SPANISH POWER EXCHANGE MARKET CONCEPTS AND OPERATING EXPERIENCE

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On January, 1st, 1998, the Spanish Electricity Market started operations. All generators, distributors, commercialization companies, and final consumers negotiate all power exchanges either through the spot market or using bilateral contracts. The Spanish Power Exchange Market Operator (Compañía Operadora del Mercado Español de Electricidad, OMEL) is responsible for the management of the market and for the economic settlement and billing of all transactions on the Power Exchange market, and the technical operational processes handled by the System Operator.

This paper describes in detail the Spanish market principles and the experience gathered through the design, installation and first two years of market operation. The paper presents also the Spanish market results from January 1998 up to December 1999 indicating each specific market results and aggregate statistics.

INTRODUCTION

Historically, the supply of electricity was carried out in Spain by a conglomerate of privately owned vertically integrated utilities. Generation, transmission and distribution were owned and managed by the same utility over a certain area. Back in 1985 a public company was created with two roles, to own, plan, maintain and operate the high voltage transportation network, and to schedule all the Spanish generation plants through a global standard per plant cost optimization process. To achieve the first objective, all the preexisting utilities sold their transportation assets to this company.

At the end of 1997, a new Electricity law (54/1997) was released. It establishes a new legal and institutional framework for the electricity sector trying to achieve a triple objective: To guarantee the electricity supply to all consumers, that this supply is made under certain quality conditions, and to reach the two previous objectives at the minimum cost for the end consumer. The law bases the achievement of the objectives on the decisions of the economic agents that are part of the electricity sector, instead of being based on the traditional cost optimization concept.

The main principles of the liberalization process are:

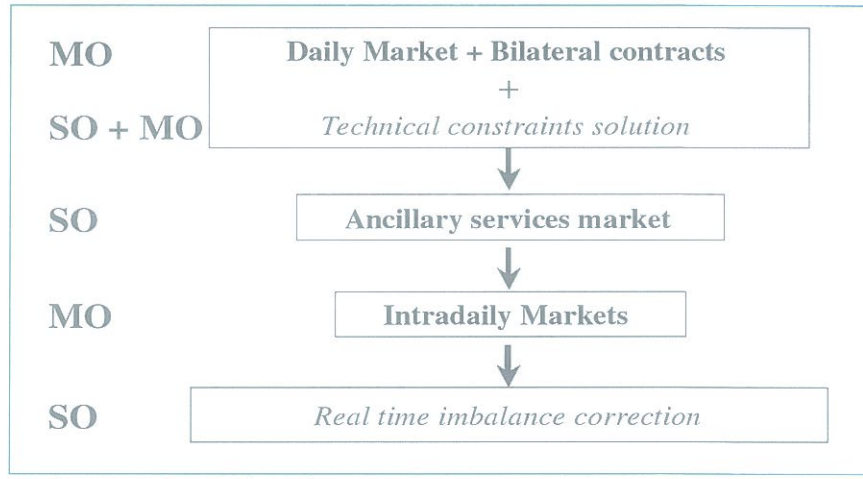
- Free access for new generation capacity
- Primary supply sources for electricity production will be negotiated on the basis of voluntary agreements
- Setting-up a competitive power production market
- Supply contracts liberalization will be gradually introduced to reach a substantial level of opening-up of the market
- Regulated TPA for eligible consumers and distributors for the use of transmission and distribution grid
- Electricity resale will be independent from other electricity activities. Commercializators will be authorized
- Promotion of renewable energy sources

The new law started to be in operation January 1st 1998 and it establishes two privately owned companies to manage the economic and the technical part of the electricity system respectively. This paper deals essentially with the economic management of the electricity business in Spain, although some references are made to its technical operation.

SPANISH ELECTRICITY PRODUCTION MARKET CONCEPT

The electricity production market is composed by four independent, although interrelated markets and processes (Fig.I):

- *The daily market*, managed by the Market Operator (MO), This is the main Spanish electricity market. The



F-I: *Electricity production market and processes*

bilateral physical contracts are also integrated on it. This market also includes the technical constraints solution process that is done in cooperation by the MO and the System Operator (SO).

- *The ancillary services market,* managed by the SO, handles the necessary ancillary services

- *The Intradaily market,* managed by the MO. It gives the agents the opportunity to adjust the previous market results to the changes on the delivery/production situation.

- *The real time imbalance correction process,* managed by the SO. It takes care of the generation/load imbalances that appears on real time and have not been resolved freely by the agents on previous markets.

Two important characteristics of the Spanish Electricity Market are:

· All transactions are firm and will be settled and invoiced by the MO.

· All markets and processes are paid at the marginal price fixed on the particular market or process.

The Market Operator (MO) company functions: The main responsibility of the company is the economic management of the system. As part of this responsibility, the daily market and the Intradaily markets are operated by the MO, together with the settlement of all the non regulated activities of the electricity sector.

The main functions of the MO are:

- Receive and accept energy bids.
- Determine marginal prices and energy assigned on each market.
- Settlement of the entire MO and System Operator (SO) set of transactions.
- Billing of all settled transactions.
- Publish information regarding market results
- Propose enhancements to the market rules

All the MO Electricity Market actions are done according to the market rules, which are public and downloadable from the MO public WEB site www.omel.es

Agents in the Spanish Electricity Production Market: Agents are companies or qualified consumers that can act in the Electricity Production market (Fig. II). The agents are:

Generators: All the generators bigger that 50 MW, that have not contracted the unit (totally or for the contracted part) on a bilateral physical contract, must present bids every day to the daily energy market. Smaller generation units can also participate, if they decide to do so, on the market.

Distributors: They are the only agents authorized to sell energy at regulated tariffs. They have to purchase all energy in the market and can not get it from bilateral physical contracts..

Commercialization or reseller companies: They submit bids to the market to purchase the energy. The energy that a commercialization company obtains in the market can be sold to an end "qualified consumer".

Qualified consumers: For a consumer to be considered "qualified" today he must have an annual consumption above 1 GWh and by next July 2000 every consumer that is connected to the network at more than 1kV will be considered "Qualified". This type of consumers can purchase energy in four ways, at their choice, mixing them, if they want:

- While the regulated tariff exist; from the tariff.
- Through a commercialization company.
- From a generator using a physical bilateral contract between the two parties.
- Directly from the electricity production market.

External agents: Agents from other countries can act in the Spanish Production Market, if they obtain the administrative authorizations that will be granted based on reciprocity conditions. Once they are authorize they will act as generators, commercializators, or qualified consumers.

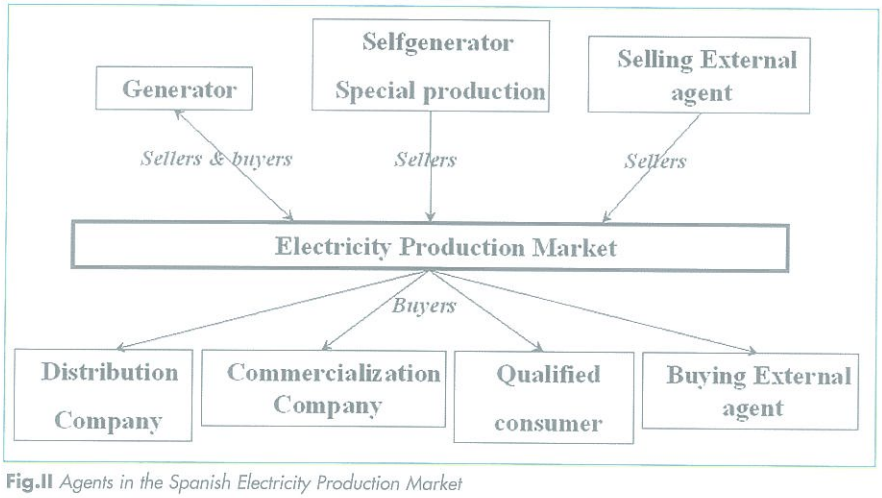


Fig.II *Agents in the Spanish Electricity Production Market*

POWER EXCHANGE MARKET

As already indicated, the two main markets operated by the MO are the day ahead market (Daily Market) and the Intradaily market.

A) Daily market organization: The market is organized as an spot day ahead market, therefore, prior to 10 a.m., each day, all the energy bids for the following day must be presented by the agents to the MO. The market is organized on an hourly basis so the bids and the energy assigned will be hourly energy blocks. The results are given to all participants prior to 11 a.m. including the daily energy values that the parties of the bilateral contracts communicate to the market that they will execute the following day.

Selling bids are presented to the daily market by generators for all their available capacity, and for every hour (except the capacity that is dedicated to a physical bilateral contract on each hour). Independent selling bids are presented, and scheduled later on, for each physical generation unit, except in the case of Hydro units where all the units that have to be scheduled in a coordinated way, due to the water flows in between them, can be presented as a single bidding unit to the market.

Distribution companies present purchase bids, commercialization companies, generators, and qualified consumers.

In the daily market sellers and buyers present only one bid per bidding unit.

Each daily market bid could be divided in up to 25 energy blocks for each hour of the next day (the maximum number of energy blocks that a bidding unit can submit is therefore 24x25).

Selling bids are allowed to incorporate to the bids two different kinds of complex conditions:

- Conditions to single blocks (indivisible block)
- Transversal conditions that impose restrictions for the whole daily bid of the bidding unit (minimum income for the bid) or for some blocks (maximum ramp rates between hours)

In order to preserve the transparency and the fair consideration of all agents, irrelevant of their size and the number of units that they own, the complex

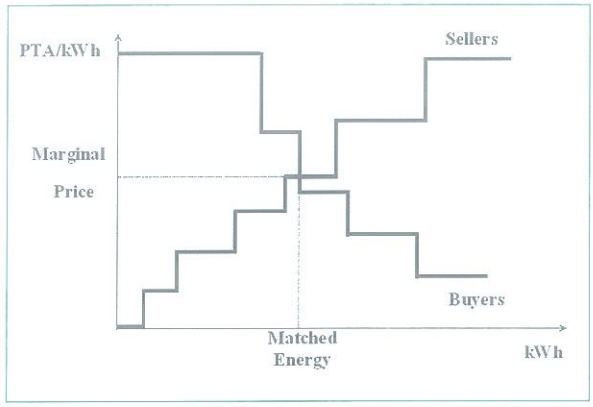


Fig. III. *Each hour Simple Matching Process*

conditions are handled by the matching algorithm in such a way, so as to insure that never a complex condition will make the bid to match more energy than the same bid considered as simple.

B) Daily market price determination (matching process): The objective of this process is to provide marginal prices for each hour and energy assigned each hour to each biding unit. The solution to the daily market, including the hourly marginal prices is the unconstraint solution, without taking into account the network situation. These hourly-unconstrained prices will be the ones fixed for the daily market and it will be the prices paid by all buyers and earned by all sellers in each hour.

To obtain the results the sellers and buyers curves are formed (actually they are step curves) and the marginal price will be determined by the point where both curves cut.

The matching algorithm for an hour in which there are only simple bids is represented in Fig.III.

The complex bid conditions are satisfied in the way described in the following steps, ensuring always to reach a viable solution, if it exists. The matching algorithm does not try to optimize the solution; it simply tries different combinations but keeping always in mind that a complex condition should never help to allocate more energy to the bid, as compare to the energy assignment that the bid will get without the complex conditions (Fig. iV).

- Step 1. Simple price setting

All bids are considered as simple ones, without any complex condition. A solution (the simple solution) is obtained.

- Step 2. First Viable Solution

Starting from the former solution, complex conditions are considered. Energies allocated to each unit are modified to fulfill their complex conditions. At the end of the process, a solution that meets all such restrictions is obtained.

- Step 3. Search of the Final Solution

Once a viable solution has been obtained, the algorithm searches in the solutions space for another viable solution, which increases the participants' satisfaction with the results. The participants' satisfaction has been measured as the minimization of the benefit that the units out of the solution would obtain at the solution market prices. The final solution is the one on which no unit out of the solution would fulfill its complex conditions at the solution's market prices (benefit obtainable equal to 0). When searching in the solutions space, the solutions first tested are those which show, at the previous market prices, the minimum distance to the final solution (minimal benefit obtainable at such prices by the units which are out of the solution).

C. Intradaily market organization: Once there is a technically viable daily schedule published, the MO starts to run several sessions of the Intradaily market, to provided the agents with a market in which to negotiate the voluntary adjustments that they wish to. The Intradaily is a voluntary market where no agent has the obligation to participate.

The intention is to run a session of the Intradaily market each hour, but at the end of February 2000 there are only 6 sessions with the following time horizons (28 hours, 24 hours, 20 hours, 17 hours, 13 hours and 9 hours). The number of sessions will be increased when the procedures are optimized and simplified, and the agents request more sessions.

In any of the Intradaily market sessions, any of the agents (sellers or buyers on the daily market) can participate making several bids (selling or buying energy). The only condition is that distribution companies, commercialization companies and qualified consumers, should have participated in the corresponding session of the previous daily market.

The bid structure and the matching processes of the Intradaily market are similar to the daily process except for the fact that the solution will be added to the previous market results, and that some of the complex conditions, like gradients as an example, need to be applied over the complete schedule (previous market plus the current Intradaily result).

Each bid to the Intradaily market could be divided in up to 5 energy blocks and, as already indicated, any agent could present as many bids as he wants for the same unit, mixing selling and purchasing bids.

D. Intradaily market price determination (matching process): The objective of this process is to obtain marginal prices for each hour of the session horizon and the corresponding bid energy assignments. As in the daily market, the solution will not take into account any network constraints. The matching process is similar, but it is important to note that in order to fulfill

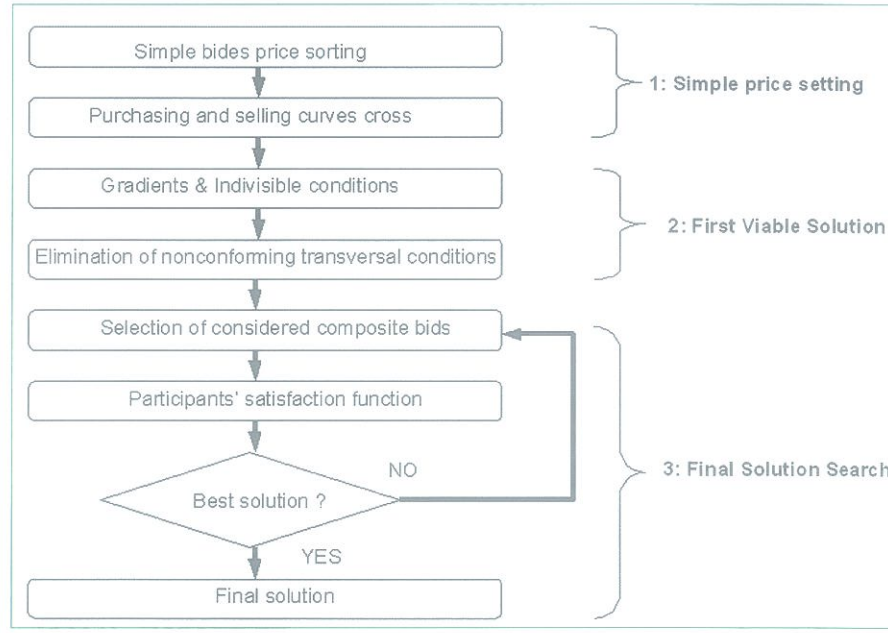


Fig.IV. *Daily Matching Algorithm*

a complex condition of the Intradaily assignment, it is not possible to remove any of the previous markets assignments since, as indicated, all transactions are firm in all markets and processes.

Once the unconstrained Intradaily market results are encountered they are sent to the SO to check the viability of the transactions. The SO will eliminate from the result the nonviable transactions and will balance the schedule again, respecting the economic merit order of the Intradaily bids.

POWER EXCHANGE INFORMATION SYSTEM (PEIS)

A) Design principles

When the Spanish Power Exchange Market started its operation the 1st of January, 1998, it was the first European market implemented after the 96/92/EC directive, although prior to the EC directive, the England and Wales and Nordic markets, were established. The Spanish regulatory law had just been put into effect and some of the market areas were still not fully defined. There was a need to look for a fast-to-implement and easy-to-maintain and to evolve solution for the application to be developed.

This solution should at least include the following functionality:

- Receive purchasing and selling bids
- Obtain the market price for each of the considered periods
- Provide market agents with all information needed
- Produce all settlements and clearinghouse activities
- Interchange information with external bodies (SO, mainly)

At the same time, the market was expected to accept in a short time a huge number of potential agents, most of them, demand side customers, not used to operating in the power system and with little experience and knowledge on the IT field. A simple, reliable and easy to maintain solution was therefore needed for the agent's client side.

Moreover, and due to the special importance of the information transmitted (offer bids, acceptance information, etc.) and its economic consequences, special measures had to be considered regarding the security and confidentiality of the information transmitted and the application reliability.

As a consequence of the above points, internet technology was chosen as the cornerstone of the chosen solution. All system accesses are done through the use of a standard browser without requiring any special software product at the agent side. Fig V, presents the resulting system configuration.

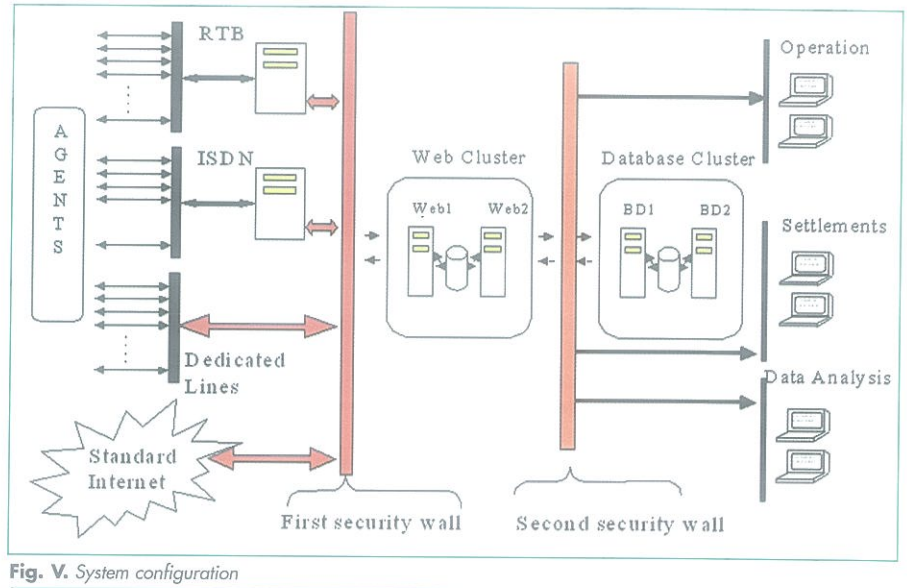


Fig. V. *System configuration*

PEIS is built on a star configuration. All external agents accesses to the system are done through the Web Server cluster.

The server connects to the database for introducing or accessing information. All information related to the market is stored in the database. A double firewall protection ensures system security.

Four alternative communication means have been introduced:

- Analog phone lines
- ISDN lines
- Internet
- Extranet (direct lines)

Each agent, depending on its particular needs, may choose the mean which better adapts to his needs, from communicating through a standard internet connection, to a private direct line. All communication channels and equipment are duplicated and switch automatically in case of failure.

The OMEL system was the first Power Exchange system to be implemented based on digital signature techniques. A Public Key Infrastructure (PKI) system, based on smart cards with authentication certificates is used to ensure security during data transmission and data privacy between agents. The application makes extensive use of secure http protocol following the Secure Sockets Layer (SSL3) standard.

A) System Architecture

PEIS has been built as a database centered application. Every action performed in the system is done through the database, which keeps a log of the time and its actor. All market processes (price setting, settlements, etc.) store there their obtained results. All information needed by the agents is accessible through established queries to the same database.

Fig. VI presents the graphical representation of PEIS's architecture. It includes five main subsystems:

- *Agents client application.* It provides the client application for the agents. It allows them to submit bids and related information to the market

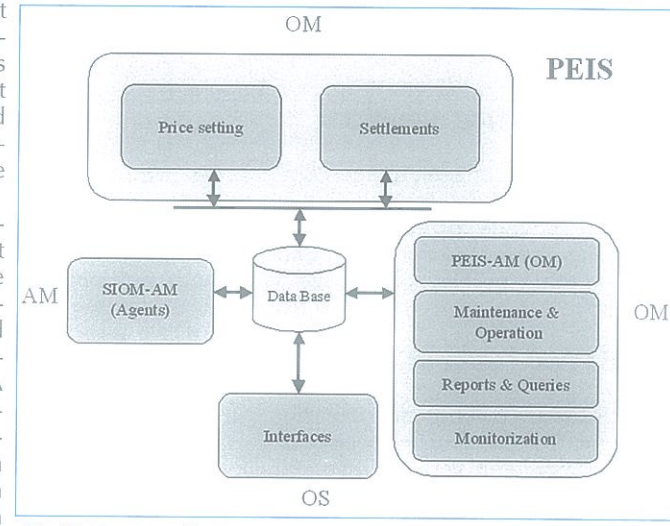


Fig VI. *System architecture*

and provides agents with an easy-to-use interface to access all market results and settlement information

- *Price setting subsystem.* Responsible of producing the matching between the purchasing and selling bids for both the daily and hour-ahead market.

- *Settlement subsystem.* Responsible of producing all market economic annotations, including the direct market ones and those produced in the ancillary services managed by the SO. It also takes care of the whole market billing process.

- *External Interfaces.* In charge of providing all market with relevant information to the related bodies (SO, specially) and receiving information from them (schedules, measurements, etc.).

- *Operation & consultations subsystem.* Which provides the facilities to operate the market, continuously access to the produced results, monitors the correct functioning of all infrastructure and applications, and includes facilities for producing value-added information from the database.

B) Agent-Client Application

The Agent client application is fully based on internet technology making use of dynamic HTML pages, JAVA and JavaScript code and specific plugins. At the client side, the agent only needs an standard browser to communicate to the market. Specific parts which must be run at the client side (plugins, Java code) are downloaded from the server.

Special care has been taken in relation to application usability considerations. Following this path, most common functions and queries are accessible form the direct access menu and all market relevant information may be downloaded from the server as an HTML page or as a formatted easy-to-treat file.

C) Price Setting Algorithm

In spite of its complexity, the algorithm is capable of finding a solution in about 10 seconds for each session. During the months in operation, in no occasion this time has gone above 3 minutes.

FIRST TWO YEARS RESULTS

The Spanish Power market behavior during the first two years of operations can be considered very positive. All the scheduled sessions have taken place and prices and energy schedules have been produced according to market rules every day. Despite a few volatile prices during the first days of the market, the prices and the energy schedules could be considered very reasonable. During the last months new commercialization companies have appear in the market and new qualified consumers are starting to obtain their energy in the market.

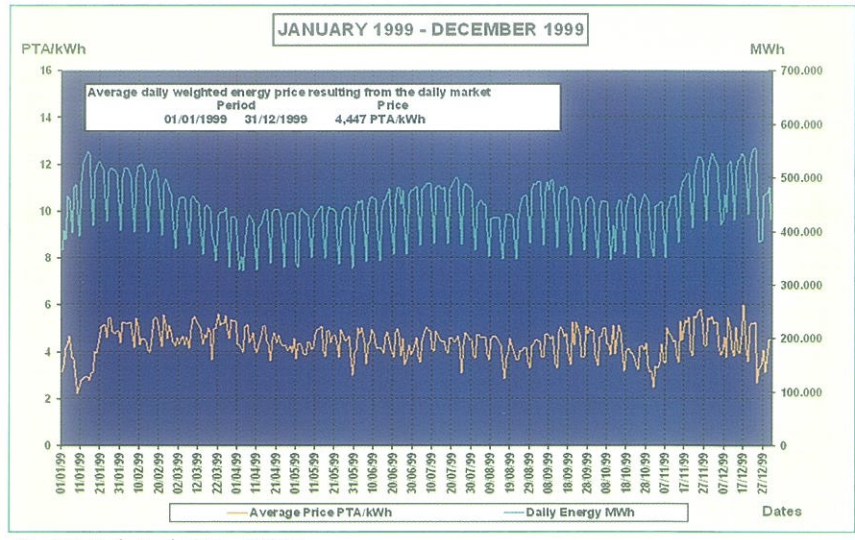


Fig. VII *Daily Market Prices (1999)*

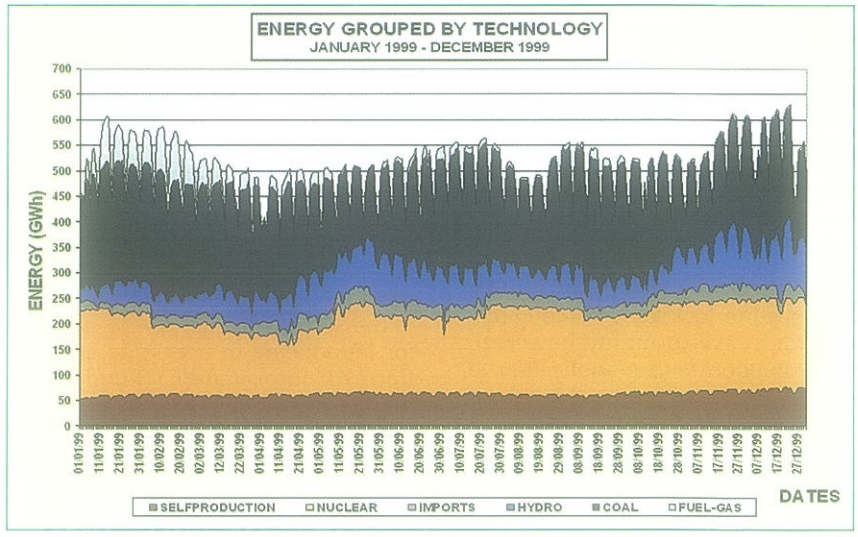


Fig. VIII *Generation technology in the daily market (1999)*

In the next graphics (Fig. VII and Fig. VIII) the results of the daily market are represented indicating the market energy volumes and average daily prices. The results are represented in Figure VII on a daily basis. Prices are represented in PTA/kWh.

The differences between the maximum and minimum hourly prices are in the order, as an average, of 2-3 PTA/kWh. As indicated before, the market results are published daily on the company public WEB site.

Fig. VIII represents the amount of energy produced each month with the different technologies.

Trading in the electricity market

During 1998 and 1999, two first operating years of the electricity market, markets and processes were fully operational, as shown by the volume of power traded, the monetary volume of trading, the development of the Intradaily market and the increase in consumption at free prices.

The power traded for the whole of the electricity market in 1998 amounted to 168,444 GWh, with a value of 924,577 million pesetas including the final measurements. During the year 1999 the provisional values are 179,539 GWh and 1,014,892 MPTA respectively.

The amount of power traded is influenced both by economic activity and a seasonal component that determine fluctuations in the energy traded, with their corresponding economic volumes.

Monthly averages of 14,037 GWh and 77,048 million pesetas were traded in the production market during 1998, and 14,962 GWh and 84,574 MPTA during 1999.

The monthly average number of contracts in all the market production sessions and processes has reached

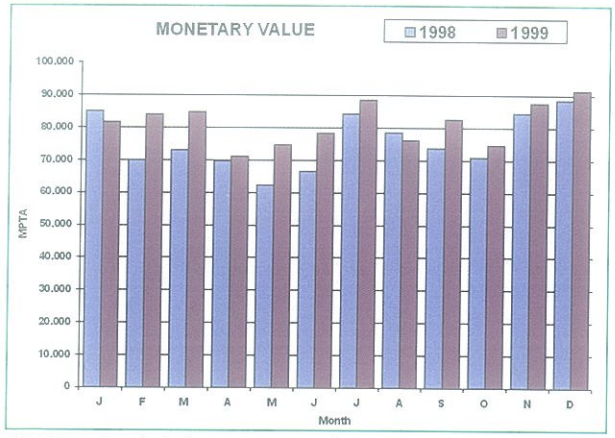


Fig IX *Total traded volume. Economic Value (MPTA) Years 1998- 1999*

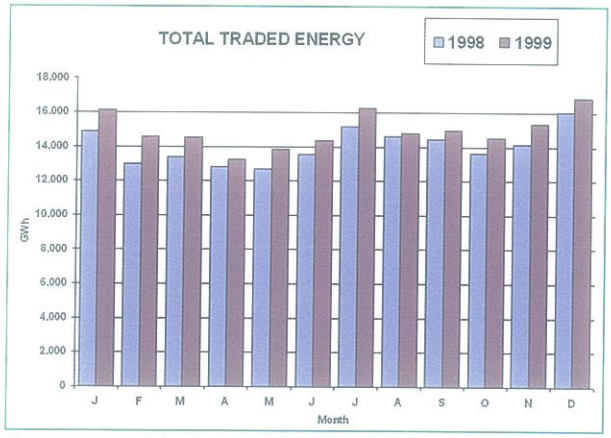


Fig. X *Total traded volume GWh.Years 1998 - 1999*

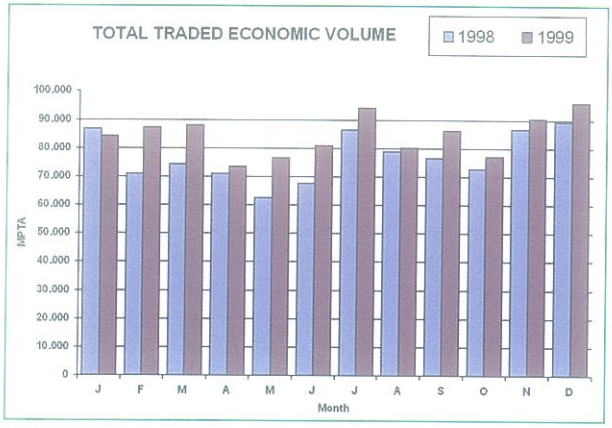


Fig.XI *Net. Economic Volume (MPTA). Years 1998- 1999*

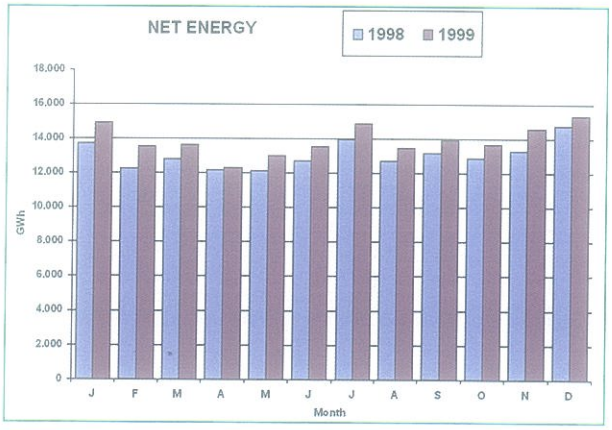


Fig. XII *Net energy (GWh). Years 1998 - 1999*

Fig. XIII *Final average price (PTA/kWh).Years 1998 - 1999*

270,000 with a daily average of 8,870 transactions. The net economic volume in 1998 was 907,626 MPTA and the net energy 156,521 GWh. It means that the final average price was 5.80 PTA/kWh.

In the year 1999 the economic volume was increased 7,57%, the net energy 6.6% and the price 0,8%.

The total amounts were 166,802 GWh, 976,128 MPTA. This figures are provisional and do not include the final measurements.

SETTLEMENTS

The settlement of the electric power production market is the process by which OMEL determines, on the basis of the final price for each market participant, the final amount to be paid by the buyers and to be collected by the sellers. Settlement also includes the notification of payment obligations and collection rights and the corresponding invoicing.

A) Determination of the final price

OMEL calculates the final price of energy on an hourly basis, and includes the following elements in its calculation:

- Daily market matching price
- Cost or income resulting from the process of solving technical constraints
- Cost or income from the ancillary services market
- Intradaily market matching price
- Cost or income from the power guarantee
- Cost or income from system technical operation processes
- Surplus or deficit from the international contracts signed by Red Eléctrica.

OMEL makes the settlement by using the information resulting from the matching processes in the daily and Intradaily markets, from the solution of technical constraints and from the information that the system operator places at the market operator's disposal, regarding the processes for which is responsible.

Thus, each market participant has a final hourly price function of his participation on each market and technical operation processes.

B) Monthly settlement procedure and time limits

Each day the market operator places the settlement corresponding to the elapsed period of the month at the participants' disposal. With all these data the monthly settlement is calculated together with the corresponding notifications of collections right and payment obligations.

The processes of settlement by the market operator, the settlement verification and the claims filing, if any by the market operator, must be accomplished within a time limit of three days for each process. These processes and time limits are common to the daily and monthly settlements calculated.

The collections and payments must be made on the last business day of the first fortnight of the month following the month to which the settlement corresponds.

Collections and payments are done through a special bank account opened by OMEL for this purpose.

FUTURE

Several changes are expected to be introduced in the Spanish Power

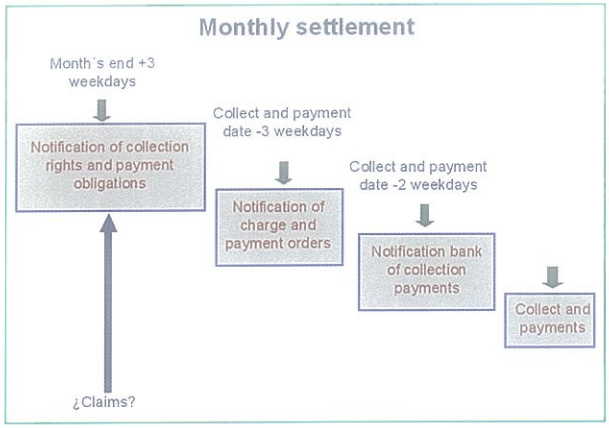


Fig XIV. *Monthly settlement*

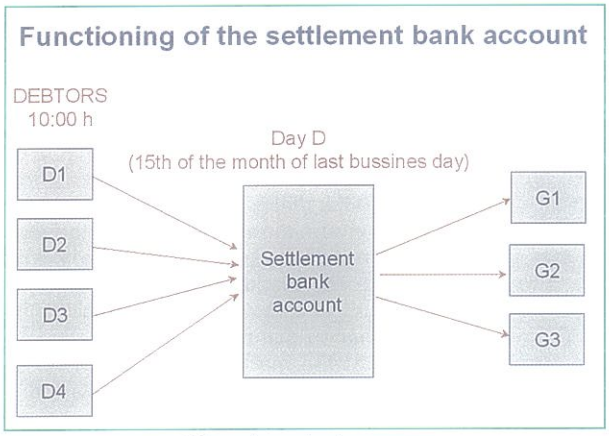
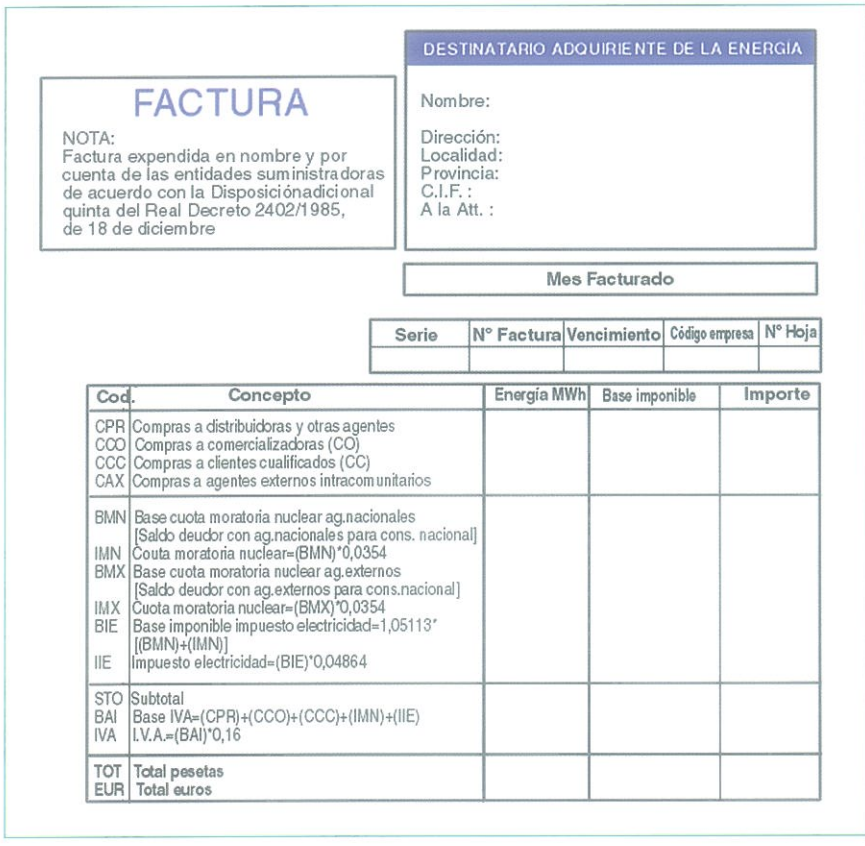


Fig.XV *Functioning of the settlement bank account*

Production Market in the near future. Mainly:

- As new agents, especially consumers and commercialization companies, operate in the market, new requirements will have to be introduced. The legal framework already states that the demand participation on the market could incorporate more options.
- New market requirements. The Spanish market may still suffer modifications in the future, specially in relation to new possibilities not implemented yet such as different energy contracting periods, forward supplies, etc..
- Integration with other countries market. So far, Spain was the first European country which has put in operation a Power Exchange Market after the 96/92/EC directive. In the near future, all European countries will follow this path. Some questions and practical problems will have to be solved for the interaction between these markets.



FACTURA

NOTA:
Factura expendida en nombre y por cuenta de las entidades suministradoras de acuerdo con la Disposiciónadicional quinta del Real Decreto 2402/1985, de 18 de diciembre

DESTINATARIO ADQUIRIENTE DE LA ENERGIA

Nombre:

Dirección:
Localidad:
Provincia:
C.I.F. :
A la Att. :

Mes Facturado

Serie	N° Factura	Vencimiento	Código empresa	N° Hoja

Cod.	Concepto	Energía MWh	Base imponible	Importe
CPR	Compras a distribuidoras y otras agentes			
CCO	Compras a comercializadoras (CO)			
CCC	Compras a clientes cualificados (CC)			
CAX	Compras a agentes externos intracomunitarios			
BMN	Base cuota moratoria nuclear ag.nacionales [Saldo deudor con ag.nacionales para cons. nacional]			
IMN	Couta moratoria nuclear=(BMN)*0,0354			
BMX	Base cuota moratoria nuclear ag.externos [Saldo deudor con ag.externos para cons.nacional]			
IMX	Cuota moratoria nuclear=(BMX)*0,0354			
BIE	Base imponible impuesto electricidad=1,05113* [(BMN)+(IMN)]			
IIE	Impuesto electricidad=(BIE)*0,04864			
STO	Subtotal			
BAI	Base IVA=(CPR)+(CCO)+(CCC)+(IMN)+(IIE)			
IVA	I.V.A.=(BAI)*0,16			
TOT	Total pesetas			
EUR	Total euros			

Fig XVI : *Model of a bill*

Jose Javier Gonzalez Fernández-Castañeda. has obtained his Civil Engineering degree from the Madrid Polytechnic University and his M.S. from the Massachusetts Institute of Technology in 1975 and 1977 respectively. He has worked for a consulting company, and for Red Eléctrica de España, where he was head of the Energy Management System Department. At present, he is the Market Operations Director at "Compañía Operadora del Mercado Español de Electricidad", the Spanish power exchange organization.

Carlos Gamito Calvo. has obtained his Civil Engineering degree from the Madrid Polytechnic University and the economist degree from the Madrid University in 1973 and 1976 respectively. He has worked for a consulting company, then for an Electric Utility, and for Red Electrica de España, where he was head of the Operations Economic management Department. At present, he is the Settlement and Billing Director at "Compañia Operadora del Mercado Español de Electricidad", the Spanish power exchange organization.