we identified and analysed fields for concrete improvement of regional congestion management methods (cf. section 3) and developed a *target model* in order to foster both regional co-ordination of congestion management and inter-regional co-ordination and compatibility (cf. section 4). The goal of the target model is to develop the blueprint of a *common* congestion management model that complies with the requirements set out in the CM Guidelines and brings the EU closer to a truly internal market, considering adequately roles, risks, rights and obligations of the involved parties.

2 Coordination of congestion management: Requirements and options

2.1 Coordination within regions

The CM Guidelines define the range of options for CM methods to be applied on EU member states' borders. For example, transmission capacity must be allocated through either explicit or implicit auctions (with the exception of intraday allocation, where continuous allocation is also allowed).

Section 3.5 of the CM Guidelines sets out fields in which coordination between TSOs within each region shall be implemented, in particular:

(a) Use of a common transmission model dealing efficiently with interdependent physical loop-flows and having regard to discrepancies between physical and commercial flows,

(b) Allocation and nomination of capacity to deal efficiently with interdependent physical loop-flows,

(c) Identical obligations on capacity holders to provide information on their intended use of the capacity, i.e. nomination of capacity (for explicit auctions),

(d) Identical timeframes and closing times,

(e) Identical structure for the allocation of capacity among different timeframes (e.g. 1 day, 3 hours, 1 week, etc.) and in terms of blocks of capacity sold (amount of power in MW, MWh, etc.),

(f) Consistent contractual framework with market participants,

(g) Verification of flows to comply with the network security requirements for operational planning and for real-time operation,

(h) Accounting and settlement of congestion management actions.

Clearly, both the general requirements for CM methods and the aspects of regional coordination leave room for interpretation, such that CM methods may considerably differ from each other while still being compliant with the Guidelines. This is an intentional degree of freedom

allowing for region-specific approaches. On the other hand it bears the risk of divergence preventing a later progress towards a common pan-European method.

2.2 Inter-regional coordination

Congestion management inside the established regions has been under intense discussion since the set-up of the Regional Initiative. The main focus has been put on two main axes of further improvement, which are the optimisation of capacity assessment (briefly summarised, Net Transfer Capacities (NTC) versus flow-based approach) and the capacity allocation method (along the discussion about implicit and explicit auctions or their combination).

Ultimately, however, the political goal remains the creation of a pan-European Internal Electricity Market. On this backdrop, the tasks of this study comprise the analysis of options for improvement of inter-regional co-ordination of congestion management.

The challenges of inter-regional coordination, as compared to intra-regional efforts, are two-fold:

- A larger number of stakeholders is involved in the discussions, making it harder to arrive at common positions. (This rather trivial issue has been the main reason to set up the regional approach to congestion management.)
- Inter-regional coordination means finding a compatible, efficient way to couple (future) existing regional CM methods whose implementation has taken significant efforts.

The focus of our analysis is on the latter issue. As we will see, solutions for inter-regional coordination depend on the basic concept adopted in the respective regions and on the defined shape of the regions.

In defining the seven regions in the CM Guidelines, the so-called „overlapping country“ approach has been chosen as the general principle (with some exceptions). This means that countries at the seam between regions belong to more than one region, and, consequently, even some borders belong to two regions (fig. 2.1). This approach respects that some countries can hardly be assigned to a single regional market, and it also offers practical advantages such as reduction of the number of allocation steps required for inter-regional trade [15]. Moreover, it leads to an intersection of stakeholders between the different regional implementation groups, thereby facilitating inter-regional compatibility (at least on an informal basis).

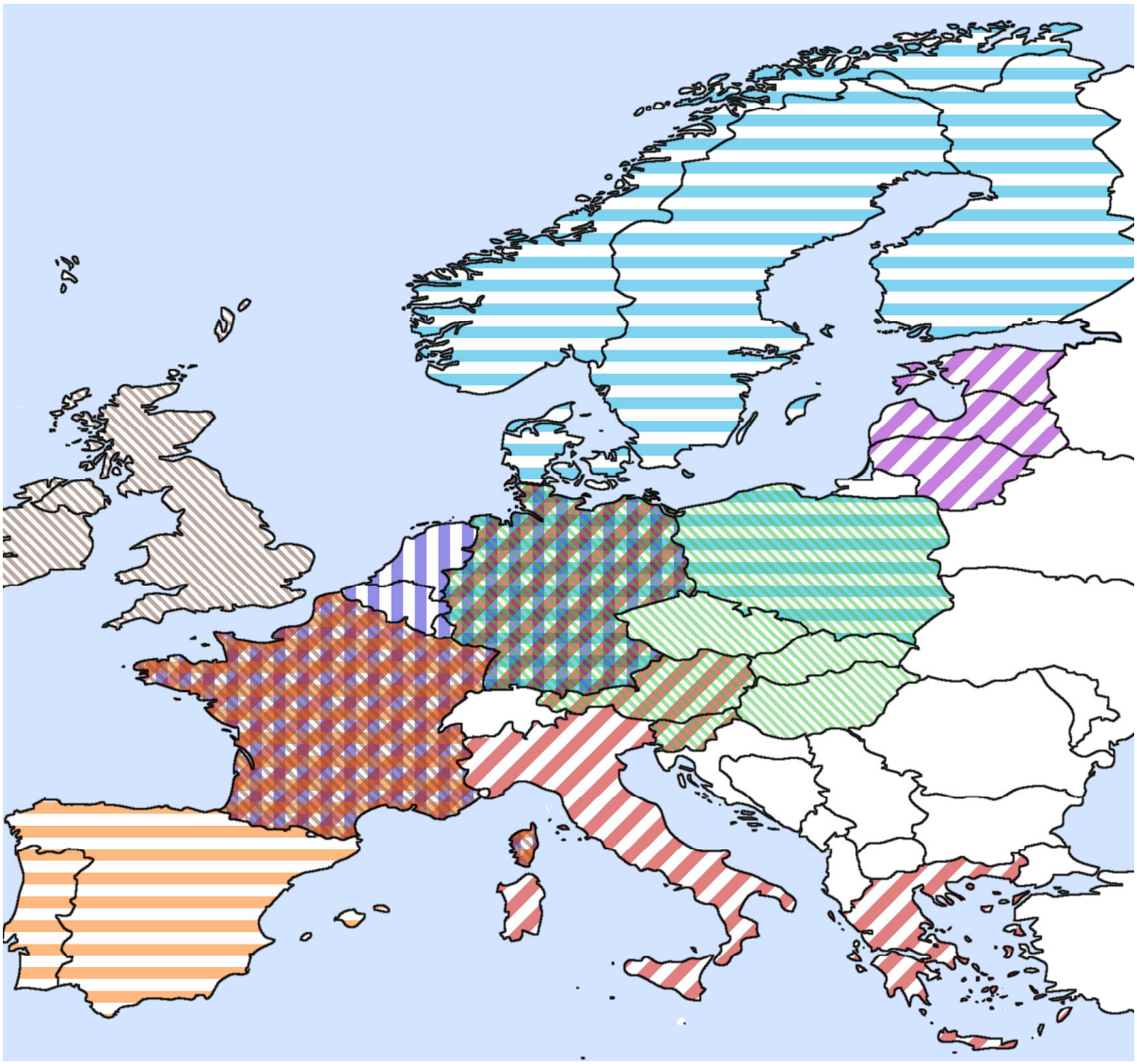

Fig. 2.1: Assignment of countries to regions, overlapping countries

In view of the overlapping assignment of countries to regions in combination with the demand for regional coordination, the CM Guidelines encounter some difficulties to direct application. In particular, the options for co-ordinating congestion management across regions depend on whether the regions are indeed overlapping or not, and on the type of allocation method (implicit or explicit auction) that is applied within the regions in question:

1. In implicit auctions, non-directional demand and supply bids of different countries[8] are cleared in a co-ordinated manner in order to determine the optimal exchange between these countries. The non-directional nature of the bids implies that each country can participate in one implicit auction only.[9] Consequently, whenever a country belongs to two regions, there cannot be individual implicit auctions in both regions (and with all members of the respective region as participants). The case that implicit auctioning is applied in two neighbouring regions therefore can only occur when no country participates in both auctions.[10] Then, three possibilities are conceivable for inter-regional co-ordination:

   - Explicit bilateral auction: On the border(s) between the two regions, an explicit auction of transmission rights would allow market participants from one region to participate in the implicit auction of the other region. The explicit auction would have to take place prior to both implicit auctions.
   - "Super auction": Similar to the way in which market coupling couples legally separate national market places, a "super auction" might be applied to couple two (or more) implicit auctions. The auction offices of the participating regions would exchange their (aggregated) bid curves or submit them to a central "super auction office" that would then perform an inter-regional clearing. The clearing of the intra-regional implicit auctions would be based on the results of the inter-regional clearing.
   - Merging of regions: In order to avoid the complexity of a hierarchical approach, all involved countries could be coupled through a single implicit auction, thereby completely integrating the two regions. Like the "super auction" solution this would offer

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[8] More precisely, in those cases where today or in the future due to internal bottlenecks several market regions exist in one country, instead of 'countries' the term 'market areas' would apply.

[9] Technically, two implicit auctions are possible for one country. But this would result in a split of liquidity in this country as well as potentially different market prices for the same area. Hence this option is economically not reasonable.

[10] This is for example the case on the frontier between the Central-West and the Northern region (border NL-NO), where NL participates in the Trilateral Market Coupling and NO is member of the Nord Pool Market Splitting area.

each market participant direct access to all countries of both regions. Therefore, the decision between merging and super auction would probably be based on historical, organisational or political considerations rather than a technical or economic differentiation.

2. In explicit auctions, directional bids for power transmission rights across borders are sold. Consequently, an intra-regionally co-ordinated explicit auction co-ordinates borders and not necessarily entire countries. Hence, a single country can be member of two (or more) regions with co-ordinated explicit auctions (as long as each border is clearly assigned to one of these[11]). This allows four possibilities for inter-regional co-ordination in a case where explicit auctioning is performed in two neighbouring regions:

   - Explicit bilateral auction: When the regions in question are not overlapping, a separate bilateral explicit auction could be implemented at the border between the regions.
   - Overlapping co-ordinated auctions: When one country belongs to two (or more) regions, it could participate in both intra-regional explicit auctions. At the expense of increased organisational effort for the TSO in the overlap country (compared to TSOs in countries belonging to one region only), this would allow network users from one region to obtain transmission rights to any country of the other region in two steps (source country→overlap country and overlap country→sink country) instead of three steps with the explicit bilateral auction solution.
   - "Super auction" and
   - Merging of regions: Analogously to the case of implicit auctions, direct access between all involved countries could be achieved by either implementing one joint auction (thereby merging the regions) or by introducing a "super auction" on top of the two regional auctions.

[11] Cf. section 3.1 of the CM Guidelines demanding for one common allocation method for each interconnection: "Capacity allocation at an interconnection shall be coordinated and implemented using common allocation procedures by the TSOs involved."

3. In cases where implicit auctioning is performed in one region and explicit auctioning in the neighbouring region the same options exist in principle as in the case of two explicit auctions. When the implicit auction covers the country at the first region's border and thereby all its internal borders with other countries of that same region, its external borders which form the region's interface with another region can be integrated in the neighbouring explicit auction (if the country belongs to both regions) or managed by a separate bilateral explicit auction. While a "super auction" seems less reasonable in this case, a joint auction for both regions could theoretically be designed as a hybrid auction such that implicit auctioning and explicit bids are cleared simultaneously in order to merge the regions while respecting differently developed national markets.[12]

The inter-regional coordination options discussed above assume that the shape of regions remains unchanged in the process. We consider this a realistic expectation for the majority of cases. Allowing countries to freely choose their region(s) might give rise to wishes to join regions that are deemed more attractive, which may weaken others. Such intentions would probably be based on particular national views rather than the idea of an efficient pan-European market. Moreover, there is a risk that the most intense discussions will be about the participation to regions instead of methodical progress.

2.3 The idea of a target model for regionally coordinated congestion management

In our views, the theoretical, legal and practical development of the past years since the first directive can be analysed and described to the shape of a funnel. This applies to many fields of the liberalisation process, but is particularly true for the topic of congestion management: In the beginning there exist only basic rules, leaving plenty of freedom for different development paths which were followed in different regions and at different borders. With further steps some degrees of freedom were reduced and the details of possible solutions became

[12] This hybrid approach is, for example, foreseen by the Open Market Coupling (OMC) concept.

more exactly prescribed. Both Regulation 1228/2203 and the CM Guidelines can be interpreted as steps along such a *funnel concept*.

Taking this concept further leads to the idea of a *target model*, which aims at further detailing future CM methods within the range of options defined by the legal framework and under consideration of recent developments. We developed the target model generically on the basis of our analysis, the ongoing projects and initiatives, the answers to our questionnaires, and the discussions we held iteratively with various stakeholders. The goal of the target model is to develop the blueprint of a *common* congestion management model that complies with the requirements set out in the CM Guidelines and brings the EU closer to a truly internal market, considering adequately roles, risks, rights and obligations of the involved parties.

Theoretically, the implementation of the target model in two or more adjacent regions would constitute the ideal basis for merging these regions. But obviously, it could take unnecessarily long to wait for this ideal situation. Therefore, a coordination of CM across regional borders could and should take place before the target model has been completely achieved in all or even in a single one of the involved regions. The current pilot projects of inter-regional coordination show that this is possible. What the target model can contribute is to align the regional developments such that the degree of compatibility between regions is improved, unnecessary differences are avoided and the likelihood of fruitful and efficient coordination is increased.

In the following chapter 3 we analyse the requirements for regional coordination in order to identify possibilities for further improvement. In chapter 4 we use these findings to develop the contents of the target model.

3 Fields for further development of regional coordination

Among the topics mentioned in section 2.1 we consider four groupings of inter-related aspects as helpful for a debate of the main aspects and findings:

- Governance and organisational structure
- Network modelling
- Information exchange and transparency
- Auctioning modalities and time frames

The possible or necessary improvements here comprise to some extent aspects that refer to the fulfilment of the requirements of the CM Guidelines as well as options for further improvements beyond these minimum requirements.

3.1 Governance and organisational structures

3.1.1 Overview

The Guidelines only give limited specifications for organisational structure in which congestion management has to be carried out – giving thereby room for the application of the subsidiarity principle but also for time consuming decision processes. The only aspect directly addressed in the catalogue or criteria of article 3.5 of the Guidelines is to coordinate the accounting and settlement of congestion management actions.

To a large extent the requirements are directed towards the TSOs, to some extent also to the NRAs. Other actors who are also affected by or necessary contributors to the introduction of congestion management mechanisms are not directly bound by the Guidelines' provisions.

Governance and organisational structures are exceedingly important and on the open basis of the Guidelines they vary considerably throughout the countries and regions and can strongly ease or hinder the process of the implementation and improvement of congestion management methods.

We differentiate two levels of governance and organisational structures, which are

- on the one hand the direct organisational structure of the congestion management mechanism inside and/or between TSOs and other involved parties, e.g. auction offices which may be subsidiaries of one ore more TSOs or not and be regulated by NRAs or other competent authorities and
- on the other hand the umbrella of legal and regulatory framework conditions and the national and regional institutions participating in the introductory process.

Both levels are intensely interrelated, the first influencing more and influenced more by the conceptual characteristics of the congestion management in place or to be introduced, the latter influencing more the process of conceptual development, decision making and real implementation.

3.1.2 Organisational structure for the operation of congestion management mechanisms

Any congestion management mechanism involves as key actors the TSOs of the region. Inside and among TSOs considerable differences exist in the scope of their activities and the direct or indirect involvement of TSOs in the management of congestions and in particular the way and steps how capacities are allocated. Separation and/or regional integration of Transmission Owner and/or Regional Market Operator are discussed very differently in the various regions. This relates back to the attribution of different TSOs' functions such as market operation / market facilitation, system operation, grid ownership, grid planning and investment decisions and grid building and maintenance to one or various entities. Responsibilities have to be analysed carefully in their consequences for market access and secure system operation.

A decisive factor for the further development towards regional coordination and for reaching the regional cooperation required by the Guidelines is the interaction and definition of interfaces between TSOs, regional Auction Offices (AO), Power Exchanges (PX) and NRAs.

Possible options range from

- **shallow** regional entities with a scope of activities strictly limited to transmission capacity allocation as e.g. the TSO Auction BV (Arnhem/NL) which – although on sub-regional level – guarantees identical timeframes and closing times for a group of borders, to

- **deep** regional entities with a wider scope of activities comprising e.g. mid-term and long-term capacity and system adequacy assessment, system and/or market operation etc.

In any way, existing sub-regional mechanisms and entities, regardless whether they have a shallow or deep scope of activities, should be extended or integrated to a full coverage of the complete region.

In the view of various stakeholders and expressed in the survey and interviews carried out in the course of this study, the governance and organizational structure of any congestion management mechanism should reflect the respective contributions and responsibilities of TSOs and PXs and could be attributed in a way that

- TSOs are responsible for ensuring that the transmission capacities to be allocated are consistent with the respective network security standards. Each national TSO is bound by national legislation – particularly in terms of liability and security standards, whereas the repercussions between the national transmission systems can only be taken into account jointly.

  The practical complexity of this issue becomes particularly evident in relation to the capacity determination for coordinated flow-based allocation methods. While the capacity model is used centrally by the AO, the allocated capacities must ensure that the individual TSOs fulfil their responsibilities for system security. Consequently, in addition to the definition of the technical concept of such model (cf. section 3.2) the interface between decentralised (TSO-wise) and centralised procedural steps needs to be defined. Such definition does not only affect system security, but also the transparency of capacity determination. Moreover, both of these aspects are coupled with the technical capacity definition (cf. section 3.2.2).

- PXs are responsible for price formation and for the orderly and fair operation of markets and determine capacity products, calculation rules for those products and provide effective settlement and clearing services. Price formation on national level is carried out individually (with the exception of Nord Pool, which operates in several countries) whereas the effects of market coupling have to be taken into account jointly.

To combine TSOs' and PXs' tasks on regional level is particularly necessary in implicit auctions for day-ahead capacity allocation, whereas for longer time frames the involvement of

PXs is less self-evident. This aspect gains peculiar importance in the concept of a deep regional entity integrating more TSO activities as e.g. market interface, scheduling, capacity calculation etc., and also long-term capacity allocation.

3.1.3 Governance for the introduction of congestion management mechanisms

In spite of the common basis with Directive 54/2003 and Regulation 1228/2003, regulatory and legal frameworks of Member States show many differences complicating the introduction of common congestion management procedures. These differences can exist in specific rulings for the electricity sector and regulatory framework as well as in general legal basics that indirectly affect the viability of different concepts under individual national circumstances. The existing problems in this field are even more serious concerning non EU member Switzerland where from an energy economic and network operation viewpoint improved coordination would be especially fruitful and the legal and regulatory framework shows the largest discrepancies.

Therefore, not surprisingly nearly all respondents to our questionnaire and interview partners point out that harmonisation of legal and regulatory frameworks in the member states is essential. Regulatory provisions should be harmonised across the different jurisdictions involved so as to provide a common framework for regional congestion management.

It is argued that full harmonisation can only reached by the implementation of a TSO platform under one jurisdiction which would require a clear division of competences by the involved regulators. TSOs refer to different national laws in the regions which render the coordination of consistent contracts impossible and explain hereby e.g. differences in timeframes and the firmness of capacities (which is a major issue for trading companies, cf. discussion in section 3.4.4 below).

Differences in the regulatory proceedings are also emphasised, e.g. the fact that approval procedures by national regulators differ on the content (what must be approved), the approval product (amendment of legal basis or just a decision by regulators) and the timelines, causing serious delays in the implementation of common frameworks.

As a consequence, improvement potential can be seen in the harmonisation of the legal and regulatory framework as well as in the coordination between NRAs.

In this regard it can clearly be stated that the set-up of the Regional Initiatives has been a big step into the right direction and gave a positive momentum for the development of workable approaches; however, as implementation remains complicated and the finding of binding decisions extremely time-consuming, streamlining of the process and more detailed supra-regional guidelines are considered worthwhile.

In CWE the Pentalateral Energy Forum (PLEF) has taken into account – although not yet solved – that the relevant legislators should amend their national legislation in order to enable regulatory authorities from different countries to exchange the necessary confidential information. We consider this as an important recommendation.

Another important issue is that CWE is the only region where – through the PLEF – governments have directly joined in the development of a region-wide concept for congestion management. This is widely considered as a remarkable improvement. Further elements of the PLEF were the request to the regulators to develop and implement one common roadmap for the region and draft a multilateral agreement on confidentiality in order to facilitate the information exchange between themselves, the call for TSOs to commit to and prepare a harmonised set of auctioning rules (dealing with the contractual framework, timeframes and closing times etc.), aiming at integrating also the explicit auctioning systems used at all borders of the region into one common procedure and to improve and elaborate on a regular basis a common report on regional system adequacy.

Given the participation of the governments and the regulators, interview partners and respondents to our questionnaire identify the need of a clear definition of their respective roles, and also claim the need of better synchronisation of those processes where governments participate, and others – as the Regional Initiative – where they do not. With the signing of the PLEF Memorandum of Understanding [6], a better coordination between both processes has been prepared. Formal and continuous integration of the Power exchanges is another advantage of this regional approach.

3.2 Network modelling

The CM Guidelines require CM methods to deal efficiently with interdependent physical flows. Effectively, this calls for ways to model on a regional level firstly the flow limitations of the transmission grid and secondly the simultaneous impact of potentially allocated transmission rights on these limitations. It is widely accepted that so-called "flow-based capacity models" are the means to achieve these requirements. However, prior to the real application of such models for capacity allocation, numerous details have to be clarified. These can be divided into two categories, namely

- the set-up of the basic load flow model (to be used as input to the capacity calculations); and
- the resolution of the capacity model (to be calculated from the basic load flow model and to be used for the allocation of capacity; see fig. 3.1)

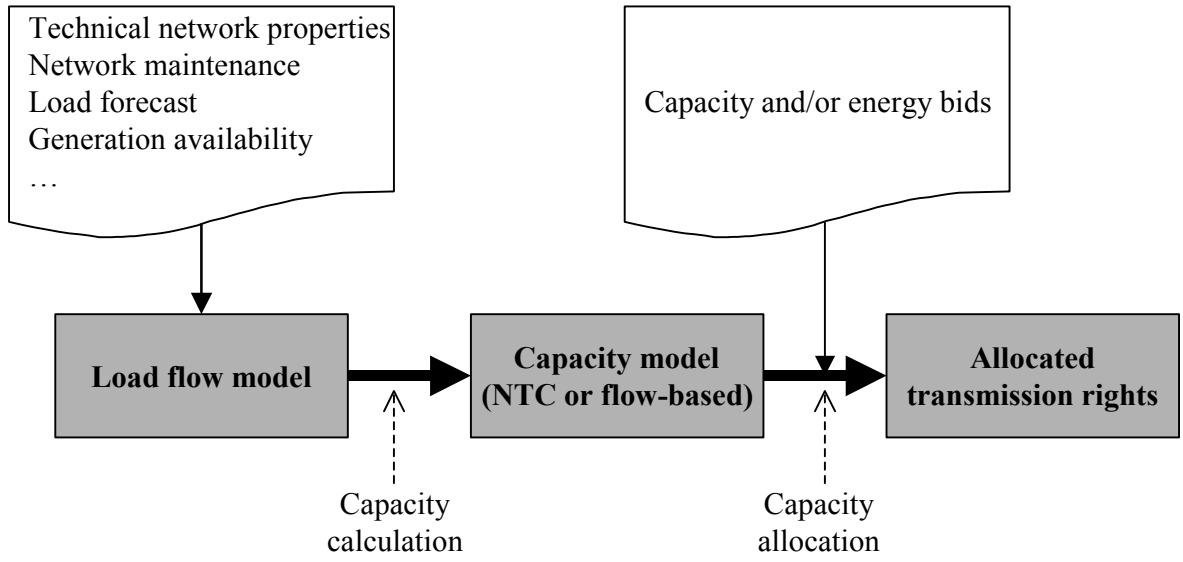

Fig. 3.1: Roles of load flow model and capacity model

3.2.1 Set-up of load flow model

All fundamental[13] assessment of transmission capacity is based on one or more load flow model(s). Such model contains the technical properties of the network elements (e.g. lines and transformers) as well as a generation and load pattern for some "base case" situation. In principle, there exist well-established procedures in UCTE to create load flow models of the entire UCTE grid. However, these models are prepared for purposes other than capacity allocation (e.g. network planning, congestion forecast and the inter-TSO compensation mechanism). Therefore, it is one of the open issues discussed in the Regional Initiatives how to prepare the appropriate load flow models:

- It is clear that the **geographical scope** of the model must at least comprise those countries (or, more generally, areas) that participate in the coordinated regional CM mechanism. But particularly those TSOs who are located at the edge of regions point out that the influence of non-participating areas on their networks is essential for the determination of transmission capacities as well. This information need can partly be accommodated by adding further countries' networks to the "base case" load flow model in order to consider up-to-date information about network and plant maintenance etc. Nevertheless, the cross-border power exchange between non-participating areas will remain an uncertain influence unless the coordinated CM method encompasses the entire interconnected network. This uncertainty will have to be considered through appropriate margins when calculating the transmission capacity. This also means that the use of including networks that are rather distant from the coordinating region in question is of limited benefit.
- The **data sources** to be used for building the model need to be agreed. While generally speaking it is logical to use most recent information on the prospective network situation at the time for which capacity shall be allocated, it is less obvious how to realise this in practice. It seems that some TSOs in principle have quite intense data exchange with their

[13] With "fundamental" we here mean the calculation of capacity based on a computer model of the network. Bilateral capacities (NTCs) are in some cases not fundamentally calculated, but determined on the basis of operational experience [7]. However, a flow-based capacity model always requires fundamental analysis in order to take account of all conceivable interrelations between the transmission capacities on several borders.

neighbours for the purpose of operational planning, but it is less clear what data is really useful – and used – for capacity determination.

- Finally, one needs to decide whether to use one **common load flow model** on which the capacity calculations for all participating TSOs are based or to let each TSO set up an individual model. While the latter option on the one allows each TSO to use its best available data and experience for the calculations, it is on the other hand subject to transparency concerns. In order to make the capacity calculations and their underlying assumptions transparent (cf. also section 3.3) it is advisable to use a common load flow model. It is notable that this advantage has not only been mentioned by network users, but also by TSOs who want to get a better understanding of capacity restrictions in foreign networks.

In any case the set up of the load flow model should be seen as an integral part of the congestion management process. Hence, it is necessary to clearly specify data sources and processing and to ensure the reliability of data provision, in particular insofar as non-participating TSOs are involved.

3.2.2 Resolution of capacity model

Different developments can be observed in the degree of detailing the capacity model. The technical starting point is always the base case load flow model with each single node (i.e. substation), transmission line and transformer represented. In the capacity calculation step, the load flow model is transformed into the capacity model, which is simpler in structure and forms the basis for the allocation. This simplification can be performed to different degrees (fig. 3.2, [4]):

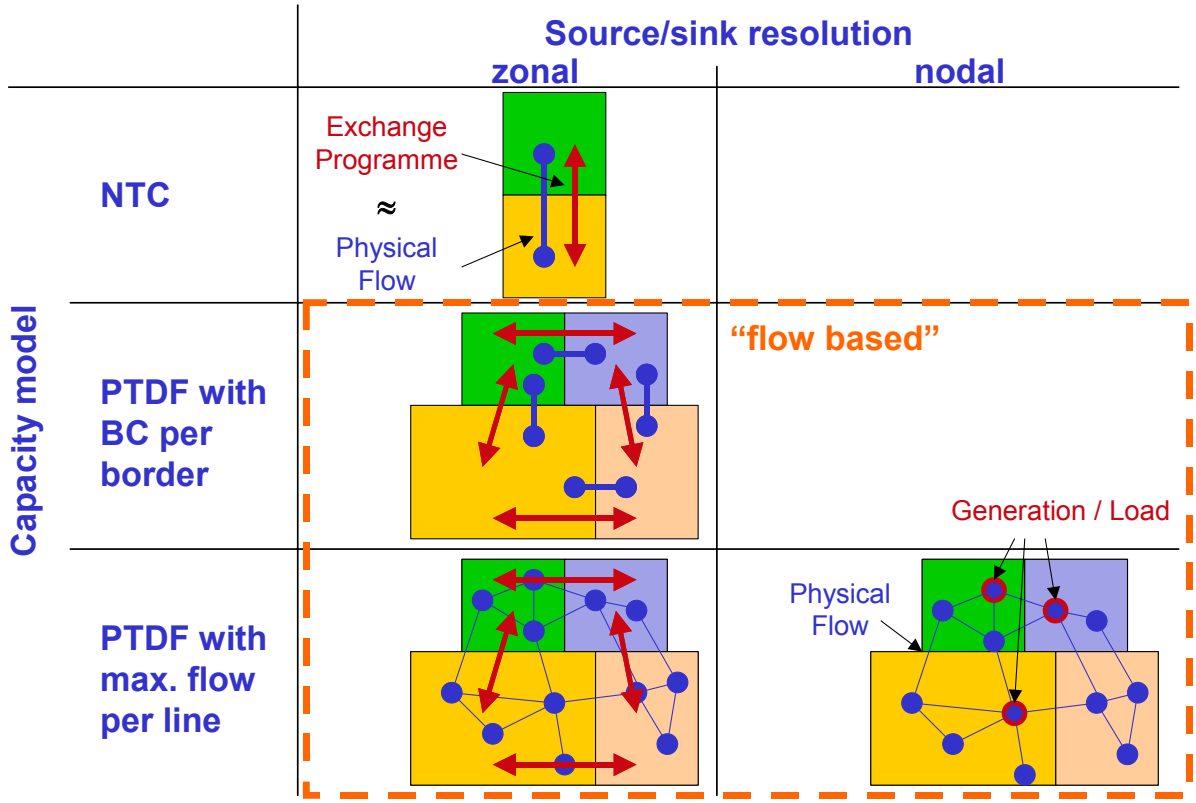

Fig. 3.2: Options for capacity model and source/sink resolution

- The NTC approach applied at most European borders to date sets a fixed limitation to the exchange programme (i.e. the total of all cross-border power transfers) between two countries, which is nominally (i.e. in the allocation procedure) independent from the power exchange between all other countries.

  Since this independence does not exist in reality, the NTC capacity model requires TSOs to either introduce high security margins or take a risk of the network being overloaded due to neglected interdependencies with other borders. Moreover, the NTC approach forces TSOs to decide *ex ante* on a regional level how to share capacity between the borders. This is necessary because the amounts of simultaneously feasible NTCs are interdependent.

  It is the purpose of the so-called "flow-based" capacity models to overcome these drawbacks.

- ETSO [8] suggested in 2001 a flow-based model where flow limitations are expressed by „border capacities" (BCs) representing the maximum flow on an interconnector (i.e. the

group of tie lines between two neighbouring countries). This was adopted in the concepts for FBA so far investigated in CEE and SEE.

- An alternative flow-based capacity model considers maximum flow (MF) constraints of individual transmission lines (and, eventually, transformers) instead of BCs. The concept is presently under investigation in CWE and also in SEE. In contrast to the BC approach the network security criteria (i.e. the (n-1) rules) are not expressed implicitly through the BC figures, but through explicit modelling of the respective contingency topologies. Prospective advantages of this technique are an increased transparency of the capacity determination process and a better grid utilisation through more accurate modelling. Yet, it remains to be further investigated if these advantages are significant in practice and if the drawback, which is the increased dimension of the resulting capacity model, is considered acceptable by market participants.

Compared to the NTC model, the principal advantages of the flow-based (be it on the level of BCs or individual lines) approach are

- the possibility to reduce uncertainty on grid usage, thereby allowing for higher capacities at the same level of operational risk; and
- the capacity competition between borders, i.e. that the amount of transmission rights between any two countries is no longer fixed by the TSOs prior to the auction, but results from the auction, based on the economic values assigned to the transmission directions by the market participants;
- the possibility to obtain direct transmission rights between any two (not necessarily neighbouring) countries.

The second advantage (competition between borders) allows for increased power transmission in those directions where it is economically most beneficial on a regional basis. It should be noted that, when comparing allocation results of flow-based allocation with those of previous NTC-based auctions, the total amount of allocated transmission rights in a region might be lower. This must, however, not be interpreted as a contradiction to the first advantage (increase of capacity through lower margins). Rather, it indicates that the decision how to share capacity between borders in the NTC model was sub-optimal in economic terms, and that the

flow-based approach has allowed to identify a more efficient utilisation of the network, even if the total exchange volume (which does not have a value in itself) has decreased.

Relating to the operational implementation and execution of the network modelling again the distribution of roles and tasks between TSOs and Auction Office arises and herewith the question of the scope of the deep or shallow regional entity and how the TSOs fulfil their legal obligation of guaranteeing network security. The contributions of several TSOs to our survey expressed the importance of perfect transparency on constraints on regional level while taking into account the security rules of the individual TSO[14].

Other respondents expressed general concerns on the complexity of flow-based modelling, referring to a higher priority of market based coupling even with ATC-based capacity assessment. We do not see this as a durable and irresolvable contradiction but agree that there may exist the necessity to prioritise in the timely development, due to the technical issues to be solved and, perhaps more importantly, commercial/regulatory challenges (such as revenue distribution, rules/procedure harmonisation and roles/responsibilities) that may prove quite difficult and time-consuming, and that development of the flow-based approach should not delay the early adoption of implicit auctions. We will come back to the subject of prioritisation in section 4.3.

3.3 Information exchange and transparency

This aspect comprises the requirement of article 3.5 (g) of the CM Guidelines, which calls for the verification of flows to comply with the network security requirements for operational planning and for real-time operation. This information exchange is also particularly important

[14] This issue can be linked to the options for the modelling of network restrictions. The PTDF/MF approach could help to minimise the (intransparent) decentralised part of the overall capacity determination process while at the same time respecting legal obligations of individual TSOs concerning their responsibility for system security.

and a necessary precondition for the definition and application of a workable and reliable network model.

For the time being, after the actual day-ahead capacity allocation (i.e. on day D-1), the so-called DACF (Day-Ahead Congestion Forecast) files, with the cross-border power exchange nominations for day D included, are distributed among the TSOs in order to anticipate possible congestions on day D.

Shared information on the network status of the different transmission networks in one region still varies widely between the regions. In some cases information exchange is lacking to the extent that a thorough mutual understanding of network characteristics and existing bottlenecks among TSO is hindered. We consider it useful that TSOs collect all appropriate information they need from producers and consumers connected to their grid and exchange between themselves all confidential information needed. In the context of flow-based capacity assessment concepts it is crucial to provide transparency on constraints (i.e. flow-limiting equipment) and related contingencies in the networks while the security rules of the individual TSO are respected.

3.4 Auctioning modalities

3.4.1 Day ahead allocation

Throughout Europe, cross-border transmission capacity is allocated in various time frames, ranging from year-ahead to intraday. This is, in principle, also demanded for the regionally coordinated CM methods (article 3.2 of the CM Guidelines). Among these stages the design of the day-ahead allocation of hourly transmission rights receives in most cases the highest attention. This is particularly valid for the recent regional and inter-regional coordination initiatives. The outstanding role of the day-ahead allocation emerges from its link to the day-ahead spot markets for energy who have a crucial role e.g. as the reference point for the valuation of future contracts.

Consequently, several respondents to our questionnaire point out that the thorough and efficient design of the day-ahead allocation stage is crucial for the overall efficiency of a congestion management concept.

This does, however, not mean that the day-ahead allocation should automatically rank first in terms of allocated volumes. While some stakeholders emphasise the importance of high liquidity in the day-ahead allocation, others demand for higher shares of capacity being allocated for longer terms [10].

It is unquestioned that day-ahead transmission rights are rights to physically deliver power to a foreign market. When the day-ahead allocation is an implicit auction, these rights are directly linked to the energy product and hence are obligations. In explicit auction regimes, the transmission rights are nowadays usually options allowing the owner to participate in subsequent energy market stages (e.g. spot market on a power exchange) and decide afterwards whether to make use of the option. (Nevertheless, it is also conceivable to allocate transmission obligations in day-ahead explicit auctions.)

3.4.2 Longer term capacity allocation

The purpose of longer term (e.g. yearly and monthly) transmission rights is different and depends on the market environment. In emerging regional markets the physical nature dominates, i.e. the ability to secure the sale of physical generation to foreign contract partners (consumers or resellers) under commercial conditions that are fixed for a certain period. The more mature and liquid the market becomes, the more the role of medium and long term transmission rights is shifted to financial risk management. In other words: When spot markets allow to buy and sell significant amounts of power at economically reasonable prices, the longer term transmission rights can be used to hedge against the volatility of these day-ahead prices. The extent to which this mechanism works depends on the design of the medium and long term allocation procedures themselves and on their compatibility with the day-ahead allocation stage.

With regard to the desired inter-regional coordination of CM, medium and long term transmission rights (jointly called “forward transmission rights”) would, at least for the time being, ideally be able to accommodate both purposes, the rather physical and the financial hedging possibility. While the former purpose calls for continuing to allocate medium and long term transmission rights as physical transmission rights (PTRs), the latter purpose can be achieved through the proper and consistent design of the CM method across the different allocation stages.

Once markets have developed such that the physical hedging facility is less required, PTRs could be replaced by financial transmission rights (FTRs). FTRs do not represent a right to nominate physical power transfer across a border, but to receive a compensation equal to the value of the physical transmission capacity at the time of day-ahead allocation. It is expected that the purely financial nature of FTRs would attract additional liquidity to the market. The question to which extent a transition from PTRs to FTRs would constitute a systematic "break" depends on the concrete implementation. This will be discussed further in section 4.1.3.

3.4.3 Intraday congestion management

The CM Guidelines demand for the introduction of intraday cross-border CM by 1 January 2008. While this shall be generally done "in a coordinated way" (article 1.9), intraday capacity allocation is not mentioned in the list of time frames for which regionally coordinated CM shall be applied (article 3.2). Therefore, intraday CM is not in the main focus of this study. However, the rules for intraday cross-border network access have repercussions on the options for the design of the day-ahead capacity allocation, because they determine how efficiently market participants can rebalance their positions after the day-ahead gate closure.

Moreover, there are already electronic cross-border intraday allocation systems implemented or under development, such as Elbas (covering Finland, Sweden, Eastern Denmark and Germany) and the recently introduced platform for capacity allocation between Germany and France. Besides the shorter planning horizon (introducing timing challenges) intraday capacity allocation shares many technical and organisational framework conditions with other CM stages. Hence there is some probability that – after a transitional period – intraday CM might become part of a sound regionally coordinated CM mechanism across all time frames.

3.4.4 Firmness of capacities

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. This would avoid a mismatch in wholesale market participants' commercial exposure when trading across borders. On the other hand, TSOs need to ensure system security at all times, and experience shows that this occasionally requires to limit cross-border power exchange on short notice to a level below the transmission capacity that has already been allocated beforehand.

When discussing this issue, one needs to distinguish between the various time frames for capacity allocation:

- At the time of day-ahead allocation, TSOs can quite well forecast network conditions such that a restriction to force majeure cases for later (intraday) capacity reductions seems acceptable.

  This is reflected by the concept of implicit auctions (market coupling / market splitting) where cross-border capacity is directly tied to energy contracts on power exchanges. These energy contracts are firm, and therefore the capacity made available by the TSOs needs to be firm after the day ahead market. Consequently, implicit auctions are implemented or foreseen for the day-ahead market only.

  Stakeholders from the Nordic market, where physical cross-border transmission capacity is only allocated through day-ahead market splitting, point out that the allocation of firm rights has proven to work for over 10 years without any real problems linked to contract settlement or real-time balancing of the power system.

- For medium and long term transmission rights (e.g. monthly and yearly capacities) it is less evident 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. Compensation payments, if any, are mostly linked to the price at which the capacity originally has been allocated [9].

For the market participants engaged in cross-border trading, this practice creates commercial risks: Since the value of the curtailed transmission rights may have changed between the time of allocation and the time of curtailment, the compensation payment might not cover the increased cost of supplying the customers from domestic sources instead of using cross-border transmission. This reduces the ability of medium and long term transmission rights to be used as hedging instruments and requires further risk management activities from the market participants. In some cases this might even hinder markets participants to enter certain national or regional markets. Hence, the combination of non-firm transmission rights with unfavourable compensation conditions may cause a reduction of cross-border market efficiency.

We conclude that

- physical firmness of transmission capacity cannot be guaranteed – TSOs need a mechanism to effectively reduce the total volume of allocated transmission rights after the time of initial allocation. If such mechanism did not exist, network security could only be maintained by offering strongly limited monthly and yearly capacity, which would contradict the market demand for medium and long term transmission rights as price hedging instruments;
- financial firmness improves cross-border competition – market participants are striving for firm transmission rights because this would avoid the mismatch between the commercial conditions of cross-border transmission and power supply, thus avoiding an additional risk exposure through the use of cross-border transmission rights.

It appears that most of today's cross-border access arrangements to some extent miss both of the above targets. On the one hand market parties do not get firm capacity and thus have to separately manage the associated risk (or decide to not engage in certain markets at all, see above). On the other hand it is reasonable to assume that TSOs have a tendency to apply the instrument of curtailment as rarely as possible in order to avoid critical reactions and investigations by traders and/or regulators. Ultimately, this can be seen as a threat to network security.

3.4.5 Secondary trading of transmission rights

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.

Trading companies propose that secondary markets be also used for another purpose, which is the readjustment of the total allocated capacity. The idea is that TSOs are allowed to participate in the secondary market in order to buy back transmission rights in cases when they notice that the previously allocated amount of transmission rights exceed the latest estimate of physical transmission capacity [10]. On the one hand this could be used as a means to reduce or avoid the need for curtailment and hence increase the firmness of transmission rights. On the other hand it would put TSOs, despite of their specific situation of regulated monopolists, in the role of traders and might be seen as a risk of market distortion, because “ordinary” and “special” market participants would be engaged in the same market.

Regarding the organisation and administration of secondary markets, TSOs clearly need to be involved. Firstly, they need to maintain a register of transmission rights ownership in order to keep track of who is entitled to exercise such rights. Secondly, in a flow-based allocation system they could take the role of "converting" capacity between different transmission directions.[15]

3.4.6 Timing issues

Two aspects relating to timing are prevailing in current discussions:

- TSOs report the existing conflict of aims of maximising the capacities they make available to the market or offering firm capacities early (i.e. in yearly or monthly auctions). This relates to the issue of firmness of capacities, which we have discussed in section 3.4.4 above and which is picked up again in section 4.1.2 below.
- Another critical issue is the harmonisation of gate closures – i.e., the time the various markets close. Currently the exchanges around Europe still close their day-ahead markets at a variety of times although there is initiative to harmonise at least in the CWE and Nordic regions. Market coupling requires that all exchanges in the region (and in linked regions) move to the same time. This typically impacts a number of processes in the exchanges as well as TSO nominations deadlines and further processes and deadlines in some markets (e.g. nomination of virtual power plan (VPP) schedules). Furthermore, synchronisation of gate closure on both sides of an interconnector that is explicitly auctioned can cause problems for traders in determining the optimal usage of the explicit transmission rights.

[15] This is further discussed in section 4.1.4.

4 Target model for coordinated congestion management

In section 2.3 we have introduced the concept of a target model for co-ordinated congestion management within regions, which should also facilitate the co-ordination of congestion management between regions. Below, based on the considerations made in chapter 3, we

- develop the content of the target model
- review its relation to existing regional congestion management initiatives
- discuss issues relating to the sequential implementation of the elements of the target model, and
- present ideas concerning the inter-regional coordination of congestion management.

The target model combines elements of CM methods already existing or under implementation, suggestions brought forward by various stakeholders as well as our own ideas and findings. The model does not claim to prescribe all details of CM procedures. In particular, in cases where the optimality of some design aspect has not been proven yet, it leaves room for further specialisation.

Following the agreed focus of this study, the target model refers to the Central-Western, Central-Eastern and Central-Southern regions in the first place. Nevertheless, many of its underlying considerations apply to further regions as well; but an adoption of the model in further regions may require additional analysis.

4.1 Building blocks of the target model

4.1.1 Overview

The target model is based on the concept that a regional entity, the auction office, performs core functions of cross-border congestion management across all time frames ranging from the allocation of forward (yearly, monthly) transmission rights to intraday capacity allocation. The main elements of the different stages are listed in fig. 4.1. They are elaborated in detail in the following subsections.

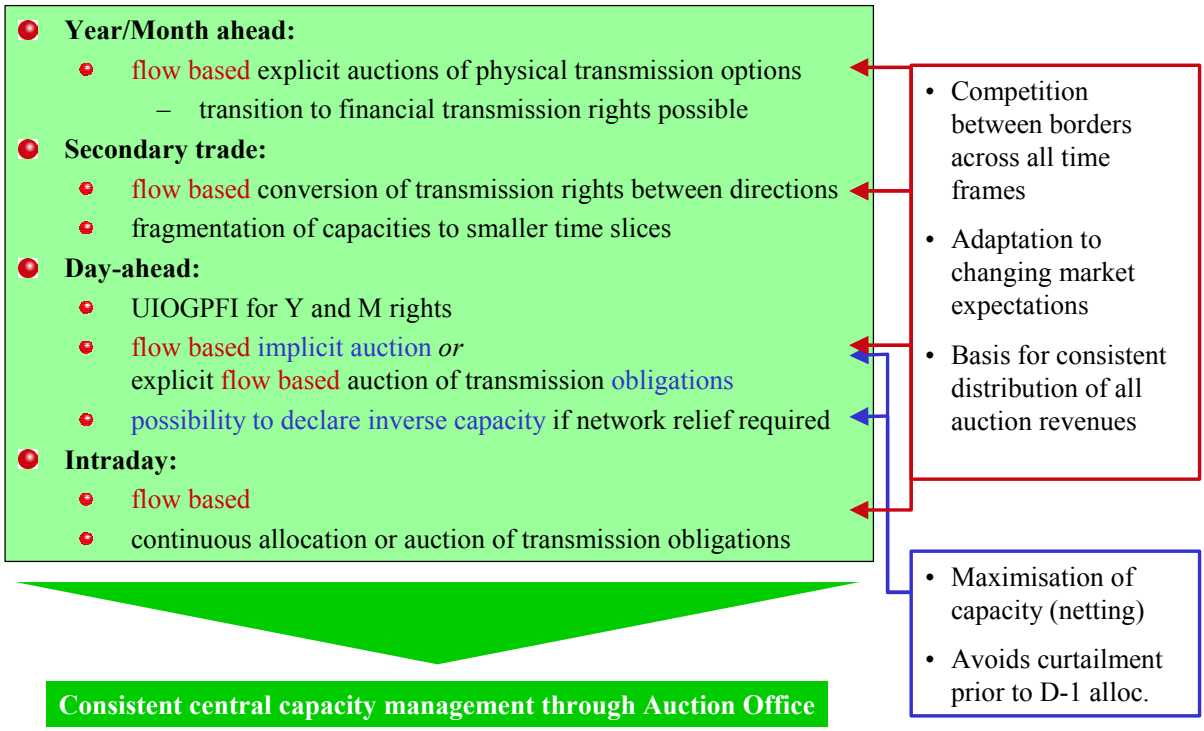

Fig. 4.1: Overview of main elements of target model

4.1.2 Day-ahead allocation

Type of auction

The CM Guidelines allow for day-ahead capacity to be allocated either through explicit auctions or through implicit auctions (market coupling / market splitting). Out of these, implicit auctions have been proven and meanwhile are widely accepted to be the more efficient alternative in terms of the achievement of social welfare [11, 12]. Consequently, **implicit auctioning is the preferred method** for day-ahead allocation in our target model.

Implicit auctions require liquid PX-based spot markets in the countries to be coupled. These organised day-ahead markets must be generally accepted as reliable indicators of the total spot market (incl. OTC) in the respective countries. This is necessary to ensure that the coupled matching of the order curves across countries leads to cross-border exchanges in the efficient

directions and magnitudes. In regions **where this prerequisite is not fulfilled, explicit day-ahead auctions are recommended**.[16]

Capacity model

Following our considerations in section 3.2, the recommended capacity model for the day-ahead allocation stage is the **flow-based** one. As of writing this report the question is still pending whether the optimal resolution of the model should be such that bottlenecks are represented per border or per individual network element (cf. section 3.2.2). Clearly, one common approach should be adopted in all regions, since the similarity of the network characteristics across continental Europe does not seem to provide a justification for fundamental differences in the capacity modelling.

Capacity products

At implicit auctions, transmission rights are naturally allocated as obligations, because the cross-border exchanges are tied to the binding energy bids of the participating PXs. This allows to perform netting within the day-ahead allocation stage, i.e. the relieving effect of flows can be taken into account to allow higher flows in the opposite direction.

At explicit auctions, it is a standard today to allocate transmission rights as options, i.e. the owner of the right can decide later (after the gate closure of the day-ahead commodity market)

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[16] In the case of the trilateral market coupling (TLC) between France, Belgium and The Netherlands the introduction of the implicit auction helped (inter alia) to establish a liquid spot market in Belgium, i.e. practically that the prerequisite for implicit auctioning was fulfilled through the market coupling itself. However, this did not happen "automatically", but was a well-defined coordinated process. Moreover, there already existed liquid market places in both neighbouring countries. Therefore, this example cannot be generalised for all other countries or regions. Where the necessary establishment or improvement of PXs is not possible for the time being, one should allow the market to benefit from regional coordination through explicit auctions. On these grounds, national PXs can later step into the cross-border capacity allocation mechanism and thus transform it into market coupling (cf. section 4.3).

whether or not he wants to use his right. So far this has been considered as necessary in order to avoid that the owner of the transmission right is exposed to imbalance cost if he fails to settle an energy deal on the basis of his cross-border transmission rights. In contrast to this, we recommend for the target model that explicitly allocated day-ahead transmission rights be obligations, for the following reasons:

- The risk for market participants is manageable – In the light of evolving national intraday markets and after establishing intraday cross-border capacity allocation, the day-ahead market is no longer the last market stage to settle cross-border trade before real-time balancing begins. An efficient and liquid cross-border intraday market would significantly reduce the commercial risk exposure due to the allocation of transmission obligations day-ahead. Therefore, efficient intraday cross-border allocation arrangements are a prerequisite for obligations to be allocated day-ahead. It is mainly for this reason that intraday allocation is part of the target model (although the CM Guidelines do not explicitly demand it to be regionally coordinated).
- The efficient utilisation of the network is optimised – As mentioned above, transmission obligations allow for the consideration of netting and hence to use the network to the best possible extent.[17] At the same time TSOs benefit through the reduction of operational risk, i.e. the risk that the network gets overloaded despite the limitation of cross-border exchange. This risk reduction may also be achieved in the case that transmission rights are allocated as options, but then at the expense of potentially reduced capacities. The then necessary discussion about the best compromise between operational risk and amount of allocable capacity may delay the introduction of flow-based capacity allocation.[18]

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[17] The ability to "fill up" the network is particularly valuable in relation to the day-ahead allocation (as opposed to yearly or monthly allocation), because at this time TSOs can quite well forecast the network conditions at the maturity time of the allocated rights (i.e. the next day). Planned outages of network equipment and major power plant, load, wind power infeed etc. are either known or at least fairly well predictable on the day ahead, whereas they constitute large uncertainties when monthly or yearly capacities need to be determined.

[18] When calculating NTCs [13], TSOs consider a certain degree of netting, because the base case load flow situation contains various simultaneous cross-border power exchanges (and their resulting flows). When allo-

- Integration with implicit auction becomes simpler – As a capacity product, explicitly allocated transmission obligations are equivalent to those implicitly allocated through market coupling. This simplifies the introduction of hybrid approaches where both explicit and implicit capacity allocation takes place simultaneously at the day-ahead stage. Such a hybrid approach might be attractive for inevitable transitional processes, e.g. when a subset of countries of an explicitly allocating region would like to introduce market coupling or when CM is to be coordinated between two regions of which one applies implicit and the other one explicit auctioning.
- Prerequisite for use of day-ahead auction as curtailment substitute – An allocation of transmission options allows the TSOs (through the AO) to limit the *additional* flows over and above those created by the firm nominations of forward transmission rights prior to the day-ahead auction. But only transmission obligations allow to even *reduce* flows relative to their level after the nomination of forward rights. This can be used by the AO to adjust its position in situations when prior to the day-ahead allocation the total volume of allocated forward transmission rights turns out to be beyond network security limits. This option is described in the following subsection.

As regards the maturity period of the allocated capacity, hourly transmission rights are a standard product in day-ahead allocation today. In some cases it is possible to also place so-called block bids, i.e. bids for transmission (for explicit auctions) or injection/withdrawal (for implicit auctions) over a period of several hours of the following day. This reflects the physical nature of day-ahead rights and the fact that for most thermal power plant minimum opera-

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cating transmission options on the basis of these NTCs, TSOs effectively take over some operational risk, because some of the power exchanges in the assumed base case (and the relieving flows they create) may not occur in practice. In contrast, the concept of flow-based allocation of transmission options is usually foreseen such that no netting is taken into account, i.e. that all combinations of execution and non-execution of the allocated rights are simultaneously feasible. Although a readjustment of the risk (e.g. to make it equivalent to the NTC case) is technically possible (e.g. by „exaggerating“ border capacities or max. flows), the practical setting of related parameters is an unresolved issue. A flow-based allocation of transmission obligations avoids this problem.

tion times are either indispensable or required for cost-efficient operation. Therefore, the joint allocation of both hourly and block bids on the day ahead is recommendable.

Option to declare inverse capacity as substitute for curtailment

As we have discussed earlier, forward transmission rights are necessary as a physical and/or financial hedging instrument (cf. section 3.4.4). In today's continental European transmission capacity auction regimes, they are realised as physical transmission rights (PTRs). We recommend to maintain this concept for the time being.[19] Nowadays the amount of PTRs follow the concept that some total capacity (the NTC) is distributed among the time frames (yearly, monthly, daily). This is based on the expectation that in the vast majority of hours the latest day-ahead estimate of total capacity (i.e. the highest exchange programme compliant with network security criteria) is higher than the sum of the already allocated yearly and monthly capacities. This means that the level of day-ahead capacity, being the residual between total and yearly/monthly capacity, can be adjusted to react to short-term changes of network conditions. However, this only works as long as the day-ahead capacity remains positive. In case the total capacity estimated day-ahead is lower than the already allocated (or, more precisely, nominated) yearly/monthly capacity, TSOs curtail the already allocated capacity [9].

We recommend to modify this concept such that in general only the adjustment of day-ahead capacity is used to make the total amount of cross-border transmission rights compatible with network security criteria. This means effectively, that in cases where the already allocated yearly/monthly capacities turn out to be too high, TSOs should have the possibility to allocate inverse capacity on the day ahead. Thus, curtailment of forward transmission rights would no longer be necessary (fig. 4.2).[20]

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[19] This will be discussed in more detail in the following subsection 4.1.3.

[20] 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.

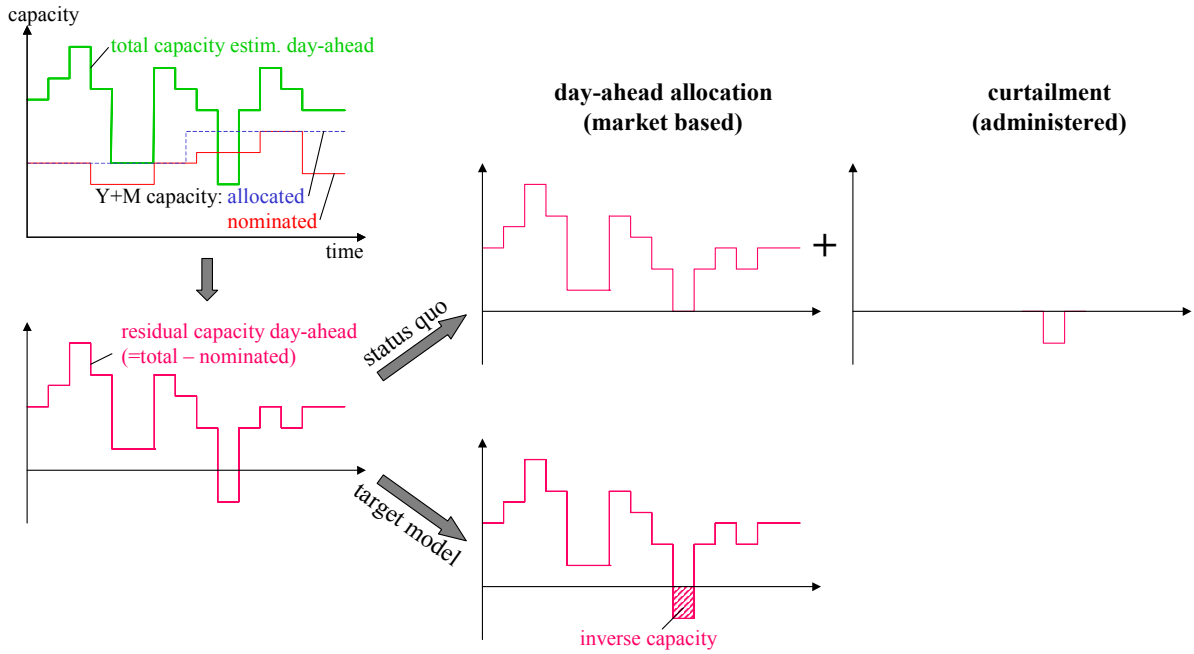

Fig. 4.2: Option to allocate inverse day-ahead transmission capacity as substitute for curtailment – schematic example (single border)

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 BC or MF 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.)

The suggested concept of optional inverse day-ahead capacity works both with implicit and explicit auctions:[21]

[21] Taking into account the liquidity of PX spot markets (which are considered a prerequsite 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.

- 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.

In both cases the day-ahead allocation may[22] yield negative revenues for the AO. In principle, this is comparable to the effect of compensation payments under presently applied curtailment rules, but with one fundamental difference: Payments for inverse day-ahead capacity are made at the day-ahead clearing price[23], whereas compensation payments for curtailment of forward transmission rights are presently based on the original auction price at the majority of European borders [9].

The CM Guidelines do not precisely specify the pricing of compensation payments, such that both valuation approaches are feasible from a legal perspective.[24]

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:

- 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

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[22] 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.

[23] In an implicit auction, based on the price differences between the participating PXs; in an explicit auction, based on the day-ahead bid prices reflecting the market participants' expectations of spot market price differentials.

[24] 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 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 [1] 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.

- 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.

  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.

Summarising from the above arguments, one can conclude that through the valuation of capacity reductions according to the day-ahead auction price PTRs become increasingly similar to FTRs. This simplifies a later transition to FTRs – and at the same time makes it less urgent.

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. However, the eventual allocation of inverse capacities has some advantages:

- The reduction of capacity is not a separate mechanism, but smoothly integrated into a CM 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.
- 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 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.[25] 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.

One should note that in the case of DC links the concept of inverse day-ahead capacity can be problematic. If the reduction of previously allocated transmission rights is necessary due to a failure of the DC link itself, this usually means a reduction to zero. (This is different from meshed AC network regions, where normally only gradual reductions are required.) The need for such drastic reduction may give rise to strategic, i.e. excessive bid prices. For this reason, curtailment with compensation based on the original allocation price may be the better alternative for DC links.[26]

4.1.3 Forward transmission rights

General principles

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

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[25] Extensive inverse capacity would be equivalent to extensive (preventive) counter-trading, which is considered unfavourable from an overall economic efficiency viewpoint [11, 14].

[26] A detailed analysis of this issue is outside the scope of this study, because it does not apply to borders inside or between the three regions on which the focus was laid.

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. To achieve this, the following conditions should be fulfilled:

- The approach to capacity allocation should be consistent across all stages. Therefore, we recommend a flow-based capacity model for yearly and monthly PTR 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. 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).[27] 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 AO – reflect the expected day-ahead capacity price.[28]
- If an eventually necessary reduction of capacity prior to the day-ahead allocation is not performed by curtailment, but by an allocation of inverse capacity, the reduction does not affect all owners of long/medium term PTRs, but only those market participants who have declared their readiness to cope with it by submitting respective bids to the day-ahead auction.

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[27] 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.

[28] 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.

Through the properties listed above, the long/medium term PTRs would become quite similar to financial transmission rights (FTRs) while still providing the physical hedging functionality. When at some time in the future this physical hedge is considered to be no longer required, a relatively smooth transition to FTR allocation seems to be possible, which would then probably attract more liquidity.

Timeframes

As regards the times at which forward transmission rights should be allocated, yearly and monthly auctions constitute a de facto standard, and they are also stated in section 3.2 of the CM Guidelines as stages to be regionally coordinated. The distinction between yearly and monthly timeframes reflects, inter alia, the increasing certainty of TSOs about the prospective network situation during the respective maturity period.

Some stakeholders demand for more frequent and thus flexible allocation of forward rights, e.g. quarterly allocation of yearly rights [10]. Yet, this may unnecessarily limit the amount of capacity available and thus the liquidity at any single auction round. Hence the desired goal, i.e. flexible access to forward transmission rights of different maturities, can probably be better achieved through a well functioning secondary market (see section 4.1.4 below).

Flow-based allocation

While the introduction of flow-based capacity models for the day-ahead allocation stage is widely accepted as a reasonable step, there seems to be less acceptance of flow-based allocation at the yearly and monthly stages [5]. However, we consider it essential for the effectiveness and efficiency of the target model that also forward transmission rights are allocated through a flow-based mechanism:

- Competition between borders – One of the major advantages of flow-based allocation is that it allows the market to determine how to share capacity between different borders. Yearly/monthly PTRs result in nominations of power exchanges and hence a partial utilisation of physical capacities prior to the day-ahead allocation. If this utilisation is inefficient (in the sense that there is relatively too much transmission in directions that have relatively little value) it is not certain that the day-ahead allocation will be able to “cor-

rect" this situation such that the ultimately nominated total cross-border exchanges are most efficient.

Moreover, a flow-based yearly/monthly allocation is the prerequisite for a flow-based secondary market (see below). But only if the ratio of the volumes of transmission rights between the different borders can be continuously adjusted in a flow-based secondary market, it can fulfil its function to continuously adapt capacity prices to their expected value at the day-ahead auction.

- Consistent revenue distribution – Only if the capacity model of all auction stages (yearly, monthly, daily) follows the same principle, a consistent distribution key for the total auction revenues can be implemented. This avoids undesired incentives and regulatory overhead. Otherwise, for instance, the decision on the share of total capacity between time frames may be biased: With NTC-based yearly/monthly allocation TSOs may have an incentive to increase yearly/monthly capacity in order to maximise the respective revenues (of which each TSO gets 50 %) if they fear to be disadvantages by the flow-based revenue distribution key. As a consequence, the capacity sharing between yearly/monthly and day-ahead auctions may be treated inconsistently among the borders of a region. This would lead to a distortion of the day-ahead allocation, because the day-ahead capacity ratio between borders may significantly deviate from the yearly/monthly one.

As mentioned above, some concerns have recently been raised with respect to flow-based allocation of forward transmission rights. However, they mostly originate from an isolated analysis of the yearly and monthly allocation steps and therefore can be overcome through consistent design of other elements of the CM method:

- With a flow-based capacity model the distribution of capacity amounts among the borders depends on the relative valuations expressed by market participants through their bids. There are concerns that this distribution may, in the course of the year/month, turn out to be inefficient, e.g. because some market participant(s) have misestimated the relative capacity values or because of unforeseen market-relevant events after the allocation.

This can be avoided by implementing a flow-based secondary market that allows for changing the distribution of capacity amounts between borders on a continuous basis (see section 4.1.4 below).[29]

- Since forward PTRs can only be options and the uncertainties about the future network situations are significantly higher one year ahead than one day ahead, there might be a risk of year/month capacity with a flow-based model being smaller than today's yearly/monthly ATCs.

  Actually, this is a question of risk sharing between TSOs and network users. If capacities decrease when migrating from NTC/ABC to flow-based capacity modelling, this is because the computational parameters have been chosen such that the TSOs' operational risk (of network overload) has been decreased. Irrespective of a discussion about the "correct" risk level to be taken (which may be stipulated by this issue) it is technically possible to perform a flow-based allocation such that the risk level of the NTC-based system is maintained.[30]

Certainly the set-up of flow-based capacity models for yearly/monthly allocation implies additional challenges on top of the considerations required for the day-ahead allocation stage.

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[29] Despite this, a flow-based allocation of forward transmission rights might yield lower capacities on some borders than today's NTC based allocation. This is a result of the regional (as opposed to national) economic optimisation criteria of the coordinated auctions. But there will always be enough cross-border capacity to supply each market – as long as the design of the national markets allow these to reflect the willingness-to-pay of consumers and/or suppliers. Eventual concerns that flow-based allocation reduces security of supply e.g. through reduced import opportunities are likely indicators of market performance flaws on the national level.

[30] Consider the case that with an NTC-based model, 30 % of the NTC is allocated year-ahead. When applying a flow-based model, allocating 30 % of the border capacity seems to be the equivalent approach. However depending on the rules by which the border capacity has been calculated, this may lead to lower capacity and lower operational risk. Then, allocation of 50 % of the border capacity may, for instance, be the risk-equivalent choice.

But the risk to implement an overall inconsistent CM method, e.g. in terms of revenue distribution, is the worse alternative and may even further delay the entire implementation process.

4.1.4 Secondary market

As mentioned above, the design of the secondary market, constituting the link between the allocation of forward and day-ahead transmission rights, is crucial for the consistency of the entire CM method in general and the suitability of forward rights as hedging instruments in particular.

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 (fig 4.3).

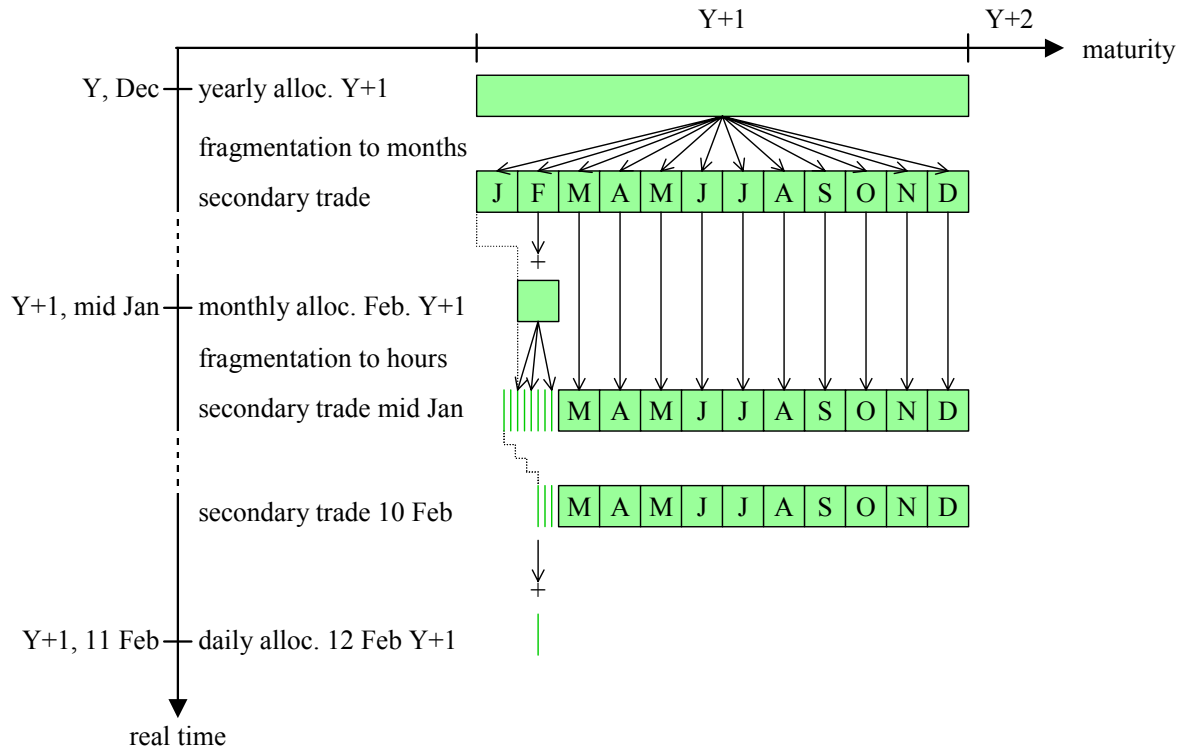

Fig. 4.3: Fragmentation of transmission right maturities after each primary allocation round as basis for secondary trading

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.

Involvement of the auction office

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

1. The AO 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 AO needs to maintain a registry of transmission rights ownership**. Buyers and sellers of transmission rights in the secondary market must notify the AO of each transfer (i.e. submit data about the buyer, the seller, the maturity period and amount transferred). However, the AO 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 AO, because the ownership transfer would not change the total amount of allocated transmission rights and thus their potential physical impact on the network.

2. We recommend to include a flow-based capacity concept in the secondary market. The reasons for this have already been highlighted in section 4.1.3. In order to include the flow-based concept the **AO should offer a means to convert transmission rights between different directions** (i.e. source/sink pairs). This must be done by the AO because it needs to keep track of the technical impact (i.e. the power flows) resulting from the potential nomination of transmission rights (cf. fig. 4.4).

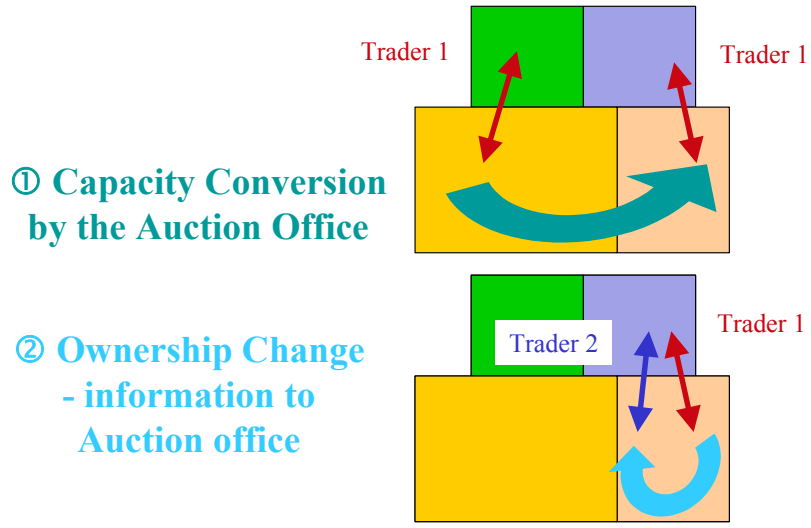

Fig. 4.4: Principle of secondary trade between different transmission directions

Practically, this would mean that the AO 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 A→B and C→D 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 A→B 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).[31]

The market participants could use this facility in the following way (cf. fig. 4.5 b): 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 AO 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.[32] After the AO 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.[33]

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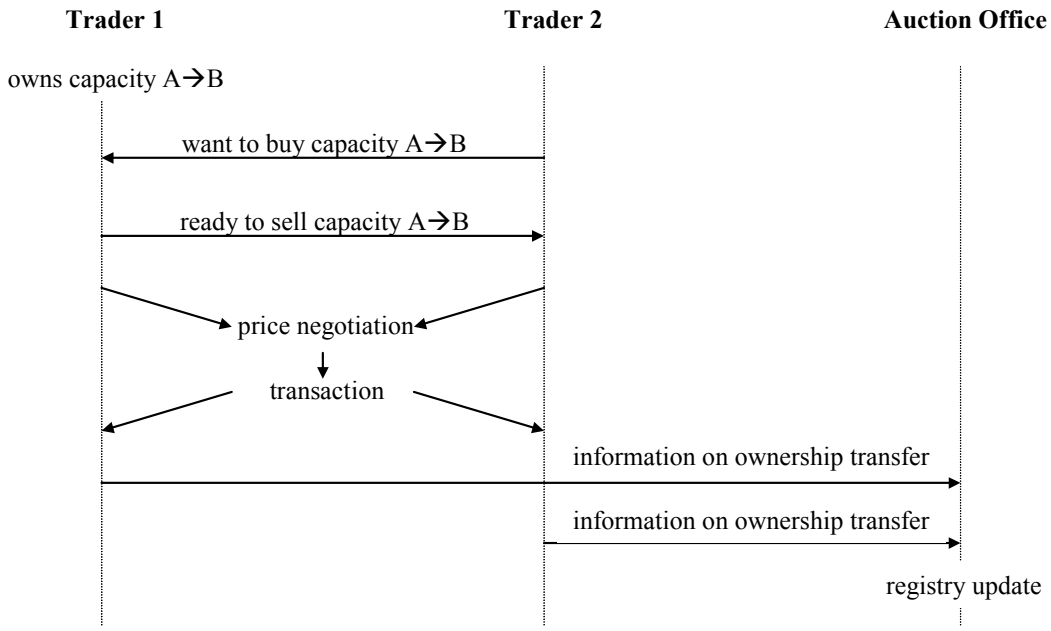
[31] It depends on the flow factors (PTDF) if the conversion ratio is greater or less than 1. In the example in the text we assume that transmission from C to D has a lower PTDF on the critical network constraints than transmission from A to B. Therefore, the conversion leads to an increase of the total amount of transmission rights. If the PTDF of C→D was greater than that of A→B, the total amount would decrease, i.e. the trader would receive less MW in direction C→D than he owns in direction A→B.

[32] 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.

[33] After each registered conversion, the AO would update all conversion ratios in case the binding constraints according to the flow-based capacity model have changed (cf. footnote 32). 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



b) secondary trade between different transmission directions

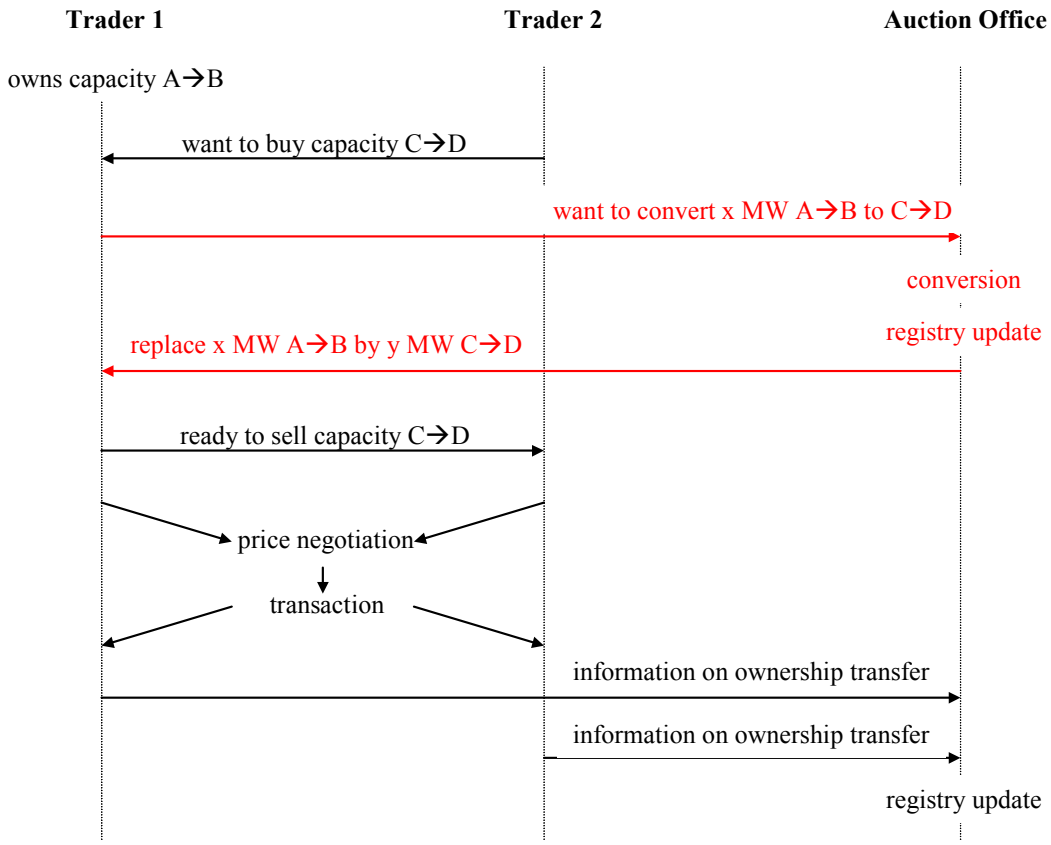


Fig. 4.5: Process of secondary trade for single direction (a) and between different directions by means of conversion through the auction office (b)

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 (fig. 4.5 a). 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 (fig. 4.5 b). 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.

Flow-based capacity model and recomputation issues

As described above, we recommend that the AO 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[34]) 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

[34] 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.

allocated for a given period are always compatible with the capacity model that has been used for the latest allocation round for that period.[35]

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.[36] This concept respects that the TSOs' knowledge on network constraints evolves over time, but that, for instance, the latest capacity update for a certain month does not apply to other months thereafter.

4.1.5 Intraday allocation

General considerations

As mentioned above, the CM Guidelines do not explicitly demand cross-border intraday CM to be regionally coordinated, such that intraday CM is not in the main focus of this study. An overview of the current state of intraday markets in Europe and open issues can be found in [3]. However, efficient intraday cross-border allocation arrangements are a prerequisite for the realisation of some desirable features of regionally coordinated day-ahead allocation (cf. p. 37). In particular, when explicit transmission obligations are allocated day-ahead, the intra-day market must be a credible means to adjust the traders' positions in order to reduce their exposure to balancing prices. While on the one hand this does not necessarily require intraday capacity allocation to be "ideal", it is on the other hand reasonable to assume that achieve-

[35] 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.

[36] 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.

ments of other allocation stages such as the flow-based capacity model could be applied to intraday allocation with limited additional effort.

For example, if intraday capacity is continuously allocated, the AO could apply a flow-based capacity model to allow shifting of transmission rights between transmission directions. If, for instance, capacity between country A and B was fully used on the day ahead, intraday allocation of a transmission obligation from B to A would not only allow further allocation from A to B (as with NTC based intraday allocation), but alternatively also between different countries C and D, depending on the network characteristics. The technical functionality required for this would be very similar to that of a flow-based secondary market.

4.1.6 Organisation of the auction office

General considerations

It is indispensable for the implementation of coordinated regional CM that a central entity, the auction office (AO), performs at least some core functions. On top of that, additional functions could also be assigned to the AO, depending on what is considered to be the best compromise between efficiency, transparency/confidentiality requirements and legal feasibility.

The necessity to centralise some core functions emerges from the fact that any form of coordinated auctioning requires bids for transmission capacity to be traded off on a regional (and not only border-wise) basis. Therefore, all bids need to be assessed simultaneously against the (flow-based) capacity model.

Additional benefits result automatically from this centralisation of the allocation process, such as the harmonisation of auction rules, capacity products, timing sequences etc. for all borders involved. From the perspective of the market participants the AO serves as a "single point of contact", thereby replacing the onerous diversity of bilateral allocation platforms.

When market coupling is chosen as the day-ahead congestion management mechanism, there is a need to also coordinate commodity related functions like (energy) price formation, market operation and linking of energy products between the national markets involved. This requires

to carefully distinguish between TSO and PX responsibilities in the coordinating entity or entities.

Core functions

The core functions of the AO comprise[37]

- the publication of allocable capacities, processing of bids and allocation of transmission rights (for explicit auctions) or submission of price independent bids (in case of day-ahead market coupling);
- the organisation of the secondary market (e.g. registry of transmission right ownership, conversion of transmission rights between different transmission directions);
- financial functions (risk management, invoicing to market participants, revenue distribution among TSOs, etc.)

Optional functions in relation to operational CM

In addition to the core functions the AO could further support the CM process, e.g. in the fields of

- creation of the regional network models to be used as the basis for capacity assessment (e.g. merging of TSO-wise network models to regional models);
- calculation of capacity (i.e. PTDF matrix, BC / max. flow)

Among these, it is certainly more difficult for the second aspect to decide to which extent the process should be centralised.

A centralised capacity calculation would be advantageous in terms of transparency and process efficiency. With flow-based capacity allocation the transparency of capacity assessment is

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[37] This list as well as those in the following paragraphs are not meant to be exhaustive, but rather to illustrate the major options regarding the bandwidth of functions to be assigned to the AO.

even more relevant than with NTC based methods, because each single capacity may influence the allocation result of the entire region. However, it is often argued that the TSOs' legal responsibility for system security requires a rather decentralised procedure, where the AO mainly gathers the calculation results delivered by the individual TSOs.

To some extent the relevance of this issue depends on the approach chosen to describe the transmission capacities. The more straightforward the calculations are, the less relevant it is where they are performed. For example, one could argue that the determination of the "max. flow" capacity model is so straightforward that transparency needs can even be fulfilled by a decentralised calculation procedure because there remains practically no degree of freedom (in contrast to calculations based on BCs).

Optional functions beyond operational CM

Some stakeholders note that it may be worthwhile considering to assign further tasks to the AO, for example

- cross-border exchange scheduling support (i.e. the AO would act as an interface between the transmission rights owners and the TSOs such that the former would nominate their schedules to the AO and the AO would transform these into TSO-to-TSO schedules);
- regional network planning studies (i.e. the AO would, based on its regional network modelling competence and potentially using historical auction data, perform analyses of options for future network extension; this would not replace individual TSOs' analyses and investment decisions, but could serve as a country-independent basis for further TSO-specific assessments)

Involvement of TSOs and PXs

Looking at the range of tasks to be (eventually) executed by the AO, it is evident that the AO mainly bundles TSO functions. Hence, it could be seen as a "service provider" for the TSOs in the region. When taking this perspective, one could set up the AO as a joint venture of the involved TSOs, as it is envisaged for the Central Eastern European (CEE) auction office, for example.

However, when market coupling is the day-ahead CM method, the central coordination comprises also functions that fall within the responsibility of PXs. This must be respected when setting up the AO, for the following reasons:

- Regulatory governance of TSOs and PXs differ from each other and among countries, requiring a clear interface between TSO and PX related functions and processes. This includes, for instance, the proper treatment of confidentiality vs. transparency requirements.
- Experience with the regional coordination processes so far shows that even among members of the same stakeholders' group (e.g. only among TSOs or only among PXs) numerous diverging opinions, priorities and country-specific requirements need to be considered in order to converge towards a common solution. While (particular, flow- based) market coupling achieves its expected overall benefits from the combination of TSO and PX specific market functions, its successful implementation and operation would be facilitated if TSOs and PXs were separately convinced that it constitutes an improvement of their specific situations.

As a consequence from the above considerations one could either organisationally separate the entire day-ahead market coupling from the other stages of the CM method or leave the TSOs' functions together for the entire chain of CM stages and set up a separate entity for the "PX part", i.e. processing of the energy bids, price formation etc., thereby using a capacity model delivered by the "TSO part". The advantages of this second alternative are

- that it ensures and underlines the consistent determination and treatment of transmission capacity over all time scales;
- that it facilitates a stepwise development such that day-ahead market coupling is added to a system of coordinated allocation of explicit transmission rights for all time scales. This may be relevant in some regions (e.g. CEE) or for the coordination of CM across regions.

4.2 Relation of target model to existing regional initiatives

As mentioned previously, the Electricity Regional Initiative recently has stipulated a quite vivid development of CM methods in many regions. The idea of the target model is to take such concepts further towards a complete and consistent methodical framework, thereby easing coordination also beyond regional boundaries. In this section we briefly analyse to

which extent the envisaged regional CM concepts in the three regions CWE, CEE and CSE already contain elements of the target model.

4.2.1 Central Western Europe

With the signing of the PLEF Memorandum of Understanding [6] the development in the CWE region clearly points towards flow-based market coupling for the day-ahead stage, involving the TSOs and PXs. However, it is less clear if or when also the allocation and secondary trading of forward transmission rights will be centrally coordinated, nor if flow-based allocation will be applied at other timeframes than day-ahead. Regarding the flow-based capacity model, the line-wise max. flow (MF) approach is under investigation.

4.2.2 Central Eastern Europe

The TSOs in CEE intend to implement a flow-based explicit auction for yearly, monthly and day-ahead transmission rights. The capacity model under investigation follows the BC approach (i.e. border-wise constraints). Like in CWE, details on a number of relevant issues, e.g. secondary market concept or curtailment/compensation issues, have not been agreed yet.

4.2.3 Central Southern Europe

Apparently coordination efforts in CSE are in a less advanced stage than in the above two regions. A joint allocation of capacity for two or more borders is not planned at the moment. However, there are efforts to harmonise the auction rules for all Northern Italian borders. Moreover, fundamental investigations of market coupling and FBA approaches have been announced. Compared to the other two regions, two main differences can be identified in the market framework conditions:

- With Italy being a strong and constant importer of electricity, the direction of cross-border power exchange is rather stable and predictable. As long as this remains the case, the expected benefit of flow-based capacity models is small compared to regions with less certain commercial flows.

- The timing of day-ahead and intraday markets differs quite significantly between Italy and its neighbours. The harmonisation of gate closure times and related steps (which is indispensable for market coupling) might, therefore, in this region be even more difficult to agree on than in others.

4.2.4 Conclusion

As far as the developments in CWE, CEE and CSE have resulted in concrete plans, they are all in line with the target model. However, for many aspects there have not been concrete decisions on their future coordination yet. When making these decisions it will be crucial to have a common target in order to allow the regions to further approach each other in terms of CM procedures and overcome existing inconsistencies and distortions.

4.3 Implementation sequence

The target model differs significantly from the CM methods presently applied in the three core regions on which this study focuses. This is partly due to the regional coordination as such, which contrasts with the so far prevailing bilateral approaches. (But examples like the trilateral market coupling [TLC] or the explicit auction CZ-DE-PL-SK have already demonstrated that multilateral allocation can work in practice.) Furthermore, details such as the concept of inverse day-ahead capacity as a substitute for curtailment have so far not even been implemented on a bilateral basis.

This raises the practical question how a migration towards the target model can be achieved. Clearly a stepwise approach is desirable, because it allows to focus the resources and discussions on a limited range of aspects at any given point of time. Moreover, a stepwise implementation of changes avoids that their theoretical advantages cannot be realised by the market ("evolution instead of revolution"). But of course one must make sure that each step constitutes a reasonable progress and that the overall development is not unnecessarily slowed down due to a too large number of too small steps.

In any region, the concrete priorities and possibilities for stepwise CM progress will to some extent depend on unforeseeable dynamics of political discussions. Nevertheless, it is possible to provide indications as to a reasonable sequence of implementation steps:

- As mentioned in section 3.4.1, the day-ahead spot markets for energy are widely recognised as reference points for other market segments. Future contracts are valued against the expectation of the day-ahead prices, and intraday markets serve to adjust residual positions in relation to the spot market outcome.[38] Consequently, the development of the day-ahead congestion management stage should receive highest attention.

- As a logical consequence of this, the development of arrangements for forward transmission rights (yearly/monthly allocation and secondary market) may lag behind the day-ahead improvements. This is temporarily acceptable because the introduction of flow-based day-ahead allocation or day-ahead market coupling does not by principle weaken the value or benefit of forward transmission rights for the market participants.

  However, the regulatory difficulties (e.g. in relation to the consistent distribution of auction revenues and the capacity division among timeframes) call for a clear timetable indicating when flow-based allocation will be extended to the forward rights. In any case, primary allocation (through yearly and monthly auctions) and the secondary market should simultaneously introduce the flow-based concept in order to keep these risk management instruments compatible to each other and to overcome otherwise justified criticism against exclusively applying a flow-based model for the primary allocation.

- In a region where explicit auctions are, for the time being, considered the most suitable day-ahead allocation method, market coupling can be introduced at a later stage. This can even be done stepwise for subsets of countries. Since this also helps coordinating between regions, we will come back to this issue in section 4.4.2 below.

- An important element of the target model is the substitution of capacity curtailments by the option to allocate inverse day-ahead capacity. This requires day-ahead transmission rights to be obligations, which in the case of explicit auctions (in contrast to market coupling) relies on the existence of efficient intraday cross-border allocation and trade ar-

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[38] This is of course only a simplified view. In practice the boundaries between the market segments are floating, and the roles and importance of the segments differ from one market participant to the other. Nevertheless, the outstanding role of the day-ahead market and, consequently, of day-ahead capacity allocation, has been referred to by several respondents to our questionnaire.

rangements in order to avoid excessive exposure to imbalance prices (cf. section 4.1.2, p. 37). However, this does not mean that "perfect" cross-border intraday arrangements must be in place before inverse day-ahead capacities can be introduced in an explicit auction. Given that cross-border intraday allocation is, according to the CM Guidelines, mandatory from 2008, one can expect that the necessary prerequisites for optimal day-ahead capacity management should be fulfilled soon. Further improvements of intraday allocation (e.g. migration from ATC to a flow-based capacity model) can be introduced separately at a later point of time.

4.4 Inter-regional coordination of congestion management

4.4.1 Benefit of target model

The idea behind the target model is that it does not only describe a desirable development of CM for a single given region, but that it is also detailed enough such that a decision of neighbouring regions to point their respective further developments towards the target model would significantly facilitate the evolution of inter-regional CM. If the methods adopted in two adjacent regions differ from each other in an unnecessarily large number of aspects, it becomes unnecessarily difficult to agree on a common approach for both regions. Given the present state of development in the regions, it seems advisable to take the opportunity and decide what are inevitable and what are avoidable differences.

The most fundamental degree of freedom in the target model is the type of day-ahead capacity allocation, i.e. market coupling vs. explicit auctioning. As mentioned earlier, we believe that the states of national electricity market development may justify different solutions in this respect (in order to allow for an improvement of cross-border CM even if market coupling is considered impossible for the time being).[39] In the following subsections 4.4.2 until 4.4.4 we

[39] Although the introduction of market coupling itself can contribute to the creation of viable spot markets in particular cases, cf. footnote 16.

will discuss issues arising from this for the coordination of day-ahead allocation between regions.

In contrast to this, many other aspects of the target model should – at least theoretically – be easier to harmonise between regions, such as the capacity model or the compensation rules for forward rights, just to mention a few. Since we do not see any inevitable differences here (in the sense that they would be justified for fundamental reasons in the networks or markets concerned), it should be possible to agree on a common target solution, and the target model could serve as the basis thereof.

The major benefit from such a mutual alignment of regional developments would be that it prepares the grounds for seamless cross-border network access between all countries of all involved regions. However, the introduction of such a seamless access possibility from the market participants' perspective does not necessarily require a complete harmonisation of all details of the respective regional CM procedures. For example, day-ahead capacity allocation could be coupled between two regions, while region-wise allocation and secondary trading of forward rights would be maintained. Of course this is theoretically suboptimal, but for practical reasons could be much easier (and, hence, faster) to realise than a complete merger of the regions.[40]

As a consequence of the above considerations, and taking account of the fact that also on intra-regional level the target model is centred around the day-ahead allocation stage, we focus in the following on the inter-regional coordination of day-ahead allocation. The relevant options are briefly summarised in table 4.1 and discussed in more detail in the following subsections.

[40] The trilateral market coupling (TLC) is an example of such development, yet on sub-regional level.

		Region 1	
		Implicit auction (market coupling)	**Explicit auction**
Region 2	**Implicit auction (market coupling)**	• no overlapping: o hierarchical coupling o merger as potential later step • overlapping regions: o independent implicit auctions in both regions: not reasonable o merger is the only option	"automatic" coordination through overlapping country/ies
	Explicit auction		• „automatic" coordination through overlapping country/ies • merger as potential later step

Table 4.1: Options for the inter-regional coordination of day-ahead allocation

4.4.2 Coordination between adjacent market coupling regimes

Assessment of coordination options

The simplest method to allocate day-ahead capacity between two market coupling areas would be a **bilateral explicit auction** on the borders concerned. However, it would be hard to argue why this shall be a permanent solution if there was a common opinion in each of the regions that market coupling is feasible and desirable. Hence, explicit auctioning should only be considered as a transitional solution until some minimal requirements for stronger coupling are fulfilled, e.g. the harmonisation of gate closure times.

As long as the regions to coordinate do not overlap, a **hierarchical coordination** approach ("super auction") is feasible. This is for example the case for the regions CWE and Northern

Europe (Nord Pool area).[41] "Hierarchical approach" here means that the regional methods would continue to exist, but the power to be exchanged between these areas would be determined by a "super coordinator" on the basis of bid information from the PXs in both regions. The final clearing on regional level would then take into account the inter-regional export/import determined by the super coordinator.

In practice, this generic concept could be implemented in different ways. One option is that the super coordinator receives the bid information from the two regions in such a detailed way (e.g. preserving market area information, block product properties etc.) that the final exchange between the regions can be determined in a single step. Alternatively, the super coordination could be based on more aggregated data (e.g. hourly net export curves), requiring a number of iterations between the regional and the super coordinator. The design of a concrete solution depends on confidentiality and complexity restrictions on the one hand and on timing issues[42] on the other.

The advantage of the hierarchical approach is that it requires much less harmonisation than a complete merger of the regions (see below). A potential disadvantage could be inefficiency due to the fact that the power exchange between the regions needs to be determined on a rough capacity model (because each region would maintain its own regional capacity model). However, in the case of coordination between CWE and Northern Europe this is less relevant because the regions are linked only by DC cables and one non-meshed AC connection (Germany to Western Denmark), such that the inter-regional power exchange can be directly controlled. A flow-based capacity model on inter-regional level would, therefore, not yield additional benefit in this particular case.

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[41] According to the CM Guidelines, the Northern European region comprises Germany and Poland besides the Scandinavian countries. However, there is already an implicit auction in place in the Scandinavian countries (Nord Pool market splitting). Hence, the foreseen introduction of market coupling in CWE can take place without overlapping with the Nord Pool market. The only exception is the Kontek market area in Germany, which would then have to be given up and replaced by a coordinating solution between the two regions.

[42] Since trading will be suspended between gate closure and the publication of the final (inter- and intra-regional) coupling result, the coupling procedure should not take unnecessarily long.

Another concern that is sometimes raised is that a low level of harmonisation (or, more precisely, integration) allows only volume coupling and no price coupling.[43] As in the case of volume coupling the coordinator may not model all price relevant details of each PX's clearing algorithm, the final market areas' prices may deviate from the price estimate with which the coordinator derives the exchange volumes. This could lead to suboptimal interconnector usage (e.g. exchange in opposite direction of price differential or partial use of capacity despite remaining price differential). However, it should be noted that such apparent inefficiencies only occur when the prices in the two volume coupled areas anyway are so similar that the imperfection in the price estimate becomes effective. But these are just the hours in which the transmission capacity has only a low value; consequently, its suboptimal use has only a small impact on social welfare. Therefore, the suboptimality of volume coupling tends to be of a nominal nature rather than being materially relevant.

When two regions are overlapping it is hardly conceivable that market coupling would evolve and persist independently in both regions, because this would require the market(s) in the overlapping country/ies to be split (not geographically, but in terms of liquidity and even prices). It is therefore more realistic that market coupling for the entirety of both regions would be achieved through a **complete merger** of the regional CM methods. The first candidates for such a development currently seem to be the regions CEE and CWE. However, a merged market coupling approach will most probably only be the second step after first the foreseen market coupling in CWE has been coordinated with the foreseen explicit auctioning regime in CEE (see next section 4.4.3). A clear advantage of a merger of the regional approaches would be that the merged method would be based on a common grid and capacity model of both regions, which would be specifically beneficial due to the long and meshed border between these regions.

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[43] Volume coupling means that the coordinator of the market coupling process only determines the volume of power exchange between the coupled market areas. The calculation of the binding market area power prices is then done by the individual PXs, based on the additional export or import determined by the coordinator. With price coupling, all final market prices are directly determined by the coordinator.

Pilot projects

While the above mentioned concepts for comprehensive coordination between market coupling regions are still theoretical, there already exist two "bilateral" pilot projects aiming at introducing market coupling between the Scandinavian market and countries of the CWE region (Norway-Netherlands/TLC and Denmark-Germany). This raises the question how these would fit in the overall inter-regional development process.

It is obvious that the pilot projects have brought together highly motivated stakeholders and pushed forward the conceptual development of possibilities for inter-regional market coupling. The limited number of involved parties is an advantage in this respect. But the limited geographical scope of each project can also be a drawback.

For example, the identity of gate closure times in the involved markets is, on the one hand, usually seen as a prerequisite for market coupling.[44] On the other hand, market participants state that the most efficient use of explicit transmission rights is achieved if the PXs in the involved markets close at different times of day (because then the transmission right allows that one can trade in all PXs subsequently). A progressive but geographically limited attempt to put forward market coupling can, therefore, be understood as a drawback on other borders that are not included in the market coupling (yet). For example, in relation to the pilot project NL-NO, the discussions about gate closure harmonisation between TLC and Nord Pool have raised concerns regarding the use of the explicitly auctioned capacity between Germany and its Western neighbours. One way to overcome this issue would be to introduce coupling between NO and NL only after market coupling in CWE has been implemented.

Another issue is the operational coordination between the two bilateral pilot coupling mechanisms. If they were introduced before market coupling in CWE, they would indirectly link the

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[44] There have been discussions about market coupling despite different gate closure times, e.g. by introducing a separate gate closure for the inter-regional coupling or by using bids from the previous day from the region with the later gate closure. However, while such solutions might formally still be called market coupling, it is much less obvious than for "true" (i.e. synchronous) market coupling that they would constitute an improvement compared to a separate explicit auction on the border between the regions.

Dutch/TLC and the German markets via a sequence of couplers. If, alternatively, a scenario is considered in which market coupling in CWE is already in operation, the two bilateral couplers NO-NL and DE-DK would be parallel mechanisms between CWE and Nord Pool. In both cases the mutual dependence of the two coupling mechanisms would have to be managed. This would require a compromise between solving time (which might practically prevent an iterative approach) and optimality. One solution could be a sequential coupling such that, after a common gate closure, the second bilateral coupler considers the result of the first one, but not vice versa.

The above considerations show that a quick success of pilot projects for inter-regional coordination can be difficult as a consequence of parallel developments on intra-regional level. The pilot projects play a helpful but probably transitional role, and they should further develop into one joint mechanism for coupling between the regions, which would constitute the hierarchical coupling architecture described earlier in this subsection.

4.4.3 Coordination between market coupling and day-ahead explicit auctions

Given the intra-regional approaches currently pursued, this situation is likely to occur between CWE and CEE or between CWE and CSE in the future. In both cases there are overlapping countries belonging to both respective regions. This makes the inter-regional coordination appear a practically automatic process: The explicit day-ahead auction in region A (taking place e.g. at 9:00h in the morning) allows market participants to acquire transmission rights to and/or from the overlapping country to any country in region A. Hence they can participate in the market coupling in region B (taking place e.g. at 12:00h) by bidding in the market area of the overlapping country. A crucial factor for the inter-regional coordination is the appropriate consideration of the respective other region in each region's capacity models. Since each region needs to consider power exchange in the other region as uncertain (at time of allocation) it must reserve corresponding margins. These margins should be based on reasonable assumptions – which should be coordinated between both regions – in order to avoid a waste of capacity and a risk for network security at the seam between the regions.

It is sometimes discussed if the coordination in this case could be further improved through a stepwise process where individual countries of region A decide to introduce market coupling between themselves and/or with region B. At first sight this seems to be an open, hybrid and

thus attractive development path. But a deeper look at practical details reveals timing problems.

In order to keep the explicit transmission rights useful (i.e. rights for transmission to, from and between countries that are not yet participants of the market coupling) they must be allocated in advance of the market coupling (thereby allowing their owners to participate in the subsequent PX spot market). This would require the maximum flows (being the limits in a flow-based capacity model) to be shared between explicit auctions and market coupling in some pre-defined way. But in order to make optimal use of the flow-based capacity concept (by determining the amount of transmission rights according to market data), it is necessary that either all day-ahead bids (explicit and implicit) be considered simultaneously or that the market coupling takes place after the firm nomination of explicit transmission rights. Both alternatives are in contradiction to the above prerequisite for optimal use of the explicit rights.

Thus, the hybrid application of market coupling between some countries of a region and day-ahead explicit capacity auctions between these and the others (and between the others) would, compared to pure explicit auctions, constitute a step back for the "remaining explicit" countries (because timing would practically exclude them from the PX spot market) or for the entire region (because of suboptimal capacity usage). Therefore, a complete switch from explicit flow-based auctioning to flow-based market coupling seems to be the more efficient development.

Analogously, a merger of the capacity model between two regions of which one performs market coupling and the other one day-ahead explicit auctions (for the sake of reducing mutual uncertain flow impact and related security margins) seems unrealistic before market coupling can be introduced in the second region.

4.4.4 Day-ahead coordination between adjacent explicit auctions

If there are overlapping countries belonging to both regions (which is the case for the three continental European core regions and, according to a proposal[45] by the European Commission, also for the borders between SEE and CEE/CSE) there would, like in the case of coordination between explicit auctions and market coupling (cf. previous subsection), be an automatic coordination through the overlapping countries participating in both mechanisms.

Again, the appropriate consideration of the mutual impact of each region on its neighbour(s) is crucial for the efficient use of network capacities. This issue can be ultimately solved by merging the regional CM methods. On the one hand this should be a realistic option if both approaches have been developed in view of a common target model. On the other hand, such merger might be seen as an obstacle for the migration to market coupling, as this seems only realistic for an entire region at once (and thus easier for smaller regions), for reasons presented in the previous subsection.

[45] The perimeter of the SEE region is still awaiting its official definition.

5 Summary

On the backdrop of the Congestion Management Guidelines amending EC Regulation 1228/2003, demanding for regionally coordinated congestion management (CM) methods, and the progress achieved so far in the context of the Electricity Regional Initiative, it has been the aim of this study

- to identify issues and propose solutions concerning the implementation of regionally coordinated CM methods and procedures; and
- to analyse how inter-regional coordination and compatibility between the existing regional CM approaches can be ensured or improved.

The focus of the study has been on the three Central European regions CWE, CEE and CSE.

In terms of contents of CM methods and procedures, we suggest a *target model* to be the goal of further developments within each region. The target model picks up elements of existing methods and ongoing development initiatives and is generic enough to allow flexibility required due to specific regional circumstances, e.g. concerning the maturity of national wholesale spot markets. But it also contains detailed suggestions for many elements of CM, some of which have so far not been in the main focus of discussions. The target model is intended to provide a comprehensive approach to cross-border CM across all timeframes, because the consistency between the different elements (e.g. primary allocation of transmission rights for different periods, secondary market) and the proper design of the interfaces between them (e.g. capacity division between timeframes, resale conditions, capacity reduction procedures) are crucial for making CM a successful contribution to the creation of the Internal Electricity Market. The main elements of the target model are:

- market coupling as preferred solution for day-ahead capacity allocation, explicit auctions as alternative in cases where the prerequisites for market coupling are not yet fulfilled;
- flow-based allocation on yearly, monthly, daily and, prospectively, intraday levels;
- improvement of commercial conditions for physical forward (yearly, monthly) transmission rights, thereby giving them more similarity to financial rights (and allowing a later migration to these);

- secondary market with fragmentation of transmission rights into smaller time slices and option for flow-based conversion of transmission rights between different transmission directions;
- use-it-or-get-paid-for-it (UIOGPFI) conditions for forward transmission rights;
- eventual allocation of inverse day-ahead capacity as substitute for curtailment of forward transmission rights.

Given the fact that the target model is hard to implement at once, the study gives hints as to stepwise implementation possibilities. Moreover, organisational and institutional issues, such as the structure and tasks of the Auction Office, are treated.

As regards inter-regional coordination of CM, the avoidance of unnecessary divergence between the regional approaches is essential. Therefore, steering the further development within the regions towards the common target model would not only improve CM on the regional level, but also be an important step for easier inter-regional coordination. On this basis, the options and recommendable solutions for inter-regional CM mainly depend on the day-ahead allocation methods:

- A merger of adjacent regions is an option when either both regions apply market coupling or both apply explicit auctions. However, this option may be hard to achieve in practice.
- In case of two neighbouring regions with explicit auctions or one region with market coupling adjacent to a region with explicit auctions, coordination can be achieved through the overlapping country/ies participating in both regional CM methods. An important issue will be the proper consideration of the mutual physical impact of the regions on each other in the respective capacity determination procedures.
- Coordination between two market coupling regions (such as Scandinavia and the foreseen solution for CWE) can be achieved through hierarchical coupling, i.e. a “super auction” determining the power exchange between the regions on the basis of information provided by the regional coupling entities. In this context, a volume coupling approach on inter-regional level will be easier to implement than price coupling and probably yield almost the same economic efficiency.

In terms of implementation steps towards the suggested solutions, it is important to note that this does not only constitute a challenge for those who will ultimately either directly or indi-

rectly run the methods, i.e. TSOs and PXs. There are also many regulatory or even legislative challenges, e.g. the removal of legal obstacles hindering regional coordination, the mitigation of incompatibilities concerning the governance of TSOs' and PXs' activities, the adaptation and further development of national energy market rules or tariff regulation aspects required to allow a proper treatment of the commercial risks associated to cross-border CM.

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