Restructuring and generation of electrical energy in the Iberian Peninsula

E. Fernández Domínguez*, J. Xiberta Bernat

Departamento de Energía, Escuela Técnica Superior de Ingenieros de Minas, Universidad de Oviedo, C/Independencia, 13, 2ª Planta, 33004 Oviedo, Spain

Received 5 September 2006; accepted 18 April 2007
Available online 21 June 2007

Abstract

Portugal and Spain are on the threshold of the creation of an Iberian electricity market. In order to help its development, the power of the electric interconnection between the countries has been increased and market mechanisms designed to resolve congestion, should it arise. A system of joint supply for the Iberian Peninsula will lead to single price for the whole area except at times when the interconnection is saturated, in which case prices will be somewhat higher in the importing zone. In the medium term, the hope is that both systems will have very similar generating equipment and that their variable costs will equalize due to the substitution of the most obsolete equipment with combined cycle power stations, and to the increase of exchange capacity. The coming into effect of this market will bring about improvements in the security and efficiency of supply in both countries. There will also be some obstacles to overcome, such as, for example, the current regulatory frame deficiencies on power generation, the contacts which exist at present in Portugal between the producers and the National Electricity Network, the asymmetry of the distribution channels in each country, the differences in rates and the limited capacity for exchange.

© 2007 Elsevier Ltd. All rights reserved.

Keywords: Iberian electric market; Investment; Interconnection

1. Introduction

Traditionally, the set of activities related to electricity have been considered to be a strategic sector in which governments intervened with the aim of assuring direct control. This was based on centralized, and binding, planning and a unified control over the exploitation of installations or means of production, all of which conceded clear protagonism to the public sector (Beesley, 1992).

In Spain, during the Stable Legal Framework (Marco Legal y Estable), the objective function was the minimization of the standard variable costs of exploitation, subject to operation and reliability restrictions. Electrical energy power generating stations were to be operated according to economic criteria, that is, of minimum costs of fuels (Ariño and López de Castro, 1998; Kahn, 1996).

With the introduction of competition in the electricity industry and after the passing in Spain of the Electricity Sector Law 54/1997 (LSE), the operational arrangements of the generating installations have become the responsibility of the firms. These arrangements, which are established in function of the supply and the energy generated by each plant, determine a payment or compensation for the marginal costs of the system. Under these conditions, the system is not subjected to any energy policy restrictions, although subsidies to domestic coal and to the so-called special system production (cogeneration and renewable energy source), which do not affect the market price, are maintained and stranded costs (CTC) are established. Given that we are dealing with a service of general interest or where activity is necessarily carried out using basic transmission networks, liberalization makes a certain level of regulation indispensable (Kahn, 1998; Sánchez de Tembleque, 2000; González and Basagoiti, 1999).

In addition to the compensation for the marginal cost, a payment for guaranteeing power has been established. This income, which the generators receive according to purchases on the market, is destined to the construction and...
maintenance of support stations and is divided among the generators in proportion to their available capacity (Pérez-Arriaga and Meseguer, 1997).

Although the production and electricity retailing are liberalized, both in technical as well as in economics terms, to the maximum possible degree, transmission (carried out by Red Eléctrica de España, REE) and distribution remain regulated. This liberalization is grounded on the principle of free access of third parties to the network, with the aim that their operation as natural monopolies be compatible with the criteria of liberalization and competition. In production activity, state planning is merely indicative, whereas this is not the case with transmission activity (Lasheras, 1999).

This change of model has been made possible due to a concurrence of economic, technological and political factors.

At present, the production of electric energy in Spain is dominated by Endesa (29%) and Iberdrola (22%) which generate 51%. Unión Fenosa (11%), HC Energía (5%), Viesgo (2%), Gas Natural (7%), Elcogas (1%) and other agents (4%) have a global participation of 30%, while the special system generates the remaining 19%. For energy sources, nuclear contributes 22%, renewable 22% (8% wind, 11% hydraulic and 3% from residues and biomass) and all types of thermal units with the remaining 56% (24% coal, 2% oil and the rest natural gas with 24% from combined cycles and 6% from cogeneration) (REE, 2006b).

The Portuguese electricity sector is significantly different from the Spanish sector. It is dominated by Energías de Portugal (EdP) which, through its subsidiaries, generates over 60% of the electricity consumed in the country. Moreover, EdP has the rights over transmission and the operation of the system, controlling the lion’s share of distribution (ERSE, 2004).

In the Portuguese electricity system, we can distinguish between:

- The Public Electricity System (SEP), which provides the public service of electricity provision.
- The Independent Electricity System (SEI), which operates according to free market principles. This can be further divided into:
  - Non-Linked Electricity System (SENV).
  - Special System Electricity System (SERE), which includes the so-called “special system production” (renewable energy sources and cogeneration).

The SEP is characterized by the existence of long-term concessionary contracts (CAEs), no less than 15 years for the generators and 35 years for the distributors, between the Rede Eléctrica Nacional, S.A. (REN) and the generation and distribution firms, which are linked in order to guarantee provision to captive consumers.

Production within the SEP is governed by centralized planning and in accordance with Portuguese energy policy. The generators which operate within the SEP are EdP and the independent producers Turbogas (60% International Power and 40% EdP) and Tejo Energia (50% International Power, 38.9% Endesa and 11.1% EdP), which cover around 75% of electricity consumption in Portugal (ERSE, 2004).

The SENV operates according to the rules of the market, that is, without long-term obligatory contracts. It comprises qualified customers and non-linked generators, which are at liberty to establish supply contracts with the SENV. Both the generators and SENV clients have rights of access to the public transmission and distribution networks at regulated tariffs. Most of the SENV generation corresponds to special system installations, with the REN being obliged to buy electricity from these installations at a regulated price (ERSE, 2004).

A further step towards a more competitive environment was taken when the Spanish and Portuguese administrations signed a Protocol for collaboration on 14 November 2001. With the signing of this protocol, an integrated electricity market was established in the Iberian Peninsula which interacts in a homogeneous manner with the rest of the European Union through the interconnections between Spain and France (CNE and ERSE, 2001).

This market will provide 12% of the electricity in the EU-15, a figure exceeded only by Germany, France, the UK and Italy (CNE and ERSE, 2002b).

The objective of this work is to analyze the restructuring which will take place on the Iberian Peninsula as a consequence of the establishment of this market, as well as the price of electricity as a function of the variations of the fuel prices, the value of CO₂ allowances, interconnection capacity and the incorporation of new technology.

We first analyze the different steps which have been taken to set up the Iberian market and determine how it will operate. With this objective, we highlight the various ways of contracting energy and the mechanisms to resolve congestion in the interconnection between Portugal and Spain. We also comment on the energy connections with bordering countries (France, Andorra and Morocco).

We follow this with a description of the characteristics of the existing generation installation and of the infrastructure necessary to achieve satisfactory coverage.

Next, using results from a simulation model which has been validated for the Spanish electricity system (Fernández, 2004), we estimate the profitability of the combined cycles which are being built and the variations in the market price under different scenarios for the exchange capacity between Portugal and Spain.

Finally, we carry out an analysis of the industrial concentration of the sector and the benefits and difficulties associated with the implantation of a single electricity market in the Iberian Peninsula.
2. The Iberian electricity market

Directive 96/92/EC established common norms for the development of an internal electricity market. The lack of a network of interconnections between Member States has made the development of such a market impossible, which in turn has led to talk of a system of 15 linked markets instead of a single market.

This lack of interconnection continues to this day, despite the measures adopted by Community institutions and the fact that it was considered as an objective of top priority in the summit of Heads of State celebrated in Barcelona in March 2002. This summit established the need for interconnections between the Member States to reach a minimum of 10% of their installed capacity before the year 2005 (Eurolectric, 2003).

As a consequence of this, the Member States have developed, or are planning to do so in the medium term, regional markets such as NordPool—the electricity market in the Scandinavian countries (Hjalmarsson, 1996)—or the Portuguese–Spanish Market, generally known as Iberian Electricity Market (MIBEL).

The MIBEL originated in the Memorandum of Agreement signed on 29 July 1998, between the Spanish and Portuguese administrations with the aim of increasing cooperation between the countries in matters of energy.

This agreement later gave rise to the Protocol for collaboration between the Spanish and Portuguese administrations, which was signed on 14 November 2001, and which established:

- The entering into operation of the MIBEL on 1 January 2003.
- Guarantees of access to the market and the interconnections on equal conditions for all agents.
- The expansion of the existing interconnections within a term of 5 years through the construction or extension of at least four new lines.
- The development of harmonized operating procedures by the operators of the system which would allow for joint management of the two systems (CNE and ERSE, 2001).

The change of government in Portugal in 2002 delayed the process, which was reinitiated as a consequence of the agreements reached in the Spanish–Portuguese summit celebrated in Figueira da Foz on 8 November 2003. These agreements took shape in the Memorandum of Understanding signed on that date. This Memorandum outlined the calendar of actions to be undertaken before 20 April 2004—3 months after the signing of the International Agreement in Lisbon—with the objective that the MIBEL enter into operation, although it was not carried out.

Some months later, at the Santiago de Compostela International Convention on 1 October 2004, the base for harmonizing the pricing structures of the countries—grounded on the principles of additivity, transparency, uniformity and reflecting the real costs incurred in the provision of electrical energy—was set taking as references the prices on the spot and term markets. Moreover, it was decided to set up a Regulatory Council comprising representatives of the national energy bodies and stock market bodies, namely the Comisión Nacional de Energía (CNE), the Entidade Reguladora dos Serviços Energéticos (ERSE), the Comisión Nacional del Mercado de Valores (CNMV) and the Comisión de Mercado de Valores Mobiliarios (CMVM). Finally, a MIBEL Technical and Economic Management Committee, made up of representatives of the systems operators and markets, was set up to manage the necessary communications and information flows between the various operators (BOE, 2006a).

At the Évora summit, which was celebrated on 18 and 19 November 2005, it was agreed that the MIBEL would enter into limited operation from 4 July 2006 (only for the term market and for 5% of fee-paying demand) (BOE, 2006b; Diario, 2006).

At the Portuguese–Spanish summit which took place at Badajoz in November 2006, there was a reaffirmation of the determination to develop the MIBEL and its extension to the Iberian Natural Gas Market (MIBGAS), and a call on REN and ENAGAS to carry out a study with the objective of strengthening the interconnection. The most important decisions taken for the year 2007 were the following: the development of a common model of spot and term energy contracting with a mechanism for managing the interconnection based on market splitting and explicit auctions; development of a mechanism for guaranteeing power which takes the particular characteristics of each country into account; the maintenance of an obligatory 10% of energy acquirement for OMIP distributors; and the coordinated organization of virtual auctions of capacity in the Iberian zone.

An important step was the approval by the EU, on 22 September 2004, of the mechanisms for ending the long-term concessionary energy acquirement contracts (CAEs) in Portugal, which had blocked freedom to negotiate over the energy produced in Portugal. In this regard, the Portuguese government published Law 12/2005 which established, for each generator which possessed a CAE, the right to receive earnings equivalent to those associated with that contract. To calculate this, the Portuguese daily market was assigned average earnings of 36€/MWh, a similar value to that adopted in the Spanish electricity system in order to determine the CTCs. The difference between the CAE and the average earnings assigned would be compensated by a mechanism which, in the Portuguese market, is known as the Cost of Maintaining Contractual Equilibrium (CMEC).

The MIBEL is based on principles of free competition, transparency, efficiency and a single price for the whole peninsula from the equalization of supply and demand (CNE and ERSE, 2002a).
Portugal and Spain have much in common but there are also significant differences in geographic, economic and energy terms.

The land surface of Portugal is one-fifth of that of Spain, and the population of Spain is four times higher. The population densities in Spain and Portugal are just above 90 and 110 inhabitants per square kilometre, respectively. As can be seen in Table 1, the per capita consumption of electricity on the Iberian peninsula (5800 kWh/inhabitant) is below the average for the EU-15 (7000 kWh/inhabitant). This difference has been falling due to the higher average rate of growth of demand in Portugal and Spain over the last 9 years (5%) (Table 2) in relation to that of the EU-15 (1.8%).

2.1. The functioning of the market

When the MIBEL is fully functioning, it will be based around three forms of contracting: spot market, term market, and bilateral contracts.

The spot market will be based on the present market for Spanish supply managed by Electric Market Operator (OMEL), which includes the daily markets and that of intra-daily settlement. The market will be run from Madrid.

The term market will be developed by the so-called Portuguese pool, and will be based on the negotiation of contracts of a maximum of 1 year with an obligation to physically hand them in when they mature, although the International Agreement provided the possibility of a purely financial settlement.

In addition to these two types of contracts, the possibility exists for producers, commercial agents and end clients to negotiate bilateral contracts for terms beyond 1 year, although producers and commercial companies from the same group will not be permitted to do so. Negotiation through bilateral contracts will also be subject to payments and charges for the guaranteeing of power.

The Portuguese market operator must communicate to the Spanish market operator, before the daily market, the contractual commitments acquired by all the agents in the term markets. Furthermore, before the closing of receipts of offers in order to clear the daily market, each agent will have allocate units of supply to their contractual commitments in the term market, as well as specifying in the same terms the bilateral contracts signed, disaggregating the units bought and sold for each country.

Producers will have to make offers of sale to the daily market according to the capacity not committed to the term market or through bilateral contracts.

The market operator will carry out a settlement of the daily market, without taking into account the technical restrictions imposed by the Portuguese–Spanish interconnection, in order to determine the price corresponding to a situation where these technical restrictions were absent. This price will be used to settle the commitments acquired in the term market. The technical management will be carried out in a coordinated fashion by the operators of the system in each country through harmonized operational procedures (CNE, 2003).

The intra-daily markets will be operated along similar lines to the daily market.

At first, ancillary services and technical restrictions will be managed by the system operator in each country and will use, as far as possible, efficient market mechanisms. Once the MIBEL has been put into place, and following the corresponding transition period, the management of ancillary services to the system will be carried out by the single operator of the transmission system (CNE and ERSE, 2002a).

| Table 1 |
| Population and consumption per capita in Portugal, Spain and EU-15 in 2006 |

<table>
<thead>
<tr>
<th>Population (millions of inhabitants)</th>
<th>Portugal</th>
<th>Spain</th>
<th>MIBEL</th>
<th>EU-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption per capita (kWh/inhabitant)</td>
<td>10.7</td>
<td>44.7</td>
<td>55.4</td>
<td>390</td>
</tr>
<tr>
<td>4800</td>
<td>6000</td>
<td>5800</td>
<td>7000</td>
<td></td>
</tr>
</tbody>
</table>

| Source: INE, INP, REE and REN. |

| Table 2 |
| Evolution of annual and peak demand (TWh, GW, %) in Portugal and Spain, 1998–2006 |

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand in Portugal (TWh)</td>
<td>33.8</td>
<td>35.8</td>
<td>38.0</td>
<td>40.0</td>
<td>40.7</td>
<td>43.1</td>
<td>45.5</td>
<td>47.9</td>
</tr>
<tr>
<td>Growth per annum (%)</td>
<td>5.9</td>
<td>6.0</td>
<td>5.4</td>
<td>1.6</td>
<td>5.9</td>
<td>5.7</td>
<td>5.4</td>
<td>2.7</td>
</tr>
<tr>
<td>Peak demand in Portugal (GW)</td>
<td>6.1</td>
<td>6.1</td>
<td>6.6</td>
<td>7.1</td>
<td>6.8</td>
<td>8.0</td>
<td>8.2</td>
<td>8.5</td>
</tr>
<tr>
<td>Growth per annum (%)</td>
<td>0.7</td>
<td>7.1</td>
<td>8.9</td>
<td>5.3</td>
<td>18.9</td>
<td>2.5</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Demand in Spain (TWh)</td>
<td>173.1</td>
<td>184.4</td>
<td>193.9</td>
<td>205.6</td>
<td>211.5</td>
<td>225.9</td>
<td>236.0</td>
<td>246.8</td>
</tr>
<tr>
<td>Growth per annum (%)</td>
<td>6.5</td>
<td>5.2</td>
<td>6.1</td>
<td>2.9</td>
<td>6.8</td>
<td>4.5</td>
<td>4.6</td>
<td>2.8</td>
</tr>
<tr>
<td>Peak demand in Spain (GW)</td>
<td>29.8</td>
<td>31.3</td>
<td>33.2</td>
<td>35.2</td>
<td>34.3</td>
<td>37.5</td>
<td>37.7</td>
<td>43.4</td>
</tr>
<tr>
<td>Growth per annum (%)</td>
<td>5.1</td>
<td>6.1</td>
<td>5.9</td>
<td>2.4</td>
<td>9.1</td>
<td>0.7</td>
<td>15.0</td>
<td>−2.8</td>
</tr>
</tbody>
</table>

| Source: REE and REN. |
This model is different from the Portuguese and Spanish models—which are based, respectively, on the almost obligatory pool and the physical bilateral almost obligatory pool—and more similar to those of Scandinavia and the United Kingdom, although it takes into consideration the particular circumstances and experiences of the electricity sector in the two countries.

The evolution of the MIBEL should be gradual, both with respect to the technical, economic and administrative criteria of the present operation of the two systems as well in terms of the development of market instruments, such as, for example, financial products for risk coverage (CNE, 2002).

The MIBEL is based on the creation of a single operator for the Iberian market with two pools: the Portuguese for the term market, and the Spanish for the spot market. This operator will be created from two initially separate institutions, Portuguese Iberian Market Operator (OMIP) and Spanish Iberian Market Operator (OMIE). Within a maximum of 1 year after the MIBEL comes into operation, these operators will have to adjust the holdings of shareholders so that none of them possesses a share greater than 5%. Two years after market integration has been completed, both operators will merge to form a single Operator (OMI).

The planning of and expansion of transmission and interconnection networks, as well as the investment and financing associated with this, will be taken over by REE and REN, with each operator being responsible for the administration of its area of control. Given the regulated nature of the activity, the investments will be recovered through fees paid by users, who are the beneficiaries of the MIBEL, following a cost-of-service methodology (BOE, 2000).

The peninsular transmission network is a mesh network which causes few technical restrictions. However, mention should be made of the congestion which is produced in the evacuation of energy from the zones of Galicia and Asturias as well as from the zones located beside the new wind power stations and combined cycle plants. Problems also exist with regard to the control of tension in the zones of Andalusia, the east and the centre (Spain) as well as in the Algarve and Lisbon (Portugal). The network is consequently being adapted to guarantee an adequate evacuation of the electricity produced in these zones (CNE, 2006a).

To aid the development of the MIBEL, the power of the electricity interconnection between Portugal and Spain must be increased. In this regard, both administrations promoted the construction of the Alqueva-Balboa line, in service since the end of 2004 (Fig. 1).

Moreover, the exchange capacity in the International Duero will be increased through the construction of a new 400 kV line or the reinforcement of the existing lines, and this is due to be completed in the year 2007. Also, the Cartelle-Lindoso line will be reinforced through the installation of a second circuit, due to come into service on 2007, in order to improve the reliability of this interconnection, and the capacity of the Cedillo-Oriol line will also be increased in such a way that it fits with the Rio Maior-Cedillo line as soon as possible (REE, 2006a).

Two new interconnections are planned for 2010. The first is located in the Northeast and is associated with the future high-velocity train line between Porto and Vigo. The other is in the Algarve, in the south of Portugal, and will run from the Portimao sub-station to the province of Huelva. The Iberian interconnection capacity, with the planned reinforcements, will be close to 20% of Portugal’s peak power limit and will be available for all MIBEL participants (MITYC, 2006b).

Although no reserve capacity of the interconnection between Portugal and Spain is provided under the present administration, the operators of both countries can make bids to the Spanish pool with the objective of exporting or importing electricity. These bids, in which the quantity (MW) and price (€/MWh) are specified, are accepted when their price is less than the marginal system price. When, under these circumstances, the exchange capacity between the countries is surpassed, the quantity supplied is reduced proportionally until maximum capacity is reached.

Any method for resolving congestion in the interconnections between Portugal and Spain must be based on market mechanisms with the agreement of the system operators. The REE and the REN propose a combination of market mechanisms adapted to the different time horizons of the methods of contracting permitted in the MIBEL, including:

- **Explicit auctions**, for the allocation of capacity to the physical bilateral contracts.
- **Counter trading**, in real time, to ensure the firmness of the transactions which are announced between the two systems.

![Fig. 1. Present electrical interconnection capacity between Portugal and Spain. Source: REE, REN and own elaboration.](image-url)
• Market splitting, to resolve congestion (the case of NordPool).

In the method of counter trading, access to the line of congested zone is made available to all interested parties. The operator of the system in the area of destination of transit will be obliged to buy the energy which, due to congestion, it cannot transmit.

The method of market splitting is based on dividing a single market into various zones and carrying out a settlement—in the process of equalling purchase offers and sales—for each zone, and adjusting so that the flow per line is equal to its maximum capacity (CNE, 2002). Market splitting, in contrast to explicit auctions, will only come into operation when there is a genuine saturation, and there will never be an extra payment for using the interconnection.

In the MIBEL, congestion takes place in the interconnection between Portugal and Spain. In many cases, the energy which is intended to be carried from Spain to Portugal is greater than the capacity of the system.

The CNE has proposed a method of administering the interconnection which essentially consists of putting into place a market splitting mechanism for the daily horizon, thereby permitting the best possible use of available capacity, complemented by explicit auctions of capacity for intra-daily horizons in order to assign physical capacity rights. Thus, market agents which have obtained capacity rights in previous explicit auctions can freely choose between the two options of using their physical rights to programme bilateral contracts or ceding their rights to the market splitting process. The right to use capacity will be acquired at the marginal price determined from the explicit auction, provided that the interconnection is congested. The explicit auction process will be carried out in a coordinated fashion by the operators of the systems. The market splitting mechanism will be carried out by the OMI when it comes into being, and during the transition period by the OMIE (CNE, 2006b).

The MIBEL leads to a single price for electricity in the whole peninsula, except when the interconnection between Portugal and Spain becomes saturated. When this occurs, prices begin to differ, being somewhat higher in the importing zone than in the exporting zone. The development of the interconnection which was agreed on in the Protocol will minimize these price differences.

2.2. Interconnection of MIBEL with Europe and Africa

From the point of view of assuring provision, the reinforcement of the international interconnections with France and Morocco are priorities as this would allow the horizontal concentration of the MIBEL to be reduced and increase the generation of intermittent energy. The interconnection with France is at present very small (1.1 GW, well below 10% of that proposed by the EU) and is a target of interest due to its impact on the quality and security of the Spanish system. The increase in the exchange capacity between France and Spain is planned to be carried out in the not-too-distant future through the creation of new interconnections which have already been programmed. The Eastern–Pyrenees interconnection will, in 2008, permit an interchange capacity in winter from France to Spain of 2.6 GW. The Western–Pyrenees interconnection involves the construction of a double-circuit line of 400 kV. These projects have the objective of reaching an exchange capacity between the two countries of 4 GW (MITYC, 2006b).

With respect to the interconnection with Andorra, plans are in place to transform the present 110 kV line into one of 220 kV, which will contribute to the increase of the interconnection capacity between France and Spain (MITYC, 2006b).

As for Morocco, there are plans to introduce a second interconnection circuit, which will reinforce the reliability of the present connection and will permit greater commercial capacity (MITYC, 2006b).

Until these new electricity interconnections between the Iberian Peninsula and bordering countries are developed, the exchange capacity will continue to be small and will function in the same way as it has been over recent years, independently of the increase in the interconnection between Portugal and Spain.

Regarding the peninsular gas system, due to the important growth in demand over recent years, and with the objective of improving the reliability of supply, there is a target of reaching an emission capacity of more than 14 Mm³/h in the year 2010. This is to be achieved using the regassifying plant planned for Asturias and the existing plants in Barcelona, Sagunto, Cartagena, Huelva, Bilbao, Mugardos (Galicia) and Sines (8.3 Mm³/h), the international gas pipelines with France and Africa (2.9 Mm³/h) and the capacity of extraction from subterranean deposits (3 Mm³/h).

An increase of over 4 bcm in the interconnection capacity with France is anticipated, using the gas pipelines of Figueras and Viella and the duplication of the Vergara-Irún pipeline. In 2009, the Medgaz undersea gas pipeline will enter into operation, connecting Algeria with Almeria with an initial capacity of 8 bcm. On the other hand, storage capacity will increase from 25 TWh in 2006 (30 days demand) to 87 TWh in 2011 (70 days demand).

Finally, it should be pointed out that the gas pipelines needed to connect the natural gas network with the new combined cycles are under construction and will be operable in the next 5 years (MITYC, 2006b).

3. Electricity generation installations

At present, notable differences exist between the total number of generating installations in both systems, though it is already designed to handle the large occasional increases in demand which have been occurring over the last 9 years in both countries (5%). The Portuguese system
has a greater dependence on hydraulic power stations, generally run of the river and with little reservoir capacity. In the Spanish system, the presence of nuclear power stations, with their low variable costs, reduces the dependence on water availability. In both systems, a large investment effort is underway in wind energy and combined cycle power stations as well as in the infrastructure needed to evacuate electrical energy from these installations and to keep the combined cycles provided with natural gas.

Figs. 2–4 show the evolution of installed power by firm and technology in the Portuguese and Spanish electricity systems during the period 1998–2006.

The White Book of the Spanish electricity sector recommends maintaining the existing payments for guaranteeing power supply and its application in both countries. It also points to the possibility of creating an additional mechanism to provide incentives to invest in new generating plants with the objective of guaranteeing a predetermined margin of available installed coverage capacity over demand in the case that the market, together with the payment for guaranteeing power, does not provide it (Pérez-Arriaga, 2005).

With regard to electrical energy generation in dry periods, the Portuguese system makes more use than the Spanish system of oil–gas power stations (which have high variable costs), rising to 20% of electricity production. This is due to the fact that their coal and combined cycle power stations always operate a high number of hours, independently of the annual water availability. This situation will change in the coming years thanks to the MIBEL and the installation of new combined cycles, which will substitute the more obsolete coal and oil–gas plants.

Figs. 5–7 show the evolution of net production, by firm and technology, in the Portuguese and Spanish electricity systems during the period 1998–2006.

In recent months, a large number of combined cycle installations have entered into service (at the end of 2006 there were 16,575 MW on the Iberian peninsula: 2190 in Portugal and 14,385 in Spain) to deal with the aforementioned large increase in demand which is occurring (5% annually over the last 10 years) and the closure of the more obsolete stations (fundamentally oil–gas) (MITYC, 2006b; REN, 2003).

The trend of companies towards generating electricity through combined cycles is motivated fundamentally by their high thermal efficiency (close to 57%), the low specific investment needs (500 €/kW), the short construction time (approximately 24–28 months for a 400 MW power plant, although the bureaucratic process is slow) and the lower personnel needs compared with coal-based technologies. Other attractive features of this technology are the short time periods needed for start-up (3 h) and the low emission levels (zero in SO₂ and particles, and around 50% in NOX and CO₂) compared with conventional thermoelectric power stations (Newbery, 2000; Sabugal and Gómez, 2006).
The large investment effort in generation activity is due to various factors such as economic growth and peaks of electricity demand, the penetration of electricity in the market, environmental limitations, programmes to extend the useful lifespan, and the high presence of an intermittent energy source such as wind power (IEA, 2004).

The implementation of Directive 2003/87/EC, from which a rule on greenhouse gases allowances is established, produces an extra cost for thermal power stations (twice as much for coal as for combined cycles). Its effect is equivalent to a variable overhead calculated as the product of each specific group emission (tCO₂/MWh) by the value of these allowances (€/tCO₂). Depending on the fuel prices and the CO₂ allowances, the merit order of the different technologies could be modified with the result that a combined cycle would have a variable cost lower than those of a coal station for low prices of natural gas (less than 4 €/GJ) and high values of CO₂ allowances (more than 25 €/tCO₂) (Linares et al., 2006).

In spite of the fact that some firms have studied the possibility of constructing supercritical technology coal power stations, it seems unlikely for the moment that any firm will carry out a project using this technology on the Iberian peninsula as long as no stable regulatory framework for the trading of CO₂ emissions exists. These power stations could complement the combined cycles in the generation mix as they consume a fuel which has low-price volatility, greater geographical diversity of supply and the capacity to be located on existing sites. Technological advances have achieved high thermal efficiency (around 45%), a slightly higher availability than that of subcritical coal power stations, relatively short start-up times (about 4 h) and a greater operating flexibility. Moreover, the installation of systems of emission reduction permits them to comply with existing environmental legislation.

To ensure supply, Directive 2003/54/EC provides that Member States will be able to give preference to the operation of generating installations which use domestic fuels in a proportion which does not annually surpass 15% of the total quantity of primary energy necessary to produce electricity. Spanish coal, which has found it difficult to compete in open markets, will be able to rely during the period 2006–2012 on State support through the national plan for strategic coal reserves, with production forecasted to be reduced from 10.4 Mt in 2007 to 9.2 Mt in 2012 (MITYC, 2006a).

Among renewable energy resources, wind power is noteworthy, closing the year 2006, with 11.5 GW of installed power in Spain and 1.7 GW in Portugal and 22.6 and 2.5 TWh of electricity generated, respectively (8.4% and 6.5% of total production). Installed wind power on the Iberian Peninsula has experienced an average annual growth of over 1600–2000 MW over the last 6 years (CNE, 2006a; REN, 2006). It is worth mentioning with regard to renewable energies that both Portugal and Spain have their own national policies.
which owns a 600 MW coal power station in Portugal, and is studying the construction of combined cycles with its partners in Tejo (International Power and EdP) and Sines; moreover, it has a joint venture with the Portuguese firm Sonae for electricity trading/commercialization. The second Spanish producer, Iberdrola, has a 9.5% share in EdP and 4% share in Galp Energía, and is planning to invest in combined cycles in the coming years. The third Spanish producer, Unión Fenosa, has a trading platform operating in Lisbon and Porto (Eybalin and Shahidehpour, 2003).

4. Practical aspects of the workings of the MIBEL

The application of the MIBEL’s system of joint supply will lead to greater usage of more efficient equipment (more modern combined cycle and coal power stations) as well as to a single price on the whole peninsula. When saturation arises in the interconnection between the countries, the prices will be higher in the importing zone than in the exporting zone, although in the importing zone these prices will be lower than those which would have existed if the Spanish and Portuguese markets were operated independently due to the greater use of the interconnection.

Through the interconnection, the transfer of electrical energy will be carried out in a system whose generation has lower variable costs. The transfer will normally be from Spain to Portugal and will be greater in off-peak hours given that the Spanish electricity system has an availability that peak electricity demand is going to increase by 20% for the period 2005–2010 whereas installed capacity will increase by almost 35% (MITYC, 2006b; REN, 2003).

Table 3 outlines the new combined cycle power installed or to be installed both in Portugal and Spain, which corresponds an investment of 15,000 million euro with half of this dedicated to substituting obsolete installations.

On the other hand, given the closure of some obsolete coal plants (0.7 GW) and the introduction of a market for CO₂ allowances, production based on this fuel will drop from 25% in 2006 to 15% in 2010 (MITYC, 2006b; REN, 2003).

Given projected investments up to 2010, the current situations of project applications, administrative processing and works in progress (1 GW for hydraulic stations, more than 14 GW for combined cycles and 13 GW for cogeneration and renewable resources) the reliability of the system, calculated as the ratio of available capacity to the peak of electricity demand estimated for each year, is going to be increased. It has been estimated that the value will increase from 1.05 in 2005 to 1.12 in 2010 due to the fact that peak electricity demand is going to increase by 20% for the period 2005–2010 whereas installed capacity will increase by almost 35% (MITYC, 2006b; REN, 2003).

4.1. Estimation of the future price of electricity

To estimate the costs of energy produced by the plants of an electricity system to satisfy demand in a given period, taking into account fuel consumption, the productions corresponding to different technologies, the extent of coverage and payments to the companies in the system, we need a model of the operation of the generating system.

To analyse the workings of the MIBEL, we will use a tool which has been specifically designed for that purpose, HESIMEL (Electricity Market Simulation Tool). This treats production on an economic basis, using marginalist economic theory in a competitive environment. The model handles both existing generating plants and new projects, some of which are in the process of construction and others which are in the hands of the Administration and which

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Installed power in Portugal, Spain and MIBEL, 2002–2010 (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2002</td>
</tr>
<tr>
<td>Portugal</td>
<td>0</td>
</tr>
<tr>
<td>Portugal accumulated</td>
<td>990</td>
</tr>
<tr>
<td>Spain</td>
<td>2733</td>
</tr>
<tr>
<td>Spain accumulated</td>
<td>2733</td>
</tr>
<tr>
<td>MIBEL</td>
<td>2733</td>
</tr>
<tr>
<td>MIBEL accumulated</td>
<td>3723</td>
</tr>
</tbody>
</table>

Source: MITYC, REN and own elaboration.
will probably go ahead in the near future (Fernández, 2004).

HESIMEL treats certain domestic fossil fuels in a special way and also pays due attention to hydrology, pumping capacity in periods of little demand, and the environmental impact of each technology. The demand in the system is modelled by constructing steps of equal size which approximate the monthly curve by dividing it into peak and off-peak periods for weekdays and weekends/holidays (Fernández, 2004).

The results obtained from HESIMEL have been validated for the present Spanish spot electricity market. For Portugal, no spot market exists and the values are direct simulations.

Table 4, which shows prices in electricity markets in Portugal and Spain for the period 1998–2006, highlights the high degree of sensitivity of these markets to fuel prices (oil and coal) and to hydraulic conditions.

Although the uncertainty surrounding whether or not future revenues will cover investment costs reduces the attraction of installing combined cycles and peak power stations, these technologies are necessary to cover demand in the coming years. For this reason, an increasing number of markets are choosing to introduce some sort of specific mechanism which will ensure their profitability, such as, for example, the capacity markets in some eastern US states (Stoft, 2000).

Table 6 compares the market price in the long run obtained from the model (corresponding to the scenarios regarding the prices of CO₂ and fuel emission rights) with the full cost of a combined cycle (characteristics in Table 5).

High oil prices (over $60 a barrel) and low emission prices (less than 10 €/tCO₂) combined with good hydraulic conditions lead to an important reduction in the price in the pool which threatens the profitability of the combined cycles. This situation is worsened if we take into account that in many cases take or pay clauses make it obligatory to consume the gas which has been contracted and preclude channelling it to other destinations, such as sales to third parties, for example.

As long as the interconnection is saturated, the higher prices in the Portuguese electricity system may provoke a shift of new investment in generating installations from Spain to Portugal. The reason lies on the fact that a combined cycle could receive up to 4 million euro a year more than it would if it were installed in Spain (Fernández, 2004).

The interconnection capacity between Portugal and Spain has increased over recent years, going from 750 MW in 1998 to 1000 MW in 2001 and to 1400 MW from 2005. Using the simulating tool, we have calculated the market price in both countries in the scenarios where the interconnection capacity was 750, 1000, 1400 and 2000 MW over the period 1998–2006. The results show that the price in the Portuguese system falls significantly as exchange capacity increases, whereas the price in the Spanish system rises. The greater the amount of electricity that can export from Spain to Portugal, the less sharp the rise in price. With the exchange capacity of 2000 MW

---

**Table 4**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Market price in Portugal (€/MWh)</td>
<td>31.2</td>
<td>31.4</td>
<td>39.4</td>
<td>37.8</td>
<td>45.1</td>
<td>36.0</td>
<td>33.8</td>
<td>60.9</td>
<td>60.2</td>
</tr>
<tr>
<td>Market price in Spain (€/MWh)</td>
<td>25.6</td>
<td>26.7</td>
<td>31.9</td>
<td>31.5</td>
<td>38.9</td>
<td>30.3</td>
<td>28.7</td>
<td>55.7</td>
<td>55.5</td>
</tr>
<tr>
<td>Brent ($/bbl)</td>
<td>12.7</td>
<td>17.9</td>
<td>28.5</td>
<td>24.5</td>
<td>25.0</td>
<td>28.9</td>
<td>38.3</td>
<td>45.6</td>
<td>66.5</td>
</tr>
<tr>
<td>Coal ($/t)</td>
<td>32.0</td>
<td>28.8</td>
<td>36.0</td>
<td>39.3</td>
<td>31.6</td>
<td>42.5</td>
<td>71.9</td>
<td>61.1</td>
<td>74.8</td>
</tr>
<tr>
<td>Hydro energy capability in Portugal (%)</td>
<td>1.0</td>
<td>0.7</td>
<td>1.1</td>
<td>1.2</td>
<td>0.8</td>
<td>1.3</td>
<td>0.8</td>
<td>0.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Hydro energy capability in Spain (%)</td>
<td>0.9</td>
<td>0.7</td>
<td>0.9</td>
<td>1.1</td>
<td>0.7</td>
<td>1.2</td>
<td>0.8</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Change ($/€)</td>
<td>1.12</td>
<td>0.107</td>
<td>0.92</td>
<td>0.90</td>
<td>0.95</td>
<td>1.13</td>
<td>1.24</td>
<td>1.24</td>
<td>1.25</td>
</tr>
</tbody>
</table>

*Source: OMEL, UNESA and own elaboration.*

**Table 5**

<table>
<thead>
<tr>
<th>Characteristics of a combined cycle</th>
<th>CCGT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant construction time (years)</td>
<td>2</td>
</tr>
<tr>
<td>Plant life (years)</td>
<td>30</td>
</tr>
<tr>
<td>Plant size (MW)</td>
<td>400</td>
</tr>
<tr>
<td>O&amp;M cost (M$/year)</td>
<td>17</td>
</tr>
<tr>
<td>Fuel cost, 60 $/bbl (€/MWh)</td>
<td>39.7</td>
</tr>
<tr>
<td>Fuel cost, 40 $/bbl (€/MWh)</td>
<td>30.2</td>
</tr>
<tr>
<td>Capital cost (€/kW)</td>
<td>500</td>
</tr>
<tr>
<td>CO₂ emissions per GWh (t/GWh)</td>
<td>365</td>
</tr>
</tbody>
</table>

*Source: General Electric. Exchange rate: 1.2 $/€.*

**Table 6**

<table>
<thead>
<tr>
<th>CO₂ allowance per t (€/t CO₂)</th>
<th>Long-term market price</th>
<th>Full cost CCGT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>32–44</td>
<td>48.0</td>
</tr>
<tr>
<td>40 $/bbl</td>
<td>34–47</td>
<td>57.5</td>
</tr>
<tr>
<td>60 $/bbl</td>
<td>42–57</td>
<td>51.6</td>
</tr>
<tr>
<td>20</td>
<td>38–51</td>
<td>61.2</td>
</tr>
<tr>
<td>40 $/t CO₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 $/t CO₂</td>
<td>46–60</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Own elaboration. Exchange rate: 1.2 $/€ and discount rate: 7%.*
forecast for 2010, the network is not predicted to be saturated, which would give a practically identical price for both systems (Fig. 8) (Fernández, 2004).

From the results of the simulation model, Iberdrola would be the company which benefits the most from the MIBEL, given the greater production of its combined cycle power stations. Endesa, Unión Fenosa and Viesgo would also have the possibility to increase their production at their coal-power and combined cycle plants, although not to the same extent. However, HC Energía—which has a set of coal-power stations with low variable cost and located in general close to the coast—would barely be able to increase production given the intense level at which they are running at present, even at off-peak hours. EdP, on the other hand, would see its revenues fall due to the drop in the price of electricity and the reductions in the energy generated, as well as from the necessity to substitute part of its fuel–gas power stations with less contaminating plants and plants with lower variable costs.

With regard to the environment, the results show that the higher production by the most efficient coal groups and the combined cycles together with the reduction in production from oil–gas (especially in the Portuguese electricity system) will reduce SO2, CO2 and particle emissions by 1% and those of NOx by up to 3%. Likewise, the lower consumption of oil–gas will reduce the global cost of the generating system by up to 50 million euro per year (Fernández and Xiberta, 2004).

4.2. Calculation of market concentration

The development of effective competition in electricity generation depends, among other factors, on the market structure and the existence or not of barriers to entry and exit. For generating activity to function in a competitive manner there should be a sufficient number of firms of comparable size and low entry and exit barriers. Market power is defined as the capacity to modify the market price in your favour away from the competitive price (Stoft, 2002).

The Herfindahl–Hirschman index of concentration (HHI) is calculated from the sum of the squares of the market shares of the companies that participate in the market (Demsetz, 1973).

The maximum value of 10,000 corresponds to the case of monopoly and the index falls as industry concentration falls. The higher the HHI, the greater the deviation from perfect competition both in terms of price and loss of output. Similarly, the higher the HHI, the greater the share of total surplus which is captured by firms at the expense of consumers. The issue is not to limit the market share of a single agent but to limit his capacity to manipulate the market price in his favour (William and Kelly, 1981).

The electricity sector in Portugal and Spain is characterized by a high degree of concentration, with six vertically integrated firms constituted in holdings which control the lion’s share of the means of production, distribution networks and commercial outlets. In particular, these companies control over 70% of production and over 90% of distribution and sales.

The HHI for generating activity for Portugal is over 5000 and for Spain it is over 2200, though it has been falling significantly in recent years, especially in the case of Spain. The introduction of the MIBEL would have recovered significantly the HHI (Fig. 9).

In 2006, the HHI for the MIBEL was approximately 1800, a value which the US Justice Department defines as corresponding to a moderately concentrated market. To achieve a more competitive and efficient market, the regulatory authorities should not demand disinvestment by the dominating incumbents but should introduce measures which facilitate the entry of new competitors. This is what has been done in Spain in recent years, where the firms Enel, ESB, Electrabel and AES entered the market (Pérez-Arriaga, 2005).

5. Conclusions

The introduction of competition into the electricity market implies the installation of smaller and more strategically located power generating stations which reduce costs and construction time, the improvement of
transmission lines so that capacity is increased and energy losses are reduced, the development of the interconnection between regions, and market liberalization.

The MIBEL has been conceived as a supranational electricity market promoted by the governments of Spain and Portugal based on the following pillars:

- Extension of the interconnections between the countries according to a fixed timetable.
- Creation of a single market.
- Single economic management of the system. With this purpose, there is created a single market operator (OMI) with two pools, one in Lisbon for the term market and the other in Madrid for the daily and intra-daily markets.
- Separated technical management, although based on a set of harmonized operating procedures.

The entering into force of the MIBEL will give rise to the following mutual benefits:

- **Greater security of supply**, as there will be a greater number of generating installations available to cover unforeseen failures.
- **Greater efficiency** from the increased competition in the sector due to the rise in the number of operators.
- **Greater benefits for the consumers** of both countries provided that they have access to the market under conditions of equality, transparency and objectivity.

The noteworthy difficulties which will arise form the introduction of the MIBEL are:

- **The present acquisition contracts** between Portuguese producers and the REN give rise to an “a priori” market reference price which will have to be adjusted to the overall charge based on real market prices.
- **The asymmetry of distribution in the countries**. Whereas in Portugal there is a single distributor of electricity and gas, in Spain there are five and three, respectively.
- **Differences in rates between the countries**, as transmission and distribution costs, among others, are higher in Portugal. It will therefore be necessary to establish rates which properly reflect the costs of provision.
- **The limited capacity of the present interconnection**. This will determine congestions which will occur from the adoption of measures which efficiently reduce the risk of exercising market power or market price control while the system goes from the present 1200 MW of interconnection capacity to 1900 MW in the near future.


BOE, 2006a. Convenio internacional relativo a la constitución de un mercado ibérico de la energía eléctrica entre el Reino de España y la República Portuguesa, hecho en Santiago de Compostela el 1 de octubre de 2004. BOE 121, Lunes 22 de mayo de 2006a.

BOE, 2006b. Orden ITC/2129/2006, de 30 de junio, por la que se regula la contratación a plazo de energía eléctrica por los distribuidores en el segundo semestre de 2006. BOE 158, 4 julio de 2006.


CNE, 2006a. Informe sobre las ventas de energía del régimen especial en España.


References


