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# The development of market power in the Spanish power generation sector: Perspectives after market liberalization

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## HIGHLIGHTS

- Competition and regulation in the Spanish electricity market.
- The methodology applied in this study: ex-post structural and behavioral measures.
- Key dominant companies behaved more competitively in recent periods.
- Important structural and regulatory changes in the Spanish electricity market.

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## ABSTRACT

This paper provides a comprehensive analysis of the market power problem in the Spanish power generation sector and examines how and to which extent the market has developed in terms of market power concerns after the market liberalization reforms. The methodology applied in this study includes typical ex-post structural and behavioral measures employed to estimate potential for market power, namely: concentration ratios (CR) (for the largest and the three largest suppliers), the Herfindahl–Hirschman Index (HHI), Entropy, Pivotal Supply Index, the Residual Supply Index and Residual Demand Elasticity (RDE). The results are presented for the two largest Spanish generating companies (Endesa and Iberdrola) acting in the Iberian Electricity Market (MIBEL), and in the Spanish Day-ahead electricity market. The results show evidence that these companies have behaved much more competitively in recent periods than in the beginning of the market liberalization. In addition, the paper discusses important structural and regulatory changes through market liberalization processes in the Spanish Day-ahead electricity market.



## 1. Introduction

In the mid-1980s, many electricity systems around the world started liberalization reforms, with the objective of transforming their electricity sector from a vertically-integrated monopoly to a competitive market. The reforms have been characterized by the introduction of competition-based practices in electricity generation while the transmission and distribution networks remained as natural monopolies. The liberalization of the electricity sector in the European Union was launched in 1996 with the Directive 96/92/EC - "concerning common rules for the internal market in electricity". Later on, the approval of two substantive electricity directives (2003/54/EC and 2009/72/EC), significantly strengthened the general liberalization trends. Although approximately 20 years passed from the start of the liberalization reforms, there have been limited studies focusing on the effects of these reforms in the European countries. Pollitt (2012) discusses the period of energy privatization and liberalization within a wider historical context. He raises an important issue for liberalization indicating that energy liberalization has become globally widespread but uncertain efficiency gains and a lack of clearly noticeable direct benefits to consumers in many countries. According to Joskow (2008), electricity sector reforms in many European countries are either incomplete or moving forward slowly and facing considerable resistance. After market liberalization, member states have shown horizontal consolidation and vertical integration due to the slow pace of development of transparent wholesale market and the inefficient congestion management, resulting in only a few significant players, increasing market power concerns. According to Borenstein et al. (2002), no market design works well if there is not proper regulation to address the

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concerns over market power from dominant firms. As of today, the market power concerns in electricity markets are of particular interest to policymakers and legislators seeking to protect final consumers from the dominant behavior of producers. Both policymakers and legislators have been very concerned in assessing the competitiveness, the detection of pivotal suppliers, the identification of actual exertions of market power and application of mitigation measures. Like in many European countries, the potential for market power has also been a serious concern in the Spanish electricity market. Although the Spanish Energy Regulatory Office fulfils its obligation as required in the Directive 2003/54/EC (amended by 2009/72/EC) by submitting to the European Commission various reports, in which competition issues are partially discussed, some concerns still exist. In particular, no broad analysis in a longer time-frame is done. This paper aims to cover that gap by analyzing the evaluation of Spanish Electricity Market (SEM) and examining how and to which extent Spanish power generation sector has developed in terms of market power concerns after market liberalization reforms over the last 15 years. Furthermore, the paper also provides the reader with an overview of the outcomes of governmental policies on the mitigation of potential market power concerns in the Spanish market. The rest of paper is structured as follows: Section 2 provides literature review, Section 3 reviews the SEM, Section 4 studies methodology for the extent of competition in SEM using different indicators of market power, Section 5 provides results and Section 6 presents conclusions with some policy remarks on regulation and competition policy.

## 2. Literature review

As most literature confirms, market power is difficult to define explicitly. Following Stoft (2002), often cited in this context, market power is typically defined as “the ability to profitably alter prices away from competitive levels”. A firm usually has market power by virtue of controlling a large portion of the market. Then, it becomes a profit-maximizer on a downward-sloping residual demand. If the market consists of a few large generators, profit-maximization leads to oligopolistic behavior, setting the price above the marginal cost. The European Union proposes another definition for market power including the provision that if a generator, alone or jointly with others, has “the power to behave to an appreciable extent independently of competitors, customers and ultimately consumers”. In the view of the U.S Department of Justice (DOJ) and Federal Trade Commission (FTC), “market power is defined as the ability to withhold capacity or services, to foreclose input markets, or to raise rival firms' costs in order to increase prices to consumers on a sustained basis without related increases in cost or value” (Reitzes et al., 2007). As seen from above definitions of market power, there are a number of implications and distinctive approaches. However, high prices alone, often recognized as a symptom of market power, do not prove that such market power exists. The literature also identifies the primary methods to exercise market power (Stoft, 2002; Helman, 2006):

– Physical or quantity withholding, - when a generator deliberately reduces the output that could be biding into the market, resulting in an increase in the market price.
– Financial or economic withholding, - when a generator offers bidding in prices higher than the competitive level for the particular unit, leading to surplus transfer from consumers to producers.
– Transmission related strategies (usually arise in vertically integrated systems) - when a generator creates or aggravates transmission congestion in order to raise prices in a particular zone or node.

There are several empirical and theoretical models studied by Borenstein et al. (1999) Wolfram (1999) and Wolak (2000) showing how market power can be exercised in electricity generation. Early experiences in UK regarding the liberalization process verified that weak competition arises due to high concentration in the wholesale market, while more intense competition had taken place in less concentrated markets such as the Nordic Pool and Germany. Moreover, the liberalization process in some markets such as England and Wales has failed due to market power abuse (Newbery, 1995). Wolak (2000) argues that the two largest generating companies in the early England and Wales markets were dominant and they were able to put prices substantially above their marginal cost of generation. Borenstein et al. (2002) have also examined that market power played a very significant role in the California electricity crisis. A complete review of methods for detecting the potential for market power was examined by Twomey et al. (2005) where authors studied structural and behavioral indices, simulation models and transmission issues. Asgari and Monsef (2010) investigated the Iranian power sector with the application of structural index-based analysis indices as the concentration ratio, the Herfindahl–Hirschman Index (HHI), Residual Supply Index (RSI), Supply Marginal Assessment (SMA) and the Lerner Index. The indices were measured under two scenarios, one assuming the current situation and the other based on a probable future configuration of the generation sector. Kaminski (2012) examined how and to which extent consolidation in the Polish power generation sector has affected the potential for market power. The author applied similar typical ex-post structural and behavioral measures employed to estimate potential for market power. The analysis shows that there was a significant increase in the potential to exercise market power held by key power generation companies. There has been also a significant number of works, which utilize computational models to analyze market power issues in various electricity markets. Some achievements in market power studies applying mathematical models are presented in Table 1.

## 3. The Spanish power sector: an overview

Like other member states, following EU Directive 96/92/EC, the Spanish government introduced the Electricity Sector Act (ESA) 54/1997, aiming at introducing competition in the electricity sector. The Spanish liberalization was a distinctive model by permitting vertical integration between the generation and distribution, which had not been allowed in many other deregulation experiences. As a result, Spanish major electricity companies within the same corporate group play several roles, selling electricity as generators and buying it from the spot market as distributors. At present, the electricity generation market in Spain is dominated by Endesa (24%) and Iberdrola (21%), followed by Gas Natural Fenosa (15%), EDP - Hidrocantábrico (6%) and E.ON (3%) (See Table 2).

Fig. 1 shows evaluation of spot prices in Spain between 1998 and 2013 years. Spot prices in Spain showed signs of decline in 2013 compared to the previous year. On the supply side, the rise in the share of wind power generation and nuclear energy technology with low marginal generation costs pushed the electricity mix towards less costly forms of power generation. On the demand side, economic downturn also resulted in decreasing industrial and residential demand for energy, providing for a support for the downward price trend of the wholesale market in Spain.

Market structure of Spanish system consists of a centralized section that includes a spot market (a daily and an intra-daily market) and market for ancillary services, and a non-centralized section to carry out bilateral transactions. The management of Day-ahead market is the responsibility of the market operator

**Table 1**
Summary of literature.

| Author | Computational models | Brief description (Market application) |
|---|---|---|
| Green and Newbery (1992) | The Supply Function Equilibrium (SFE) | The paper analyses the scope for the exercise of market power in the British Electricity Spot Market |
| Borenstein et al. (1995) | Cournot oligopoly equilibrium | The study describes approaches to analyzing the prospects and impacts of the market power abuse in various product markets in the context of Californian Electricity marketplace. |
| Borenstein and Bushnell (1999) | Cournot oligopoly equilibrium | The paper analyses the potential for market power during high demand hours under the structure of generation ownership in northern California. |
| Day et al. (2002) | Conjectured supply function (CSF) | The paper shows the relationship of the CSF model to other approaches. An application is made to the England–Wales system, demonstrating the advantages of the CSF approach relative to Cournot models |
| Yang et al. (2002) | Cournot oligopoly equilibrium | Authors develop the spatial equilibrium Cournot model to the US coal market and compare its performance to that of the original Takayama–Judge model |
| Song et al. (2004) | A conjectural variation based learning method | The dynamic conjectural variation based learning method is proposed in the study for generation firms' strategic bidding in an oligopolistic spot market. |
| Baldick et al. (2004) | the Supply Function Equilibrium (SFE) | The choice of SFE over Cournot equilibrium and the choice of affine marginal costs is studied in the paper |
| Hobbs and Rijkers (2004) | The conjectured transmission price response model | Complementarity-based models of strategic generator behavior on transmission networks is applied with the application of the model to northwestern Europe |
| Tanaka (2009) | Cournot oligopoly equilibrium | Authors simulate the Japanese wholesale electricity market as a transmission-constrained Cournot market using a linear complementarity approach. |
| Ciarreta and Espinosa (2010) | the Supply Function Equilibrium (SFE) | Authors represent strategic interaction in the electricity market through a supply function equilibrium model |
| Kaminski (2012) | The game theoretic model of the power generation market (the PolMark model) | The paper presents an analysis of the market power in the Polish power generation sector. |
| Lagarto et al. (2014) | A conjectural variations model | The paper proposes a conjectural variations model to study the competitive behavior of generating firms acting in the Iberian electricity market |

**Table 2**
Installed capacity shares of three largest generator of Spain in 2013. Sources: REE (1998-2013), CNE (1998-2013), ERSE (1998-2013), CNMC (2011-2013) and OMIE (1998–2013).

| | Endesa (MW) | Iberdrola (MW) | Gas natural – Fenosa (MW) |
|---|---|---|---|
| **Thermal Plants** | 13,662 | 7162 | 9242 |
| **Nuclear** | 3687 | 3410 | 604 |
| **Large Hydro Units** | 4754 | 8807 | 1914 |
| **Renewables** | – | 6109 | 968 |
| **Total** | 22,103 | 25,448 | 12,728 |

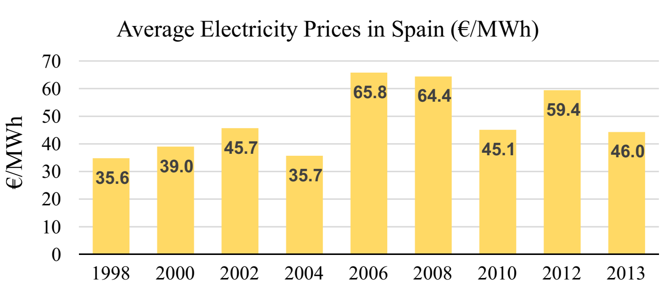


**Fig. 1.** Evaluation of spot prices in Spain, 1998–2013.
Sources: Own elaboration based on date adopted from REE (1998-2013), CNE (1998-2013), ERSE (1998-2013), CNMC (2011-2013) and OMIE (1998–2013).

"Operador del Mercado Ibérico de la Energía-Polo Español, S.A" (OMIE), which is in charge of the economic management and bidding process. OMIE collaborates closely with the system operator to determine the electricity transactions to take place and the commitment of the generators needed to accomplish the economic transactions. The technical management of the electric system is controlled by the system operator, Red Eléctrica de España, S.A., which is responsible for the technical management of the Spanish system, developing the transmission system and the management of international electricity exchanges. Fig. 2 represents SMP as a representative hour at 6 a.m. for 8th of April,

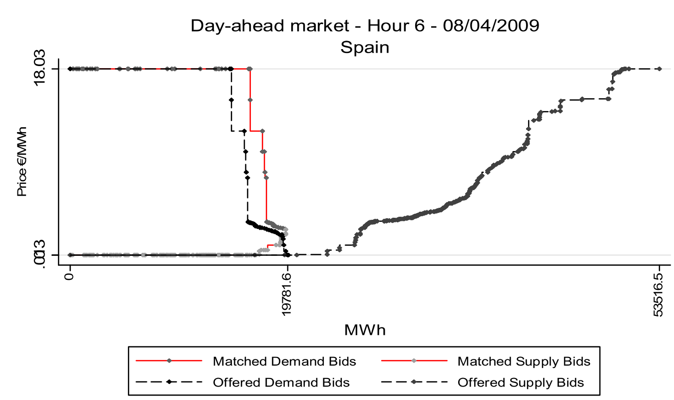


**Fig. 2.** System Marginal Price at the Day-ahead market (6 a.m. for 8th of April, 2009).

2009 using data adopted from OMIE.

In 1998, the integrated Portuguese–Spanish market, generally known as Iberian Electricity Market (MIBEL), was founded with the aim of increasing cooperation between the two countries. The joint market was implemented in July 1st, 2007. The establishment of MIBEL provides a single operator for the Iberian market with two pools: the Portuguese for the term market, and the Spanish for the spot market. In the absence of transmission congestions, a single price for the whole peninsula is obtained from the intersection of supply and demand for Day-ahead market. Fig. 3 presents market results of the Day-ahead market for the 8th of April, 2009 as a representative day.

### 3.1. Technology mix

According to norms established by Act 54/1997, generators in the market can offer their product either under the "Ordinary Regime" (OR), which includes thermal plants and large hydroelectric units, or under the "Special Regime" (SR), which includes generating plants with an installed capacity of 50 MW or less that use cogeneration or any renewable energy source as their primary

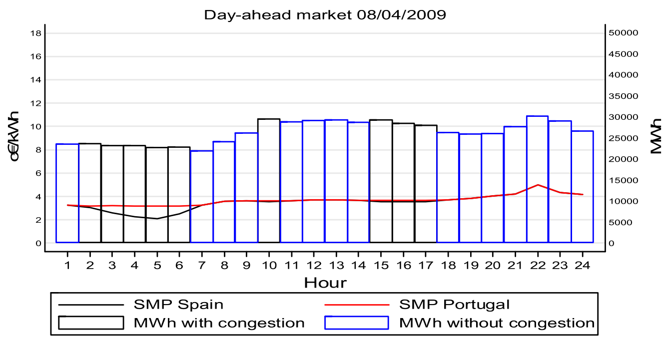


**Fig. 3.** Market results at the Day-ahead market (8th of April, 2009).

energy.[1] SR has dispatch priority in the grid at regulated tariffs that vary depending on the type of generation technology. As of 2013, SR contributed 40% (mainly wind and small hydro sources) and OR with the remaining 60% (12% large hydro, 28% thermal plants and 20% from nuclear) of total energy generation in Spain (see Table 3). Installed capacity and power generation per technology between 1998 and 2013 are shown in Tables 3 and 4, including the Balearic and Canary islands.

As shown in Table 3, installed capacity increased significantly, almost 230% between 1998 and 2013, while the trend in electricity demand has not changed significantly, even decreased at some points. The growth in installed capacity comes mainly from wind energy and combined-cycle plants. The share of renewable generation has been increasing over time. In particular, the share of thermal plants (gas-fired generation plants) saw the biggest reduction in 2013, with annual operations reaching to 2000 h a year, compared to 5000–6000 h a year that was planned when the gas-fired plants were constructed.

Table 4 reports generation, consumption and trade balance by type of technology.

Tables 3 and 4 show the excess in generating capacity together with a depressed demand in the Spanish electricity market. Continuing a decreasing trend from 2008, electricity demand felt in 2013 by 2.3% compared to 2012. In contrary, generation capacity reached over 100 GW, with peak demand at less than 40 GW.

**Table 3**
Installed capacity by technology (MW) in Spain. Source: own construction based on data adopted from REE (1998-2013), CNE (1998-2013), ERSE (1998-2013), CNMC (2011-2013) and OMIE (1998–2013).

| Year | Special regime | Ordinary regime | | | Total | Peak demand | Capacity margin (%) |
|---|---|---|---|---|---|---|---|
| | | Large hydro | Thermal | Nuclear | | | |
| 1998 | 5400 | 13,420 | 20,000 | 7700 | **46,520** | 29,484 | 37.0 |
| 2000 | 5500 | 15,400 | 19,500 | 7700 | **48,100** | 33,236 | 31.0 |
| 2002 | 13,205 | 17,000 | 20,000 | 7700 | **57,905** | 37,212 | 36.0 |
| 2004 | 19,500 | 17,000 | 21,000 | 7710 | **65,210** | 37,724 | 42.0 |
| 2006 | 21,307 | 16,658 | 37,358 | 7716 | **83,039** | 42,153 | 50.0 |
| 2008 | 28,128 | 16,658 | 37,444 | 7716 | **89,944** | 42,961 | 52.0 |
| 2010 | 34,230 | 17,561 | 39,475 | 7777 | **99,043** | 44,122 | 55.0 |
| 2011 | 35,754 | 17,537 | 39,509 | 7777 | **100,577** | 44,107 | 56.0 |
| 2012 | 38,507 | 17,761 | 38,403 | 7853 | **102,524** | 43,010 | 59.0 |
| 2013 | 40,171 | 17,766 | 42,345 | 7866 | **108,148** | 39,960 | 64.0 |

Special regime includes mainly wind and solar power. Thermal Plants include CCGT (Combined Cycle) Fuel+gas (conventional) and Coal.

## 4. Methodology

The issue of market power in electricity markets has been the subject of extensive research. The literature provides several methods to assess the potential of market power. These methods vary from simplified to sophisticated ones. The methods applied in this study include both typical ex-post structural indices and alternatives measures aimed to obtain insights in the potential to exercise market power in the Spanish Day-ahead electricity market.

### 4.1. Structural indices

Structural indices have been the first indices to be applied to electricity markets. The aim of these subsections is to make an ex-post analysis of these indices considering the period after market liberalization between 1998 and 2013. Structural indices include Concentration Ratios, the Herfindahl–Hirschman Index, entropy coefficient and number of producers with at least a 5% market share (NR5).

#### 4.1.1. Concentration ratio for the biggest and the three biggest producers

Concentration ratio (CR) is considered to be a basic measure of potential for market power in many electricity markets.[2] CR is used as an indicator of the relative size of the largest firms in relation to the industry as a whole (Twomey et al., 2005; Asgari and Monsef, 2010). In this study CR was calculated for the largest and three largest generation firms of Spain: CR1 and CR3 – total market share of top 1 and top 3 market participants. In accordance with EU practices (Kaminski, 2012), the value of CR1 may be interpreted as follows: (1) the competition level is presumed if CR1 is less than 20%; (2) a value of CR1 > 40% may suggest a dominant position on the market; (3) a value of CR1 > 50% is almost unanimously interpreted as an indication of a dominant position on market. The values of CR3 may be interpreted as follows: (1) CR3 almost 0% - perfect competition; (2) 40% < CR3 < 70% medium concentrated market; (3) 70% < CR3 < 100% highly concentrated market.

#### 4.1.2. Number of producers with at least a 5% market share (NR5)

The national competition authorities examine the existence of a dominant position based on the market share as well as based on the assessment of other influences such as number of generators/market participants with a potential market share. Reporting number of producers with a market share greater than or equal to 5% in the generation and supply markets could be another measure as an extension of the previous indicator. This indicator is often used by the EC in its annually published reports for the internal gas and electricity markets (COM, 2008; COM, 2009; and COM, 2010). This refers that more producers with a market share of at least 5% of the total, the more competitive the market and hence, the lower the potential for market power.

#### 4.1.3. Herfindahl–Hirschman Index (HHI)

The HHI is the most prominent measure of concentration and it is extensively used for assessing structural features and examining competition levels in the power market analyses. HHI is calculated as the sum of the squared market shares for each firm competing in a given market (Jun et al., 2009). According to Horizontal

[1] The Spanish energy regulator is in charge of operations under the SR and the legal framework is based on *Real Decreto 661/2007* that maintains the basic principles of previous legislation. Ciarreta et al. (2014) analyzes the implementation mechanisms of renewable energy sources under SR and discuss the effectiveness of these mechanisms adopted and recommendations on market design.

[2] The indicator Concentration ratio (CR) was also used in the USA until 1982, when the Herfindahl- Hirschman Index (HHI) was introduced instead of CR. The Spanish antitrust authority frequently reports both in the evaluation of merger cases.

**Table 4**
Generation by technology and consumption (TW h) in Spain. Source: own construction based on data adopted from REE (1998-2013), CNE (1998-2013), ERSE (1998-2013), CNMC (1998-2013) and OMIE (1998–2013).

| Year | Special regime | Ordinary regime | | | Total | Import/Export | Consumption |
|---|---|---|---|---|---|---|---|
| | | Large hydro | Thermal | Nuclear | | | |
| 1998 | 19,615 | 33,992 | 65,848 | 59,003 | **178,458** | +3402 | 172,963 |
| 2000 | 26,526 | 27,842 | 86,623 | 62,206 | **203,197** | +4441 | 205,630 |
| 2002 | 33,595 | 22,439 | 100,558 | 63,004 | **219,596** | +5330 | 209,640 |
| 2004 | 43,682 | 29,750 | 112,976 | 63,428 | **249,836** | −3208 | 233,505 |
| 2006 | 50,755 | 24,761 | 150,702 | 60,184 | **286,402** | −3303 | 268,027 |
| 2008 | 67,343 | 21,171 | 156,589 | 58,756 | **303,863** | −11,221 | 279,868 |
| 2010 | 91,866 | 38,653 | 103,626 | 61,990 | **296,135** | −8333 | 275,772 |
| 2011 | 93,443 | 27,650 | 108,992 | 57,670 | **287,775** | − 6105 | 270,362 |
| 2012 | 103,206 | 19,039 | 109,032 | 61,238 | **292,515** | −11430 | 267,372 |
| 2013 | 111,679 | 34,225 | 78,348 | 56,378 | **280,630** | −6958 | 260,870 |

Includes international exchanges, consumption in generation and consumption in pumping.
Special Regime includes mainly wind and solar power. Thermal Plants include CCGT (Combined Cycle) Fuel+gas (conventional) and Coal.

Merger Guidelines by the US Department of Justice and the Federal Energy Regulatory Commission (FERC, 1992, 1996, 2004), an HHI below 1000 indicates that the market is highly competitive; values between 1000 and 1800 indicate moderate concentration, while HHI above 1800 suggest the market is characterized by high concentration. These standards are also applied by the European Commission (SEC (2008)460) (EC, 2006).

#### 4.1.4. Entropy coefficient (EC)

The EC is another measure to assess market concentration. EC is calculated as the sum of market share weighted by the logarithm of the inverse of market share (David and Wen, 2001). EC was applied in empirical studies of industrial concentration for the first time by Theil (1967), but it has also been employed to examine market power in electricity markets (Asgari and Monsef, 2010; Rahimi and Sheffrin, 2003). Asgari and Monsef (2010) first proposed an entropy coefficient above 3.32 as a rough indication of a non-concentrated market.

### 4.2. Alternative measures

Concentration measures are considered inappropriate to assess the level of market power in the electricity industry because they ignore key factors such as demand elasticity, transmission constraints, forward contracts and the inter-temporal variations in the exercise of market power. Rahimi and Sheffrin (2003) showed that in electricity markets, even generating firms with a smaller net supplier position can exercise market power. For instance, within a specific hour when the demand level is close to capacity, a generator can become 'pivotal' and exercise market power even been relatively small compared to the market. We employed some of alternatives measures, including Pivotal Supply Index (PSI) and Residual Supply Index (RSI), aiming to incorporate demand conditions.

Among the alternative measures, the Lerner Index is also widely used as a measure of the unilateral market power in electricity markets. The Lerner Index reflects the relative mark-up of a generator and it is defined as a ratio of the difference between the market price and the marginal cost of a generator to the market price (Chang, 2007; Sandsmark and Tennbakk, 2010; Shukla and Thampy, 2011). However, since there is lack of good quality and detailed data on marginal cost of individual power producers in the Spanish market, as a solution, we linked the market power indices of Lerner Index and Residual Demand Elasticity in the study. As it is well known, the first order condition of a generator maximizing profit unilaterally shows that the Lerner index equals the inverse elasticity of the residual demand curve facing the generator. Following Wolak (2003) approach, we estimated the Lerner index empirically based on the Residual Demand Elasticity which is computed as arc elasticity as discussed in Section 4.2.3.

The alternative measures comprised of competitive behavior of two largest generating firms in the SEM: Endesa (EN) and Iberdrola (IB) under two conditions: (1) if there was congestion and as a result, there is a separate system marginal price for each zone; (2) if there was no congestion and as a result there is a single system marginal price for the whole Iberian market.

#### 4.2.1. Pivotal Supply Index

Pivotal Supply Index (PSI) studies whether a given generator is pivotal at a specific hour in meeting positive residual demand at that hour. In particular, it examines whether the capacity of a generator is larger than the total surplus supply (the difference between total supply and demand) in the wholesale market. Using an approach developed by Bushnell et al. (1999), we built a binary indicator for a generating firm at a point in time which is set equal to one if it is pivotal, and zero otherwise. Federal Energy Regulatory Commission (FERC, 1992, 1996, 2004) adopted criteria for this measure: if the value of the PSI is one for more than 20% of the time, then this is indicative of a pivotal supplier.

#### 4.2.2. Residual Supply Index

Residual Supply Index (RSI) is similar to PSI but it is based on a continuous level rather than a binary level. The RSI for a producer measures the percentage of supply capacity that would remain in the market, relative to demand in a given specific hour. This metric was developed by the California Independent System Operator (CAISO) (Sheffrin, 2001). According to the CAISO, for a market to be fairly competitive, RSI should be significantly above 1, but usually at 1.2 or more (Sheffrin, 2002). The methodology of calculation and interpretation of RSI is also well described in Twomey et al. (2005).

#### 4.2.3. Residual Demand Elasticity

Residual demand elasticity is a more sophisticated measure of market power that is derived from testing residual demand curve faced by a firm (Baker and Bresnahan, 1992). If a generating firm is pivotal then it faces a highly inelastic residual demand curve (Twomey et al., 2005). Upon this concept, in electricity markets, Wolak (2000) used an explanatory model for producers' behavior in the electricity sector, which allows to measure market power without calculation of marginal cost. This will be based on the relationship between the elasticity of the residual demand on the SMP and the price-cost margin. Wolak (2003) measured the market power in Californian wholesale electricity market by using the five largest electricity suppliers during the period 1998–2000.

Following the Wolak (2003) approach, in this section we estimate the Lerner index empirically based on the Residual Demand Elasticity, which is computed as arc elasticity. We study the elasticity of residual demand on the actual behavior of firms with highest market share at the Spanish electricity market.

## 5. Results

A quantitative analysis of data from the Day-ahead market was employed for the period between 2006 and 2013. Table 5 summarizes the results from the structural indices.

### 5.1. Concentration Ratios (CR)

An analysis of the CR for the largest generating firm shows that as of 1998, Endesa alone controlled approximately 60% of market share in installed capacity and 48% of total production in the SEM (See Table 5). However, from 2008 and on, Iberdrola seized the position of the largest shares in the market, by increasing its installed capacity market thanks to large investments in renewable energy plants. Also, the other large participant, Endesa, sold some of its assets to E.ON in 2008 and new operators entered the market through largely investments in renewables and combined cycle plants.

Since the Electricity Law was approved in 1998, the entrance of new suppliers has taken place either through investment in combined cycle plants (Gas Natural, AES, TXU and Electrabel) or through the purchase of existing companies (ENEL and EDP). Concentration ratio for the three largest power producers (CR3) presents that electricity market was highly concentrated with approximately 86% of total installed capacity and 80% of total energy production shares between 1998 and 2004 years. From 2005 and on, we see a large increase in the number of players in the market due to creation of the Iberian Electricity Market with Portugal and investment boom in renewable energy plants, improved market concentration indicators largely. Concentration Ratio for three largest firms reached a level that was under critical level in 2013.

**Table 5**
Calculation results for structural indices in Spain, 1998–2013. Source: own calculations based on data adopted from REE (1998-2013), CNE (1998-2013) ERSE (1998-2013), CNMC (2011-2013) and OMIE (1998–2013).

| | 1998 | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|
| ***Market share of the biggest producer (CR1)*** | | | | | | | | | |
| **Installed Capacity** | 59.2 | 43.2 | 43.0 | 37.0 | 29.9 | 29.4 | 31.6 | 29.1 | 24.0 |
| **Electricity Production** | 48.0 | 42.4 | 39.0 | 43.0 | 25.9 | 27.6 | 24.3 | 23.8 | 23.1 |
| ***Market share of three biggest producers (CR3)*** | | | | | | | | | |
| **Installed Capacity** | 92.9 | 83.0 | 85.0 | 85.0 | 67.4 | 66.6 | 81.2 | 75.6 | 56.2 |
| **Electricity production** | 88.0 | 76.1 | 89.0 | 82.0 | 60.0 | 63.9 | 69.1 | 58.3 | 55.8 |
| ***Number of companies with at least 5% market share (NR5)*** | | | | | | | | | |
| **Installed Capacity** | 3 | 4 | 4 | 4 | 5 | 5 | 4 | 5 | 5 |
| **Electricity production** | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 6 | 6 |
| ***Herfindahl–Hirschman Index (HHI)*** | | | | | | | | | |
| **Installed Capacity** | 4200 | 3050 | 2969 | 2900 | 1843 | 1805 | 2331 | 1650 | 1246 |
| **Electricity production** | 3244 | 2772 | 2810 | 2920 | 1610 | 1789 | 1262 | 1329 | 1191 |
| ***Entropy coefficient (EC)*** | | | | | | | | | |
| **Installed Capacity** | 1.12 | 1.33 | 1.34 | 1.47 | 1.67 | 2.00 | 1.68 | 1.78 | 3.10 |
| **Electricity production** | 1.29 | 1.41 | 1.30 | 1.13 | 1.46 | 2.36 | 2.52 | 2.05 | 3.20 |

### 5.2. Number of producers with at least a 5% market share (NR5)

Since the liberalization of Spanish market, the number of generators with a market share of at least 5% has changed overtime. As of 1998, the ownership was in the handful of suppliers, in terms of installed capacity -only three suppliers (Endesa, Iberdrola and Union Fenosa) and in terms of generation - four main suppliers (Endesa, Iberdrola, Union Fenosa and HidroCantabrico), having a market share of at least 5% each. The merger and acquisition transactions among the major suppliers of the market in the 2000s have been a major cause of fluctuations of this indicator. For instance, a merger between the second largest supplier of gas- Gas Natural and the third largest electricity generator- Union Fenosa reduced the number of suppliers and on the contrary, a takeover of formerly ENEL-owned Viesgo by E.ON increased the number of suppliers with a market share of at least 5%. As of 2013, the number of suppliers in the market was five in terms of installed capacity and six in terms of electricity production.

An analysis of competition by structural indices for the year 2013 shows that in comparison to Spanish market, most European markets are highly concentrated (see Table 6). Especially the Belgium, French, Portuguese and Greece markets were characterized as highly concentrated because in these markets the number of generation companies with a market share of at least 5% is low. In contrary, power markets in the United Kingdom and in Norway exhibit large number of generating companies.

### 5.3. Herfindahl –Hirschman Index (HHI)

As mentioned in the methodology, HHI is the metric that more clearly points out the potential for the competitiveness of a given market structure. The value of HHI calculated for the generation and installed capacity in the Spanish market was under the critical values of 1800 in 2013 (See Table 5). In comparison to HHI values obtained in early 2000s, the evaluation of market structure in terms of concentration has developed significantly. The difference in values of HHI for installed capacity and generation is because the installed capacity is not always transferred into market share

**Table 6**
Structural indices in the other European markets in 2013. Source: Eurelectric, 2015.

| | Generation | | Installed capacity | | HHI[a] > 1800 | HHI 1000–1800 | HHI < 1000 |
|---|---|---|---|---|---|---|---|
| | NR5 | Market shares | NR5 | Market shares (%) | | | |
| **Belgium** | 3 | 95% | 4 | 90 | X | | |
| **Czech Republic** | 1 | 60% | 3 | 90 | X | | |
| **Germany** | 4 | 60% | 3 | 41 | | X | |
| **Greece** | 2 | 83% | 1 | 92 | X | | |
| **France** | 2 | 86% | 2 | 97 | X | | |
| **Italy** | 4 | 50% | 2 | 45 | | X | |
| **Netherland** | 4 | 55% | 4 | 70 | | X | |
| **Portugal** | 2 | 54% | 3 | 91 | X | | |
| **United Kingdom** | 9 | – | 6 | 100 | | | X |
| **Norway** | 5 | 60% | 4 | 50 | | | X |

[a] HHI adopted from average values of generation and installed capacity.

since it depends on the availability of renewable power stations and the dominance of hydraulic power. In comparison with other European countries (SEC (2010)251 final), HHI values for Spain enrolled at the group of moderately concentrated countries where there are Germany, Italy and Netherlands (see Table 6).

### 5.4. Entropy coefficient

Following Asgari and Monsef (2010) who suggested a value of 3.32 as a rough indication of a market that is not concentrated, the power generation sector in Spain remained below this threshold until 2013. Although, an upward trend has been observed in the levels of the entropy coefficient, the level of approximately 3.0 confirms a market concentration in the Spanish power generation sector (Table 5).

### 5.5. Pivotal Supply Index (PSI)

Historically, Endesa and Iberdrola have been considered pivotal generating firms in the market as their capacity have been large enough to provide the additional supply needed on the market in order to meet the demand, especially at times of peak demand. This means that the combined supply of the rest of the generators were suspected insufficient to satisfy demand and the pivotal firms can increase their prices in response to demand, generally without fear of losing share in the market.

Table 7(a) reports PSIs under the market with SR and OR and Table 7(b) reports PSIs under market with only OR.

The results for PSI show that Endesa and Iberdrola were the dominant firms in the market until 2007. However, as years passed, this trend has been steadily declining up to a point where generators can be considered pivotal suppliers only during few peak demand hours where there exists a tighter balance between demand and available supply. Moreover, available capacity in the Spanish pool is more difficult to define when RES generation accounts for a significant amount in the Spanish market. The problem arises from intermittence of the generation, as a result, the need to maintain an operating thermal capacity. In this case, total generation is used in the complex bids as a proxy for available capacity. For this particular situation, we intended to define the number of hours in which generators are pivotal under the market with only OR (thermal capacity) and the entire market including OR and SR (renewable capacity). This case is especially relevant for Iberdrola that it has 25% of its shares in renewable energy capacities.

Note that considering only the market without renewable energy results do not change much. This is because during the period there has been entry at large scale of combined cycle plants from other generators.

### 5.6. Residual Supply Index

An analysis of the distribution of RSI calculated for the largest generating firm in SEM shows that RSI experienced significant increase in the 1998–2013 period. Until 2005, although the shape of the RSI curve is steeper, the values of RSI fluctuated at the level of 0.6–1.1 revealing restricted margin between its capacity and the peak load (See Fig. 4). The largest supplier of the Spanish market was the one that has sufficient market power to manipulate market prices for profit in market. From 2005 and on, the RSI curve shows a significant upward shift due to entrance of new suppliers through investments in combined cycle plants and RES and consolidations of existing producers in the market. The values of RSI at the level of 1.5–2.2 in 2005–2013 reflect significantly above the critical values of 1.2 defined by CAISO.

**Table 7(a)**
Pivotal Supplier Index SR+OR.

| | | 2006 | 2008 | 2010 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| **ES** | EN | 0.083 | 0 | 0 | 0 | 0 |
| | IB | 0.527 | 0.038 | 0.002 | 0 | 0 |
| **MI** | EN | – | 0 | 0 | 0 | 0 |
| | IB | – | 0.178 | 0 | 0 | 0 |

**Table 7(b)**
Pivotal Supplier Index OR.

| | | 2006 | 2008 | 2010 | 2012 | **2013** |
|---|---|---|---|---|---|---|
| **ES** | EN | 0.158 | 0 | 0.002 | 0.011 | **0.008** |
| | IB | 0.219 | 0.044 | 0.011 | 0.014 | **0.012** |
| **MI** | EN | – | 0 | 0 | 0.002 | **0.001** |
| | IB | – | 0.141 | 0 | 0.001 | **0.001** |

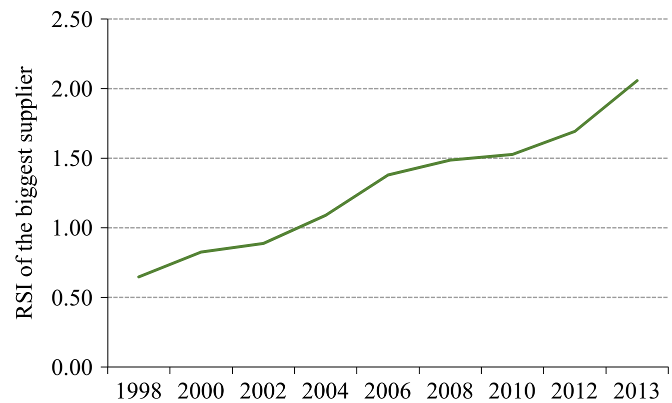


**Fig. 4.** RSI curve of the largest supplier in SEM, 1998–2013.

### 5.7. Residual Demand Arc-Elasticities

Table 8 summarizes the values of inverse elasticity of residual demands for Iberdrola and Endesa. The results show very low, even close to zero, inverse arc-elasticities for Iberdrola (ES) and Endesa (ES) from 2006 and on. The results of RDE also presents that no generator can be considered a pivotal supplier in Spanish Day-ahead market in 2013.

## 6. Conclusion and policy implications

The overall results of the analysis of structural indices estimated for the Spanish power generation sector in terms of electricity production and installed capacity (in parenthesis) are as follows:

- The concentration ratio of the largest supplier decreased from 48% (59.2%) in 1998 to 23.1% (24%) in 2013.
- The concentration ratio of the three largest suppliers decreased from 88% (92.9%) in 1998 to 55.2% (56.0%) in 2013.
- The number of companies with a 5% market share was 4 in the case of electricity production in 1998 and increased to 6 in 2013.

**Table 8**
Residual Demand Arc-Elasticities.

| | | 2005 | 2006 | 2008 | 2010 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|
| **ES** | EN | 0.342 | 0.012 | 0.010 | 0.009 | 0.018 | 0.036 |
| | IB | 0.261 | 0.014 | 0.055 | 0.018 | 0.025 | 0.058 |
| **MI** | EN | – | – | 0.009 | 0.006 | 0.015 | 0.023 |
| | IB | – | – | 0.020 | 0.011 | 0.016 | 0.041 |

In the case of installed capacity the number was 3 in 1998 and increased to 5 in 2013.
– The HHI decreased from 3244 (4200) in 1998 to 1191 (1246) in 2013.
– The entropy increased from 1.29 (1.12) in 1998 to 3.20 (3.10) in 2013.

As far as the alternative measures for the two major Spanish generating firms (Endesa and Iberdrola) acting in the Spanish pool are concerned as following:

– PSIs under the market with SR and OR together in the case of Endesa decreased from 8.3% in 2006 to 0% in 2013 and in case of Iberdrola, occurred a large decrease from 52.7% in 2006 to 0.0% in 2013.
– PSIs under the market with only OR in the case of Endesa decreased from 15.8% in 2006 to 0.8% in 2013, and in case of Iberdrola, dropped from 21.9% in 2006 to 1.2% in 2013.
– PSIs for the two major Spanish generating firms (Endesa and Iberdrola) acting in the MIBEL is almost zero for all periods
– RSI for largest generating firm increased from 0.6 in 1998 to 2.2 in 2013.
– RDEs in the case of Endesa decreased from 0.342 in 2006 to 0.036 in 2013 and in case of Iberdrola, a drop from 0.261 in 2006 to 0.058 in 2013.

In general, our findings show that in terms of market power concerns, SEM has improved after market liberalization reforms. Since then, the market has experienced important structural and regulatory changes through market liberalization processes. In order to address the prevention of a dominant position abusing in the market, the Spanish government has implemented a series of interventions to mitigate it and to provide better performance of the industry in general. These interventions are classified into two major methods: structural methods and regulatory methods. This section highlights the key details of both methods and in addition provides some insights on key competition incentives in the market.

### 6.1. Structural methods

Structural methods include privatization-the transition of a public company into a private one, and conditions for mergers and acquisitions; the reduction of entry barriers to increase a new capacity; and the integration with other markets.

– Takeovers and the evolution of the SEM

Spain's structural model based on combining mix of state-owned and private utilities began to change since early 1990s. The main aspects of the control of mergers established by the Spanish legislation include certain limitations that allow a generator to possess a certain market share above a predetermined limit and a notification procedure to direct the market operations. The role of takeovers over the evolution of the Spanish electricity sector can be divided into two major periods: the processes at the eve of the market liberalization and after market liberalization. Table 9 lists key takeover and merger cases took place in Spain during these periods.

Historically, Endesa – state owned company- and Iberdrola have been considered to be the largest electric utilities in Spain, what is more they have also been very active in foreign electricity markets, primarily in Latin America. Endesa was initially only engaged in generation. Private companies were required to buy all of the electricity that Endesa generated. Endesa and Iberduero (the predecessor of Iberdrola) embarked on an aggressive policy of acquisitions and takeovers of their small competitors at the eve of the market liberalization. Prior to the market liberalization, Iberduero merged with Hidrola that, in turn, led to the creation of Iberdrola in 1992. As part of plans to liberalize the electricity industry, the Spanish government decided to privatize Endesa. The large - scale privatization was expected to divide the company into a number of smaller competitors in order to promote competition in the future liberalized market. However, in addition to its dominant position, Endesa was also allowed to take control of other key generation companies; Sevillana and Fecsa, which they had 10% and 9% of the total capacity respectively in the market. As a result, contrary to the earlier expectations, Endesa and Iberdrola ended up strengthening their positions in the market with a total market share of almost 80% prior to liberalization. After market liberalization, Spanish electricity companies have been unequally exposed to takeovers in the wake of the EU-driven liberalization process. The new legislation requirement was that any acquisition over 10% of share capital in an entity in Spain would be subject to approval by market regulator. Since early 2000s, several takeover and merger attempts have been vetoed by the Spanish Government (See Table 8) mostly due to perceived ‘risks’ in relation to the regulated activities and ‘the general interests’.

**Table 9**
Mergers and takeovers in the SEM. Source: CNMC (1998-2013).

| Generators engaged | Operation type | Outcome | Year |
|---|---|---|---|
| Iberduero/Hidrola | Merger | Acceptance | 1992 |
| Endesa/Fesca, Sevillana | Takeover | Acceptance | 1996 |
| Endesa | Public offer for sale | Acceptance | 1998 |
| Union Fenosa/Hidrocantabrico | Takeover | Veto | 2000 |
| Endesa/Iberdrola | Merger | Veto | 2000 |
| Asset Sales of Endesa to ENEL/Viesgo | Acquisition | Acceptance | 2001 |
| Gas Natural/Iberdrola | Takeover | Veto | 2003 |
| EDP/Hidrocantabrico | Acquisition | Acceptance | 2004 |
| ACS/Union Fenosa | Acquisition | Acceptance | 2005 |
| E.ON/Endesa | 10% Acquisition | Acceptance | 2006 |
| Endesa/Enel | Takeover | Veto | 2009 |
| Gas Natural/Union Fenosa | Takeover | Acceptance | 2009 |

The lessons from takeovers that did take place in the SEM show that merger control and merger remedies have not been applied more effectively to improve the competitive structure of the market and increase competition. The merger policy in Spain has been politically divisive. In negotiating the conditions, the protection of the public interests (in particular the maintenance of sector policy objectives, special regard been had for strategic assets) through supporting the position of Endesa as a national champion energy player has been priority rather than competition in the market. It was concerned that competition might weaken the security of its energy supplies.

– Reduction of entry barriers: entrance of renewables and combined cycle gas plants

The studies in the literature show that in concentrated markets, generators have substantial capacity to raise prices above marginal cost. A fundamental question is how to provide sufficient capacity investment in the sector where the investment growth period is long and the existence of a reserve margin to ensure the supply is crucial.

Following market opening in the late 1990s, Spain experienced a strong growth in new capacity, mostly driven by combined-cycle gas turbines and renewable capacity while electricity demand has not exhibited big changes. As can be seen from Fig. 5, between 1998 and 2013, total installed electricity capacity soared by 230%, which was very much from the capacity growth in EU average of 20%. Until first half of 2000s, this trend was consistent with past

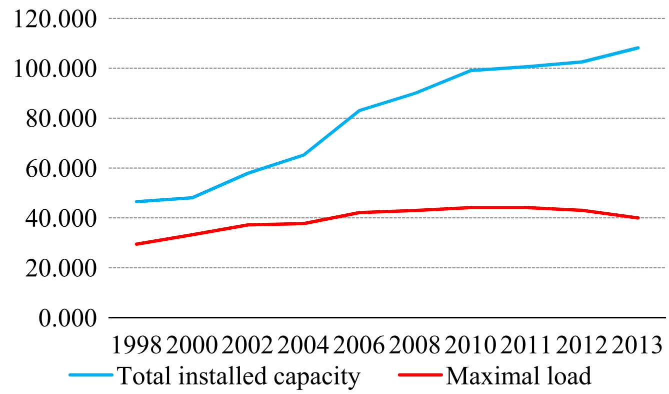


**Fig. 5.** Capacity Margin in SEM, 1998–2013.

demand growth and most predicted future scenarios. However, reality has been very different. Starting from 2008, the economic crisis adversely affected electricity consumption in Spain more than most countries in Europe.

Weak demand and an impressive expansion of generating capacity have significantly increased the capacity margin between installed capacity and maximum load (approximately at the level of 35–64%) in 1998–2013 (see Fig. 5). As a result, SEM had the largest reserve margin (without considering import capacity) among the largest European economies, against 8.7% for France, 4% for the UK and 3.3% for Germany. This implies that there is huge excess capacity and even a complete withdrawal of generation capacity by one of the three largest generators (Iberdrola, Endesa and Gas Natural Fenosa) would leave some excess capacity so that the peak demand could be met by the residual supply.

Excess generation capacity emerged thanks to huge investment in renewable generation capacity in Spain over last years. An effective inclusion of the renewable capacity under SR, smaller companies has helped to diversify the supply side and significantly contribute to effective competition in supply side.

During the last decade, wind power has turned into one of the most important renewable energy sources in Spain. Wind power ranked as third most important technology in terms of generation level, and first including only renewable technologies. The generous support scheme for different types of renewable technologies has been key reason in fostering investment in RES, especially in the case of wind energy technologies. In Spain, a combined system of regulated feed-in tariffs and fixed premiums was used to support RES from 2004 to 2012. This mechanism included in the Spanish system was that renewable energy producers might sell in the Day-ahead market and they would receive the market price, plus a fixed premium. The support mechanism also included the obligation of the distribution companies to purchase all electricity produced from RES, and the obligation of the system operator to dispatch it with the highest priority. The Day-ahead market feature is quite interesting as a large share of wind power producers entered through this market, reaching to 93% in 2007 and 85% in 2012 (CNE, 2013). Wind power plants normally have a low marginal cost (zero fuel costs) and they usually bid at zero or very low prices in the market. Therefore, market clearing prices are expected be low during periods with higher wind supply. There is a large and ever growing amount of literature analyzing the impact of the penetration rate of wind energy into the Spanish energy market. Most of them find strong evidence that large entrance of wind capacity, mostly thanks to the growth in new small and independent operators and their active participation in the Day-ahead market drove average spot prices down. Ciarreta et al. (2014) estimated the merit order effect of renewable energy generations in Spain between 2008 and 2012. They showed that wind technology alone has reduced the market price by 13–15 €/MW h. Similarly, Sáenz de Miera et al. (2008) studied the impact of wind energy in the period of 2005–2007 in the Spanish Market. They calculated a reduction in the wholesale price of electricity in the 5–12 €/MW h range, with yearly wind generation of around 20 GW h.

The generosity of the public support generated investment bubbles, so that the penetration of renewable electricity exceeded government targets that were set for period 2005–2010. It is reflected in the fact that the share of SR in the installed capacity and generation has been increasing considerably within the last eight years in the Spanish pool. Given that in 2005 generation share of RES accounted for 19%, this number reached to 35% in 2012, mostly thanks to the growth in new small and independent operators the mostly with wind and cogeneration capacities. In contrary, solar photovoltaic technologies received 35.2% of the total amount of public support, however, its shares on RES electricity production were only 6.1%. This means that higher incentives did not necessarily translate into higher production. Therefore, the generous feed-in tariffs and premiums led to high incentive payments and contributed to a large tariff deficit that resulted in a large raise in regulatory costs.

– The Iberian integration experience

In order to promote competition and consumer choice, and therefore, respond to domestic market power, it is important to strengthen the integration with neighboring systems. The regional integration provides an opportunity to generating companies abroad to compete with possibly dominant domestic generators, reducing market power (Newbery, 2002). As of today, the Iberian Peninsula currently has one of the lowest interconnection ratios in the EU. Integration capacity of Spain with the European system only represents 3% of the installed generation capacity that does not even reach minimum level of 10% recommended in Europe.

The interconnection with Portugal is currently functioning well. Since the establishment of the Iberian market in 2007, the integration has evolved towards further spot price convergence. In the beginning, spot prices in both countries did not converge, due to the limitations of the interconnection capacity (around 1200 MW in 2007), not allowing the arbitrage in price differences between the two countries. Different generation mixes in both countries were also key obstacles because in Portugal, fuel gas plants were still the marginal thermal technology, while in Spain more efficient gas fired generation were already substituting fuel power plants. Moreover, the Portuguese market was more concentrated – with one generator (EDP) evidently holding a dominant position – while in Spain an oligopoly structure existed alongside a competitive fringe. However, during a short period the Iberian market has achieved a double expansion of the interconnection capacity between both countries, reaching to 2400 MW in 2013. The degree of congestion in the Portuguese-Spanish interconnection has decreased each year due to increasingly more uniform generation mix. While in 2007 the interconnection was congested around 80% of the time, in 2013 market splitting was applied almost 11% (i.e. 944 h over 8760 h). As a result of greater integration, the market prices in the both pools reduced by average 0.5 €/MW h in 2013 (see Table 10).

In fact, expanding interconnection capacity was a key factor to promote integration and minimize price divergence in the both countries. Nevertheless, it is important to take into account that due to different market dimensions – Spanish demand is six times the Portuguese demand – the effects of the market integration in the Iberian Peninsula are likely to be very asymmetrical. For instance, as seen from Table 10, total energy exported from Portugal to Spain in 2013 was 2913 GW h representing only 1% of total energy demand in Spain and total energy imported from Spain to

**Table 10**
Monthly evolution of the Iberian electricity market integration in 2013. Source: OMIE (1998-2013) and own elaboration.

| Month | Congestion | Average price (PT) | Average price (ES) | Imports PT < ES | Export PT > ES |
|---|---|---|---|---|---|
| | % hours month | (€/MW h) | (€/MW h) | (MW h) | (MW h) |
| **January** | 18 | 48,53 | 50,50 | 161,674 | 303,881 |
| **February** | 18 | 43,74 | 45,04 | 141,433 | 275,012 |
| **March** | 26 | 22,82 | 25,92 | 44,023 | 629,636 |
| **April** | 17 | 16,08 | 18,17 | 23,096 | 613,515 |
| **May** | 6 | 43,25 | 43,45 | 203,767 | 272,546 |
| **June** | 7 | 41,70 | 40,87 | 316,803 | 139,313 |
| **July** | 7 | 51,40 | 51,16 | 1044,899 | 4875 |
| **August** | 1 | 48,12 | 48,09 | 614,258 | 22,296 |
| **September** | 8 | 50,68 | 50,20 | 668,021 | 57,918 |
| **October** | 5 | 51,58 | 51,49 | 508,689 | 158,421 |
| **November** | 6 | 42,10 | 41,81 | 260,051 | 249,134 |
| **December** | 12 | 62,99 | 63,64 | 365,842 | 186,907 |
| | **11 (Average)** | **43.5 (Average)** | **44.0 (Average)** | **4352,556 (Total)** | **2913,454 (Total)** |

Portugal was 4325 GW h representing 9% of total energy demand in Portugal. From perspectives of peak demand hours usually when generators can reduce output to exercise market power, Portuguese import capacity represents between 15% and 20% of the Portuguese peak demand; on the contrary, Spain's import capacity from Portugal represents less than 4% of the Spanish peak demand. Although Iberian regional integration has led to wholesale price convergence, it is still early to conclude that events in one market will have a large impact on the neighboring market, especially in the Spanish market.

### 6.2. Regulatory methods

The key regulatory reforms implemented after the market liberalization include Costs of Transition to Competition which aimed to provide a compensation to the companies for regulatory transition and to mitigate market power incentives, virtual power auctions in which the production capacity of key generators is auctioned and the general promotion of forward contracts.

– Costs of Transition to Competition *(CTCs)*

In the beginning of the liberalization, CTCs agreement was one of the basic pillars of the Electricity Law 54/1997 aiming to compensate companies for stranded costs to recover the investment costs made under previous regulatory regime. CTCs were also used by the Spanish government to mitigate market power incentives of generators in early periods. The structure of CTCs was based on a fixed payment of the difference between the net-back retail revenues[3] and wholesale electricity prices to generators during a transition period lasting until end of 2010. The revenue is divided among the generators in proportion to their available capacity (Pérez-Arriaga and Meseguer, 1997). At the beginning, CTCs payment have been an effective tool in mitigating market power keeping market prices equal to 36 €/MW h in the Spanish Pool. However, this mechanism lost its effectiveness over time as the bidding behavior of generators changed when the cost of generation started to increase. This was particularly the case in 2006 when wholesale generation costs exceed largely. Besides, other factors such as entrance of new generators under no CTCs entitlement, existence of regulatory uncertainty over further allocation of CTCs fund, and high electricity prices caused the final suspension of CTCs in Spain in 2006.

– Virtual power plant (VPPs) auctions
From 2007 and on, Spanish regulator implemented VPPs targeting to mitigate dominant potential of the two largest generators in Spain (Endesa and Iberdrola). This regulatory regime obliged Endesa and Iberdrola to auction part of their generation output to the market through quarterly or semiannual forward contracts. During the operation of the program, a total of 2.6 GW of baseload and peak output was auctioned by the program, which was equivalent to 5% of Endesa's and 7% of Iberdrola's capacity. However, the relatively small size of the auctions during the lifetime of the intervention and their limited roles in making wholesale market outcomes more competitive caused the suspension of VPPs in Spain in 2010.
– Promotion of forward contracts

From the beginning of the liberalization process until 2005, almost all wholesale electricity in the Spanish market was traded in the Day-ahead and intra-day ahead market. However, as part of an improvement of competition in the market- to protect consumers from price volatility, market abuses by dominant firms and to improve liquidity, forward trading was developed gradually with the evolution of the regulations in 2007. There exists an extensive literature claiming that by the use of long-term contracts, generators can sell part of their electricity ex-ante, at a locked – in price. As a result, generators will behave more competitively in the spot market. Allaz and Vila (1993) show that oligopolies have a strategic motive to sell forward and forward markets increase competitiveness between firms, raising consumer surplus and efficiency. Another study by Ausubel and Cramton (2010) show that forward markets can greatly improve the market design of wholesale electricity markets concerning serious problems of risk, market power and investment. Forward trading in the Spanish market has experienced an upward growth trend. For instance, forward trading volume in 2014 (109.85 TW h) increased 42.2% compared in 2013. Furthermore, the OTC volumes cleared and settled by the Portuguese and Spanish clearing houses (i.e. OMIP clearing house (OMIClear) and by BME Clearing) reached to 71.84 TW h, increasing significantly (95.1%) in year 2013 compared to year 2012 (36.82 TW h).

### 6.3. Future developments

In order to optimize the use of large excess installed capacity, to improve the flexibility, reliability, and efficiency of the system and to achieve better integration of RES generation within the grid, harmonized and efficient measures and regulatory mechanisms must be established in the Spanish power system. Some of the measures required for a more efficient network in the future include: (1) Reinforcement of the Price Coupling of Regions initiative, (2) increase capacity of storage, and (3) promote demand responsiveness.

Increase in the interconnection capacity on integrating with the Central and Northern European markets, as part of a Europe-wide market coupling process is a challenging task to be realized in the future. Recent investment in a new electrical interconnection line between Spain and France in 2015 allows doubling the interconnection capacity of Spain from its current 3–6%. This is expected to improve the quality of service and the development of energy exchanges in the European market. This is especially relevant in terms of fostering a greater integration of renewable energies into the electricity system considering renewable generation is quite variable and dispersed geographically and demands a greater level of interconnection to provide more

[3] This was computed as the actual revenues from regulated tariff minus the regulated cost.

flexibility to the system. The implementation of market coupling will likely to have the biggest impact on Spanish Day-ahead prices. As renewable generation affects the Day-ahead price so much in Spain, importing more power from France on days when renewable output is low may reduce some of the volatility.

The future power system will be a very flexible network in which storage systems play an important role. Currently, there is limited energy storage in the Spanish energy system (around 6% of total installed capacity) with almost exclusively from pumped hydro-storage. However, the investment in storage technologies in the future promises multiple benefits in the system through its ability to decouple demand from the supply sector. This will allow the better integration of renewables to the grid and will pave the way for improvements in the flexibility, reliability, and efficiency of the Spanish electricity network.

During two decades of liberalization, increased integration of renewable energy resources and the growing peak demand for electricity in the Spanish market drive the need for increased flexibility, the active participation of the consumers in order to maintain an affordable energy system. Creating flexibility on the demand response resources holds significant promise to make the market more competitive and efficient by increasing the elasticity of demand, thus limiting market power.

## Acknowledgments

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