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Market failures of Market Coupling and counter-trading in Europe: An illustrative model based discussion

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ABSTRACT

The horizontal integration of the energy market and the organization of transmission services remain two open issues in the restructured European electricity sector. The coupling of the French, Belgian and Dutch electricity markets (the trilateral market) in November 2006 was a real success. The extension of the system to Germany in November 2010 also proceeded smoothly and the intent is to continue with the same market architecture. But Market Coupling is based on a zonal system which has often failed in meshed grids. This may cast doubts on what will happen in the future when electricity demand picks up again and wind develops. The nodal system has generally been more successful than zonal architectures but its implementation is not currently foreseen in the EU.

This paper analyzes versions of Market Coupling that differ by the organization of counter-trading. While underplayed in current discussions, counter-trading could become a key element of Market Coupling as its geographic coverage expands and wind penetrates. We simplify matters by assuming away strategic behavior between the energy and counter-trading markets and conduct the analysis on a stylized six node example taken from the literature. We simulate Market Coupling for different assumptions of zonal decomposition and coordination of Transmission System Operators (TSOs). We show that these assumptions matter: even in the absence of strategic behavior, Market Coupling can be quite vulnerable to the particular situation on hand; counter-trading can work well or completely fail and it is not clear beforehand what will prevail. Our analysis relies on standard economic notions such as social welfare and Generalized Nash equilibrium, but the use of these notions is probably novel. The nodal organization is the reference first best scenario: different zonal decompositions and degrees of coordination are then studied with respect to this first best solution.

1. Introduction

Congestion management remains a controversial issue in the restructured European electricity sector. Congestion occurs when the infrastructure constrains transactions in the energy market. Grid congestion evolves with short and long term shifts in generation and consumption patterns and with the development of the grid. Methods of congestion management can be characterized by the integration of energy and transmission that they impose. This determines the extent to which one accounts for the possibilities of the grid when clearing the energy market. Nodal Pricing (see Hogan, 1995, 1998) controls the energy and transmission markets through a single entity and is thus the paradigm of the full integration of these two functions; this results in electricity prices that directly include congestion costs. From a technical point of view the integration of energy and transmission is achieved by solving a welfare maximization problem that involves both functions. With reference to European internal market discussions, the nodal system is the perfect implementation of the "implicit auction" that is becoming a reference option in European Cross Border trade (Article 12 paragraph 2 of Regulation No 714/2009 (European Commission, 2009). Nodal Pricing has now been implemented with success in many regions of the US and in New Zealand[1] (see Frontier Economics, 2009; Joskow, 2008; Sioshansi and Pfaffenberger, 2006).

Other architectures separate energy and transmission markets, with this separation taking different forms. Market Coupling considers both an energy market operated by Power Exchanges (PXs) and a transmission system controlled by Transmission System Operators (TSOs). The energy market is subdivided into price zones operated by different PXs. The market clears taking into account limited "transfer capacities" (TC) between zones. TSOs maintain the security of the different control areas of the grid and provide the PXs with the TC linking the price zones. It is also the duty of the TSOs to guarantee that the grid can

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[1] The nodal system was first first implemented in New Zealand in 1996 (see Bertram, 2006).

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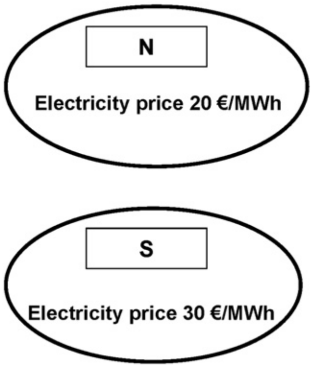

Fig. 1. Northern (N) and Southern (S) zones.

effectively accommodate the transactions resulting from the clearing of the energy market by the PXs.

This organization does not fully integrate the energy and transmission functions, but it creates explicit links between them. The energy market clears on the basis of TCs provided by the TSOs and the resulting power injections and withdrawals are communicated back to TSOs. If the transmission capacities provided by TSOs are small enough compared to the real possibilities of the grid, the energy market does not entail congestion. If not, grid lines are overloaded and TSOs have to restore grid feasibility by reshuffling power flows among energy market participants (producers/consumers). This is the so called counter-trading or re-dispatching function: it relies on increases and decreases of injections/withdrawals in order to restore grid feasibility. TSOs remunerate generators and consumers for these services and socialize these costs that are then charged back to the agents connected to the grid.

Market Coupling realizes a spatial arbitrage between different zones of the energy market. Even though electricity is not economically storable today except in hydro reservoirs, the characteristics of the machines also pose problems of inter-temporal arbitrage that will become increasingly important with the penetration of wind. This paper concentrates on spatial arbitrage and leave inter-temporal arbitrage for further research. The following elaborates the description of Market Coupling on the basis of Fig. 1.

Consider two markets North (*N*) and South (*S*) with supply and demand bids in each of them. Assume that there are two generators in *N*. Denote them as "gen1" and "gen2". Gen1 controls a 100 MWh[2] plant whose marginal cost is 5 €/MWh, while gen2 can at maximum run 400 MWh at a marginal cost of 20 €/MWh. Demand in the North is 200 MWh. There are two generators "gen3" and "gen4" in market *S*. Both generators have an available capacity of 300 MW, but gen3 has a marginal cost of 20 €/MWh, while gen4 operates at a marginal cost of 30 €/MWh. The electricity demand in *S* amounts to 600 MWh. Note that generation in *N* is cheaper than in *S*.

Consider first the equilibrium in each market taken in isolation as depicted in Fig. 1. The equilibrium price in market *S* is higher than the equilibrium price in market *N* as shown in Fig. 1. This creates an arbitrage opportunity between the two markets: electricity should move from *N* to *S*. Suppose now that the two markets are linked by a Transfer Capacity (TC) as depicted in Fig. 2. If this transfer capacity is large enough the usual arbitrage reasoning will imply a flow between the *N* and *S* markets that equalizes the prices in both markets: this is shown on Fig. 2a. If this transfer capacity is limited, the arbitrage will be limited to what the TC allows (in our case 250 MWh, as illustrated in Fig. 2b) and the electricity prices will be zonal.

This principle can be applied to more complex systems such as depicted in Fig. 3. Fig. 3a is a stylized version of the trilateral Market Coupling including France (F), Belgium (B) and the Netherlands (NL) that went live on 21 November 2006. Fig. 3b represents the extension of that market after the coupling with Germany (G) on 9 November 2010 (referred to as the pentalateral market as Luxembourg has part of its system integrated both with Germany and Belgium[3]).

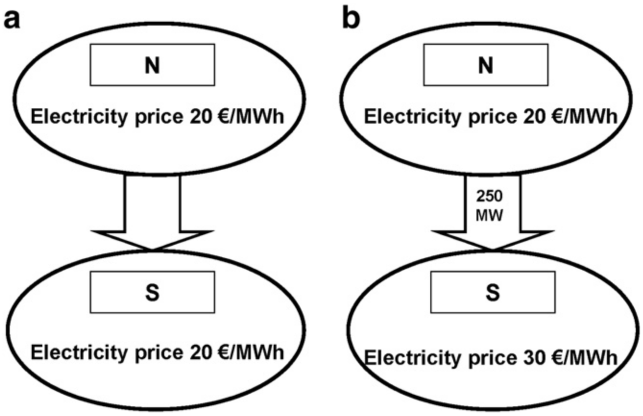

Fig. 2. Northern (N) and Southern (S) zones with TC.

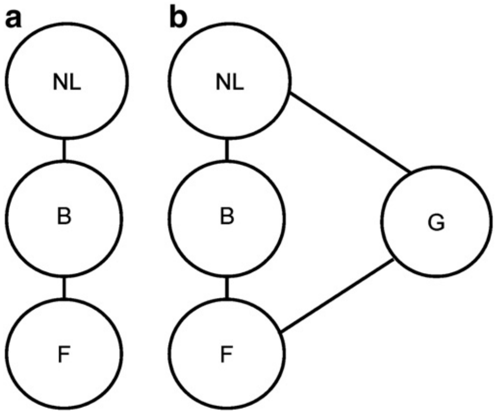

Fig. 3. Stylized representation of the Central Western European power market.

Leaving aside issues related to the representation of the characteristics of the generators such as block bids the questions raised by Market Coupling boil down to the definition of the price zones and the determination of the TCs linking them and more generally to whether electricity transmission can really be represented by TCs between zones. The relevance and importance of these questions is well acknowledged. Hogan (2005) quotes the US federal electricity regulator stating that transfer capacities are artificial constructs without economic or physical reality that were inherited from the regulatory period when trade was not a key concern. Less assertively, European Transmission System Operators cautiously advise that they do not guarantee the validity of the transmission capacities that they publish. Last but not least, one can observe that TSOs have postponed the publication of their method for computing transmission capacities for several years. At least we know some of the principles that they use (see Rious et al., 2008, for a detailed explanation) and will invoke them later in the discussion.

This paper addresses these questions on an example. It is organized as follows. Section 2 gives a brief history of Market Coupling. Section 3 presents a test problem that consists of two configurations

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[2] Following Stoft (2002), we conduct the whole analysis on hourly basis or MWh. Capacities are thus expressed in MWh and not in MW.

[3] See "Memorandum of Understanding of the Pentalateral Energy Forum on Market Coupling and Security of Supply in the Central Western Europe". Available at http://www.benelux.int/pdf/pdf_nl/dos/dos14_PentalateralMoUMarketCouplingAndSecurityOfSupply.pdf.