Market Coupling vs Market Splitting

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Abstract- In current paper we present a comprehensive definition of market coupling and market splitting. The main objective of this article is to investigate impact of market coupling vs market splitting in electricity market of EU-area, Austria and Czech Republic. Here we also give an overview how market coupling and market splitting are utilized in EU-area, Austrian and Czechs electricity market. At the end, a brief comparison of the market coupling and market splitting was presented. In summary, market coupling and market splitting are both different forms of implicit auctions which have only slight difference. However, under market splitting one power exchange operates across several price zones, whereas market coupling links together separate markets in a region. We ultimately concluded that market coupling compared to market splitting merges transmission allocation and eliminate many of the inefficiencies at the day-ahead market.

1 Introduction

Liberalisation began in European energy market through national initiatives in England and Norway. Subsequently, other European countries started the liberalisation of their national electricity markets in the second half of the 1990s. One purpose of the liberalisation of the electricity supply industries was to establish a pan-European electricity market, referred to as internal electricity market (IEM). IEM aims at restructuring a competitive market which leads to a more cost-effective electricity system for consumers (1). That requires a complex process of integrating different markets via involving broad range of stakeholders, observing various regulations and combining diverse market structures. The European electricity day-ahead markets are based on zonal pricing. It means that markets are organized in relatively broad areas where in each area there is a homogenous price for every individual electricity products. At each border, a physical linkage between different areas exists. These so called "interconnectors" are the physical connections between different national grids. Initial purpose of the establishment of the interconnectors was better over-all system stability, which should be achieved through the possibility of electricity exchange between two countries in case of emergency (2). These exchanges occurred between vertically integrated utilities, which insured that cross-border transports did not exceed the available interconnector capability. In order to achieve a liberalized electricity market, the national transmission networks entailed to be operated by independent transmission system operators (TSOs). An important objective of the liberalisation was that consumers must be able to buy electricity from a supplier of interest. If electricity is dramatically cheaper in one country than a neighbouring country, large demand of cross-border electricity transfer capacity can occur. If this demand exceeds the available transmission network capabilities of the cross-border interconnectors, congestion occurs. As such, congestion is able to hamper the complete integration of different electricity markets into a single market (3). Therefore, for an appropriate congestion management, several special conditions in a cross-border exchange such as physical features of electricity, the organization of the electricity system and the type of congestion have to be taken into account. There are different congestion management methods to allocate available capacity to the market (Figure 1). The principles for congestion management in a country or a broader area are based on the legislation and regulation in the place. An increased attention to handling of congestions has developed over recent years. In Europe the EU Directive 2003/54/EC and the Regulation 1228/2003/EC draw up the basic principles for congestion management throughout Europe (4). The other legislative package was implemented in 2009 and contains different directives and regulations handling cross-border trade of electricity (5). Explicit and implicit auctions are the favoured congestion management methods by the European Union. They are market- and allocation- based methods. In an implicit auction, energy and capacity are traded at the same time, while, in an explicit auction only transmission capacity is traded. Implicit auctioning can be implemented over the two methods “market splitting” and “market coupling”. The main difference between market coupling and market splitting is as follows: market coupling is the implementation of implicit auctions in a market operated by co-operation of multiple power exchanges whereas market splitting describes a method used in a market operated by a single power exchange (6). There is not necessarily any difference in the calculation algorithms or principals used for market coupling and market splitting. What differs market coupling from market splitting is how the algorithm is operated, and which results from the central calculation the local markets use subsequently. This paper will represent a comprehensive definition of market coupling and market splitting and their impact on electricity market of EU-area, of Austria and of Czech Republic.

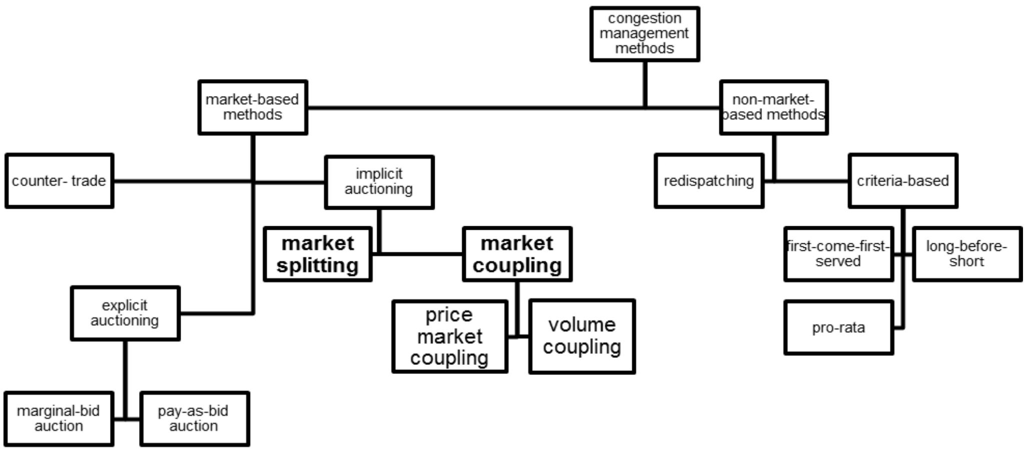

Figure 1: Order of congestion management methods, market splitting and market coupling which are the main focuses of this paper are shown in bold.

2 Market splitting

The market splitting is a form of implicit auctioning where the capacity is traded simultaneously with the energy. Market splitting is a simplified form of nodal pricing that was implemented in the Nordic system in 1993 (7). In cases with congestion, the market operator splits the market into two or more price areas. Each price area is then balanced while exploiting the transaction capacities between the areas. By using market splitting to manage congestion, an operator divides the market by congested interconnector. There should either be an organized market with a separate price on each side of the interconnector, or should be two closely cooperating power exchanges. In a first step, the two markets are treated as completely independent. Normally this results in a price difference between both markets. Subsequently, the market operator buys electricity in the lower-price market up to the amount of the interconnection capacity and sells it in the higher-price market. This transaction leads to a price increase in the exporting market and to a price decrease in the importing market. However, the price difference does not fully disappear. To perform market splitting, an organized electricity market on both sides of the interconnector is required as well as good coordination and cooperation between the market operators or two closely cooperating power exchanges. The transaction profit is kept by the market operator. Although in the case explained above a joint market was split into two markets, this allocation mechanism also can be applied to markets already separated. In the latter case market parties only have access to their own national or regional network (8). An example of a region which practices markets splitting is the Scandinavian market. In Scandinavia market splitting is used as an expression for a method where a single market is "split" in case of congestion. In continental Europe, however, market splitting often means the coordinated use of power exchanges where different neighbouring markets are operated separately before congestion (9).

2.1 Market splitting in Austria

A study provided quantitative insights to the potential split of the German-Austrian bidding zone. It compared the economic costs and benefits of splitting up the German-Austrian power market into two bidding zones. If the bidding zone is split, costs for re-dispatch can be decreased in some cases while continuous inefficiencies arise from uncertainties when determining total transmission capacities between the smaller zones. Comparing these two cost factors, the study demonstrates that a split of the German-Austrian bidding zone would enhance total cost of power supply by up to € 100 m per year. Additional factors such as loss of liquidity and substantial transaction costs are on top of those inefficiencies. They claimed that their results recommend avoiding a split of large and liquid bidding zones, especially looking at the benefits provided by the already integrated and well established German-Austrian power market. Its unmatched liquidity provides a reference price for Europe. They suggested that instead of splitting bidding zones, markets should be further integrated. For this, grid extension is the only viable solution (10).

3 Market coupling

Market coupling is described as the application of implicit auctioning involving two or more power exchanges (PXs). Market coupling is the implementation of implicit auctions in a market operated by cooperation of multiple PXs (11). To integrate various national markets, different market coupling models exist. Markets linked with an interconnection can be coupled either through the coordination of the volumes of use of the interconnection capacity [called volume coupling] or through a wider mechanism combining price and volume coordination [price coupling] (12). Market coupling integrates transmission allocation and energy trading, removing many of the inefficiencies at the day-ahead stage. Market coupling has obvious benefit of improving net welfare of the whole system (Figure 2). The two coupling mechanisms differ mainly in the way they produce prices.

3.1 Volume coupling

Volume coupling is defined as a form of implicit allocation which only fixes the cross-border flows on a set of interconnectors between various areas that can cover one or more zones. It thus only serves the allocation objective for a set of interconnectors (3). Process of volume coupling works therefore as follows: firstly, the capacity of the interconnector is calculated by TSOs and communicated to the coupled markets. Secondly, the capacity of the interconnection is allocated according to the balance of supply and demand in each trade zone and the constraints of the interconnector. Lastly, the trade zones determine the prices in their zones separately by taking in to account the cross-border import and export volume attributed to them by the quantity allocation mechanism. Therefore, "volume coupling" allows the coupled markets to stay more independent while being coupled (12). The major difference between volume coupling and price coupling is where the price calculation takes place. If the price calculation is done centrally the coupling is called price coupling and if the price calculation is done on a decentralized basis it is called volume coupling. In the case of volume coupling the price calculation can thus be kept at the power exchanges. (14)

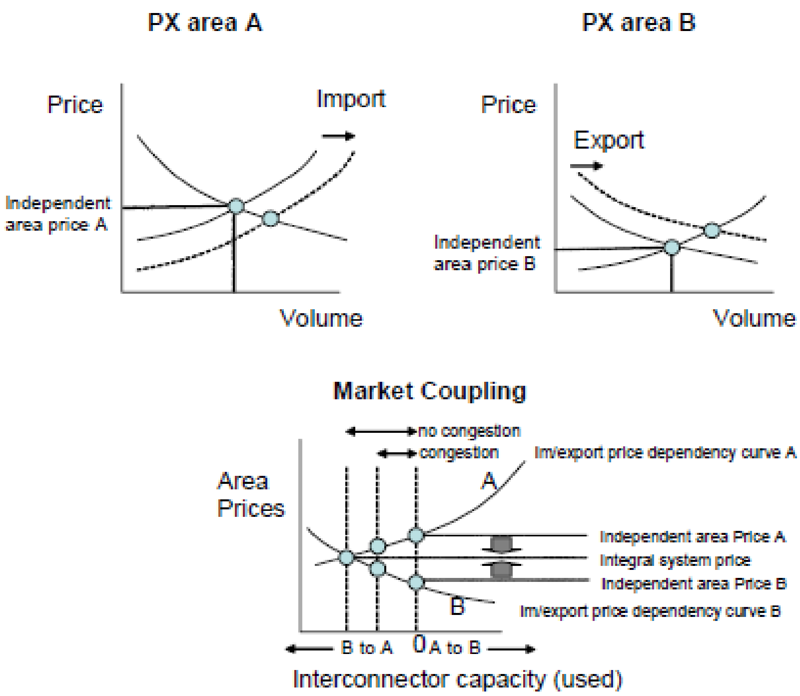

Figure 2: market coupling between two markets leading to increase in the net welfare (13).

3.2 Price Market Coupling

The approach used the most is price market coupling or simply price coupling. In this approach, a single coupling algorithm is computing centrally both, prices and cross-border volumes at the same time based on all relevant information. This means that the power exchanges of the involved regions, do not set prices but just forward bids to the coupler and receive prices (and volumes) in return (6). Price coupling between different countries allows the creation of a single exchange zone and consequently a single price zone if interconnection capacities do not limit cross-border power exchange. Price coupling was first introduced in 2006 between France, Belgium and the Netherlands (trilateral market coupling (TLC)). One advantage of price coupling is that this process avoids price or flow discrepancies like exports from a high price zone to a low price zone or price differences in case of no congestion (14,12,6). Therefore, price coupling is serving both, the allocation and the matching objectives at the same time (3). In this paper, the term market coupling refers always to price coupling from now on.

3.3 Market coupling in Europe

In Europe, there are various market coupling mechanisms in use. It is the declared goal of the EU to implement a single, market-based mechanism. Therefore, the EU provides a so called EU Target

Model. Electricity trade takes place in different timeframes. Consequently, this fact has to be taken into account in the implementation of transfer capacity allocation mechanism.

3.3.1 Trilateral market coupling (TLC)

TLC is an implicit market coupling initiative for daily cross-border capacity between Belgium, the Netherlands and France. The TLC was operated by the power exchanges of the three countries and was operational since November 2006. As such, the first implicit trading system on the European continent emerged. The TLC has been replaced by central western Europe (CWE) market coupling (CWE MC) on the 9th of November 2010 (15). Beside these market-coupling initiatives, in each of the seven described electricity regional initiatives additional coupling projects were implemented or are planned to be:

1. **Central east:** Markets of Hungary, Slovakia and the Czech Republic are coupled
1. **Central south:** Italy and Slovenia are coupled
2. **Central west:** Countries are coupled over central western European (CWE) initiative and are coupled with the Nordic region over the interim tight volume coupling (ITVC) initiative
3. **Northern:** Countries are coupled with each other under Nordic, over ITVC with the CWE region, over the NorNed cable with the Netherlands and over the SwePol-cable between Sweden and Poland
4. **South west:** Iberian market (MIBEL)
5. **FUI:** The IFA interconnector couples the UK with France, the east west interconnector connects UK with Ireland and on a cross-regional level through the BritNed cable linking the UK over Netherland with the CWE region. (16)

3.3.2 Cross-Regional Market Coupling

In a second step, different electricity regions are coupled through cross-regional coupling projects to inter-regional markets. The main cross-regional project is the NWE (north-western Europe) price coupling project. NWE price coupling aims at coupling the day-ahead markets across CWE, Nordic countries and Great Britain and later the Baltic countries and the SwePol link between Sweden and Poland. The project's lead is held by CRCC, a Cross Regional Coordination Committee of NRAs from CWE, the Netherlands and Great Britain along with a partnership between 13 TSOs and 4 PXs. NWE will cover 75% of the European electricity market, accounting for approximately 2,400 TWh consumption. As starting point, a coupling solution for the NWE project is developed under the so called (Price Coupling of Regions) PCR initiative. It is planned, that the different regional electricity markets (REMs) are joining the NWE market one by one. In 2013, the south west Europe (SWE) REM, central eastern Europe (CEE) REM and the Baltic countries are integrated. For the Integration of the different REM it is necessary that different regional market coupling solutions like ITVC are changed to fit the European solution of Price coupling. Over all, the NWE aims at optimizing the congestion management of more than twenty borders across thirteen countries and to maximize social welfare in the involved countries (17, 18, 19).

3.3.3 The EU Target Model

As described previously, electricity is traded in different ways. Unlike in financial markets, the spot market for electricity can be divided into an auction based market and an intraday market. The auction based market, often based on so called day-ahead auctions, trades spot market contracts for electricity deliveries for the next day. In the intraday market contracts, which lead to electricity deliveries within the same day, are continuously traded. In the Forward or Future market, Futures/Forwards with different maturities are traded. In coupled markets with an interconnector the available transfer capacity has to be traded according to the representative electricity contract. To clarify this issue, the European commission in cooperation with relevant stakeholders has developed a target model for market integration. The EU target model for market integration is a model that proposes a market design for forward, day-ahead and intraday markets for a single electricity market in Europe. The target model was developed by involving the European commission, regulatory associations like agency for the cooperation of energy regulators (ACER), national regulators (NRAs), TSOs and other relevant stakeholders. In December 2009 the establishment of the European target model for congestion management in electricity markets was approved by the European commission and relevant stakeholders at the electricity regulatory (Florence) forum. Since then, a basic framework on capacity calculation and congestion management was developed, which contains propositions on the handling of cross-border issues within a single European electricity market (20). The EU target model proposes two different methodologies to calculate available transfer capacity (ATC). For the day-ahead and the Intraday market the flow-based methodology is preferred. For the forward market the target model foresees both methods the ATC and flow-based approaches. The transfer capacity allocation for future markets is proposed to be done in explicit auctions via physical transmission rights (PTRs) with “use-it-or-sell-it” principle or via financial transmission rights (FTRs). In some cases, contracts for differences (CfDs) may be sufficient. The target model for the day-ahead markets is based on implicit auctions, specifically market coupling. It was agreed, that the model should be based on one single price coupling algorithm within the EU, the previously explained price coupling. For the intraday market the target is also an implicit allocation of capacity. Unlike in the day-ahead market the implicit allocation of transfer capacity is based on continuous trading instead of auctions (21). Based on the EU target model, the agency for the cooperation of energy regulators worked out framework guidelines on capacity allocation and congestion management (referred as CACM). The most important step of European market integration took place on 4 February 2014, when price coupling in NWE went live. It was the first initiative to use the pan-European PCR (price coupling of regions) solution for the calculation of prices and flows - the starting point for all other regions to join. At the time of the launch, NWE stretched from France to Finland and from Great Britain to German/Austria, covering the region of CWE, Great Britain, the Nordics and the Baltics. EPEX SPOT has provided a crucial role to this project, in close cooperation with other Exchanges and transmission system operators. Since the launch of NWE, two extensions of the PCR-coupled area have taken place: In May 2014, Spain and Portugal joined; in February 2015, Italy coupled with France, Austria and Slovenia. As a result, the now-coupled area is called multi-regional coupling and covers now 19 countries, standing for about 85% of European power consumption (22).

3.4 Market coupling in Austria

Austria consumes around 69TWh of electrical power per year, which is produced primarily by large hydroelectric plants in the Alps. Austria has one TSO and over 120 distribution network operators (DSO), of which 11 have more than 100,000 delivery points. Energy prices for Austrian consumers are around $0.26 per KWh, which is very close to the EU average (23). In Austria, the process of re-organisation started in 1998, in which – under EU directives – there was a gradual liberalisation. Today, the areas of electricity generation and electricity distribution are subject to competition and since 1 October 2001 the market has been opened to all customers. Austria has thereby liberalised faster than called for by the EU (24). In Austria, for the day-ahead and intraday marketing, implicit auctioning represents the target model based on CACM guideline. In this case, the available cross-border transport capacities and the energy are dealt with together (and so simultaneously) in order to avoid potential inefficiencies. With the exception of the border to Germany, all of Austria's borders with neighbouring countries are congested. There is congestion at the borders with the Czech Republic, Hungary, Italy, Slovenia and Switzerland. On the Italian (Austria-Italy) and Slovenian (Austria-Slovenia) borders, market coupling has already been successfully implemented (25). The Italian-Austrian, Italian-French and Italian-Slovenian borders have been coupled with the Multi-Regional Coupling (MRC), thus linking the majority of EU power markets–from Finland to Portugal and Slovenia. Capacity for the Italian-Austrian, Italian-French and Italian-Slovenian borders has been implicitly allocated through the PCR solution for the Day-Ahead markets, making those borders part of the MRC. This full price coupling allows the simultaneous calculation of electricity prices and cross-border flows across the region. This will bring a benefit for end-consumers derived from a more efficient use of the power system and cross-border infrastructures as a consequence of a stronger coordination between energy markets. With this achievement, cross-border capacity of all interconnectors within and between the following countries is now allocated in the day-ahead timeframe: Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Great Britain, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland (via the SwePol Link), Portugal, Slovenia, Spain and Sweden (26).

3.5 Market coupling in the Czech Republic

The Czech Republic takes part in the 4M market coupling together with Slovakia, Hungary and Romania since 2014. The members of this 4M MC project are TSOs, PXs and NRAs from all four countries, together with Polish TSO, PX and NRA as observers. They began the cooperation in 2012 and launched coupling on November 19 2014. The 4M MC is a day-ahead market coupling based on ATC method. It is using the pan-European PCR solution developed by several power exchanges across Europe. This means that the coupling procedures are compatible with those already running in NWE and SWE region, allowing smooth transition when coupling with NWE region. This stepwise approach seems to be the fastest way of market integration in slowly developing CEE region. In 2015, 4M began negotiating to join a Multi-Regional Coupling. The goal is to develop a flow-based coupling between both regions. The interim solution is joining the MRC on DE-CZ, CZ-AT and AT-HU border via NTC based coupling. Then, still planned in 2018, but it will be probably postponed, is to launch flow-based coupling between NWE and 4M (27,28).

3.6 Impact of Market Coupling on Market Power

Based on the literature review, by opening markets through an efficient allocation of transfer capacity, welfare and economic gains can be achieved. For instance, Pellini evaluates the replacement of explicit auction mechanism with market coupling in the Italian electricity market by applying a research methodology which is based on a deterministic simulation of the Italian day-ahead market under two alternative market scenarios. The simulations are done by using a model called ELFO++ which is a production cost-based model for simulating the outcomes of a liberalized day-ahead market with the option that the generation companies either sell their power output to a power exchange or over OTC contracts. By the use of market coupling the use of interconnection capacity can be maximized as it allows flows-netting and an elimination of inefficient arbitrage. The results of the paper support the theoretical view that market coupling provides a net welfare gain for market participants. The paper states for its reference scenario (weak electricity demand in the Italian economy and an overcapacity on the supply side) a net welfare gain of € 33m/year to € 396m/year for 2012. For a modelled high scenario (higher demand and higher cost of production) the estimated output ranges even between € 132m/year and € 741m/year for 2012. Thus, it is summarized that a high price area such as Italy could greatly benefit from the introduction of market coupling mechanism (29).

4 Conclusion

Transmission capacity allocation methods, is grouped into either explicit or implicit auctions. Implicit auctioning can be implemented over the two methods “market splitting” and “market coupling”. There is not necessarily any difference in the calculation algorithms or principals used for market coupling and market splitting. What differentiates market coupling from market splitting is how the algorithm is operated and owned, and which results from the central calculation the local markets use subsequently. Market splitting is not the same thing as the separation of markets. It is actually a form of congestion management. It is used to level out price differences. In market splitting the market operator splits the market into two or more bidding zones. This then results in a price difference between both markets. This transaction leads to a price increase in the exporting market and to a price decrease in the importing market. Market coupling is the implementation of implicit auctions in a market operated by cooperation of multiple PXs. Compared to market splitting, market coupling integrates transmission allocation and energy trading. It removes many of the inefficiencies at the day-ahead market, as well. Market coupling also has obvious benefit of improving net welfare of the whole system. However, it is demonstrated that the correct definition of bidding zones is a crucial element of market designing to ensure economically efficient and secure operation of the interconnected power system, as well as correct pricing of capacities. Splitting and coupling of bidding zones should be done in coordination (30).

Project Name	Description	ERI	Status
NordPool and Estonia	market splitting among Norway, Finland, Sweden and Denmark since 1999, extended to Estonia since April 2010	Northern and BS	On-going
Trilateral Coupling (TLC)	price coupling among Belgium, France and the Netherlands since November 2006	CWE	Ended and substituted by CWE coupling in November 2010
Iberian Electricity Market (MIBEL)	market splitting between Spain and Portugal since 2007	SWE	On-going
Czech Republic and Slovakia	price coupling between Czech Republic and Slovakia since September 2009	CEE	On-going
European Market Coupling Company (EMCC)	tight volume coupling between Germany and Denmark and Germany and Sweden since November 2009	CWE and Northern	Ended and substituted by CWE-Nordic ITVC coupling in November 2010
Central West Europe (CWE)	price coupling among Belgium, France, Germany (including Austrian area), Luxemburg and the Netherlands since November 2010	CWE	On-going
Central West Europe and Nordic Interim Tight Volume Coupling (CWE-Nordic ITVC)	tight volume coupling between CWE and Nordic market via: Baltic cable between Germany and Sweden, Kontek cable between Germany and East Denmark, DK West cable between Germany and West Denmark and NordNed cable between the Netherlands and Germany the since November 2010	CWE and Northern	On-going
Nordic and Polish market coupling (SWE-POL)	price coupling between Northern region and Poland via the SWE-POL cable between Sweden and Poland since December 2010	Northern and CEE	On-going
Italy and Slovenia coupling (ITA-SI)	price coupling between Italy and Slovenia since January 2011	CSE	On-going
Central West Europe and Great Britain coupling (CWE-GB)	price coupling between CWE and Great Britain via the BritNed cable between the Netherlands and Great Britain since April 2011	CWE and FUI	On-going

Table: Current and past projects of market coupling and market splitting cross Europe (31).

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