Zvonko Bregar, M.Sc.
Milan Vidmar Electroinstitute
Ljubljana, Slovenia

SLOVENIAN AND SPANISH ELECTRICITY MARKETS

Abstract

Spanish electricity market has served as a basic model in the construction of the electricity market in Slovenia. However, in the final phase of its development additional solutions were adopted from other European and worldwide electricity markets. The electricity market thus obtained is in some aspects more complex and in others simpler with regard to the original model. This article describes two of the new solutions on the Slovenian electricity market: the introduction of numerous standardized electric energy products (Band, Peak, Off-peak, Hourly power etc.) to be traded on completely separate markets, and the introduction of continuous, real-time type trading on all of them but the hourly market.

SLOVENSKO I ŠPANJOLSKO TRŽIŠTE ELEKTRIČNE ENERGIJE

Sažetak

Osnovni model konstrukcije tržišta električne energije u Sloveniji bilo je španjolsko tržište električne energije. U završnoj fazi konstrukcije prihvaćena su i dodatna rješenja iz drugih europskih i svjetskih tržišta električne energije, pa je dobiveno tržište stoga u nekim pogledima kompleksnije, a u nekim pogledima jednostavnije u usporedbi s početnim uzorom. Ovaj rad opisuje dva nova rješenja na slovenskom tržištu električne energije: uvođenje specijalnih proizvoda trgovine (bazna, trapezna, noćna, satna električna energija itd.), kojima se trguje na posve odvojenim tržištima, i uvođenje simultanog trgovanja, povezivanja ponuda prodaje i kupnje u samom trenutku davanja ponuda na svim tržištima osim na satnom.

1. INTRODUCTION

In September 1999 Slovenia adopted the Energy Act into its legal system. This act, among other things, introduced a whole new market-oriented concept of electric power system derived from Directive 92/96/EC. The same year saw the Slovenian Ministry of economic affairs issue a tender for Slovenian electric market rules. The task was assigned to MVEI. In January 2000 MVEI started the intense work of drafting market rules, which involved at that time comparatively new and broad fields that were still being developed. The resulting Draft Rules were based on the Energy Act. They were strongly influenced by the structure of the Spanish electricity market. [1,2]. In autumn 2000 the

process of creating the Slovenian power market was intensified by the operator Borzen. The company finalized the market rules before the official opening in April 2001.

2. SPANISH ELECTRIC POWER SYSTEM

In 2003, the total installed capacity of the Spanish electric power system (EPS) was 47,362 MW. Some 35 percent of the installed power were hydro-, 24 percent were coal-thermal-, 25 percent were oil-gas-thermal power, and the rest was nuclear power. In the same year, renewables, waste and cogeneration produced under special (looser) financial conditions came to additional 12,504 MW and 38,852 GWh. The annual total demand was 223,480 GWh. Some 32 percent were produced in coal units, 27 percent in nuclear-, 17 percent in hydro-, and 10 percent in oil/gas-thermal units, while renewable account for the remaining 18 percent. Only 0.5 percent energy was imported. [3]

2.1. Electricity Market

The largest amount of electricity in Spain is bought and sold at the large Spanish electricity market. To make this possible, prior to market opening on January 1st, 1998, a special system of financial treatment was introduced into the production units that use domestic resources in order to make them compatible with the units using imported resources. The stranded investments units also put their bids but their annual income cannot be lower than the annual income expected initially in non-market conditions at the time of their build-up, since in this case they would be paid the difference. [2]

During 2003, 228,571 GWh of power were traded for a total of 8,185 million Euros, a 9.9 percent increase in terms of power and a 11.5 percent decrease in terms of economic value with respect to the previous year. The 2003 weighted average final hourly price was 3.73 ¢€/kWh. [4]

Figure 1. shows the daily market price for a randomly chosen working day[1] in a recent past: Wednesday, September 15th, 2004. The data have been obtained from the Internet. [5] The demand ranges from 20,263 to 25,811 MW, while the market price ranges from 1.47 to 4.91 ¢€/kWh. Both curves follow basically equal trends: a low demand leads to a low marginal price, whereas a high marginal price is brought about by a high demand. This trend is the result of the fact that the marginal price essentially equals the bid price of the most expensive generation unit that is still required to cover the demand.

Figure 1. presents the 24 values of marginal prices for each daily market session. It also shows that there is only one electricity price for any given hour. The latter price holds for all sellers and buyers. A uniform price for electricity is recognized to band load generation units as to the necessary peak load generation units. The assumption is that both unit types provide the same service at any given hour and thus should get the same

[1] All Figures in this article are related to this date

compensation. Moreover, a uniform daily market marginal price implies a lack of price variation among participants – apart from bilateral contracts – with respect to the time of bid submission, as long as this was within the trading time.

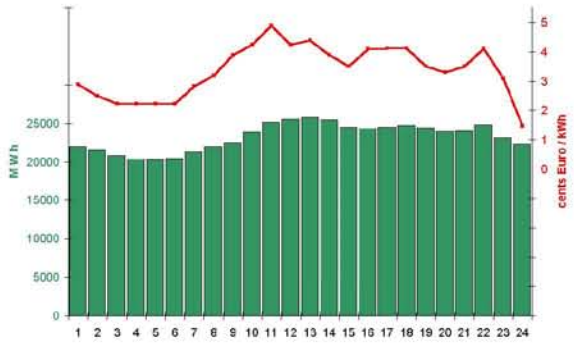

Figure 1. Demand, including the pumping power plants consumption [MW] (the bars) and the marginal price [¢€/kWh] (the line) on the Spanish electricity day ahead market, Wednesday, September 15th 2004

2.2. Ancillary services market

Secondary reserve bids are traded on the ancillary services market, which hosts a number of sellers and only one buyer: the transmission system operator. Figure 2. presents the results of this market for the same day as before. The reserve provided has two components: a positive and a negative one. The total ranges from –600 to 894 MW, which is slightly less than ± 3 percent of the peak demand 25,811 MW for that day. The marginal price for secondary reserve ranges from 0.90 to 3.01 ¢€/kW and has a similar dynamics magnified with respect to the total range of the secondary reserve.

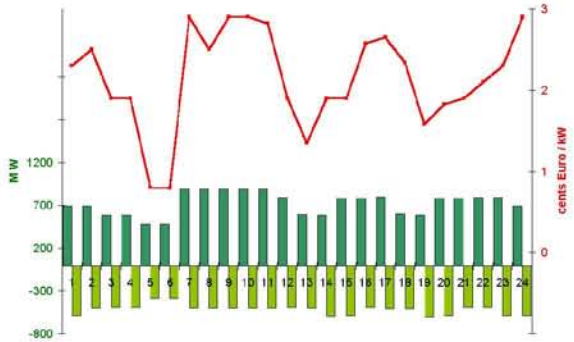

Figure 2. Secondary reserve range [MW] (the bars) and secondary reserve price [¢€/kW] (the line), Spanish electricity market, Wednesday, September 15th 2004

2.3. Marginal price calculation

Figure 3. presents the price calculation for hour 12 of the same day as before.

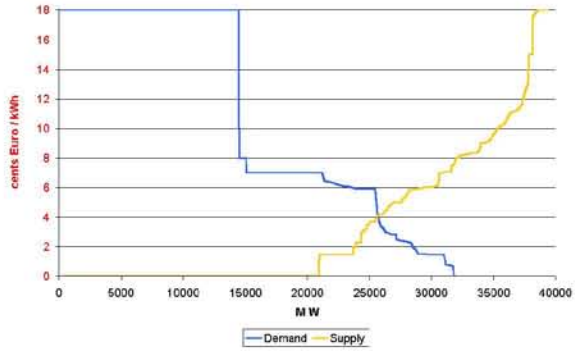

Figure 3. The matching algorithm marginal price calculation for the hour 12 [¢€/kWh], Spanish Electricity Market, Wednesday, September 15th 2004

The total demand curve has a falling shape, beginning at 18 ¢€/kWh – the current administrative maximum price for this market. Up to some 14,500 MW all buying offers are set up to the latter price. The fact that these offers do not specify the price on their bids demonstrates the preferences for the electricity in some segments of life and work. After 14,500 MW the curve breaks and falls rapidly.

The curve of total supply has a rising shape. Some 21,000 MW are offered at price zero (0). These are mostly run-of-river hydro-, nuclear plants and the minimum stable loads of other thermal units, including the minimum load of peak units (at peak hours). The fact that the rise of the total supply curve after 21,000 MW is much slower and more price-sensitive than is the fall of the total demand curve at 14,500 MW demonstrates that the Spanish EPS contains very diverse producing units.

Of course, the marginal price and the amount of energy traded at this hour are set by the matching algorithm at the point of intersection of the curves of total demand and supply. In our example - Wednesday, September 15th, hour 12 - the point falls exactly at 4.25 ¢€/kWh and 25,481 MW.

The procedure of marginal price calculation for any given hour using aggregated demand and supply curves can be implemented only if both the selling and buying offers are gathered first and processed later. Each step of the total demand and supply curves is made of at least one offer for buying and selling electricity, respectively. A joint treatment of all offers enhances the fairness and competitiveness of the market, since all offers for selling are confronted with all offers for buying electricity.

The marginal price of 4.25 ¢€/kWh in the above example is recognized as the system price (or simply the price) at this hour, at which all the electricity is sold and bought. The

system price is valid for all supplied electricity units, regardless of whether their offered price is as low as 0 ¢€/kWh or as high as 18 ¢€/kWh.

All bids for a particular hour, regardless of their unit type, are treated together, at the same market. The same matching algorithm applies to sell-bids of both band load units (the left half of the supply curve) and to of peaking units (the right part of the supply curve).

2.4. Coordination

Concerning the creation of the total demand and supply curves, the respective markets for each hour could be independent of each other. However, this is not so on the Spanish market. All 24 daily market calculations are performed simultaneously and afterwards, if necessary, repeated until the sufficient level of cross-coordination and verification among the bids is achieved (an iterative solution process).

Bids for buying or selling can be either simple or complex. Simple bids state only the price and quantity for each hour, whereas the complex ones may include one or several additional constraints, such as the ramps (the gradients), the minimum income conditions for selling bids, the maximum payment condition for buying bids, the number of minimum continuous hours of operation for selling bids, and the like.

In some cases, additional constraints do not allow a proportional division of bids: any bid can be either accepted or rejected, which considerably complicates the problem from a mathematical point of view. A solution is found in one step by applying the A* algorithm from the production systems theory. Each phase of the system is described by the chosen minimum income bids. [6] For the sake of simplicity, the matching algorithm can be described in two phases [1]:

1. First, all bids are treated as simple bids and a marginal price is determined for each hour as the point of intersection of the curves of total demand and supply, Figure 3.

2. Second, the elements of complex bids are considered. The results of the first phase are systematically confronted with complex bid requirements, which imposes new limitations, and the first phase is repeated until the requirements of the complex bids are observed in the results. Thus the second phase achieves a coordination between separated markets by hours, whereby the markets influence each other and become a whole.

2.5. Settlements

The accepted bids are determined by the intersection point in Figure 3. at 4.25 ¢€/kWh and 25,481 MW. Bids to the left of the intersection point are accepted (all at the marginal price) whereas those to the right are declined. Neither the identity of the participants nor the amount of the electricity traded between them are revealed at this point.

Electricity is both sold and bought on the market in accordance with the matching algorithm. The market organizer performs a public service of organizing the trade, and should not be involved as a participant in the trading process. To initiate the financial transfer from buyers to sellers based on the results of the matching process, the market organizer issues a monthly "financial certificate" (to be distinguished from a regular bill), which includes the value added and other taxes demanded by the state.

There is a special bank account intended for the buyers' payments (directed by the certificates). The market organizer by no means owns the account, they are only authorized to demand the financial transactions from the account to the sellers of electricity and to the state as specified in the seller's certificates. If a buyer should fail to pay on time, the organizer will execute the buyer's financial guarantees and take additional steps to protect other participants and the market.

3. SLOVENIAN ELECTRIC POWER SYSTEM

The installed capacity of the Slovenian EPS in 2003 was 2,456 MW. Some 51 percent of the installed capacity were thermal, 35 percent were hydro, and 14 percent were nuclear power. The final consumption reached 12,677 GWh. About 40 percent were produced in thermal-, 24 percent in hydro units, and 20 percent in the nuclear unit. Ca 16 percent electric energy were imported. [7]

Spanish system is over 15 times the size of the Slovenian system, which, in addition, imports large amounts of electric energy. However, the diverse energy generation sources structure of the latter is comparable to the structure of the former.

The total electric energy traded on the Slovenian electricity market in 2003 amounted to 386.9 GWh, which represents a 45 percent increase with regard to the previous year. In the same period, the overall annual average price rose by 52 percent, reaching 3.59 ¢€/kWh – presumably due to a very hot summer. Most of the trading – as much as 94 percent - was executed in form of the Band energy standardized product (see section 3.2.). The total financial value traded amounted to some 16 million Euros. [10]

Figure 4. shows daily market prices for the same day as Figure 1. Wednesday, September 15th 2004. The data have been obtained from the Internet. Total energy traded on that day was 677 MWh, out of which some 64 percent on the Band power standardized products market (see section 3.2), 17 percent on the Peak power market, 11 percent on the Euro-peak power market, 5 percent on Hourly power markets, and 3 percent on the Off-peak power market.

3.1. Continuous trading

In pre-trading period the participants can place their bids, [9] Art. 78, Art. 92 and Art. 93. Before being processed, the bids are placed in the order book and used as the basis for calculating the starting price at the beginning of a new trading session. The starting price

varies in the course of a trading season. This is the reference price that is displayed to participants.

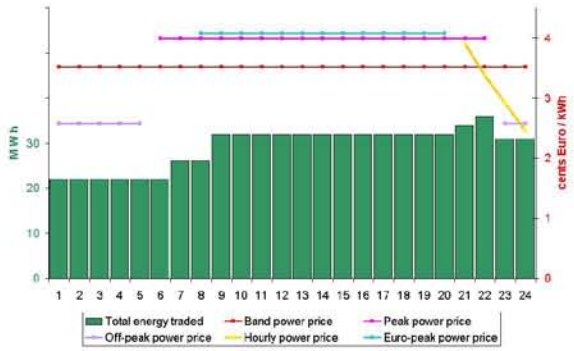

Figure 4. The total energy traded [MWh] (the bars) and the various weighted-average standardized products prices [¢€/kWh] (the lines) on the Slovenian electricity market, Wednesday, September 15th 2004.

Continuous trading implies matching the bids to the greatest possible extent at the very moment of their submission, [9] Art.98. There are two basic types of bids: those for selling electricity and those for buying it. Although each bid should specify the amount of electric energy and the price, it is possible to place market bids for selling at price 0 or for buying at the administratively determined maximum market price, [9] Art.61.

Any bids that for any reason have failed to be matched are placed in the order book. When a new bid is received, it can be either matched (entirely or partially) to the existing bids in the order book, or – if it fails to be matched for the time being – placed in the order book.

If the new bid is of a different type from the previous bid(s) on the opposite side of the order book, it can be instantly matched with them provided that the sell-bid price is lower than the buy-bid one(s) for the attempted contract(s). If the size (the amount) of the new bid equals the size of the previous bid, it is a perfect match and an appropriate contract can be determined between the two participants. However, since the consecutive bids are usually of different sizes, the matching is only partial, and an amount of energy remains unsold. If the new bid is smaller in size than the previous one(s), a part of the previous bid remains in the order book. Alternatively, if the new bid is larger in size than the previous one(s), a part of the new bid remains in the order book. Changes in he current reference price reflect each total or partial match using a simple 4 × 3 table of rules, Figure 5. [9] Art. 98. If the new bid is contracted to several bids from the order book, the settlement price is calculated as a weighted average. If the new bid is of the same type as two consecutive or waiting bids in the order book, no matching can be done, and the new bid is placed in the order book.

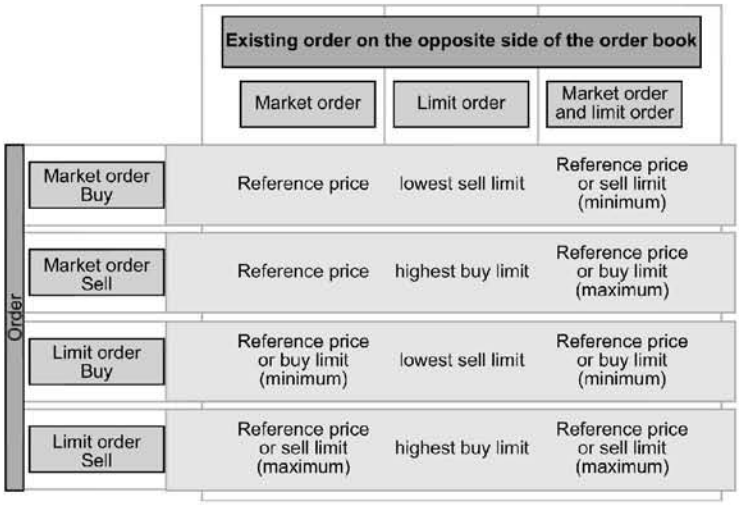

Figure 5. Matching in continuous trading, the rules of pricing, [12]

Such a trading procedure is both logical and efficient. At each step of the procedure, the identities of both the producer and the consumer of electricity, as well as the amount of electricity traded, are quite transparent. All contracts recognizing such transactions can thus be set up strictly between the participants, without the market organizer's intervention. However, such a solution would not be practical. To prevent numerous billings of each partial matching, the multilateral clearing approach is used on a daily basis. [10] Participants transfer their market-results-based financial rights and obligations to the market organizer. In this financial settlements interpretation, the market organizer is viewed in turns as a buyer (by the sellers) and as a seller (by the buyers). [11]

In continuous trading, price changes over time reflect the matched contracts between participants. The participants view the price and make their decisions about future bets on the basis of the current price. To protect the participants, the variation may not be greater than ± 60 percent of the starting price or ± 30 percent between two consecutive transactions. ([9] Art. 62 and Art. 63) If the price hits its limit, appropriate action is taken. ([9] Art. 70 and Art. 71.)

As a current deal between any seller and buyer is recognized on the continuous trading market, some of the bids have been matched in previous transactions and are thus no longer available. The bids which are yet to be received by the end of the trading time are also unavailable at the time since they have not been sent yet. Consequently, on a continuous trading market a bid is confronted indirectly (through the price-changing mechanism) to all previous bids, and directly to several previously unprocessed bids in the order book.

3.2. Standardized products

Art. 67 of market rules [9] introduces a perfectly logical concept of standardized products (Figure 6.) to be traded with[2] on the daily market for the next working day:

- Band power, from 0:00 to 24:00; the minimum amount that can be traded is 24 MWh;
- Peak power, from 6:00 to 22:00; the minimum amount traded is 16 MWh;
- Off-peak power, from 0:00 to 6:00 and from 22:00 to 0:00; the minimum amount traded is 8 MWh;
- Hourly power for any given hour in the day; the minimum amount traded is 1 MWh;
- Euro-peak power, from 8:00 to 20:00; the minimum amount traded is 12 MWh; and
- Euro-off-peak power, from 0:00 to 8:00 and from 20:00 to 24:00; the minimum amount traded is 12 MWh.

Trading with any standardized product is carried on completely separate markets, [9] Art. 76 for Hourly power and [9] Art. 90 for all other standardized products. There are also various other kinds of market[3]: the preferential dispatch market, the transmission rights market, the network losses market, the woody biomass market, the emission allowances market, the green certificates market, the guarantees of origin of electricity from renewable sources market etc. Trading with Hourly power standardized products is carried out by means of constructing aggregate supply and demand curves and by calculating a marginal price as in Figure 3, [9] Art. 76, whereas trading on all other markets is carried out continuously, as presented in section 2.1, [9] Art. 90.

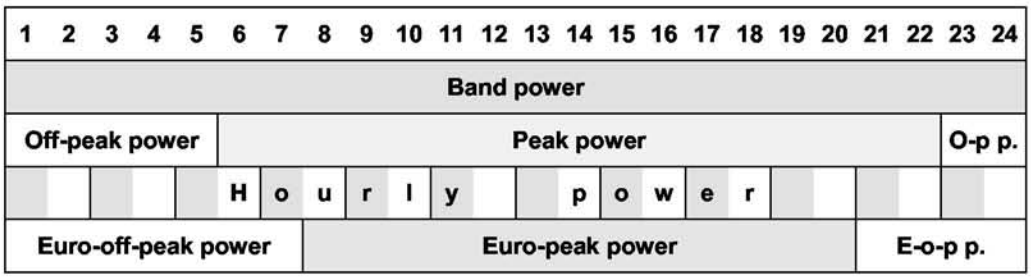

Figure 6. Standardized products on Slovenian electricity market

The classification of bids into individual markets reduces the number of bids on each market. In order not to jeopardize the competitiveness of any market, it should be seen to it that the overall number of bids is large and that the bids are distributed as evenly as possible among different markets. Clearly, this construction allows plenty of room for the

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[2] The Euro-peak and the Euro-off-peak power standardized products have been introduced recently (in May 2004)

[3] Some of these existing and some planned for the near future.

enlargement of the market in years to come, which is likely to occur due to very good interconnecting lines of Slovenian transmission system and due to future electricity market opening reforms all over Europe, [13].

Different markets yield different average marginal price levels during a daily market session. The lowest price levels are to be expected on the Band power market and on Off-peak power markets. The expected selling bids at these markets mostly concern electricity from run-of-river hydro- and nuclear plants, and the minimum stable loads of all other thermal units that may be offered at very low prices, Figure 3. In terms of price, this is a desired market to buy electricity on, but an undesired one to sell it. The opposite is true of Hourly power energy markets at the peak hours of the day, which are the most desired markets for selling and the least desired for buying.

The average price level differences thus provide hints to buyers, sellers and resellers as to where to place their bids to achieve maximum benefit. This promotes both flexible generating units which can produce at the peak hours, and the buyers who can shift their supply to off-peak hours.

Every participant has his or her preferences as to where to put their bids. However, in placing their bids the participants should anticipate also the overall demand and the technical characteristics of their generation or consumption units since they are required to accept and execute the market results strictly, [9] Art. 39.

4. CONCLUSION

Slovenian electric market has overcome its early difficulties and gained a fair amount of operational experience since its opening in April 2001. Though its energy traded volume is comparatively small, it is expected to rise significantly in the following years. Technical conditions for achieving this goal are very favourable, as Slovenia is very well connected to the neighbouring countries. Additional drives towards the expected growth are the processes of opening and deregulation of European electric power systems, in particular the activities related to the construction of a regional South-East European energy market. [13] These predictions are in line with the creation of the HSE Group, which integrates ten (mostly generation) companies and presents a unified front to the market. The present article has outlined two features of the Slovenian electricity market – the introduction of numerous standardized electric energy products and the prevailing usage of a continuous type of trading – and compared them to the Spanish electricity market.

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