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A STATISTICAL MODEL FOR THE ELECTRICITY SPANISH MARKET

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1.0 GENERAL DESCRIPTIONS OF THE SPANISH ELECTRICITY SECTOR

1.1 Antecedences

Starting from the electricity invention used for illumination and industrial aims during the second part of the 20thcentury, rose in Spain a big quantity of electricity plants, in the majority located in the city of big size.

The growing electricity demand, the new technologies for the alternate current generation, the use of higher voltages in the transmission lines and the improvement of the electricity engine, provoked at the beginning of the 20th century the consolidation of the biggest enterprise groups, first of all due to the fact that the construction of hydroelectric plant of big size required a big initial investment. In the 1930 the ten first companies controlled about 70% of the installed capacity.

In 1944 was found UNESA, with the 17 mains companies, that represented the 80% of the total generation, with the aim of establish coordination between electricity companies.

With UNESA begun the unified satisfaction of the Spanish demand, so that the plants of every company were at the service of the demand of the country in his totality, as though a unique company managed the totality of the production and transport instrument of the existent electricity energy.

Joined to the economic development, in the following years begun the construction of big hydroelectric and thermal plants: it was in fact needed a growth of the transport network, in order to interconnect the different plants dislocated in all the area, in particular the big generation plants.

The energetic crisis of the seventies modified the policy of the country, planning the objective of reduce the reliance on petroleum. In order to obtain this objective was approved the Nation Energy Plan, with which begun the construction of carbon and nuclear plants.

The delay in the development of the investment in nuclear plants, jointed to the high debt load of the company, provoked big financial problems, being necessary the research of regulatory alternatives in order to generate major stability in the sector.

After dialogue between the government and the electricity plants, in the 1983 was firmed an agreement which enabled to evolve a new regulatory framework which could guarantee the return on investment and allowed revenues sufficient for the enterprises to recuperate the costs.

At the same time, were enacted laws that paralyzed the nuclear plants that were in construction (“moratoria nuclear”).

The energetic plant 1983-1992 folded the agreements mentioned before and permitted the development of new instruments for the improvement of the financial situation if the plants.

The mains instruments were: financial reorganization, off-setting between companies and assets exchange between enterprise that bore in 1985 and 1986 with the aim of balance their financial situation.

Moreover, were created enterprise that realized the function of management and the realization of system dispatch, which was realized through the law 49/1984, in which was established “Red Eléctrica de Espana” (REE) as administrator of the transport network.

In the 1987 was approved the “ Marco Legal y Estable”, a law that established the regulation of the electricity sector for the next ten years, in particular the aspect related to the incomes of the electric enterprises. This law established that the tariffs should be fixed annually, aggregating the different components of the recognized costs, narrowed through standards values.

Consequently the total cost was divided for the foreseen demand, obtaining the mean value of the tariff, which is translated to the consumers according to the structure of existence tariff.

In order to adjust the electric legislation to the Europe Union, to the liberalizations processes of the others county and with the objective of introduce new elements of competitiveness, was approved the Law 40\1994, of Organization of the National Electricity System, by means of which was stabilized the freedom of install new generation plants, forcing the division of the activities of transmission, generation and distribution.

The National Commission of the Electricity System was also created, as the regulatory body for Spain’s energy system, with the main goal of watch over the transparency in the working of the system.

1.2 The liberalization of the sector

During the 1990s, a deep transformation in the electricity industry took place in many countries. This sector is moving from a monopoly structure to a more competitive one, as are the transportation and telecommunications sectors. For example, in Latin America, Chile was a pioneer in the early 1980s with the development of a competitive system for electricity generation based on marginal prices. In 1992, Argentina privatized an inefficient government-owned electricity sector, splitting it into generation, transmission, and distribution companies, and introduced a competitive generation market.

In Europe, Scotland and Northern Ireland followed the experience of England and Wales (Littlechild and Beesley, 1989). The Scandinavian countries, following Norway, have gradually created a Nordic wholesale electricity market.

In the European Union in 1996, the European Parliament and Council issued the Internal Electricity Market Directive 96/92/EC that set goals for a gradual opening of national electricity markets and rules for transmission access in the 15 member states. Spain in 1998 and Netherlands in 1999 created fully competitive generation markets.

In New Zealand, Australia, and some provinces of Canada (Alberta and Ontario), deregulation of the electricity industry is being introduced as a way of increasing efficiency and reducing prices. This is also true in some states of the United States; restructuring legislation has already been enacted in half the states, with California and Pennsylvania-New Jersey-Maryland in the lead.

However, the California electricity crisis of 2000 and 2001 has slowed the move toward electricity deregulation in the United States.

Under restructuring and deregulation, vertically integrated utilities, in which producers generate, transmit, and distribute electricity, have been legally or functionally unbundled.

Competition has been introduced in the wholesale generation and retailing of electricity. Wholesale electricity markets are organized with several generation companies that compete to sell their electricity in a centralized pool and/or through bilateral contracts with buyers.

Retail competition, in which customers can choose among different sellers or buy directly from the wholesale market, has also been implemented. This was done instantaneously for all customers (as in Norway), or progressively, under a multiyear program, according to different customer sizes (as in Spain, England and Wales, Australia, Argentina, etc.).

Transmission and distribution are still considered natural monopolies that require regulation to achieve effective competition, regulation is still needed to ensure open, non discriminatory access to the transmission grid for all market participants.

Restructuring and deregulation involve a transformation in the structure and organization of electricity companies. Traditionally, a single utility, vertically integrated, was the only electricity provider in its service territory and had the obligation to supply electricity to all customers in its territory. This provider could be owned by a national, regional, or local government, owned by a cooperative of consumers or privately.

Because of the monopoly (single seller) status of the provider, the regulator periodically sets the tariff to earn a fair rate of return on investments and to recover operational expenses.

Under this regulated framework, firms maximize profit subject to many regulatory constraints. But because utilities have been allowed to pass costs on to customers through regulated tariffs, there has been little incentive to reduce costs or to make investments with due consideration of risk.

Under perfect competition, in theory, the interaction of many buyers and sellers yields a market price that is equal to the cost of producing the last unit sold. This is the economically efficient solution. The role of deregulation is to structure a competitive market with enough generators to eliminate market power (i.e., the ability of a firm or a group of firms to set prices "a small but significant and non-transitory amount" above production cost.

With deregulation, electric utilities must split regulated from deregulated activities and compete with new firms originating from other energy businesses or retail services. The economic decision-making mechanism, under competition, responds to a decentralized process whereby each participant maximizes profit equal to the difference between total revenue and total cost. However, under competition, the recovery of investment in new plant is not guaranteed. So, risk management becomes a crucial part of the electricity business.

There are many forces driving electricity restructuring around the world. These forces are :

- New generation technologies, such as combined-cycle gas turbines (CCGT), have reduced the optimal size of an electricity generator;
- The competitive global economy requires input cost reduction; electricity is a primary input for many industries.
- The State, as owner and manager of traditional infrastructure industries, cannot respond as quickly as private owners to economic and technological change, prompting privatization.

- Information technologies and communication systems make possible the exchange of huge volumes of information needed to manage electricity markets.
- CCGT manufacturers have been racing to achieve technical efficiencies close to 60%, short power plant construction periods (less than 2 years), and low investment costs (around U.S.$500/kW). These technical developments (along with low natural gas prices and new natural gas transportation networks) have made this technology the dominant choice for new investment in competitive generation markets.

Even before the opening of generation to competition, CCGT technology was being built by independent power producers selling electricity to traditional utilities under different types of regulated agreements. The efficient size of these power units is currently between 150 and 300 MW. This is much smaller than efficient scales for traditional fossil or nuclear power stations.

Global competition promoted by international firms is emphasizing international price comparisons and, consequently, inducing nations to reduce electricity costs to be globally competitive. Restructuring and deregulation processes are carried out by governments through the introduction of electricity markets to increase efficiency and reduce prices. Markets also promote participation of external agents and neighbouring countries with lower production costs as a way to achieve lower prices.

After World War II, in many countries, for strategic reasons, the electricity industry was gathered in a single, nationalized company. This situation was common in Europe and Latin America. But public ownership has been in crisis during the last decade for various reasons. For instance, in Latin American countries that had high rates of electricity demand growth, the State, with a significant external debt, was unable to carry out the needed generation investments.

This situation, plus the recommendations of international financial institutions, such as the World Bank and the Inter-American Development Bank, led governments to initiate privatization and restructuring.

Also, the internationalization of fuel markets called into question national subsidies to specific primary energy sources. For instance, in several countries in Europe, the State has been subsidizing the coal industry. Low international coal prices (and the usual environmental problems associated with burning low-quality domes-tic coal) prompted governments to progressively abandon this type of intervention. Similarly, the nuclear power industry was developed with a high level of State support. However, political opposition has undercut this support, postponing or stopping new investment in nuclear plants.

Finally, information technologies and communication systems are making possible day-ahead and on-line electricity markets with multiple agents and multiple types of transactions. Further, metering, billing, quality control, and load management options based on new information technologies and communication systems are being offered under restructuring and deregulation. Also, retail competition and customer choice based on these technologies encourages entry of new electricity service providers with new commercial relationships, offering attractive prices, high quality, and other integrated services.

Although regulators' objectives differ across countries and sectors, their primary objective is to protect the short-term and long-term interests of consumers by promoting economic efficiency. The most direct way to achieve efficiency is to encourage competition. However, economic regulation must be used where competition is not feasible, for example, in sectors that have natural monopoly characteristics or in situations where externalities have not been internalized.

Traditionally, the electricity industry has been dominated by monopolies. Under restructuring, only high-voltage transmission, distribution, and system operation exhibit natural monopoly characteristics. Achieving economic efficiency in natural monopoly industries requires regulation. In these industries, the largest firms can charge the lowest prices, driving rivals from the market. Once there is no competition, the surviving firm can charge monopoly prices, reducing quantity and social welfare. There are several solutions to this problem, including government ownership of the industry, with a mandate to provide adequate output at reasonable prices or private ownership with government regulation to ensure adequate output and a reasonable return on private investment.

The economic theory of regulation (see overview in Joskow and Noll, 1981) attempts to predict which institutional arrangement is preferable as a function of the comparative social costs and benefits of private monopoly without regulation, government monopoly and private monopoly with regulation .

Each solution involves costs, including the social cost of the monopolist using its market power, the cost of maintaining a regulatory agency, and the costs imposed on the monopolist by the regulator. Besides the administrative costs associated with regulation, another potential cost arises from misguided regulatory interventions that can create social welfare losses. Therefore, the regulator must carefully consider the costs and benefits of each regulatory requirement on the regulatory agency and the regulated utility.

The role of regulation is to encourage enough investment to meet customer demand and to compensate investors with a reasonable rate of return. There are several ways of accomplishing regulatory goals in the electric power industry. Two basic regulatory forms are Rate-of-Return (ROR), also known as Cost-of-Service (COS), regulation, which requires the regulator to actively monitor the electric utility; and Performance-Based Ratemaking (PBR), which requires much less regulator intervention. Under ROR or COS regulation the regulator determines appropriate expenses, the value of invested capital and the allowed rate of return on invested capital.

This process requires a costly exchange of information between the regulator and the electric utility. PBR involves mechanisms that attempt to reduce the cost of regulation by allowing utilities to keep profits resulting from efficient operation.

As an electricity industry is restructured, the role of the regulator becomes one of setting market guidelines to yield competitive conditions in which prices and quantities are similar to what they might be under perfect competition.

Establishing competitive electricity markets requires a reduction in the market power that could be exerted by the formerly integrated utilities. In some cases, the regulator has obliged these utilities to divest their generation assets. Economic efficiency gains from deregulation can disappear if there is no real competition at the wholesale level.

On the other hand, usually, retail competition is initially dominated by the utilities that formerly distributed electricity to customers. They can also create their own retail or service provider companies as deregulated firms. The role of the regulator in this area is crucial to ensure fair competition. Regulated distribution companies, as former vertically integrated utilities, will provide preferential treatment to their own spin-off retailers rather than to new entrants. The regulator should establish clear rules to avoid this discriminatory behaviour, while actively promoting the entrance of new participants.

Where regulation is maintained or introduced after privatization, regulators should adopt open, transparent, and objective decision-making procedures (i.e., observable data sources, replicable methods, open debate, and reasoned decisions).

This is because regulatory decisions are always a part of an ongoing regulatory regime. Electricity companies will continue to be regulated where capital-intensive investments can lead to monopoly conditions. In the current environment, these conditions clearly apply to investments in transmission and distribution.

In a regulatory regime that sets revenue for an industry characterized by assets with long lives, the credibility of regulatory commitments is extremely important.

Before investors will commit funds to such investments, they must be convinced that the regulator will allow future revenues that provide reasonable assurance of cost recovery. For example, preventing the recovery of stranded costs or assets associated with past investments would allow the regulator to make an immediate price reduction, but also reduces the necessary credibility that future investments might be recovered. Therefore, the regulator must consider both consumers' short-term interests in low-price, high-quality service and their long-term interests in continued maintenance and investment in the electric power sector.

The economics of natural monopolies, markets, and regulation are not enough to understand the complexities of real regulatory reforms. There are many issues of practical implementation that should be analyzed through case studies to obtain a clearer understanding of electricity restructuring.

With the liberalization process, California addressed the issue of the stranded costs of the former investor-owned regulated utilities. To recover these stranded costs, electricity tariffs were frozen at a regulated tariff 10% below 1996 levels and a competition transition charge was added to them. Consequently, when the stranded costs were recovered and regulated tariffs disappeared, customers faced the high prices of the wholesale market.

Electricity restructuring in Spain is, in some aspects, similar to California's wholesale market design and stranded cost recovery. However, the starting point before deregulation in Spain was different from California's. For several years, a single independent company in Spain was operating as transmission owner and operator. In addition, the previous regulatory framework in Spain set a national benchmark for efficiency whereby utilities were regulated in competition by comparison.

Many organizational, institutional, and regulatory issues must be solved with deregulation. Although the ultimate objective is to achieve a technically reliable and financially viable competitive electricity supply industry, each government has adopted different approaches to restructuring. In the remainder of this chapter, we review the motivations that led to restructuring and the solutions adopted to address transitional issues.

A combination of factors promotes the political will to deregulate. Nationally owned systems have been segregated into different companies and then privatized under a new regulatory competitive framework. This is the case for the experiences in Argentina, Chile, and England and Wales, where the ideology of the government was clearly oriented toward a general liberalization program in the country. In Argentina, in addition, the situation of a chronic lack of investment, high growth in demand, and frequent power outages, encouraged the adoption of dramatic changes.

Electricity prices higher than those in neighbouring countries or regions have also pushed deregulation. In high-price areas, customers and governments influenced by a general wave of deregulation have advocated restructuring.

For example, Spain was encouraged by European Directive 96/92/EC that called for the introduction of competition. In both Spain and California, the electricity industry was primarily private before restructuring. Therefore, privatization was not an issue.

However, another issue arises when private, regulated utilities have expected required revenues that are greater than what they would be in a competitive market. This difference is known as stranded cost A recovery procedure for stranded cost can be designed by the regulator and used during a transition period. Also, where investor-owned utilities are required to divest their generation assets to mitigate possible market power problems, the difference between the book value of these generating assets and the price received for them in the market is known as stranded assets.

Another objective pursued by deregulation is to avoid cross-subsidies among different customer classes by designing more transparent tariffs. Electricity is bought in the market at posted prices, whereas regulated costs (e.g., for transmission services) are charged under a separate system through access tariffs. Additionally, under deregulation, subsidies to domestic primary fuels, such as coal, and to nuclear power, progressively disappear, as in Spain and in England and Wales.

The introduction of electricity competition requires the separation of competitive from still-regulated functions. In most restructuring experiences, the transmission grid has been separated, in ownership and in operation, from generation companies by creating a regulated transmission owner and operator. This is the case in England and Wales, Argentina (with separation between system operator and transmission owner), Norway, and Spain.

However, the situation is more complicated in California and other US states in which utilities have retained ownership of some generation assets and parts of their transmission grid. Here, new entities have been created to control the operation of the interconnected transmission grid. This is an attempt to prevent a utility from manipulating its grid to the disadvantage of competing generators.

Another key regulatory issue concerning system operation is how to maintain reliable operation under the unbundled structure. Regulated, vertically integrated utilities cooperated voluntarily to operate a reliable system by coordinating their resources with neighbouring utilities, knowing that regulated tariffs would cover bundled costs. Under deregulation, the system operator is responsible for system reliability.

It buys different ancillary services from generators and users to maintain a reliable system. However, legal responsibilities of system operators (particularly those that do not own transmission assets) must be clearly defined by new regulations.

On the other hand, transmission grids were not designed to transmit power flows from electricity markets. To do so requires updating transmission planning procedures and defining transmission investment responsibilities between system operators and transmission owners. This is especially true in those cases in which these functions have been separated, as in Argentina and throughout the US. Further, systems with transmission congestion problems use zone prices as a mechanism of sending market participants the right economic signal for using congested paths.

In that sense, market participants can promote grid investments according to the economic value they perceive. Chile, Argentina have nodal prices, whereas Norway and California have zone prices.

Therefore, under deregulation, transmission and distribution, also known as "wires businesses," continue to be regulated. Performance-Based Ratemaking (PBR) regulation is being introduced through price or revenue caps that limit company revenues during a regulatory period of several years. England and Wales were the first to experience price caps as a formula to remunerate regulated activities performed by distribution companies. In addition, associated with the concern that cost reductions can lead to quality degradation, mechanisms to control service quality are also being used.

A major objective of electricity deregulation is to achieve a workably competitive wholesale market.

At first, wholesale markets were designed for economic dispatch of generating units in a centralized pool, managed by the system operator. Participation in the pool was mandatory for all generators. This was the case in Argentina, Chile, and England and Wales.

Generators declared costs, or submitted bids, to the system operator who (using economic dispatch algorithms) obtained the generation schedule and hourly marginal prices (in England and Wales for each half hour). There was no demand-side bidding. Also, in Chile and in Argentina long-term marginal prices (3 to 6 months), instead of hourly prices, were passed through to regulated final customers. Unregulated customers could buy electricity with financial contracts.

In Norway, however, the wholesale market design was based on bilateral bidding with both generation and demand bids. A market for-futures contracts (up to 3 years in advance) was also instituted. Market operations were coordinated by a separate entity distinct from the system operator, specifically created for this purpose the market operator. Later, as in California and Spain, market operations were separated from system operations. Energy transactions can be made in a centralized pool or directly, outside the pool, through bilateral contracts.

Wholesale electricity markets have high price volatility due to daily and seasonal variations in supply and demand. This raises two important issues under deregulation: demand responsiveness to price variations and new investment in generation resources.

Under regulation, electricity demand was considered inelastic and new capacity was built to cover projected demand to minimize investment plus operating costs. Under deregulation, it is assumed that competitive prices will encourage new generation.

In Spain, for example, besides energy revenues obtained from selling electricity, generators are paid a supplemental capacity payment to encourage generation investment. In other cases (Australia, California, New Zealand, and Norway), this supplemental payment is not used.

Elsewhere, there are proposals to address the issue of long-term electricity supply.

For example, by using market mechanisms, consumers and generators can arrange long-term contracts so consumers can cover their expected needs and generators can stabilize incomes to recover fixed investment costs.

The aim of deregulation is to provide market-based electricity prices to customers with reliable service at efficient prices. Wholesale competition is enhanced, on the supply side, by participation of several generation firms, and, on the demand side, by allowing customers to buy directly or indirectly from generators through customer choice and retail competition.

The introduction of customer choice differs from country to country. In Norway, all customers were qualified to choose their supplier when the competitive wholesale markets started. In most other cases [e.g., Argentina, Australia, the European Union, and the United Kingdom (UK)] there has been a progressive implementation of conditions defining qualified customers, starting with the largest customers under a multiyear phase-in transition program.

A good indicator of competition and market maturity is the number of effectively non-regulated customers and total energy consumed outside regulated tariffs. For example, in California all customers were qualified in 1998, but two years later most of them continued under regulated tariffs, frozen at 10% below 1996 rates (not including charges to cover stranded costs). Later, during the electricity crisis in California of 2000 and 2001, retail choice was suspended. In Spain, on the other hand, the regulator adopted specific measures, such as the reduction of access tariffs, to promote the exit of regulated customers. At the end of 1999, of the more than 10,000 qualified customers about 80% were non-regulated customers, but the corresponding consumed energy was a small portion (2%) of the total consumption in Spain. For concluding, restructuring and deregulation of the electricity industry is a movement with the aim of achieving lower prices to customers through cost savings. However, the brief history of this process shows that there is still much to be learned. Despite this, there is a consensus to introduce competition into wholesale and retail markets by deregulating generation and opening retail and continuing to regulate network activities. But the experience also shows that those governments that started deregulation are continually revising their regulations. Argentina, California, England and Wales, and Spain, are still carrying out important revisions. The regulatory solutions adopted, and the designs of a transitional period to implement the new organizational structures are strongly influenced by the starting point of the industry and the political and institutional constraints in each country

1.2.1 The liberalization of the Spanish electricity sector

The liberalization of the Spanish electricity sector took place in 1997 with the approval of the Law 54/1997 that modified deeply the functioning of the electricity sector. The activity of generation became a liberalized activity and was created the activity of energy retailing. The retailing activity addressed the functions of buying energy for other market agents, in order to sell it to third party, especially to final users.

The transport and distribution activities kept being regulated activities, given the fact that they are natural monopolies. They allow the access of third party to the network, under the conditions established in the regulation and through the payment of a toll (access tariff).

The Law 54/1997 also established the juridical and accounting separation between the regulated activities (transport and distribution) and the liberalized activities (generation and retailing), even if it is possible to integrate these activities in the same group enterprise.

The juridical and accounting separation was realized with the finality of guarantee the independence of the distributors and the transport companies, in respect to the entities that solicit the access to the network, and further for guarantee that the actions of the unregulated activities do not put in financial danger the regulated ones.

the liberalization of the consumers will be realized gradually: in order to obtain this liberalization were set different periods and characteristics for qualify the clients, permitting to these one negotiate the energy supply through a retailer or directly in the market.

The timetable of the supply liberalization, established in the Law 54\1997 and behind modified with RD 2820/1998, RDL 6/1999 and RDL 6/2000, are shown in the figure.

<table>
<tr><th>Date</th><th>Ley 54/1997</th><th>RD 2820/1998</th><th>RDL 6/1999</th><th>RDL 6/2000</th></tr>
<tr><td>Gen-98</td><td rowspan="4">> 15 GWh</td><td rowspan="4"></td><td rowspan="10"></td><td rowspan="14"></td></tr>
<tr><td>Apr-98</td></tr>
<tr><td>jul-98</td></tr>
<tr><td>oct-98</td></tr>
<tr><td>gen-99</td><td rowspan="4"></td><td>> 5 GWh</td></tr>
<tr><td>apr-99</td><td>> 3 GWh</td></tr>
<tr><td>jul-99</td><td>> 2 GWh</td></tr>
<tr><td>oct-99</td><td rowspan="3">> 1 Gwh</td></tr>
<tr><td>gen-00</td><td rowspan="5">> 9 GWh</td></tr>
<tr><td>apr-00</td></tr>
<tr><td>jul-00</td><td rowspan="8"></td><td rowspan="4">> 1.000 Volt</td></tr>
<tr><td>oct-00</td></tr>
<tr><td>gen-01</td></tr>
<tr><td>gen-02</td><td rowspan="2">> 5 GWh</td></tr>
<tr><td>gen-03</td><td rowspan="4"></td><td rowspan="5">All</td></tr>
<tr><td>gen-04</td><td rowspan="3">> 1 GWh</td></tr>
<tr><td>gen-05</td></tr>
<tr><td>gen-06</td></tr>
<tr><td>gen-07</td><td>All</td><td>All</td><td>All</td></tr>
</table>

Fig.1 timetable of the liberalization energy supply

1.3 Main protagonist of the Spanish electricity sector

The Electricity Sector Law 54, of 27 November 1997, and Royal Decree 2019, of 26 December 1997 explain the main subjects that can participate in the market, and the rule that can assume each of them. Follow a brief description of these subjects.

1.3.1 The market operator

The functions related to the "Operador del Mercado Ibérico de Energía-Polo Español, S.A." can be classified as follows:

a) Functions relating to the operation of the markets :

   a. Assume the functions required to perform the economic management required in order to ensure the effective development of the electricity production market.

b. Receive sale bids issued for each scheduling period by the owners of electricity production units, by retailers and by production aggregators representing special regime producers.
c. Receive and accept power purchase bids and, where appropriated, any guarantees.
d. Match sale and purchase bids.
e. Provide the system operator with information regarding results of the matched bids in the daily and intraday markets, the scheduling of network access as a result of those matches, and the marginal power price; and notify participants of the information regarding their production and purchase units.
f. Receive from the system operator any information regarding modifications made to matching due to technical constraints or exceptional situations in the transmission network or, where appropriate, the distribution network.
g. Determine final energy prices for each scheduling period and report these prices to all the participants involved.
h. Settle and report the payments and collections to be carried out in accordance with the final energy price resulting from the real operation of the production units, the availability of production units in each scheduling period and any other cost that may be determined in accordance with existing regulations.
i. Receive information on producers who have contacted the system operator, in order to ensure that the latter confirms any incidents that may warrant an exemption from bidding.
j. Define, develop and operate the computer systems required to guarantee the operation and transparency of transactions performed on the electricity production market.

b) Functions relating to information on other deregulated transactions
   a. Receive contract information from signers of physical bilateral contracts, with indications of the time periods in which the contracts will be performed.
   b. Receive details of any contractual information from signers of other types of contracts, in accordance with existing regulations.

c) Functions relating to Market Activity Rules and the Contract of Adherence
   a. Present the Electricity Market Activity Rules to the Ministry of Industry for approval.

b. Submission of modifications to the Rules and of the Contract of Adherence for Ministerial approval.
c. Require market participants to show their compliance with the rules governing their duties as market participants.

d) Functions relating to information to be provided to market participants
   a. Regarding the results of the matching, providing participants with the information concerning their production and purchase units.
   b. Regarding the base daily operating schedule, providing participants with the information relative to their production and purchase units, and providing distributors with information concerning only their distribution network, aggregated for each of their electricity hubs defined and notified by the system operator.
   c. Regarding the final schedule derived from each intraday market session, providing participants with information relative to production and purchase units; an providing the distributors with information concerning only their distribution network, aggregated by each of their electricity hubs defined and notified by the system operator.
   d. Providing market participants with the marginal price of electricity in the daily market and in the intraday market sessions, as well as the final prices of electricity.
   e. Notifying the participants of the collections and payments that must be done in accordance with the final price of electricity.
   f. Guarantee the confidentiality of any confidential information made available by market participants, in accordance with applicable regulations.

e) Functions relating to information given to third parties
   a. Publish the aggregate supply and demand curves of the daily and intraday markets, with an explicit breakdown of each of the points included, as well as the modifications derived from the process of solving technical constraints, adding, in this case, the affected bilateral contracts.
   b. Publish the commercial capacities and intra-Community and international exchanges by border.
   c. Publish the results of the power programs aggregated by participant and month in the electricity production market, one month after the last day of the month to which they refer.

d. Publish monthly the bids submitted by the participants in each of the daily and intraday markets, three months after the end of the month to which they refer.
e. Publish information on market developments with the frequency required in each case.
f. Publish, in domestic mass media, information that is deemed to be public and of general interest.

f) Functions relating to the principles of independence, transparency and objectivity.
   a. Adopt any measure and agreements that may be necessary in order to ensure effective compliance with the limitations on direct or indirect capital stock holdings in the Company, including via purchases of stock, obligatory for the affected party, of the capital stock that constitutes a breach of this legal requirement.
   b. Prepare and publish the market operator's code of conduct.
   c. Notify the competent authority of any behaviour exhibited by the market participants that may disrupt the proper operation of the market.

g) Functions relating to short and medium term forecasts
   a. Forecast, in the short and medium term and in co-ordination with the system operator, the use of production equipment, and particularly the use of hydroelectric reserves, in accordance with demand forecasts, the availability of power equipment and the different conditions of hydraulicity that may arise during the forecast period.

h) Information envisaged in article 3.6 of Directive 2003/54/EC on common rules for the internal electricity market.
   a. The transposition of this Directive requires, in terms of the electricity negotiated through the organised market and importable through companies positioned outside the Community, the use of accumulated figures facilitated in the year, in the previous year, so that the factors indicate the contribution of each energy source to the global mix of fuels of the aforementioned amount of negotiated power.

1.3.2 The System Operator

Red Eléctrica is the leading power transmission company in Spain and it is responsible for management of the technical aspects of the Spanish electricity system. It owns most of the Spanish high voltage transmission grid.

As the company responsible for management of the transmission grid, Red Eléctrica has been assigned responsibility for development and improvement of the grid's installations. It handles maintenance and improvements in accordance with uniform and coherent criteria. It manages the transit through Spain of electricity which is traded between foreign systems and which must pass through the networks of the Spanish electricity system and it also arranges access to these networks by third parties so that all traders in this sector can use the grid under uniform conditions and without discrimination.

As the operator of the Spanish electricity system Red Eléctrica manages the technical aspects of the system to ensure continuity and safety of supply. It also ensures appropriate coordination between generation and transmission.

Red Eléctrica was the first company devoted exclusively to electricity transmission and operation: since its creation in 1985, it has been responsible for the transmission network and for operation of the Spanish electricity system, ahead of recent trends worldwide towards the segregation of such activities, with transmission being seen as a separate activity from generation and distribution.

This system led to a radical change in the structure and working of the Spanish electricity sector which was one of the models for the deregulation of systems in other countries.

In 1997, the electricity sector act confirmed that Red Eléctrica played a key role in the electricity system. This act created a wholesale electricity market which required a well-managed transmission network and system operation that would coordinate generation and transmission as a whole, to allow the transfer of energy negotiated between producers and distributors and to guarantee that demand would be met at all times.

Red Eléctrica provides the market agents with a reliable transmission network, guaranteeing access to it under the same conditions for all.

As system operator, Red Eléctrica guarantees a balance between energy production and consumption, ensuring quality supply in all places and at all times and providing the market system with the safety and liquidity it needs. Its specialisation guarantees its independence and the use of non-discriminatory criteria regarding access to the electricity system by agents.

1.3.3 Producers

Electricity producers are all individuals or legal entities that engage in the production of electric power, as well as in the construction, operation and maintenance of electricity production plants.

The construction, exploitation, substantial modification and closure of electricity production facilities must receive prior administrative authorisation. The transmission of these installations must be notified to the Administration awarding the original authorisation.

The issuance of the administrative authorisations is regulated and governed by the principles of objectivity, transparency and non-discrimination.

Applicants for authorisations for electricity production installations must accredit the following:

a. The energy efficiency, technical and security conditions of the proposed installations.
b. Due compliance with conditions of environmental protection and the minimization of environmental impacts.
c. Details of the location of the installation.
d. Confirmation of their legal, technical and economic-financial capacity to carry out the project.

Authorisations shall be issued by the competent Autonomous Community Administration, without prejudice to the necessary concessions and authorisations, pursuant to other applicable regulations and particularly those relating to land planning and the environment.

In the event of failure to resolve the authorisation requests referred to in the present article, the aforementioned requests shall be rejected. Nevertheless, ordinary appeals may be presented before the corresponding administrative authority.

Holders of authorisations are obliged to maintain the production capacity stipulated in the authorisation and provide the competent Administration on a regular basis with any information that affects the conditions pursuant to which the authorisation was issued.

Failure to comply with the conditions and requirements established in the authorisations or the substantial variation of the conditions that were established for the issuance of the authorisation may lead to the cancellation of the authorisation, in the terms and conditions envisaged in the applicable penalty system.

Producers have the capacity to offer electricity and other services relating to electricity supply on the production market. Owners of pumping installations are also classified as producers.

Agents that produce electricity must present economic electricity sale bids through the «Operador del Mercado» for each production unit that they own, when they have not availed themselves of bilateral contracting systems that, given their characteristics, are excluded from the bidding system.

Electric power production units include thermal generator groups, pumping stations and management units of hydro-electric power plants or wind power plants, in accordance with the following terms:

a. A thermal production unit is a thermal turbo-generated group integrated in each plant registered with the Administrative Register of Electricity Production Installations.
b. A hydro-electric power production unit is a unit that manages hydro-electric plants belonging to the same hydro graphic basin, and is responsible for the management of their reserves associated with a common hydraulic flow that mutually conditions the plants in the group and belong to owners represented by the same agent authorised to present bids. In spite of this, each pumping station is in itself a single hydroelectric management unit.
c. A wind-power production unit is a unit that manages a group of wind generators within the same park and which unload their energy in the same node on the transmission or distribution network of the zone in which it is located and represented by the same agent authorised to present bids.

In addition to the rights mentioned previously, producers are also entitled to:

a. Use primary energy sources that they deem to be the most appropriate at their production units, respecting at all times the efficiency, technical characteristics and conditions of environmental protection stipulated in the authorisation of corresponding to that installation.
b. Contract electricity sales pursuant to the terms envisaged in legislation and in the regulations implementing same.
c. Dispatch their energy through the system operator.
d. Access transport and distribution networks.
e. Receive remuneration to which they are entitled in accordance with the terms and conditions envisaged in the Law.

f. Receive compensation to which they are entitled for costs incurred by them in the event of constraints in the operation of the system. These constraints in the operation of the system are determined by the Government, which may adopt, for a specific period, the measures required to guarantee the electricity supply in the event of any of the following circumstances:
    i. Confirmed risk to the provision of the electricity supply.
    ii. Shortages in the supply of one or several primary energy sources.
    iii. Situations that may threaten the physical integrity or the safety of persons, equipment or installations or the integrity of the electricity transmission or distribution network.

In the situations described above, the Government shall determine the remuneration regime applicable to the activities that are affected by the adopted measures, guaranteeing, whenever necessary, a balanced distribution of costs.

When the measures adopted by the Government in accordance with the provisions envisaged in this section only affect one or several Autonomous Communities, the decision shall be taken in collaboration with the latter.

The measures adopted by the Government to deal with the situations described in the previous section may relate to the following aspects, among others:

1. Temporary modifications or limitations of the electricity market referred to in Chapter I of Title IV of the Law.
2. Establishment of special obligations in terms of the security of supplies of primary energy sources for the production of electric power.
3. Temporary modification or suppression of rights established for self-producers and producers under the special regime in Chapter II of Title IV of the Law.
4. Modification of the general conditions governing the regularity of overall supply or with reference to specific categories of consumers.
5. Temporary modification or suppression of third-party network access rights and guarantees.
6. Limitation or assignation of primary energy supplies to electricity producers.
7. Any other measures that are recommended by international Organisations of which Spain is a member or that are determined in application of any agreements to which it is a party.

In turn, the obligations of producers may be summarised as follows:

1. The development of all those activities required producing electricity in the terms envisaged in the corresponding producer authorisations and, in particular, in relation to the safety, availability and maintenance of installed power and compliance with stipulated conditions relating to the environment.
2. The presentation of electricity sale bids to the market operator.
3. The ownership of measuring equipment that enables them to determine, for each programming period, the power actually unloaded into the corresponding network.
4. Adherence to the operating conditions of the bid system, particularly in terms of the electric power settlement and payment procedure.
5. The application of measures that are adopted by the Government, in accordance with the aspects described above.

1.3.4 Producers under special regime

Electricity producers shall be classified under the special regime in the following cases, when production is performed at installations with an installed power that does not exceed 50 MW:

1. When certain non-consumable renewable energies, biomass or any type of bio fuels are used, provided that their owner does not engage in any production activities under the ordinary regime.
2. When primary non-renewable waste is used as energy.
3. Electric power produced at plants for processing and reducing agricultural, livestock and services sector waste are classified as producers under the special regime if their installed power is equal to, or lower than, 25 MW, and provided that they offer high levels of energy efficiency.

The construction, exploitation, substantial modification, transmission and closure of electricity production facilities under the special regime must receive prior administrative authorisation as provided in the applicable regulations.

Installations authorised to engage in this type of electricity production are treated differently in accordance with their specific status, but not on a discriminatory or privileged basis.

Producers requesting these authorisations must accredit the technical and safety conditions of the proposed installations, full compliance with the conditions of environmental protection and sufficient legal, technical and economic capacity to engage in the type of production that they intend to develop; once the authorisations have been awarded, they must provide the competent Administration on a regular basis with any information that affects the conditions pursuant to which the authorisation was issued.

Authorisations shall be issued by the competent Autonomous Community Administration, without prejudice to the necessary concessions and authorisations, pursuant to other applicable regulations and particularly those relating to land planning and the environment.

In the event of failure to resolve the authorisation requests referred to in the present article, the aforementioned requests shall be rejected. Nevertheless, ordinary appeals may be presented before the corresponding administrative authority.

Failure to comply with the conditions and requirements established in the authorisations and the substantial variation of the estimates that determined their issuance may give rise to revocation.

Electricity producers under the special regime shall have the following obligations:

1. Adopt the safety regulations and technical and accreditation or certification standards required for the installations and instruments that are established by the competent Administration.
2. Comply with technical regulations governing electricity production and technical transmission and system management regulations.
3. Maintain installations in optimum operating condition so that they do not cause injury to persons or damage third-party installations.
4. Provide the Administration with information on energy production, consumption and sales and any other information that is required.
5. Comply accordingly with all the conditions established in terms of environmental protection.

Producers under the special regime shall have the following specific rights:

1. Incorporate their surplus electricity in the system and receive the corresponding remuneration.
2. Establish parallel connections between their installations and the network of the corresponding distributing or transmission company.
3. Receive electricity supplies that they require from the distribution company.

1.3.5 Resellers

Electricity reselling agents are all legal entities that access the transmission and distribution networks and sell electricity to qualified consumers or other system participants. Legal entities wishing to participate as resellers must obtain prior administrative authorization, which is regulated and issued by the competent Administration provided, where appropriate, that the applicant has the sufficient legal, technical and economic capacity to participate as a reseller. The administrative authorization request must specify the territorial scope in which the applicant intends to develop its activity.

Under no circumstances shall authorizations be deemed to have been awarded on a monopoly basis, nor shall they contain any exclusive rights.

In order to be able to purchase electricity to supply their customers, resellers must register with the Industry and Energy Register of Distributors, Resellers and Qualified Consumers and present sufficient guarantees to the market operator to cover its electricity requirements in accordance with existing regulations.

Reselling companies are required to fulfil the following supply obligations:

Measure, either directly or through the corresponding distributor, the supplies established in applicable regulations, ensuring, where appropriate, the accuracy of the aforementioned supplies and accessibility to corresponding equipment, allowing the competent Administrations to control the same accordingly.

Implement demand management programmes approved by the Administration

Promote the rational use of power.

Purchase the power required to develop their activities, paying for purchases by means of the corresponding settlement procedure.

Reselling companies shall be entitled to:

Demand that installations and equipment available to users meet the specified technical and construction conditions, as well as the proper use of the aforementioned installations and equipment in compliance with established terms and conditions to ensure that the quality of supply is maintained without undermining or degrading its quality for other users.

Invoice and receive payment for power supplied.

1.3.6 Distributors

Electricity distributors are all companies that distribute electric power, and construct, maintain and operate distribution installations designed to supply power to consumption points and sell electricity to end consumers purchasing electricity under the tariff system or other distributors also purchasing electricity under the tariff regime.

The construction, modification, exploitation and transmission and closure of electricity distribution installations are subject to administrative authorization regardless of their location or use.

Administrative authorization ordering the closure of an installation may require the owner to dismantle the installation.

The competent Administration will refuse authorization in the event of failure to comply with legally established requirements or if the company does not offer guarantees of its legal, technical and economic capacity necessary to engage in the proposed activity, or in the event of any incident that undermines the operation of the system.

Under no circumstances shall the authorization be deemed to have been awarded on a monopoly basis nor shall exclusive rights be awarded.

Authorizations shall be issued by the competent Administration, without prejudice to the necessary concessions and authorizations, pursuant to other applicable regulations and particularly those relating to land planning and the environment.

In the event of failure to resolve the authorization requests referred to in the present article, the aforementioned requests shall be rejected. Nevertheless, ordinary appeals may be presented before the corresponding administrative authority.

Distributing companies shall have the following obligations:

1. Supply electricity to users under the tariff system.
2. Perform their activities in the authorized manner and in accordance with applicable legislation, rendering the distribution service on a regular and continual basis, and in accordance with established quality levels, maintaining electricity distribution networks in adequate conditions of repair and technical conformity.
3. Enlarge distribution installations whenever necessary in order to meet new electricity supply demands, without prejudice to the results of the application of the regime established on a regulatory basis for electricity supplies. When there are various distributors with installations that may be enlarged and none of the aforementioned distributors performs the enlargement work, the competent Administration shall determine which of these distributors must distributors must

enlarge their installations, in accordance with the conditions stipulated by the aforementioned competent authority. Distributing companies must notify the Ministry of Industry and Energy of any installation authorizations that they are awarded by other Administrations, as well as any modifications relating to their activity in order to recognize their costs when calculating the tariff and establishing the applicable remuneration system.

4. Notify the Ministry of Industry and Energy and the competent Administration of any information that they obtain on prices, consumption, invoicing and sale conditions applicable to consumers, distribution of consumers and corresponding volumes by consumption categories, as well as any information relating to activity performed within the electricity sector.
5. Meet, in conditions of equality, new electricity supply demands in areas in which they operate and enter into supply contracts in accordance with the provisions established by the Administration.
6. Measure the supplies established in applicable regulations, ensuring, where appropriate, the accuracy of the aforementioned supplies and accessibility to corresponding equipment, allowing the competent Administrations to control the same accordingly.
7. Apply corresponding tariffs to consumers in accordance with the provisions established by the General State Administration.
8. Inform consumers of the most appropriate electricity tariffs for their needs.
9. Implement demand management programs approved by the Administration.
10. Promote the rational use of power.
11. Guarantee the quality of the service that is established in regulations, pursuant to the criteria differentiating between areas and types of consumption described in the following chapter.
12. Purchase the power required to develop their activities, paying for purchases by means of the corresponding settlement procedure established for this purpose.

Distribution Companies shall have the following rights:

1. Recognition by the Administration of remuneration for exercising their activity within the National Electricity System.
2. Purchase electricity required to meet customer supply demands.
3. Receive remuneration in return for distributing electricity.

4. Demand that installations and equipment available to users meet the specified technical and construction conditions, as well as the proper use of the aforementioned installations and equipment in compliance with established terms and conditions to ensure that the condition of quality of supply is maintained without undermining or degrading its quality for other users.
5. Invoice and receive payment for power supplied.

The Government publishes details of the country's different electricity zones in «Spain's Official State Gazette», as well as information on the Distribution Company or companies operating as network managers in each zone.

The different electricity zones and network manager or managers of each zone are determined after a meeting with the distribution companies and the presentation of a report of the corresponding Autonomous Regional Communities, when the electricity zone affects the territorial area of more than one Autonomous Community, and after agreement with the corresponding Autonomous Regional Government when the zone is encompassed with its territorial scope.

The distribution network manager in each zone will establish the operating and maintenance criteria of the networks, guaranteeing the conditions of security, reliability and efficiency of these networks in accordance with applicable environmental regulations.

The network manager must guarantee the confidentiality of the information of which it has knowledge in the performance of its duties, whenever the disclosure of such information may give rise to problems of a commercial nature, without prejudice to the obligation to provide information to public Administrations.

Distribution networks may be used by qualified consumers and resellers. The price for the use of distribution networks shall be established by the toll approved by the Government.

The National Electricity System Commission will resolve any disputes arising in connection with the application of network access contracts.

1.3.7 Qualified consumers

Qualified consumers are all those consumers who can purchase electrical power.

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1. Since April 1, 1999, consumers with consumption levels of at least 3 GWh/year are deemed to be qualified consumers.
2. On July 1, 1999, the limit was reduced to 2 GWh/year.
3. On October 1, 1999, the limit was reduced to 1 GWh/year.
4. By January 1, 2007 at the latest, all consumers must have qualified consumer status.

1.3.8 The national energy commission

The National Energy Commission (Comisión Nacional de Energía or CNE) is the regulatory body for Spain's energy systems. It was set up under the Hydrocarbons Act 34/1998, dated October 7th, and developed by Royal Decree 1339/1999, dated July 31st, which approved the Commission's Bye-laws.

The goals of the Commission are to ensure the existence of effective competition in Spain's energy systems and their objective and transparent functioning for the benefit of all agents operating in those systems and that of consumers. To this end, the energy systems are deemed to be the electricity market and the liquid and gaseous hydrocarbons markets.

The CNE is a public body with its own legal personality and patrimony and full capacity to act. The Commission's activities are subject to the provisions of Act 30/1992, dated November 26th, governing the Legal Regime of Public Administrations and the Common Administrative Procedure whenever it exercises administrative powers. It must abide by legislation covering Public Administration contracts when contracting goods and services and for all other activities it is subject to private law.

The National Energy Commission draws up an annual draft budget structured according to Treasury guidelines and submits it to that Ministry for its approval by the Government and subsequent referral to the Spanish Parliament as part of the State General Budgets.

The economic and financial control of the National Energy Commission is undertaken by the State Controller's Office without prejudice to any functions that are the responsibility of the National Audit Office.

The CNE is attached to the Ministry of Industry, Tourism and Commerce which monitors the efficiency of the Commission's activity and is governed by the provisions of the Hydrocarbons Act and its own Bye-Laws, by any of the provisions in the Budget Act that may apply to it and by Act 6/1997, dated April 14th, on the Organisation and Functioning of the Central State Administration.

Personnel working for the National Energy Commission are bound to it by an employment relationship subject to labour laws. With the exception of management level staff, personnel are recruited through a public notice of vacancies and in line with selection procedures based on principles of equality, merit and ability. CNE staff are subject to the general rules on the holding of incompatible posts established for Public Administration employees.

1.3.9 CNE Functions

The National Energy Commission has been assigned wide-ranging functions in order to fulfil the goals stated above and it also acts as a consultative advisor on energy matters to the Central State Administration and the Governments in the Autonomous Regions.

The functions assigned to the CNE under the Hydrocarbons Act 34/1998 can be classified as follows:

Implementing legal rules and standards:

1. It issues Circulars developing and implementing the legal rules and standards contained in Royal Decrees and Orders issued by the Ministry of Economy to develop energy legislation, provided those provisions expressly authorise it to do so. The Circulars have to be published in the Official State Journal, the "Boletín Oficial del Estado".

Issuing proposals and reports:

The Act grants the CNE the power to make proposals in the following processes:

- Drafting of general provisions affecting energy markets and, in particular, the regulatory development of the Hydrocarbons Act.
- Energy planning.
- Drafting of proposals for the determination of tariffs, rates and the remuneration of energy activities.

CNE reports are mandatory in these three cases.

Furthermore, the CNE acts as a consultative body on the following matters:

- It furnishes mandatory reports on proceedings to authorise new energy installations whenever such matters fall within the scope of authority of the Central State Administration.
- It issues any reports that may be requested from it by the Autonomous Regions when exercising their authority on energy matters.
- It furnishes mandatory reports on operations involving the concentration of companies or the takeover of one or more energy companies by another company that is also engaged in activities in the same industry whenever such operations have to be submitted to the Government for a decision to be taken and in line with the competition legislation in force at the time.

It issues a report on the disciplinary proceedings instituted by different Public Administrations whenever requested to do so.

Playing an executive role:

- In the electricity industry, it carries out the settlement of electric power transmission and distribution costs, the permanent costs of the system and any other costs as may be determined for the whole electricity system whenever the CNE is explicitly assigned this settlement task.
- It determines which specific agents in the system may be responsible through their actions for deficiencies in supply to users and proposes the steps to be taken.
- It decides on the opening of disciplinary proceedings and to conduct said proceedings whenever they fall within the scope of authority of the Central State Administration.
- It authorises the stakes taken by companies engaged in activities that are considered to be regulated in any company carrying on business activities.
- It decides on its own organisation and external functioning and selects and recruits its own staff, satisfying the requirements set out in the relevant legislation in force within the scope of the Central State Administration.

Defending competition:

- It ensures that agents acting in energy markets abide by the principles of free competition when carrying on their activity.

Settling disputes:

- It settles any disputes that may be submitted to it concerning contracts for third party access to transmission networks and, as the case may be, distribution networks, on the statutory terms set out in regulations.
- It acts as an arbitrator in any disputes that may arise between the agents carrying on activities in the electricity industry or the hydrocarbons industry and any that may arise between qualified consumers and those agents.
- In the case of the electricity industry, it settles any disputes that are referred to it with regard to the management of the system.
- In the case of the gas industry, it settles any disputes that are referred to it with regard to the management of the system.

Inspecting:

At the request of the Central State Administration or the Autonomous Regions with authority to do so, or ex officio, the CNE inspects:

- The technical conditions of installations;
- Compliance with the requirements stipulated in authorisations;
- Right use of the domestic coal as a fuel in the power plants eligible of subsidies
- The economic conditions and activities of the agents insofar as they may affect the application of tariffs and the criteria for remuneration of energy activities;
- The availability of power plants under the ordinary regime
- Billing and sale conditions to eligible consumers by distributors and suppliers
- The reliability of the supply
- The quality of the supply
- The effective unbundling of these activities whenever this is required.

In addition, the CNE may carry out any checks it deems necessary in order to confirm the accuracy of the information furnished to it in compliance with its Circulars.

1.4 Electricity market organization

The Spanish electricity market now has over nine years experience of normal and effective operation, providing seven electricity trading sessions to market participants: the first and main daily market and six subsequent intraday, throughout the 24 hours of each day. Currently, more than 600 companies are able to participate in the market as agents, with 27 of them being external agents. Of this group of agents, around 550 are producers. The number of resellers in the market, presently 64, is also noteworthy, with most of them being independent resellers. The settlement and invoicing process in the market changed significantly in 2006 as a result of the application of Royal Decree 1454/2005, by means of which the economic management of the electric system concerns both the market operator and the system operator, according to the markets or processes under their respective responsibility.

With regard to increasing the generation capacity in Spain, it is important to note the high number of new combined cycle plants,

which reached a total of 22097 MW at the end of 2007, contributing 24% to the electricity demand coverage.

On this point, it is worth noting that this policy of building combined cycle plants makes it necessary to increase coordination between the development of gas infrastructures and gas supply, with the construction of new electricity infrastructures, as well as guarantee the supply and availability of sufficient reserves of natural gas for these electricity production units.

The price of natural gas, as in other European countries, or even to a greater extent due to the proportion of new combined cycle gas plants in the Spanish system, is currently a very significant factor in shaping electricity prices.

With respect to renewable energies, there has been a notable effort made these past few years to add new production units, particularly in wind power. This type of energy, in addition to being environmentally friendly and therefore enabling compliance with the commitments made in terms of greenhouse gas emissions, also contributes substantially to the electricity supply, having provided coverage of 8.7% of the electricity demand in 2006. Installed wind power is currently over 11,800 MW, more than 94% of this capacity participates in the organised market directly or through sellers. Furthermore, cogeneration power participating in the market amounts to 2,900 MW, representing 48.3% of the total. 523 special regime producers, mostly cogeneration and wind producers that present bids either directly or through sellers have an installed capacity of 15,479 MW.

An additional 775 MW is for production facilities previously under the special regime, but as their installed capacities exceed 50 MW, they have become ordinary regime facilities, in accordance with existing legislation. Since January 2003, all consumers have become qualified consumers.

There are now over 88,800 high voltage consumers and 23.3 million low voltage domestic and commercial consumers. All of them may now choose to acquire the electricity under any form of free trading through contracts with resellers, by going directly to the organised market or through bilateral contracts with producers.

This ability to choose, which had experienced a continuous decline from the middle of 2005 to the second half of 2006, has become stabilised at around 25% of the total energy acquired in the production market and began recovering in the first quarter of 2007, once the negative effects of the integral tariff regulation on the market disappeared.

With this, retail activities slowed down, although electricity trading continued. Both activities will be encouraged in the future if, as a result of consumer freedom to choose suppliers and improved conditions for international electricity trading, this sluggish phase is overcome and integral tariffs reflect price variations seen in free markets.

It is also important to highlight the market's operational rules proposal in order to adapt them to changes in the regulatory framework. They have led to the approval of the following rule proposals:

As a result of a decision on the 11 May 2006 by the Secretary General of Energy, certain operational rules for daily and intraday markets have been altered for their adaptation to the provisions in Order ITC/4112/2005 on international and intra-community exchanges. As a result of the decision of the 24 May 2006 by the Secretary General of Energy, the operational rules for daily and intraday markets were approved for the adoption of the provisions in Royal Decree 1454/2005 to enable the full application of the provisions established in Royal Decree Law 5/2005, in particular with regard to responsibilities over the settlements of the market operator and system operator.

Within the European Union, there has been analysis and debate in 2007 over the development of the interior electricity and gas market. On the one hand, mention should be made of the results of the survey produced by the European commission in June 2005 analysing the internal market from the competition's viewpoint, with their final report published in January 2007. The conclusions of this report underline the need to strengthen regulators' functions in terms of competition and for greater coordination on a European scale with the resulting supervision of the Commission itself. Reference is also made to the negative impact of retail tariffs on liberalised markets and the need to harmonise and improve methods that affect the management of interconnections, as well as the possibility of the European commission implementing a supervision system for wholesale markets to increase participants' confidence and limit the risk of them being manipulated.

Of particular relevance are the prospects for the domestic market prepared by the European Commission as one of the bases for defining the axes of community strategy on energy, together with energy efficiency, the reduction of carbon dioxide emissions and a single international energy policy for the entire European Union. With regard to the domestic market, the European Council considers the observance of its existing directives as essential as well as effective separation between supply and production activities and activities related to operating networks.

Within this context, the creation of organised spot markets has become more widespread, which are basically daily markets accompanied by intraday markets in many countries. The development of these markets is considered a key factor for the development of investment processes and the access of new purchasers or sellers to electric systems. At the same time, both bilateral and organised forward market transactions have been developed with the main objective for producers and purchasers to hedge their risks under sufficient market liquidity conditions.

As a result, spot market prices are becoming a necessary reference for determining electricity consumer prices and forward. In fact, and despite pressures recorded in 2005 and the first few months of 2006 in primary energy markets and electricity markets, most electric systems have significantly increased the liquidity of daily markets and futures transactions.

The last international agreement on the Iberian market signed in October 2004 came into force in April 2006 and anticipates that in the future the market will be managed by a single Iberian Market Operator (OMI), resulting from the integration of OMEL and OMIP.

The 22nd Spanish-Portuguese summit was held in Badajoz on the 24 and 25 November 2006, where both countries agreed to study the Iberian electricity market (Mibel) implementation process and integration of the operators in both countries in more depth at the end of 2007, as well as raise from 5% to 10% the contracting of electricity sold by Spanish distributors to tariff Spanish customers in the forward market managed by OMIP.

In the meeting held on the 8 March 2007 in Lisbon, the Spanish and Portuguese ministers agreed the main principles for integrating the current management functionsof the spot and forward markets with a view to a future Iberian Market Operator (OMI).

It was agreed in this meeting to structure the shareholdings model of the future Iberian Market Operator based on two holdings:

OMI – Polo Español (shareholding) and OMI – Polo Portugués (shareholding).

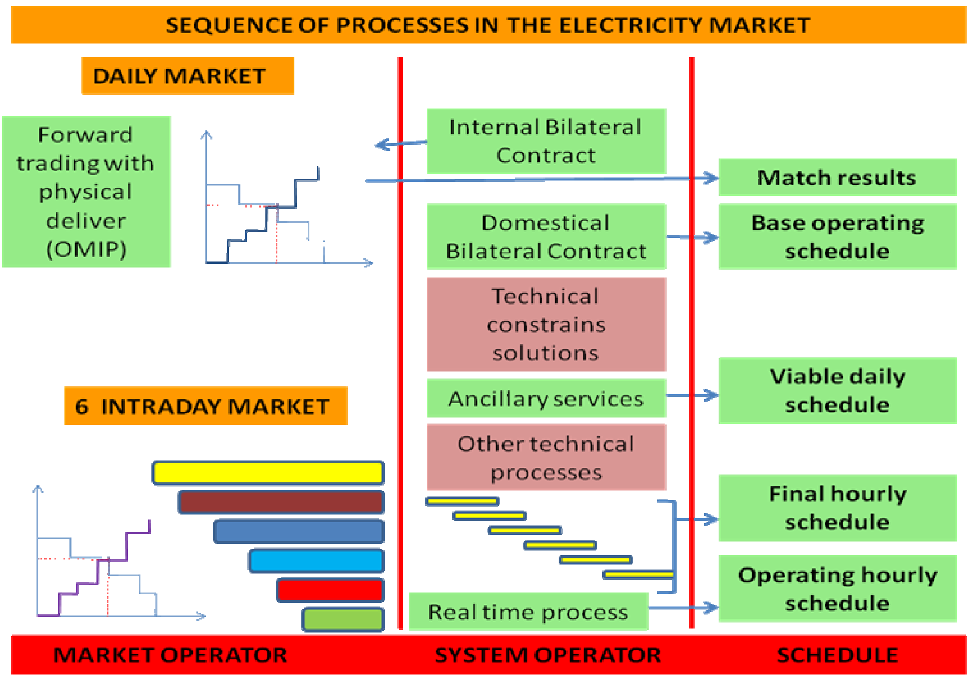
Both entities will have 50% of the management companies in the markets, run by a joint Board of Directors.

The full operation of the organised market managed by OMEL since its establishment and the adaptation of our activities to the latest information technologies available, to the deregulation process in contracting, and to the relationship with agents within the scope of information and training, has continued to improve making it a useful and efficient instrument for the development of competitive trading.

1.4.1 Principles governing the electricity market in accordance with established Regulations

The electricity market must be managed in accordance with the principles of transparency, objectivity and independence and in compliance with the Electricity Sector Act and the regulations that developed the Act.

Participation in the market is carried out using an electronic trading system capable of handling efficiently and transparently a large number of electricity purchasers and sellers of electricity and a very high volume of transactions and resultant settlements.



1.4.2 Market characteristics

1. Similarity to other markets

The electricity market is a regulated market similar to other organised markets. It guarantees the objectivity and transparency of transactions that are completed in the market.

2. Public market

This is a public market that can be accessed by the entities and system agent who meet the general terms and conditions established in the legislation and regulatory standards. These terms are applicable on equal basis to all participants.

3. Participants' guarantee

The participants' guarantee in the market is founded basically on the following points:

• The Market Activity Rules and, in general, all associated regulations are public and known to all participants and to those who wish to be participants. Moreover, electricity market courses organised by Operador del Mercado Ibérico de Energía – Polo Español, S.A., with the occasional involvement of other institutions, ensure that all interested parties are informed of these regulations, as does the general public information system established by OMEL, via the Internet and the public media, as described later.

• The Rules are the same for all participants, regardless of their volume of business or the nature of their activity, whether this be production, distribution, retailing or final consumption.

• The rights and obligations of all the market participants are stated in the Market Activity Rules and expressly accepted in the Contract of Adherence, leaving no room for any discretionary treatment of any party by the market operator. Matters related to bids submitted and the matching of these bids and aspects related to economic rights arising in connection with bid matching, are regulated and detailed in the Rules; hence, all the actions of the Company and the market operator can be reproduced by the market participants.

• The Market Activity Rules envisage all possible contingencies in order to facilitate matching results and subsequent transactions under any circumstances. Even in force major events, emergency mechanisms are provided in order to conclude the processes.

• The collateral scheme system established in the Rules ensures the proper performance and economic effectiveness of the transaction for the benefit of all participants.

1.4.3 Market sequence and processes

The aim of all the sessions held on the electricity production market on the day prior to the corresponding supply, is to determine the electricity transactions and the scheduling of the production units that are required to perform the transactions.

In compliance with the Market Activity Rules and the system operating procedures, the operating scheme is as follows:

• The daily market, to which bids can be sent at any time within the limit set by the closing time of the bid reception period, publishes the results of the corresponding session before 11 a.m. The transactions derived from the daily market session, together with the bilateral contracts and the international contracts set up the base daily operating schedule.

• Before the deadline established in the Rules, information will be received from the forward Market Operator, OMIP/OMI Clear, on the open-ended positions in the forward market from which agents have requested to carry out the physical delivery.

These open positions will be transformed into instrumental price bids to the daily market with information sent by their agents.

• Before the close of the reception of bids from the daily market, the required information will be received on the communication of the execution of power acquired by the distributors in the forward auctions and of the execution of the options on primary energy communicated by the buyers of this energy.

• Reception of the communications of the system operator on the results of the interconnection capacity auctions, with identification of the agents who have obtained user rights over such capacity.

	DAILY MARKET	INTRA DAILY 1° SESSION	INTRA DAILY 2° SESSION	INTRA DAILY 3° SESSION	INTRA DAILY 4° SESSION	INTRA DAILY 5° SESSION	INTRA DAILY 6° SESSION
Session opening		16:00	21:00	1:00	4:00	8:00	12:00
International bilateral contracts reception	10:00						
Addition of open positions in the forward market	10:00						
Session closing	10:00	17:45	21:45	1:45	4:45	8:45	12:45
Matching results	11:00	18:30	22:30	2:30	5:30	9:30	13:30
Domestic bilateral contracts reception	11:00						
Special regime production from distributors	11:00						
Base operational schedule publication (PBF)	11:00						
Reception of breakdowns of products and demand inputs	12:00	18:45	22:45	2:45	5:45	9:45	13:45
Constraints analysis	14:00	19:20	23:10	3:10	6:10	10:10	14:10
Adjustments for constraints	14:00						
Final daily viable schedule publication (PVD)	16:00						
Adjustments for constraints (PHF)		19:35	23:20	3:20	6:20	10:20	14:20
Checkpoints to follow guarantees	11:00	19:15	23:15	3:15	6:00	9:40	15:45
SCHEDULE HORIZON	24 hours	28 hours	24 hours	20 hours	17 hours	13 hours	9 hours

• Once the daily market session has closed, contracts and the bilateral declarations have been received any technical constraints that may have been derived from the daily market result are studied and solved. The process is completed before 2 p.m.

• On the basis of the provisional daily viable schedule, the system operator assigns, by means of an auction based on marginal price, the secondary regulation reserve (increases and decreases) to the participating production units. The result, which is published prior to 4 p.m., is the viable daily schedule.

• At that point, the first of the intraday market sessions (currently six) start to take place. The results of each intraday session is the final hourly schedule.

• The physical balance in the network between electricity production and consumption, based on market results, is ensured at all times by the system operator through the utilisation of ancillary services.

1.4.4 Creation of market price

Both markets are based on the formation of a supply curve and a demand curve that are created on the basis of sale and purchase bids, respectively. The intersection of these two curves, determines the market breakeven point and the matching result.

1.4.4.1 The daily market

The purpose of the daily market, as an integral part of electricity power production market, is to handle electricity transactions for the following day through the presentation of electricity sale and purchase bids by market participants.

Submitting bids to the daily market can be done as follows:

• The open positions communicated by the operator of the OMIP/OMIClear forward market will be integrated as sale or purchase instrumental price bids.

• The results of the communications of the execution of the power auctions of energy purchased by the distributors.

• The results of the execution of the options acquired by purchasers in primary power emissions.

• Owners of production units that are subject to the ordinary regime (y del regimen especial) submit sales bids, as long as such units are available and their energy is not linked to a bilateral contract.

• Distributors of electrical energy present specific sales bids relating to energy they are obliged to acquire under the special regime which are not covered by bilateral contracting systems with physical delivery.

, retailers, can also submit sale bids.

• Purchase bids are submitted by owners of purchase units, be they retailers, distributors, consumers.

Sale and purchase bids can be made using between 1 and 25 energy blocks in each hour, with power and prices offered in each block.

In the case of sales, the bid price increases with the block number, and it decreases in case of purchases.

The sale bids may be simple, or may include additional conditions. Simple bids are presented for each hourly period and production unit, indicating a price and an amount of energy. Complex bids are those which, fulfilling the simple bid requirements, also include some or all the technical or economic conditions, pointed out in the following picture. OMEL matches purchase and sale bids received prior to 10 a.m. each day, whereby the price in each hour will be equal to the price of the last block of the sale bid of the last production unit whose acceptance has been required in order to meet demand that has been matched.

The interconnection capacity affected by bilateral contracts on the one part and organised market operations on the other, will be split proportionally in order to incorporate bids through interconnections with Morocco.

The order ITC/843/2007, of 28 March establishes a market splitting mechanism in the daily and intraday markets, within the framework of the Iberian Market, in the event of congestion on the Spanish-Portuguese border.

This procedure could be accompanied by another of the explicit auctions similar to that referred to in Phase I, that will be mentioned later for the border with France.

The order ITC/4112/2005 also establishes that the mechanism for the resolution of technical congestion of the interconnection between Spain and France is governed by the provisions of its Appendix I, once the operating procedures established in said Appendix I have been approved and market operation rules have been adapted in line with it.

This international interconnection will be managed by means of a mechanism comprising two complementary processes. One of them will be based on the assignment of physical capacity rights via explicit auctions in different time periods, and the other will be he daily market process and will be included in market coupling between markets in France and Spain. The first of the processes will be managed by the system operator and the second by the market operator. The management of both processes will be carried out by the aforementioned operators and coordinated with their respective French counterparts.

The establishment of the congestion management mechanism will be carried out in three phases:

• Phase1: Only the explicit auction mechanism will be applied. In the event that the subject who holds a capacity assignment

does not notify the use of the said capacity for the scheduling of bilateral contracts in the deadlines established before the daily market for Spanish production, such capacity will be reassigned to other via explicit auctions on a daily and intraday basis. Capacity assigned on a daily basis, including reassignments referred to in the above section, may be used both for the execution of bilateral contracts with physical delivery and for the scheduling of transactions in the daily market.

• Phase 2: It is characterised by limited introduction of the Market coupling process, reserving for it capacity value which in no case may be higher than 15% of total capacity in the corresponding flow direction. In the event that the capacity assigned in explicit auctions for the scheduling of bilateral contracts in the daily market remains unused, this capacity may be reassigned to other system agent in the market coupling process.

• Phase 3: It is characterised by the unlimited application of both processes. The capacity split between explicit auctions and market coupling will be established in the regulation governing the entry into force of this phase.

The matching result contains the marginal price and the hourly production and demand schedules established by OMEL on the basis of the matching procedure for power purchases and sales.

The base operating schedule is drawn up by the system operator, include the result of the matching process and the notification of bilateral contracts.

1.4.4.2 Solution of technical constraints

If the base operating schedule does not comply with safety requirements, the system operator will modify the base operating schedule, incorporating or removing the production necessary to resolve technical problems.

The process for resolving technical restrictions in the base daily operating schedule comprises two different phases: in the first phase, the system operator will determine the technical congestions which might affect the execution of the base daily operating schedule, establishing the schedule modifications strictly necessaries to resolve the detected congestions and comply with safety criteria, as well as the limitations affecting the scheduled units. If congestions are identified in the production of several units in one area, the system operator will preferably establish a system of limitations aggregated by zone. If there are several technically equivalent modification alternatives, the cheapest are will be adopted.

All sales units will participate in this same phase of the process, except those representing imports from countries outside the European Union. With regards to acquisition units, only those corresponding to pumping units will participate in this phase and, in case there are no other means of resolving restrictions on the Spanish production system or there is a certain risk to domestic supply and acquisition, units outside the Spanish electrical system may also participate.

In the second phase, the system operator will introduce the modifications necessary to achieve a schedule which is balanced in terms of production and demand, in accordance with system operating procedures and respecting established limitations.

Sales units and acquisition units corresponding to pumping units will also participate in this phase.

System agent representing units which participate in the first or second phase of the technical constrains phase may present bids to increase or reduce their scheduled energy.

Pursuant to article 8 of Royal Decree 2019/1997, sales bid must be by system agent obliged to present bids to the daily market and representatives of pumping acquisition units respecting always the results of the base daily operating schedule.

Sales bids will be presented to the system operator once the result of the daily market is known and before any technical restrictions which might affect the execution of the base daily operating schedule is known.

Bids for the reduction of scheduled energy in sales units must be presented to the system operator by subjects representing units which participate in the second phase of the restriction resolution process. The same subjects may present bids to increase scheduled energy with respect to their pump acquisition units.

The settlement of costs arising from the process will be made by the system operator.

The costs arising from modifications of the programme carried out in the process of resolution of technical constraints will be paid by the owners of the acquisition units, in proportion to their consumption measured in the corresponding period. The pumping acquisition units and the acquisition units whose destination is the supply outside the Spanish electricity system will remain exempt from this assignation of costs.

1.4.4.3 The intraday market

The intraday market is currently structured in six sessions. Several sale and/or purchase bids may be presented for each production or purchasing unit.

The following market participants may submit bids in the different sessions of the intraday market:

• Daily market agents which participated in the corresponding session of said daily production market.

• Production units which returned to operation, which were not in operation at the time and did not participate in the daily market.

• Holders of bilateral contracts which, without participating in the daily market, have provided notification of contract execution for the hours included in the corresponding session of the intra-day market.

Participation in this market is on the sole condition of respecting prior commitments relating to ancillary services.

As regards the incorporation of international bids in the intraday market, this will be the same as indicated in daily market.

Sale or purchase bids can include between 1 and 5 energy blocks or sections per hour, and in each of which the prices must be increasing for sale bids and decreasing for purchase bids.

Simple bids consist in a price and an amount of energy for each hour, and may also include optional additional conditions.

These conditions may include the following:

• Load gradient.

• Minimum income or maximum payment.

• Complete acceptance in the matching process of the first block of the bid.

• Minimum number of consecutive hours with complete acceptance of the first block of the bid.

• Maximum matched energy.

OMEL matches the purchase and sale bids so that the marginal price in each hour is equal to the price of the last sale bid block which had to be accepted in order to ensure that purchase bids were fully or partially met at a price equal to or exceeding the marginal price. The system operator shall resolve technical restrictions resulting from the intra-day market, selecting withdrawal of all bids which resolve the restrictions identified and those other additional bids necessary to restore balance between production and demand. The market operator in order to select the bid, it will use the economic order sent by the market operator. The final schedule is so obtained.

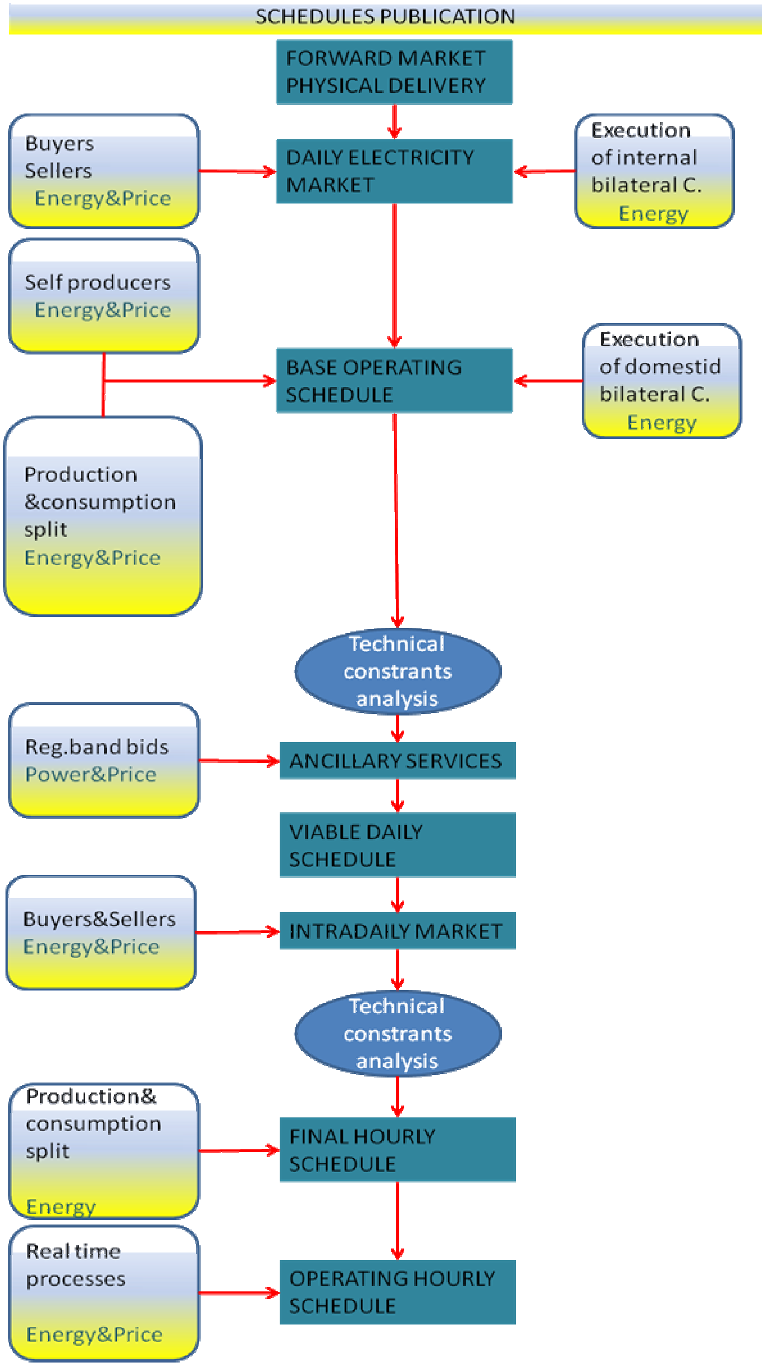
1.4.4.4 System technical management processes

The system technical management processes are those that are required in order to guarantee the supply of electricity under the required conditions of quality, reliability and safety, through deviation management and ancillary services, which may be either mandatory or voluntary:

- Mandatory ancillary services: primary regulation and voltage control (minimum requirement).
- Voluntary ancillary services: secondary regulation, non spinning reserve, voltage control and black start service.

Whenever possible, these processes are managed by means of auctions of power and energy requirements requested by the system operator. Installations authorised to provide mandatory ancillary services can present bids stating the concepts, amounts and prices offered. The system operator will assign the bids and determine the applicable retribution for the services effectively provided. This retribution will be at the marginal price.

The cost of ancillary services will be assigned only to energy consumed within the Spanish electricity system.



1.4.4.5 Information flows

In any organised market it is essential to structure and correctly manage information flows, which are set up between the entity managing the market and market participants, in order to guarantee the principles of transparency and competition. It is also essential that the market provides information, as long as it is not confidential, to the general public.

Likewise, in the case of the electric market, it is essential to have adequate and properly regulated communication between the market operator and the system operator.

Royal Decree Law 5/2005 modifies Royal Decree Law 6/2000 and after July 1st, 2005 establishes that all information on the electricity market shall be transparent and published in the following way:

• The market operator:

– Shall immediately make the information affecting the setting of prices on the organised market public to all agents.

– Shall publicise the results of the matching that occur within the scope of its competencies.

– Shall publish the aggregated curves of offers and demands of the daily and intraday markets, as well as (until the Ministerial Order ITC/400/2007 of 26 February comes into force) the programme resulting from matching that does not incorporate the offers assimilated into bilateral contracts between companies belonging to the same group, in accord with that established in the Royal Decree-Law 3/2006, with explicit splitting of each one of the points that are included in it.

• The system operator:

– Shall Publish the forecast for the demand, the commercial capacities of the interconnectors, and the situation of the hydro-electric reservoirs.

– Shall publish the results of the processes of operation and effect the settlement of those which may be within his responsibility.

• The Directorate General of Energy and Mining Policy shall determine the facts and the information considered relevant for setting the prices on the market This relevant information will be published by the National Energy Commission, telematically, pursuant to the second additional provision of Royal Decree 1454/2005.

• The aforementioned additional provision also establishes that the National Energy Commission will calculate and publish the final prices and average price indices for hourly electrical energy. In order to do so, the market operators and system operator will provide the necessary information on the markets and services managed by them.

In brief, the flow of information that is currently produced between the market operator, the system operator, the market agents, and the general public can be summarised as follows.

1.4.4.6 Exchange of information between the market operator and the system operator

The exchange of information between the market operator and the system operator is structured according to the following information:

• Communication by the system operator to the market operator of the following information:

– forecast demand, for complete months, published in the first half of the month prior to the month to which the forecast refers, – situation of the transmission network,

– partial or total unavailability of electricity production units,

– interconnections capacity,

– any other information that may be established or that the system operator or the market operator believe is relevant.

– Communication from the market operator to the system operator of the schedule system resulting from the matching of the daily market, till the entry in force of the Royal Decree 1454/2005.

– Communication from the market operator to the system operator of the daily viable schedule, which to the schedule resulting from the matching adds the resolution of technical restrictions and the result of ancillary services markets.

– Communication from the market operator to the system operator of the schedule resulting from the matching of the different session of the intra-day market.

1.4.4.7 Exchange of information between the market operator and market participants

• Communication by the market agents to the market operator, through the system operator, of the elements of the formal contracts for electrical power supply, or bilateral, be these national or international, or a consequence of the energy acquired by the distribution companies or by the buyers of options of primary energy emissions.

• Communication to the market operator by the holders of the units of production negotiating their energy through the Management Companies of the forward markets (OMIP/OMIClear), of the information necessary so that this energy can be taken into consideration in the process of matching and the determination of the daily programmes, and for the settlements that are the responsibility of the market operator.

1.4.4.8 Communications by the market operator to the public and to market participants

As a consequence of the urgent measures for the intensification of competition of Royal Decree-Law 6/2000, collected in the Reglas de Funcionamiento del Mercado (Rules for the Functioning of the Market), OMEL publishes the information referring to the daily and intraday market prices, the energy exchanged, the aggregated curves of offers and demand, the offers formulated by the agents and the market quotas.

It also publishes the capacity reserve displayed by market bid curves, based on the following three hypotheses:

• First hypothesis: amount of all residual energy, excluded imports;

• Second hypothesis: amount of residual thermal power bids. Obtained by deducting the amount of unmatched hydraulic plants from the first hypothesis;

• Third hypothesis: amount of limit residual thermal power bid, deducing from the bids in the second hypothesis the bids of thermal plants mode at more than 9.15 c€/kWh (half of the instrumental price), although the plants that resolved technical restrictions are incorporated.

1.4.4.9 Communications of the market operator to the Spanish Energy Commission (CNE)

Both the Spanish Energy Commission (CNE) and the Ministry of Industry, Tourism and Commerce have access to all information available on the databases of the market operator one day after the negotiations sessions.

Notwithstanding the foregoing, OMEL systematically provides the CNE with information that can be grouped into four sections:

a) Information necessary for settlements of regulated activities performed by the CNE:

• Cost of the energy acquisitions by each distributor, valued at the average final hourly price of the group of distributors, in agreement with the current legislation.

• Energy and average monthly sale price of production units that consume autochthonous coal.

• Average sale price of generating companies for their national production units.

• Amounts paid and collected as tariffs of the nuclear moratorium on invoices issued by the market operator with monthly settlement.

• Cost of deviations of special regime installations that do not make offers to the market as provided in articles 10, 11 and 12 of R.D. 841 of August 2, 2002.

b) Information on energy settlements made by OMEL. With each daily or monthly settlement, the market operator provides the CNE the hourly annotations and settlement summaries of all the market participants for each of their bid units and regulation zones.

c) Regular reports on the evolution of the market and on settlements. OMEL provides the CNE, whenever requested by the latter, with a half-yearly report on market settlements.

d) On a weekly basis, and whenever requested by the CNE, it provides the latter with information on the evolution of the market and the behaviour of the participants, in conformity with the criteria presented by OMEL for consideration by the CNE, as well as information on any anomalous situations observed by the market operator that goes against the market rules.

1.4.4.10 Settlements

The process of settlement and invoicing of the electrical energy production market has seen significant changes in the year 2006 as a consequence of the application of Royal Decree 1454/2005. The responsibility for economic management is shared between the market operator and the system operator, with each one being responsible for their own markets or processes.

From 1 June, the market operator will perform settlement and invoicing of the daily and intraday markets and the system operator will perform the settlement and invoicing of the processes of technical operation of the system of the capacity payment and of the deviations. The collections and payments have also been separated into two independent processes with their corresponding rules and timetables. In a similar way, the system guarantees have also had to be divided in two: some guarantees for the purchases in the daily and intraday markets and other for the payments for ancillary services, capacity payment and possible deviations

The market operator, in the application of the Royal Decree mentioned above, completes the settlement of the daily market and of each session of the intraday market once the results of the matching have been published and as an integrated process with receiving the market results.

Settlement, which for each of the daily and intraday sessions of the markets determines the rights of each of the agents to collect and the obligations to pay, also incorporates a calculation of the volume of current available guarantees for each agent starting from the following market session.

All the information is accessible by queries that can be run at any time.

Daily settlement is the result of incorporating the settlement of the daily market, the period of 24 hours of the first intraday market corresponding to that day, the 5 sessions of the subsequent intraday market and the first 4 hours of the first intraday of the following day, also corresponding to that settled and invoiced day.

Once daily settlement has taken place, the corresponding invoices are prepared as, according to the Rules of the functioning of the Market, invoicing is daily.A period of three days is available for each of the processes: settlement by the market operator, confirmation of settlement or claims to be raised, if any, by the agents and their resolution by the market operator.

Regarding the issuing of invoices, it should be highlighted that trading through the electricity market has a multilateral character, so that all the sellers trade with each and every one of the buyers. In consequence, each of the sellers must issue independent invoices for all the buyers, proportionally dividing between them the total of their production and its sale. This procedure will create a large number of invoices, some of them with very small quantities.

In order to resolve this problem, Royal Decree 215/1999 of 5 February, and later Royal Decree 1496/2003 of 28 November, by the which the Regulation by which the obligations of invoicing were regulated and the Regulation of the Value Added Tax was modified, establish that the delivery of energy realised through the market will be documented through invoices issued by OMEL in the name and for the account of the supplying organisations, returning to these a copy of these invoices and keeping the originals; in parallel, OMEL will issue invoices to the acquirers of energy, sending them the originals and keeping a copy. In this way the fiscal obligations of the market agents are significantly simplified in relation to the issuing of invoices.

Collections and payments of the daily and intraday markets will be made weekly, thereby achieving a weekly settlement, and details of these will be provided to the agents every Monday, or the following day in case this falls on a public holiday. Claims and resolutions of claims can be made during a period of three days in a similar way to that applicable to daily settlement.

Payments must be made on the third working day of the week following the corresponding settlements and collections must be made on the following day, except if this falls on a public holiday, in which case they must be made on the previous evening. The collections and payments are made through a bank account opened by OMEL, completely independent of its own assets and only used by the market agents for those purposes.

All the information generated, as well as the invoice signed electronically for all the agents who request it, around 500, are placed at their disposition on the agents' website for their analysis, checking and electronic processing in their accounts departments through files in XML format that can be loaded automatically.

With reference to the producers in the special regime, it should be pointed out that currently, a large percentage of these sell their energy in the market, either directly or by means of a representative. In this latter case, these producers can opt to receive settlement directly or through their representative. Consequently, the market operator effects the corresponding settlement and invoicing to the producer or the representative as requested.

1.4.5 Capacity payment

The cost of capacity payment is a component of the total price of electricity in the market, the object of which can be identified as a correct signal in the medium term for all the market participants and which expresses the cost of guaranteeing the supply to all consumers, as foreseen in the Law 5/1997 of the Electricity Sector.

The twelfth additional disposition of Royal Decree 1364/2006 of 29 December on tariffs from 1 January 2007 establishes that before 1 June 2007, the National Energy Commission will supply a proposal for the mechanisms of assignation and procedures for collection and payment of capacity payment to the Ministry of Industry, Tourism and Commerce For the buyers in the organised market, the capacity payment is equivalent to a minimum prices that they must pay over specified periods.

1.4.6 Measurements and deviations

The measurements coming from each meter-recorder are received in the main concentrator of electrical measurements, managed by the system operator, the current requirements of which are the following:

• Meter reading digitally encrypted and signed on the meter, for high voltage measuring equipment, optional on low voltage, except for those that directly participation the market or subscribe a bilateral contract with a producer.

• Readings are received individually without any type of manipulation at the main electricity measurement concentrator, except for qualified consumer points with consumption levels of less than 750 MWh/year contracting with a retailer, and which can be added.

• Secondary concentrators may exist, whose owners are distributors as the entities entrusted with transferring measurements from the meter to the main electricity measurement concentrator.

• Existence of secondary concentrators that may be owned by retailers.

Deviations are defined as differences between measured power and traded power, which is the difference between traded power and actual production or consumption.

Where applicable, measured power includes losses through the transmission network.

Until 1 January 2007, the costs of the processes of technical system management that provoked them will be applied to all deviations, irrespective of the direction of the deviation. From then, the agents whose deviation is in a contrary direction to that of the system have a penalty or surcharge.

1.4.7 Determination of the final price

From the time when the modifications introduced by Royal Decree 1454/2005 come into force, the final price of energy is calculated hourly by the National Energy Commission, incorporating the following components:

• Price of daily market matching.

• Cost or benefit resulting from the process of resolving technical restrictions.

• Cost or benefit of the secondary regulation auction.

• Price of daily market matching.

• Cost or benefit of the processes of technical operation of the system necessary for the regulation and to compensate for the deviations on the trading.

• Cost or benefit of the capacity payment.

• Surplus or deficit on international contracts underwritten by Red Eléctrica.

• Compulsory transaction costs of the distributors in OMIP. The final price is used to effect the settlement of acquisitions of energy made in the extra-peninsular and insular electricity systems, within the framework of the introduction of competition in these systems. It is also incorporated as a reference in specific transactions between the distributors and generators in the special regime.

1.4.8 Extra peninsular systems

The extension of the deregulation of the electricity activities established in Electricity Sector Law 54/1997 to the extra peninsular and island territories has been regulated by Royal Decree 1747, of 19 December 2003, which, in addition to incorporating the principles of competency, third-party access to the network and freedom of consumers to choose their electricity supplier, takes into account the specific aspects of the territorial location, in accordance with the provisions established in article 12 of the aforementioned Electricity Sector Law.

The regulation established by the aforementioned Royal Decree is complemented by Order ITC/913/2006, of 30 March, approving the method for calculating the cost of each of the fuels used and the procedure for dispatch and settlement in insular and non-peninsular electrical systems, a And order ITC/914/2006, of 30 March, establishing the calculation method for paying for the capacity payment for generating facilities covered by the ordinary regime for insular and non peninsular electrical systems, both published in the BOE of 31 March 2006.

The Royal Decree establishes a system for dispatching production based on the declaration of variable costs and on the regulation of fixed costs for producers. As regards the acquisition system agent i.e. the consumers, resellers and distributors, they are treated in the same way, from a cost standpoint, as their counterparts on the peninsula; they are entitled to exercise their right to choose supplier and participate in the market by communicating the estimated consumption paying the final price of energy on the peninsular market.

1.4.9 Presentation of sale and purchase schedules

The delivery of sale and purchase schedules by the agents has objective to the presentation of bids to the peninsular market and will be performed at least once a day (similar to the peninsular daily market) and will provide the starting point for the competition of the generation/consumption schedules in the corresponding territories.

1.4.10 Access to the final price of electrical power

The demand of each island and extra-peninsular system, i.e. demand by consumers, resellers, and distributors, has access to the final market price by participating in the dispatch process. Consumers may also establish bilateral contracts with resellers and producers.

1.4.10.1 Settlements paid by buyers

The Market Operator will settle the final price paid by all buyers according to the peninsular final price, taking into account the deviations estimated by the system operator. Another settlement corresponding to distributors is carried out in the National Energy Commission by means of a system similar to that applicable to peninsular distributors. The applicable complementary regulation had not yet been published when this document was completed.

1.4.10.2 Settlement to generators

The market operator must pay settle generators using the funds paid by buyers participating in the dispatch. Since the generation costs in the extra-peninsular and island systems do not normally coincide with the purchases of consumers valued at the peninsular final price, an imbalance exists between the price paid by buyers and the price collectable by generators based on their costs. In this way, the settlement performed by the market operator provides generators with funds that are normally insufficient.

In order to make up this difference, the National Energy Commission will pay generators the sum of the following items:

• The difference between the cost of energy purchased by distributors from generators valued at the final hourly generation price in each SEIE (island and extra-peninsular electricity system) and the cost of this energy valued at the average price on the peninsular system payable by all distributors.

• The difference between the cost of energy purchased by resellers and consumers from generators, valued at the final hourly generation price in each SEIE, and the cost of this energy valued at the average price on the peninsular system payable by all resellers and consumers purchasing energy directly on the market.

1.4.11 Basic conditions of energy purchase and low voltage network access contracts

Royal Decree 1435, of 27 December 2002, which sets out the basic contract terms for energy acquisition and low voltage network access, incorporates the following fundamental aspects:

• It establishes the specific terms and conditions governing the contracting of energy supplies between low voltage consumers and resellers.

• It offers consumers the option of either managing the contract governing access to the networks with the corresponding distributor or entrusting the reseller that supplies power on their behalf with this task.

• It establishes the creation of computer databases that the distributors must keep accessible for their clients at no cost, differentiating between supply point data accessible by all the players in the system and restricted data that can only be accessed by certain participants.

• It standardises the procedures to follow in the event of termination or cancellation of the contracts and determines the deadlines for the changeover from supply tariff to access tariff and the periods for changing reseller. These deadlines are differentiated depending on whether or not actions are requested on the installations and according to the meter reading cycle and invoicing of supply.

• It determines the conditions, means of communications, deadlines and procedures for dealing with requests for modification of contacting characteristics to the distributors.

• It enables low voltage consumers to contract through the organised market and by means of bilateral contracts with producers.

This means that all the consumers have access to the same existing contracting possibilities for qualified high voltage consumers.

1.4.12 Plan for the installation of measurement equipment.

The twenty-second additional Disposition of Royal Decree 1364/2006 of 29 December on tariffs from 1 January 2007 establishes that before 1 July 2007, the National Energy Commission will provide a report to the General Directorate of Policy for Energy and Mines where a plan is established for the national replacement of existing meters with meters that allow hourly discrimination of measurements and tele-management of the electricity power supply up to a contracted potency of 15 kW.

In this plan, the criteria for the substitution of this measurement equipment as well as the number of meters to be installed annually, as a percentage of the total national installed meters of this type, will be described.

The extension of deregulation to all consumers following the implementation of the current legislation, and which is now a reality, represents a fundamental element for the short- and medium-term development of the market. Its full effectiveness will depend on factors linked to the possibility of choosing suppliers, price formation with growing importance in the market and stronger links between market wholesalers and retailers. The design characteristics of the market managed by OMEL contributes positively to this process and can be strengthened with the integration of long term supplies through bids to the market operator or by developing demand management programs in order to stimulate an efficient response to prices on the part of consumers.

2.0 DESPRIPTION OF THE LINEAR REGRESSION MODEL DEVELOPED BY CARLOS GUZMAN

2.1 Introduction

In this chapter will be described the work done in the thesis of Carlos Guzman. His aim was to develop a linear regression model that can explicate the final electricity price in the diary market. In other words, the objective was to reproduce with a statistic function and in the most reliable way the electricity daily price starting from historical data.

In the paragraph 2.2 is described the theoretical basis of the regression model, while in the paragraph 2.3 are described one by one the variables that has been studied because considered as variable that could influence the final price. Finally, in the last paragraph 2.4 are described two different type of regression applied.

2.2 Regression analysis

The regression analysis is a technique used for the modelling and analysis of numerical data consisting of values of a dependent variable (response variable) and of one or more independent variables (explanatory variables). In our case the dependent variable will be the electricity price, while the independent variables are energy demand, installed capacity, hydraulic reservoir in the dams, hydraulic generation, pumping generation, combined cycle gas turbine generation, fuel oil generation, coal generation, etc.(for a better description see the paragraph 2.3).

The dependent variable in the regression equation is modelled as a function of the independent variables, corresponding parameters ("constants"), and an error term. The error term is treated as a random variable. It represents unexplained variation in the dependent variable. The parameters are estimated so as to give a "best fit" of the data. Most commonly the best fit is evaluated by using the least squares method, but other criteria have also been used.

Data modelling can be used without there being any knowledge about the underlying processes that have generated the data; in this case the model is an empirical model. Moreover, in modelling, knowledge of the probability distribution of the errors is not required. *Regression analysis* requires assumptions to be made regarding probability distribution of the errors. Statistical tests are made on the basis of these assumptions.

Regression can be used for prediction (including forecasting of time-series data), inference, hypothesis testing and modelling of causal relationships. The use that we are doing is creating a model of the electricity price generation and then, as will be explicate in the next chapter, we will try to use this mode to forecast the future energy price.

These uses of regression rely heavily on the underlying assumptions being satisfied. Regression analysis has been criticized as being misused for these purposes in many cases where the appropriate assumptions cannot be verified to hold. One factor contributing to the misuse of regression is that it can take considerably more skill to critique a model than to fit a model.

2.2.1 Underlying assumptions

1. The sample must be representative of the population for the inference prediction.
2. The dependent variable is subject to error. This error is assumed to be a random variable, with a mean of zero. Systematic error may be present but its treatment is outside the scope of regression analysis.
3. The independent variable is error-free. If this is not so, modelling should be done using Errors-in-variables model techniques.
4. The predictors must be linearly independent, i.e. it must not be possible to express any predictor as a linear combination of the others.
5. The errors are uncorrelated, that is, the variance-covariance matrix of the errors is diagonal and each non-zero element is the variance of the error.
6. The variance of the error is constant (homoscedasticity). If not, weights should be used.
7. The errors follow a normal distribution. If not, the generalized linear model should be used.

2.2.2 Linear regression

In linear regression, the model specification is that the dependent variable, yi is a linear combination of the *parameters* (but need not be linear in the *independent variables*). For example, in simple linear regression for modelling *N* data points there is one independent variable: x_i, and two parameters, β_0 and β_1:

Straight line: $y_i = \beta_0 + \beta_i x_i + \varepsilon_i$ with i =1...n

In multiple linear regressions, there are several independent variables or functions of independent variables. For example, adding a term in x_i^2 to the preceding regression gives:

Parabola: $y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \varepsilon_i$ with i =1...n

This is still linear regression as although the expression on the right hand side is quadratic in the independent variable x_i, it is linear in the parameters β_0, β_1 and β_2.

In both cases, ε_i is an error term and the subscript *i* indexes a particular observation. Given a random sample from the population, we estimate the population parameters and obtain the sample linear regression model:

$$y_i = \hat{\beta}_0 + \hat{\beta}_i X_i + \hat{e}_i$$

The term e_i is the residual, $e_i = y_i - \hat{y}_i$. One method of estimation is Ordinary Least Squares. This method obtains parameter estimates that minimize the sum of squared residuals, SSE:

$$SSE = \sum_{i=i}^{n} e_i^2$$

Minimization of this function results in a set of normal equations, a set of simultaneous linear equations in the parameters, which are solved to yield the parameter estimators, β_0, β_1.

In the case of simple regression, the formulas for the least squares estimates are

$$\hat{\beta}_1 = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2} \text{ and } \beta_0 = \bar{y} - \hat{\beta}_1 \bar{x}$$

Where $\bar{x}$ is the mean (average) of the x values and $\bar{y}$ is the mean of the y values

Under the assumption that the population error term has a constant variance, the estimate of that variance is given by:

$$\hat{\sigma}_{\varepsilon} = \sqrt{\frac{SSE}{N-2}}$$

This is called the root mean square error (RMSE) of the regression. The standard errors of the parameter estimates are given by

$$\hat{\sigma}_{\beta_0} = \hat{\sigma}_{\varepsilon}\sqrt{\frac{1}{N} + \frac{\bar{x}^2}{\sum (x_i - \bar{x})^2}}$$

$$\hat{\sigma}_{\beta_1} = \hat{\sigma}_{\varepsilon}\sqrt{\frac{1}{\sum (x_i - \bar{x})^2}}$$

Under the further assumption that the population error term is normally distributed, the researcher can use these estimated standard errors to create confidence intervals and conduct hypothesis tests about the population parameters.

2.2.3 General linear data model

In the more general multiple regression model, there are p independent variables: The least square parameter estimates are obtained by p normal equations. The residual can be written as

$$e_i = y_i - \hat{\beta}_0 - \hat{\beta}_1 x_1 - \ldots - \hat{\beta}_p x_p$$

The normal equations are $$\sum_{i=1}^{n}\sum_{k=1}^{p} X_{ij} X_{ik} \hat{\beta}_k = \sum_{i=1}^{n} X_{ij} y_i, \quad j = 1, p$$

In matrix notation, the normal equations are written as

$$(X^T X)\bar{\beta} = X^T y$$

2.2.4 Regression diagnostics

Once a regression model has been constructed, it is important to confirm the goodness of fit of the model and the statistical significance of the estimated parameters. Commonly used checks of goodness of fit include the R-squared, analyses of the pattern of residuals and hypothesis testing. Statistical significance is checked by an F-test of the overall fit, followed by t-tests of individual parameters.

Interpretations of these diagnostic tests rest heavily on the model assumptions. Although examination of the residuals can be used to invalidate a model, the results of a t-test or F-test are meaningless unless the modelling assumptions are satisfied.

- The error term may not have a normal distribution.

The response variable may be non-continuous. For binary (zero or one) variables, there are the "probit and logit" model. The multivariate probit model makes it possible to estimate jointly the relationship between several binary dependent variables and some independent variables. For categorical variables with more than two values there is the multinomial logit. For ordinal variables with more than two values, there are the ordered logit and ordered probit models. An alternative to such procedures is linear regression based on polychoric or polyserial correlations between the categorical variables. Such procedures differ in the assumptions made about the distribution of the variables in the population. If the variable is positive with low values and represents the repetition of the occurrence of an event, count models like the Poisson regression or the negative binomial model may be used .

2.2.5 Interpolation and extrapolation

Regression models predict a value of the y variable given known values of the x variables. If the prediction is to be done within the range of values of the *x* variables used to construct the model this is known as interpolation. Prediction outside the range of the data used to construct the model is known as extrapolation and it is more risky.

2.2.5.1 Non linear regression

When the model function is not linear in the parameters the sum of squares must be minimized by an iterative procedure. This introduces many complications which are summarized in differences between linear and non-linear least squares.

2.2.6 Other methods

Although the parameters of a regression model are usually estimated using the method of least squares, other methods which have been used include:

- Bayesian methods
- Minimization of absolute deviations, leading to quantile regression
- Nonparametric regression. This approach requires a large number of observations, as the data are used to build the model structure as well as estimate the model parameters. They are usually computationally intensive.

2.3 External Variables

Here is a list of the entire externals variables that are considered in all the different models studied:

- Energy demand

As mentioned in the chapter that describes the demand and supply curve, the demand is formed in agreement to the bids sent to the energy buyers.

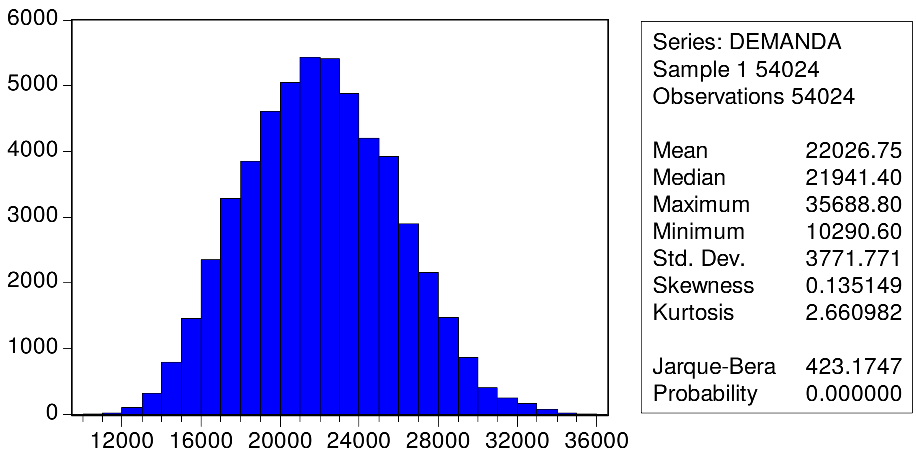
In the point in which the bids and the offers meet, that point is the market equilibrium, where is created a price that is the one present in the daily market.

According to this reasoning, the variable demand corresponds to the point in which demand curve intercept the supply curve and became the demand matched in the daily market.

Due to the fact that the equilibrium must exist between supply and demand, this last one is obtained as sum of the generation matched by OMEL in the daily market. We have date demand from the first of January 1998.

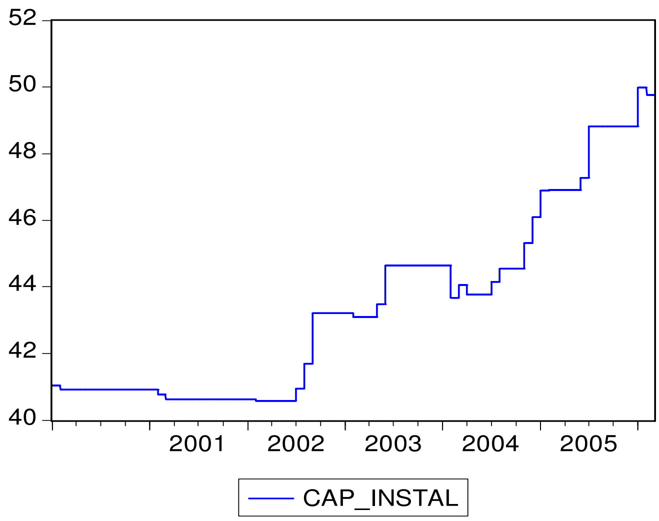
However, in the development of the model it couldn’t be admitted contemporary the generation of every plant existing and the demand, because between one and the other there is total correlation, being the value of the demand the sum of all the existing plants.

Analyzing the data of the demand it can be seen that they have a distribution with a mean value of 22.026 MWh and a standard deviation of 3.772; besides, looking to the profile of the demand frequency distribution, it is easily to notice that his profile is similar to a normal distribution, with a small tail on the right side. The graphic 2.0 show the histogram frequency of the data set with the statistics parameters more relevant.



Graphic 2.0 distribution of demand frequency (MWh)

The variable "installed capacity" is conformed to the total generation capacity existing in the country in ordinary regime plants. In order to obtain the capacity evolution curve are used monthly data; were considerate opening of new plants, closing of olds one and the strengthening achieved. The values used are shown in the annex 1.



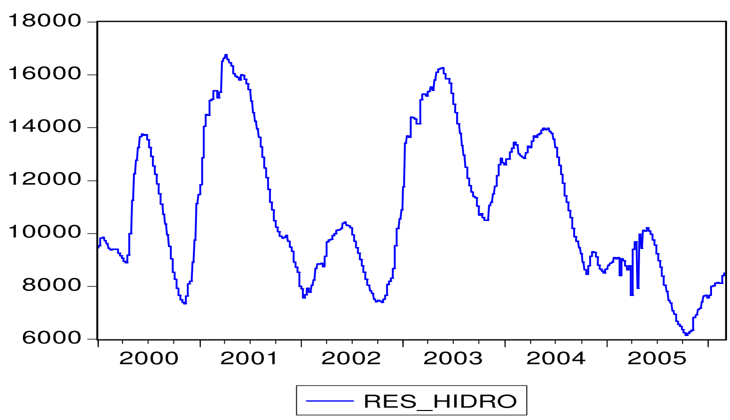
Graphic 2.1 Installed capacity evolutions (GW)

- Hydraulic reservoir in the dams

The hydraulic reservoir in the different hydraulic plants with dams is a measure that conditions the generation bids and therefore the system curve bids. The curve is formed using data on weekly base, published by the Environmental Ministry. These data pinpoint the potential in GWh of water stored in each dam. In the case that the plants are in line the value reflect the potential that could be generated in all the dams downstream.

Is natural that the samples have a seasonal behaviour, dictated by the hydrologic cycle, as shown in the graphic 2.2. It can be observed that the samples has a big variability between one years and the other.

Indeed the frequency distribution has a mean value of 10.887 GWh, and a standard deviation of 2.771. The data have a swelling on the right and are more focused around the mean value than in a normal distribution. The graphic 2.2 show the frequency distribution with the mains statistics parameters.

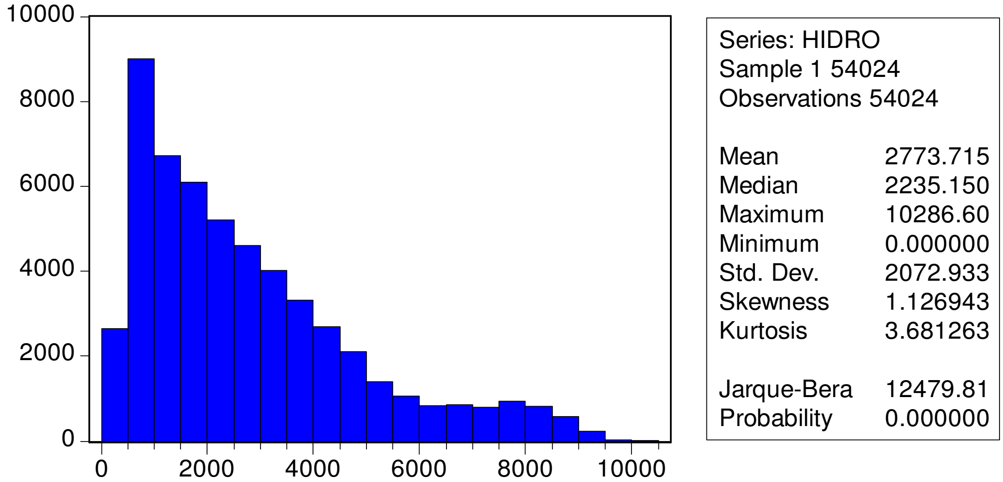


Graphic 2.2 evolution of hydraulic reservoir (GWh)

- Hydraulic generation

This variable regard all the electricity generation related to this type of resource matched in the diary market. The data are on an hourly base, and indicate the generation in MWh.

Also this data set has a high seasonal behaviour, as seen in the hydraulic reservoir set. Just this two series has a high correlation: 0.6296 (this value was obtained for reservoir value on weekly base and hydraulic generation on diary base).

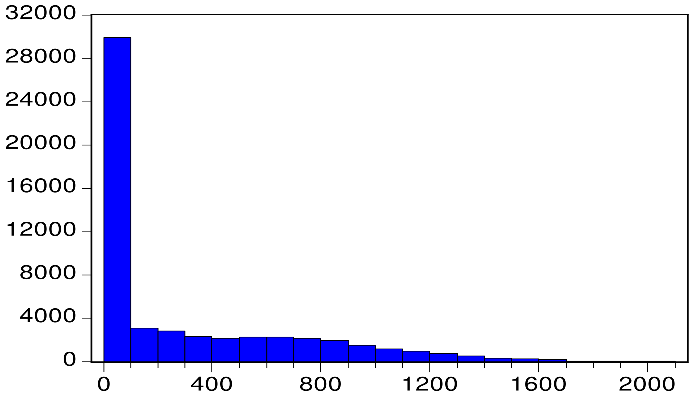


Graphic 2.3 Distribución de Frecuencias de la Generación Hidráulica (MWh)

- Pumping generation

Due to the fact that the function of pumping generation is buy energy in high price hours and generate when the prices are high, its activity is concentrated in very few hours and with small quantities, generally no more than 100 MW.

This is evident looking at the graphic 2.X that shows the histogram of frequency of the data.



Series: BOMBEO	
Sample 1 54024	
Observations 54024	
Mean	279.4874
Median	1.900000
Maximum	2019.000
Minimum	0.000000
Std. Dev.	393.4789
Skewness	1.341949
Kurtosis	3.858710
Jarque-Bera	17874.49
Probability	0.000000

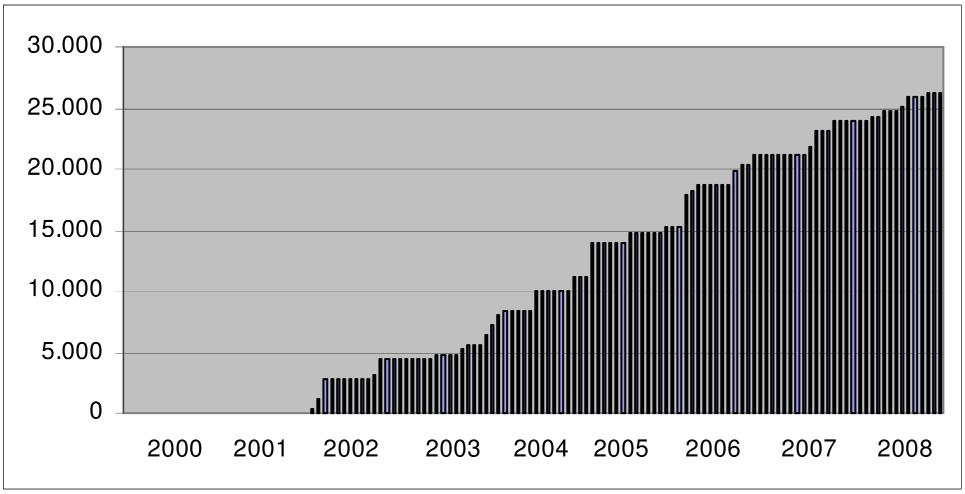
Graphic 2.4 pumping frequency distribution (GWh)

- Combined cycle gas turbine generation

In a combined cycle gas turbine (CCGT) plant, a gas turbine generator generates electricity and the waste heat is used to make steam to generate additional electricity via a steam turbine; this last step enhances the efficiency of electricity generation.

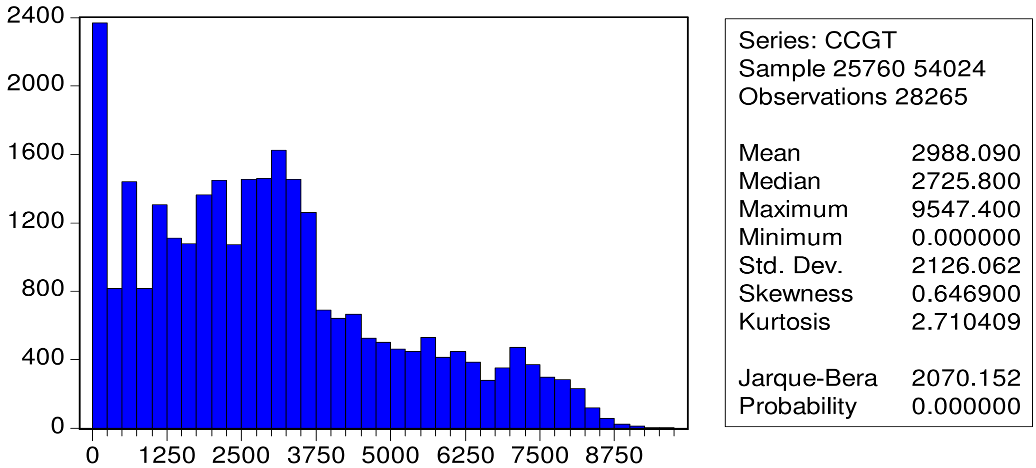
This kind of generation is quite recent in the Spanish system, with the first plant installed in the 2002, with a very fast rate growth.

The following graphic displays the evolution of the installed capacity of the combined cycle in Spain in the years of interest.



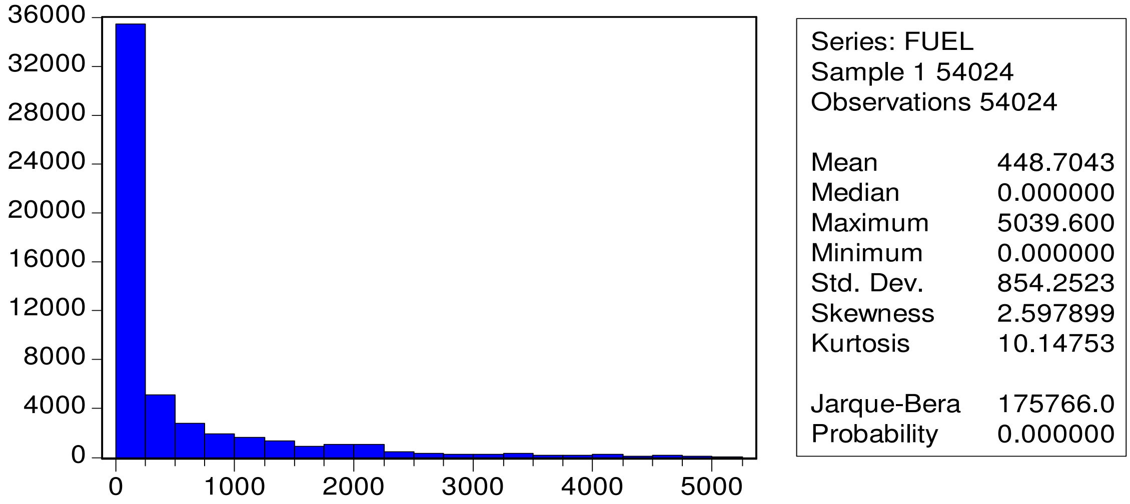
Graphic 2.5 Spanish evolution of Combined Cycle (MW)

Looking instead to the frequency distribution of the production, it can be appreciated a high numbers of CCGT generation with values smaller than 3750 MW, despite in the future are expected values a little bit higher, due to an expectation of new entrants in the system.



Graphic 2.6 CCGT generation frequency distribution (MWh)

The fuel oil units are destined to function rarely, due to the fact that they are quite costly, and so these plants enter in the bids matched only at times (the most due to technical restrictions). This behaviour is shown in the graphic 2.9, where the production is concentred in a range below 250 MW.



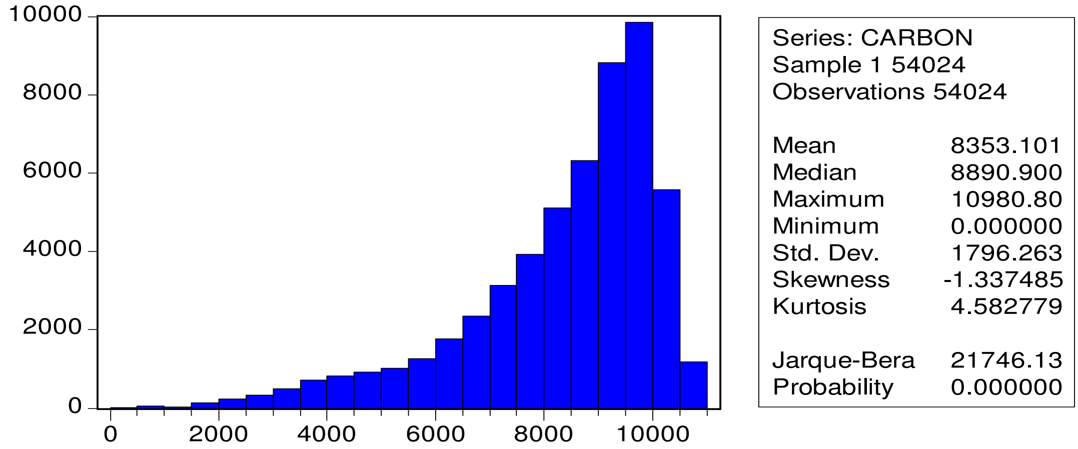
Graphic 2.7 Fuel oil frequency distribution (MWh)

- Coal generation

Coal is primarily used as a solid fuel to produce electricity and heat through combustion. World coal consumption is about 6.2 billion tons annually, of which about 75% is used for the production of electricity.

Different from the fuel oil behaviour, the dispatch of the coal plant is more frequent, insomuch as sometimes it can be operate as a base load generation.

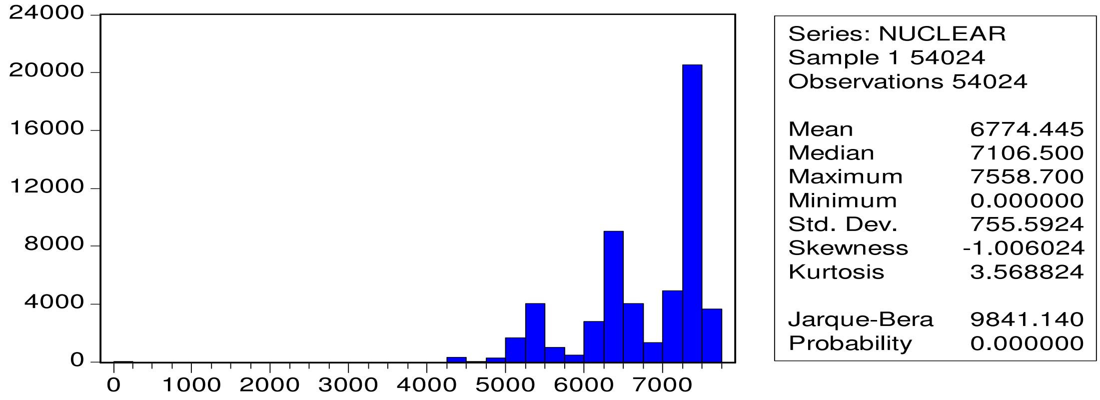
In the future almost all plants of fuel oil will be closed, and for the final formulation this kind of variable will have very low (or nothing) influence in the creation of the final price.



Graphic 2.8 Fuel oil generation distribution frequency (MWh)

- Nuclear generation

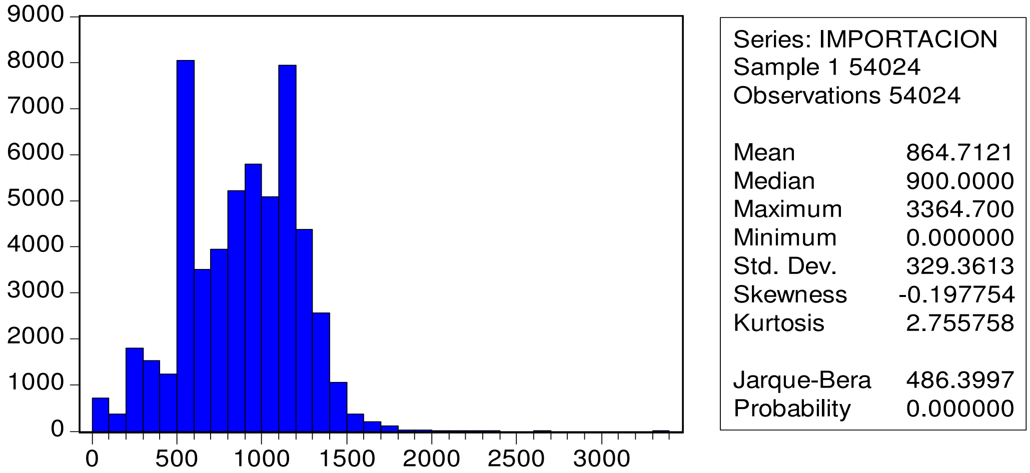
The mayor number of nuclear plants took place in the seventies and in the eighties; this kind of plants are destined to form the base load, being enterprise with a very low variable cost and a very high investment cost. This fact is reflected in the graphic 2.11: the Spanish electricity system usually generate hourly with this technology around 7000-8000 MWh in mean, with minimum values around 5000 MWh.



Graphic 2.9 nuclear generation distribution frequency (MWh)

- Importations

This variable corresponds to all the energy imported in Spain from France, Portugal and Morocco. Generally importations are opportunity transactions used for make arbitrage in different market in order that is to buy in a market where the energy is cheaper and sell it where it cost much. The transactions are in mean between 500 and 1500 MWh.



Graphic 2.10 Importations distribution frequency (MWh)

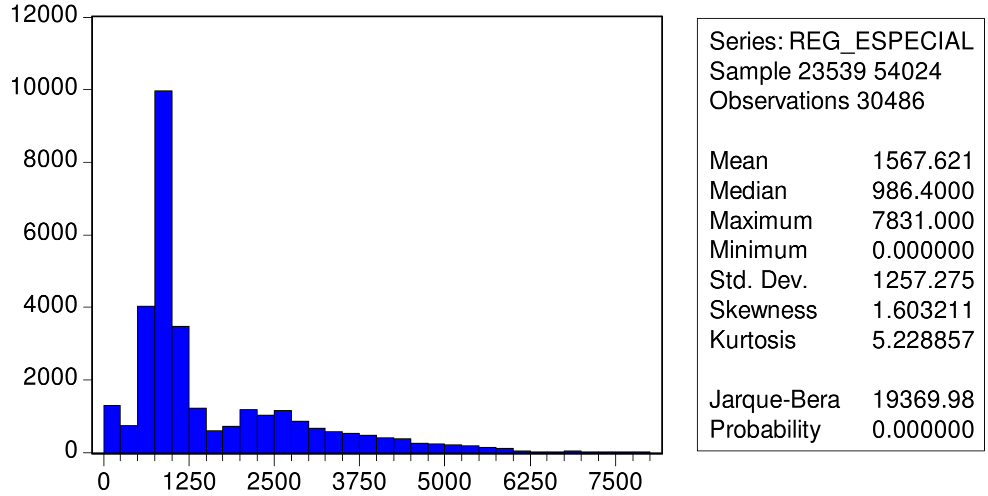
- Special regime generation

As described with more details in the first chapter, Special Regime Generators are those using renewable resources with an installed capacity of up to 50 MW and cogeneration. Special Regime Generators may sell their net electricity production to the system at:

- The tariff fixed by royal decree, which is indexed to the average or reference tariff of the Spanish system.

- The Spanish pool price, plus certain premiums and incentives.

In the market the energy is sold at zero prices, in order to put always in the system the energy produced with renewable sources.



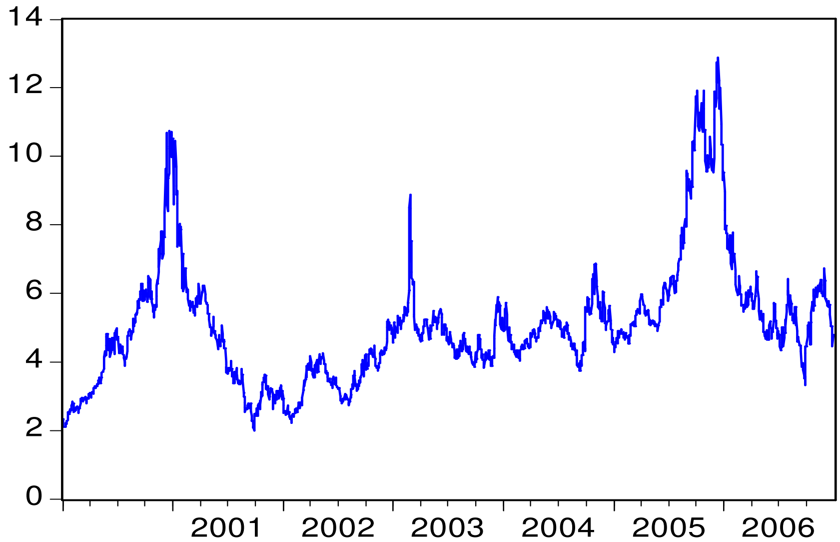
Graphic 2.11 Special regime frequency distribution (MWh)

- Gas price

The gas price is the fuel used for he CCGT plants, and so the gas price is translated in a measure of variable costs of this kind of generation.

In order to obtain the sequence we dispose on diary quotation of the Henry Hub Index.

Generally this index presents a high volatility, with two high rises at the end of the 2000 and 2005.



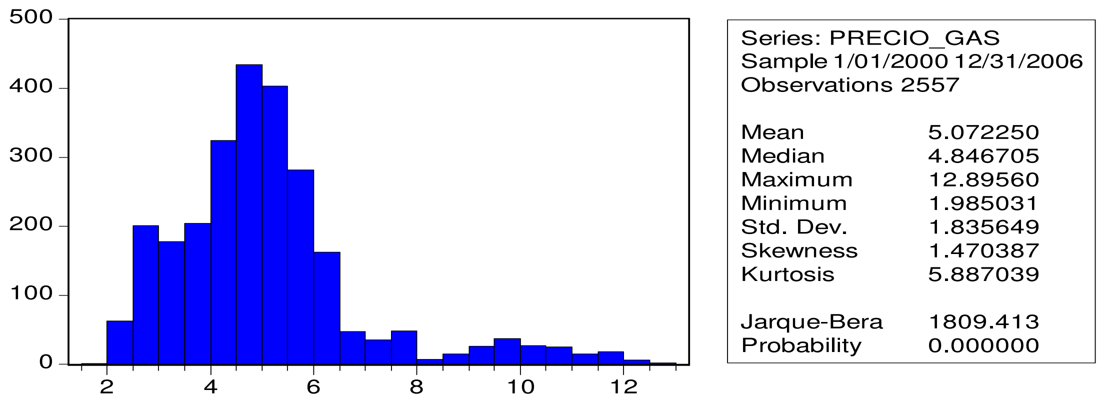
Graphic 2.12 HH gas price evolution, 2000 - 2005 (€/MMBTU)

Considering the frequency distribution of the gas price trend in the graphic 2.14, the quotation has been concentred between 2.5 and 6.0 €/MMBTU.

What's more there are a big number of values higher of 8 €/MMBTU, creating a tail in the right side of the distribution.

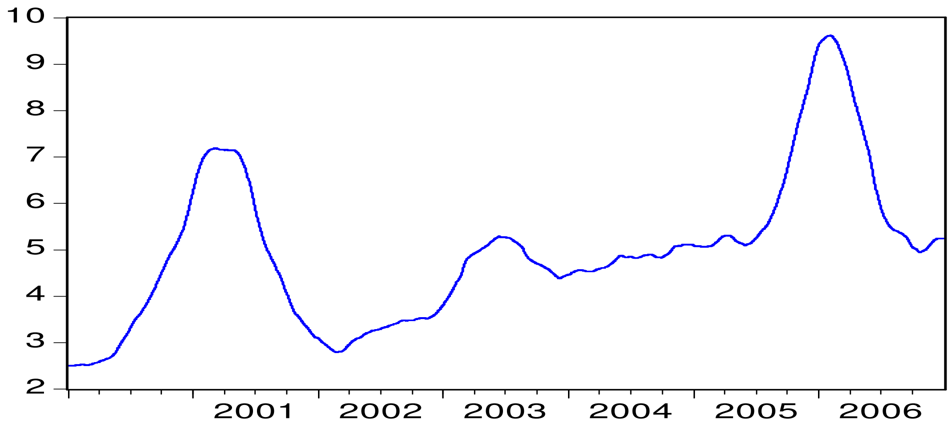
However, the generators have generally contracts for long time, but the price that is reflected is indexed to mean values.

For this reason, in some cases, has been used a gas price series with an average mobile of "n" days back.



Graphic 2.13 HH gas price frequency distribution (€/MMBTU)

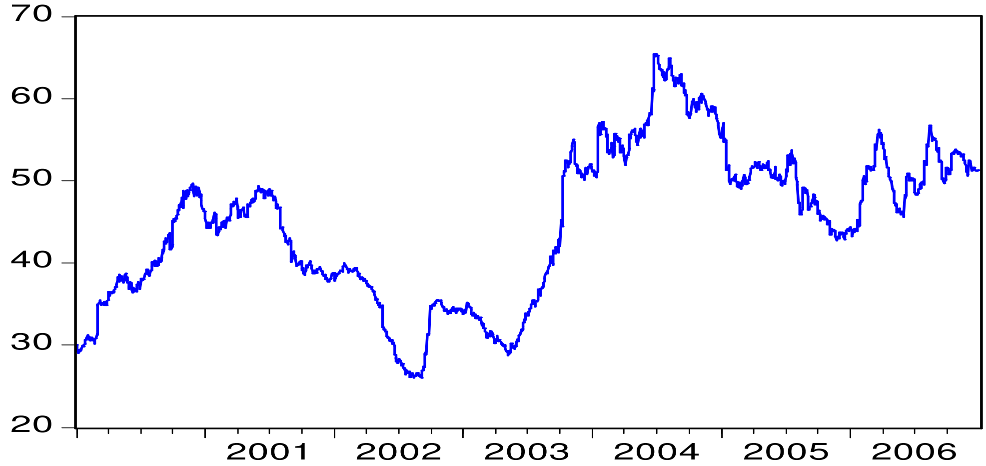
As example the following graphic is a series with a mobile average of 180 days.



Graphic 2.14 Gas price evolution with a mobile average of 180 days (€/MMBTU)

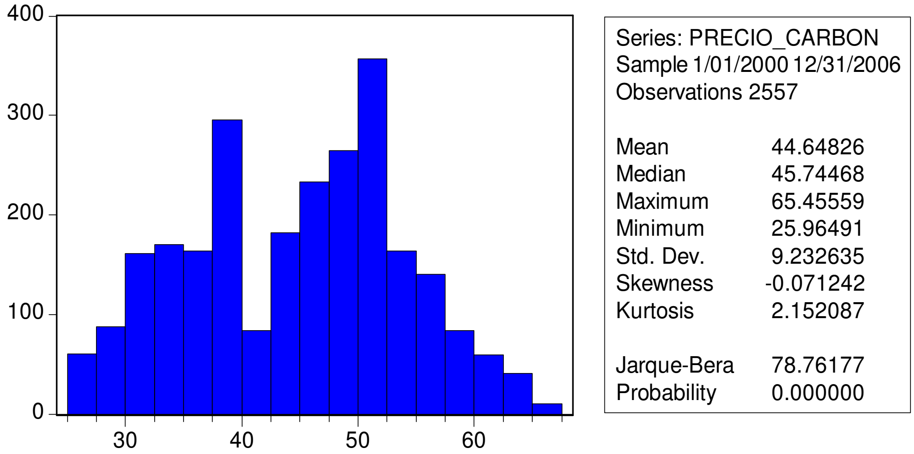
- Coal price

As the gas price, also the coal price has a high volatility: looking at its frequency distribution for the period 2000-2006 his standard deviation is 9.23.



Graphic 2.15 coal price API 2 evolution (€/TM)

This volatility, always with a similar behaviour to the gas, is not translated to the final bid price, and in order to reflect this in the mathematic model has been used an average mobile of “n” days back.

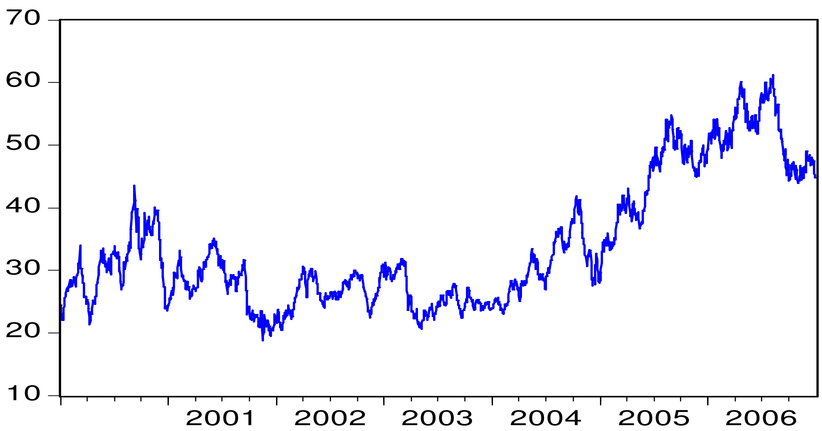


Graphic 2.16 API 2 frequency distribution (€/TM)

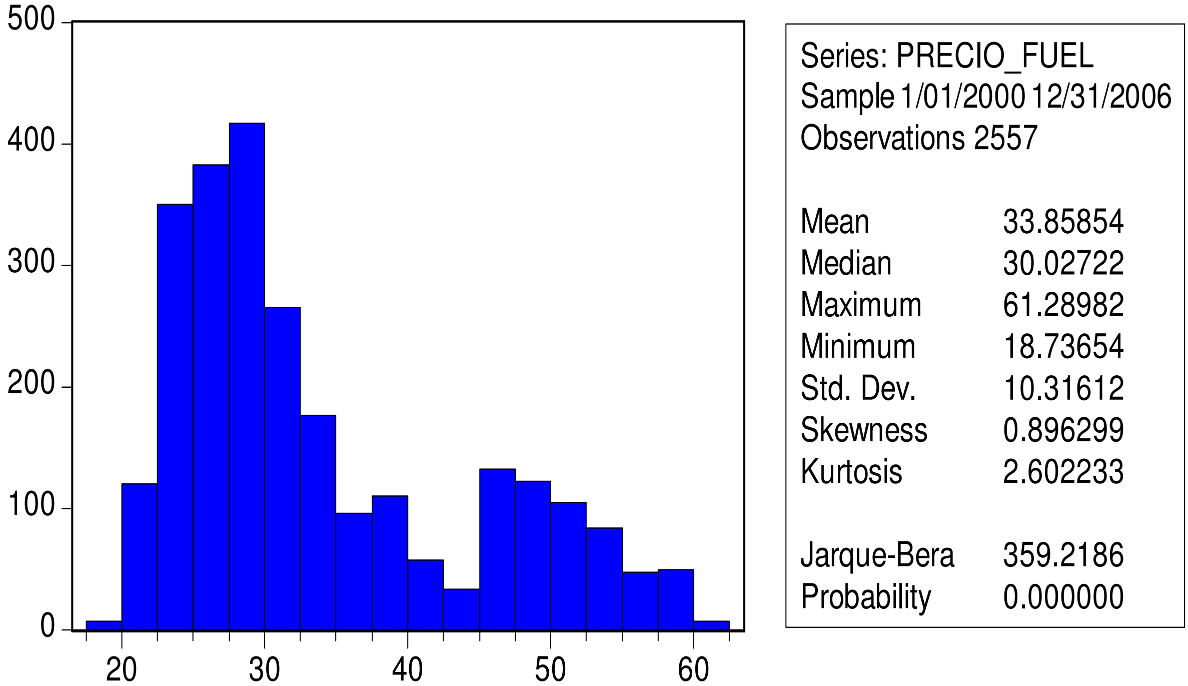
- Fuel oil price

The fuel oil price series is obtained using the diary quotation of the Brent (€/Bbl) starting from the year 1997.

The Brent is a kind of fuel oil that is extracted mainly in the North Sea and fixes the reference for the crude in the European markets. In its price evolution the crude has been a steep incline from the half of the 2005 to the half of the 2006, arriving to values around 60 €/Bbl.



Graphic 2.17 Brent price evolution (€/Bbl)



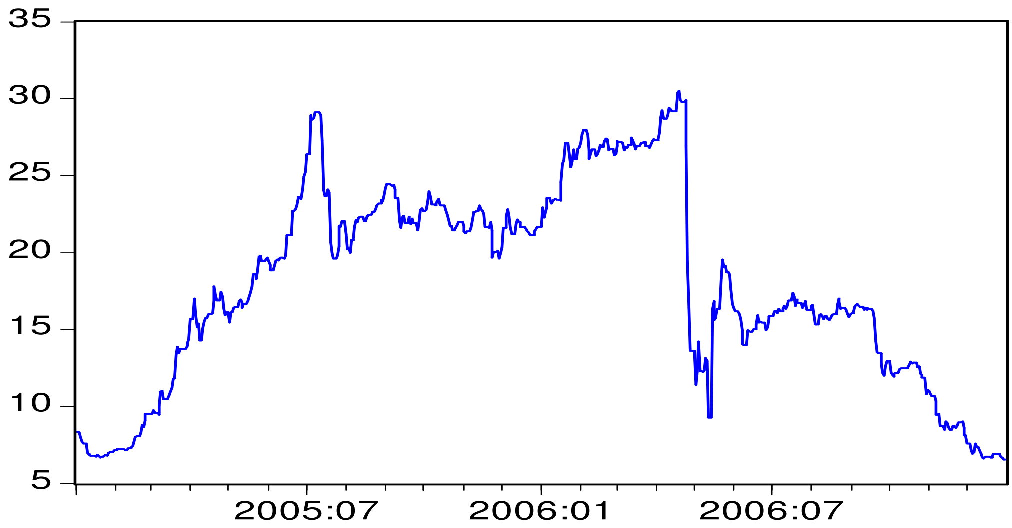
Graphic 2.18 Brent distribution frequency (€/Bbl)

Due to the evolution of the market, in which the fuel oil power plant are always more expensive and so goes out of the matched bids, the importance of this type of variable is decreasing.

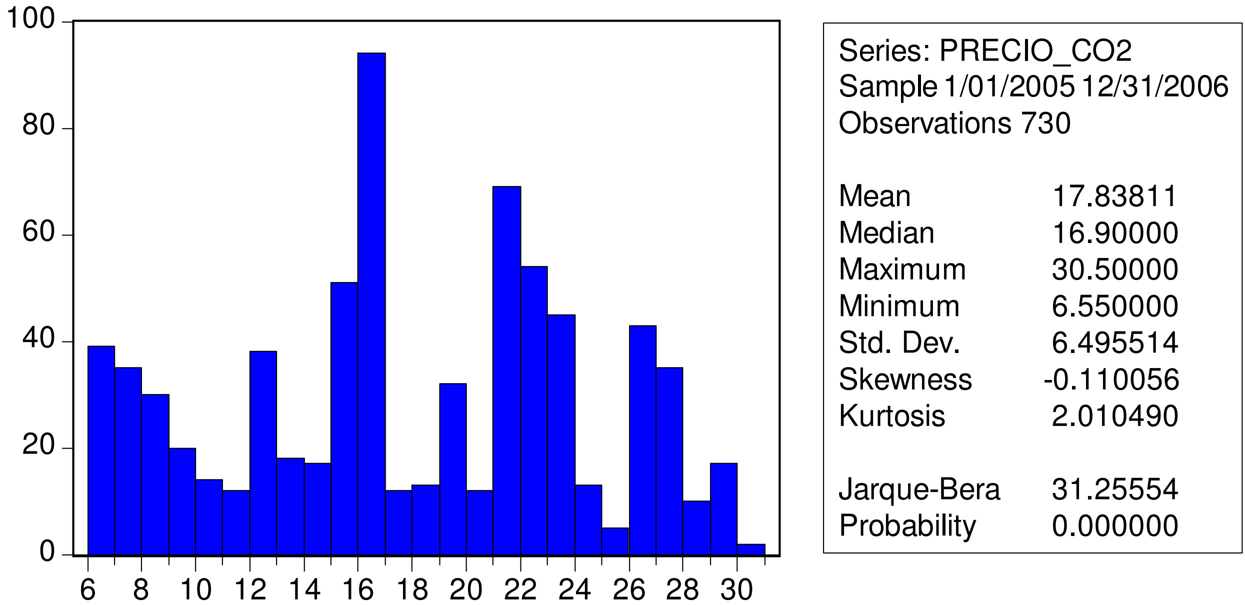
- CO_2 price

According to the Kyoto protocol, that imposes an emission reduction, the plants that use fossil fuel for the electricity power generation and therefore emit CO_2 to the environment have to obtain the rights necessary.

This rights are negotiated in Europe in different markets; the one that has been used is the PowerNext.



Graphic 2.19 EUAs allowance price evolution (€/t)



Graphic 2.20 EUAs allowance distribution frequency (€/t)

In the graphic 2.22 can be seen how there is not a pinpoint distribution, and the standard deviation is quite high, around 6.5.

- Working days and holidays

The fact that the day taking into account is a working day or a holiday affect the load profile, and so it is considered in the model created. It is clear that this variable can assume only two values, zero for a working day, and one for the holidays.

2.4 results of the previous model

As can show the table 2.X Carlos Guzman made many different models each one of them with different characteristics:

- Input variables: Has been chosen 4 different groups of variables:
  - A group: demand, installed capacity, hydraulic reservoir, holidays and combustible price (gas, coal, fuel y Co2)
  - B group: demand, installed capacity, hydraulic reservoir, holidays and the generation of the different technologies (hydro, pumping, combined cycle, fuel, coal, nuclear, import and special regime).
  - C group: all the variables the group A and the group B
  - D group: demand, installed capacity, hydraulic reservoir, holidays, the generation of the different technologies (hydro, pumping, combined cycle, fuel, coal, nuclear, import and special regime). Also is considered the coal price and gas price, each one multiplied for the correspondent generation, as a measure of the total variable cost for the system of thermal plants.
- Time scope: there are model constructed on hourly bases and models constructed on daily basis.

One time that the values of the independent variable and of the dependent variable are known, are constructed two different models that has product the best results; this are the *daily weighted model* and the *block weighted model*.

Serie	Grupo	Regresión	No. Observ	Horas x obser	k	Variables																						R^2	t	F	Akaike	Shuartz	DW	Skewnes	Kurtosis
						DM	CI	RH	H	B	N	C	G	F	RN	IM	Pg	Pc	Pf	Pco	Mg	Mc	Mf	Mco-g	Mco-c	Mco-f	F/L	1	0	0	Min	Min	2	0	3
D	A	Diario ponderado	2251	24	7	+	--	--									--	--	+	+								0,738	0	0	2,32	2,34	0,48	0,67	5,77
D	B	Diario ponderado	2251	24	9	+	--	--	--	+	--	--		+	+													0,805	0	0	2,02	2,051	0,53	0,52	4,56
D	C	Diario ponderado	2251	24	8	+	--		--	+				+				--	+	+								0,877	0	0	1,56	1,59	0,685	0,65	6,27
D	D	Diario ponderado	2251	24	12	+	--	--	--	+					+	--					--	--	+	+	+			0,83	0	0	1,88	1,91	0,56	0,84	6,4
H	A	Horario (24 h)	54024	1	8	+	--	--									--	--	+	+							+	0,764	0	0	2,56	2,56	0,26	0,67	5,17
H	B	Horario (24 h)	54024	1	11	+	--	--	--	+	--	--	+	+		--											+	0,823	0,008	0	2,24	2,25	0,34	0,86	7,36
H	C	Horario (24 h)	54024	1	16	+	--	--	+	+	--	+	+	+	+	+	+	--	+	+							+	0,826	0	0	2,26	2,26	0,35	0,89	8,31
H	D	Horario (24 h)	54024	1	11	+	--	--	--	+					+	+					+		+	+			+	0,829	0	0	2,24	2,25	0,34	0,86	7,33
VH	A	Valle horaria	13507	1	8	+	--	--									--	--	+	+							--	0,77	0	0	1,89	1,89	0,18	0,44	5,85
VH	B	Valle horaria	13507	1	9		--	--	--	+		+	+	+	+												+	0,81	0	0	1,7	1,7	0,22	0,505	6,4
VH	C	Valle horaria	13507	1	10		--			+		+	+	+	+			--	+	+							+	0,82	0	0	1,64	1,65	0,24	0,15	5,5
VH	D	Valle horaria	13507	1	10	+	--		--	+					+						+	+	+	+			+	0,63	0	0	2,95	2,95	0,236	0,8	5,71
LH	A	Llano horaria	27011	1	8	+	--	--									--	--	+	+							--	0,765	0	0	2,49	2,49	0,3	0,73	5,54
LH	B	Llano horaria	27011	1	9		--	--		+	--	+	+	+	+	+												0,813	0	0	2,25	2,26	0,4	0,86	6,79
LH	C	Llano horaria	27011	1	10		--	--		+		+	+	+	+	+			+	+								0,813	0	0	2,26	2,26	0,4	0,96	8,55
LH	D	Llano horaria	27011	1	10	+	--	--	--	+					+	+					+		+	+				0,661	0	0	2,99	3	0,27	0,88	6,7
PH	A	Punta horaria	13506	1	8	+	--	--									--	--	+	+							+	0,744	0	0	2,71	2,72	0,228	0,73	5,92
PH	B	Punta horaria	13506	1	10		--	--		+	--	+	+	+	+	+											+	0,818	0	0	2,37	2,38	0,33	1,022	8,511
PH	C	Punta horaria	13506	1	11		--	--		+		+	+	+		+	+		+	+							+	0,806	0	0	2,44	2,45	0,309	1,16	9,34
PH	D	Punta horaria	13506	1	12	+	--	--	--	+					+	+					+		+	+	+		+	0,662	0,016	0	2,21	2,23	0,423	1,84	11,66
VP	A	Valle ponderado	2251	6	7	+	--	--									--	--		+							--	0,78	0	0	1,78	1,8	0,47	0,15	5,1
VP	B	Valle ponderado	2251	6	9	+	--	--	--	+	--		+	+		--												0,798	0,009	0	1,69	1,72	0,55	0,916	8,4
VP	C	Valle ponderado	2251	6	11	+	--		--		--	--	+	+		--	+	--		+								0,841	0	0	1,45	1,47	0,514	-0,05	7,01
VP	D	Valle ponderado	2251	6	9	+	--		--		--										+		+	+	--	--		0,833	0	0	1,5	1,54	0,65	0,66	6,6
LP	A	Llano ponderado	2251	12	7	+	--	--									--		+	+							--	0,688	0	0	2,6	2,6	0,5	0,74	5,48
LP	B	Llano ponderado	2251	12	5			--		+			+	+		+												0,76	0,022	0	2,34	2,36	0,49	0,44	3,76
LP	C	Llano ponderado	2251	12	11	+	--		--		--	--	--	+				--	+	+							--	0,826	0	0	2,02	2,05	0,88	0,624	6
LP	D	Llano ponderado	2251	12	10	+	--	--	--	+	--										+	--	+		+			0,84	0	0	1,93	1,96	0,69	1,2	9,25
PP	A	Punta ponderado	2251	6	8	+	--	--									--	--	+	+							+	0,708	0	0	2,76	2,78	0,56	0,82	7,18
PP	B	Punta ponderado	2251	6	8	+		--	--	+	--		+	+													+	0,747	0	0	2,62	2,64	0,49	0,59	5,31
PP	C	Punta ponderado	2251	6	12		--	--		+		+	+	+		+	+	--	+	+							+	0,848	0	0	2,11	2,15	0,75	1,088	10,2
PP	D	Punta ponderado	2251	6	11	+	--	--	--	+											+	--	+		+	--	+	0,833	0,019	0	2,21	2,24	0,726	1,2	10,18

Table 2.1 results of the linear regression model

a) *diary weighted model*

In this set of data the price is obtained as a weighted mean for the corresponding demand. In the other side, the power generated by different technologies, of which we have hourly data, is obtained as sum of the twenty-four hour of thee day.

The other variables, as fuel price, hydraulic reservoir, installed capacity, of which we have daily, weekly or monthly data, is assigned the correspondent value.

Dependent Variable: price	**Model: diary weighted Group C**			
Method: Least Squares				
Date: 05/22/07 Time: 02:28				
Sample: 1/01/2000 2/28/2006				
Included observations: 2251				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Co2 price	0.105807	0.003817	27.71773	0.0000
coal price	-0.011031	0.001439	-7.663793	0.0000
Hydro	-0.007051	0.000331	-21.30463	0.0000
Fuel	0.026890	0.000830	32.40475	0.0000
Demand	0.004234	0.000302	14.02359	0.0000
Installed capacity	-0.110658	0.009952	-11.11938	0.0000
Pumping	0.076774	0.003014	25.46967	0.0000
Fuel price	0.029456	0.002912	10.11588	0.0000
Constant	5.049695	0.373115	13.53390	0.0000

R-squared	**0.877404**	Mean dependent variance	3.654501
Adjusted R-squared	0.876967	S.D. dependent variance	1.504852
S.E. of regression	0.527843	Akaike info criterion	1.563954
Sum squared residual	624.6617	Schwarz criterion	1.586820
Log likelihood	-1751.230	F-statistic	2005.720
Durbin-Watson stat	0.685008	Prob(F-statistic)	0.000000

Table 2.2 Result of the regression model for the diary weighted data set

An improvement to this model has been developed in order to get better results: it is the time division of the days into holidays and working days.

These results will be used in the model that I will develop for the forecasting of the electricity price. The results are shown in the tables 2.3 and 2.4.

Dependent Variable: PRECIO DIARIO LABORABLES
Method: Least Squares
Date: 06/13/07 Time: 04:10
Sample(adjusted): 1/03/2000 2/28/2006 IF FESTIVO=0
Included observations: 1555 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PRECIO_FUEL180D	0.023965	0.007653	3.131614	0.0018
PRECIO_CO2	0.100858	0.005678	17.76349	0.0000
BOMBEO	0.067533	0.003499	19.30051	0.0000
HIDRO	-0.009013	0.000537	-16.78295	0.0000
DEMANDA	0.004706	0.000520	9.047676	0.0000
FUEL	0.025414	0.000981	25.89693	0.0000
CAP_INSTAL	-0.129492	0.016563	-7.818260	0.0000
PRECIO_GAS180D	0.173820	0.023064	7.536468	0.0000
NUCLEAR	-0.006307	0.000952	-6.627340	0.0000
REG_ESPECIAL	-0.006246	0.001512	-4.130590	0.0000
RES_HIDRO	-4.77E-05	9.05E-06	-5.265795	0.0000
C	6.421355	0.664827	9.658680	0.0000

R-squared	0.881894	Mean dependent var	3.930913
Adjusted R-squared	0.881052	S.D. dependent var	1.528312
S.E. of regression	0.527098	Akaike info criterion	1.564825
Sum squared resid	428.6946	Schwarz criterion	1.606105
Log likelihood	-1204.652	F-statistic	1047.410
Durbin-Watson stat	0.478071	Prob(F-statistic)	0.000000

Table: 2.3 Results for the daily working model

Dependent Variable: PRECIO DIARIO FESTIVOS
Method: Least Squares
Date: 06/13/07 Time: 04:12
Sample(adjusted): 1/01/2000 2/26/2006 IF FESTIVO=1
Included observations: 695 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PRECIO_CO2	0.105488	0.005490	19.21385	0.0000
BOMBEO	0.083259	0.006151	13.53597	0.0000
HIDRO	-0.010224	0.000471	-21.70223	0.0000
DEMANDA	0.007506	0.000428	17.53088	0.0000
FUEL	0.024492	0.001831	13.37546	0.0000
CAP_INSTAL	-0.136878	0.015041	-9.100560	0.0000
PRECIO_GAS180D	0.150877	0.016488	9.150575	0.0000
NUCLEAR	-0.007655	0.000972	-7.875558	0.0000
IMPORTACION	-0.006671	0.002383	-2.799959	0.0053
REG_ESPECIAL	-0.006219	0.001520	-4.090593	0.0000
RES_HIDRO	-2.58E-05	8.05E-06	-3.210209	0.0014
PRECIO_FUEL	-0.013187	0.003847	-3.428270	0.0006
C	6.731266	0.609170	11.04990	0.0000

R-squared	0.905795	Mean dependent var	3.036679
Adjusted R-squared	0.904137	S.D. dependent var	1.248217
S.E. of regression	0.386470	Akaike info criterion	0.955002
Sum squared resid	101.8628	Schwarz criterion	1.039996
Log likelihood	-318.8631	F-statistic	546.4581
Durbin-Watson stat	0.876961	Prob(F-statistic)	0.000000

Table 2.4 Results for the holidays model

b) *block weighted model*

The general results for the weighted model for hourly block are shown in the table 2.5, 2.6 and 2.7.

The peak block corresponds to the six hours of the day in which the demand is the highest; then the off-peak correspond to the following hours with the highest values, and, at the end, the last six hours correspond to the valley block.

Dependent Variable: PRECIO   Model: Bloque Ponderado Valle
Method: Least Squares
Date: 05/22/07   Time: 04:56
Sample: 1/01/2000 2/28/2006
Included observations: 2251

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PREC_GAS	0.027196	0.009562	2.844234	0.0045
PREC_CO2	0.045050	0.004032	11.17339	0.0000
PREC_CARBON	-0.013008	0.001489	-8.734591	0.0000
G_HIDRO	-0.000463	3.03E-05	-15.27739	0.0000
G_FUEL	0.000407	4.37E-05	9.298448	0.0000
G_CCGT	8.17E-05	3.13E-05	2.612785	0.0090
G_IMPORT	-0.000463	4.86E-05	-9.526481	0.0000
G_NUCLEAR	-0.000458	3.41E-05	-13.44229	0.0000
G_CARBON	-0.000309	2.97E-05	-10.41718	0.0000
DEMANDA	0.000346	2.93E-05	11.82989	0.0000
CAP_INSTALADA	-0.235510	0.013651	-17.25267	0.0000
C	12.78240	0.548882	23.28809	0.0000

R-squared	0.799313	Mean dependent var	2.553160
Adjusted R-squared	0.798327	S.D. dependent var	1.254112
S.E. of regression	0.563197	Akaike info criterion	1.694942
Sum squared resid	710.1904	Schwarz criterion	1.725431
Log likelihood	-1895.658	F-statistic	810.6962
Durbin-Watson stat	0.552392	Prob(F-statistic)	0.000000

Table 2.5 weighted model results for the valley block

Dependent Variable: PRECIO   Model: Bloque ponderado punta
Method: Least Squares
Date: 05/22/07   Time: 05:41
Sample: 1/01/2000 2/28/2006
Included observations: 2251

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_HIDRO	-4.15E-05	7.20E-06	-5.765570	0.0000
PREC_GAS	0.044194	0.012174	3.630022	0.0003
PREC_FUEL	0.033319	0.004160	8.008331	0.0000
PREC_CO2	0.113013	0.005196	21.74932	0.0000
PREC_CARBON	-0.010144	0.001924	-5.271244	0.0000
G_IMPORT	0.000295	5.47E-05	5.401061	0.0000
G_FUEL	0.000752	1.91E-05	39.39768	0.0000
G_CCGT	0.000133	1.84E-05	7.223768	0.0000
G_CARBON	0.000160	1.32E-05	12.09508	0.0000
G_BOMBEO	0.001448	4.62E-05	31.37080	0.0000
FESTIVO	0.248077	0.039367	6.301727	0.0000
CAP_INSTALADA	-0.109551	0.014759	-7.422636	0.0000
C	5.067045	0.647501	7.825538	0.0000

R-squared	0.848572	Mean dependent var	4.423364
Adjusted R-squared	0.847760	S.D. dependent var	1.781082
S.E. of regression	0.694942	Akaike info criterion	2.115781
Sum squared resid	1080.829	Schwarz criterion	2.148810
Log likelihood	-2368.311	F-statistic	1045.107
Durbin-Watson stat	0.753307	Prob(F-statistic)	0.000000

Table 2.6 weighted model results for the peak block

Dependent Variable: PRECIO   Model: Bloque ponderado llano
Method: Least Squares
Date: 05/22/07   Time: 05:18
Sample: 1/01/2000 2/28/2006
Included observations: 2251

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CAP_INSTALADA	-0.183036	0.016712	-10.95241	0.0000
DEMANDA	0.000350	3.04E-05	11.52352	0.0000
G_CARBON	-0.000224	3.10E-05	-7.217323	0.0000
G_CCGT	-0.000112	3.29E-05	-3.396515	0.0007
G_FUEL	0.000452	3.61E-05	12.52721	0.0000
G_HIDRO	-0.000402	2.96E-05	-13.56337	0.0000
G_NUCLEAR	-0.000342	3.56E-05	-9.616530	0.0000
PREC_CARBON	-0.017587	0.001833	-9.592159	0.0000
PREC_CO2	0.061728	0.005278	11.69607	0.0000
PREC_FUEL	0.035479	0.003682	9.634843	0.0000
FESTIVO	-0.264613	0.044931	-5.889338	0.0000
C	8.669476	0.667662	12.98483	0.0000

R-squared	0.827298	Mean dependent var	3.686303
Adjusted R-squared	0.826450	S.D. dependent var	1.591283
S.E. of regression	0.662918	Akaike info criterion	2.020987
Sum squared resid	983.9522	Schwarz criterion	2.051475
Log likelihood	-2262.620	F-statistic	975.0494
Durbin-Watson stat	0.881555	Prob(F-statistic)	0.000000

Table 2.7 weighted model results for the llano block

3.0 PREVISION OF THE ELECTRICITY DEMAND

3.1 Introduction

In the previous chapter has been shown the solution of the regression done with the aim of find the variables that can explicate the unknown variable that is the hourly electricity price. As we have seen, there are different types of models with different characteristics, adherence and numbers of variables taken under advisement.

All of these use the regression model based on the least square analysis.

At this level, the next step that we want to do is apply an equation of this kind

$$Electricityprice = f(hydroreserve, demand, generation, etc.)$$

That will be used in order to predict the future value of the electricity price.

Despite the final use of this equation is to obtain a single value for the electricity price for the next year (2009), we will use a model based on hourly values: this is due to the fact that this model is enough accurate , with a determination coefficient R^2 (a general measurement that describe the general goodness of the model) quite high, more that 0.8.

3.2 Description of the model used: hourly block model

In the entire possible model that can be use for the prediction of the electricity price, we will use the daily regression model.

- Three level corresponding to the different level of demand: one level for the on-peak hours, one level for the mid-peak hours, and one for the off-peak hours;
- Two different type periods: one corresponding to the working days and one to the holidays.

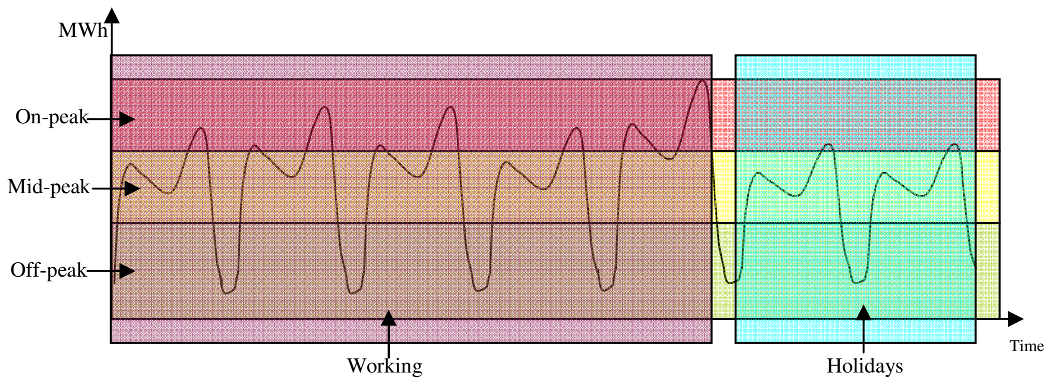


Table 3.1 description of the model chosen;

The variables taken into account that affect the final value of the price are:

- ✓ RES_HIDRO: Hydro reservoir;
- ✓ PREC_FUEL180D: fuel price with the mean of the lasts 180 days;
- ✓ PREC_GAS_180D: gas price with the mean of the lasts 180 days;
- ✓ PREC_CO2:CO2 price;
- ✓ G_IMPORT: imported generation;
- ✓ G_FUEL: fuel generation;
- ✓ G_CCGT: ccgt generation;
- ✓ G_CARBON: coal generation;
- ✓ G_BOMBEO: pumping generation;
- ✓ G_HIDRO: hydro generation;
- ✓ G_NUCLEAR: nuclear generation;
- ✓ DEMANDA: demand;
- ✓ CAP_INSTALADA. Installed capacity;

For a better description of this variables see in the previous chapter the paragraph 2.3.

a. *On-peak block*

The results of the regression model obtained in the previous thesis are presented in the table 3.2 for the working days and in the table 3.3 for the holidays.

MODEL PPR-CL DS(Y)= 1,7743

	RES_HIDRO	PREC_FUEL180D	PREC_CO2	G_IMPORT	G_FUEL	G_CCGT	G_CARBON	G_BOMBEO	CAP_INSTALADA
Beta*	-0,0001	0,0754	0,0932	0,0004	0,0007	0,0002	0,0001	0,0014	-0,1611
DS(X)	2771,86	6,65	7,99	285,27	1080,27	2361,61	1126,49	360,13	2,81
Beta ajust*	-0,0783	0,2827	0,4195	0,0685	0,4493	0,2343	0,0883	0,2829	-0,2551

Table 3.2: Working days, on-peak block

MODEL PPR-CF DS(Y)= 1,64893

	RES_HIDRO	PREC_GAS180D	PREC_CO2	G_IMPORT	G_FUEL	G_CCGT	G_CARBON	G_BOMBEO	CAP_INSTALADA	G_HIDRO
Beta*	-0,0001	0,2137	0,1105	0,0002	0,0009	0,0002	0,0002	0,0015	-0,1159	-0,0001
DS(X)	2770,99	1,57	7,92	293,90	543,95	1795,84	1672,43	319,36	2,82	2014,86
Beta ajust*	-0,0970	0,2030	0,5309	0,0392	0,3075	0,1634	0,1927	0,2998	-0,1981	-0,0699

Table 3.3.: Holidays, on-peak block

b. Mid-peak block

The results of the regression model obtained in the previous thesis are presented in the table 3.4 for the working days and in the table 3.5 for the holidays.

MODEL LPR-CL DS(Y)= 1,614046

	CAP_INSTALADA	DEMANDA	G_FUEL	G_HIDRO	G_NUCLEAR	PREC_CO2	PREC_GAS 180D	RES_HIDRO	G_BOMBEO
Beta*	-0,163961	0,000103	0,000595	-0,00021	-0,000151	0,10054	0,217686	-7,22E-05	0,001639
DS(X)	2,809508	2552,097	978,345	1775,451	746,2218	7,98762	1,330804	2771,854	228,6433
Beta ajust*	-0,285400627	0,16286152	0,3606559	-0,2277	-0,069812	0,49757	0,179485	-0,123991	0,23217825

Table 3.4: working days, mid-peak block

MODEL LPR-CF DS(Y)= 1,235679

	CAP_INSTALADA	G_FUEL	PREC_CO2	PREC_GAS 180D	G_CARBON	G_CCGT
Beta*	-0,110744	0,000831	0,099931	0,125457	0,00026	0,00017
DS(X)	2,817705	454,9088	7,923739	1,333561	1875,689	1644,65
Beta ajust*	-0,252528304	0,30592833	0,6408033	0,135395	0,3946649	0,2276

Table 3.5: holidays, mid-peak block

c. Off-peak block

The results of the regression model obtained in the previous thesis are presented in the table 3.6 for the working days and in the table 3.7 for the holidays.

MODEL VPR-CL DS(Y)= 1,34754

	PREC_GAS 180D	PREC_CO2	G_HIDRO	G_FUEL	G_CCGT	G_IMPORT	G_NUCLEAR	G_CARBON	DEMANDA	CAP_INSTALADA	RES_HIDRO	G_BOMBEO
Beta*	0,2178	0,0537	-0,0004	0,0005	0,0001	-0,0004	-0,0003	-0,0002	0,0002	-0,2498	0,0000	0,0033
DS(X)	1,55	7,99	1610,30	500,76	1976,56	324,06	773,07	1697,32	2547,72	2,81	2771,86	93,34
Beta ajust*	0,2512	0,3183	-0,4613	0,1996	0,1439	-0,0856	-0,1939	-0,2066	0,3725	-0,5209	-0,0543	0,2319

Table 3.6: working days, off peak block

MODEL VPR-CF DS(Y)= 0,96135

	PREC_GAS 180D	PREC_CO2	PREC_FUEL180D	G_HIDRO	G_FUEL	G_CCGT	G_CARBON	CAP_INSTALADA
Beta	0,1264	0,1001	-0,0189	0,0000	0,0006	0,0001	0,0002	-0,1055
DS(X)	1,57	7,92	6,71	1608,23	250,27	1439,53	1893,28	2,82
Beta ajust	0,2059	0,8247	-0,1321	-0,0738	0,1434	0,1842	0,4293	-0,3093

Table 3.7: holidays, off peak block

3.3 How to adapt the model to the forecast

3.3.1Introduction

In order to foresee the price of the electricity at a hourly level, has to be known exactly how many are the MW that at each hours are generated with hydro plants, how many MWs are generated with nuclear plants, etc.

- *Nuclear generation*

The generation with nuclear plants is quite constant in all the years, and is studied as fixed data, this mean that the production of the nuclear the next years is considered easily as the production of this year.

- *Special regime*

The generation with the special regime isn't constant, but due to its total unpredictability, it has been considered as a base load curve supposing a fixed energy.

- *Hydro generation and thermal generation*

On the other hand, the hydro generation and the thermal generation are more difficult to estimate (the word "thermal generation" indicate the generation with two different kind of plants: combined cycle gas turbine and coal generation; in the thermal generation should also be considered the generation with fuel, but the fact is that every year the production of electricity done with this kind of plant is always less; more other, for the next year, in Spain the fuel oil generation is estimated to be around zero.

In the next two paragraphs will be described how are calculated the hydraulic generation and the thermal generation.

3.3.2 Hydraulic function

When we talk about hydraulic generation we are trying to evaluate which are the factors that determine the hourly quantity (in MW) that will be produced using a hydraulic reservoir.

Has been considerate different types of variables, but before has been done a previous consideration: intuitively it is clear that when there is a high level of the hydro reservoir (this means that the dams are quite full) the possibility of using water for generate electricity is quite high; while, on the other side, if the reservoir level is low, is clear that the availability of generation with water is very low.

Due to the fact that the hydraulic generation is very different depending by the period in which we are, has been decided to evaluate three different function: one for the hydro production in the humid period, one in the normal period and one in the dry period.

The data that are available are at a hourly level from the January 1996 to the December 2006 ;

for each hours can be used:

- hydraulic generation;
- hydraulic reservoir: indicate the MW available as a aggregate data for all the dams;
- total demand(MW);

In order to divide the data into three periods has been developed the program written in Matlab (Anexo1):

Using this program now are available all the data divided into three different periods(humid, normal and dry).

If a week is considered humid it has to be reservoir values between 14000 and 17000 MW; a week is considered a normal one with reservoir values between 10000 and 14000; a week is considered normal with reservoir values between 6000 and 10000.

These values has been chosen naturally studying the historical data and trying to obtain the maximization of the R2 factor in each regression equation.

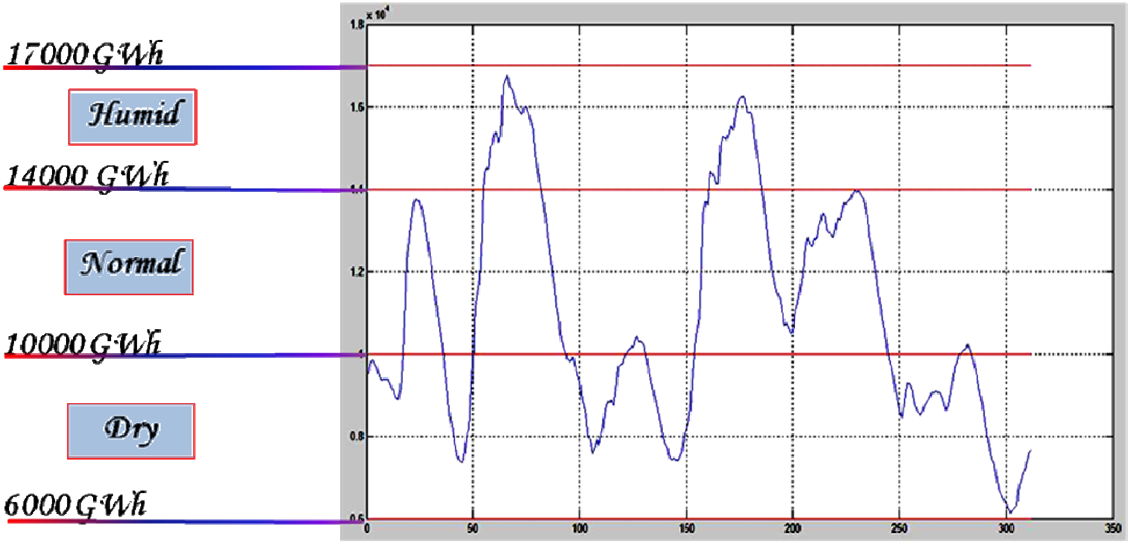


Figure 3.1 :historical hydraulic reservoir from 1996 to 2006

Levels	R2
6000-7000	0,825
6000-7500	0,821
6000-8000	0,801
6000-8500	0,772
6000-9000	0,729
6000-9500	0,828
6000-10000	**0,840**
6000-10500	0,722
6000-11000	0,718
6000-11500	0,701
6000-12000	0,699
6000-12500	0,644

Table 3.8: bound study for the humid level

Levels	R2
7000-14000	0,516
7500-14000	0,544
8000-14000	0,532
8500-14000	0,653
9000-14000	0,684
9500-14000	0,725
10000-14000	**0,760**
10500-14000	0,714
11000-14000	0,656
11500-14000	0,696
12000-14000	0,745

Levels	R2
10000-12500	0,746
10000-13000	0,733
10000-13500	0,752
10000-14000	0,761
10000-14500	0,742
10000-15000	0,721

Table 3.9: bound study for the normal level

Levels	R2
11000-17000	0,301
11500-17000	0,344
12000-17000	0,403
12500-17000	0,492
13000-17000	0,602
13500-17000	0,766
14000-17000	**0,802**
14500-17000	0,803
15000-17000	0,811
15500-17000	0,817
16000-17000	0,823

Table 3.10 : bound study for the dry level

At this point of the work can be possible do the regression's analysis.

3.3.2.1 Hydraulic generation: Humid equation

As described in the previous chapter, has been used a regression function in order to calculate the relation that can occur between a set of variables that determine the final value of the electricity price.
In Matlab has been used the function “regress”:

B = REGRESS(Y,X) returns the vector B of regression coefficients in the linear model Y = X*B. X is an n-by-p design matrix, with rows corresponding to observations and columns to predictor variables. Y is an n-by-1 vector of response observations.

The program in the Anexo2 is the one used to evaluate the regression function.
At the beginning has been considerate a big number of variables, trying to evaluating if this variables would affect the output. The first analysis of the equation considered, as input data, all the following variables:

- reservoir;
- reservoir.^2;
- demand;
- demand.^2;
- demand.^3;
- log(demand);

the solution of the algorithm give the following result:

$$Humidproduction = -0{,}112 \cdot Demand^2 + 119{,}09 \cdot Demand - 4008$$

with a R2 of 0,84.

Executing the same structure of the programs, but applied at the normal and dry weeks, the results are the followings:

$$Normalproduction = 1{,}894 \cdot Demand^2 - 222{,}68 \cdot Demand + 8427{,}56$$

$$R^2 = 0{,}76$$

$$Dryproduction = 1{,}7153 \cdot Demand^2 - 202{,}58 \cdot Demand + 6769{,}68$$

$$R^2 = 0{,}80$$

The real and the estimated production for each periods are showed in the following three figures, where the blue lines represent the real productions, the red ones represent the estimation of the production, and the yellows ones are the errors.

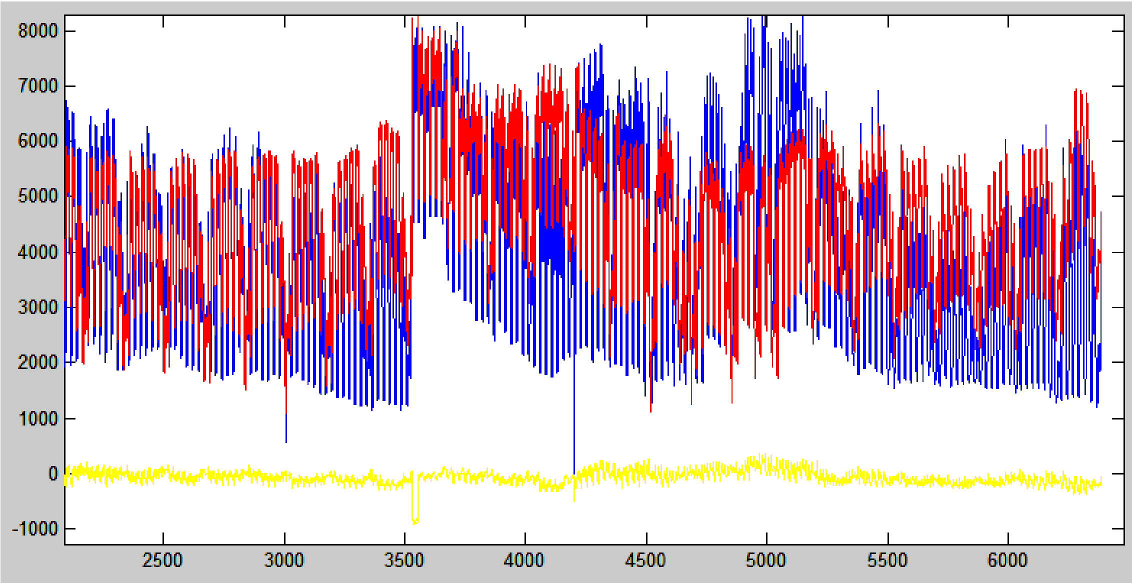


Figure 3.2.: humid regression

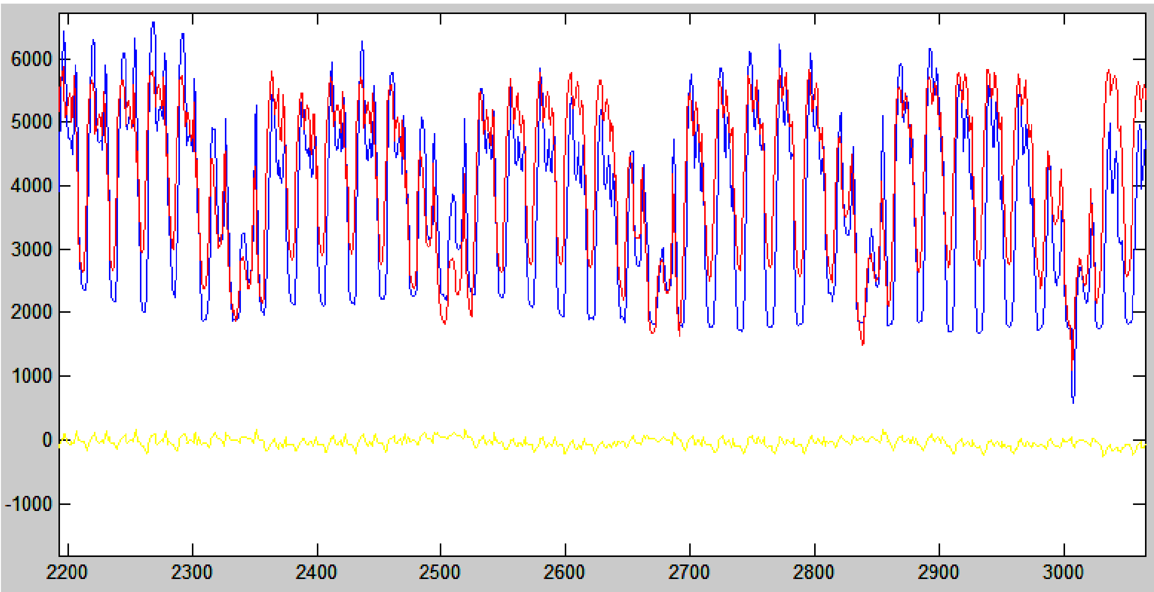


Figure 3.3: A detail of the humid regression

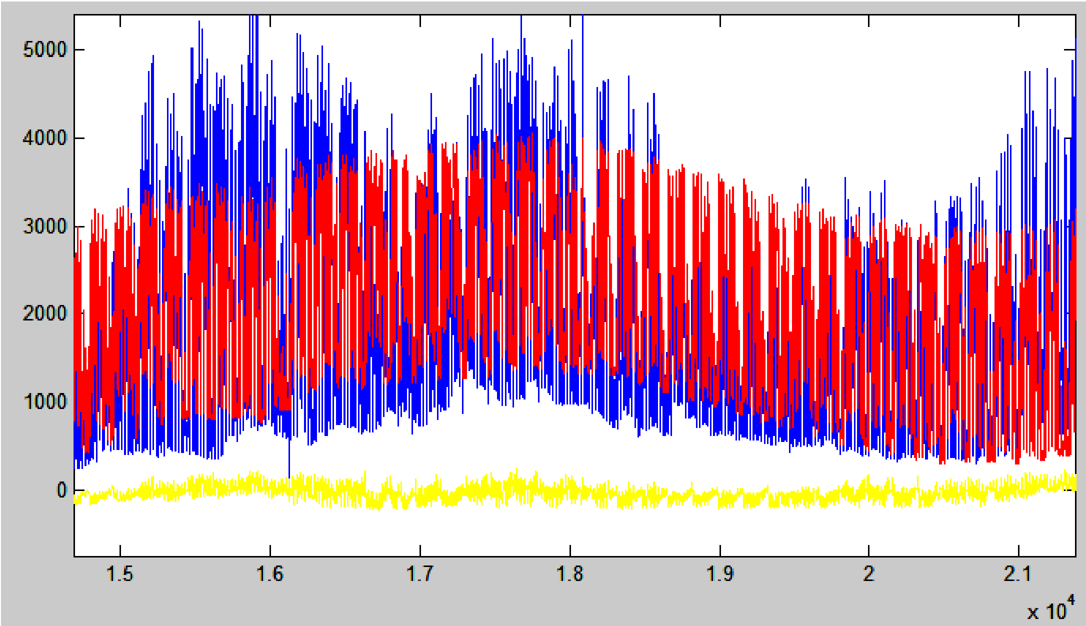


Figure 3.4: normal regression

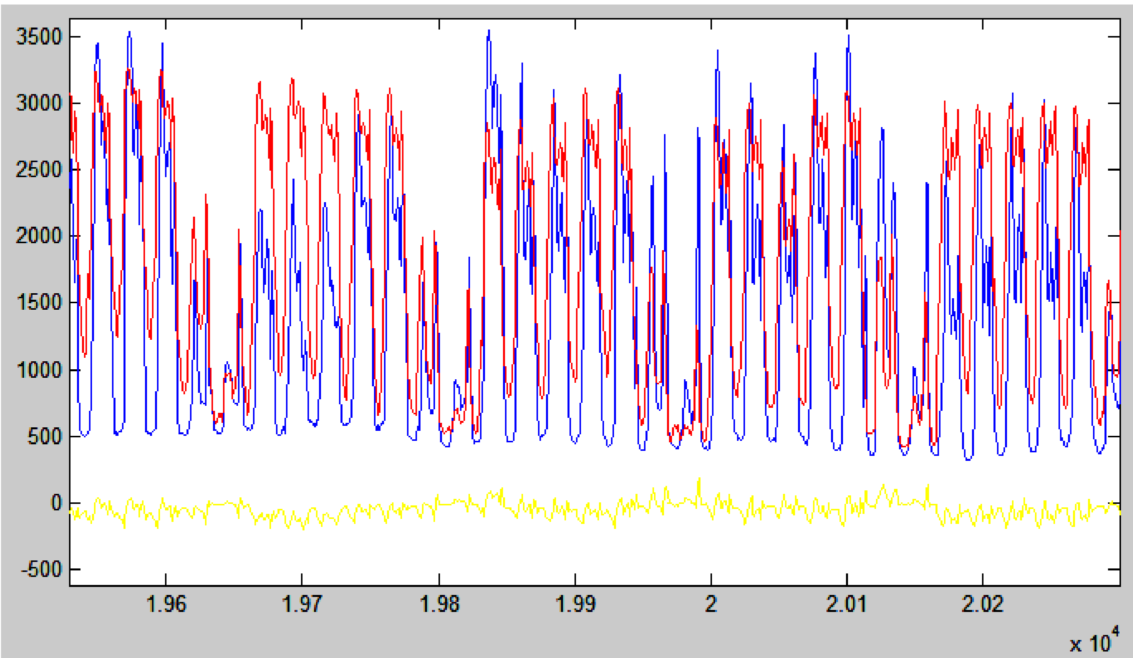


Figure 3.5: a detail of the normal regression

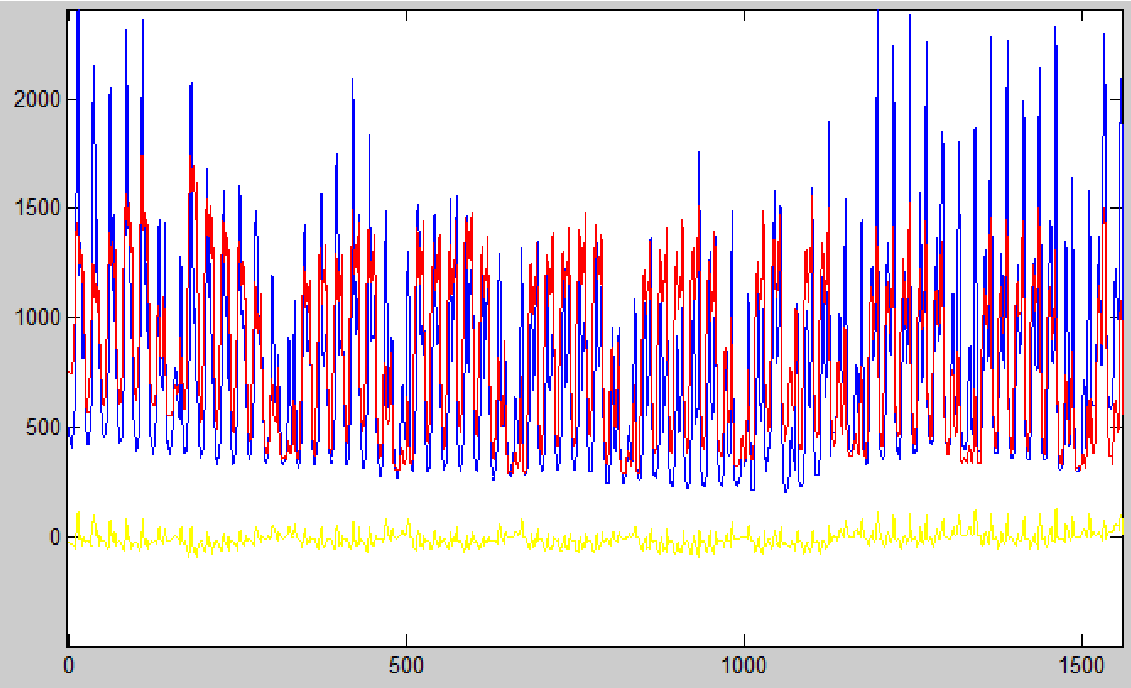


Figure 3.6.: dry regression

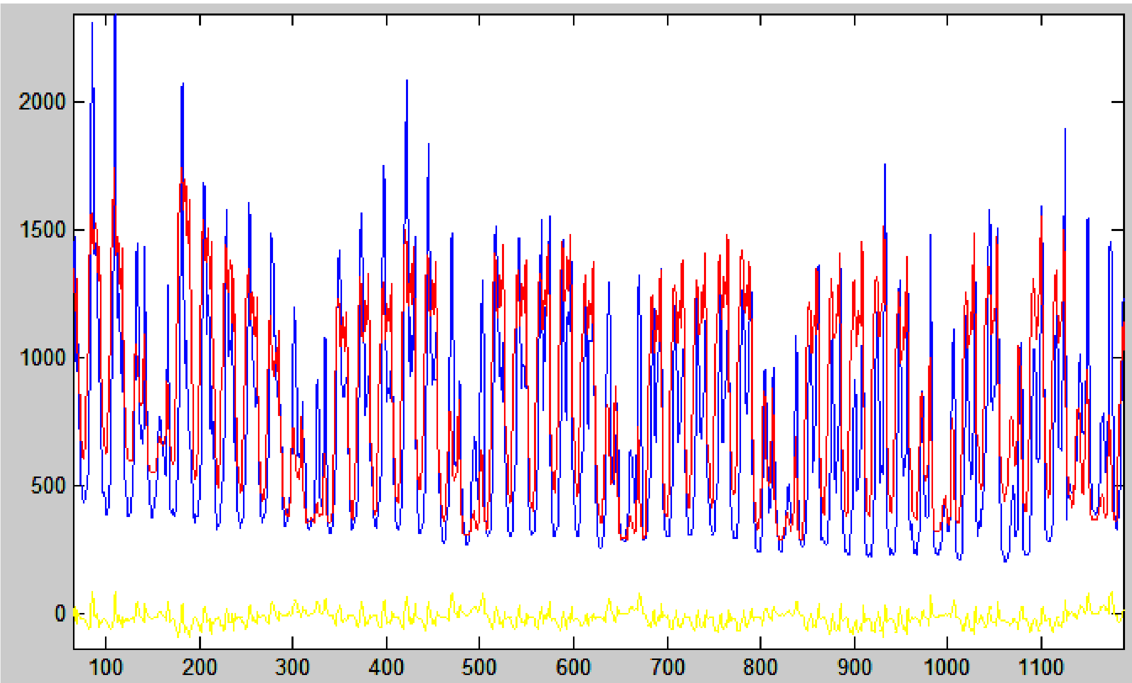


Figure 3.7: A detail of the dry regression;

Analysing the residuals has to be notice that for all the regression equations the errors have a zero mean and a very small variance, validating the results.
The division in three periods is the best one possible, this means that this is the best solution that permit a simple division (three periods) with a quite good resolution (with a mean value of the R2 indicator around 0,80).
In order to verify this has been done a division in two periods (only humid and dry) and one in four periods(one humid, one dry and two normal periods). With the division only in two periods the solutions worst too much, reaching values of R2 that degrade until values of 0,50: these values are not acceptable. On the other hand, the division, based on the reservoir study, into four period do not improve sensibly the solution, and these results do not support the decision of dividing the analysis into four periods.
It has also been studied the possibility of using a regression formula with a daily resolution, and not an hourly resolution, this means that the data are used as mean of the previous 24 values available.

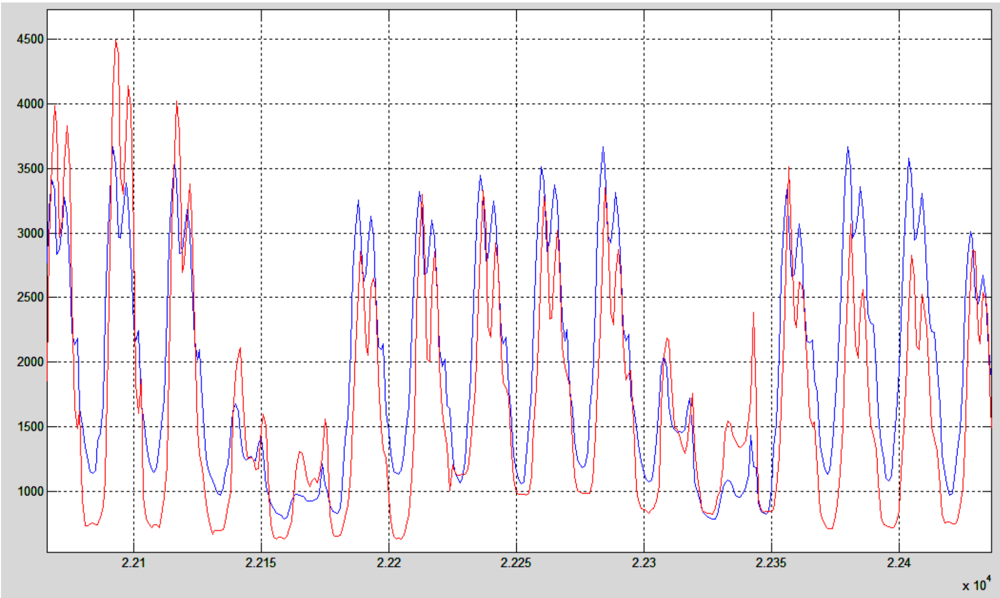


Figure 3.8.: detail of the regression (humid block)

3.3.3 Thermal generation

As it has been said, the equation of the thermal generation (combined cycle gas turbine and coal generation) is more difficult to evaluate. This is mainly due to the fact that the identification of the factors that affects the combined cycle gas turbine and coal generation are more difficult to recognize compared to the case of the hydraulic regression.

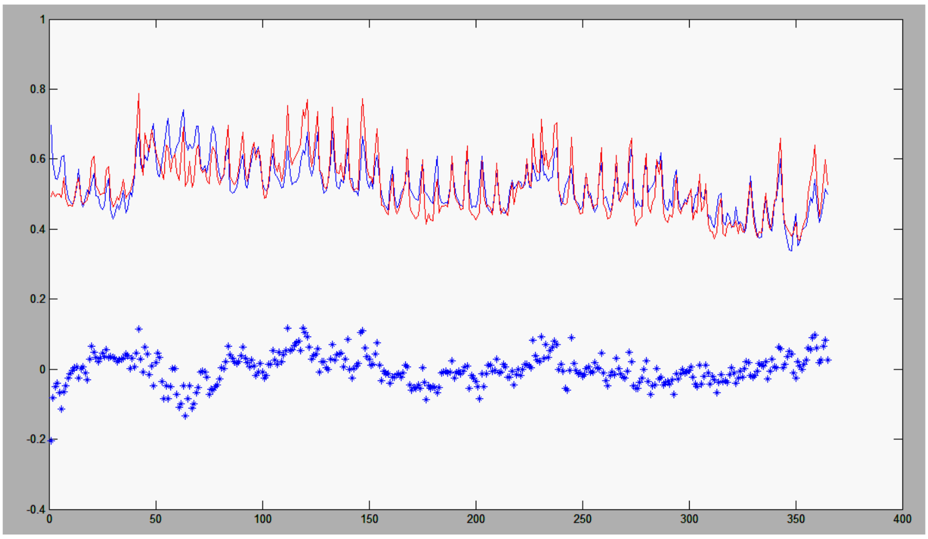


Figure: 3.9 thermal regression

the factors that has been studied and that could affect the thermal generation are:

- coal power: for this factor is used the table 3.11.. In this table is present the historical value from January 2000 to December 2006 (for the model has been used data only from January 2003, due to the fact that before the generation with ccgt was zero) where for each kind of sources of energy, there is a value for month. The model used has an hourly resolution, and this input variable will be the same for all the hours of a month.
- gas power: this variable is very influential, because has became in a few time a generation source important in the generation mix: looking the table x.x is shown how it increase from values around zero to values that two years after represent the 15% of all the generation mix power.
- coal price and gas price: this is probably the variable that will be more influent in the creation of the regression formula, due to the fact that the cost of the raw materials (coal and gas in this case) affect directly the final generation cost.

	Hidraulica	Bombeo	Nuclear	Carb Nac	Carb Imp	Fuel	CCGT	Total
ene-00	12.781	2.630	7.562	9.412	1.880	6.770	0	41.035
feb-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
mar-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
abr-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
may-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
jun-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
jul-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
ago-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
sep-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
oct-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
nov-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
dic-00	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
ene-01	12.650	2.630	7.562	9.412	1.880	6.770	0	40.904
feb-01	12.650	2.630	7.562	9.412	1.880	6.638	0	40.771
mar-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
abr-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
may-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
jun-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
jul-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
ago-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
sep-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
oct-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
nov-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
dic-01	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
ene-02	12.650	2.630	7.562	9.412	1.880	6.495	0	40.629
feb-02	12.649	2.630	7.562	9.412	1.880	6.425	0	40.558
mar-02	12.649	2.630	7.562	9.412	1.880	6.425	0	40.558
abr-02	12.649	2.630	7.562	9.412	1.880	6.425	0	40.558
may-02	12.649	2.630	7.562	9.412	1.880	6.425	0	40.558
jun-02	12.649	2.630	7.562	9.412	1.880	6.425	0	40.558
jul-02	12.649	2.630	7.562	9.412	1.880	6.425	366	40.924
ago-02	12.649	2.630	7.562	9.412	1.880	6.425	1.132	41.690
sep-02	12.649	2.630	7.562	9.412	1.880	6.425	2.651	43.209
oct-02	12.649	2.630	7.562	9.412	1.880	6.425	2.651	43.209
nov-02	12.649	2.630	7.562	9.412	1.880	6.425	2.651	43.209
dic-02	12.649	2.630	7.562	9.412	1.880	6.425	2.651	43.209
ene-03	12.649	2.630	7.562	9.412	1.880	6.425	2.651	43.209
feb-03	12.648	2.630	7.562	9.412	1.880	6.291	2.651	43.074
mar-03	12.648	2.630	7.562	9.412	1.880	6.291	2.651	43.074
abr-03	12.648	2.630	7.562	9.412	1.880	6.291	2.651	43.074
may-03	12.648	2.630	7.562	9.412	1.880	6.291	3.040	43.463
jun-03	12.648	2.630	7.562	9.412	1.880	6.291	4.204	44.627
jul-03	12.648	2.630	7.562	9.412	1.880	6.291	4.204	44.627
ago-03	12.648	2.630	7.562	9.412	1.880	6.291	4.204	44.627
sep-03	12.648	2.630	7.562	9.412	1.880	6.291	4.204	44.627
oct-03	12.648	2.630	7.562	9.412	1.880	6.291	4.204	44.627
nov-03	12.648	2.630	7.562	9.412	1.880	6.291	4.204	44.627
dic-03	12.648	2.630	7.562	9.412	1.880	6.291	4.204	44.627
ene-04	12.648	2.630	7.562	9.412	1.880	6.291	4.204	44.627
feb-04	12.646	2.630	7.562	9.281	1.880	5.452	4.204	43.657
mar-04	12.646	2.630	7.562	9.281	1.880	5.452	4.593	44.046
abr-04	12.646	2.630	7.562	9.281	1.880	5.167	4.593	43.761
may-04	12.646	2.630	7.562	9.281	1.880	5.167	4.593	43.761
jun-04	12.646	2.630	7.562	9.281	1.880	5.167	4.593	43.761
jul-04	12.646	2.630	7.562	9.281	1.880	5.167	4.982	44.150
ago-04	12.646	2.630	7.562	9.281	1.880	5.167	5.371	44.539
sep-04	12.646	2.630	7.562	9.281	1.880	5.167	5.371	44.539
oct-04	12.646	2.630	7.562	9.281	1.880	5.167	5.371	44.539
nov-04	12.646	2.630	7.562	9.281	1.880	5.167	6.149	45.317
dic-04	12.646	2.630	7.562	9.281	1.880	5.167	6.927	46.095
ene-05	12.646	2.630	7.562	9.281	1.880	5.167	7.705	46.873
feb-05	12.645	2.630	7.562	8.930	1.880	5.167	8.094	46.910
mar-05	12.645	2.630	7.562	8.930	1.880	5.167	8.094	46.910
abr-05	12.645	2.630	7.562	8.930	1.880	5.167	8.094	46.910
may-05	12.645	2.630	7.562	8.930	1.880	5.167	8.094	46.910
jun-05	12.645	2.630	7.562	8.930	2.231	5.167	8.094	47.261
jul-05	12.645	2.630	7.562	8.930	2.231	5.167	9.650	48.817
ago-05	12.645	2.630	7.562	8.930	2.231	5.167	9.650	48.817
sep-05	12.645	2.630	7.562	8.930	2.231	5.167	9.650	48.817
oct-05	12.645	2.630	7.562	8.930	2.231	5.167	9.650	48.817
nov-05	12.645	2.630	7.562	8.930	2.231	5.167	9.650	48.817
dic-05	12.645	2.630	7.562	8.930	2.231	5.167	9.650	48.817
ene-06	12.645	2.630	7.562	8.930	2.231	5.167	10.817	49.984
feb-06	12.645	2.630	7.562	8.858	2.231	5.021	10.817	49.765
mar-06	12.645	2.630	7.562	8.858	2.231	5.021	10.817	49.765
abr-06	12.645	2.630	7.562	8.858	2.231	5.021	13.151	52.099
may-06	12.645	2.630	7.410	8.858	2.231	5.021	13.151	51.946
jun-06	12.645	2.630	7.410	8.858	2.231	5.021	13.151	51.946
jul-06	12.645	2.630	7.410	8.858	2.231	5.021	13.151	51.946
ago-06	12.645	2.630	7.410	8.507	2.231	5.021	13.151	51.596
sep-06	12.645	2.630	7.410	8.507	2.231	5.021	13.151	51.596
oct-06	12.645	2.630	7.410	8.507	2.231	5.021	13.929	52.374
nov-06	12.645	2.630	7.410	8.507	2.231	5.021	13.929	52.374
dic-06	12.645	2.630	7.410	8.507	2.581	5.021	13.929	52.724

Table 3.11.: generation historical value

all these variable has been used in the regression model, obtaining the following formula:

$$\%coal = 0.000189976790748 \cdot CoalPower - 0.000166223765436 \cdot CCGTPower -$$
$$- 0.000256346001999 \cdot \Delta(coal\,\mathrm{Pr} - Gas\,\mathrm{Pr}) - 0.000001149378973 \cdot ThermicDemand -$$
$$- 4.292234179528661 \cdot \%CoalPower + 2.764261422676028$$

Obtaining a R2 value around 78%.

Has to be notice that in the coal price and in the ccgt price has been included the CO2 price, and this last variable has not been considered as an independent one. The regression formula in which the CO2 was a direct input data had a worst value of the R2 index.

$$FinalGas\,\mathrm{Pr}\,ice = \mathrm{G}as\,\mathrm{Pr}\,ice \cdot 1{,}1 \cdot \left(\frac{1}{2{,}52}\right) \cdot 16{,}1 + 0{,}365 \cdot CO2\,\mathrm{Pr}\,ice$$

$$FinalCoal\,\mathrm{Pr}\,ice = Coal\,\mathrm{Pr}\,ice \cdot \left(\frac{24}{60}\right) + 0{,}95 \cdot CO2\,\mathrm{Pr}\,ice$$

Where:

- 2,52 is the factor that is needed for the conversion from MBTU to Thermie;
- 1.1 is the factor that is needed for the conversion from PCS to PCI;
- 16,15 is the specific use, and is divided for 100 due to the fact that the fuel is in eurocents;
- If is considered the imported coal it is necessary to divide for 60, because the calorific power is 6000 kcal/kg.

The program that has been used to obtain this equation is in the Anexo3.

In order to verify the goodness of the regression equation has been studied also a regression formula with a diary scoop. The value of the R2 do not improve.

4.0 VARIABLES TO FORECAST AND RESULTS

4.1 Introduction

In this chapter will be described how are applied the function studied to the prevision of the future electricity price. This is the final step, in which all the word done achieve confirmation of its applicability. Finally we obtain a value of the energy for the next year.

In this new regulatory contest, in which there are achieving many regulatory changes that affect the incomes of the electric company, is essential know and understand the impact that the variation of a group of parameters have in the costs of the system.

In this optic, the estimation of the future energy price, done with statistical tools, can help a company in the valuation of different scenarios of costs.

There are already models that can be used for forecast the energy price, but they are very complex and the time that they need for obtain a result in very long.

This is the reason why the creation of model, a little less precise, but more efficient, easy and fast is essential for the easy evaluation of the number of different scenarios that a company wants to evaluate in a very short time.

It has to be remembered that the output of the model is a value of the electricity price for every hours, this because the model has a resolution of hours, while the output we need is a single value for all the next year.

In order to obtain this value is executed the following calculation:

$$\text{Electricity price (next year)} = \frac{\text{Hourly electricity price x hourly demand}}{\text{Total demand}}$$

The single value of the electricity price for the next year is calculating as a weighted mean taking in consideration the energy hourly generated. This mean, exactly, multiply the hour electricity price (that is the output of the model) for the hourly demand, and dividing this for the total demand of the year taken in consideration.

4.2 Variables

There are four variables that have to be forecasted , ore studied with scenario analysis in order to evaluate all the possible situation in which the enterprise will must work.

4.2.1 Week characteristic

The equation obtained for the Hydro generation is in reality divided into three different equation, corresponding to a Humid period, a Normal period or a Dry period, as described in detail in the third chapter. This mean that for the next year there will can be 52 weeks each one different from each others.

week(h=Humid,n=Normal,d=Dry)			
1	h	27	h
2	d	28	n
3	h	29	h
4	n	30	d
5	h	31	h
6	n	32	n
7	h	33	h
8	n	34	d
9	h	35	h
10	n	36	n
11	h	37	d
12	n	38	n
13	h	39	h
14	n	40	n
15	h	41	h
16	n	42	n
17	h	43	h
18	n	44	n
19	h	45	h
20	n	46	n
21	h	47	h
22	n	48	n
23	h	49	h
24	n	50	n
25	h	51	h
26	n	52	n

Table 4.1 : week characteristic

This is the table used as input to evaluate the situation of the next year. It is clear that there could be $2^{52} = 4503599627370496$ different possibilities, but the studies could be narrowed down until a pair of cases: for example could be studied a normal year, a dry year and a wet year, and then some cases with some mix with the different cases. Sure is that is unusual, ore quite rare, that a Humid weak follow a dry weak, or the opposite.
And more other, studying the historical behaviour of the rains and the puffiness of the dams can be studied a pattern of weeks (for example the summer weeks are generally dry, ore dryer than weeks in November, and so on).
In the effective implementation, finally, for a Humid week will be used the regression equation

$$Humidproduction = -0{,}112 \cdot Demand^2 + 119{,}09 \cdot Demand - 4008$$

for a normal week the equation:

$$Normalproduction = 1{,}894 \cdot Demand^2 - 222{,}68 \cdot Demand + 8427{,}56$$

and for the dry weeks the equation:

$$Dryproduction = 1{,}7153 \cdot Demand^2 - 202{,}58 \cdot Demand + 6769{,}68$$

that has been obtained in the paragraph 3.3.2.1 of the third chapter.
This kind of division (week-scope) has been considered the best possible, respect a day division that is excessively high, and respect also a mouth division, that has been considered too simplistic.

4.2.2 Demand

The forecast of the demand is based in the assumption that every year the demand feels and increase more ore lest constant. As inputs are used:

- the total system demand of the year 2007 used is 261.273.000 MWh;
- the year to evaluate: this input is introduced from the user;
- year increase of the demand, evaluated around the 3% each year;

this mean that knowing the shape of the system demand for the year 2007 and applying a year increase of 3%, it is obtained the demand of the year to calculate.

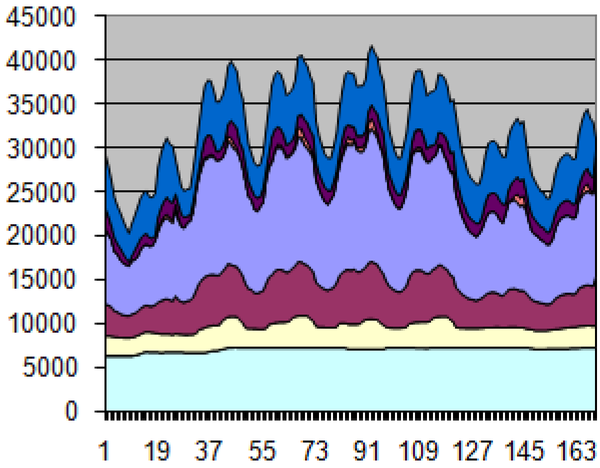


Table 4.2 total system demand year 2007

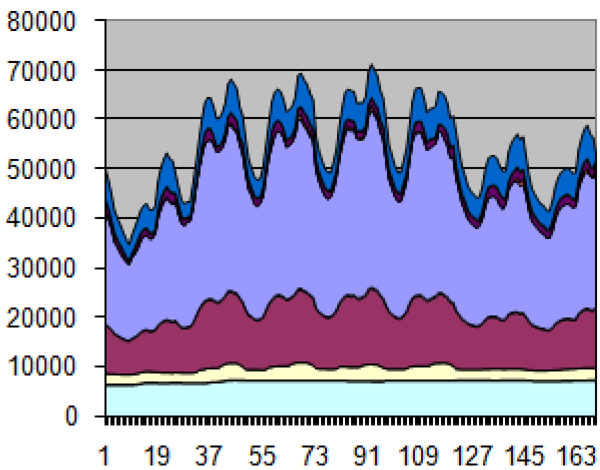


Table 4.3: example of total system demand year 2012

4.2.3 Coal price

The Coal is a fossil fuel formed in ecosystems where plant remains were preserved by water and mud from oxidization and biodegradation, thus sequestering atmospheric carbon.

It is composed primarily of carbon and hydrogen along with small quantities of other elements, notably sulphur.

For its properties, coal is the largest source of fuel for the generation of electricity world-wide, as well as the largest world-wide source of carbon dioxide emissions, contributing to climate change and global warming. In terms of carbon dioxide emissions, coal is slightly ahead of petroleum and about double that of natural gas.

The coal is not unique, but there are many different types: As geological processes apply pressure to dead biotic matter over time, under suitable conditions it is transformed successively into

- Peat, considered to be a precursor of coal. It has industrial importance as a fuel in some countries, for example, Ireland and Finland.
- Lignite, also referred to as brown coal, is the lowest rank of coal and used almost exclusively as fuel for electric power generation. Jet is a compact form of lignite that is sometimes polished and has been used as an ornamental stone since the Iron Age.
- Sub-bituminous coal, whose properties range from those of lignite to those of bituminous coal and are used primarily as fuel for steam-electric power generation. Additionally, it is an important source of light aromatic hydrocarbons for the chemical synthesis industry.
- Bituminous coal, a dense mineral, black but sometimes dark brown, often with well-defined bands of bright and dull material, used primarily as fuel in steam-electric power generation, with substantial quantities also used for heat and power applications in manufacturing and to make coke.
- Anthracite, the highest rank; a harder, glossy, black coal used primarily for residential and commercial space heating. It may be divided further in to metamorphic ally altered bituminous coal and petrified oil, as from the deposits in Pennsylvania.

- Graphite, technically the highest rank, but difficult to ignite and is not so commonly used as fuel: it is mostly used in pencils and, when powdered, as a lubricant.

The coal is considered as a traded commodity and the price of coal has gone up from around $30 per short ton in 2000 to around $123.50 per short ton as of June 25th, 2008.

In North America, a Central Appalachian coal futures contract is currently traded on the New York Mercantile Exchange. The trading unit is 1,550 short tons per contract, and is quoted in U.S. dollars and cents per ton. Since coal is the principal fuel for generating electricity in the United States, the futures contract provides coal producers and the electric power industry an important tool for hedging and risk management.

In addition to the NYMEX contract, the Intercontinental Exchange (ICE) has European (Rotterdam) and South African (Richards Bay) coal futures available for trading. The trading unit for these contracts is 5,000 tons, and are also quoted in U.S. dollars and cents per ton.

For all these considerations the value of the coal in the future is valuated always with scenario analysis taking in consideration a multiplicity of factors as: coal forward marker, evaluation of the trend of the coal reservoirs, regulatory environment, etc.

4.2.4 Gas price

As the coal price, or more than the coal price, the gas price suffer bug fluctuation; strong and increasing worldwide demand for petroleum has caused gasoline prices to fluctuate. Weather has also affected the available supply of gasoline. Hurricanes Katrina and Rita reduced the supply of refined oil in the US in 2005.

Seasonal demands affect gasoline prices. For example in the past, many families in the US have chosen to take vacation drives in the summertime, thus gas prices have usually increased 5% in these months.

OPEC countries also have significant control on pricing of petroleum. Its members control 40% of the crude oil production around the world and have two-thirds of the world crude oil reserves. OPEC sets production levels for its member countries in order to keep oil prices at a target level. However, some peak oil analysts doubt OPEC still has the spare production capacity to significantly reduce petroleum prices (although it still has the ability to increase prices).

Despite high demand in the country and despite rising fuel costs, gasoline prices are low in the United States when compared with most other Western countries. As of August 10, 2008, the United States average price of self-serve regular unleaded gasoline was $3.85/gal. Finished motor gasoline amounts to 44% of the total US consumption of petroleum products. According to national figures from the US Department of Energy, in March 2007 52% of the cost of gasoline went to pay for crude oil, 24% for refining, 15% to taxes, and 9% for distribution and marketing. By April 2008, these had changed to 72.7% for crude oil, 10% for refining, 11% to taxes, and 6% for distribution and marketing.

In 2008, a report by Cambridge Energy Research Associates stated that 2007 had been the year of peak gasoline usage in the United States, and that record energy prices would cause an "enduring shift" in energy consumption practices. According to the report, in April gas consumption had been lower than a year before for the sixth straight month, suggesting 2008 would be the first year US gasoline usage declined in 17 years. The total miles driven in the US began declining in 2006.

Most European countries have high fuel taxes. The prices have traditionally been three to four times the price in the United States, with prices during 2000-2005 of €1/litre (about US$1.54/l or $5.82/gal) while the US had prices around $1.50/gal or $0.40/l. In 2007-2008, the market price before taxes has risen, raising the price of gasoline everywhere. However, the price of gas in Europe is still more than double the US price.

Russia and some neighbouring countries have a much smaller tax, with gasoline prices similar to the US.

All these information are used in order to forecast the gas price in the future, looking, similarly to the coal price, to a set of information that can be useful for its estimation.

4.2.5 Data used

- Installed power (2007): Ccgt:16.050 MW and coal: 10.967 MW;
- Installed power (2009): Ccgt: 21.208 MW and coal: 11.384 MW;
- Demand(2007): 261.273.000 MWh;
- Special regime production(2007): 56.302 MWh;
- Pumping production(2007): 2.283.000 MWh;
- Imports(2007): 8.870.000 MWh;
- Demand(2009). 286.152.000 MWh;
- Special regime production(2009): 77.982 MWh;
- Pumping production(2009): 2.283.000 MWh;
- Imports(2009): 8.870.000 MWh;
- CO2 Price: 21 €/Tn;

5 CONCLUSIONS

- The variables taken into account for the equation do not have generally a normal distribution, making the search of the solution more difficult, and sometime the final value obtained is not so near to the expectation. The only one variable nearest to the normal distribution is the demand.
- Exist multi-correlation between some variables:
    - Fuel oil price: coal, gas and fuel;
    - Hydro reservoir and hydro generation;
    - Total demand and generation related to singles sources: hydro, ccgt, fuel, coal, etc.;

  This situation provoke that some variables present coefficient with opposite sign different from the expectation.
- In general the CO_2 emission price has an high influence in the energy price. The fuel price has an high influence for the on-peak and mid-peak block (working days), while hydro generation and importation have a very small influence in the determination of the final electricity price;
- Differently from the thesis of Carlos Guzman, the use of the regression lineal model for the determination of the two equation (hydro and thermal function) has obtained goods results, reaching in the hydraulic function R^2 values around 80%, and in the thermal function around 78%.
- The applicability to the future of the model created is quite shrunk in time: in fact the conditions in which the model is applied should be the same, ore quite similar, to the situation in which the model is based.
- The statistical model permit explicate the prices with data of the past, but is not able to predict future prices. This conclusion is taken evaluating the output of the model for the year 2007: the real values of the electricity price are around 40 €/MWh, while the output of the model is 58 €/MWh.

ANNEX I: Hydro function

```
function
[WeekDemandHumidperFinal,WeekHydroHumidFinal,WeekReserveHumidFinal]=Hy
droHumid
    file='C:\Ale\master\tesi di master\hydro data';
    Datainput=xlsread(file);
    Demand=Datainput(:,1);
    Hydro=Datainput(:,2);
    Reserve=Datainput(:,3);
    minimo_dry=Datainput(:,4);
    minimo_dry=minimo_dry(1,1);
    minimo_normal=Datainput(:,5);
    minimo_normal=minimo_normal(1,1);
    medionormal=9000;
    max_normal=Datainput(:,6);
    max_normal=max_normal(1,1);
    max_humid=Datainput(:,7);
    max_humid=max_humid(1,1);
    weeks=312;
    hours=168;

    for N = 1:weeks
        WeekDemand(1:hours,N)=Demand(1+hours*(N-1):hours*N,1);
        WeekHydro(1:hours,N)=Hydro(1+hours*(N-1):hours*N,1);
        WeekReserve(1:hours,N)=Reserve(1+hours*(N-1):hours*N,1);
    end

    maxWeekDemand=max(WeekDemand);
    for J=1:weeks
        for I=1:hours

    WeekDemandperc(I,J)=(WeekDemand(I,J)*100)/maxWeekDemand(J);
        end
    end

    for N = 1:weeks
        WeekReserveClassification(N)=Reserve(hours*N,1);
    end
```

```
%plot(WeekReserveClassification);
%grid;
%hold on;
%classification of a period humid, dry or normal

MinDry(1:weeks)=minimo_dry;
MinNormal(1:weeks)=minimo_normal;
medionormal(1:weeks)=medionormal;
MinHumid(1:weeks)=max_normal;
MaxHumid(1:weeks)=max_humid;
%plot(WeekReserveClassification);
%hold on;
%plot(MinDry,'r-');
%hold on;
%plot(MinNormal,'r');
%hold on;
%plot(MinHumid,'r');
%hold on;
%plot(MaxHumid,'r');
%hold on;

%initialization
WeekDemandDry=zeros(hours,1);
WeekDemandDryper=zeros(hours,1);
WeekDemandNormalUP=zeros(hours,1);
WeekDemandNormalperUP=zeros(hours,1);
WeekDemandNormalDOWN=zeros(hours,1);
WeekDemandNormalperDOWN=zeros(hours,1);
WeekDemandHumid=zeros(hours,1);
WeekDemandHumidper=zeros(hours,1);
WeekHydroDry=zeros(hours,1);
WeekHydroNormalUP=zeros(hours,1);
WeekHydroNormalDOWN=zeros(hours,1);
WeekHydroHumid=zeros(hours,1);
WeekReserveDry=zeros(hours,1);
WeekReserveNormalUP=zeros(hours,1);
WeekReserveNormalDOWN=zeros(hours,1);
WeekReserveHumid=zeros(hours,1);
```

```
        %with this we put the value of the demand dry divided from the
normal and
        %the humid
        for M=1:weeks
            if WeekReserveClassification(M)<MinNormal(1)
                WeekDemandDry =[WeekDemandDry WeekDemand(1:hours,M)];
                WeekDemandDryper=[WeekDemandDryper
WeekDemandperc(1:hours,M)];
                WeekHydroDry=[WeekHydroDry WeekHydro(1:hours,M)];
                WeekReserveDry=[WeekReserveDry WeekReserve(1:hours,M)];
            end
            if        (WeekReserveClassification(M)>=MinNormal(1)        &&
WeekReserveClassification(M)<medionormal(1))



                WeekDemandNormalDOWN                 =[WeekDemandNormalDOWN
WeekDemand(1:hours,M)];
                WeekDemandNormalperDOWN=[WeekDemandNormalperDOWN
WeekDemandperc(1:hours,M)];
                WeekHydroNormalDOWN=[WeekHydroNormalDOWN
WeekHydro(1:hours,M)];
                WeekReserveNormalDOWN=[WeekReserveNormalDOWN
WeekReserve(1:hours,M)];
            end

            if       (WeekReserveClassification(M)>=medionormal(1)       &&
WeekReserveClassification(M)<MinHumid(1))
                WeekDemandNormalUP                   =[WeekDemandNormalUP
WeekDemand(1:hours,M)];
                WeekDemandNormalperUP=[WeekDemandNormalperUP
WeekDemandperc(1:hours,M)];
                WeekHydroNormalUP=[WeekHydroNormalUP
WeekHydro(1:hours,M)];
                WeekReserveNormalUP=[WeekReserveNormalUP
WeekReserve(1:hours,M)];
            end

            if (WeekReserveClassification(M)>MinHumid(1))
                WeekDemandHumid=[WeekDemandHumid WeekDemand(1:hours,M)];
```

```
            WeekDemandHumidper=[WeekDemandHumidper
WeekDemandperc(1:hours,M)];
            WeekHydroHumid=[WeekHydroHumid WeekHydro(1:hours,M)];
            WeekReserveHumid=[WeekReserveHumid
WeekReserve(1:hours,M)];
        end
    end

    %%%%%%%%Humid
    %put in order the demandHumid
    righe=size(WeekDemandHumid,1);
    colonne=size(WeekDemandHumid,2);
    for i=1:colonne
        for j=1:righe
            WeekDemandHumidFinal((i-
1)*righe+j,1)=WeekDemandHumid(j,i);
        end
    end
    WeekDemandHumidFinal=WeekDemandHumidFinal(hours+1:size(WeekDeman
dHumidFinal,1));

    %put in order the demandHumidper
    righe=size(WeekDemandHumidper,1);
    colonne=size(WeekDemandHumidper,2);
    for i=1:colonne
        for j=1:righe
            WeekDemandHumidperFinal((i-
1)*righe+j,1)=WeekDemandHumidper(j,i);
        end
    end
    WeekDemandHumidperFinal=WeekDemandHumidperFinal(hours+1:size(Wee
kDemandHumidperFinal,1));

    %put in order the demandHumid
    righe=size(WeekHydroHumid,1);
    colonne=size(WeekHydroHumid,2);
    for i=1:colonne
        for j=1:righe
            WeekHydroHumidFinal((i-
1)*righe+j,1)=WeekHydroHumid(j,i);
```

```
        end
    end
    WeekHydroHumidFinal=WeekHydroHumidFinal(hours+1:size(WeekHydroHu
midFinal,1));

    %put in order the demandHumid
    righe=size(WeekReserveHumid,1);
    colonne=size(WeekReserveHumid,2);
    for i=1:colonne
        for j=1:righe
            WeekReserveHumidFinal((i-
1)*righe+j,1)=WeekReserveHumid(j,i);
        end
    end
    WeekReserveHumidFinal=WeekReserveHumidFinal(hours+1:size(WeekRes
erveHumidFinal,1));
    end
```

ANNEX II: Evaluation formula

```
function
[y,y_val,mse_stima,B,BINT,R,RINT,STATS]=stima_completa(domanda,produzi
one,riserva,cont)
%
y=produzione;



x=[riserva,riserva.^2,domanda,domanda.^2,domanda.^3,log(domanda),ones(
size(produzione))];
[B,BINT,R,RINT,STATS] = regress(y,x);

y_val=B(1,1)*x(:,1)+B(2,1)*x(:,2)+B(3,1)*x(:,3)+B(4,1)*x(:,4)+B(5,1)*x
(:,5)+B(6,1)*x(:,6)+B(7,1)*x(:,7);
plot(y);
hold on;
plot(y_val,'r');
hold on;
err=y-y_val;
plot(err,'y');
mse_stima=mse(err);
legend('reale','valutato ','errore');
```

ANEXO III: Thermal function

```
function [x,y,ydis,ymed,R2,B,BINT,R,RINT,STATS]=Thermic;

%'C:\Ale\master\tesi di master\termica\thermic diary 2007'
file='C:\Ale\master\tesi di master\termica\Termica';

Datainput=xlsread(file);
PercentualeCarbone=Datainput(:,1);
Potenza_carbon=Datainput(:,2);
Potenza_ccgt=Datainput(:,3);
Delta_prices=Datainput(:,4);
ThermicDemand=Datainput(:,5);
%PercentualePotenzaCarbon=Datainput(:,6);

x=[Potenza_carbon,Potenza_ccgt,Delta_prices,ThermicDemand,ones(size(Po
tenza_carbon))];
ics=x;
x1 = x(:,1);
x2 = x(:,2);
x3 = x(:,3);
x4 = x(:,4);
x5 = x(:,5);
%x6 = x(:,6);
y=PercentualeCarbone;

[B,BINT,R,RINT,STATS]=regress(y,ics);

%beta=nlinfit(x,y,@modelreg,beta);

ydis=B(1)*x1+B(2)*x2+B(3)*x3+B(4)*x4+B(5)*x5;
plot (ydis);
hold on;
plot(y,'r');
hold on;
err=y-ydis;
plot(err,'*');
ymed=mean(y);
```

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