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ENERGY IN SPAIN: EFFICIENCY AND ELECTRICITY COSTS

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RESUMEN.

La energía desempeña un papel fundamental en el desarrollo económico de los países. Las empresas intentan optimizar su uso y adquirir las distintas fuentes de energía al mejor precio para poder competir en los mercados internacionales. Este trabajo de fin de grado analiza las fuentes de energía primaria y final, la eficiencia energética y los costes de la electricidad para las empresas españolas con la finalidad de compararlos con otros países europeos. De este modo, la situación en la que se encuentren los principales socios comerciales de España puede dar una idea más o menos clara de las posibles ventajas o desventajas competitivas de las empresas españolas. Se han utilizado diferentes fuentes de información que permiten analizar la evolución del mix energético, las intensidades energéticas y los componentes de la tarifa eléctrica, así como la evolución en Francia, Alemania y la Unión Europea en un periodo de referencia determinado. Los resultados señalan la existencia de problemas energéticos para ciertos sectores económicos o tipos de empresas.

Palabras clave: mix energético, balance eléctrico, intensidad energética, tarifa eléctrica.

ABSTRACT

Energy plays an important role in the economic growth of countries. Companies attempt at optimizing their use and acquiring best price energy sources to compete in international markets. It is the purpose of the present paper to analyze the primary and final energy sources, energy efficiency and electricity costs for Spanish companies in order to compare them to other European countries. Thus, the current situation of the most important Spanish trade partners in the EU could give insight into potential competitive advantages or disadvantages of companies in this country. Different data sources have been considered to analyze the evolution of the energy mix, energy intensities and the different components of the electricity tariff, as well as the evolution in France, Germany and the European Union in the reference period. Results point out some problems that may be detrimental to certain economic sectors and businesses.

Key words: energy mix, electricity balance, energy intensity, electricity tariff.

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1. INTRODUCTION

The European Union is formed by different countries that attempt at reaching politic and economic integration to keep peace and tackle globalization challenges. One of these challenges is to compete with companies from other countries where energy costs are lower and energy efficiency is higher. Consequently, those factors that affect energy efficiency and costs have become a central issue in Europe because they directly influence the competitive position of companies.

The Spanish energy sector has similar problems to other European countries, that is why common policies are sometimes implemented. Many researchers have recently turned to the analysis of energy external dependence because it is a factor that influences prices across the continent and it may create strong price fluctuations, which have bad consequences for the economy. However, little attention has been paid to efficiency issues, which modify the quantity of energy that companies need to carry out their activities, and to electricity prices, which are different in each country and largely determine companies' energy costs.

The aim of the paper is to give insight into energy efficiency and electricity costs in the Spanish economy after a brief description of the available energy sources. The evolution of energy sources (primary and final) is useful for the analysis of the two main topics, because some authors and reports put emphasis on the fact that some energy sources make productive processes more efficient and energy sources with low variable costs also have an effect on electricity prices.

Secondly, energy efficiency can be used as an indicator of the quantity of energy sources that a specific economic sector needs to produce a unit of product, in such a way that it influences energy savings. Thirdly, electricity prices have different components that could make a difference between those countries with lower electricity prices and those with higher prices and, therefore, higher costs. Therefore, this paper examines the main dissimilarities among Spain, the European Union, France and Germany regarding the aforementioned issues. The latter countries are chosen because they are the main Spanish trade partners, that is to say, their performance might change the competitive position of Spanish enterprises.

Generally speaking, policy makers could address the main issues that are described in this paper and take some measures to improve competitiveness of Spanish companies as far as possible. Additionally, there can be drawn conclusions about policies and regulations that have affected efficiency and electricity prices.

This dissertation is divided into five sections. Chapter 1 reviews the literature necessary to develop the dissertation. It explains previous works and publications that have led the author to choose the topic. Chapter 2 is a primary focus on the energy sources in Spain. It sets out the evolution of primary energy sources and breaks down the final sources in 2016, especially electricity.

In the next two sections, efficiency and electricity costs are explained. Chapter 3 defines the efficiency concept and compares final, transport and industrial energy intensities in Spain to European Union, France and Germany between 2007 and 2015. Chapter 4 describes electricity tariff components, explains the importance of electricity as an input in the manufacturing sector and compares Spanish electricity prices to the European Union, France and Germany for a similar reference period (2007-2016). Finally, Chapter 5 discusses the study findings and draws the main conclusions.

2. LITERATURE REVIEW.

Studies related to energy have many different economic and technical approaches. Energy is a broad topic and authors only focus on some characteristics of this sector in order to make better analysis. For instance, there are some papers that attempt at making a relation between companies' energy costs and competitiveness. This dissertation deems some of these issues; however, it provides a unique approach based on different reports and articles and it summarizes the main characteristics of the energy efficiency and electricity costs in Spain.

Section 2 explains the evolution of primary energy sources and the current breakdown of final energy sources and electricity. All of this data is taken from official reports that display information about the energy sector in Spain and the factors that have had an effect on the most important changes in the energy sources. The report on "La energía en España" from the Ministry of Energy describes the main primary and final energy sources, their origin and analyzes the variation between 2015 and 2016; however, other data were required to elaborate a broader analysis of the evolution in the last few years. For instance, the International Energy Agency (2015) briefly explains these variations and it also suggests some measures to tackle the main problems. On the subject of electricity, the Red Eléctrica de España report on "El Sistema Eléctrico Español" provides information about the main electricity sources and their production price, which is considered in section 4.

Although these topics are important for this dissertation, efficiency and electricity costs are the main sections. According to Segarra and Batalla (2016), there are three drivers of companies' energy costs: external dependence of energy sources, unitary energy consumption or efficiency and energy prices. This paper does not explain in detail external dependence of energy sources as a factor that strongly affects Spanish companies' costs with respect to its trade partners in Europe because they are also highly dependent on energy (Eurostat, 2016) and currency exchange rates are equal for all the countries in the Eurozone. External dependency would be a major factor if Spanish energy costs are compared to countries outside Europe such as Japan, China and USA.

Moreover, this paper does not analyze all the energy costs and it focuses only on electricity prices. The reason why this energy source has been chosen is that electricity prices are fixed in national markets and there could be bigger costs differences among companies from different countries. For instance, there are other energy sources like petrol and coal that are traded in international markets. Thus, this study only considers two drivers of companies' energy costs: energy efficiency and electricity prices.

The work of Jiménez (2017) introduces the Spanish energy sector and defines energy efficiency as a factor that is measured by the energy intensity ratio, which is usually accepted by international institutions and researchers. However, there are other ways to measure energy efficiency that are used for the same purpose. Its conclusions were necessary to set the basis for a further analysis in section 4, because it considers primary energy intensities and compares them to OECD countries. This dissertation attempts at making a comparison with certain countries and at analyzing energy efficiency in different economic sectors. In addition, the Plan Nacional de Eficiencia Energética (2017) not only describes the energy intensities for different sectors but also suggests some measures or policies that are considered in this paper.

To end up, some readings about the electricity sector in Spain were necessary to synthesize the key elements that comprise electricity prices and make a relation between them and companies' competitiveness in the reference countries. Fabra (2012) places importance on the fact that electricity prices for households are one of the most expensive in Europe and states that regulated costs have a real influence on final prices but it does not take into account prices for different types of companies. As a consequence, this paper focuses on the three tariff electricity elements (regulated costs are one of them) and distinguishes between different end-users. Additionally, Consejo Económico y Social (2017) relates electricity to competitiveness and treats this energy source as an input for companies, therefore, this report sets the basis for section 5.

3. ENERGY IN SPAIN

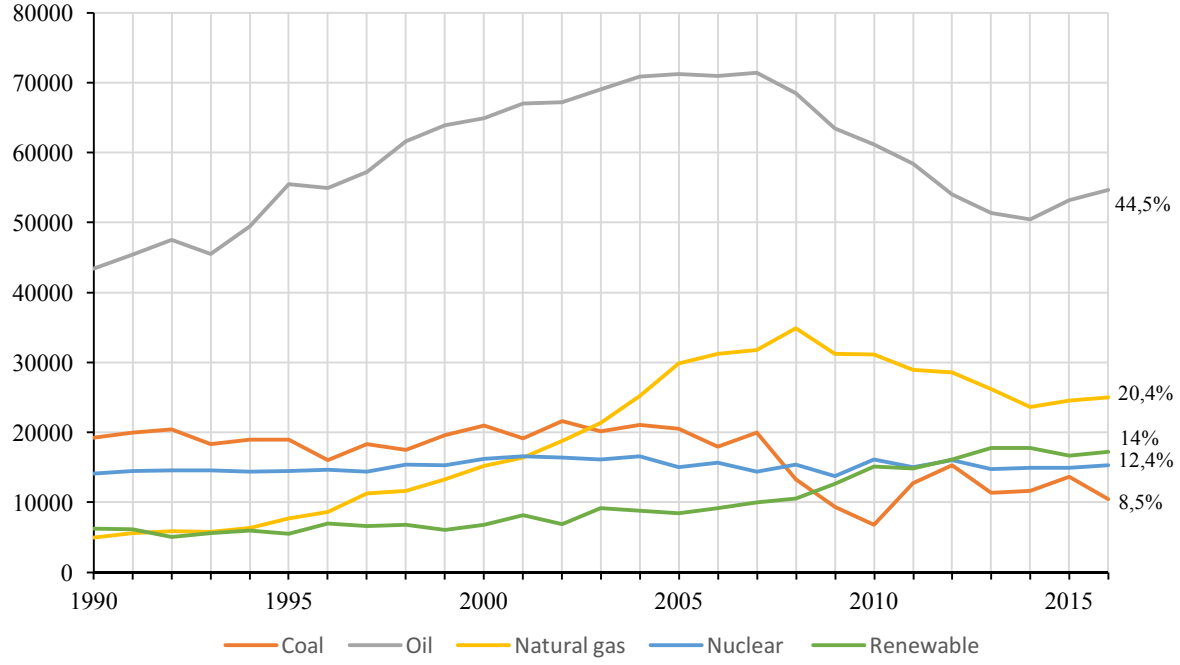
The different types of available energy sources and their use set the basis for a further explanation about the energy efficiency and costs in Spain because not all the energy sources are equally efficient and these differences have an effect on electricity prices. That is why this study investigates the evolution of the Spanish energy mix and focuses on electricity as a secondary source.

3.1 PRIMARY AND FINAL ENERGY SOURCES.

The energy mix can broadly be defined as a group of different primary sources from which secondary energy for direct use is produced. They refer to coal, oil, natural gas, nuclear power plants and renewable energies, while secondary sources are those which have a final use, such as electricity or petrol. The consumption of these sources has gone up for the simple reason that energy demand has increased since the last century. Nevertheless, the 2008 economic crisis stopped this upward trend and reduced energy demand. Graph 1 presents the evolution of the Spanish energy mix and shows this change in energy consumption.

On the one hand, the consumption of oil and natural gas is quite high because the sum of both is virtually 65% of the total. They increased its presence in the last years although the economic crisis reduced their consumption. Oil is the most consumed source of energy (44,5%) and as it can be seen in table 1, it increased by 26% since 1990. In spite of the fact that it represents most of the energy consumed, it strongly decreased since 2007 because of the demand shrinkage and the high oil prices in 2011, which led the government to implement some restrictions linked to petrol consumption. Regarding natural gas, its consumption increased around 404% in the period. Some events, such as the construction of international connections through gas pipelines with France in 1993 and Algeria in 1996 pushed up the consumption of this energy source (International Energy Agency, 2015). Finally, natural gas consumption underwent a considerable fall since the economic crisis (21%) although oil and natural gas increased in 2014 due to economy recovery.

Graph 1: Consumption of primary energy sources in Spain, 1990 -2016 (Ktoe).



*Ktoe: 1000 tons of oil equivalent

Source: Own, MINETUR.

On the other hand, coal, nuclear power and renewable energies have a lower presence although the latter are taking off and becoming more important. Coal consumption flattened out from 1990 to 2007 and fell by 46% since then. Its downward trend began 30 years before, in 1960, when Spain was opened to international markets, laid aside autarky and started to import cheaper coal from other countries due to national coal inefficiency in terms of energy power and price (Fernández, 2015). Moreover, policies to give up consuming non-clean energies, brought investments in this subsector to a standstill. Coal consumption had the smallest share (8,5%) in 2016. In contrast, Nuclear power production has been sustained over the years and its growth was around 8%. The first nuclear plants were built in the 70's.

Renewable energy is the only source that grew almost every year since 1990, over 178%. There are many types of renewable energies but in Spain the most common sources are biomass (4,2%), wind power (3,4%), hydropower (2,5%), solar power (2,4%), biofuels (0,8%), biogas (0,2%), geothermal power (0,2%) and thermal solar energy (0,2%). Two facts illustrate the importance of renewable energies in the energy mix: the share of solar power is the highest in the International Energy Agency (IEA) member countries while wind power is the third-highest behind Denmark and Portugal.

Table 1: Changes in demand by primary sources.

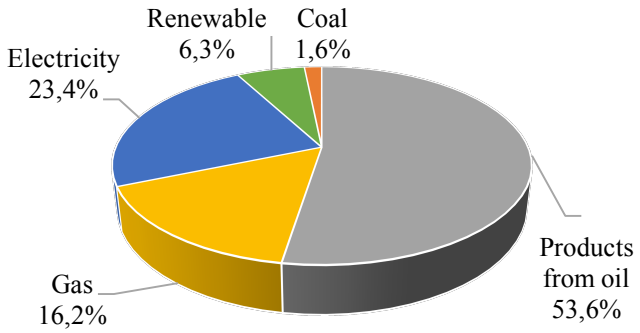
	1990-2016	2007-2016
Coal	-46%	-48%
Oil	26%	-24%
Natural Gas	404%	-21%
Nuclear power	8%	6%
Renewable	178%	72%

Source: Own, MINETUR

With regards to energy sources origin, Spain and European Union countries are quite dependent on external markets. Indeed, the 28 countries need to buy energy to meet their demand and Spain has to import 71,9% of the total energy demand (see graph 1, Appendix I). The reason why this figure is so high is the scarce of resources such as oil and natural gas, which are 65% of the primary energy consumption in 2016. National natural gas production only represents 0,19% of the total and there are nine suppliers: Algeria (57%), Nigeria (14%), Norway (11%) and Qatar (8%) are the main ones. Regarding oil, the number of suppliers is higher and Mexico is the biggest one (14,40%), followed by Nigeria (12,6%) Arabia Saudi (10,3%) and Iraq (8,1%).

Finally, primary energy sources are transformed into secondary or final energy sources, which have a direct use; for example, electricity or heating. Thus, coal, gas, oil and some renewable energies such as biomass are used for heating but these energies can also be used for making electricity. That is why final energy breakdown differs from the consumption of primary energy. Graph 2 displays the final energy sources in Spain.

Graph 2: Final energy sources in Spain, 2016.



Source: Own, MINETUR.

3.2 ELECTRICITY BALANCE.

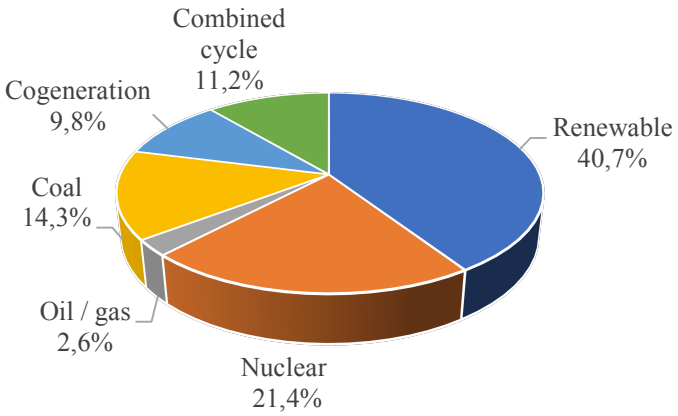
Electricity is generated from many different types of primary sources: nuclear, renewable energies, coal, gas and oil. However, their percentage is different depending on the year we analyze, because renewable energies production changes according to the climate conditions and coal, oil and gas prices might encourage or discourage their purchase. In addition, Spanish government and European Union policies are aimed at reducing those energy sources that pollute the environment and at achieving certain goals: 40% less greenhouse gas emissions in 2030 (European Commission, 2018).

According to the International Energy Agency (IEA), the use of oil and coal as electricity sources has nearly halved and, in comparison with other countries, electricity generation from these sources is very low (twelfth-lowest in 2014). In contrast, wind and solar power are continuously growing and nuclear power and hydropower fluctuate frequently, averaging 20% and 11% of total generation over the last decade, respectively. Gas had more importance in the past, it peaked at 38,8% of the total in 2008, but declined fast since that year.

As shown in graph 3, electricity in 2016 was mainly produced by renewable energies, which represented 40,8% of total electricity production. They were fostered by the features of the hydrological year; hydropower energy went up 25% with respect to the previous year. Nevertheless, non-renewable energies brought down their share in the total production of electricity. These energies include nuclear power (21,4%), coal (14,3%), combined cycle (11,2%), cogeneration (9,8%) and fuel and gas (2,8%). Combined cycle uses thermal energy from natural gas to produce energy and cogeneration is a process that produces electrical power and thermal power at the same time.

Considering international exchanges of electricity (see graph 2, Appendix I), there was a negative net balance in 2016, in other words, Spain had to import this kind of energy from other countries. As a consequence, it needed 7660 GWh in 2016 to cover electricity demand while in 2015 exports were higher than imports and resulted in a positive net balance of 147 GWh. France (5483 GWh) and Morocco (4952 GWh) were the main electricity buyers in that year. Generally speaking, Spain usually sells electricity to France, Morocco, Portugal and Andorra and buys electricity from France and Portugal.

Graph 3: Electricity sources, 2016



Source: Own, Red Eléctrica de España.

4. ENERGY EFFICIENCY.

In every productive process, there are inputs that turn into outputs and most of the times energy is used to make this transformation. The way companies use energy determines the productive process efficiency, therefore, it affects their competitive position. It is necessary here to clarify exactly what is meant by energy efficiency. In this dissertation, efficiency will be used in its broadest sense to refer to energy intensity, that is, the ratio of final energy consumption (kgoe) per unit of real gross domestic product adjusted for purchasing power parity (GDP PPP). Purchasing power is taken into account in order to make a comparison among Spain, France, Germany and EU average.

4.1 FINAL ENERGY INTENSTIY.

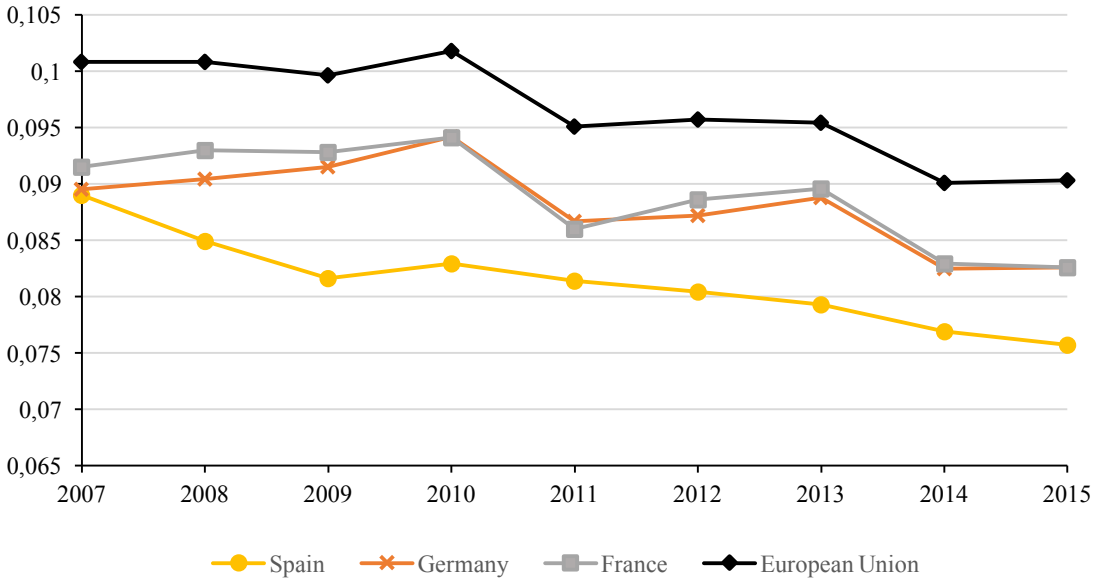
Although energy intensity allows us to measure energy efficiency, there are some economical features that affect this ratio so that low efficiency levels do not necessarily mean that countries save more energy or use a more advance technology to make productive processes more efficient. According to the report on "Plan Nacional de Acción de Eficiencia Energética 2017-2020", there are four types of factors that affect energy intensity changes: structural, technological, economic activity and efficiency policies. As consequence, it might be better to pay attention to energy intensity evolution rather than comparing data in a specific moment of time.

First of all, structural factors are related to the economic structure of a country. For example, there are some activities that need more energy to produce a unit of product and there are some activities which require a small amount of energy although their GDP share is high. Secondly, technological drivers can reduce the energy necessary to produce a unit of product and improve the transformation of primary energy into final energy too. Thirdly, economic growth or recessions decrease or increase the energy intensity due to changes in the productive capacity; for instance, during economic crises production levels are not adjusted to facilities capacity and running costs and efficiency levels slow down. Finally, efficiency policies implemented by the government aim at replacing less efficient energy sources by more efficient sources and force companies to reduce their energy intensity.

As revealed by graph 4, the energy intensity evolution in Spain may be split into three periods. From 2007 to 2009 Spanish energy intensity underwent a considerable decrease (8,3%) while most of European countries energy intensity levels remained constant or slightly increased. The work of Jiménez (2016) claims that this upward trend was driven by structural and technological factors. On the one hand, some Spanish economic activities were substituted by others which required less energy, therefore, energy intensity went down. On the other hand, some energy sources like coal were replaced by more efficient energy sources such as natural gas and cogeneration. In addition, the government implemented efficiency plans.

From 2009 to 2013, energy intensity slowly decreased by 2,8% in Spain but it strongly decreased in France, Germany and EU after a slight upturn in 2010. The main reason why the fall of energy intensity was not as strong as in the last period was the economic recession, which led to a lower productive capacity (Plan Nacional de Acción de Eficiencia Energética, 2017). During the period 2013-2015 the ratio decreased by 4,6% owed to the economic recovery, which improved productive capacity.

Graph 4: Final energy intensity, 2007-2015 (kgoe/€05)*.



*kgoe: kilogram of oil equivalent.

Source: Own, IDAE.

Regarding energy intensity ratios from 2007 to 2015, they decrease in all the countries. In other words, the final energy required to produce products and provide services was lower in 2015. Nevertheless, this decrease was stronger in Spain, where final energy intensity declined by 14,9%, and it was moderate in Europe (10,4%), France (9,7%) and Germany (7,7%). It is important to highlight the fact that final energy intensity was very similar in Spain and these two countries in 2007 and since then, French and German ratios followed similar trends while Spanish ratio underwent a stronger decrease. However, the energy intensity evolution was different in each sector.

According to the last data available from Spanish Ministry of Energy, the transport sector represents 42% of the energy demand and cars comprise more than a half of this energy consumption. Secondly, the industry sector represents 24% of total energy demand, it is composed of non-metallic minerals, metallurgy, chemistry, food, drinks and tobacco, paste and paper, construction, metallic products and equipment, and mining. Thirdly, the domestic sector energy demand is 18,5%. Finally, services sector, which includes many activities such as offices, trade, catering, health and education makes for 12,5% of the energy demand, albeit it contributes to 67,2% of the GDP.

Table 2 shows the variations of energy intensity by sector between 2007 and 2015 by sector. In all the sectors except services there is a negative variation. Transport energy intensity had the strongest reduction and it was followed by the domestic and industry sectors. On the other hand, the service sector followed an opposite trend and energy intensity was higher in 2015 than in 2007.

Table 2: Changes in final energy intensity, 2007-2015 (kep/€05)

SECTOR	2007-2015
Industry	-11,75%
Transport	-17,75%
Services	8,11%
Households	-13,87%

*Unit of measurement tep/household.

Source: Own, IDAE.

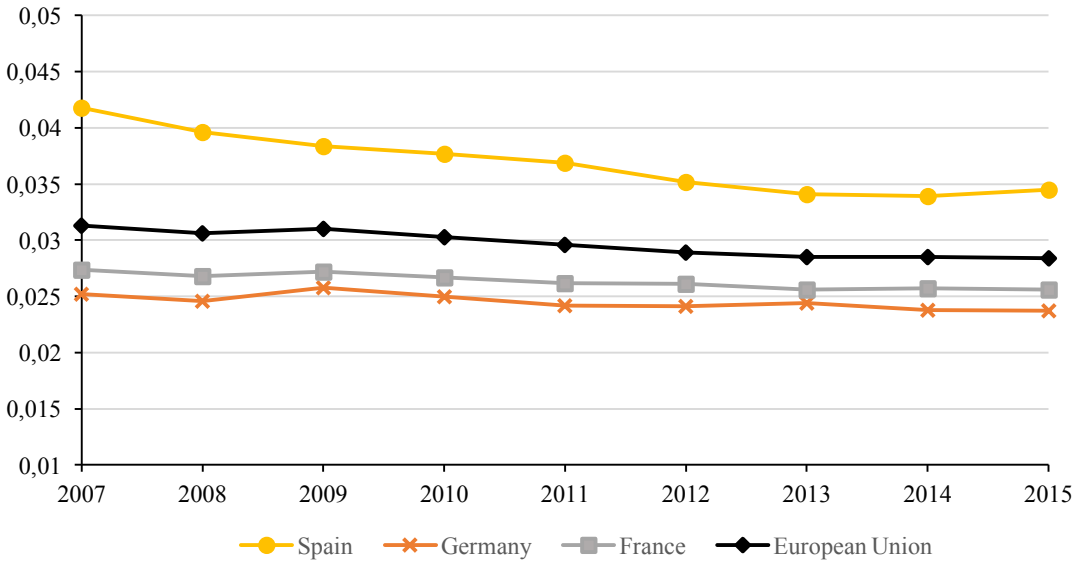
4.2 ENERGY INTENSITY IN TRANSPORT AND INDUSTRY.

The transport and industry sectors are the economic sectors that consume more energy in Spain. That is why it is important to compare energy intensity in these sectors in Spain to Germany, France and EU and observe if energy intensity is also lower in these sectors. For that purpose, energy intensity ratio is measured as the relation between the final energy used in each sector and the sector gross added value. Limited data available does not allow us to adjust these figures to the purchasing power parity.

The transport sector embodies all means of transport: land (roads and railway), maritime and air. The transport energy intensity is determined by the use of each of them; for example, freight trains and public transport are more efficient than other vehicles and that is the key to understand why transport energy intensity is higher in Spain than in other European countries as can be seen in graph 5. From 2007 to 2015 transport efficiency was lower than in Germany, France and EU; however, this ratio went down by 17,5% in Spain and less than 9% in the other reference countries.

On the one hand, railway transport in Spain, which requires less energy than other vehicles to carry the same load, represented only 5% of total transport in 2015, while in France and Germany it was 13% and 19% respectively. On the other hand, private vehicles have higher presence in Spain and their efficiency is lower because of their limited capacity to transport people. Moreover, the private vehicle fleet is older than in France and Germany, hence their limited technology implies higher energy consumption (mainly petrol and diesel).

Graph 5: Transport energy intensity, 2007-2015 (kgoe/€05)

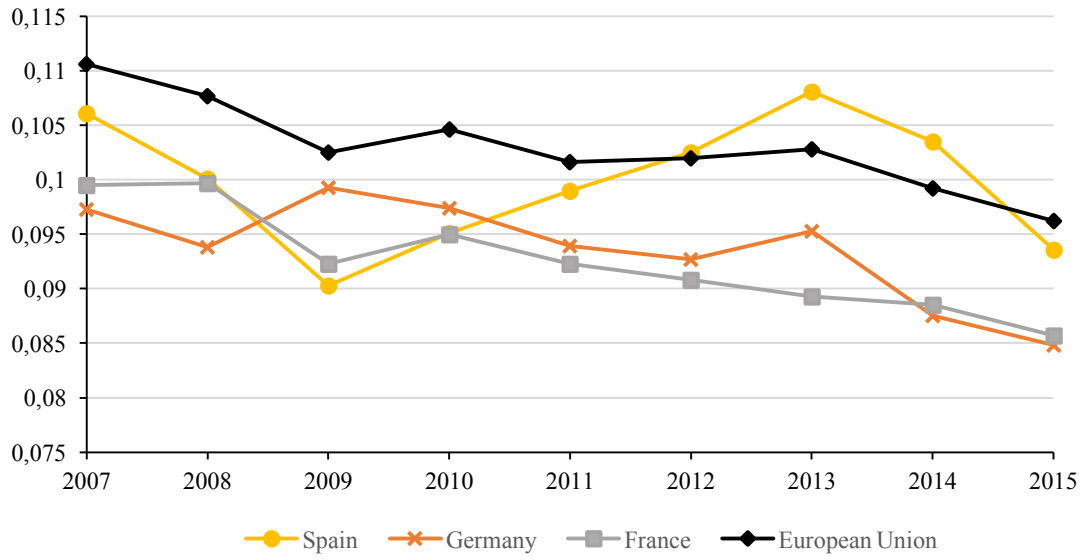


Source: Own, IDAE.

As revealed by graph 6, industry energy intensity has been higher than in France and Germany for the reference period and there were some years when it overcame the European average energy intensity. The reason why global final energy intensity, which has been explained before, was lower than industry intensity is the structure of this sector. Spanish manufacturing industry demands more energy than the industry in the two other countries, where manufacturing activities are more related to food, drinks and capital equipment production and they require less energy in their productive processes (Plan Nacional de Acción de Eficiencia Energética, 2017).

The evolution of industry energy intensity slowed down from 2007 to 2009 but then it rapidly went up from 2009 to 2013, while this ratio was decreasing in Germany, France and EU. This trend seems to be in line with the economic crisis, therefore, productive capacity was one of the reasons why this ratio went up. Equipment used in industrial facilities (boilers, ovens, engines, etc.) had lower performance as it ran under its nominal capacity, while at the same time, other energy demands such as lighting, heating, and the fitting out of the facilities are independent from the activity level. Energy intensity overcame EU in 2013 but the economic recovery changed the trend again and in 2015 Spanish industry almost recovered pre-crisis efficiency levels.

Graph 6: Industry energy intensity, 2007-2015 (kgoe/€05)



Source: Own, IDAE.

Based on these observations, efficiency does not seem to be a big problem for Spanish companies' competitiveness in the European context. Indeed, intensity ratios were lower than in Europe, France and Germany in 2015 and the upward trend was stronger in Spain due to transport, households and industry efficiency improvements. The "Plan de Eficiencia Energética" that came into force in 2004, together with technology, had a positive impact in energy intensity. Nonetheless, transport energy intensity has always been higher than in reference countries for the period analyzed although it significantly slumped. In short, industry energy intensity has changed a lot but it started a downward trend in 2013 and it was lower than in the EU in 2015.

5. ELECTRICITY COSTS

Spanish electricity prices are determined by electricity tariffs. These tariffs depend on the type of consumer, so they can imply higher electricity costs for some companies or for individual consumers. For this reason, it is important to know which are the components that form Spanish electricity tariffs and how they affect companies' costs.

5.1 ELECTRICITY TARIFFS

Electricity tariffs are classified according to two different markets: regulated and free market. Prior to these two markets, there was only a regulated market but the liberalization process that started in the last century introduced some changes. According to Flores (2015) three periods can be distinguished in the electricity market.

1) 1987-1997. "Marco Legal Estable", Royal Decree 1538/1987. During this period, the state had the control over the electricity sector through energy plans. These plans regulated most of the activities, in such a way that activities were compensated on the basis of the recognized cost principle: the government decided how much consumers had to pay for the maintenance and running of the sector (access tariff). There was a common tariff for every end-user, no matter whether they were domestic or industrial consumers. Besides, electricity companies were vertically integrated and there was not a free market to compete.

2) 1997-2013. "Ley del Sector Eléctrico", Act 54/1997. It was the beginning of the liberalization process. Since then, there are two types of activities related to electricity, regulated and liberalized activities. The former are composed of transport, which transmits electricity through high-voltage networks (> 220kV), and distribution, which transmits electricity through low-voltage networks (< 220 kV) to the end-user (domestic or industrial consumer), and the latter are electricity production and commercialization. The company in charge of transport activities is Red Eléctrica de España (REE) and distribution activities are carried out by different companies. Regarding production and commercialization, there are five big companies that produce and sell electricity: Endesa, Iberdrola, Gas Natural Fenosa, EDP and Viesgo. Their market share in the wholesale market is around 90%. Nevertheless, since the appearance of new renewable energies (wind and solar power) the number of independent producers soared in the last few years.

3) 2013-2018. “Ley del Sector Eléctrico”, Act 24/2013. The most important changes were: the substitution of Tarifa de Último Recurso (TUR) by Precio Voluntario del Pequeño Consumidor (PVPC) in the regulated market and new criteria to reduce the tariff deficit. As regards with PVPC tariff, it can only be applied for those consumers with a contracted power less than 10 kW and prices change every day due to the influence of renewable energies in the energy mix. According to “Comisión Nacional del Mercado y la Competencia”, the number of consumers that have this tariff was roughly 12.000.000 in 2016. On the other hand, those consumers who have a contracted power higher than 10 kW are in the free market, where prices are fixed and do not change every day. The number of consumers who were in the free market was around 17.100.000. This study focuses on electricity prices from the free market because most companies have a contracted power higher than 10 kW.

Finally, the EU dimension in the regulatory framework of the electricity sector has grown in importance in the last years. The development of an integrated Internal Electricity Market has become a political priority and it has focused on two areas: first, integrating national and regional electricity markets and coordinating system operations via commonly agreed mechanisms based on the European regulations and guidelines and, secondly, constructing cross-border interconnections and coordinating network infrastructure planning via the European Network of Transmission System Operators for Electricity’s (ENTSO-E) ten-year network development plans and regional plans (International Energy Agency, 2015).

As shown in table 3, electricity tariffs can be split into three components: energy costs, access tariff and taxes. Energy costs are related to wholesale market prices, while access tariff and taxes are regulated costs.

Table 3: Electricity tariff components in Spain.

ENERGY COSTS	Spot market
	Adjustment service
	Capacity service
	Peninsular costs
	Losses
ACCESS TARIFF	Transport costs
	Distribution and commercial costs
	Payment RECORE
	Extra-peninsular costs
	Permanent costs
	Tariff deficit
TAXES	Electricity tax
	VAT

Source: Own, Consejo Económico y Social.

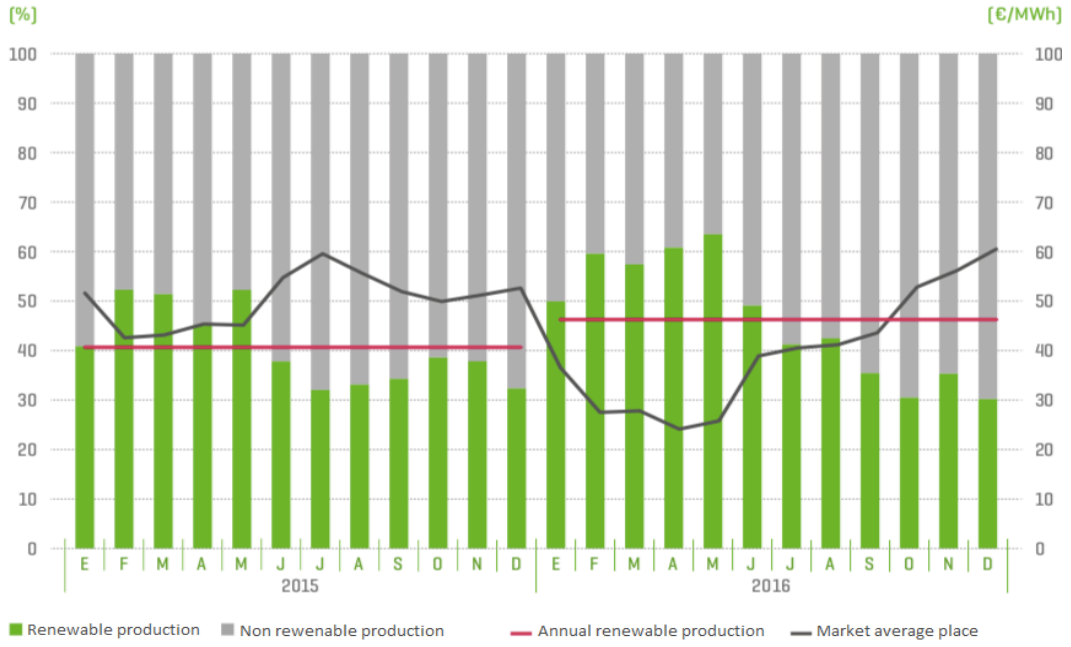
The electricity market is the place where agents sell and buy electricity. One of the main issues is the problem that arises from a technological hurdle: energy cannot be stored. That is why supply and demand must go together and form an equilibrium point that determines the electricity price and quantity. Furthermore, it is impossible to know the demand for electricity in a specific moment so it is important to develop reliable techniques that allow electricity agents to forecast it.

The Spanish electricity wholesale market is part of the Iberian power market (Mercado Ibérico de Electricidad – MIBEL) created in 2007. OMIE in Spain manages the spot market (daily and intraday markets) while OMIP in Portugal manages the futures market. Both are part of the Operador del Mercado Ibérico (OMI, Iberian market operator) business group which is 50/50 owned by the Spanish (OMEL) and Portuguese (OMIP SGPS) wholesale market operators from the pre-MIBEL times. There are over 800 agents operating in the Iberian electricity market (wholesalers, distributors and retailers) and the way it is running is similar to other European electricity markets such us Nord Pool Spot in Nordic countries, EPEXSPot in France and Germany, and GME in Italy. Moreover, buying and selling agents might trade on the market regardless of whether they are from Spain or Portugal. The final price that retailers have to pay comes from the daily market and the intraday market, which are marginal markets controlled by OMIE (see graph 3, Appendix 1).

The daily market. Electricity prices are set on a daily basis (365 days a year) at 12 noon, for the 24 hours of the following day, in what we refer to as the Daily Market. The volume and price of energy over a specific hour are determined by the supply and the demand curve, that meet in a point according to the marginal pricing model adopted by the EU. This model works because of an algorithm approved for all European markets called EUPHEMIA and it is considered the most efficient solution from an economic perspective. However, the process also needs to be feasible in physical terms and that is why once the results are obtained they are sent to the System Operator for their validation regarding technical viability. This means that results can undergo some adjustments affecting around 5% of the energy.

Electricity sellers are presented to the market operators and they are included in a matching procedure that affects the daily programming schedule 24 hours. Furthermore, all available production units except for bilateral contracts are obliged to present bids for the daily market and buyers (reference retailers, resellers and direct consumers) may present bids to purchase electricity. With respect to resellers, they participate in the market to purchase electricity to sell to the direct consumers. In 2016, 73,6% of the total energy (250TWh) was bargained in the spot market while 26,4% was negotiated through bilateral contracts (Red Eléctrica de España, 2016). During the auction, the supply curve is firstly formed by those energies with lower variable costs and energies with higher variable costs are added after (Quiroga, 2013).

Graph 7: Renewable and non-renewable production 2015-2016.



Source: REE, 2016

Renewable energies variable costs are very low so they are the first energies offered in the market with a low price (see graph 4, Appendix I). Nuclear power is also cheap in terms of variable costs so it is offered after the "clean energies". It is known that renewable energies production fluctuates in accordance with environmental factors that electricity companies cannot control, therefore, electricity from coal, combined cycle and fuel sometimes replace them and rise up prices in the spot market due to their higher variable costs there is an inverse relation between electricity prices in OMIE market and the use of renewable energies. Graph 7 shows this relation.

The intraday market. After the daily market, the same agents who have operated in that market can buy and sell electricity in the intraday market at different trading sessions some hours earlier than real time. There are six trading sessions and the way quantity and price are determined is the same as the daily market so this market allows wholesalers and retailers to readjust their commitment up to four hours ahead of the real time (see graph 5, Appendix I). Agents who can bid in this market are those authorized to present sale and purchase bids on the daily market and who have participated in the corresponding daily market session, or who have executed a physical bilateral contract. As in the case of daily market, bids can be simple or complex. The latter includes load gradient, minimum income, complete acceptance in the matching process of the first block, complete acceptance in each hour in the matching period of the first block, minimum number of consecutive hours of complete acceptance and a maximum matched power.

Finally, OMIE is in charge of managing the economic rights and obligations of sellers and buyers as a result of their market trading. This process is called settlement processes and they are made for each hour in the day, for both daily and intraday market sessions. The average spot price in 2016 was 40,63 €/MWh and it represented 83,9% of total energy costs (Red Eléctrica de España, 2016). Once the equilibrium point (price and quantity) has been reached in the OMIE market, Red Eléctrica de España (REE) checks whether or not generation and consumption can be possible regarding the system features. This process is called adjustment service and amounted to 3,10€/MWh (6,4% of total energy costs) in 2016. In addition, companies are paid according to their contribution to the power reserve, which is necessary to guarantee the supply reliability (capacity service). In 2016, this payment was 2,75 €/MWh and it displayed the 5,7% of the total. Finally, Peninsular costs are those related to technical issues that affect the electricity supply and amounted to 1,93 €/MWh (4% of the total).

On the subject of access tariff, it consists of different regulated costs: transport, distribution and commercial, RECORE payment, extra-peninsular, permanent and tariff deficit. Their amount varies every year depending on future demand, technologies structure and prices in the wholesale market. In addition, they are fixed by the government through the BOE (Boletín Oficial del Estado). Table 5 shows the quantity and the percentage they represented in 2016.

Table 5: Access costs in the electricity tariff, 2016.

	Thousand €	**% over total**
Transport costs	1.764.429 €	**10,3%**
Distribution and commercial costs	5.080.499 €	**29,5%**
RECORE payment	6.726.000 €	**39,1%**
Extra-peninsular costs	740.632 €	**4,3%**
Permanent costs	20.966 €	**0,1%**
Tariff deficit	2.871.904 €	**16,7%**

Source: Own, CNMC.

Supply companies (retailers) charge the access tariff to end-users and then, they have to pay it to distributors which have been previously set out: Endesa, Iberdrola, Gas Natural, Viesgo (called E.ON until 2015), EDP and CHC. The amount of money that consumers have to pay for the access tariff depends on variable factors (consumption of kW) and fixed factors (contracted power and tension). For this reason, there are significant differences between business and households, as it can be seen in section 5.2

- Transport costs. Transport activities require high-voltage networks, which are owned by Red Eléctrica de España (REE) so there is only one company that transport electricity.

- Distribution and commercial costs. Distribution activities are those related to electricity transport through low-voltage networks, which are directly connected to the final consumer: households and enterprises. In contrast, commercial companies supply electricity to consumers and charge the electricity tariff. There are roughly 340 companies that distribute electricity and 260 that trade electricity (data available in 2013).

- Permanent costs. They fund the Comisión Nacional del Mercado y la Competencia (CNMC), which is the institution that guarantees proper market functioning, transparency and competitiveness.

- Extra-peninsular costs. The Canary Islands and the Balearic Islands generate additional costs that are offset by higher electricity prices all over the country.

- RECORE payment (renewable energies). They are subsidies to foster renewable energies production, which reduce energy dependence and CO2 emissions, promote self-supply, increase competitiveness and go down prices. Legal reform in 2013 included cutbacks in renewable energies subsidies in order to bring down the tariff deficit. They accounted for half of the total access tariff in 2014 and now they represent less than the 40%. In any case, they are the highest regulated costs.

- Coal subsidies. Due to the low profitability of Spanish coal mines, the government assigns subsidies to cover losses and avoid shutting down coal mines.

- Tariff deficit. It is generally seen as a factor related to tariff increases in the last few years; that is why it is important to put emphasis on it. Tariff deficit can be loosely described as the difference between electricity system revenues and recognized costs However, recognized costs are not the same as actual costs. The former refers to the established costs used to compensate the electricity system and the latter means the costs that companies incur in their activities (transport, maintenance, commercialization, distribution…). The main problem was that electricity system revenues were lower than recognized costs and the reasons why they were lower are challenging to define (see graph 6, Appendix I).

  Fabra Portela and Fabra Utray (2012) state that there are three factors that created the tariff deficit in 2000. Firstly, there were some periods of time when actual costs were higher than recognized costs in the electricity tariff. Secondly, some facilities like nuclear and hydropower plants were overpaid. Thirdly, renewable energies subsidies were too high.

As a result, the tariff deficit turned into debt that consumers had to pay back to the wholesalers, which were the holders. Consequently, the outstanding debt amounted to 23.070,4 EUR millions at the end of December 2016. Nowadays, there are three types of holders: Fondo de Amortización del Déficit Eléctrico (FADE) owns 79,9% of the total debt, financial entities that bought collection rights in 2013 have 12,6% and foreign investors own 7,5%. Although the outstanding debt amounted to 23.070,4 EUR millions in 2016, costs and revenues were in balance and the deficit is likely to vanish in less than 15 years because of the 2013 Reform, which implied higher taxes and subsidies cutbacks for renewable energies and coal (International Energy Agency, 2015).

Finally, the third component are taxes. There are two different types of taxes that are applied equally to every consumer; the electricity tax and VAT. The former was created in 1997 to levy the electricity supply and accounts for 5,1% of the electricity price before taxes. The latter is the Value Added Tax and it levies the electricity supply after the electricity tax. Although electricity could be classified as a basic need, the VAT rate is 21% and it has increased in the last years. Spanish VAT is higher than in the UK, France, Italy, Germany or Ireland. Only Portugal and Northern European countries have higher taxes.

5.2 ELECTRICITY AS AN INPUT

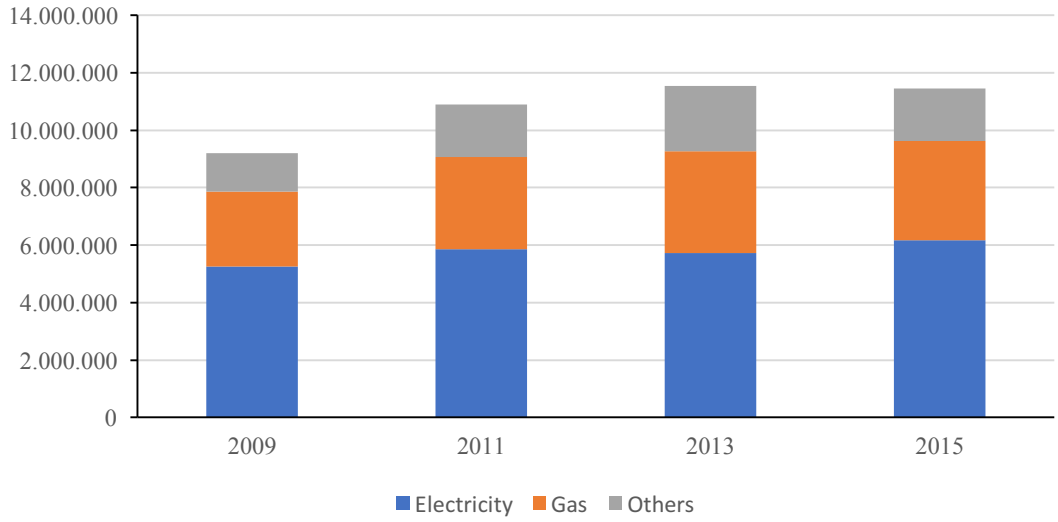
Electricity tariffs have an effect on companies' costs, hence they may determine a sector competitiveness. Despite the fact that many companies do not use electricity as one of their main inputs, those related to industrial activities, specifically manufacturing enterprises, consume more electricity than other economic sectors.

Regarding the world context, the difference between final electricity prices between Europe and its trade partners like the USA has increased in the last few years (see graph 7, Appendix I). This upward trend started in 1999, when they were lower than USA or Japan electricity prices. Research by Segarra and Batalla (2016) suggests that market regulations have been the main cause and renewable subsidies, together with other regulated costs, have had a negative effect on prices competitiveness in Europe. In addition, differences among European countries have also increased and Spain is one of the countries with higher electricity costs for certain types of consumers.

Generally speaking, energy costs represent around 2,5% of total expenses in Spanish businesses (García Bahíllo, 2017) but there are some companies whose dependence on energy is very high and electricity can represent more than the 50% of the total costs. In order to know which are the economic sectors that consume more electricity, this study divides electricity consumed in each sector (MWh) by the number of factories that operate in that sector. The biggest electricity consumers are those related to manufacturing activities: oil refinery, metallurgy, steelmaking, coking, paper production, cement and chemical industry. In contrast, companies in the service sector and households are the smallest electricity consumers.

Considering this, manufacturing enterprises are the biggest electricity consumers so it is important to quantify this input. Graph 8 represents Spanish manufacturing industry energy costs from 2009 to 2015. The most important energy sources in terms of costs were electricity (57,1%), gas (28,4%) and others (14,5%). All of them grew in absolute terms but not in relative terms; for example, gas and other energy sources represented 30,1% and 15,9% of total energy costs at the beginning of the reference period. However, electricity costs had lower presence in manufacturing companies and they represented 54% in 2009. Total costs increased by 24,6% and they amounted to 11.448.317 thousand euros in 2015.

Graph 8: Manufacturing industry energy costs (thousands €).



*Others: oil, coal, biofuel and heat.

Source: INE, 2017

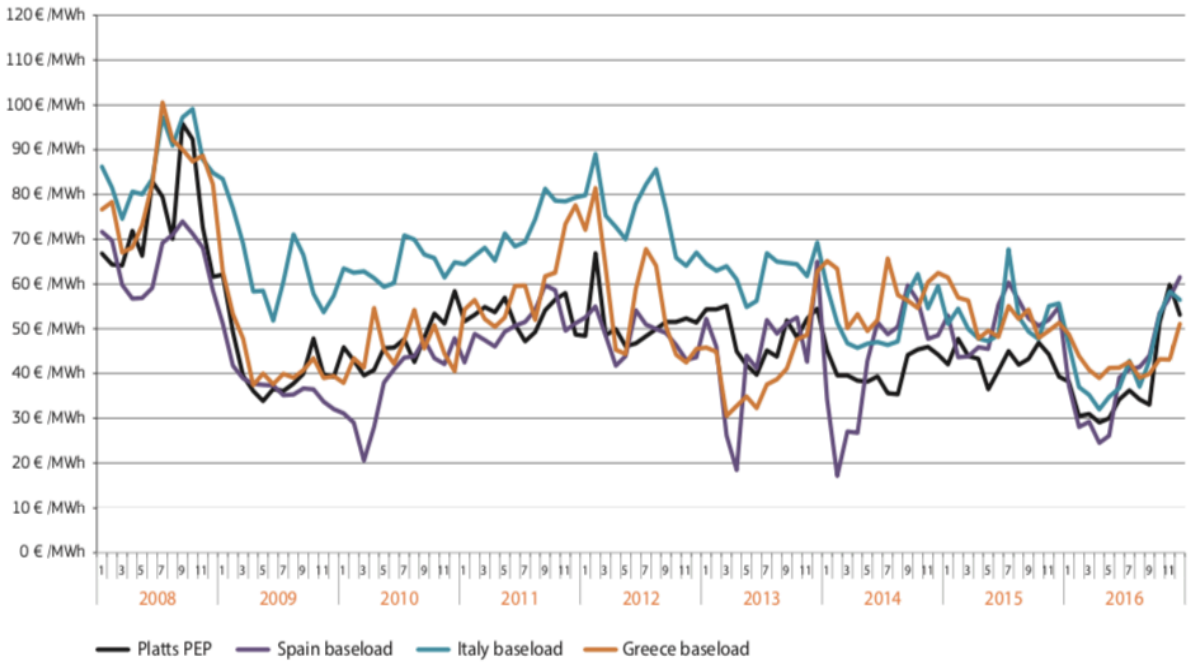
Companies with high electricity demand are grouped in a partnership called AEGE (Asociación de Empresas con Gran consumo de Energía) to defend their interests, because electricity prices are a major issue for them. AEGE is composed of 82 companies that consume 11% of the total electricity demand in Spanish Peninsula. Due to their large electricity consumption, they usually consume during the hours that prices are lower and less when hourly prices reach maximums. As a result, prices are smoother and electricity tariffs diminish for all the consumers.

As it is explained in section 5.1, there are three price components in the electricity tariff and two of them are regulated by the government: access tariff and taxes. The evolution of the three tariff components, their proportion and comparison with Europe may help to understand whether or not electricity prices are high and what is the reason why they are high.

Regarding the first electricity tariff component, OMIE market prices started a downward trend in 2008 but in the following years prices levelled off. On this basis, prices decreased by 38% from 2008 to 2016. There are many factors that may have influenced prices decrease in the wholesale market; for instance, lower electricity demand, commodity prices and the use of renewable energies. As it has been explained by previous sections of this dissertation, electricity demand per capita declined since 2008 and renewable energy production strongly rose since the same year. In addition, commodity prices have decreased by 50% in the last years according to Bloomberg Commodity Index, hence energy production costs, that influence the supply curve, could have had an effect on the final price.

Furthermore, if average wholesale electricity prices are compared to the Platts European Power Index (PEP), which embodies day ahead prices, intraday and forwards prices in the main power regions in EU, it can be seen that the Spanish wholesale market behaves in a similar way to other European countries. In fact, the Spanish monthly prices are even lower than the average most of the years and they are clearly lower than Italy and Greece prices. Consequently, we can say that the wholesale market is competitive and there are other components that rocket electricity tariffs. Graph 9 shows the monthly average wholesale electricity prices in Spain, Italy, Greece and European average.

Graph 9: Monthly average baseload wholesale electricity prices (Mwh) 2008-2016.-



Source: European Commission, 2017.

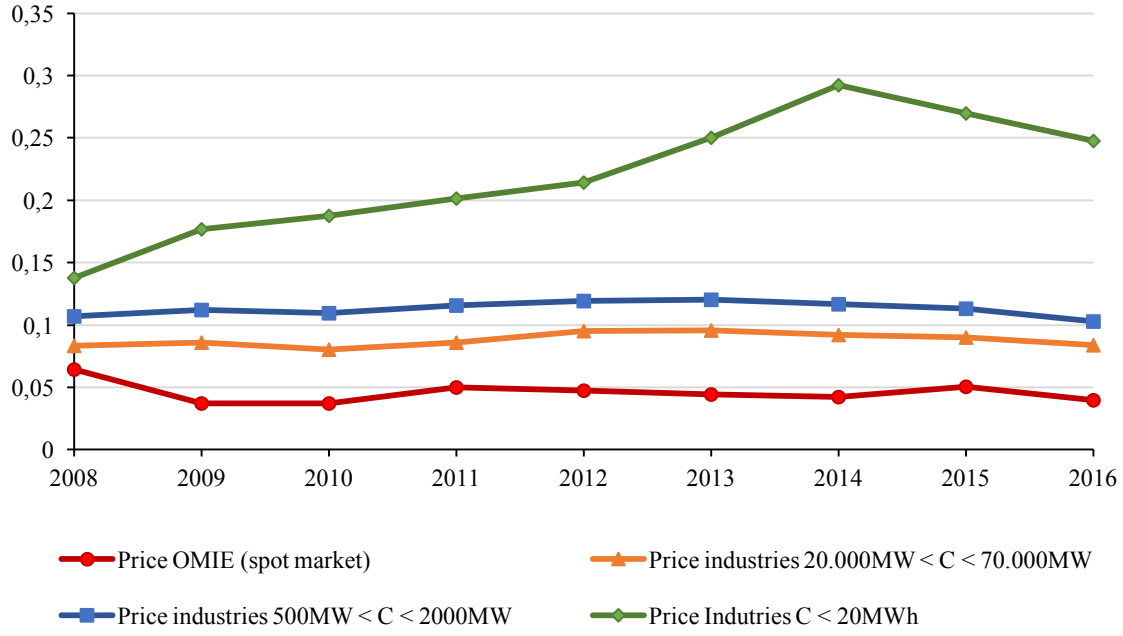
Once it is known that electricity prices in the wholesale market did not increase for the reference period and they were not higher than other European wholesale markets, the second and third tariff component must be analyzed. Nevertheless, taxes are not analyzed individually in this study because of the lack of homogeneity in Eurostat statistics that is explained in "Compilers guide on European statistics on natural gas and electricity prices, 2016". The main conclusion of this report is that taxation is different among European countries and difficult to calculate.

Despite the fact that the spot price is unique and retailers buy the electricity with the same price, the final price before taxes depend on the type of consumer because it variates regarding the power contracted: less power implies higher prices. Given this, it is necessary to differentiate between three different consumption ranges according to Eurostat: range IA for small enterprises or micro-PYMES (lower than 20MWh), range IC for medium size companies (between 200 and 2.000 MWh) and those industrial consumers that consume a lot of electricity are in range IE (between 20.000 and 75.0000 MWh). There are enterprises that consume more than 75.000 MWh but they have similar electricity prices to companies of range IE. Graph 9 shows electricity prices evolution for these three consumption ranges.

Graph 10 shows electricity prices evolution for different consumption ranges from 2008 to 2016. While prices for small enterprises rose 80%, prices for medium and big size enterprises did not undergo big changes and they decreased by 3,7% and increased by 0,6% respectively. That is why there are two facts to be highlighted. First of all, price differences among the three consumption ranges were very small in 2008 and since then the gap became bigger. These variations are explained by the regulated costs that correspond to each group because OMIE prices are the same for all of the consumption ranges and they remained stable.

Secondly, prices for small enterprises slowed down since 2014, while prices for the two other consumption groups remained constant. This decline started the same year as Ley del Sector Eléctrico was passed. This new law may have contributed to reduce electricity prices because it cut down regulated costs from renewable energy subsidies. However, it was not strong enough to reduce the huge price gap between both ranges (Consejo Económico y Social de España, 2017)

Graph 10: Electricity prices* evolution 2008-2016 (€/kWh)



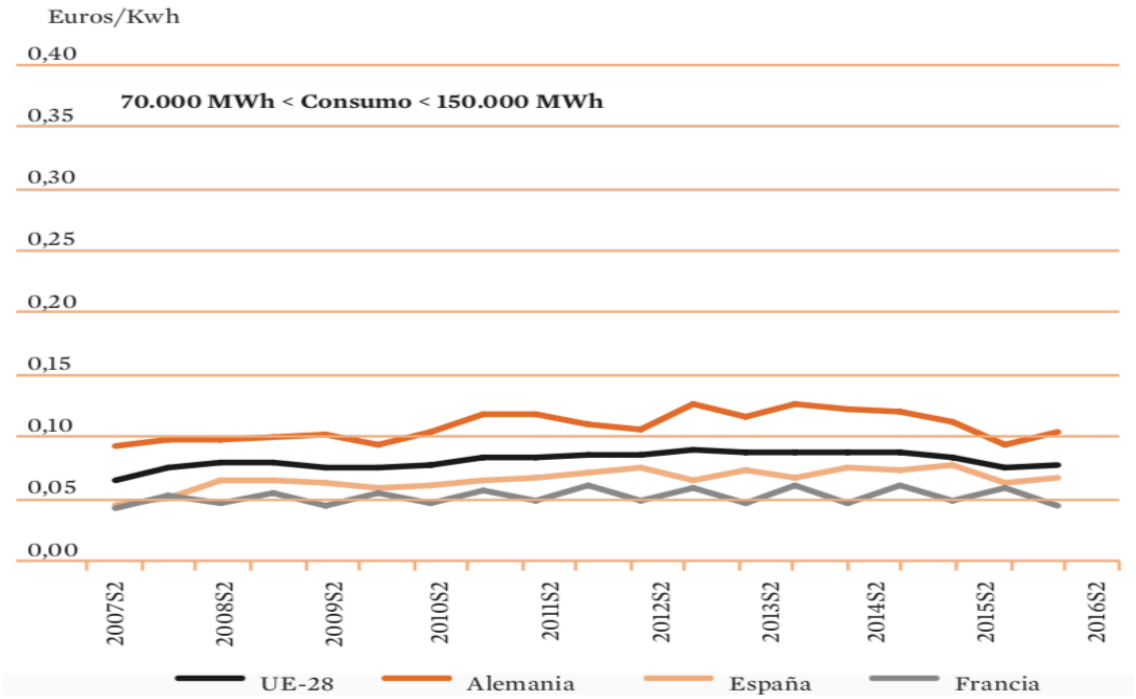
*Final price before taxes.

Source: Own, OMIE and Eurostat

On the limited data available, comparison of final electricity prices (taxes included) can be made among Spain, Germany, France and Europe for consumption range IA, IC and IF. Although there is not reliable data of final prices after taxes for range IE, this study considers range IF (between 75.000 and 150.000) as the contracted power for big companies. Price fluctuations are very similar for both ranges before taxes so it is assumed that the final price after taxes of range IF could be similar to range IE.

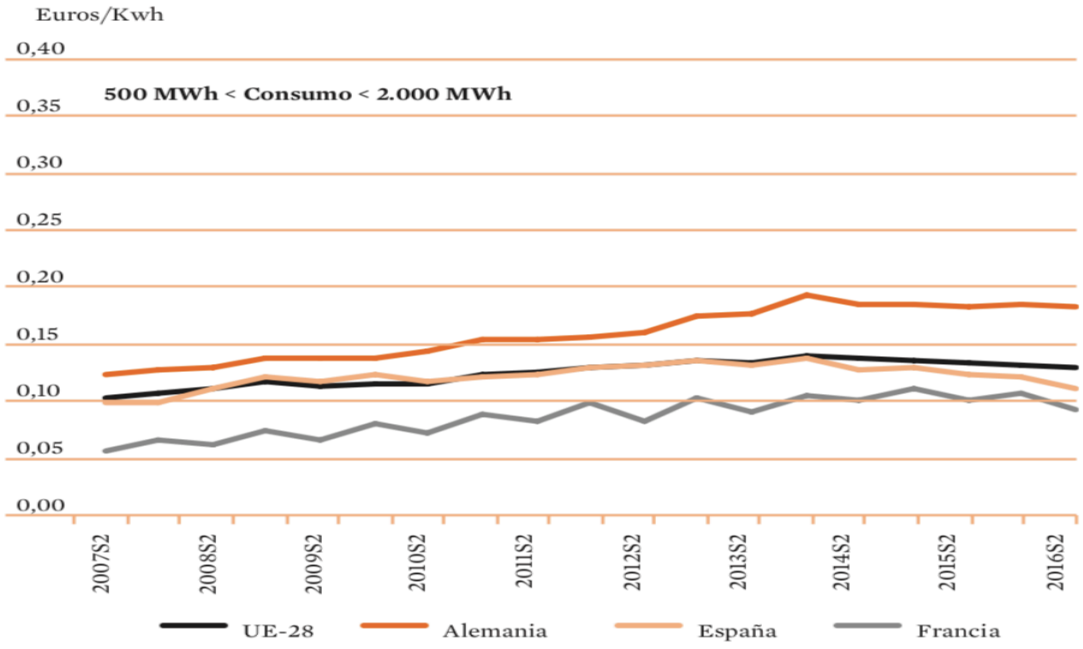
On the one hand, Spanish electricity prices for big size enterprises (range IF) stayed at the same level from 2007 to 2016 as revealed by graph 11. In 2016, they were lower than German and European average electricity prices and a little bit higher than prices in France. With respect to prices for medium companies (range IC), results are very similar: Spanish prices followed a similar path to European prices and electricity prices in Germany were higher, while in France they were lower than the rest. Moreover, price gap among the selected countries was higher for range IC. Graph 12 shows final prices for consumption range IC.

Graph 11: Final electricity prices comparison for consumption range IF, 2007-2016 (kWh).



Source: Consejo Económico y Social de España, Informe del sector eléctrico en España 2017.

Graph 12: Final electricity prices comparison for range IC, 2007-2016 (kWh).

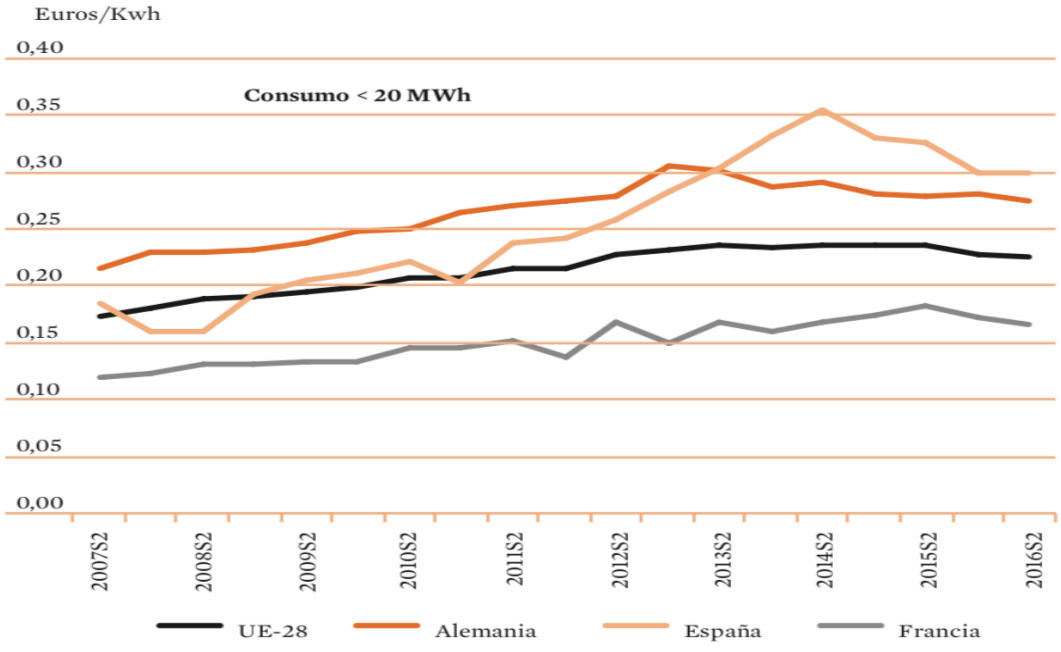


Source: Consejo Económico y Social de España, Informe del sector eléctrico en España 2017.

On the other hand, prices for small enterprises were higher than the European average, France and Germany (range IA). They fluctuate in a similar way to European prices until 2011 but they boomed since that year and overcame German electricity prices, which are one of the highest in Europe. These trends have placed Spanish small enterprises in an unfavorable competitive position with respect to electricity costs. Furthermore, the price gap among different countries was even higher than in other consumption ranges. Graphs 13 shows electricity prices evolution for small consumers.

In all, Spanish companies that consume a lot of energy are not in a worse competitive position than their direct competitors (France, Germany and other European countries) in terms of electricity costs. Likewise, electricity prices are lower than in Germany and EU and price differences are higher for medium enterprises among these countries, therefore, Spanish companies may have taken advantage of this situation. In contrast, businesses that consume less energy, pay higher electricity prices than France, Germany and other European countries, put it differently, their costs are higher and have a competitive disadvantage.

Graph 13: Final electricity prices comparison for range IA 2007-2016 (kWh).



Source: Consejo Económico y Social de España, Informe del sector eléctrico en España 2017.

6. DISCUSSION AND CONCLUSION

The aim of the study is to know the different types of energy sources, efficiency levels and businesses electricity costs in Spain to determine whether they could affect companies' performance and competitive position in the European context. Regarding primary and final energy analysis, its main purpose was to understand the situation of the energy mix in a broader sense and provide basic knowledge about the final energy sources, specially electricity, whose variations can determine not only energy costs but also the efficiency of the different types of economic sectors.

The main conclusions can be drawn from the sections with respect to efficiency and electricity costs. On the one hand, efficiency is considered as a factor that influences the energy quantity needed to carry out production activities so it affects companies' costs. The study focuses on data from the economic sectors that consume more energy, that is to say, those that could be more affected by the energy intensity levels. On the other hand, electricity prices analysis had a similar purpose: finding out the potential effects that they could have on the competitiveness. Thus, this dissertation provides three main ideas.

Firstly, energy sources have an effect on efficiency and prices. There are some primary energy sources like natural gas and renewable energies that are easier to transform into final energy sources such as electricity. In addition, the use of renewable energies is directly related to electricity prices, which go down as soon as "clean" energies production increases. That is why consuming these energy resources could be useful to avoid wasting energy and reduce prices as long as their promotion does not imply higher regulated costs in the access tariff.

Secondly, final energy intensity does not seem to be a competitive disadvantage for Spanish companies because it is lower than intensities in France, Germany, and EU average. However, the economic sectors that consume more energy in Spain, transport and industry, are more energy intense than in other countries. There are some issues that place transport efficiency at the bottom of the ranking and they need to be tackled in order to reach efficiency levels in the rest of Europe. As the "Plan Nacional de Acción de Eficiencia energética 2017-2020" report revealed, the use of more efficient means of transport, such as railways and public transport, may allow the Spanish transport sector to reach other European countries efficiency levels.

The second sector that consumes more energy is industry and it has undergone many changes in the last few years. The economic crisis negatively affected energy intensity and led the industry sector to lower efficiency rates. However, energy intensity was lower in Spain than in EU in 2015 and activities related to the manufacturing sector result in higher energy intensity levels that do not imply inefficiency problems. Considering this, the Spanish industry may not have a competitive disadvantage in terms of energy efficiency.

Thirdly, the electricity costs section is the most extensive one and deserves more explanations. The electricity tariff is composed of three different elements (energy costs, regulated costs and taxes) whose weight variates depending on the contracted power by the consumer. This study shows that prices are competitive for those enterprises with high contracted power; however, those companies with contracted power lower than 20 kW have to pay higher prices than in France, Germany and EU. The reason why these electricity prices are higher is regulated costs, which are decided by the government. This research goes against the idea that energy costs or spot market prices are high, because they are similar to other European electricity spot markets and it cannot draw conclusions about the third tariff component (taxes) due to the limited data available.

If it is assumed that small companies consume less electricity and their contracted power is lower, they are likely to have a competitive disadvantage in terms of electricity costs, which can influence their value added. Nevertheless, small businesses or micro-enterprises do not consume a lot of electricity and energy costs accounts for less than 2,5% of all their expenses according to some estimations. Considering that energy costs for small enterprises are mainly electricity costs, it may seem that they do not affect their performance greatly. In addition, these companies do not usually operate in foreign markets, therefore, they do not have to compete with companies set up in markets where electricity prices are more competitive. Finally, it should be noted that this research has not examined households as electricity consumers but high electricity tariffs could affect individual consumers' disposable income and final consumption.

Overall, the study suggests that the use of some sources of energies can improve energy efficiency and reduce electricity costs and it explains that some measures should be taken in order to reduce transport sector energy intensity and the regulated component of the electricity tariff.

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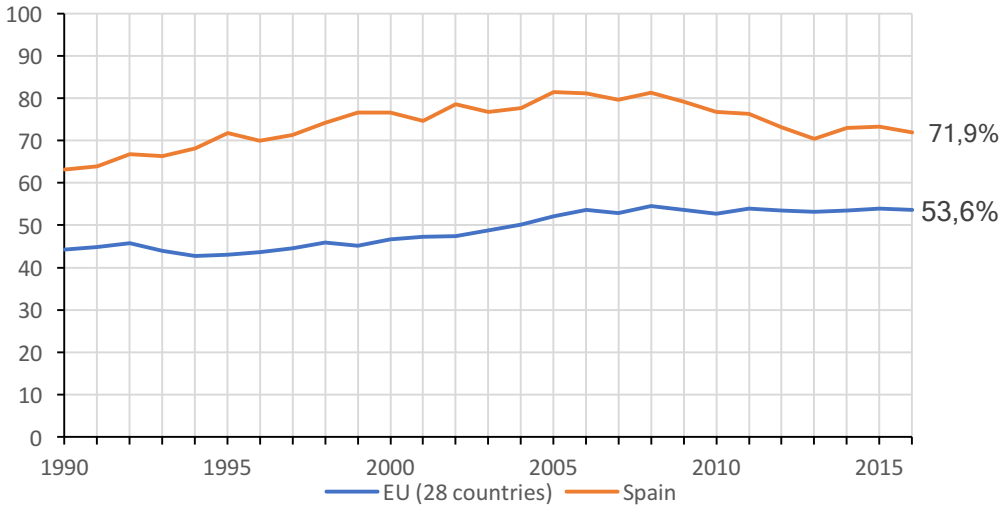
8. APPENDIX I

Graph 1: Spanish and European energy dependence, 1990-2016 (% of total demand).



Source: Own, Eurostat.

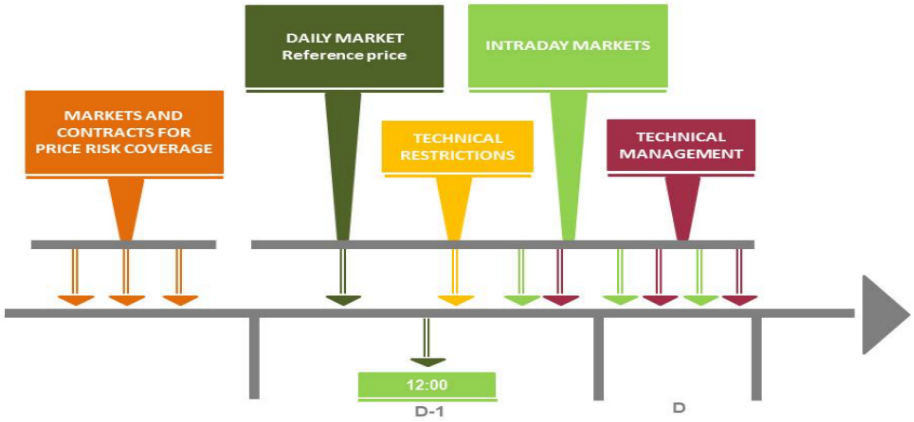
Graph 2: Energy balance 2016 (GWh)

	PENINSULA	EXTRA-PENINSULA	TOTAL
Hydropower	39168	3	39171
Nuclear power	56099	0	56099
Coal	35188	2304	37492
Fuel and gas	0	6765	6765
Combined cycle	25686	3574	29260
Hydro wind	0	18	18
Wind power	47296	399	47695
Photovoltaic solar power	7567	398	7965
Thermal solar power	5060	0	5060
Other renewable energies [1]	3416	11	3427
Cogeneration	25782	35	25817
Residues	3121	271	3392
GENERATION	**248383**	**13778**	**262161**
Pumping consume	-4819	0	-4819
Connection Peninsula-Balearic [2]	-1251	1251	0
Net international balance [3]	7667	0	7667
TOTAL DEMAND	**249980**	**15029**	**265009**

[1] It includes biogas, biomass, sea hydrowind and geothermal.
[2] Positive value: energy enters in the system; negative value: energy exits the system.
[3] Positive value: import balance; Negative value: export balance.

Source: REE

Graph 3: Time sequence for markets and processes in MIBEL.



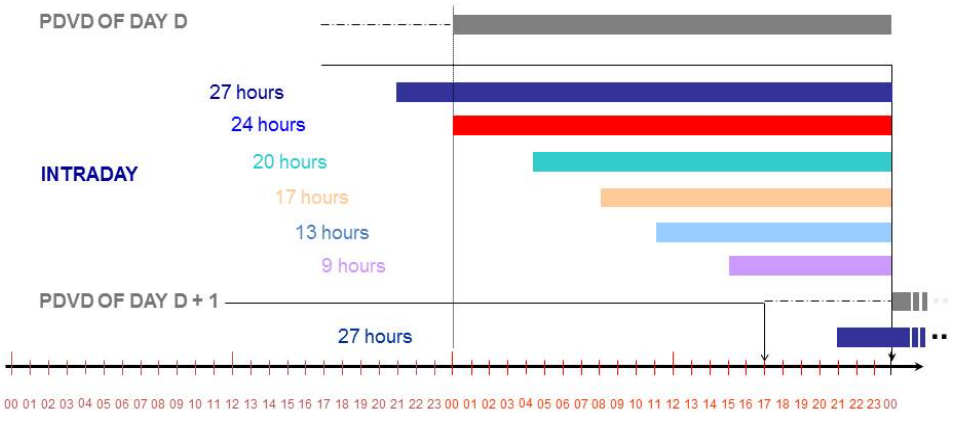
Source: OMIE, 2018

Graph 4: Variable and fixed costs of electricity sources.

	VARIABLE COSTS	FIXED COSTS
Solar power	Almost null	Very low
Wind power	Almost null	Very low
Hydropower	Very low	Medium
Nuclear power	Very low	High
Coal	Medium	Low/Medium
Combined cycle	Medium	Medium/High
Fuel/oil	Very high	Very high

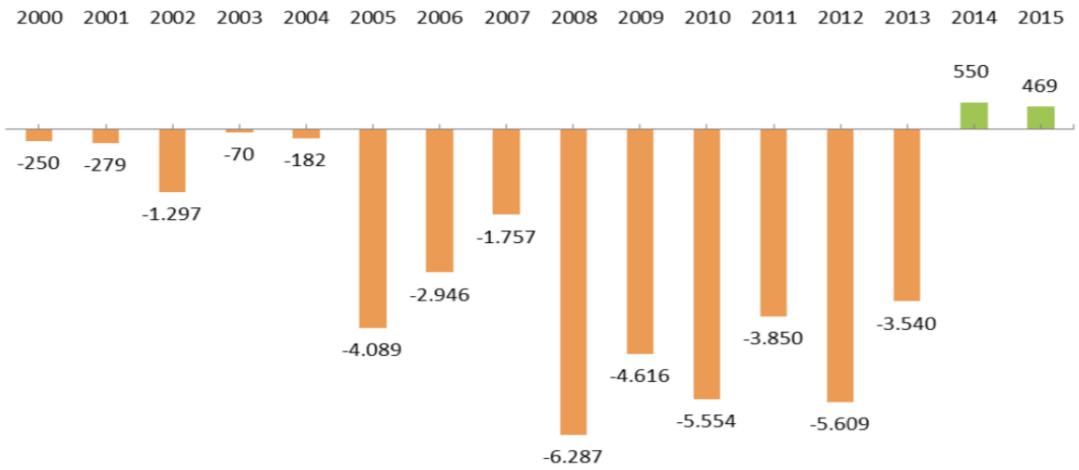
Source: Own, Energía y Sociedad.

Graph 5: Intraday market sessions



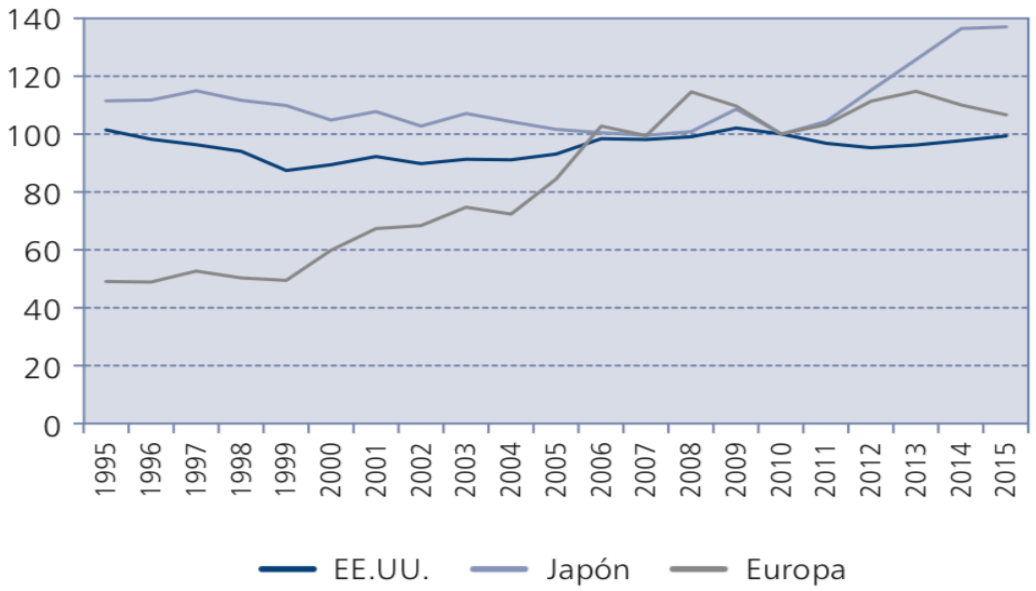
Source: OMIE, 2018

Graph 6: Deficit/surplus of the Spanish electricity system (thousands of €).



Source: CNMC, 2016

Graph 7: Electricity prices for industrial consumers (1995-2015). Index 2010=100



Source: Papeles de Economía Española, 2016.