OVERVIEW OF CROSS-BORDER TRADING IN CENTRAL WEST EUROPE

L. Gyselen, C. De Jonghe, R. Belmans

KU Leuven, Electrical Engineering Department ESAT–ELECTA / EnergyVille, Kasteelpark Arenberg 10, BE-3001 Heverlee, Belgium, lynn.gyselen@esat.kuleuven.be, 0032 (0)16326773

Abstract – *The goal of this paper is to provide a clear understanding of the history of international electricity trading in Central West Europe. To enhance comprehensibility, the relevant trading principles applicable in Central West Europe are defined by means of a literature study. Transitions from one trading principle to another are clarified by an overview of the advantages and disadvantages, discussed in academic literature. The general finding of this paper is that, over time, trading in the CWE region clearly replaces the second best option by the better solution proposed in literature. If this trend continues, three major transitions are still to be expected to take place in the future, not only for the CWE region, but for the whole of Europe. The first one is the price coupling of all European regions, the second the transition from the Available Transfer Capacity methodology to the Flow Based methodology for the whole of Europe and the third is the evolution from zonal to nodal pricing, possibly with a transition where market zones are defined different from national borders.*

1 INTRODUCTION

When exchanging electricity from a generator in one country to a consumer in another country, this volume is contracted between the two countries. Exchanges between two countries are limited by the maximum power flow over the different affected branches. The maximum power flow is decided on by the transmission system operators (TSOs). To be able to transfer electricity, a consumer or producer must acquire a transmission right. The auctioning of the transmission rights can be done explicitly, separate from the energy auctioning, or implicitly, which signifies that energy and transmission rights are traded jointly. Once they are acquired, they can be lost if not used, or resold to the market (the UIOLI and UIOSI principles). The acquisition of energy and/or transmission rights can be done bilaterally, including two contracting parties, or on a power exchange, which is an organized market place.

One power exchange can divide a country into multiple zones with different prices (market splitting) or several power exchanges/zones can be linked to each other (market coupling). The degree to which they are coupled varies, according to the implemented volume or price coupling. Market splitting and market coupling are two examples of zonal pricing. When one or multiple countries are divided in the smallest possible zones, these zones are called nodes and nodal pricing is installed. To conclude, depending on the accuracy of the representation of the physical trades in the commercial trades, a distinction between the Available Transfer Capacity and the Flow Based methodology can be made.

The current European exchange markets are undergoing major evolutions. On the one hand the market coupling evaluates from a trilateral coupling to a multi-lateral coupling, whereas on the other hand the methodology used to couple markets changes from Available Transfer Capacity to Flow Based market coupling. Since these evolutions have a significant impact on the trading behavior, electricity prices, traded volumes and welfare, an overview of the evolutions is presented in this paper. The goal of this paper is to present the history of cross-border electricity trading in Central West Europe (CWE). However, to do so, a general understanding of the main trading principles applicable in CWE is necessary. A literature review provides the definitions of the most important terms and principles in section 2. To be able to assess the different possibilities, their advantages and disadvantages are discussed in section 3. Finally, in section 4, the history of trade in Central West Europe is presented in brief. Section 5 argues on possible further evolutions of trading in CWE with an extension to the whole of Europe.

2 TRADING PRINCIPLES

2.1 EXPLICIT VERSUS IMPLICIT AUCTIONING

Explicit auctioning is when the right to cause a power flow over individual critical elements of the transmission network is auctioned to the market separately and independent from the marketplace where electricity is auctioned. The generator must buy a transmission right in order to implement a trade. The physical capacity is signed on by the procuring party to the transmission operator. The transmission operator allows these contracts as long as the physical interconnection capacity is not exceeded. The capacity is normally auctioned in portions through annual, monthly and daily auctions. This can be done on the bilateral market or on an exchange. In explicit auctions the transmission capacity is timely separated from the spot market where the energy is being traded (Boisseleau, 2004; Creti, Fumagalli, & Fumagalli, 2010; Kunz, 2012; Ranci & Cervigni, 2013; Solem, Wangensteen, & Sæle, 2007; Stoft, 2002).

On the contrary, implicit auctioning signifies that cross-border capacities are included in the centralized clearing of local power exchanges. Transmission rights and energy are coupled and traded simultaneously, thus the resulting price per area reflects both the cost of energy and congestion. Different electricity market prices may prevail in the different markets and a separate transmission capacity market is not required as in an explicit auction. It is a pricing mechanism derived from the early work on nodal pricing (Boisseleau, 2004; Jullien, Pignon, Robin, & Staropoli, 2012; Kunz, 2012; L.

Meeus, 2006; Ranci & Cervigni, 2013; Solem et al., 2007; Stoft, 2002; Weber, Graeber, & Semmig, 2010).

2.2 Use-It-Or-Lose-It (UIOLI) versus Use-It-Or-Sell-It (UIOSI)

Use-It-Or-Lose-It (UIOLI) is an automatic process of re-auctioning unused annual or monthly capacities by the transmission system operator without return of the proceeds to the previous owner. Applying Use-It-Or-Sell-It (UIOSI) means that proceeds are being returned to the previous owner (Batlle & Gómez-Elvira, 2011).

2.3 Bilateral trade versus power exchange

Bilateral trades occur between two parties, a buyer and a seller, on a confidential basis. Participants thus enter into contracts without involvement, interference or facilitation from a third party. Depending on the amount of time available and the quantities to be traded, buyers and sellers will resort to different forms of bilateral trading: customized long-term contracts, OTC trading and electronic trading. The essential characteristic of these three forms of bilateral trading is that buyer and seller have to search each other and the price, volume, time and duration of each transaction is set independently by the parties involved (Boisseleau, 2004; Karas & Sulamaa, 2013; Kirschen & Strbac, 2004; Ranci & Cervigni, 2013; Shahidehpour, Yamin, & Li, 2002; Stoft, 2002).

Bilateral contracts are currently still the most popular means of electricity trading (Dorsman, Westerman, Karan, & Arslan, 2011), however, Pellini (2014) indicates that the use of a power exchange is increasing in the European region. The Power Exchange (PX) is an independent, non-governmental and non-profit entity that ensures a competitive marketplace or spot market by running a day-ahead auction for electricity trades. The PX facilitates trading by calculating a public price index based on supply and demand bids received. These bids contain quantity and prices for a particular period. In explicit trading a PX is an energy only market because it does not take into account technical aspects such as transmission constraints or capacity payments, which is not the case when auctioning implicitly. It can use multiple rounds of bidding or multipart bids to determine this price. An exchange is absolutely neutral toward the market because its rules apply to buyers and sellers. A power exchange is a voluntary marketplace in competition with the classic bilateral market (Boisseleau, 2004; Karas & Sulamaa, 2013; Ranci & Cervigni, 2013; Shahidehpour et al., 2002; Stoft, 2002).

2.4 Market coupling versus market splitting

The goal of a power exchange is to maximize total welfare, which can be done according to different methodologies. The market splitting methodology starts with one single electricity market, which is divided into market zones or bidding areas according to the network congestion. To start, the power exchange calculates the market price, without considering possible congestions. All branches are examined whether the outcome of the power exchange creates congestion. If not, the calculated price will be the price for the whole region also referred to as the “system price”. If a specific branch is congested, the market will be split in different areas and the price calculation will be repeated for the identified areas. The price in one area will therefore be higher than in the other. The exchange will then purchase in the low price area and sell in the high price area. This will be done until the amount of electricity bought and sold reaches the maximum capacity of the interconnector. The revenues are paid back to the TSOs (Androcec & Krajcar, 2012; Boisseleau, 2004; Kunz, 2012; Solem et al., 2007).

Market splitting and market coupling supply the same market outcome in terms of prices and traded volumes if the definition of (possible) market zones and the representation of network constraints are identical (Kunz, 2012). Market coupling means that the cross-border flows are determined by using the price signals in the spot markets in each participating country. Market coupling starts with a set of predefined independent markets, with the goal of linking them together during every trading period. This enables an efficient European wide price formation mechanism and optimized use of the transmission grid through a strong interaction between price zones. The only complexity in comparison with a single exchange optimization problem is that these orders come from different exchanges which represent a different network location. The demand and supply volumes traded on the different exchanges do not have to be equal, as long as the traded volumes equalize in total and the resulting flows between locations are feasible given the limited available network capacity (Androcec & Krajcar, 2012; Kunz, 2012; L. Meeus, Vandezande, Cole, & Belmans, 2009; Solem et al., 2007; Weber et al., 2010). Adamec, Indrakova, & Pavlatka (2009) describe all features of market coupling and give a very broad definition. Different degrees of market coupling and recommendations for the best market coupling solution are made by Karas & Sulamaa (2013).

2.5 VOLUME COUPLING VERSUS PRICE COUPLING

If a market is coupled by means of volume coupling, this signifies that this market takes into account all order information of the other relevant markets to calculate an independent volume bid. The power exchanges of all relevant markets will send all order books or calculate their order curves and send them to the volume coupled market. The volume coupled market will use them to calculate a price independent volume bid. This independent volume bid is included in the order books of the other relevant markets. Taking into account the independent volume bid, the power exchanges of the other relevant markets clear their bids and offers again. The volume coupled market is a price taker for the volume bid it supplied (Adamec et al., 2009; Biskas, Chatzigiannis, & Bakirtzis, 2012; mercados & everis, 2010).

With price coupling, the price calculations are executed by the market coupling system. All aggregated order information of the relevant markets, including prices, volumes, block offers, etc., are used to clear the individual markets. The prices derived are used as settlement price on the local power exchanges and the defined exchange volumes are exchanged between the countries. Price coupling is done by one common office (Adamec et al., 2009; Djabali, Hoeksema, & Langer, 2011; mercados & everis, 2010). If multiple coupling mechanisms are combined, volume coupling takes place before price coupling.

2.6 Zonal versus nodal pricing

Using zonal pricing, the market is divided into several zones depending on congestion costs or country borders. Zones are usually pre-defined and fix. If there is congestion between two zones, the prices differ between the two zones. Inside one zone the same price holds, regardless whether there is congestion inside that zone or not (Holmberg & Lazarczyk, 2012; Leuthold, Rumiantseva, Weigt, Till, & Hirschhausen, 2005).

The method of nodal pricing starts from a node representing a physical location in the transmission system, including producers and consumers. For each node a market clearing price is determined. The nodal pricing works with an implicit auctioning method, so the cost of congestion is included in the price. Because of the locational differences between prices, also losses and the cost of transmission are included. The incremental cost of serving one additional MW of load at each respective location subject to system constraints is represented by the nodal price (Leuthold et al., 2005).

2.7 Available Transfer Capacity versus Flow Based methodology

The Available Transfer Capacity based model limits the volume of each cross-border exchange between neighboring countries or zones (Sores, Divenyi, & Raisz, 2013) (Ranci & Cervigni, 2013) (Burstedde, 2012). The maximum power flow between two countries is a net amount which remains after subtracting the already allocated yearly and monthly capacity. The calculation of the net maximum power flow is based on historical data of the network and takes into account a security margin. The net maximum power flow cannot be exceeded by the sum of the flows of the contracted transactions between two countries.

In the Flow Based approach, each constraint sets a limit to the flow over a critical infrastructure or critical branch, a physical transmission network element affected by the cross-border transactions. With each exchange, multiple branches in the network partly transfer the induced power flow. The proportion in which this power flow is divided over the different branches, is presented by the Power Transfer Distribution Factors (PTDFs). The PTDF is the ratio of the induced power flow on a branch caused by a shift in net electricity exchange and the shift in net electricity exchange of a zone (Kirschen & Strbac, 2004; Kurzidem, 2010). The maximum flow is deducted from the physical maximum power flow over the branch instead of historical data. For each branch, the maximum power flow over that branch is a constraint to the sum of the net exports from a market zone multiplied by the relevant PTDF (Ranci & Cervigni, 2013).

3 ADVANTAGES AND DISADVANTAGES

3.1 EXPLICIT VERSUS IMPLICIT AUCTIONING

The advantages and disadvantages of explicit versus implicit auctioning can be subdivided into four linked categories: the liquidity of the market, the complexity of auctioning, the risk it entails and the efficient usage of interconnection capacity.

3.1.1 Market liquidity

Implicit auctioning improves market liquidity, while explicit auctioning does not. When trading transmission capacity separately from electricity, there is a lack of information about the availability or prices of the other commodity (European Commission & CONSENTEC, 2004). When the price of both commodities is included in the price formation of the exchange, this contributes to the development of the exchange market (Karas & Sulamaa, 2013). Glachant & Lévêque (2009) notice that implicit auctioning enforces arbitrage between transmission and electricity prices. Another advantage of implicit trading is the fact that capacity payments are made to the right parties (Boisseleau, 2004).

3.1.2 Complexity

The separation of the energy and transmission capacity market increases the complexity of the entire market as market participants have to value transmission services prior to clearing of the energy market. The increased complexity can lead to a misjudgment of market outcome and thus market inefficiency as available transmission capacity is not optimally used (Kunz, 2012).

3.1.3 Risk

Explicit auctioning also entails risk, the generator is forced to guess market conditions in order to set an appropriate offer price in one market or the other (Stoft, 2002). The UIOLI principle entails the risk of losing the obtained capacity without financial compensation, when this capacity is not used in trading (Weber et al., 2010).

3.1.4 Interconnection capacity

Adverse power flows, when the real power flow deviates from direction of the contracted power flow, may result from explicit auctioning and are addressed by Weber, Graeber, & Semmig (2010). A relevant price signal is send to promote investment in transmission capacity. Implicit trading enhances the possibility to harmonize prices between different regions due to the more efficient use of interconnection capacity.

In a perfect market situation, explicit and implicit auctioning are both optimal solutions, however, since the market is not perfect and lacks perfect information, implicit auctioning is preferred (Squicciarini &

Perekhodtsev, 2010). A literature study of advantages and disadvantages of explicit and implicit trading is given by Pellini (2014).

3.2 Use-It-Or-Lose-It (UIOLI) versus Use-It-Or-Sell-It (UIOSI)

Batlle & Gómez-Elvira (2011) conclude that if there is sufficient coordination between markets and market liquidity is good, the acquisition of physical transmission rights should include a UIOSI clause. A UIOLI clause entails too much risk as already explained. Use-It-Or-Sell-It (UIOSI) provides market participants with the opportunity of buying energy with a purely financial motivation and reselling it later. It also increases market liquidity (ACER, 2012).

3.3 Bilateral trade versus power exchange

3.3.1 Flexibility

As the bilateral market is a heterogeneous market, differing, flexible and tailor-made contracts can be obtained and prices can be compared between different suppliers (Shahidehpour et al., 2002).

3.3.2 High cost

The downside of bilateral contracts is their limited potential for price discovery. Because contracting parties are oblivious concerning the prices, there is no benchmark price for new contracts. The price, if available, is also an indicator for new investments or entry of new participants. A consequence of limited price discovery is price discrimination between different customers. Due to bilateral contracts, market liquidity is hampered as contracts cannot be resold to other parties. The transaction costs are high and there is a significant cost in searching the right price and in negotiating the contract, which is specifically problematic for short time contracts (Boisseleau, 2004; Stoft, 2002). A power exchange provides a transparent index price for OTC benchmarking. Anonymous bidding removes the risk of price discrimination, reduces the credit risk and enhances liquidity.

3.3.3 Market power

The advantage of bilateral contracts is that there is no opportunity in withholding unneeded capacity from the market, which is the case in organized marketplaces such as exchanges. In those organized markets, manipulated bids can alter the market price, which is not possible when contracting bilaterally (L. Meeus, 2006).

Adjacent to it there is the financial motivation of possible commodity trading, as volumes can exceed the physical consumption. Furthermore, the availability of aggregated information facilitates the technical problem solving for the transmission system operator (TSO) (Boisseleau, 2004). A well-functioning exchange is an indication of a more mature market (L. Meeus, 2006). Glachant & Lévêque

(2009) state that organized wholesale markets are essential to the single energy market because they play a vital role in the coupling of different markets.

3.4 Market coupling versus market splitting

Market coupling and market splitting are an improvement over uncoupled markets, as international trade will foster more exchange between countries, increase trading volumes and decrease the price in the high priced countries. Androcec & Krajcar (2012) argue that the European market coupling system could be improved by splitting Europe into bidding zones reflecting congestions in the transmission network. This would improve the efficient operation of the grid, investment signals and more efficient installment of generation. The problems to implement market splitting are threefold, first the complexity of the highly meshed network in Europe makes it difficult to define zones. Second, the widespread use of bilateral contracts complicates market splitting. Third, to implement market splitting, the exchange markets have to be coordinated by a covering office and apply the same rules, according to Boisseleau (2004) the European exchange markets lack compatibility to achieve this (Boisseleau, 2004). This discussion is parallel to the discussion of nodal versus zonal pricing, which will be discussed more in depth in section 3.6.

3.5 Volume coupling versus price coupling

Volume coupling has to be seen as a suboptimal, interim solution. It is a good short-term strategy for integration of a new market in the coupling mechanism. Price coupling requires a higher harmonization effort and is institutionally more complex to achieve. It has the potential of reduce efficiencies in a short period of time (Creti et al., 2010). Volume coupling requires several different entities to calculate the same optimization problem. The exact outcome may differ because of differing calculation algorithms, which leads to price discrepancies. These price differences will in turn lead to different possible independent volume bids and no optimal market outcome will be reached. The second problem is the possibility that higher priced countries export instead of import due to the unwanted results of the former problem. Another unwanted side effect is that the price can rise although the country imports more due to re-commitment of units. The last theoretical issue is due to the fact that under optimal conditions quantities and prices should be derived from the same coordinated market process. If not, sub-optimal solutions are attained and side-payments are necessary to resolve the market inefficiencies. The volume coupling approach is a classic example of this issue, leading to market inefficiencies (Biskas et al., 2012).

3.6 ZONAL VERSUS NODAL PRICING

3.6.1 Cost of congestion

In reality, each node in a network bears a different cost. When assigning uniform prices to zones, this difference in cost is neglected, so the cost do not represent the real cost of the network congestion (Holmberg & Lazarczyk, 2012). Further, in nodal pricing, congestion is addressed in the day-ahead market, reducing the need to perform balancing market transactions, which are often more expensive (Ranci & Cervigni, 2013).

3.6.2 Market power

Glachant & Lévêque (2009) argue that the bidding in nodal pricing should be done according to the marginal cost of the producers and consumers, to enforce this, automatic bid mitigation should be installed to avoid exercising market power. On the other hand, gaming opportunities arise also when zonal prices are maintained (Neuhoff et al., 2011). Nodal pricing does not create the opportunity to exercise more market power than zonal pricing, but makes market power more transparent (Ranci & Cervigni, 2013).

3.6.3 Complexity

Zonal pricing may seem a practical approach, but the definition of the zones is complex, as it has to be based on the market structure, but also on welfare, liquidity, competition and re-dispatch costs (Burstedde, 2012). At the other hand, nodal pricing may seem complex, but the calculation of the prices is executed by means of a constrained optimization process and thus transparent. Complex rebalancing and linked cost redistributions are more complex, which is avoided using nodal pricing (Ranci & Cervigni, 2013).

3.6.4 Incentives for investment

Application of nodal prices results in a surplus which, under ideal conditions, would allow the recovery of the construction, operation and maintenance costs of the grid (Olmos Camacho & Pérez-Arriaga, 2007). Leuthold et al. (2005) argue that nodal pricing sends adequate investment signals. Incentives for network development can be put in place regardless of the chosen congestion management mechanism, but signals for generation investment are more accurate using nodal pricing (Ranci & Cervigni, 2013).

3.6.5 Single national price

Politically it is often more acceptable to have one price in one country (Holmberg & Lazarczyk, 2012). Ranci & Cervigni (2013) argue that one price can still be achieved by side-payments between use, such as contracts for difference.

3.6.6 Wealth distribution

Neuhoff et al. (2011) conclude from their research that traded volumes increase and prices decrease when using the nodal pricing instead of the zonal pricing. Olmos Camacho & Pérez-Arriaga (2007) conclude that there is a wide agreement that nodal prices are optimal short-term economic signals in the electricity market.

3.7 AVAILABLE TRANSFER CAPACITY VERSUS FLOW BASED METHODOLOGY

Kirchhoff's and Ohm's laws determine the real physical flows on a network, the ATC approach is thus a substantial simplification as it does not take into account these flows. The results of the ATC methodology will be sub-optimal or even infeasible in reality. The Flow Based methodology is preferred over the ATC methodology in terms of welfare (Burstedde, 2012). Several premises are made regarding the advantages of the FB methodology over the ATC methodology. Jong, Hakvoort, & Sharma (2007), Kurzidem (2010), and M. Sharma (2007) promise lower prices in importing countries, higher prices in exporting countries, an increase in price convergence, increased importing/exporting volumes, higher social welfare and a decrease in congestion rent. The Flow Based methodology allows for a linear representation of power flows, but it neither reflects reactive power flows nor losses. In general, each change in network topology induces a new calculation of the base case. Burstedde (2012) argues that although multiple authors justify the approximation of the network with a Flow Based model, a substantial error occurs when zones are not defined in accordance with the fundamental market structure. The Flow Based calculation method can be seen as a compromise between the simple market splitting approach and the more detailed nodal pricing (Solem et al., 2007). Regulators and participants appear to have reached a consensus that, for meshed networks, flow-based capacity calculation is most efficient (mercados & everis, 2010).

4 HISTORY

Starting from 1996, the European Commission strives to create conditions more conducive to genuine, fair competition and to put in place a true single market for electricity (European Commission, 2003). Meeus, Purchala, & Belmans (2005), Meeus & Belmans (2008) and Squicciarini & Perekhodtsev (2010) discuss the state of progress and how the legislative packages and implemented European policies support or hamper the development of a single European electricity market.

Before 01/07/2002, only monthly capacity, so no annual or daily capacity, was traded on the French-Belgian borders. Since then also daily capacity was traded explicitly for flows from France to Belgium. The capacities were jointly calculated but were allocated by RTE, the French TSO, in case of daily capacity and by Elia, the Belgian TSO, in case of monthly capacity. For the allocation of monthly capacity an explicit capacity auction was organized, accepting the bids according to submitted prices. In the daily allocation process, all bids are accepted but excess demand is reduced proportionally to the available capacity (Purchala, Meeus, & Belmans, 2004). Starting from 01/01/2006 explicit auctions for daily, monthly and annual capacity took place on the French-Belgian border applying the UIOLI rule. For day-ahead auctions, explicit auctioning was conducted until 22/10/2006 (Elia, 2013).

On the Belgian-Dutch and Dutch-German borders, since 2000 an explicit capacity auction was organized on yearly, monthly and daily basis by the TSO Auction Office. Monthly or yearly capacity could be resold to the market up to four days ahead, otherwise the Use-It-Or-Lose-It (UIOLI) rule, where buyers lost all unused annual or monthly capacity without financial compensation, was in force (Purchala et al., 2004).

Trilateral Market Coupling (TLC) was introduced in the Netherlands, Belgium and France from 22/10/2006 on. The Belgian power exchange (Belpex) was created to have a trading platform for day-ahead auctions and to participate in the TLC. The Dutch and French power exchanges, respectively APX and Powernext (now replaced by EpexSpot), were already operative (Leonardo Meeus & Belmans, 2008). In November 2009, UIOLI was replaced by UIOSI, where the contracted capacity on a yearly and monthly basis can be resold to the day-ahead market. The market coupling was expanded to Germany in November 2010, under the name Central Western Europe (CWE). Simultaneously, a volume coupling methodology was implemented between Germany, the Netherlands and Scandinavia by the name of Interim Tight Volume Coupling (ITVC). As the name implies it is an interim, suboptimal solution.

This solution has been replaced in February 2014 by extrapolating the ATC methodology to Austria, Denmark, Estonia, Finland, Great Britain, Latvia, Lithuania, Luxemburg, Norway, Poland, and Sweden under the name North West Europe (NWE). June 2014 the ATC methodology will be replaced by the Flow Based methodology for CWE.

5 FUTURE EVOLUTIONS

5.1 MARKET COUPLING THROUGH PRICE COUPLING OF REGIONS

The driver behind all current evolutions, is the willingness of the European Commission to create an internal energy market (IEM). A first interim solution was the creation of seven regional initiatives[1].

[1] The seven regional initiatives:
Baltic States (BS): Estonia, Latvia, Lithuania
Central East (CEE): Austria, Czech Republic, Germany, Hungary, Poland, Slovakia, Slovenia
Central South (CSE): Austria, France, Germany, Greece, Italy, Slovenia
Central West (CWE): Belgium, France, Germany, Luxembourg, Netherlands
Northern (NE): Denmark, Finland, Germany, Norway, Poland, Sweden
South West (SWE): France, Portugal, Spain
France, UK, Ireland (FUI): The electricity market of Ireland is denoted as single electricity market (SEM) since it encompasses the Republic of Ireland and Northern Ireland.

The aim is to couple the seven regional initiatives in the near future. In February 2014 the NWE market coupling joined the regional initiatives of the Baltic states, North Europe, CWE, U.K., Ireland and Austria. Before the end of 2014, South West Europe and Central South Europe will be coupled with the NWE coupling. An overview of the status of the initiatives in Europe is given by Weber et al. (2010) and by ACER (2013). The goal is to couple the whole European region.

5.2 From ATC to FB market coupling

The discussed advantages of the Flow Based methodology over the ATC methodology indicate the importance of moving to a FB methodology. This evolution is planned in June 2014 for the CWE region. Expansion to the whole NWE region, and later the whole European region, would be favorable in terms of prices, traded volumes and welfare. But also management of network congestions and security of supply will improve. ACER (2013) favors this expansion of the FB methodology, but no specific planning is put forward for implementation. Coordination and cooperation of different countries could hamper the implementation, but it is projected that future evolutions will eventually lead to the FB methodology across Europe.

5.3 From zonal to nodal pricing

The advantages of market coupling over no coupling and the Flow Based model over the ATC methodology are discussed in section 4. These evolutions move the European markets from the sub-optimal to the better solution, according to the literature. The coupling initiatives and the Flow Based methodology are both based on the zonal pricing. As also discussed in section 4, zonal pricing is the sub-optimal solution, where nodal pricing is the overall improvement. Although the European instances do not mention moving from zonal pricing to nodal pricing in their future projections, academic literature does favor this step. A lot of research focusses on the division of the European market into optimal zones, with borders not equal to the national borders but determined according to congestion. This could provide an interim step, by defining more accurate zones according to congestion, the market splitting approach could offer a solution. As discussed in section 4, the complexity of defining the zones and all related problems, would imply a rapid transition from the zonal to the nodal approach. This evolution would be expected for the day-ahead trading in the whole European region, once all markets are successfully coupled.

6 Conclusion

To enhance comprehension of the history of the CWE market coupling, section 2 defines, according to academic literature, most important trading principles. These trading principles characterize the international trade in the electricity markets. In section 3, the advantages and disadvantages of these trading principles, based on a literature study, are compared. The goal is to compare the theoretic optimal solutions to the evolutions in the CWE region.

A few conclusions can be drawn from the analysis of section 3. To start, it can be stated that implicit auctioning is preferable over explicit auctioning. If explicit auctioning is used, for example in the forward markets, then a UIOSI clause should be included. The flexibility of bilateral trading could benefit long term contracts. However, the power exchange is the desired means for combined electricity and transmission capacity trading on the day-ahead market. Separate electricity markets should be coupled to benefit from additional trading possibilities, in this respect, volume coupling is always a sub-optimal solution in comparison with price coupling. When coupling markets, this can be achieved using a zonal model, where zones are defined by regional boundaries or using a zonal model where the entire market is considered as a whole and split into regions according to the market splitting model. When the zones become as small as possible, this results in the most optimal solution according to literature, nodal pricing. To conclude, the Flow Based methodology represents the underlying network more accurately and can be favored above the ATC methodology.

Section 3 puts forward clear advantages of one trading principle over the other. These advantages are acknowledged by European instances such as ACER, e. g. the target models to be implemented in the European markets are a day-ahead price coupling with implicit auctions, applying a ATC or FB methodology. In the forward interconnection capacity market, the explicit auction should auction a financial transmission right or a physical transmission right with a UIOSI clause. These target models and all historical evolutions discussed in section 4 are in line with the favorable trading principles lined out in section 3. It can be deducted that CWE evolves towards the theoretic optimum proposed in literature.

If the evolutions in CWE follow the same trend as perceived, some projections can be made towards the future, as discussed in section 5. First, the price coupling of regions will continue until the whole of Europe is coupled. Second, the Flow Based methodology is expected to expand to the whole of Europe. Third, Europe will move from zonal pricing to nodal pricing, possibly with market splitting as an interim stage.

7 BIBLIOGRAPHY

ACER. (2012). *Forward Risk-Hedging Products and Harmonisation of Long-Term Capacity Allocation Rules Consultation Document*.

ACER. (2013). Regional Initiatives Status Review Report 2013.

Adamec, M., Indrakova, M., & Pavlatka, P. (2009). Market Coupling and Price Coordination between Power Exchanges. In *IAEE* (pp. 1–13).

Androcec, I., & Krajcar, S. (2012). Methodology of market coupling/splitting for efficient cross-border electricity trading. *2012 9th International Conference on the European Energy Market*, 1–8. doi:10.1109/EEM.2012.6254650

Batlle, C., & Gómez-Elvira, R. (2011). *Forward Cross-Border Transmission Capacity Allocation: Physical versus Financtial Transmission Rights* (pp. 1–27).

Biskas, P. N., Chatzigiannis, D. I., & Bakirtzis, A. G. (2012). Volume-Coupling Between a Power Pool and a Power Exchange. In *European Energy Market (EEM), 2012 9th International Conference on the* (pp. 1–8).

Boisseleau, F. (2004). *The role of power exchanges for the creation of a single European electricity market: market design and market regulation*. PhD Technische Universiteit Delft.

Burstedde, B. (2012). *Essays on the Economics of Congestion Management Theory and Model-based Analysis for Central Western Europe*. PhD Universität zu Köln.

CASC. (2013). *Public consultation document for the final design and implementation of the CWE Flow-Based Market Coupling* (Vol. 2013, p. 33).

Creti, A., Fumagalli, E., & Fumagalli, E. (2010). Integration of electricity markets in Europe: Relevant issues for Italy. *Energy Policy*, *38*(11), 6966–6976. doi:10.1016/j.enpol.2010.07.013

Djabali, R., Hoeksema, J., & Langer, Y. (2011). *COSMOS description CWE Market Coupling algorithm*.

Dorsman, A., Westerman, W., Karan, M. B., & Arslan, Ö. (2011). *Financial Aspects in Energy* (pp. 11–30; 109–128).

Elia. (2013). Previous Allocation Mechanisms. Retrieved January 09, 2013, from http://www.elia.be/en/grid-data/interconnections/previous-allocation-mechanisms

European Commission. (2003). DIRECTIVE 2003/54/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC.

European Commission, & CONSENTEC. (2004). *Analysis of Cross-Border Congestion Management Methods for the EU Internal Electricity Market* (Vol. 44, pp. 1–138). Aachen.

Glachant, J.-M., & Lévêque, F. (2009). *Electricity reform in Europe: towards a single energy market*. (J.-M. Glachant & F. Lévêque, Eds.)*Energy* (Vol. 31, p. 383). Edward Elgar Publishing. Retrieved from http://www.dieterhelm.co.uk/node/978

Holmberg, P., & Lazarczyk, E. (2012). *Congestion Management in Electricity Networks: Nodal, Zonal and Discriminatory Pricing*.

Jong, H. D. E., Hakvoort, R., & Sharma, M. (2007). *Effects of Flow-based Market Coupling for the CWE region* (pp. 1–11). Delft.

Jullien, C., Pignon, V., Robin, S., & Staropoli, C. (2012). Coordinating cross-border congestion management through auctions: An experimental approach to European solutions. *Energy Economics*, *34*(1), 1–13. doi:10.1016/j.eneco.2011.08.017

Karas, J., & Sulamaa, P. (2013). *The Increasing Scope and Authority for Power Exchanges* (pp. 1–72). Stockholm.

Kirschen, D. S., & Strbac, G. (2004). *Fundamentals of Power System Economics*.

Kunz, F. (2012). *Managing Congestion and Intermittent Renewable Generation in Liberalized Electricity Markets*. PhD TU Dresden.

Kurzidem, M. J. (2010). *Analysis of Flow-based Market Coupling in Oligopolistic Power Markets*. PhD ETH Zurich. Retrieved from http://e-collection.library.ethz.ch/eserv/eth:1438/eth-1438-02.pdf

Leuthold, F., Rumiantseva, I., Weigt, H., Till, J., & Hirschhausen, C. Von. (2005). Nodal Pricing in the German Electricity Sector – A Welfare Economics Analysis, with Particular Reference to Implementing Offshore Wind Capacities, (September).

M. Sharma. (2007). *Flow-based Market Coupling*. PhD Delft University of Technology. Retrieved from http://www.tbm.tudelft.nl/fileadmin/Faculteit/TBM/Over_de_Faculteit/Afdelingen/Afdeling_Infrastructure_Systems_and_Services/Sectie_Energie_en_Industrie/Afstuderen/Jaaroverzichten/2007/doc/Sharma.pdf

Meeus, L. (2006). *Power Exchange Auction Trading Platform Design*. PhD KU Leuven.

Meeus, L., & Belmans, R. (2008). Electricity market integration in Europe. *Revue-E*, *124*(1), 5–10.

Meeus, L., Purchala, K., & Belmans, R. (2005). Development of the Internal Electricity Market in Europe. *The Electricity Journal*, *18*(6), 25–35. doi:10.1016/j.tej.2005.06.008

Meeus, L., Vandezande, L., Cole, S., & Belmans, R. (2009). Market coupling and the importance of price coordination between power exchanges. *Energy*, *34*(3), 228–234. doi:10.1016/j.energy.2008.04.013

mercados, & everis. (2010). *From Regional Markets to a Single European Market* (p. 163).

Neuhoff, K., Boyd, R., Grau, T., Barquin, J., Echavarren, F., Bialek, J., … Papaefthymiou, G. (2011). Renewable Electric Energy Integration : Quantifying the Value of Design of Markets for International Transmission Capacity Smart Power Market Project.

Olmos Camacho, L., & Pérez-Arriaga, I. J. (2007). Comparison of several inter-TSO compensation methods in the context of the internal electricity market of the European Union. *Energy Policy*, *35*(4), 2379–2389. doi:10.1016/j.enpol.2006.09.004

Pellini, E. (2014). *Essays on European Electricity Market Integration*. PhD University of Surrey.

PLEF, & CWE. (2011). CWE Enhanced Flow-Based MC feasibility report. Retrieved from http://www.apxgroup.com/wp-content/uploads/CWE_FB-MC_feasibility_report.pdf

Purchala, K., Meeus, L., & Belmans, R. (2004). The analysis of the cross-border capacity allocation in the Benelux Region. In *Cigré C5-204* (pp. 1–8).

Ranci, P., & Cervigni, G. (2013). *The economics of electricity markets* (p. 213).

Shahidehpour, M., Yamin, H., & Li, Z. (2002). *Market Operations in Electric Power Systems : Forecasting, Scheduling, and Risk Management*. *New York* (Vol. 9, p. 531). Wiley-IEEE Press. Retrieved from http://www.amazon.ca/exec/obidos/redirect?tag=citeulike09-20&path=ASIN/0471443379

Solem, G., Wangensteen, I., & Sæle, H. (2007). Transit in the European Power Market, (November).

Sores, P., Divenyi, D., & Raisz, D. (2013). Flow-based capacity calculation method used in electricity market coupling. In *2013 10th International Conference on the European Energy Market (EEM)* (pp. 1–7). Ieee. doi:10.1109/EEM.2013.6607285

Squicciarini, G., & Perekhodtsev, D. (2010). *The integration of the european electricity markets at a turning point: from the regional model to the third legislative package* (No. EUI Working Paper RSCAS 2010/56). *EUI RSCAS 2010/56* (pp. 1–29).

Stoft, S. (2002). *Power System Economics Designing Markets for Electricity*.

Weber, A., Graeber, D., & Semmig, A. (2010). Market Coupling and the CWE Project. *Zeitschrift Für Energiewirtschaft*, *34*(4), 303–309. doi:10.1007/s12398-010-0033-x