EuroPEX
Association of European
Power Exchanges

Using Implicit Auctions to Manage Cross-Border Congestion:

'Decentralised Market Coupling'

Paper by EuroPEX

Tenth Meeting of the European Electricity Regulatory Forum

8 July 2003

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1. The association of European Power Exchanges, EuroPEX, has been asked to present its views on methods for managing cross-border congestion. The last Florence Forum on the European electricity market supported five basic principles proposed by CEER concerning the allocation of interconnector capacities as a basis for a possible future revision of the guidelines on congestion management. This paper describes a new approach developed by EuroPEX called 'Decentralised Market Coupling' that is based on the concept of implicit auctions and is designed to deliver on these principles.

Implicit auctions preferred

2. EuroPEX believes that the design of the spot (i.e., day-ahead and intraday) trading arrangements for energy and use of the horizontal network are a critical issue in the development of a successful European energy market. Liquid, robust spot markets provide the price transparency that is essential for improving market access, promoting the development of forward markets and enabling competition to flourish.

3. EuroPEX fully supports the emerging preference amongst traders, regulators and TSOs for the use of implicit auctions that simultaneously trade energy and the use of transmission capacity. This is an approach that has proven to be very successful in Scandinavia and has contributed to the successful development of that market. Combining capacity and energy removes the risks of trading one before the other, while energy auctions have now established themselves across Europe as the preferred method for spot trading.

4. In implicit auctions all accepted bids and offers become firm commitments by the participants. This enables the efficient netting of cross-border flows.

5. EuroPEX also supports the continuation of short-term bilateral cross-border trading. This leads to a requirement for an efficient and fair cross-border congestion management mechanism that can embrace both bilaterals and exchange based energy trading.

6. Implicit auctions are capable of supporting bilateral trading. Both ETSO and EuroPEX have both previously described this approach to the Forum. Appendix 1 describes the basic implicit auction model comprising two countries and simple hourly bids.

Practical barriers

7. There are, however, several practical barriers to applying implicit auctions across Europe. The basic model assumes simple hourly bids in each market, but in reality it is more complex. Between countries there is a wide diversity of physical arrangements (e.g., notification and balancing arrangements, transmission pricing, half hour or hourly

metering) and exchange trading arrangements (e.g., block bids, intraday markets, matching rules).

8. Possibly these arrangements could be harmonised, but at the very least this is likely to take a long time. In many cases the differences may represent an efficient response to the different physical systems in each area. For example, block bids are necessities in a number of regions due to participants' needs and the production or consumption mix. They can enhance the liquidity and trustworthiness of spot prices - but they substantially complicate the basic model.

9. When the basic model is extended to several countries it becomes even more complicated due to loop flows. In theory, a Europe-wide optimisation is conceivable using a linear programme (as, for example, in PJM or ETSO's Coordinated Auction). However, these approaches imply a centralised, pan-European market and system operator, which is probably a distant prospect given the current status. Furthermore, it is very difficult to simultaneously resolve loop flows and incorporate block bids and local market rules in a single, massive, central optimisation algorithm.

Decentralised Market Coupling

10. EuroPEX believes that a *decentralised* implicit auction approach is able to deliver an efficient outcome incorporating loop flows, bilaterals, block bids, and counterflows, and all in a way that is very flexible and easy to develop progressively over time. It is possible to start with a simple coupling of certain markets, and then further markets can be linked in later. In addition, the sophistication of the coupling can be increased as experience builds. The approach does not require harmonisation across markets, but mutually beneficial standards and arrangements can emerge over time. EuroPEX's approach also has the flexibility to accommodate transitional arrangements to tackle such issues as historical long-term contracts.

11. In EuroPEX's version of implicit auctions, called *Decentralised Market Coupling (DMC)*, all physical cross-border capacity is made available at the day-ahead/within-day stage; there are no forward transmission access rights. This enables the optimisation of the physical network, while forward price risk can be managed through financial contracts.

12. The physical capacity would be made available through the power exchanges who would seek to optimise the use of that capacity through the matching between themselves of bids and offers in their respective markets. Bids to execute a bilateral cross-border contract would also be handled via the power exchanges, with a bilateral being scheduled whenever its bid (including negative bids for counterflows) was more than the price difference between the markets. A participant scheduling a bilateral would pay the difference in area prices across the interconnector (or receive this price if the flow is counter to the congestion).

13. Rather than require a large central optimisation algorithm, DMC would deal with the most complex situations (in particular, loop flows and block bids) through a number of

iterations between power exchanges. In less complex situations (such as isolated regions, no loop flows, or no block bids) it is possible to use simplified methodologies, such as a sequential process from one market to the next.

Iterative solution

14. For each iteration, the exchanges share with each other their 'net export curves' that represent the resultant net export (long) or import (short) volume arising from their domestic bids and offers, depending on the market price. Individual net export curves are calculated according to the rules in each market. Then the cross-border flows and area prices are calculated using an algorithm (for example, a linear programme) that seeks to reduce price differences by maximising usage of the available cross-border capacity (it would maximise the bid-offer surplus). Bids to execute bilateral contracts would also be included, as in the basic two-country model.

15. More than one iteration will be required to produce a satisfactory result – in particular, one that satisfies block bid constraints. It would be the exchanges' responsibility to ensure that no bidder paid more than he bid or a seller received less than he offered and that any block bid constraints were met.

16. The model can take into account loop flows by using actual line capacities and power transfer distribution factors (PTDFs) provided by the TSOs. Modelling the system in this way removes from the TSOs much of the risk of committing to firm ATC values before they know the likely power flows. However, in situations where loop flows are relatively insignificant it is simpler to use only ATC values.

17. Under either approach, the TSOs would need to make appropriate allowance for subsequent, unplanned events ('contingency-constrained dispatch'). However, often such unplanned events can be efficiently resolved in intraday (or 'adjustment') markets. Such markets could operate on broadly similar lines to the day-ahead market. In order to prevent a reduction in liquidity, EuroPEX does not support the idea that some interconnector capacity should be deliberately held back for the intraday markets.

18. Appendix 2 illustrates the possible processes and procedures. This is not intended to be definitive, but to show how it could operate.

19. For some regions of the network it may be possible to resolve interconnector flows through a sequential process of solving one market at a time. This could be simpler to implement, and would reduce the size and complexity of the iterative DMC model for the rest of the system. Suitable regions would need to be simple linear or radial clusters that are isolated from the rest of the system by DC lines or permanently congested interconnectors.

20. The exchanges would be responsible for notifying to the TSOs all the commitments that they have made on behalf of their participants. Where a participant fails to generate or consume as contracted, they would be exposed to their local imbalance arrangements.

This approach enables the netting of contracts in opposite directions across a congested interconnector.

21. To maximise transparency, the method by which the prices and volumes transacted at each border are calculated would be set out in published rules and procedures. These rules and procedures would need to be auditable to give assurance to all market participants. In addition, the exchanges, together with their participants and the regulators, would continually review and seek to improve the arrangements.

22. DMC, like any other methodology, will result in financial surpluses when there is congestion. These will be clearly identifiable and verifiable. It is for others to determine how these surpluses are used.

Forward contracting

23. Hedging long-term cross-border trade should be done through financial contracts settled against the day-ahead cross-area prices. There may be a role for both CfDs ('Contracts for Difference') and FTRs ('Financial Transmission Rights'), as appropriate (see Appendix 3). Key to this is the emergence, from the DMC, of robust day-ahead reference prices.

24. At present, however, there is extensive auctioning of forward physical transmission access rights. EuroPEX believes that all physical capacity should be managed in the day-ahead arrangements. Existing explicit auctions for forward capacity rights should be phased out as quickly as possible.

25. Under DMC, owners of long-term capacity rights will have the option of scheduling a countertrade (thereby increasing the 'available' capacity on a congested interconnector) and receiving back any congestion price. However, historical long-term contracts could be converted into financial transmission rights, thereby freeing up the capacity for all of the market while at the same time preserving the commercial interests of the initial contract parties.

Making it happen

26. To date there has been considerable discussion on the theoretical models for allocating capacity, but EuroPEX also recognises the practical issues that must be addressed. Power Exchanges are uniquely positioned to enable the rapid implementation of solutions that meet the needs of traders, TSOs, EU authorities and regulators alike. All market participants have access to the exchanges; there are collateral and settlement arrangements in place; and the exchanges have special regulatory, governance and market surveillance structures that ensure fairness, transparency and openness.

27. Implementation can begin with one or more pilots, which can then be enlarged. For example, a number of markets could be coupled initially on a simple, two-country basis using ATCs and solved sequentially. As clusters of adjacent markets come together, the

method can evolve: loop flows can be addressed more efficiently using PTDFs and multiple iterations between power exchanges can be introduced.

28. There are, however, a number of essential issues that need addressing for the Decentralised Market Coupling method to be implemented.

    - Appropriate regulatory arrangements are needed to ensure that the maximum level of capacity is made available by the TSOs. The capacity made available to the exchanges in the day-ahead process needs to be firm, with the TSOs responsible for managing any redispatch in the event of capacity having to be withdrawn. An alternative approach of indicative capacities that are only confirmed in a second step ('soft ATCs') is not supported: it is more complex and lacks transparency, and it would delay the publication of the market prices and accepted orders, creating uncertainty for participants.
    - In order to incorporate loop flows in the methodology, the affected TSOs would need to publish daily a network capacity model and set of PTDFs that could be used by the market.
    - Basic qualifying criteria for power exchanges to be responsible for managing cross-border flows in the manner described need to be defined, and each exchange needs to demonstrate its compliance. This could include aspects such as membership requirements, disputes procedures, market surveillance procedures, publishing requirements, and audit.
    - The methodology needs to be confirmed and fine tuned, and it is likely that computer modelling and simulation work will be useful.
    - Initial pilots need to be agreed and detailed work undertaken to define the matching rules and procedures in each. The resulting rules may require the exchanges to modify their existing arrangements – e.g., to adopt harmonised times for receiving bids and publishing results. Possibly this rule making process could be overseen by a regional group comprising the affected regulators, TSOs, power exchanges and participant representatives. The same group could monitor the arrangements once implemented, and agree any subsequent modifications. These organisations need to be properly established.

EuroPEX
Association of European Power Exchanges

About EuroPEX

EuroPEX was first formed as a regional group within the worldwide Association of Power Exchanges (APEx). In 2002 it was reformed as the Association of European Power Exchange Operators, *EuroPEX A.S.B.L.*, which is a non profit legal entity.

The objectives of EuroPEX are:

- to promote the role of power exchanges as a way of increasing competition by creating price transparency and implementing the European single electricity market
- to support the liberalisation of the different European electricity systems
- to deal with the issue of international trading with special emphasis on providing a market solution to congestion problems
- to increase co-operation between European power exchanges and to promote free trading

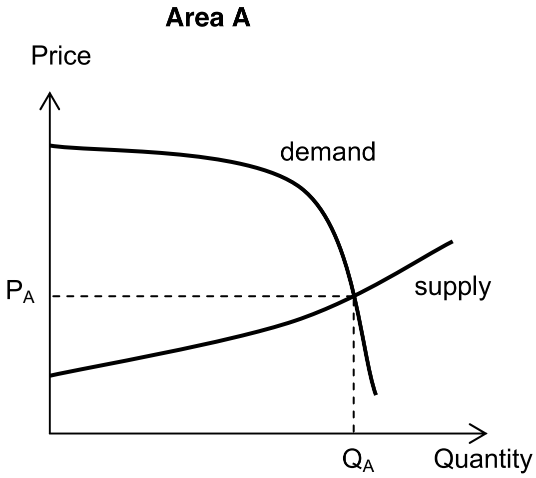
Active members of EuroPEX must operate a power exchange. Current members are:

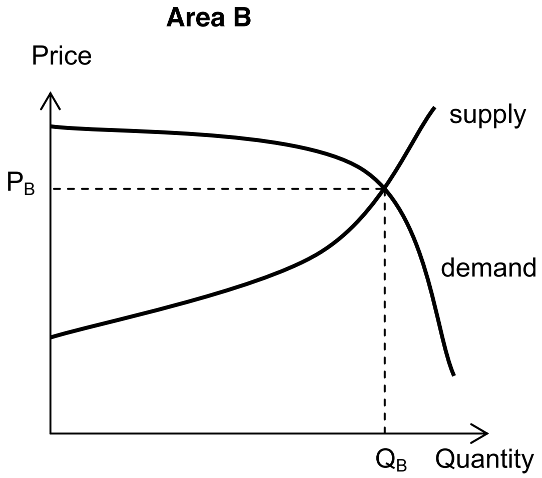
Amsterdam Power Exchange Spotmarket B.V.	The Netherlands
APX Amsterdam Power Exchange (UK) Limited	United Kingdom
Borzen, Organizator Trga z Elektricno Energijo, d.o.o.	Slovenia
Compañia Operadora del Mercado Español de Electricidad SA	Spain
European Energy Exchange	Germany
Gestore del Mercato Elettrico S.p.a.	Italy
Nord Pool ASA	Denmark, Finland, Norway and Sweden
Opcom S.A.	Romania
Powernext S.A.	France

Appendix 1
Implicit Auctions: Basic Two-Country Model

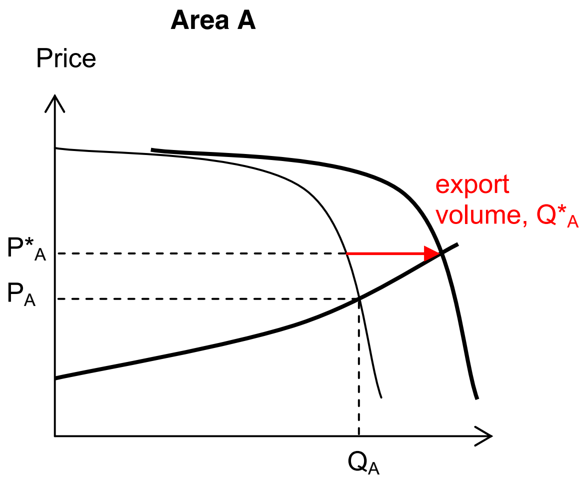
1. The basic model assumes two areas (e.g., countries), A and B, connected by a single transmission line. Each area has a power exchange that operates a day-ahead energy auction for hourly contracts (there are no multiperiod block bids).

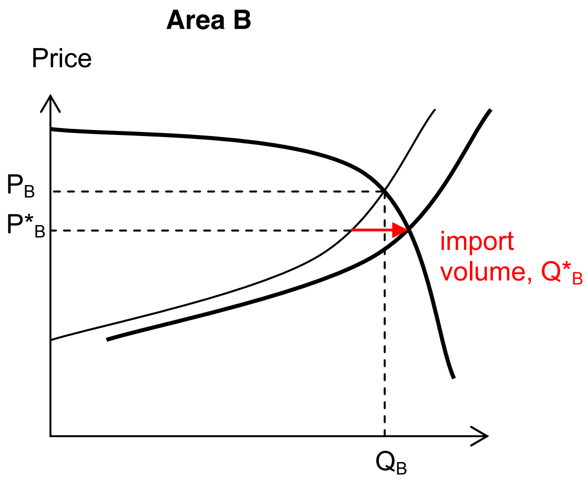
2. Bids and offers in the day-ahead market are stacked, and the isolated system (i.e., with no cross-border transfers) clearing price, P and volume, Q can be found for each hourly period in both markets.



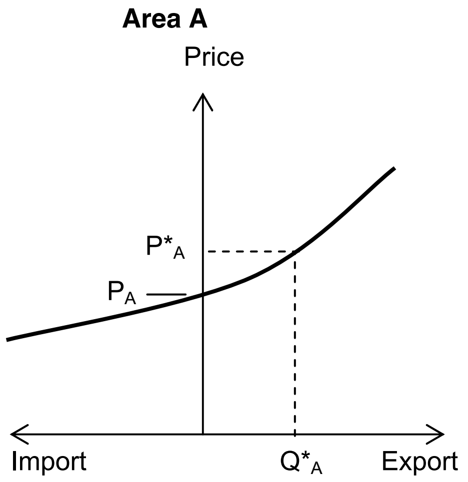


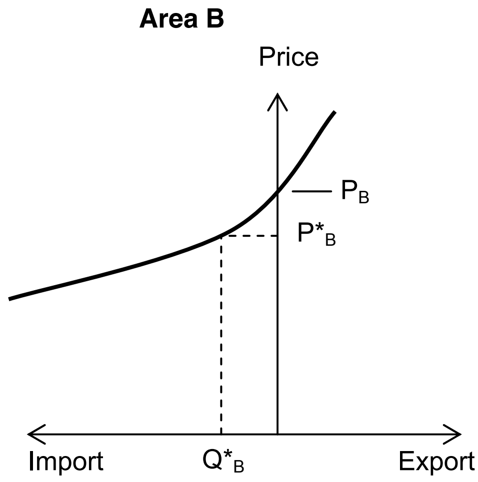
3. The price impact of exporting from an area (i.e., the exchange being net long) can found by treating the export as additional demand in that area. The impact of importing can be found by increasing supply.



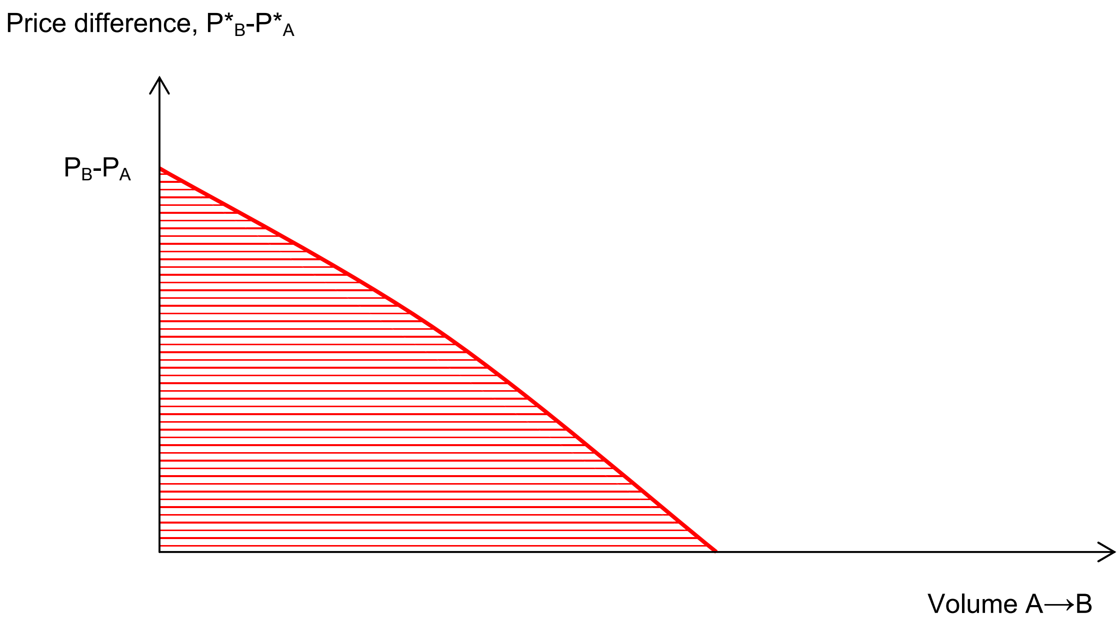


4. A 'net export curve' can be calculated for each market which shows the relationship between market price, P* and net export (or import) volume, Q*. (When there is no export or import, the area price is the isolated system clearing price, P).

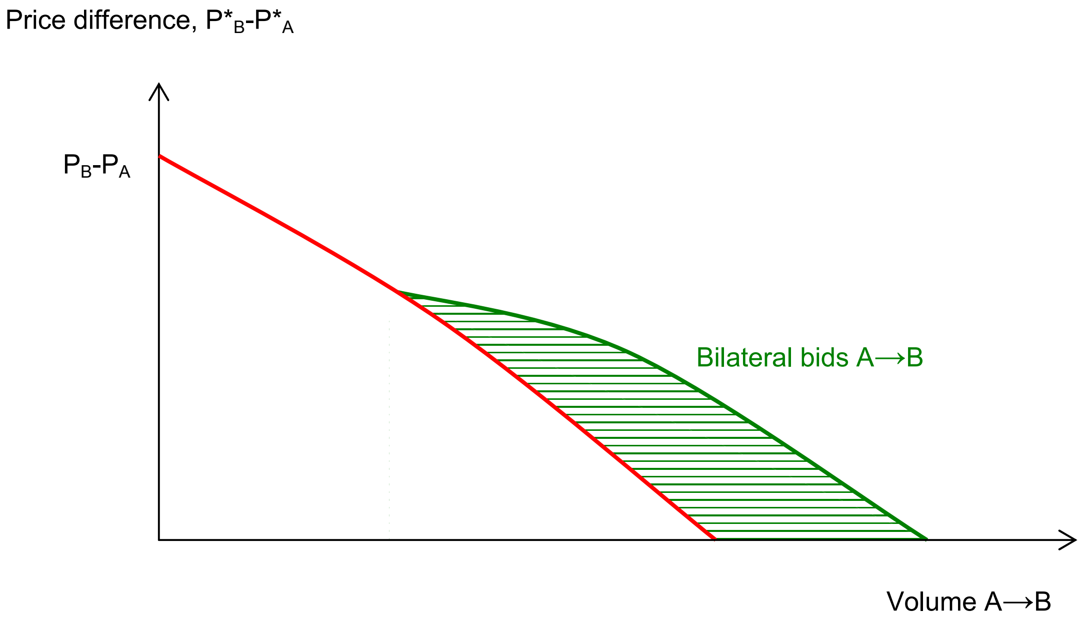




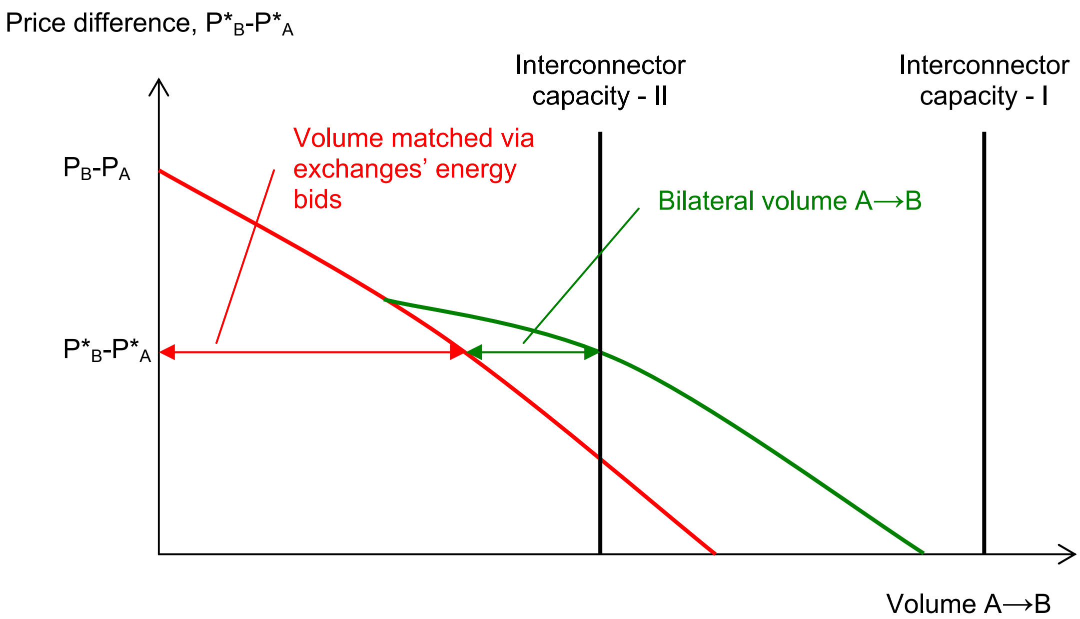
5. The two net export curves can be combined to show the relationship between the volume transferred between markets (in this example, export from area A and import into area B, where $Q^*_A = Q^*_B$) and the price difference between the markets (P^*_B - P^*_A). This is, in effect, a transmission demand curve.



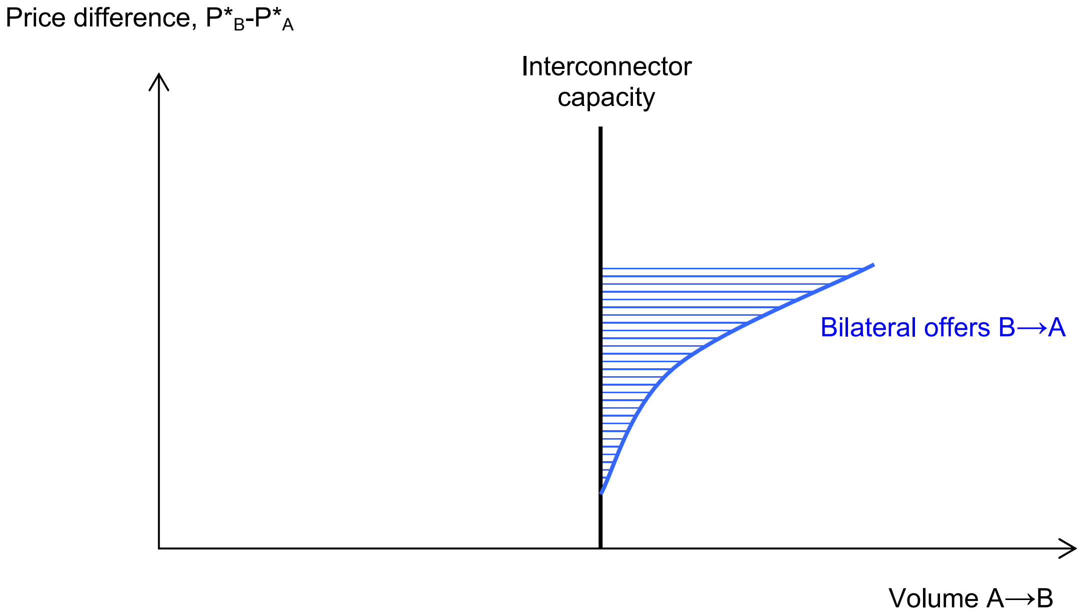
6. Bilaterals can also indicate a price they are willing to pay to be scheduled in the direction A→B. Their bids, which could be submitted to either power exchange, are combined and added to the transmission demand curve from the exchanges' energy markets.



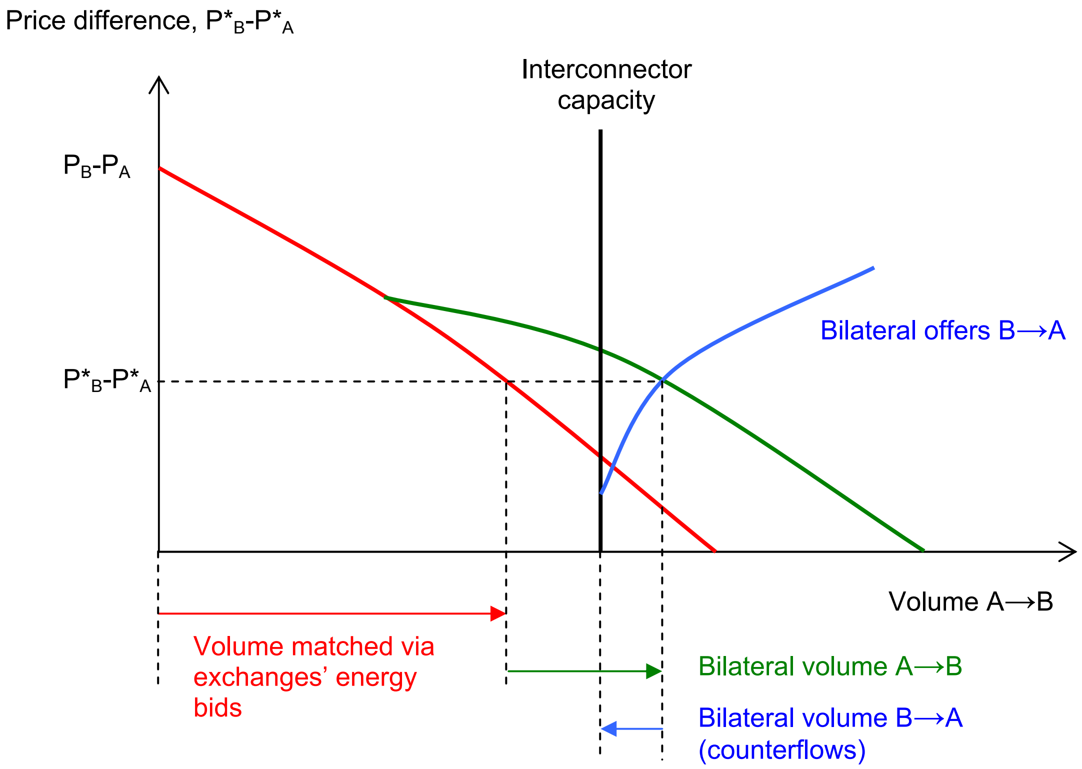
7. If there is sufficient capacity to meet all the demand, then the interconnector is uncongested, the area prices are the same and there is no cost to execute the bilaterals (situation I). If there is insufficient capacity (situation II), the interconnector is congested, the area prices are different, and bilaterals flowing A→B pay the price difference (P^*_B-P^*_A). In effect, they pay P^*_B to buy in area B and receive P^*_A selling in area A.



8. Lastly, bilaterals wishing to flow in the opposite direction, relieving the congestion, can offer a price at which they are willing to be scheduled. Where a party owns forward physical rights these can be offered into the implicit auction in exactly the same way.



9. This reduces the price difference between markets and increases the overall volume of trade. In effect, counterflows receive P^*_B selling in area B and pay P^*_A buying in area A.



Appendix 2
Decentralised Market Coupling: Illustration

1. (D-2) TSOs publish firm interconnector capacities and the firm PTDF matrix (or just ATCs where appropriate) for delivery day D, covering the areas in the DMC region.

2. (D-1) Participants submit bids and offers into each power exchange's energy market by a common deadline. Bids to schedule bilaterals and offers to schedule counterflow bilaterals (or to sell back forward physical rights) are submitted to the power exchanges by the same deadline.

3. To be used as an initial point in the iterations, the power exchanges in the DMC region predict the likely cross-border flows based on historical patterns and any known, material changes to likely load, generation or transmission.

4. Using the bids and offers in its energy market and the assumed cross-border flows (from step 2 initially, then step 6 for subsequent iterations), each exchange separately calculates the hourly prices in its market according to its rules (including any block bid constraints) and its own methodologies. In addition, each exchange produces a 'net export curve' (see Appendix 1) that shows how the aggregate import/export volume in each hourly period would vary depending on the market price in its area.

   Note: the net export curves are 'simple' - i.e., they do not specify any intertemporal block bid constraints. Where an exchange allows block bids from its participants the hourly net export curve will reflect these constraints. Indeed, this is an advantage of the decentralised approach because it is very difficult to incorporate these various forms of block constraints in a centralised model. The individual power exchanges are best able to solve these bid constraints.

5. Each exchange shares with all others their net export curves and bilateral bids (and offers for counterflow bilaterals).

6. Each exchange calculates a revised set of area prices and cross-border flows that seeks to maximise usage of the available network and ensure that all possible beneficial trades are contracted.

7. Steps 4, 5 and 6 are repeated using the revised cross-border flows resulting from step 6. Iterations would continue until the materiality of change each time is below an agreed level, or a maximum number of iterations are reached.

8. Each exchange publishes prices and informs participants and bilaterals of the volume contracted/to be scheduled.

9. Each exchange is responsible for notifying all the commitments (including cross-border bilaterals) to their local TSO.

10. Each exchange is responsible for settlement, including cross-border bilaterals - which for this purpose are treated as buying from the exchange in the import area and selling to the exchange in the export area.

11. Participants failing to generate or consume according to their notified positions in an area are subject to the imbalance arrangements in that area.

Appendix 3
Financial Products

1. Financial products are useful tools to manage future price uncertainty, including the impact of interconnector congestion - making it possible to fulfil long-term cross-border contracts. They can also be used to give a market-based indication of the benefits of system reinforcement and offer a way to terminate historical long-term cross-border contracts.

2. The main effect of congestion in the transmission grid is the existence of different prices either sided of the congestion. Cross-border trades need assured transmission access, but in EuroPEX's DMC model physical delivery can only be acquired day-ahead by the paying of the price difference (if any) across the congested border on an hourly basis. There are two basic forms of financial product to handle the forward price risk of this cost: contract for differences (CfDs) and financial transmission rights (FTRs). (Volume risk – i.e., the risk that sufficient capacity is available – is minimised because all physical capacity is made available day-ahead and netting of counterflows is maximised).

3. A contract for difference means that two counterparties voluntarily agree an equalization payment between themselves that converts future exposure to a variable price into a fixed price. An example: G is a generator in country A with a 50MW contract in country B for 2004. G agrees with a trader, T a CfD for 50MW with a strike price of €3/MWh for flows from country A to B for 2004. For each hour throughout 2004 the following applies:

   - either, G receives from T €(ΔP-3) x 50/h when the hourly congestion price from A to B, ΔP, is greater than the CfD strike price;

   - or, G pays T €(3-ΔP) x 50/h when the hourly congestion price, ΔP, is less than the CfD strike price.

4. As a result, G always pays a net cost of €3/MWh for delivery into country B, irrespective of the hourly prices for access coming from the spot market. With this hedge, G can bid a maximum price for bilateral capacity in the day-ahead auction to be sure of being scheduled.

5. A CfD is a purely financial contract that places no physical obligations on either party. When combined together with other hedging instruments (for example futures) participants are able to fully hedge their risk of price movement in one country by reference to another. CfDs may be exchange traded, like at Nord Pool, or traded bilaterally (OTC).

6. A financial transmission right (FTR) is a right to the price difference across a congested line for a period of time (it is equivalent to a CfD with a strike of €0/MWh). Where there is an expectation that the line may be congested at some time, the FTR will have a value.

7. Like CfDs, FTRs are purely financial and do not impose any physical obligations.

8. A long-term physical contract can readily be converted into a FTR and the physical capacity released into the DMC day-ahead auction. The owner of the long-term contract can still replicate the original contract by bidding to acquire capacity in the DMC auction, being fully compensated by the FTR for any price he has to pay.