

## BALANCING RENEWABLES ON INTRADAY ELECTRICITY MARKETS

**Sokol, R., Bemš, J. \***

*Czech Technical University in Prague, Czech Republic, +420 725 628 093,  
Czech Technical University in Prague, Czech Republic, +420 732 485 015  
radoslav.sokol@gmail.com,  
bemsjuli@fel.cvut.cz e-mail*

### **Annotation**

*Intraday electricity markets contribute to facilitate transition from conventional sources to renewables which need to be balanced on real-time basis due to the unpredictable nature of weather. This paper describes the way from regional electricity markets to a single pan-european market model which is target model of the European Commission. Single liquid intraday electricity market where market participants can balance their portfolios is prerequisite to a full utilisation of renewable power sources and a solution for some problems experienced by TSOs with loop and parallel flows from neighbouring countries. Integrated German and French intraday electricity market which uses FITS (Flexible Intraday Trading Scheme) is described in this paper as a market which could be extended further to the CEE region with very poor liquidity of its local intraday markets.*

### **Keywords**

*Intraday, trading, renewables, electricity*

## **1 INTRODUCTION**

The disaster in Japan resulted in decision to shut all German nuclear plants by 2022 which together with binding EU-wide target to source 20% of their energy needs from renewables represents pressure not only on building of a new transmission capacities but also on functional electricity trading scheme for Europe. The purpose of this paper is focused on intraday cross-border trading scheme rather than planning for new overhead transmission lines which is very hot topic at the moment.

The problem is caused by lack of grid investments which pushes neighbouring grids for balancing foreign energy caused by loop and parallel flows. The very common example of such situations is high PV or wind power generation in Germany which is routed through Poland and Czech Republic. These flows cause congestion on the interconnectors and endanger balance or stability in neighbouring countries. Sources say that phase shifters across the borders could be installed which would make the German grid more unstable. That would also mean to curb building of a new wind farms in Germany or shut down in certain situations some of the existing ones.

This situation impacts not only neighbouring TSOs but also market participants who complain of having no cross-border capacity which is cut because of loop flows. Despite grid upgrades are already planned it's possible that the ongoing process of building of a new wind power plants exceeds the new overhead lines capacity.

The impact of increasing installations in renewables causes shift in volumes traded as forwards or futures thus products with delivery in the future to shorter term products traded on day ahead and intraday markets which is caused by balancing rapid changes of renewable generation.

Easiest and cheapest way of balancing ever changing generation from renewables is well functioning intraday electricity market but available local demand or supply are often insufficient to do the job. In most of the European countries we can find all different kinds of platforms for trading electricity on intraday basis which are more or less user-friendly. Unfortunately regulations, trading rules and deadlines in the whole trading process are not harmonised. Smaller markets like the one in the Czech Republic or Slovakia lack liquidity and market participants have small chance to close their open positions. In this specific case market participants have chance to bid for the cross-border capacities to/from Germany to access liquid intraday market if they want to trade for „market prices“ but this is connected with high expenses for being registered on both markets so that not every power producer can afford it.

Efficient solution for intraday cross-border trading is to interconnect local markets with available cross-border capacities. For all traders would be most desirable to have only one platform with common rules and tradable products for all the interconnected markets. The envisioned target modes is to allow the trader to see bids and offers from neighbouring markets up to maximum of available cross-border capacity allocated by TSOs for trading. Traders don't need to know if the electricity which is to be purchased/sold will be generated/consumed in his country or somewhere abroad if the transmission capacities allow this deal to be concluded.

This concept to be approved and implemented needs general acceptance by all participating parties starting with TSOs, regulators, PXs, traders and all stakeholders. TSOs will be responsible for continuous update and recalculation of available cross-border capacities in a manner that no concluded deal between two parties causes breach of local security rules. Most important role in the whole project will play entity responsible for free cross-border capacity calculation. Let say that keeping traders order books won't be difficult task since this has been already implemented in many projects and no new particularly difficult functionalities will be needed.

The core of the whole project will be the data which TSOs supply to the entity which will be responsible for calculation and allocation of cross-border capacities within the whole electricity market. We already had a chance to see that this is no easy task in implementation of a common CEE explicit capacity auction based on FBA method. The method was to give better results compared to the present NTC capacity allocation method but no better results were given to the market participants. Some of the problems were caused by the data supplied by the TSOs describing the state of their grid which consists of thousands of different values and even one miscalculated value can cause that no cross-border deal can be concluded.

As an example of a well-functioning intraday market we can surely consider the market in France and Germany where Flexible Intraday Trading Scheme (FITS), which allows seamless implicit cross-border trading between the two countries, was implemented. Volumes traded in this market were partly increased due to the new renewables installations but mostly by cross-border trading between both markets.

Since the launch of FITS, introduced in December 2010, liquidity on the French Intraday Market has doubled. Over the year, cross-border trades accounted for 11.4 percent of traded volume on FITS. Growing demand for balancing renewables resulted in introduction of 15min products which contribute to facilitate the German energy transition. Liquidity on intraday markets is growing every year and we can see it in total traded volume which in 2010 reached 10,244 GWh in Germany compared to 15,898 GWh in 2011. In France 1,695 GWh in 2011 compared to 1,027 in 2010 was traded.

Looking at changes in 2012, trilateral market coupling between Czech Republic, Slovakia and Hungary is to be started with Romania as an adept to join possibly next year. As a software solution EPEX SPOT was chosen which operates also intraday electricity market in Germany and France so we can expect possible transition towards this platform which is popular between traders because of its intuitive operability and flexible interface which is easy to personalize according to individual requirements. The decision to use this software is crucial on the way towards day-ahead and intraday target models of the European Commission.

## **2 DAY-AHEAD MARKET COUPLING**

Market coupling is a mechanism that allows the optimization of allocation cross-border capacities thanks to a coordinated price formation mechanism.

Traders to be able to profit from divergence in the price on two separate electricity markets need to bid for the cross-border capacities. They are undergoing several risks throughout the whole process. Traders risk the price on the cross-border profile together with possibility that the volume they need will be only partly accepted. Also the whole process of scheduling the nominated capacities is very time-consuming and represents significant risk. In case of some system malfunction either on traders or capacity auction office side the trader stays open or imbalanced on both markets. The open positions will be balanced by the TSOs which represents huge loss for the trader and possible problems with the regulators resulting from creating imbalances and thus breaching grid code.

In market coupling process trader no longer bids for the cross-border capacity and is only placing orders on the corresponding markets. Market coupling process uses the available transmission capacity to minimize the price difference between neighboring areas/markets and allocates it automatically to those participants creating highest social welfare on the market. It is also increasing convergence between the market areas which helps to prevent occurrence of price spikes caused by power plant outage/-s in one of the markets. Successful market coupling project was implemented in CWE (Central Western Europe) managed by EPEX SPOT. Project launched in November 2010 in Central Western Europe covers Benelux, France and Germany. In parallel, CWE has been volume coupled with Nordic region via the Interim Tight Volume Coupling ITVC.

Single price coupling as target model by 2015 requires use of a single pricing algorithm, harmonized gate closure times, sharing of all bid data between PXs and compatible bids/products. Day-ahead market establishes a reference price for transmission rights.

## **3 BALANCING MARKET**

With new installed renewables the need for balancing the unpredictable generation increases substantially. The deviations will be either balanced by TSO or by market participants.

In case of no flexible intraday trading scheme available for the market participants, TSO will have to balance the deviation by themselves. This will create pressure on balancing services prices since TSOs will have to tender for more AnS (Ancillary services) to support the transmission of electric power and maintain the reliability of the power grid. TSOs can purchase AnS as long or short term contracts (day-ahead) for individual AnS categories.

Czech TSO (ČEPS) purchases roughly 10% of AnS in the day-ahead market for ancillary services. In these auctions marginal price is applied so that highest bid price offered and accepted during given trading hour is used to pay for all AnS bids accepted by ČEPS. Since market participants offering AnS must meet the required technical conditions with regard to its generating units, i.e. so-called certification, the AnS market is not as liquid as day-ahead electricity market which is resulting in higher prices which are sometimes far away from the day-ahead auction prices. For the market participants it is almost always cheaper to balance their imbalances on the intraday market than being balanced by TSO.

In some situations TSOs might not be able to balance the changes in renewables generation by their own means that is why TSOs associated in ENTSOE (The European Network of Transmission System Operators for Electricity) are currently working on a scheme where AnS would be provided and activated from generators situated in neighboring TSOs. That would mean diametric change in the whole structure of AnS markets in Europe since most of them are only local markets where generators don't provide ancillary service to neighboring markets.

The most controversial topic connected with the cross-border AnS market is certainly the question of cross-border capacity allocation/reservation for providing these services. If reserves are to be precontracted, corresponding level of cross-border capacity needs to be reserved on day-ahead basis or even before. If for instance this reserve is precontracted/blocked after day-ahead auction it always represents loss of social welfare for the market participants because they are losing a chance to balance themselves on intraday markets because the available intraday transmission capacity is no longer fully available for them so they will be balanced by the TSO which is always expensive. The optimal solution or the acceptable solution from trader's point of view is that TSOs can allocate all the cross-border capacity which is left after the gate closure for intraday capacity auctions. In this case traders have a chance to close all of their open positions on the market and simultaneously help the TSO to minimize imbalances to be balanced. On the other hand there is no need to precontract any services from neighboring TSOs if the TSO has no guaranteed cross-border capacities.

On the balancing market the focus is mainly on manually activated reserves. There is no need for full harmonisation of balancing markets as a prerequisite for cross-border balancing. Nevertheless gate closures, technical characteristics and responsibilities of all major parties have to be harmonised. PCG recommends to start with bilateral TSO-TSO mechanism with multilateral TSO-TSO mechanism as mid-term target model and multilateral TSO-TSO mechanism with CMO as long-term target. Some of the pilot projects already exist. Prerequisite for the market harmonisation is coordinated capacity calculation methodologies amongst European TSOs together with standards regarding necessary information and information amongst TSOs, generators and traders. Also maximum possible capacities for each time horizon should be provided to the market by respecting TSOs security standards. Target model leads to increased level of coordination and cooperation. Establishment of European-wide common grid model (EU-CGM) implies coordinated reliability assessment, security analysis and transparent calculation methodologies.

#### **4 PAN-EUROPEAN INTRADAY TARGET MODEL**

Target model for inter-regional cross-border capacity allocation in intraday timeframe is implicit continuous allocation (continuous trading). Any specific national/regional ID trading solution must be compatible with the inter-regional target model. In the target model concept each area/TSO is represented with its "local order book" on the lowest level with bids inside visible only to the market participants who have their long/short positions physically inside this area/TSO. Above this structure of "local order books" is "shared order book" which function is to make bids between "local order books" available subject to the availability of cross-border capacity. Target model has to allow block bids which would otherwise be concluded on bilateral basis.

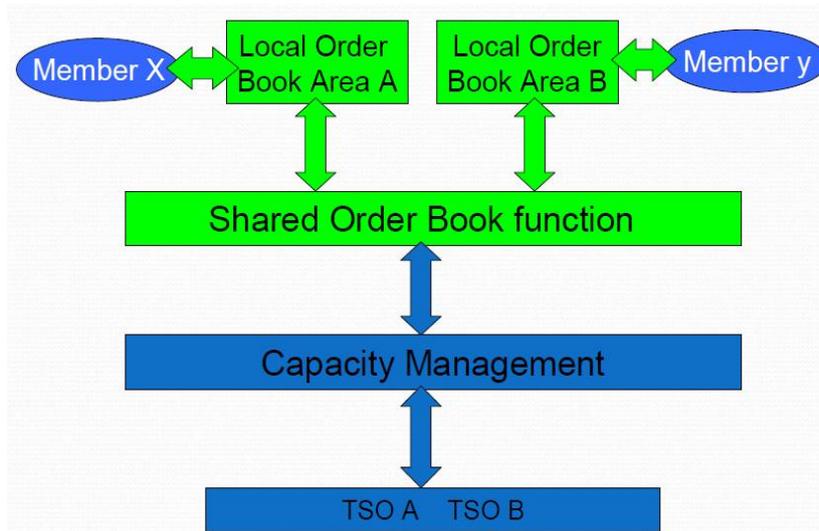


Fig.1 Shared order book functionality

For the continuous implicit auction cooperation of PXs is needed to allow their ID liquidity to match between them, irrespective of the exchange it was submitted to, but taking into account the available cross-border capacity.

Design of “Capacity Management Module” shall ensure compatibility with the target model for cross border balancing (at the target, a multiborder mechanism should be put in place). Balancing would occur after intraday gate closure.

Tab.1 Roadmap for establishing of pan-european intraday market

	Description	2010	2011	2012	2013	2014	2015
Stage 1	Common principles + compatibility Requirements for ID trading						
Stage 2	Centralized capacity management and shared order book function						
Stage 3	ID National/Regional development*						
Stage 4	Stepwise implementation of TM						
End	EU wide trade (target model)						

\*new development or copy/paste

Together with the platform/software implementation of the pan-european intraday market legally binding guidelines and network codes has to be harmonised and approved amongst all participating TSOs, regulators etc.

## 5 PAN-EUROPEAN INTRADAY TARGET MODEL

As an example of existing local intraday markets with very poor liquidity in the CEE region are intraday markets in the Czech Republic, Slovakia and Poland. These markets exist separately with their own trading platforms, rules, deadlines, access certificates etc. Market participant to be able to trade on any of these markets has to register first and pay for the licence regardless of the traded volume. Because of a really few “big” market participants on each local market the liquidity on the local markets suffers and market participants don’t even bother to spend their time trying to make some deals on intraday because of the prices which are not really market based. These three markets are connected with overhead transmission lines and market participants can bid for the intraday cross-border capacity to access the adjacent markets. The capacity is allocated on FCFS (first-come-first-served) principle with no payment for allocated capacity. The market is organized as right-with-obligation so that the market participant must use the acquired capacity. This is not entirely true because the capacity can be partially or fully netted with counter flows (capacity allocated in the opposite direction). In this case, as it was already mentioned, market participants are undergoing several risks throughout the whole process as it is the case with the day-ahead capacity allocation process. TSO CEPS acts as allocation office (transmission capacity allocator) for these borders:

- CEPS–APG
- CEPS–SEPS
- CEPS–TENNET
- CEPS–50HzT
- PSEO–50HzT
- PSEO–CEPS
- PSEO–SEPS
- MAVIR–SEPS

The market is held seven days a week without any regards to any holiday within the related areas. The allocation is held in six sessions of four-hourly blocks. This model is about to change during 2012 between TSO CEPS and TSO SEPS when 24 sessions will be introduced which is discusses in the next chapter. This is being understood as next step towards the single European market.

The evaluation algorithm consists of two steps. In the first step, bids are assessed with respect to the current grid condition using flow-based mechanism. In the second step, the preliminary accepted bids are compared with capacity limits on technical / commercial borders and bids exceeding such limitations are rejected. The evaluation of bids is performed continuously so that each bid is evaluated immediately after receiving by the allocation office.

As it was already mentioned, ID capacity allocation is performed in multiple auctions for time intervals inside the day D (one auction for one continuous time-interval). The nomination process is applied for the same time intervals defined. In the Tab.2 below you can see time lines for each intraday session.

Tab.2 Time lines for intraday auctions

Session No.	Time Interval (CET)		Bids submission	
			start time	closing time
			T1	T2
1	00:00	04:00	18:00 (D-1)	21:30 (D-1)
2	04:00	08:00	22:00 (D-1)	01:30 (D)
3	08:00	12:00	02:00 (D)	05:30 (D)
4	12:00	16:00	06:00 (D)	09:30 (D)
5	16:00	20:00	10:00 (D)	13:30 (D)
6	20:00	24:00	14:00 (D)	17:30 (D)

The ID evaluation process is executed by the auction office every time new bid is submitted by the market participant. All not yet evaluated bids are subject of the evaluation, considering the already accepted bids. The algorithm itself is described in the next chapters. Results are available immediately after each individual evaluation.

As an interim step towards target model, CEPS and SEPS decided to introduce enhanced intraday concept (1-hour Intraday) which should provide market participants with more flexibility as to when cross-border transmission capacity can be obtained and fully matched. This enhanced intraday concept will be put into operation in April 2012. The difference between the present state (4-hour Intraday) and the enhanced Intraday is not only in length of time intervals for which traders can submit their bids but also in the process of evaluation and publishing of allocation results. For 4-hour session model gate opens 6 hours and closes 1.5 hour before the start of the session. For 1-hour session model the gate opens 18 hours and closes 1.5 hour before the start of the session which in this case corresponds to one business-hour. In both cases market participants are obliged to use all acquired capacity.

TSO CEPS uses two types of evaluation algorithms. Flow-based evaluation which is at the moment applied only on CEPS commercial borders and NTC-based evaluation. For the flow-based evaluation firstly common merit order list of the not yet evaluated bids is created based on First-Come-First-Served (FCFS) principle. Bids are evaluated one by one in the order in which they have been received by the system. Each transaction is assessed in terms of its effect on each border up to the remaining available capacity. The available capacities are determined on the basis of specified capacity limit values on borders (using the PTDF matrix) and DACF forecast models.

Each bid is distributed to individual physical borders using the calculated distribution coefficients (PTDFs). The effect of individual transactions is thus simulated step by step, and the resulting model flows are added to the flows in the predictive DACF models created in D – 1. The computing system continuously compares physical flows on borders with forecasts obtained from the DACF model. If the deviation of these values exceeds a specified insensitivity threshold, the system cancels all bids concerning the hours for which the threshold was exceeded. Netting level applied within the allocation algorithm will be configurable (considering the risk of the non-fulfilling of the rights-with-obligation rule). The initial value will be 0 %.

In NTC-based evaluation, preliminary accepted bids are compared with capacity limits (ATC) on technical/commercial borders and bids exceeding such limitations are rejected. After accepting of new bid the actual remaining ATC is recomputed for considering of all already accepted bids.

## **6 INTRADAY IN THE SEE REGION**

First step towards intraday capacity auctions made Romania together with Hungary. Available intraday transfer capacity is allocated by the intraday auction office, operating through the DAMAS platform. TRANSELECTRICA is appointed by the TSOs as intraday auction office. In this specific case, capacity is purchased. Traders do not allocate the intraday capacity on FCFS principle but traders have to participate in the auction. So the capacity is allocated on the same principle as in the daily auctions. Market participant can submit up to 10 independent bids for the profile and one transaction direction. We understand that this was the very first and cautious step towards intraday auctions as we know them from CEE region since market participants want to have more flexibility to balance their portfolios.

Compared to the capacity auction in the CEE region here we have only two sessions of twelve-hourly blocks. Market participant can bid for the ATC early in the morning from 06:00 to 06:45 for the interval 12:00 – 24:00 and from 18:00 to 18:45 for the interval 00:00 – 12:00. There are not many traders who participate in these auctions due to the fact that the time in which they can submit their bids doesn't really fits into the normal working hours. Also the fact that the whole process of scheduling is quite complicated and time consuming plays against the use of this type of "intraday" scheme.

Since 2012 market participants can bid for intraday transfer capacity between these borders:

- Serbia–Hungary
- Serbia–Albania
- Serbia-Bosnia and Herzegovina
- Serbia-Montenegro
- Serbia-Macedonia
- Serbia-Bulgaria

The allocation procedure is more or less the same as in the CEE region. The day is split into six sessions of four-hourly blocks and FCFS method is applied on all borders. Market participant can see the available intraday capacity on Serbian TSO (EMS) web pages for the above stated profiles. One disadvantage is that both TSOs have to be contacted over the phone to confirm the validity/disponibility of the intraday capacity. On the other hand there is no risk for the market participant in case he wants to transit the electricity between three TSOs because in this case he has to bid on two profiles which would be in the CEE region evaluated separately but for instance in case of transit between Hungary-Serbia-Montenegro the EMS TSO contact person from Serbia tells you if he accepts/rejects the whole direction. Intraday auctions played an important role in February 2012 when the whole region was struck by the snow storms and plenty of force majeure resulting in many regions being cut off the power supply. Some of the missing electricity was supplied on intraday basis from Hungary.



Fig.2 TSO EMS with its physical borders

Given the increasing installations in renewables in the SEE countries the pressure will be put also by the market participants on market based ways to balance their portfolios where generation can be predicted on day-ahead basis only with limited probability. At the moment all additional costs connected with balancing deviations are transferred to end consumers which create pressure on prices of electricity. Working intraday market even only local one could change this dramatically.

## 7 FLOW-BASED CAPACITY CALCULATION

On most of the commercial borders, transmission capacity available for intraday is calculated as a capacity which was not used/nominated by the market participant on D-1 and D-2 basis. This is not the ideal solution because commercial and real flows can differ substantially. Capacity available for intraday trading should rather reflect real flows than commercial flows because of the already mentioned differences between real and commercial flows. Flow-based method should reflect real flows and it should replace the obsolete NTC method for intraday capacity allocation.

The main difference between NTC-based and flow-based allocation is that NTC represents only subset of capacity available for the purpose of trading. None of the method can violate SoS (security of supply) domain which defines all possible combinations of all flows in all possible directions without violating any technical and security limits. Flow-based method should correspond to the SoS domain while ATC domain is just part of the SoS domain. When TSOs provide ATC constraints, they have to make a choice on how to split the capacity among their borders (A to B and A to C) as you can see in the Fig.3. That does not necessarily mean that the ATC domain is chosen according to the current market needs/situation. The market itself should define how to split the capacity as long as it does not violate SoS domain.

SoS domain in the Fig.3 below is inside the blue bounded polygon while ATC-domain is inside the green bounded rectangle. No part of such defined rectangle can be outside the polygon.



welfare for the market as it was expected. It is not likely flow-based daily auctions to start in the near future due to the volatile or unpredictable results showed in the dry-run auctions.

## 8 TRANSMISSION CAPACITIES

Transmission capacities play an important role in the market price making process. To be able to fully understand how they affect electricity markets we have to look at some basic terms used for trading purposes.

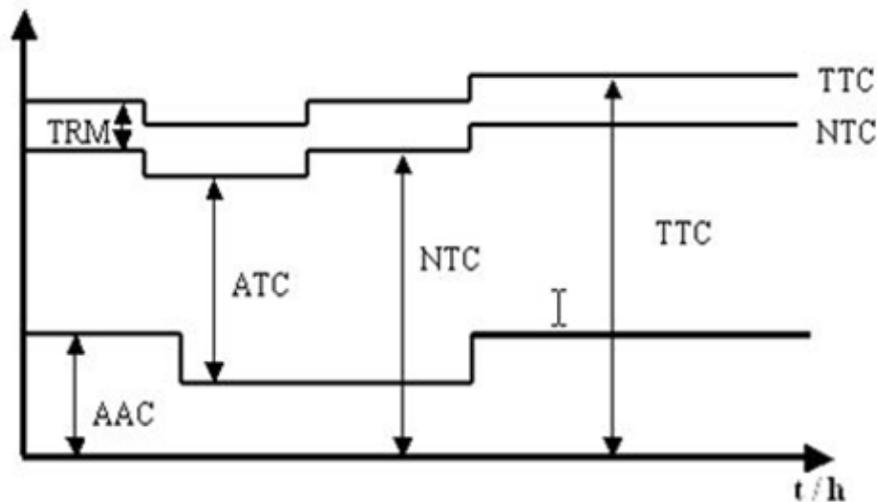


Fig.4 Cross-border capacity terminology for trading purposes

- **TTC** (Total Transfer Capacity) - represents the maximum exchange of active power between two neighbouring electric power systems that is compatible with operational security standards applied in each electric power system
- **NTC** (Net Transfer Capacity) - (intended for commercial purposes) represents the difference between the total transfer capacity and the transmission reliability margin
- **ATC** (Available Transfer Capacity) - Part of NTC that remains available after each phase of the allocation procedure for further commercial activity. ATC is given by the following equation:  $ATC = NTC - AAC$
- **AAC** (Already Allocated Capacity) - Total amount of allocated transmission rights, whether they are capacity or exchange programmes depending on the allocation method
- **TRM** (Transmission Reliability Margin) - represents a portion of total transfer capacity that must be ensured by the system operator to cover the possible outage of the largest generator in the control area, due to angle or voltage stability problems etc.

There are many ways how transmission capacities can be allocated. For different borders we have different auction types. Usually market participant can allocate the transmission capacity in yearly, monthly, daily and intraday auctions. Some portion of NTC is made available in yearly auctions. Part of the remaining capacity is made available in monthly auctions and the not nominated capacity from D-2 is available as ATC in daily and intraday auctions.

Between TSO CEPS and TSO SEPS there is no daily auction which is available in the market coupling. Market coupling is the use of so-called implicit auctioning involving two or more power exchanges (PX). In the auction, capacities are allocated automatically in the direction from cheaper to more expensive market so that the price between the markets is flattening. Transmission capacity is allocated only in case price difference exists between the markets.

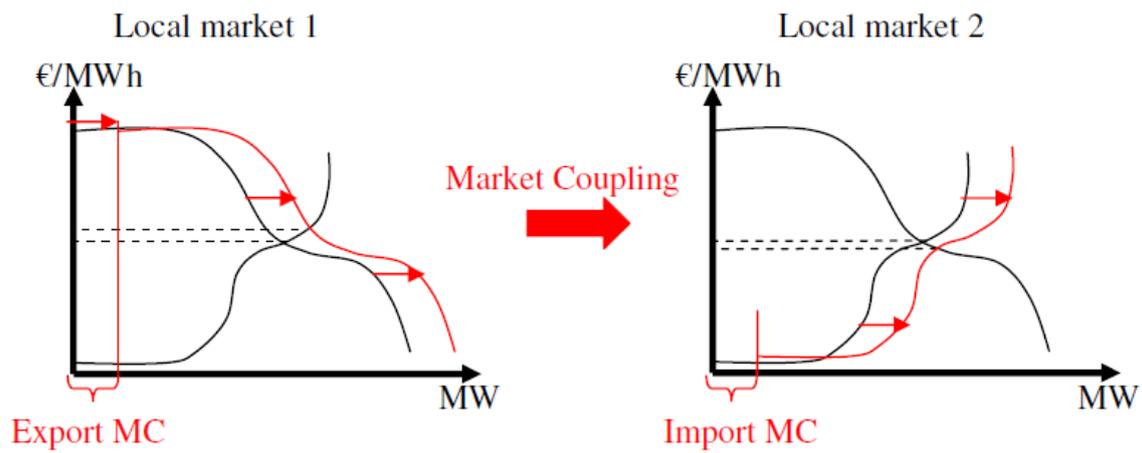


Fig.5 Implicit auction principle between two markets

The purpose of connecting two and more markets is to reach highest social welfare where only the cheapest power generators from all participating markets are dispatched to cover the power demand with the least cost. It gives the market the right impulse to invest in new technologies and to switch-off old, expensive and noncompetitive power generators.