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Flow-based Coordinated Auctions:

income Distribution Analysis and Developments in

Applied European Congestion Management

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Agenda

1. **Introduction: Congestion Management**
2. **Situation in Europe**
3. **Procedure**
   1. Hypothesis and Methodology
   2. Mathematical Formulation
   3. Data
4. **Results**
5. **Conclusions**
6. **Developments**
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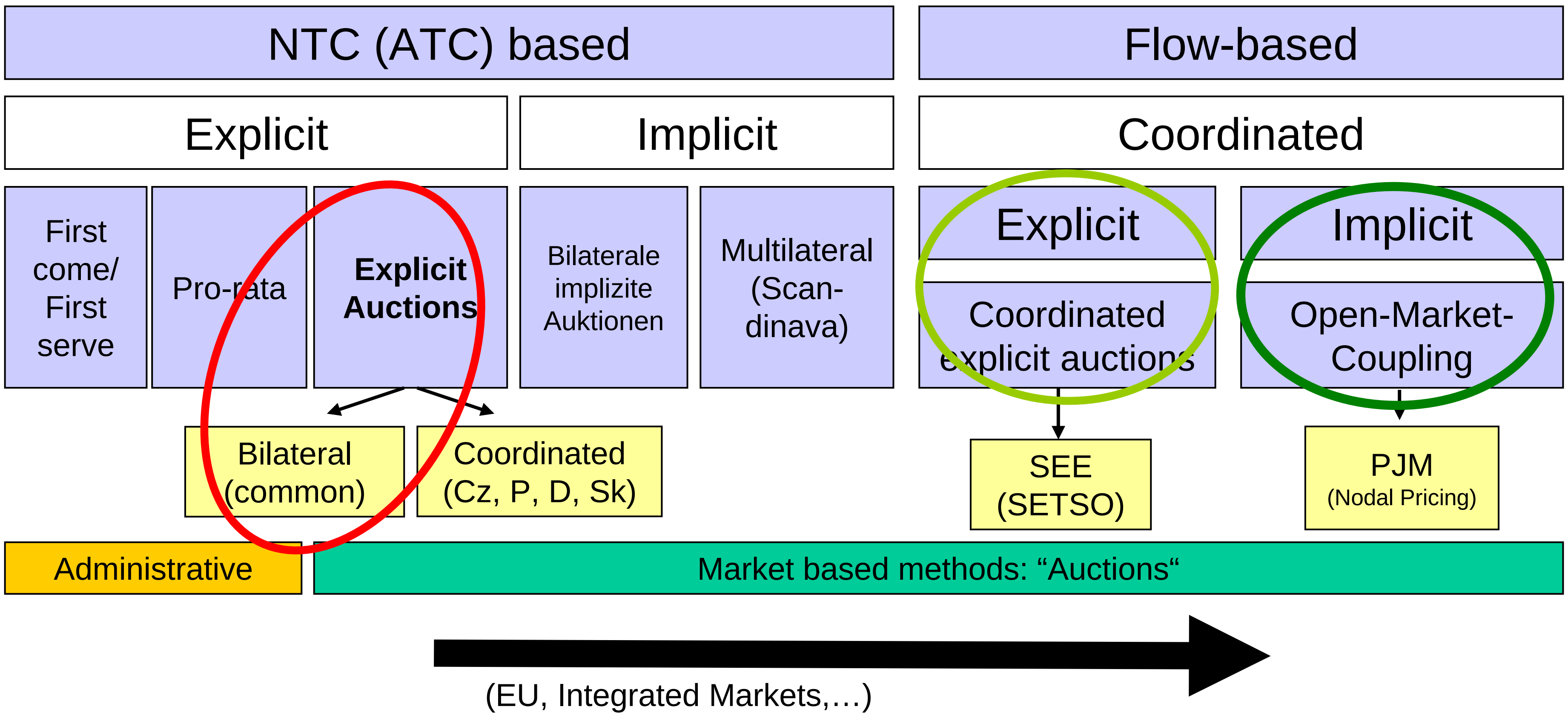
Introduction: Congestion Management



Source: Vujasinovic, 2005, p. 3; own illustration.

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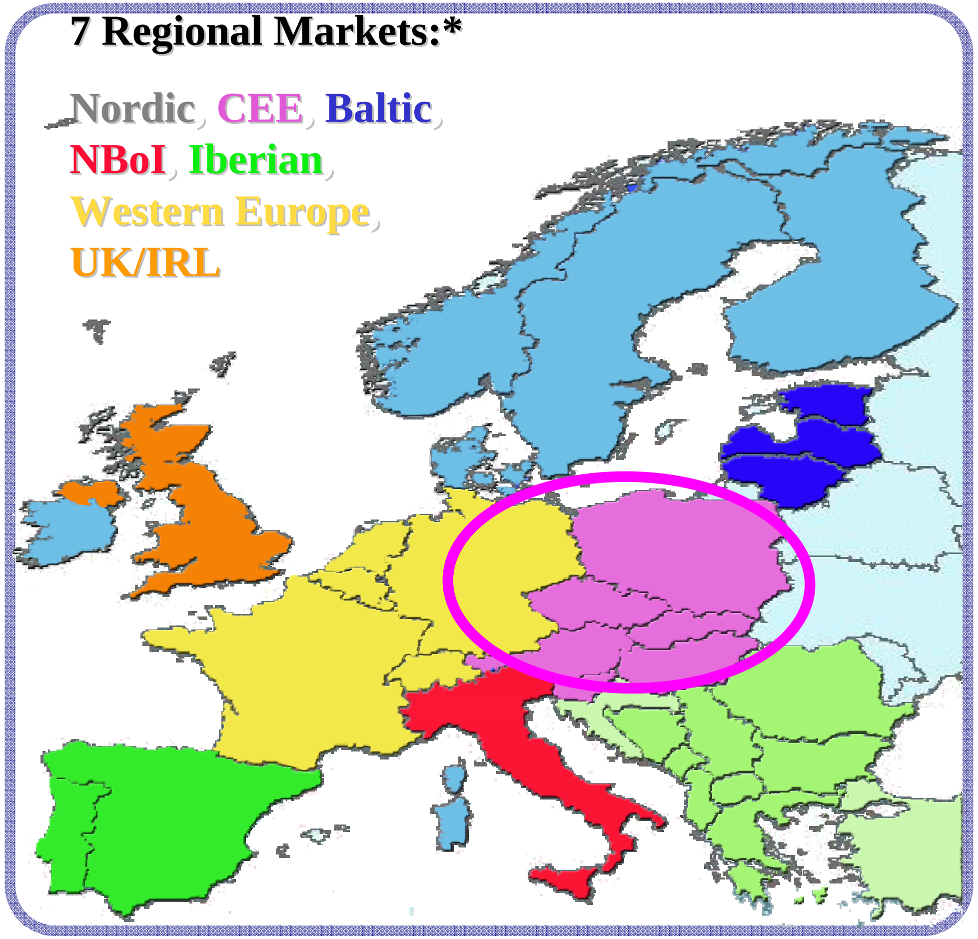
Situation in Europe: Politics



*) Schematic figure – some countries are in more than one regions

11th Florence Forum in 2004:

Establishment of <u>7 Mini Fora</u> in order to develop coordinated market systems on a regional level.

➔ **EU claims for introduction of flow-based allocation systems (Guidelines for Congestion Management).**

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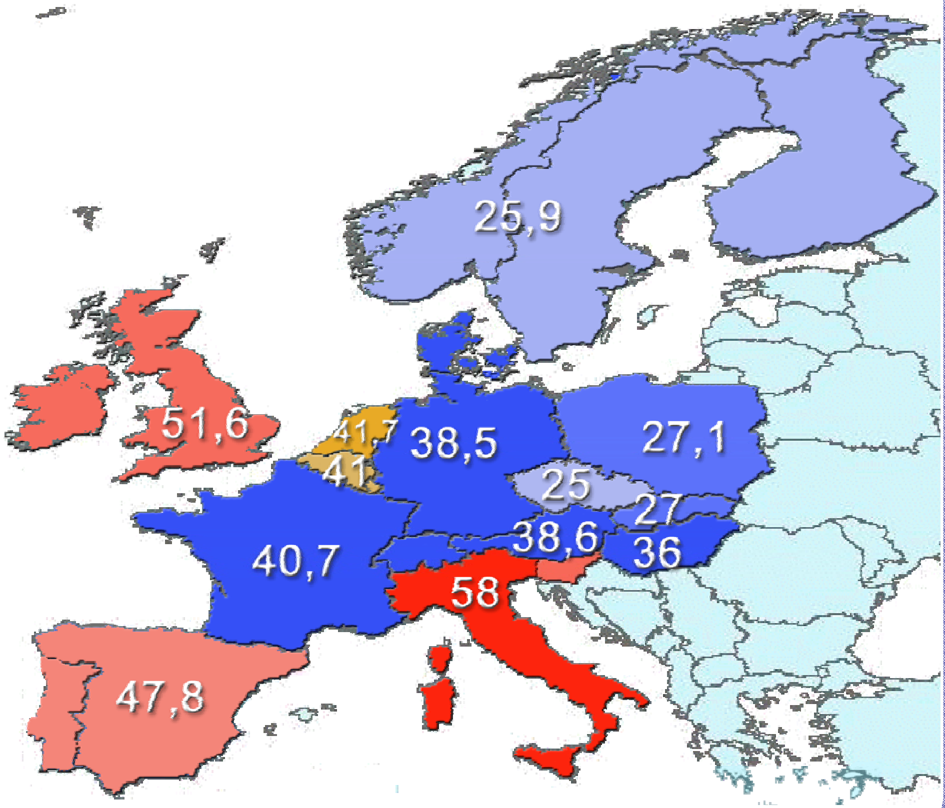
Situation in Europe: Energy Prices

Energy prices in €/MWh

1st Quarter 2005*



Price differences in Europe:

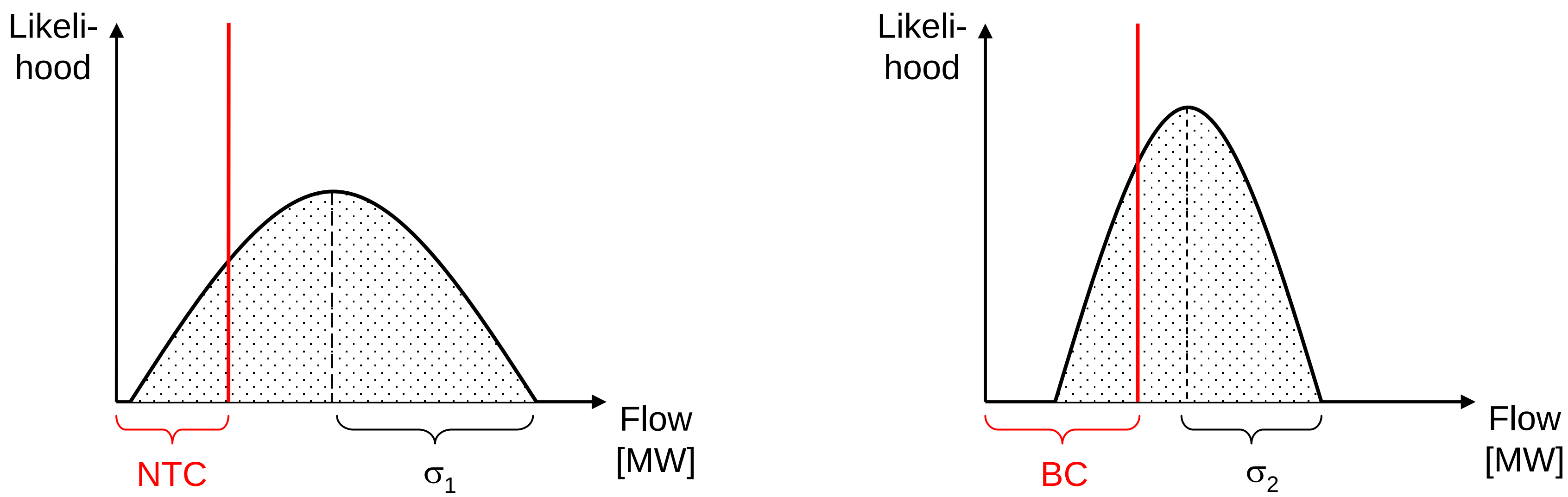
The driving force of interregional trading activities.

- **High demand in Southern Europe (mainly Italy)**
- **Generation surplus in Northern Europe**

➔ **Economic incentive to 'transport' energy from North to South**

*) average base prices

Situation in Europe: Technical Requirements



Expected advantage of flow-based methods: Variance s of occurring physical flows to expected flows decreases ($\sigma_2 < \sigma_1$)

→ BC for the same connection higher than NTC (BC > NTC) as the reliability is still guaranteed at higher offered capacity

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Targets

Conclusion from the current situation in Europe:

- **The introduction of flow-based explicit auctions is a purposeful first step towards the right (flow-based and market based) direction**
- **Targets that have to be defined and incentivized through income distribution**
  - Efficient resource utilization.
  - Create a stability of auction incomes and a relative continuity of income for TSOs compared to currently applied methods – for a transition period.
  - Allocating income according to right scarcity signals in order to indicate the necessity of network investments at the right location.

Example Rating Criterion Resource Utilization

Observation	Rating
Revenue/Revenue share always increase while increasing BC	++
Revenue/Revenue share mainly increase while increasing BC	+
Revenue/Revenue stagnate while increasing BC	**o**
Revenue/Revenue decrease and stagnate while increasing BC	**-**
Revenue/Revenue decrease while increasing BC	**--**

Hypothesis and Methodology

- **Hypothesis: Auction income allocation methods proposed by ETSO (2001) send wrong incentives**
- **Aim: Finding an allocation method that is in accordance to the consensus**
- **Software GAMS: Linear optimization problem**
- **Analysis**
  - Procedure: Stepwise Changing BCs ceteris paribus for a border
  - Then (re)calculating the auction incomes (absolute and shares) per TSO as well as the total auction income (TAI)

→ **Maximizing auction income per TSO by changing BCs**

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Mathematical Formulation

$$\max\{\sum_{X,Y,B}[p_{bid}(x,y,b)*d(x,y,b)]\};$$

s. t.

$$\sum_{X,Y}\{r(x,y,j,k)*\sum_{B}[d_a(x,y,b)]\} \geq BC\_R(j,k);$$

$$\sum_{X,Y}\{r(x,y,j,k)*\sum_{B}[d_a(x,y,b)]\} \leq BC\_F(j,k);$$

$$d_a(x,y,b) \geq 0;$$

$$d_a(x,y,b) \leq d_{bid}(x,y,b);$$

Where:

b = bid within the auction

j = zone as source of a line

k = zone as sink of a line

x = zone as source of a bid

y = zone as sink of a bid

d_a(x,y,b) = accepted quantity per bid

d_{bid}(x,y,b) = demanded quantity per bid

p_{bid}(x,y,b) = bid price per bid

r(x,y,j,k)= element of the PTDF matrix (zone-to-zone notation)

BC(j,k) = (Available) Border Capacity

Data

Source: Own illustration.

- **Physics represented by PTDFs**
  - Empty grid model for the region
- **Zonal Model**
  - CEE: Eight zones, 11 Lines
- **Bid structure**
  - CEE: ~1500 bids based on the bids for the yearly coordinated NTC auction and bilateral NTC auctions in the CEE region of 2005
- **Values for BCs: NTCs for 2005**
- **Values for CBCs: TPs for 2005 (+ own estimations)**

Analysis

• Combined Border Capacities (CBCs)

A CBC (also ‘Technical Profile’) pools several borders and defines a sum BC for all of them, i.e. all flows leaving a zone (zone_out).

• Considered cases

	Excluding CBCs	Including CBCs
With netting	**Case 1**	**Case 2**
Without netting	**Case3**	**Case 4**

•Income allocation can be done according to different reference measures: *Next slides*

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Income Allocation Methods I

- **ETSO1**

The sum of all shadow prices is calculated. Then, the individual share of a lines SP in respect to the sum of SPs is determined. The income is allocated according to these shares and equally distributed to the TSOs ‘owning’ the tie-line

$$Share_{ETSO1}(x) = \sum_{B,Y}[p_a(x,y) * d_a(x,y,b)] / TAR$$

- **SP = Shadow Prices (ETSO2)**

The sum of all shadow prices is calculated. Then, the individual share of a lines SP in respect to the sum of SPs is determined. The income is allocated according to these shares and equally distributed to the TSOs ‘owning’ the tie-line

$$Share_{ETSO2}(j) = \sum_{K}\{MP(j,k) / \sum_{J,K}[MP(j,k)]\}$$

- **AF = Absolute Flow**

Calculating the share of a line flow in respect to the sum of all line-flows. Then, allocating the income according to these shares and then in equally to the TSOs owning the line

$$Share_{AF}(j) = \sum_{K}\{[ABF(j,k)] / \sum_{J,K}[ABF(j,k)]\}$$

Income Allocation Methods II

- **CP = Clearing Price**

Calculating the clearing price for each line based on the shadow prices of congested lines. The sum of clearing prices is calculated. Then, the individual share of a lines CP in respect to the sum of CPs is determined. The income is allocated according to these shares and equally distributed to the TSOs ‘owning’ the tie-line

$$Share_{CP}(j) = \sum_K \{[|CP(j,k)| * |ABF(j,k)|] / \sum_{J,K} [|CP(j,k)| * |ABF(j,k)|]\}$$

- **RF = Relative Flow**

Calculating the ratio of line flow to border capacity. This yields the relative line usage. Then, summing up all line usages and calculating the share of individual line usage in respect to the sum of line usages. The income is allocated according to these shares and equally distributed to the TSOs ‘owning’ the tie-line

$$Share_{RF}(j) = \sum_K \{[ABF(j,k) / BC(j,k)] / \sum_{J,K} [ABF(j,k) / BC(j,k)]\}$$

- **TU = Thermal Usage**

Calculating the ratio of line flow to thermal limit. This yields the thermal limit usage. Then, summing up all thermal limit usages and calculating the share of individual thermal limit usage in respect to the sum of usages. The income is allocated according to these shares and equally distributed to the TSOs ‘owning’ the tie-line

$$Share_{TU}(j) = \sum_K \{[ABF(j,k) / TL(j,k)] / \sum_{J,K} [ABF(j,k) / TL(j,k)]\}$$

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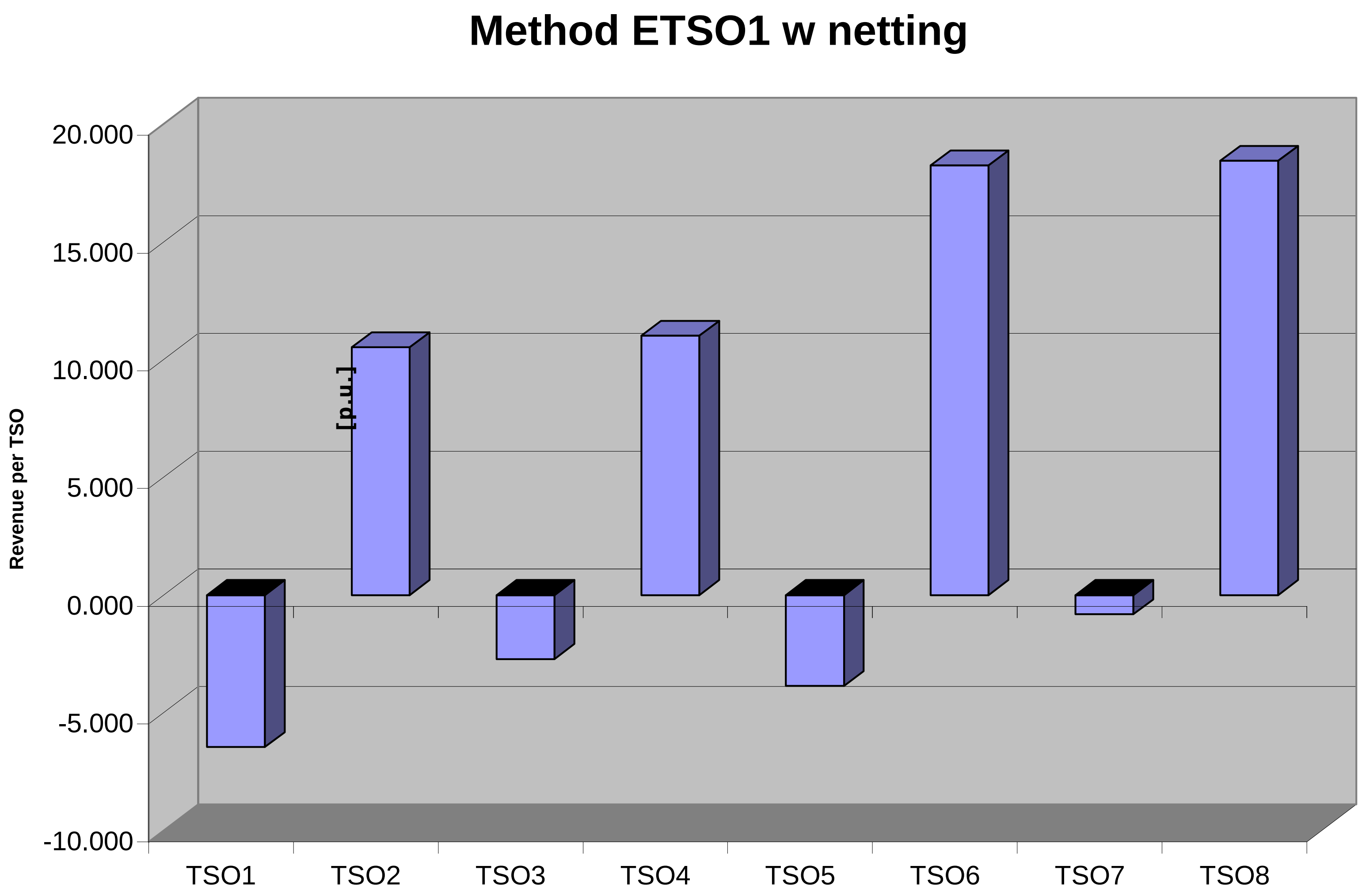
Results: Example ETSO1 TSO2-TSO1 50 MW



Results: Rating ETSO Methods

Criterion	Rating			
	Case 1	**Case 2**	**Case 3**	**Case 4**
Resource utilization incentives	+	-	+	-
Network investments	--			
Stability of revenues	+	+	--	--
Continuity with current revenues	-	-	++	**o**

ETSO1

- The rating for ETSO1 is alternating.

Criterion	Rating			
	Case 1	**Case 2**	**Case 3**	**Case 4**
Resource utilization incentives	+	-	--	--
Network investments	**o**			
Stability of revenues	+	+	--	-
Continuity with current revenues	**o**	**o**	--	--

ETSO2

- Surprisingly acceptable rating for Case 1
- Incentives to reduce BCs
- Indicate where investments are most urgent

Results: Resource Utilization

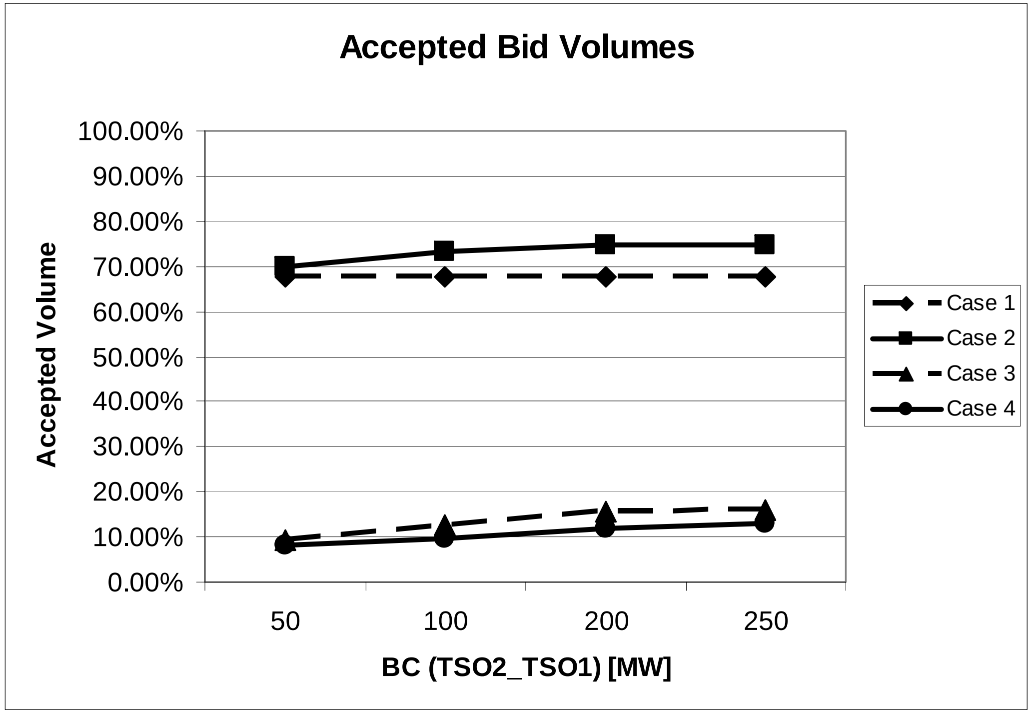
Method	Rating			
	Case 1	Case 2	Case 3	Case 4
AF	+	o	+	o
CP	+	o	o	--
RF	-	--	--	--
TU	+	+	--	o

Here, for example, it becomes evident that only method AF delivers acceptable results for all cases

Results: Network Investments

Method	Rating
AF	+
CP	+
RF	--
TU	-

Results: Accepted Bid Volumes



Accepted bid volumes per case

Ratio per accepted bid volume (RPV) indicates which case is most efficient.

→ Case1 > Case2 > Case3 > Case4

		BC (TSO2_TSO1) [MW]			
		50	**100**	**200**	**250**
RPV [per unit]	**Case 1**	65.64	65.64	65.64	65.64
	Case 2	74.06	74.71	74.51	74.51
	Case 3	304.12	328.79	340.37	332.29
	Case 4	425.21	491.95	458.81	390.77

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Conclusions

• Methods proposed by ETSO do not generate efficient incentives

• An allocation according “only” to the economic “right” method (shadow prices) sends false incentives signals

• In order to fulfill consensus an allocation according to accepted bid flows (flows resulting from accepted bids) seems favorable

• Market constraints in form of CBCs (or wo netting) result in a loss of efficiency

• Netting is economically much more efficient than without netting (note: network security issues are ignored.)

• The rating for the different methods differs with the considered cases → Policymakers are asked to define the acceptable framework.

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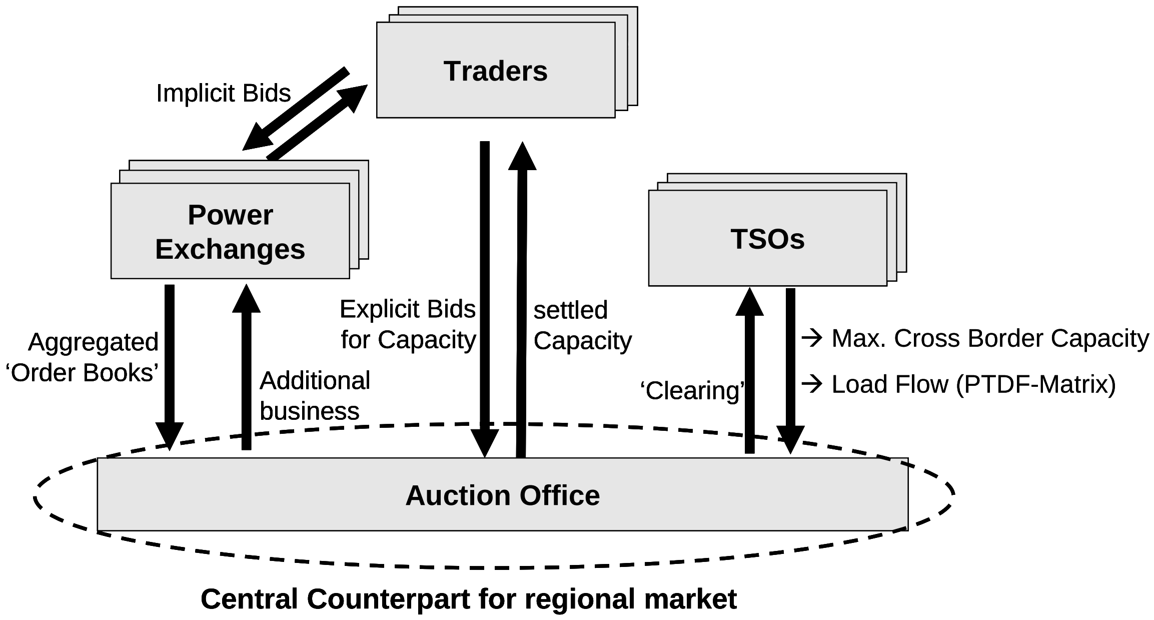
Developments

- From FBCA to hybrid auctions, e.g. open market coupling



Source: EEX, 2005; own illustration.

- Obligations vs options
- Physical vs financial transmission rights (FTRs)

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