European Energy Markets Integration and its effects on Prices and Efficiency of Electricity Producing Firms

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Thesis title:

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Date:
September 2015

Universitat de Barcelona

I. Acknowledgements and dedication

To Daniela, without her support this and many other things wouldn't be possible.

I would like to thank my supervisor, Joaquim Solà for all the guidance, patience and time, without his help this dissertation wouldn't be what it is.

The road would be also harder to cross without the help of Maria Eugenia Negrete, her suggestions and comments were of much help.

Finally, I would like to thank my friends for their support, for asking how the theses was going and for comment and question.

This work is dedicated to my parents. They were my first teachers, and have been the more dedicated ones.

II. Index

0. Introduction

Why should we be concerned about electricity markets and, particularly, about the recent reforms and their effects on prices and efficiency? Our first response to such questions is that electricity markets are currently undergoing a significant transformation. This transformation began in the late 1970s but remains far from over, not just in Europe or the European Union (EU), but also in other developed and developing countries. However, it is in the European Union that such reforms affect a heterogeneous group of countries in a very particular manner, that is, with the obligation of following a set of measures that are known as the European directives. This constitutes a great opportunity to study the effect of the transformation of electricity markets, the results that these markets it produces and eventually the effect on consumers' wealth.

In addition to legislation and public policy changes on energy it is also relevant to note other trends that are equally important and that we wish to mention here. First, in recent years important changes have taken place with respect to the sources from which electricity is produced, we refer here to renewable electricity sources that have increased their presence in European energy mixes. Solar photovoltaic electricity production of electricity accounts for around 7-8% of the total electricity produced in Italy, Greece or Germany, about 3-4% of the total electricity production in Bulgaria, Belgium or Spain, but only around 1% in The Netherlands, Portugal or France. The figures for wind power are somewhat more impressive, for example, Spain has reached a record of supply of electricity coming from windmills with a 59% (nonetheless on one particularly windy day); Denmark supplies about 39% of its electricity with wind power, but still there is a long way to go. These new and emerging realities affect a constantly changing sector. How the electricity sector is affected by the new ways of sourcing electricity? How the support schemes for renewable sources affect production costs or final prices? These and many other queries make relevant the concurrence of economists in the study of the transforming electricity sector.

Electricity is a commodity that has entered our lives and has acquired a very relevant position in more than one of our dairy activities. There is also a common belief that in advanced economies, the electricity supply is taken for granted until something goes wrong and a blackout occurs, leaving a trail of economic loses. On the other hand, we have the common worry about prices of electricity or how expensive is the electricity we consume in our country; in both relative and absolute terms, some countries of the European Union are among those paying the highest prices in the world for this commodity, and this constitutes an important worry for the European Union leaders, since it can come to jeopardize economic growth.

As it can be observed, there are a vast number of confluent points between electricity supply and economics, but in this thesis we solely expect to focus on a few of themes as follows: first, some of the main features of the reform conducted by European Union representatives, the obstacles that they have encountered and the results they have achieved; second, we sample certain factors that we think are related with the evolution of prices within the context of a liberalizing and under-construction European electricity market; and third, we focus our attention on the evolution of efficiency of the electricity producing plants, also within the context of the creation of the European electricity market.

With this enormous number of possibilities, why is it that we decided to focus on prices and efficiency of power plants? The immediate response is that these two factors are those most directly connected with consumers' wealth and that often is assumed that introduction of competition is directly related with lower prices and improvements in efficiency. In a complex sector such as that of the supplying of electricity, to what degree are these results straightforward? At first, as Newberry (2002; Joskow P. L., 2008) pointed out, the trend in Europe was to leave outside of the liberalizing and privatization trend a group of State owned services, including electricity, but as other services, such as telecommunications were indeed liberalized the grater effectiveness of the "market forces" in resource allocation was employed as an argument to set out along the long pathway toward liberalizing electricity markets in Europe, clearly stating as goals better quality and lower prices (European Commission, 1996). Even when the expected results were clear, it was also clear that the way to reach them would not be easy and that careless liberalization would lead to unwanted results.

The case for efficiency improvements related with the liberalization and reform of the electricity supply sector is to a certain extent more complex. Pollitt (2008) indicates five ways by which we can relate electricity sector reforms –unbundling of vertically integrated firms- and efficiency improvements, which will finally impact on consumers' welfare. First, firms at different stages of the production chain may confront exposure to different interest rates (due to their different needs for capital), thus a wise decision can be to separate those activities. Second, with vertically differentiated firms, regulators can take advantage of higher market transparency and reduce prices closer to costs. In addition to allocative and financial efficiency, there is also the case of performance improvements derived from increasing competition like Førsund and Kttelsen (1998) described and that we will discuss further in this introduction and particularly in the fourth chapter of the present dissertation.

0.1 Definition of the topic

We would like to take some time to explain exactly what we understand as the European electricity market and which might be its most relevant features. Beginning with a very simple definition, we can state that the European electricity market is the addition of national or regional electricity markets of countries that are part of the European Union (EU-28) or have a particular relationship with it (e.g. Norway or Switzerland). The European electricity market is subdivided into seven regional wholesale markets as follows: 1) the Central Western Market, comprising Austria, Belgium, France, Germany, The Netherlands and Switzerland; 2) the British Isles comprising the UK and Ireland; 3) Northern Europe comprising Denmark, Estonia, Finland, Latvia, Lithuania, Norway and Sweden; 4) the Apennine Peninsula comprising Italy; 5) The Iberian peninsula comprising Spain and Portugal; 6) Central eastern Europe comprising Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia and finally; 7) Southern Eastern Europe comprising Greece.

Beyond the definition of the participant countries, the main features of the creation and enhancement of the European electricity market including the increasing exchange of electric power among its members, between 2013 and 2014, for example, cross-border physical power flows reached an average of 29.3 TWh, being a 10% higher than the previous year. We can cite three basic trends: improvement of liquidity, growing interdependency and further integration of electricity markets within the EU and partner countries. Further integration might help some countries to compensate, for example, for high wholesale prices (e.g. Poland or the UK lately), and the impact on retail prices and consumers' welfare can be direct (European Commission, 2014). In addition to their role in the regional markets and in order to better characterize some of the relevant participants of this European electricity market, we would like to indicate here as clear net importers of electricity the following countries: Italy, UK and Ireland, the Netherlands, Belgium, Denmark, Portugal, Austria, Croatia, Slovenia, Montenegro, Greece, Macedonia, Serbia, Hungary, Slovakia and Poland. On the other hand, the group of countries that are net exporters of electric power within the market are: Sweden, Norway, Estonia, Germany, Switzerland, Czech Republic, France, Spain, Bosnia and Herzegovina, Bulgaria and Romania.

The prior information is a snapshot of the current state of exchanges within the European electricity market, but we wish to take some space here to succinctly address the creation of this market. We refer to the creation of the European Electricity market as the group of reforms leaded by the European Commission and conducted by all member states of the EU (and other associated countries) that shared following goals: through competition, the idea was to generate the conditions for internal efficiency improvements (firm level) as well as to improve market efficiency (external), in addition due to the increase in competition prices will approach costs, resulting all together in increasing costumers welfare (Jamasb & Pollitt, 2005).

These reforms have undergone different moments in synchronicity with world trends and experiences outside Europe. The first stage of the reforms occurred during the 1980's and arose as a consequence of the oil crisis in the precedent decade. Particularly in Europe it started in 1988 with the publication of the White Paper of Internal Market and Industrial Cooperation. In the 1996-98 arrived the first energy package mandating a number of reforms in all member States, the second and third energy packages arrived in 2003 and 2007.

The most important steps towards the creation of the electricity markets can be summed up in the approval of the three energy packages. In these packages the main reforms were to distinguish the activities that were potentially competitive from those that were not, mandate the free access of third parties in non-competitive activities to avoid discriminatory behaviour, remove barriers of entry to alternative suppliers or producers of electric power (free up supply side of the industry), remove gradually any restrictions that prevented costumers changing supplier and introducing independent regulators to monitor the sector.

As we noted previously, the principal goals of the reforms were to impact in efficiency of the energy-producing firms (internal), create the conditions under which to improve market efficiency as well as to create the conditions for price contention or even decrease. In this dissertation we particularly focus our analysis in efficiency improvements in electricity-producing firms and in the evolution of prices, as they relate with the proposed reforms.

0.2 Outline of the dissertation

In the second chapter of this dissertation we extensively address the most recent round of approval of electricity market reforms, known as the third energy package. We speak of the actors that were relevant for such approval, their preferred outcomes and what was finally approved. To do this we use qualitative methods to venture beyond the description of what happened and to explain the conditions that rendered the entire process be favourable for the European Commission proposal.

In the third chapter of the dissertation we deal with the issue of electricity prices in European countries. We propose a group of variables as drivers of electricity prices, we discuss the relationship that these variables might have with electricity prices and we conduct an analysis in which we set up a model to test the possible relation of these drivers with the prices paid by industrial and household costumers. In particular we test the relationship that might exist between the suppliers' ownership and the prices charged to final consumers, as well as the quantity of primary energy available and the exchanges of electricity or the concentration of the electricity markets and the amount of renewable energy supplied in the different European countries. To test our model and the relationship of the proposed drivers with net prices we constructed a panel data that covers the years from 2001 to 2010 a few years before and after the second and the third energy packages, the last major reform packages in European countries.

Finally in Chapter 4 we focus on dealing with what we consider to be one of the most important consequences of liberalizing the electricity sector, which is the possible changes in the firms' efficiency. Particularly we focus in internal efficiency, that is, the more efficient ways that power plants may find to continue with their activity in a more competitive context. Said in a different way, due the increasing competition because of the liberalization measures, producers of electricity must adjust their production methods to keep been competitive or even gain competitiveness, this, in turn, is connected with gains in consumers welfare. In this case we first make a review of the best and most used methods to assess changes in the performance (efficiency) of firms, we set up a database that takes in account three different years of 130 power plants in eighteen European countries, sixteen of them European Union members and two non-EU members but important partners in what concerns to electricity markets (Norway and Switzerland); the three years taken in account are 2004, 2009 and 2013, the database is not a panel data, but observations made in three different points in time to tests each of the years while the results are used to calculate the Malmquist indexes that will give tell us how firms move relative to the frontier and if the frontier is actually moving.

0.3 State of the art

The literature that deals the liberalization of electricity markets is vast, not only because it is a subject with defenders and objectors, but also because there are many studies that concern the liberalization of energy and electricity markets from very different perspectives. During the last few decades, the interest in energy markets in the social sciences has exhibited two peaks, the first in 1980 and the second after 2010, coinciding with the peaks of crude oil prices (Hughes & Lipscy, 2013). Even if we restrain the discussion within the bounds of the perspective of economics, the possible particularities and viewpoints are numerous. However, before focusing on what economics has stated, we would like to assign some space and time to voice our opinion with respect to the discussion on the liberalization of electricity markets from the political science viewpoint, that is, a supporting character of economics in the present thesis.

When addressing the integration of electricity markets, the main woe of political scientists is the process of European integration and the manner in which this might affect governance within the context of the constant construction of new European realities. Eising (1999) informs, for example, the existence of two twin, or contemporary, processes: the liberalization of energy markets and European integration; when both processes advance, institutions and power, thus governance, change their patterns, modifying not only the basic settings, but also the level of government to which this might refer, ranging from national governments to European-level authorities. European integration is the point at which economics and political science cross roads more clearly and are concerned about the consequences that such a process might have on different areas for citizens or consumers (Pollack, 2010; Baldwin & Wyplosz, 2009).

Taking the previous context into account and according to some scholars, stress is placed on the relevance of non-State actors in terms of strengthening the position of supranational entities such as the European Commission or new supranational regulatory entities (Eikeland, 2011; de Hauteclocque & Rious, 2009). The new institutional and governance set-up or arrangement is, according to these viewpoints, potentially welfare-improving and can prevent possible position abuse from the major or incumbent electricity companies.

The first of the intended consequences in consumer welfare that we wish to study is the effect on final electricity prices. This is doubtlessly one of the most pertinent issues when approaching electricity market liberalization. Nonetheless there are very different approaches; from the statistical point of view, the main goal is to predict the behavior of electricity prices with some anticipation, that is, intra- or within-day. ARIMA, GARCH, or other types of time series models are applied to forecasting prices, such as the day-ahead ARIMA model presented by Contreras et al. (2003) or the GARCH model presented by Garcia et al. (2005), both possessing one-day forecast predictability and both focusing on the series' seasonal behavior and the series' previous values as the main predictability component.

But what if we were to proceed beyond the spot markets and beyond intra-day or intra-week price analysis? Because liberalization has exposed consumers to more volatile prices, some scholars have also analyzed the possible changes in demand by, in turn, analyzing elasticity of demand. Kirschen et al. (2000), for example, use cross-elasticities to analyze the possible response of consumers to more volatile electricity prices and to consider elasticity as a possible factor of price setting.

A different approach to changing prices within the context of market liberalization is the core of studies that attempts to study the way that certain factors will impact prices (thus, consumer welfare) within the emerging context of competitive markets. In these types of studies, we can cite that of Fabbri et al. (2005), in which the authors utilize the costs of wind energy and the prices at which they sell this energy. One of the primary concerns once the liberalization process began was the issue of how electricity firms' performance would change and, in particular, how this might affect final prices; Pollitt (1995) addresses this issue by searching for changes in costs in recently privatized firms, and finds a slim difference between private and public firms, the former those that charge slightly higher prices. Villalonga (2000) finds that these effects might be transitional, and after five years of negative changes, these might change after eight years of private ownership. With respect to what concerns other possible price-affecting drivers or factors, some additional studies have been performed to test two divergent forces regarding the possible effect of renewable energies entering into the energy mix. The first of these divergent forces is the effect that some governmental support schemes might exert on final prices (Bryce, 2012), such as feed-in tariffs. According to scholars who defend this viewpoint, the higher the proportion of renewable energies (particularly solar and wind), the higher the prices would be. The other effect is what has been termed the "merit order effect", which might appear when the network operator bestows preference on production methods with lower marginal costs: on windy or sunny days, the marginal cost of these renewable electricities is particularly low (Sensfuß, Ragwitz, & Genoese, 2008; Sáenz de Miera, del Río González , & Vizcaíno, 2008).

Finally, in terms of changes in the performance of energy-producing firms, there is a group of interesting studies covering the subject from very different vantage points and employing very different tools to assess this performance. In direct relation with the liberalization process, the first studies that attempted to seriously prove the effects of policy reform on performance were those conducted in the late nineties, such as that conducted by Pollitt (1995), in which the author tested the performance of a large number of private and public electricity operators. Pollitt's main interest was to test whether there is a difference in technical efficiency if the firm is owned by private initiative or if it is public; his finding is that there are no significant differences. Also, among the first group of studies, there is that of Førsund and Kittelsen (1998), in which the authors utilize non-parametric techniques, such as Data envelopment analysis (DEA), to acknowledge changes in the performance of a group of Norwegian electricity distribution utilities; additionally, Førsund and Kittelsen also calculate the Malmquist indexes of different pairs of observed years to assess whether changes in performance are due to improvements in the way firms do things or are due to technological changes (movements in the production frontier). The first study of Førsund and Kittelsen does not take in account the, at the time, recent trend of reforms; they do, however, take such a context into account in a later paper, in which the authors directly address the question of whether or not the reform might exert an effect on electricity distribution utilities (Edvardsen, Førsund, Hansen, Kittelsen, & Neurauter, 2006).

As we mentioned previously, with respect to acknowledging how performance is affected by different factors, and particularly by reforms, in the electricity sector, there has also been a constant development of new tools and the improvement of others in order to better assess the changes in the efficiency of different firms. The most frequently used tools to assess the performance of different firms comprise DEA, first developed by Farrell (1957) and reintroduced and improved by Coelli (2005; Pollitt M. G., 1995; Førsund & Kittelsen, 1998), In a regular manner, this technique is also accompanied by Stochastic Frontier Analysis (SFA), for tool's cross-checking purposes. However, it is noteworthy that that the former is a more flexible, more powerful, and easier-to-use methodology (Coelli & Lawrence, 2006). This is one of the main reasons why we decided to employ DEA as one of our principal tools in the Chapter 4 of the present dissertation.

0.4 Objectives and limitations of the thesis

Now that we have stated the relevance of the study of the electricity sector, justified the study of the subject, and addressed what different authors have said about the topics that we study in this dissertation, we would like to close this present introductory chapter by clearly stating the main objectives of the thesis, as well as some of the limitations of it; the latter constitute the seed of future work in the short and medium term. We present the objectives in the order in which we treat them in this dissertation, and not necessarily in order or relevance.

The first objective of the present thesis is to describe the electricity sector, together with disclosing the particularities of this sector from the viewpoint of economics, the sector's complexity, and why it is said to be a strategic sector. We begin with addressing the relevance of the electricity sector and the manner in which it has become relevant in nearly all activities of our daily life.

After the descriptive part of the thesis, we also shed some light on the bargaining process that took place during the last reform stage or during the construction of the European electricity market. We focus on the negotiation and results of the third energy package, because there were relevant changes during it and as a consequence of the process. At this point, we identify the relevant actors, discuss its strategic alternatives, the outcomes related with its strategic combinations, and finally address the actors' preferences over possible outcomes. We wished to ascertain the conditions under which the third energy package for the improvement of the European electricity market was approved. In other words, we were searching for the principal changes that took place during the 2003–2007 period that rendered the negotiation of a third energy package possible, taking in account the previous resistance to such a negotiation. We state two hypotheses that led our work in the Chapter 2 of this dissertation: first, the Commission's proposal of a third energy package of policies was finally approved because the coordination of different actors (demand side organizations) was more effective than some national State interests, and second, the relative success of the process might be attributed to the leading role of the European Commission and to its increasing relevance in policy-making in the European Union.

In Chapter 3 of this dissertation, we first talk about the way prices are stated in Europe. One of the features to include while dealing with electricity markets is that the whole package of reforms has not yet been finished; in particular, the single electricity market continues to be divided into seven different regional markets. We then characterize the different forms into which the European energy markets are organized, the way that these different forms condition the organization of the sole European Energy Market. We also propose a set of factors that may exert an influence on the fluctuation of electricity prices in European countries; we discuss the way that such factors affect prices. We set a model and a dataset with which we attempt to measure or quantify the influence of the main factors discussed and test for the impact that these really have on electricity energy prices.

Finally, the fourth set of objectives that we proposed in this dissertation is related with efficiency improvements in energy-producing firms. We first discuss the most frequently employed measures in the literature to assess changes in efficiency and the cases in which these methods have been utilized in electricity- or energy- related studies. We then discuss some advantages and drawbacks of the different measures and indicate two of the best ones, which we will employ in the empirical part of this chapter. The third objective of the fourth part of this dissertation is to focus on the empirical data that will allow us to compare the different methods previously selected, we rank the different countries and energy-producing firms, and attempt the assess the most likely causes of improvements in production efficiency. Finally, we contrast our results with the expectations at the beginning of the energy sector reform, and of the electricity-producing firms in particular.

Finally, we would like to end this introductory chapter by speaking of certain boundaries that we encountered during the elaboration of this dissertation and that might constitute the seed of future research. In the Conclusions chapter at the end of the dissertation, we extend this section somewhat more, but now we only point out the most relevant of these.

First, and perhaps most importantly, the process of reforms in the electricity (and energy) sectors in Europe has not yet concluded. Currently, it appears that although there have been many and very important changes, the completion of the process is currently far from its end. This possesses an important implication for those dedicated to the study of the electricity sector in Europe, and perhaps worldwide, that is, studies on this subject can only present partial results. Even if these partial results were to accumulate and sketch a picture of the electricity sector, this is in reality an additional feature that aids in qualifying the sector as complex but, at the same time, fascinating.

Second, we have presented the discussion and the testing of a group of price drivers that we thought were the most important ones; however, there remain certain others that are equally interesting and that can and should be discussed at future opportunities. In particular, the effect comes to mind that an innovative environment might exert on electricity prices, for example, the effect that R&D might exert on productivity improvements, thus on production efficiency. Also, a quite appealing discussion has emerged recently regarding the effect that the CO_2 emissions trade in Europe may have on wholesale and final electricity prices.

Finally, there is a very attractive discussion on the methods that have been utilized to measure efficiency changes in different firms or branches. Such a discussion proceeds beyond what is the best method and enters into the fascinating terrain of how these methods can be improved to achieve more and better results while applying these methods. This discussion is closely related with the availability and development of software to bring about the applicability of these methods.

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Chapter 1

Electricity markets: Electricity as a commodity, as an economic sector and as an industry

Abstract:
In this chapter, we describe the role of electricity markets, the main characteristics of electricity as a commodity, and the main features of this particular and strategic economic sector, as well as the role it plays in the wider energy industry. We first characterize the electricity market and state its relevance in everyday life, as well as its study from the economic point of view. We later speak about the consumption of electricity in developed countries and particularly in Spain. Third, we address the recent reforms that this sector has undergone in recent decades, the reason why it was decided upon, and the main characteristics and main models that have been put forth to explain it. We also produce a description of the main components of the typical electricity bill in developed countries. Finally, we close this chapter with some concluding remarks.

1.0 Introduction

In this first chapter, we would like to describe the main subject of study of the present dissertation and the different aspects surrounding this object of study, that is, electricity. In the following pages of this chapter, we will describe in depth the role of electricity as a commodity and how electricity production, transmission, and retail activity is organized, and finally, how electricity interacts as part of the energy industry.

The electricity sector is both complex and strategic. We need electricity on daily basis and at nearly all times during the 24 hours of the day. "Electricity is essential but it has not been always so. There are vast benefits, for sure, but also a high degree of dependency that we take for granted until a blackout occurs" (Hausman, Hertner, & Wilkins, 2008). We are constantly plugged in, but electricity possesses very important particularities as a commodity, and this creates also particularities in the way that the electricity sector is organized in terms of production, transport, transmission, and retail operations.

This chapter consists of the following parts: first, we characterize the electricity markets, their main features, their basic structure, how they operates, and how they are managed; second, we explain why we think the electricity sector is important; third, we talk about the role of electricity within the energy sector; fourth, we speak a little about energy mixes around Europe, together with some presentation of figures on electricity consumption of electricity; fifth, we talk about recent trends on the reforms in electricity markets and what the main goals of this are, while introducing competing in an efficient manner; sixth, we present the main components of the electricity bill and the contribution of these factors to the final amount paid by consumers in different countries; seventh, we address the electricity industry and its relationship with finances, and finally, we offer some concluding remarks.

1.0 Electricity Markets, a simple characterization.

We have decided to call this a simple characterization because we will only outline the main characteristics of electricity markets. During the remainder of the chapter and of the dissertation, we delve deeper into just a few of the most important issues.

The use of electricity for household and other daily applications is one of the most important revolutions of modern times (Harris, 2006). Electricity has been known from ancient times in the form of static electricity, but it was not until two thousand years later (until the 1880s) that it was used as power for motors and for lighting; the first public building in the world to employ electricity for lighting was the Savoy Theatre in London, in 1889. The initial years of the electricity industry were characterized by rapid innovations and development, as well as a high rate of new companies, while the immediate following step was in reality electricity standardization to 60 Hz.

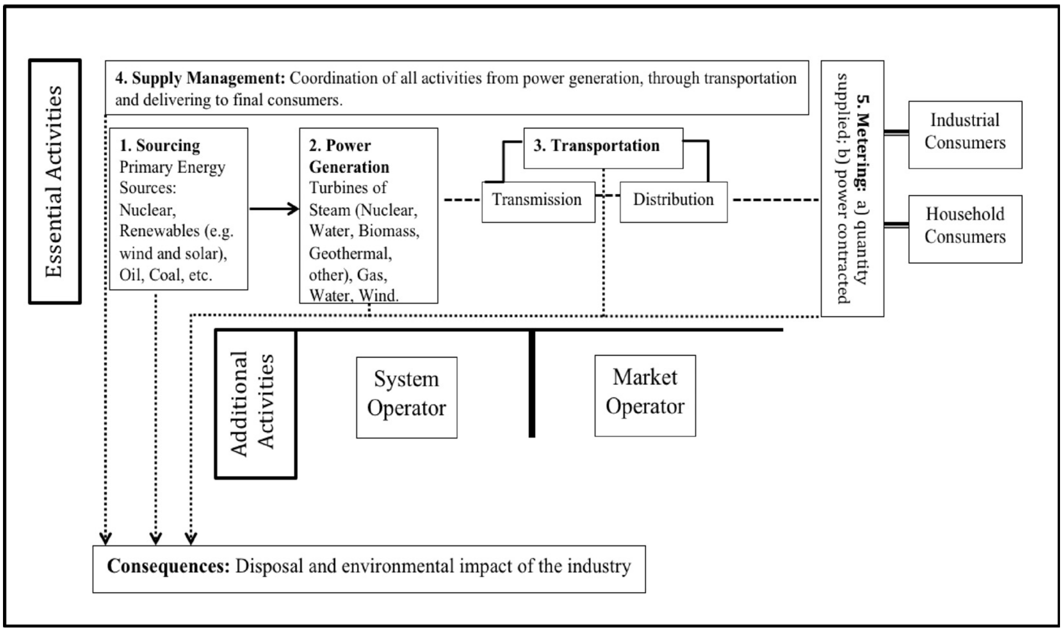
One of the main features of electricity as a commodity is the problem of storage. Other commodities can cope with mismatching production and demand with stock management; this is currently impossible with electricity; a common assumption is that electricity must be consumed as it is produced, storing electricity in large quantities is just not economically unviable. In the first place, for a characterization of the electricity market, it might be useful to describe the lifecycle of electric power. To do so, we will follow the description offered by Harris (2006), in that the weight of such a description lies on economics rather than on engineering, policy-making, or another area. When appropriate, we will also stress the main economic features of the particular stage of the electricity lifecycle and note which of these cycles, and why these cycles, have been susceptible to liberalization for competition.

The lifecycle of electric power entails some essential stages, certain additional activities, and some consequences. The first ones are as follows: a) energy sourcing; b) power generation; c) network transportation (high and low voltage); d) management of supply and, finally e) consumption. The additional activities that we would like to refer to are i) the system operation; ii) market operation, and iii) metering. While finally, in terms of impact or consequences, the disposal and environmental impact of the whole process is noteworthy.

The cycle, then, begins with energy sourcing, that is, the exploitation of a given asset to create electric power. Assets can be extracted (e.g., oil, coal, uranium), harvested (e.g., energy crops), or captured (e.g., wind, water, sunlight). Due these very different realities of energy sources, there can also be long and complex processes before the source of energy arrives at power plants.

The second step in this condensed electricity lifecycle is power generation, that is, "the process by which an in situ energy supply is converted into electricity and delivered into the electricity transportation infrastructure". A crucial consideration at this stage is the necessary coordination between production and demand, in order to avoid problems with grid load, power losses, and voltage stability. It is at this stage that the first complications in production and supply arise, e.g., physical accessibility to the grid and consumers. In recent years, with the development of new methods and new production technologies (i.e., combined cycle, wind, or solar photovoltaics), the decentralization of decision-making or the development of fuel markets (rendering them more accessible) has reduced the economies of scale, making small plants more competitive and capable of participating in the market (Nieto & Solà, 2003).

Fig 1.1



Source: Own elaboration based in (Harris, 2006; Nieto & Solà, 2003)

Once electricity is produced, the next step in its life cycle is its transport, its transmission, and its distribution. This particular step entails its own complications, ranging from the need for physical equipment, such as poles and high towers, to property and use rights for the terrains involved (opposition due to landscape modification); to do all of these, the support of different levels of government is often required. Finally, one of the most important features of electricity transportation is the fact that this particular activity is a natural monopoly, thus subject to strong regulations, particularly regarding prices.

At this point, the step after that of transportation is supply management, that is, final consumers only pay for a retailed product and are not required to do anything else in order to receive electricity from the supplier, which arranges everything else, from generation to transportation and delivery.

One of the essential activities that can be also considered as part of the supply chain is the systems operation, by this we are referring to the electrical management of the system. As already stated, supply and demand must be coordinated and perfectly and continuously matched, within a margin of only seconds. The latter should be the task of a single operator, in that there is no margin for interactions.
An additional step that is also essential is the market operation, which involves commercial exchanges of electricity and capacity trading between producers and the system operator, as well as the coordination of all agents. It is also worth mentioning that in the more mature and unbundled markets, electricity is traded many times on its way from production to consumption.
Of course, in order to ascertain how much consumers should pay for the electricity delivered to them, one of the crucial activities is metering. This is the only source of revenue and can sometimes be a complicated process, with many factors at stake (e.g., quantity of electricity delivered, amount of power contracted). Metering occurs twice during the whole cycle: in the wholesale market when producers sell their output to the owner of the transportation grid, and when these retailing companies sell to final consumers. It was not until the decade of the 1990 that it occurred to someone that retailing could be a separate activity and that competition could be introduced at that stage (Hunt, 2002).
Finally, while not a particular step in the life cycle of electricity, although an extremely relevant consequence of it, we find the disposal and environmental impact of the whole activity. It is also true that in recent times, the environmental aspect of electricity production has gained relevance and currently is found far beyond the acknowledgement of the impact itself and heading toward the reduction of such an impact.

1.2 Why is the Electricity sector important?

Electricity is an important resource, but the companies and the industry in general that produce and deliver it are imperfect. Thus, electricity is subject to failures and blackouts. Modern society depends on the reliability of electricity as an essential resource for national security, health, welfare, communications, finance, transportation, the food and water supply, heating, cooling, and lighting; many appliances require an electricity supply, and computers, electronics, and businesses, as well as leisure and entertainment, also use electricity to run. Nearly all aspects of modern human life depend to some extent on electricity. Electric power has also substituted for, to some extent, other, more polluting sources of energy, changing the popular concept of modernization, from smoking chimneys to a more high-tech panorama (even if some smoking chimneys remain behind that high-tech picture).

As we have already inferred, the electricity sector is quite complex because of its high technification at all of its life-cycle stages (production, transmission, and distribution). We have also mentioned that electricity a strategic sector, and we should understand this in the same sense as the military employs it; due to this, it is also a sector that is heavily regulated (Nieto & Solà, 2003). The electricity sector has gained relevance in the last decade or so, and this has also been reflected in the number of studies that have appeared lately; while in the late nineteens and first years of our century the more appreciated examples for regulatory studies or grid economies were railway grids or telecommunications, we have seen an increasing interest in the specifics of the electricity sector regulation (or in some cases de-regulation), the sector's challenges and likely future. Beyond technical and regulatory details that may help the sector to be more appealing for scholars, it is also true that higher oil prices has contribute to an increasing interest for renewable sources of energy and particularly for renewable sources to produce electricity.

1.2.1 Electricity within the energy industry

The electricity sector is solely one part of a broader industry, i.e., the energy industry; this industry comprises all activities related with energy, such as production and the sale of energy, extraction of fossil fuels, manufacturing and refining, as well as distribution. Electricity is a secondary form of energy; it is transformed energy that derives from certain sources of primary energy, such as oil, natural gas, uranium, or others. Not all primary energy is utilized for generating electricity; of course, some is used with other purposes in mind (e.g., transport or heating). We present in the following paragraphs a catalogue of the energy sector in an attempt to distinguish in which situations electricity plays a role. Sometimes, though, in the name of simplicity, we succinctly note the main activities of the subsector:

Petroleum industry. This comprises the extraction, refinery, and commercialization of both crude oil and manufactured fuels for different activities, such as transport, the manufacturing industry, construction, and others.

Gas industry. This comprises both natural gas extraction and the manufacture of coal gas (gas made from coal for household and industrial purposes). As in the case of the petroleum industry, in this case we must include also the distribution and retailing of gas.

Electrical power industry. In this case, we will include its four main activities, namely, the generation, transmission, distribution, and sale of electric power, for industries, households, and businesses. In a wider sense, we should include here all types of sources of electricity power, renewable and non-renewable sources, but for the sake of clarity, we will divide the sector into two additional categories.

Nuclear industry. This is the activity that mainly employs nuclear reactions to release nuclear energy for creating electrical power. It comprises the generation of electrical power, and the treatment of power sources and radioactive waste.

Renewable energy industry. At this point, we refer mainly to alternative and sustainable energy companies, including those of more recent development, such as wind and solar energy (mainly for electricity production), but also some renewables, but not as new, such as hydroelectric power. We also should include in this class some alternative fuels, such methanol or ethanol, as differentiated from conventional fossil fuels.

Coal industry. We also reserved a part of the classification for the coal industry; even though it has been losing relevance in developed countries, it has also maintained a certain role in the energy industry. The main concerns with respect to the exploitation of this energy source are high levels of pollution and other negative externalities that accompany it, but its relative abundance in some countries deters them from stopping its exploitation. According to the U.S. Energy Information Administration, no European country is found among the top five coal producers, these being China, the U.S., India, Australia and Indonesia, with China leading an exponential increase in coal extraction and exploitation from the year 2000 onward.

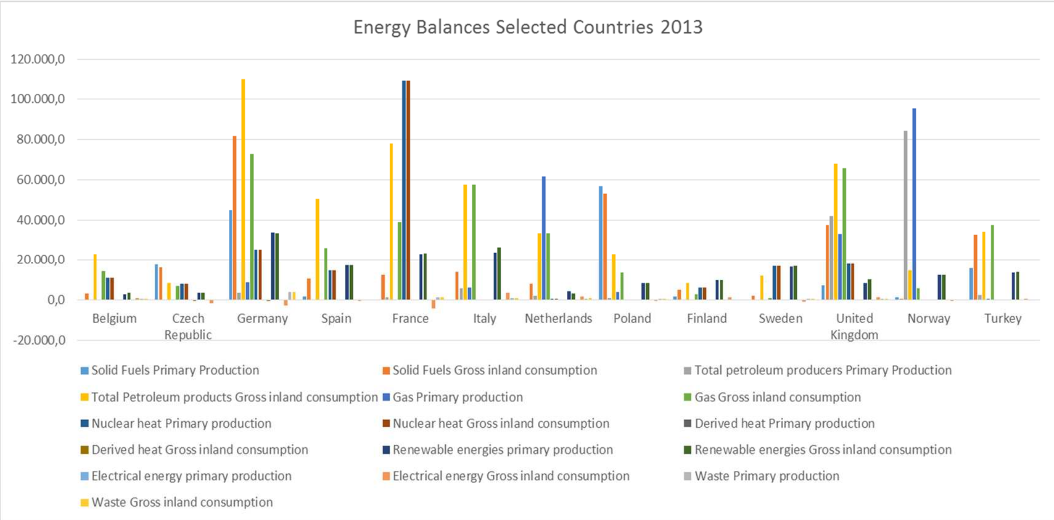
Other related industries. Finally in this part of the catalogue, we are mainly thinking of traditional sources of energy, e.g., the combustion of wood and other materials for heating and cooking purposes. These activities are increasingly residual, but continue to be fairly visible in poor countries.

1.2.2 Energy mix throughout Europe

As we can observe for the previous categorization, the energy industry is fairly intricate, and at present, the production of electricity can be found in different classes of the catalogue, e.g., electrical power, nuclear power, or in the renewable energy industry. In the following paragraphs, we will comment on some highlights of the energy balances of certain countries.

As we can see in the figure below, France is by far the country with more nuclear heat production and consumption, this doubtlessly the main characteristic of the French energy mix. France is also the second greatest consumer of petroleum-derived products, and also the second biggest consumer of energy in Europe.

Fig 1.2



Source: Own elaboration with data from Eurostat.

It is also worth to comment that Germany is the first consumer of petroleum derived products and also the first consumer of gas and solid fuel. It is doubtlessly the first consumer of energy in Europe (324,271.6 TOE [1]). Germany is also the first producer and consumer of renewable energies, followed by Italy, France and Spain.

It is also noteworthy that Germany is the first consumer of petroleum-derived products and also the first consumer of gas and solid fuel. It is doubtlessly the first consumer of energy in Europe (324,271.6 TOE). Germany is also the first producer and consumer of renewable energies, followed by Italy, France, and Spain.

[1] TOE: tonnes of oil equivalent, is a standardized measure that correspond to the energy produced by one metric ton of oil (1000 kilograms), it is equivalent to the generation of 11.63 megawatt hour (MWh)

Spain is in fourth place in renewable energies production and consumption after Germany France, and Italy; it exhibits a fairly diversified energy mix and is also the fifth consumer of energy in Europe after Italy. Germany is a fairly energy-intensive country. This is true even if such an indicator has improved in recent years. If we consider the distance in energy consumed relative to the fourth place (Italy), Spain consumes 74.4% of the energy consumed by the next consumer, but it only accounts for the 64.8% of its GDP (and 76% of its population).

In the selected group of countries, The Netherlands is also worth mentioning. It is the second largest producer of gas, immediately after Norway. Gas production in The Netherlands is mainly thanks to the Groningen Gas Field, the largest natural gas field in Europe and one of the biggest in the world.

The consumption of solid fuels in Poland is due mainly to the consumption of coal. This country is the second largest consumer of coal in Europe; it comes in just after Germany, but with a little less than one half of the latter's population.

Regarding the UK, we should also say that it is one of the fairly diversified energy mixes and the third energy consumer in the whole European Union, after France. In the energy mix, it is noteworthy that it is the second largest producer of all petroleum products, immediately after Norway, thanks to the North Sea oil fields. Finally, the UK is the third largest consumer of solid fuel, after Germany and Poland.

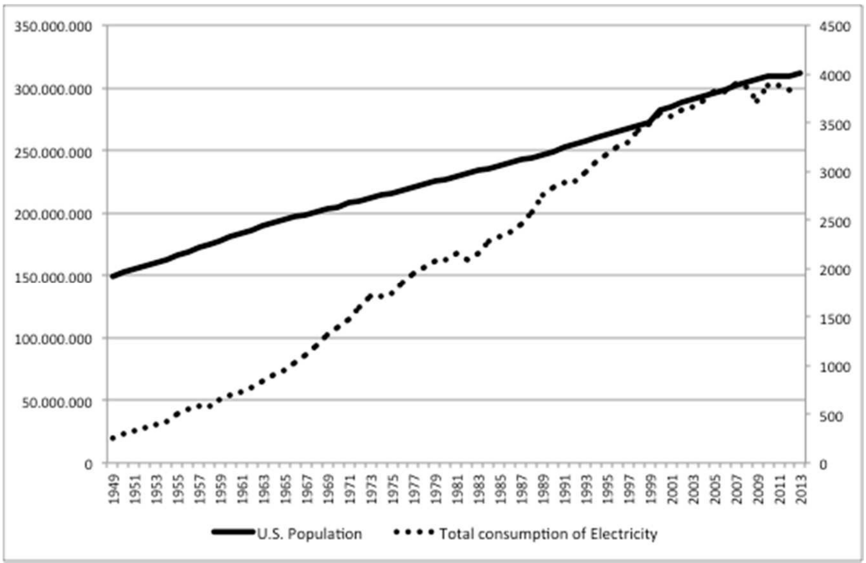
Finally, Norway is the first largest producer of petroleum and natural gas in Europe, producing nearly double that of the country in second place. In addition, they produce a fair share of renewable energy, mainly hydropower.

1.2.3 Electricity consumption

As we have already stated, although electricity has been known from ancient times, the real development of the electricity industry has taken place in the last 130 years or so. Since then, the countries consumption of electricity has increased to a great degree, and particularly in the last few decades. In the following graphs, we can see exactly how this evolution has occurred. We take as examples the cases of the U.S. and Spain but for the cases of the rest of developed countries is somewhat similar. In the graph 1.3 we plot the evolution of electricity consumption in the U.S. from 1949–2013 (right axis in Gw) and the evolution of the population of the U.S.; we can clearly observe how the consumption of electricity per person has increased during this period. We plot, in the next graph also (1.4), the consumption of electricity per person in the same period (1943–2013), also following the example of the U.S. Similarly, we plot, in graphs 1.5 and 1.6, the same variables for the case of Spain, this time for a slightly shorter, but still fairly long, period, from 1960 to 2012.

Two main trends are important to mention at this point. First, we note the somewhat obvious increase in the number of appliances used in households and businesses, particularly since the popularization of personal computers and other related technology. Second, the trend we would like to talk about now is a little more recent, that is, that the regulations in wealthy countries (mainly) have exerted an observable impact on the technical efficiency of appliance, thus on the stabilization or the less-sharp increase in electricity consumption. It is true that every day, new households acquire new appliances (more personal computers per household, more mobile phones, more tablets, etc.), but it is also true that these are more efficient in terms of electricity consumption, and other traditional or major appliances (refrigerators, washing machines, etc.) are also more efficient.

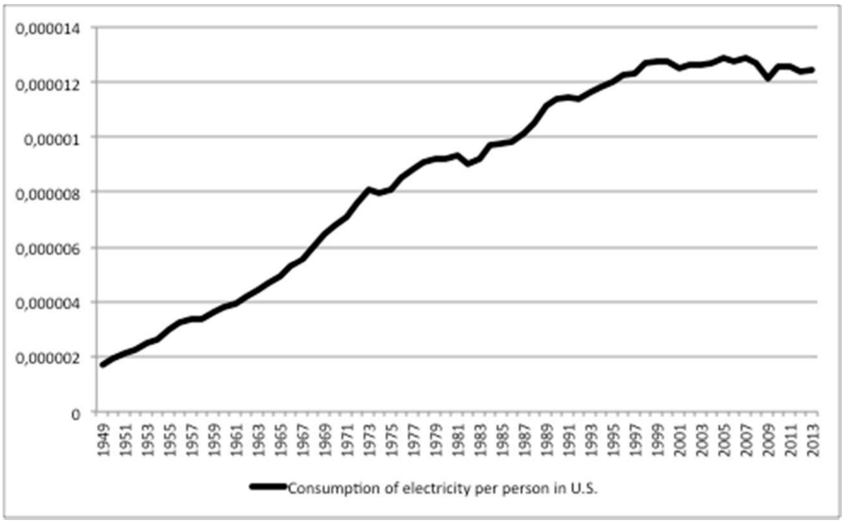
Fig 1.3 Population and Total Consumption of Electricity (U.S.)



Source: U.S. Energy Information Administration.

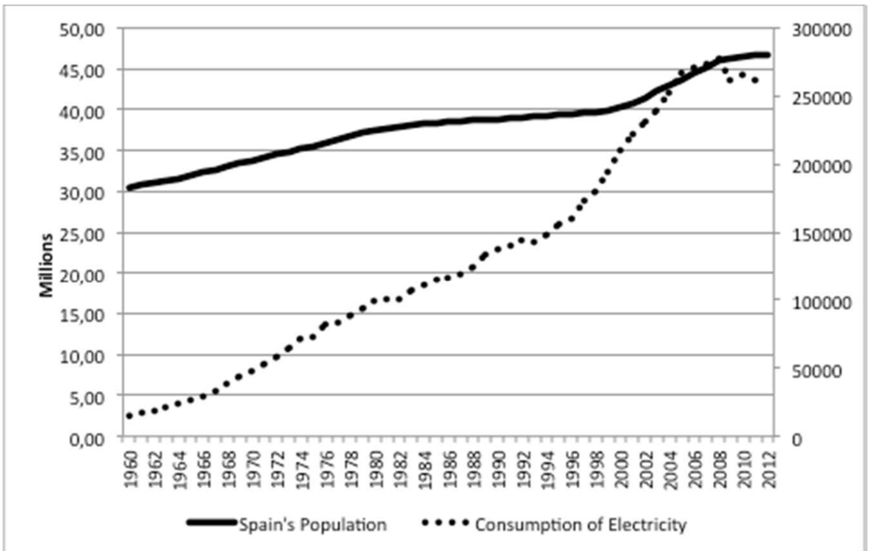
Together with regulations devoted to the improving the efficiency of electrical appliances, it is important to mention the role that increasing energy prices in general and of electricity in particular have played in the less-sharp increase of electricity consumption. Finally, in order to conclude this subsection, we wish to point out that these general trends that apply to developed countries can be different to a certain extent in the group of developing economies (particularly in Asia), where energy intensity has evolved quite differently in recent decades.

Fig 1.4 Consumption of electricity per capita in Gigawatts per capita (U.S.)



Source: U.S. Energy Information Administration.

Fig 1.5 Population and total consumption of electricity (Spain)

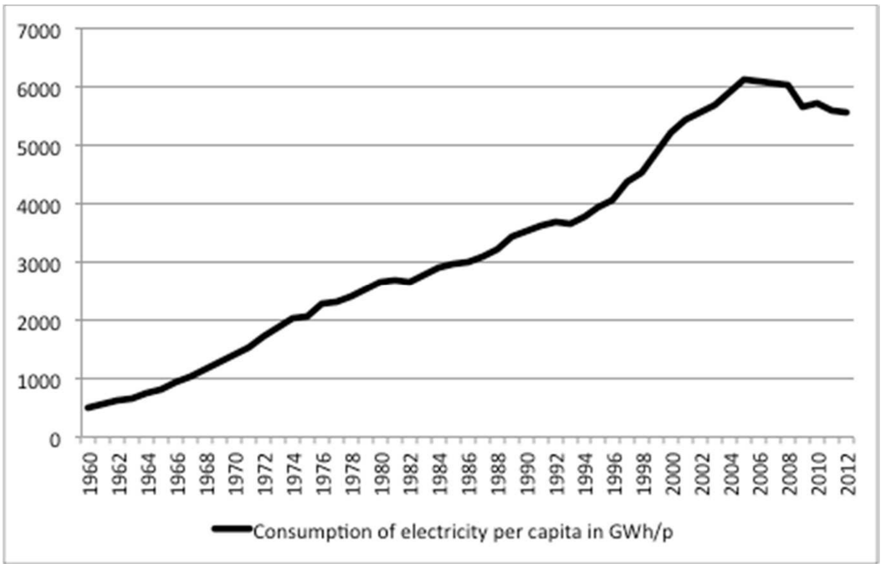


Source: Wold Bank; IEA.

Figure 1.5 above, which depicts the Spanish case, also reflects the two trends that we have already spoken about, which is, for one, the increasing consumption of electricity, mainly caused by the increase in the number of appliances. Two different points are worth noting in the consumption line; the first of these points comprises the change in slope in the first part of the

decade of the nineteen nineties: while the population appeared to be stable, electricity consumption increased. The second point is that after 2008, when the trend changed again, it was this time obviously influenced by the world economic crisis that shocked Spain in particular.
In the case of consumption per capita for the Spanish case (pictured in Fig 1.6, immediately below these lines), it is easy to observe the second part of the two trends that we spoke about at the beginning of this section, that is, in just one half of the past decade in 2005, per-capita consumption of electricity suddenly halted in its soaring trend and actually slightly decreased until 2008 when, as we already noted, the drop became clearer because of the economic crisis that began in that year.

Fig 1.6 Consumption of electricity per capita in Gigawatts per capita (Spain)



Source: World Bank; IEA.

1.3 Liberalization and Reform of the electricity sector

As has already been mentioned, analysis of the electricity sector is somewhat complicated: it is also the analysis of the reforms that affect the sector. The main difficulties in this case are that, depending on the country's reform, it may assume different forms, it may involve many interrelated steps, and it is a constant and ongoing process (Pollitt M. , 2009). The fact that it is an incomplete process also complicates the evaluation and renders discussion more acrid and more difficult to follow. Partial results provide both critics and advocates of the reform with a surfeit of examples in which the reforms have constituted a partial success and a partial failure. However, it is also true that electricity reforms in recent decades have also delivered clearer results, such as access and reliability in developing countries and some productive efficiency in developed ones (Bergara, Heinisz, & Spiller, 1997; Pollitt M. , 2009)

Electricity sector reform should be approached in broader economic terms, thus related with general trends advocating privatization, containing direct state action in certain sectors and companies, and increasing market-driven reforms. Observed from this vantage point, evaluation of the reforms requires high doses of the careful and thoughtful evaluation of three main aspects: effects on electricity consumers and producers; promotion of efficient markets and finally, good governance. In one of the main surveys of the empirical results of recent energy reforms Pollitt (2009), acknowledges the limitations of recent studies (mainly because of partial reforms), and that more conclusive results will take still some time to emerge; individual results (by country) can be clearer, but overall results are still to come and cannot be completely accounted for. In addition, a way to summarize the main reforms in recent decades is that employed by Ceriani et al. (2009), in which the authors summarize the main reforms under three types: Privatization, unbundling, and liberalization of markets; their point of view is that it is not obvious that the welfare of the population actually improves after the reform occurs, which, on the other hand, is the main motivation of the reforms (Steiner, 2001).

Definitively, the success of the reforms and the direct increase of welfare power depends, among many other factors, on the potentially competitiveness of certain activities of the electricity sector. While designing the reforms, regulators have often distinguished between regulated activities, i.e., transport and distribution, and potentially competitive activities, i.e., production and commercialization. In the following subsections, we will discuss the latter.

1.3.1 Reform, restructuring and competition

In regard to standards of reforms, there are two basic models; one described by Littlechild (2006) and denominated "the Textbook Model" for restructuring and competition, and the other, described by Jamasb & Pollitt (2005), Both have important coincidences, but also some discrepancies. In the following paragraphs, we will describe both models and talk about some of their characteristics.

1.3.1.1 The Littlechild Textbook Model

This suggested model of reform consist of the following ten basic components: 1) Privatization as a performance enhancer and to reduce the abilities of the public powers to use public enterprises to pursue "costly political agendas"; 2) Vertical separation of competitive activities and monopoly sectors, to facilitate both competition and regulation; 3) Horizontal restructuring, to create an adequate number of generators and suppliers; 4) Creation or designation of an independent systems operator, to maintain the stability of the system and to facilitate competition; 5) Creation of voluntary energy and ancillary services, markets, and trading arrangements, including contract markets and real-time balancing of the system; 6) Creation and application of new rules, to promote access to the transmission network and to provide incentives for the efficient location and interconnection of new generation facilities; 7) Unbundling of retail tariffs and rules, to enable access to the distribution network in order to promote competition at the retail level; 8) Specification of arrangements for supplying costumers until retail competition is in place; 9) Creation of independent regulatory agencies with adequate information, staff, and powers, and duties, to implement incentive regulation and promote competition, and 10) Provision of transition mechanisms that anticipate and respond to problems and that support the transition rather than hinder it.

According to Littlechild (2006), those that have been faithful to the textbook model are examples of successful reforms, e.g., the UK, Argentina, the Nordic countries, Victoria, and Texas, whereas those that have deviated from the path to outside the model cannot claim the same. Sometimes, as in the case of Chile, doing too much is bad (too much regulation or too many restrictions in generation and competition), but sometimes doing too little is also a problem, such as insufficient reform in certain U.S. states coupled with excessive retail price controls.

1.3.1.2 Jamasb and Pollitt's model

In their paper Jamasb and Pollitt (2005) also acknowledge some particular difficulties or characteristics of the electricity supply industry that should be taken in account while designing the optimal reform path. These particularities comprise mainly that firms in the electricity supply industry face high sunk costs that constitute important barriers to entry, that the different stages in the process (generation, transport, distribution, and retailing) have very different optimal scales and that, very importantly, the goods delivered are non-storable and depend on the constant balance of supply and demand.

Jamasb & Pollitt (2005) are not as categorical as Littlechild in terms of the possibility of deviation from one particular point of the model; they simply outline a plan for those willing to reform vertically integrated and publically

owned electricity supply industries into competitive and privately owned ones. Their model consists of four measurement categories: restructuring; competition and markets; regulation, and ownership. In the following paragraphs, we will succinctly describe these.
Restructuring measures refer to the unbundling of different stages of the whole process of electricity supply: generation; transmission; distribution and retailing, as well as the horizontal splitting of generation and supply. In this respect, the main goal is to separate the potentially competitive generation and supply from the natural monopoly activities of transmission and distribution networks. Also, the aim of horizontal separation is to create sufficient competition in generation and retailing, where the optimal firm size can be a particularly important issue.
Competition and market measures include enhancing competition in the wholesale market and in electricity-sector retailing. In order to do this, it is crucial to effectively separate generation and transmission activities, to both avoid anti-competitive behavior and non-discriminatory access to the network. There are different degrees of separation of unbundling, from less to more effective and deeper ones: these include functional, accounting, legal, and ownership unbundling.
With regard to market regulation, the main measures that should be taken in account are the establishment of an independent regulator, providing third-party access to the network, and incentivized regulation of the transmission and distribution networks.
Finally, according to the Jamasb & Pollitt model (2005) in terms of what ownership is, it is crucial to allow new private actors, as well as to privatize publicly owned businesses. The main idea of allowing new private owners and privatizing public firms is that, through the pursuit of profit, private owners will attempt to improve efficiency and save on costs, as in Vickers & Yarrow (1988); however, this automatic association between private ownership and improvements in and savings costs has been recently contested, as in Ceriani, Doronzo &Florio (2009) and should not longer be taken as a consensus.
In the following two sections, we will discuss in some detail the potentially competitive activities in the electricity sector, i.e., generation and retailing, the reforms that can be pursued or have been pursued to date.

1.3.2 Electricity-producing firms. Generation

The first changes in regulation related with the generation of electricity firms came during the early 1980s in Latin America, particularly in Chile and

Argentina (Pollitt M. , 2004). Later, in the 1990s, these changes arrived in Australia and New Zealand, and even later, in the countries of the European Union (Jamasb & Pollitt, 2005). It is a popular belief that in order to improve competition, it is crucial to separate generation from transmission activities, particularly for competition in wholesale markets (Jamasb & Pollitt, 2005; Joskow P. L., 2005; Newberry D. M., 1999); the reasoning is that this aids in preventing anti-competitive behavior from the incumbent firms and that this avoids possible discrimination in accessing the transmission network, while failing to separate both activities may deter new initiatives or the entry of new producers.

One relevant issue of the generators is, of course, the source with which each firm produces electricity. If electricity-producing firms are publically owned and are not seeking profitability and, above all, other results, the mix can only be a matter of availability of primary results. However, because many producing companies are privately owned and one of the main results, if not the most important one, is economic profit, they should look for energy sources that help them to recover the huge sunk costs attached to certain production methods. Until the 1990s, due to the technologies employed to produce electricity, the long-term marginal cost was higher than the average cost of generation; thus, it was necessary to have rules in place that permitted the firms to cover their costs (Nieto & Solà, 2003). Currently, and principally due to the new technologies, the long-term marginal cost is smaller than the average cost of generation, permitting a price set by the market that is based in this long-term marginal cost.

In addition to the long-term marginal cost, it is also important to shed some light on certain extra-economic and technologic changes. At present (while the initial investment might still be high), new and less expensive technologies are easy to build, reducing the economies of scale. Now, small power plants can be as cost-efficient as a large one and, in this manner, can compete in an open market (Nieto & Solà, 2003; Joskow P. L., 2005).

1.3.3 Electricity retailers

Commercialization or retailing activity has experienced great growth as a consequence of the deregulation of the activity (Nieto & Solà, 2003), at first, the bigger clients were offered the option of accessing the liberalized market and later, the smaller consumers, until access reached households and those with a smaller monthly consumption.

The situation retailers face in general terms is that of price fixing (the share, of course, that is not fixed by the government and that tends to be more stable); retailers, therefore, are required to manage two different risks: the risk of the volume that they are requested to provide, and the risk of the price at which they will end up selling the electricity. The relevant task of the retailers is, then, to cover both risks and to charge competitive prices to the final consumers.
By risk of price, we refer to the risk that the retailer faces by charging a final price below the price that it paid while buying the energy on the wholesale market. Retailers purchase at different prices at different times during the day; thus, there is also an hourly risk, which also varies depending on the country's energy mix, due to the quantity of variables at stake during the process of generation. Statistical foresight of the pool price with high certainty in a competitive market is nearly impossible.
The risk of volume is that which is associated with variations in the consumption profile or the charge curve of the grid. Since retailers purchase the energy hourly, these variations may influence the mean price. Thus, the variation in the level of demand possesses an important impact on the price of electricity and, as we previously mentioned, on the consumption profile.

1.3.4 Reform in Europe: The Spanish case

We would like to take some space and time to speak about the Spanish case. It is not just that it is the closest example we have, but also that this case has some particularities that will help us to illustrate the previous discussion. The first of these particularities is that in Spain (together with Portugal), the liberalization process actually started after a period when market concentration was encouraged and not prevented, as it would actually wish to be perceived (Glachant & Lévêque, 2009). In the 1990s, for instance, the two major electricity companies produced nearly 80 percent of the electricity consumed and controlled about 80 percent of the retail market. This situation has not improved a great deal. Matthes, Poetzch & Grashoff (2005) presented two different measures of market concentration for the Iberian Peninsula and for the 1996-2004 period: while production has increased and market concentration has been constantly decreasing, this remains above the critical values of the two concentration measurements that they present (one concentration ratio and an HHI index).
As we observed before, in the section devoted to the description of the electricity lifecycle, there are in particular two parts of it that have been recognized as potentially competitive: generation and retailing. The first

measures undertaken by the Spanish government in order to liberalize the electricity sector occurred in the second half of the 1990s and focused particularly on introducing competition into the generation activity (García-Álvarez, García-Rodríguez, & Mariz-Pérez, 2005). However, after this first step toward liberalization, the Spanish market (as well as those of other European countries) remained highly concentrated, and a second package of reforms was negotiated within the context of the European Union in order to prevent uncompetitive behavior. In the Spanish case, for example, the largest producers used their market power, even after the introduction of the wholesale (pool) market, because they were certain that the market operator would need its output when the demand increased (García-Álvarez, García-Rodríguez, & Mariz-Pérez, 2005).

From the horizontal integration perspective, it is important to recall that in the year 1996, the Spanish market underwent a process of horizontal integration that ended with the two largest companies –Endesa and Iberdrola- controlling 70% of the market, with the direct negative consequences that that this had on competition. This said, it was clear that concentration, as well as vertical integration, comprised a significant problem in Spain. The introduction of the wholesale market was an improvement, but not a complete one.

Since the major reforms were thought of within the context of European integration and European construction of the single electricity market, the European Commission took the lead at the beginning of the past decade and initiated a negotiation toward the implementation of the second energy package that came into life in 2003. In this package, it was mandated that all European countries set up regulatory agencies, and a first approximation to mandatory ownership unbundling (vertical separation of activities) was proposed. Notwithstanding this, ownership unbundling was rejected at that time.

It was not until 2007 that, also under initiative of the European Commission and as part of third energy-package ownership, unbundling was negotiated and approved, but not in the exact terms that the Commission wanted. Three models of ownership unbundling cohabit currently in Europe. The most frequent option, and in reality the option that Spain selected, is full-ownership unbundling, but there are two additional options: Independent System Operator or ISO, which is a fully unbundled system operator but with grid assets continuing to be owned by an integrated company, and Independent Transmission Operator or ITO, which owns the assets (grid) and forms part of a vertically integrated company, but that follows strict rules that guarantee its independence.

The Spanish electricity market, similar to all other European electricity markets, is still under reform; however, we would like to assay a summary of the state of reforms, the positive effects that we are able to observe and, of course, the challenges that it must still face. The main improvement is in the terrain of competition, even while the Spanish electricity market has a long way to go toward a fully competitive market. However, it is also true that there are important improvements that have come about with the accession of European firms, in both generation and retailing activities and in what concerns the vertical separation of activities.

As we have noted, there continue to be important challenges other than that of improving competition. One of the more relevant of these is the tariff-deficit that has been created and that continues to grow; this tariff-deficit was created by shortfall between regulated revenues and real costs. It is crucial to state that these costs are costs estimated by the government, not the real costs of the electricity-producing firms. Finally, in Spain, as in other European markets, there remain some concerns of the impact that financial support schemes in terms of renewable energies may exert on final prices, as well as the impact that local support but costly local energies (such as coal) may also have on production costs.

1.3.5 The case for competition

The main goal that nearly all reforms attempt to achieve is that of enhancing competition, but in reality, competition is not the final goal. However, it is thought that through competition, we will achieve much better and relevant results. Through competition, it is assumed that consumers will pay lower prices, but not sufficiently lower prices to force suppliers to withdraw from the market. Competition is supposed to have a positive effect on service reliability, as well as on the predictability of consumers' bills (transparency of prices and metering); finally, competition is expected to be accompanied by more value-added services, which may become available for attracting consumers to a particular supplier.

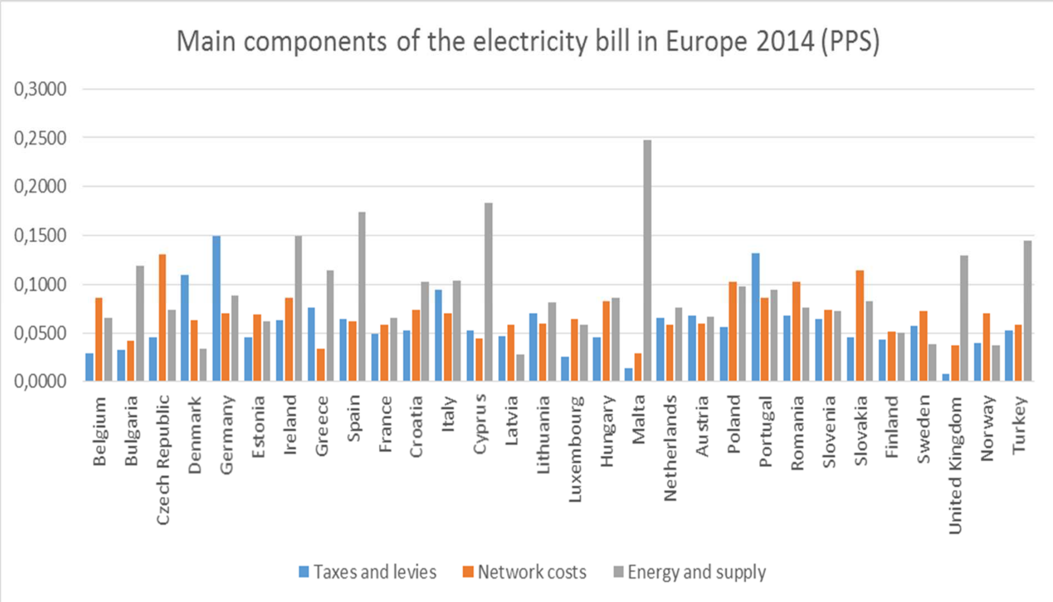
Although the introduction of competition has occurred in a great majority of countries, it is also true that these reforms are far from forming a consensus, and there a group of critics has emerged. While some of these only criticize the manner in which certain reforms have been introduced, some others entertain concerns about the introduction of the whole package of reforms

and, more specifically, how it can be that a strategic sector such as energy is at present nearly totally in the hands of big multinational companies (Beder, 2003). Because we have gained some experience with regard to reform and the introduction of competition, we can also convey that there have been some gains, but also some bad experiences, such as the case of Enron in the U.S. and the huge blackouts in California during the Western U.S. energy crises in 2000 and 2001.
Obtaining good results is not as easy as in other sectors, where there have been also pro- competition reforms. We have already addressed the technical difficulties of electricity as a commodity, where the storage problem along with other technical complications renders it impossible for regulators to issue a "call for withdrawal" and permit the market itself to deliver the best results. Regulators must pay close attention to what they do and to what they do not do and to leaving things in the hands of the market forces. As in the previously explained models of Littlechild (2006) and also in Jamasb & Pollitt (2005), a briefer suggestion about what should be done is stated by Hunt (2002): give open access to the grid to all possible competitors in order to avoid possible discrimination. The second basic measure should be restructuring the sector, by separating activities and merging or creating new companies, again to prevent discriminatory behavior and, finally, deregulation, but again ensuring that solely retreating and leaving everything to the market forces can be a too simplistic approach: because many suppliers are local monopolies, deregulation can deliver an outcome that is the exact opposite of what was expected in the beginning; deregulation must be employed to promote competition, not to make it impossible for it to happen.

1.4 Electricity bill, main components

As one can observe in the figure below these lines, in general terms, electricity prices are composed of three basic components: the cost of producing and supplying the energy; taxes and levies, and the network costs imputed to the consumers. In terms of a purchasing power standard, the country charging the lowest taxes is the UK, while second and third places in this regard are occupied by Malta and Luxembourg. On the other hand, the countries that charge the highest taxes are Germany, Portugal, and Denmark; Germany, as we have noted previously, is the largest consumer of energy in Europe, with a very complex scheme of subsidies for renewable energy financed with taxes (there is no consensus about the results that such a scheme has for final consumers with respect to whether it results in higher final prices or whether it improves overall consumer welfare).

Fig 1.7



Source: Own elaboration with data from Eurostat.

It is quite clear that Maltese consumers pay the highest prices for the generation of electricity, followed by Cypriot, Spanish, and Irish consumers. What can be also illustrative to a certain degree is that three of these four countries are actually islands; thus, the interconnection with other electric systems is complicated, affecting generation costs. On the other hand, the lowest electricity prices are paid by Latvians, which is somewhat surprising, because this small Baltic country depends to some extent on Russian gas imports. The second least expensive country is Denmark (for energy generation), and this is so because we are reporting prices in Purchasing Power Standard (PPS); otherwise, Denmark would rise to one of the first places; we also commented previously about the share of Danish energy prices of energy, which due to taxes and levies.

Finally, the countries with highest network costs are Czech Republic in the first place, followed by Slovakia, Romania, and Poland, all four members of the Central and Eastern European electricity market. But these countries present very different results concerning the degree of reform and liberalization: while Czech Republic and Slovakia have nearly totally completed the process, Poland is found at a very early stage and Romania, at a middle stage. On the other hand, it is noteworthy that of the three price components, network costs are those that are homogeneous, with a variability of ±5%, while the remaining components are far more disperse, like the energy and supply components of final prices.

1.4.1 Decomposing the European electricity bill

It might appear obvious, but there are many ways to construct an electricity bill, one for each company. But here we prefer to explain, in general terms, which the main components of the typical electricity bill and which the most common ways are that each part of the bill is calculated. We will see different forms, from very general ways of decomposing the electricity bill to more specific ones.

First, in a very broad sense, there are basically two types of charges included in the electricity bill: first, an energy component that measures the quantity of electricity supplied in kilowatts hours (kWh), and what is also known as a demand component, which measures the power supplied in kiloWatts (kW). As we have already pointed out, electricity is difficult and expensive to store; thus, the electricity system must provide energy at the moment that it is demanded. Therefore, the capacity must be ready to meet the consumers' requirements, both in kWh and in kW.

To understand the two different types of charges, we can mention here that one measures the quantity of energy used, and with the second type, the intensity at which this energy has been used. Imagine, for example, the dashboard of your car: the component that measures the kilometers that you have covered with your car (the odometer) informs you of the amount of energy that you have used (kWh), whereas the speedometer tells you the speed at which the automobile moves (in kW, in the case of the electricity bill). Even if a car never reaches the highest speed at which it can run, the engine is actually built to reach it; similarly, electricity-producing firms must possess the available capacity to provide the sum of the demand contracted by all of their consumers, even if they will hardly reach the potential demand.

Because all households, businesses, and other types of consumers demand different amounts of electricity at different hours of the day, kilowatts measure the demand, or rate of electricity usage, at any given point in time, while kilowatts/hour measure the total amount of energy consumed.

Second, if we also decompose the electricity bill into different components relative to the final cost paid by household consumers, we can focus our attention on the following components: a) Wholesale costs. This type of cost might be very different depending on the country, from 25% in Germany to 70% in Spain; b) Network costs. Also a constant in nearly all electricity bills, that is, the toll that all companies have to pay for using the grid (sometimes publicly owned, but sometimes also privately owned); costs of grid usage vary less than other types of costs, but even so, they range from 20% in the UK to 45% in Australia; c) Environmental and social levies. These are also very different depending on the country, and the range is from a very modest 1.5% in Ireland to a significant 23% in Germany; d) Supplier costs, imputed to final consumers, when reported, range from 5% in Ireland to 10% in Australia and the UK; e) suppliers' profit margins also vary greatly, but not also through countries but also through companies, can range from an average of 3 to 5% in the UK, to an average of 25% in Germany 5%; f) Other costs, depending on the country, can include metering, storing primary sources, or costs of balancing the energy system, which can range from 4% in the UK to 21% in Spain, and g) Finally, we should also include the corresponding Value-added tax (VAT), which varies widely depending on the country, from 4 to 5% in the UK to 21% in the case of Spain. You can see in some figures in greater detail in the Table 1.1 (below).

Table 1.1

	UK	**Australia**	**Germany**	**Ireland**	**Spain**
Wholesale	37%	33%	25%	50%	45%
Network costs	23%	45%	23%	30%	22%
Environment & social levies	14%	13%	21%	1.5%	4.86%
Supplier cost	9%	10%	n.a.	5%	n.a.
Supplier profit margins	5%	n.a.	25%	n.a.	6.7%
VAT (and similar)	5%	10%	16%	13.5%	21%
Other costs	4%	n.a.	7%	n.a.	21%

*Sources: Parliament of the UK; House of Commons; Australian Competition and Consumer Commission; Clean Energy Wire; Other sources are included in the reference section at the end of this chapter; *The sum of these percentages are not exact due to rounding figures and intervals. "n.a." = not applicable or non-available.*

Summing up all of the types of charges, we can distinguish three charge types: first, those related with the energy itself, either charges for wholesale or retail charges; second, charges related with the network, either for transmission or distribution and, finally, a third part of every electricity bill, i.e., taxes, levies, and exemptions, which can also refer to a general budget or to specific policies (to the electricity sector, to the climate change control, to environmental protection, etc.). The way that different suppliers decide to explain their own bill or the way that different countries set forth to explain the electricity statement varies widely throughout Europe, and of course, worldwide. Due to this diversity of statements, the general approach is to report the components of the electricity bill in aggregated terms and to report only the three main groups, i.e. energy, network, and taxes & levy charges.

1.5 Electricity and finances. Whose initiative is this?

We have been insisting, during this chapter, on the short but intense history of the electricity sector and how it has evolved in a little more than a century. An additional and crucial feature is the relationship that this industry has with finances. As might appear obvious, the development of the electric industry is closely related with the major events of the XX century e.g., the two World Wars, the Great Depression, or the oil crises.

The development of the electricity supply industry is contemporary to many processes, such as those that facilitated the flow of capital across different countries, and those capital flows also facilitated the spread of the electricity industry throughout the entire world. The financial resources employed for the development of the industry were both local and international; the electricity industry is capital-intensive, and often, the first companies needed to create a joint venture with local and foreign investor (Hausman, Hertner, & Wilkins, 2008). After World War II, the prevalent model of ownership in Western countries was the public monopolies or publicly regulated companies; capital investments came directly from the public vaults, as did management decisions.

This simple story changed dramatically from the late 1970s on when public involvement was heavily questioned regarding the management of public utilities, such as electricity companies. The main claim was that government ownership or strict regulations comprised an obstacle to entrepreneurial activities, that government should take a back seat and yield to deregulated private initiatives (Beder, 2003). These points of view were exemplified in the figures of Ronald Regan in the U.S. or Margaret Thatcher in the UK.

It is not the goal of this section to discuss the full reform and the relationship with the finances (the more relevant issues on this subject will be discussed later in the dissertation), but we would like to sketch some general ideas about the relation of finances and electricity markets. In the following paragraphs we will talk briefly about pricing in electricity markets, since it is the basic driver of changes in financing the electricity supply industry.

One easy and somewhat simplistic way to speak about electricity prices is to begin with the part of the price that is regulated. In many countries, even in some with broad reforms, there is a part of the price that is controlled by the regulator (the government). In the time prior to the expansion of electricity market deregulation, electricity prices (together with those of other energy commodities), were utilized as a complementary policy instrument; for example, energy prices were formerly artificially low in order to control inflation, but these sorts of actions are less effective or even useless in contemporary, less regulated markets.

Prices in deregulated markets or in reformed electricity markets comprise a much more diverse landscape than can be imagined. Where there was only a policy decision, now there are many considerations at stake, e.g., the firm's strategy, the consumer's choice, the business risk, the value-added services, etc. Some considerations that should be taken into account are the following: a) cost factors, such as marginal costs, accounting costs, opportunity costs; b) the value of service factors, such as price elasticity of demand; c) specific market factors, such as consumer usage characteristics, and d) pricing by objective, taking into account whether the objective is efficiency or equity (Faruqi & Eakin, 2000). Pricing in electricity markets becomes much more complicated than simply the sheer calculation of costs, value, and compensation for negative externalities. We have made our own contribution to the general discussion in Chapter 3 of this dissertation.

1.6 Concluding remarks

Finally we would like to close this first chapter with a brief summary of this descriptive chapter as a form of conclusions. We first characterized the electricity sector and we provided the electricity lifecycle, that is, the process that electricity assumes from its sourcing through production, transport, and distribution to basic and complementary outcomes. We then addressed the relevance of the electricity sector and made our case about the relevance of this industry in our everyday lives and as a commodity in the economy.

In Sections 1.2 and 1.3, we delimitated the scope of the electricity supply industry within the broader energy sector and presented the picture of the energy mix within the context of the European countries. We closed this section by describing the evolution of electricity consumption in advanced economies, and in the U.S. in particular, to stress the increasing relevance of electricity in our day-to-day lives.

We discussed different proposals for reform in the electricity sector, from more detailed models such as that of Littlechild and that of Jamasb and Pollitt, to more schematic models such as that proposed by Hunt. A common thread in all three proposals is that in order for competition to work, it should ensure grid access to different producers, restructuring the whole industry is important (either through unbundling or by horizontal merging or the creation of new companies) and finally, all three proposals appear to convey that deregulation should be orchestrated with care to achieve the desired results from competition and to avoid possible market failures.

We also compared different electricity bills within the European context regarding their basic components (i.e., taxes and levies, network costs, and energy), but we also presented a more detailed breakdown of electricity bills in Europe and worldwide, in which we were able to observe a more diverse reality, which reflects the complex sector that we described in this chapter.

Finally, in the last section of the current chapter, we talked about the main investors in the electricity sector, how these have been changing, as reflected by the different trends in the industry, how, along the century, the industry has been developing, and even more so, how more recent changes have introduced important factors as drivers of energy prices.

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Chapter 2

The Key Role of European Institutions in the Bargaining Process of the European Energy Market

Abstract:

In this chapter we focus our attention on the bargaining process of the third energy package. This process of negotiation took place between the first months of 2007 and mid 2009 and was promoted by the European Commission for the purpose of going forward in the liberalization and integration of European energy markets. We wish to find the conditions under which the third energy package was finally approved, and we propose that better coordination between some relevant actors favoured the position of those supporting the proposed reform. In order to reach our goals we identify the relevant actors, discuss its strategic alternatives, the outcomes related to its strategic combinations and finally we mention the actors' preferences over possible outcomes

2.0 Introduction

One of the most important issues in the process of European integration is the creation of the European Energy Market. This process started in 1988 with the publication of the White Book of the European Commission on the interior market construction –the main idea in that paper was to create a totally liberated commodity market, in which any consumer may buy electricity or gas from any supplier regardless of the ownership of the intermediary grid structures (European Commission 1988). However, it was not until 1992, with the signing of the Lisbon Treaty that the process got under way, and the actions in its construction started to intensify. It was at this point that four basic objectives were settled: 1) Improve the assurance of supply; 2) achieve lower prices; 3) respect the environment; 4) promote the saving of energy (European Commission 1988, 1992; García Mezquita 2006).

The process of construction of the European Energy Market was first designed in three stages (García Mezquita 2006), corresponding to a group of European Directives (First stage: three directives; second stage; two directives and third stage: two directives). All these directives were negotiated, and a long period of bargaining between member states started. Once the most of the measures were adopted a fourth stage came into action with a proposal for the negotiation of a third package of measures (Eikeland 2008). In this chapter we will focus on the negotiation of the fourth stage of the construction of the European Energy Market, how majorities were formed and how options were combined before agreements were reached. We focus on the roles played by institutional actors at a supranational level, their capabilities, their preferences, their alternatives and the outcomes of the process. Thus, we would like to centre on answering the general question of: to what extent did European institutions (particularly the European Commission) exert their power in the decision-making processes.

The chapter is structured as follows: in section one we present a summarized discussion of the theoretical background in which we will base our work; in section two we state our objectives, the questions that guide our work, and we make some statement on what we expect to find and how we expect to find it. In section three we draw an outline of how European laws are created, the background of the process and how the third energy package of policies was first proposed; in section four we speak about the relevant actors, their preferences and so on; in section five we make a scenario analysis and finally; in section six we outline our conclusions.

2.1 Theoretical background

Concerning European integration, a debate between two different approaches has dominated scholarly production. Intergovernmental approaches sustain that sovereign member states are the ones that matter most in the decision-making processes, furthermore, some say that the construction of the EU improves the power of nation-states rather than that of cross-border institutions (Milward 1992). "The Liberal Inter-governmental" model, developed by Moravcsik (1991; 1995), is a three-step model in which, first national leaders 'collect' their national interests concerning the EU in their own nations, secondly, a bargaining process between governments is carried on, and lastly, member states concede some sovereignty to supranational institutions for the purpose of gaining some credibility for future bargaining processes. Due the collection of national interests in the first step, member states concentrate great part of the analytical power on this model. This model has raised much criticism, mainly because of the absence of analysis of institutions (Garrett & Tsibelis, 1996), but also because of a lack of methodological rigour and refinement (Wincott, 1995).

Meanwhile, institutionalism was re-introduced in scholarly discussion of EU integration, and basically three different interpretations were developed of how institutions matter. Firstly, rational-choice institutionalism put the emphasis on how actors choose or design institutions in order to minimize costs in bargaining processes, or to obtain some gains. Secondly, sociological institutionalism including informal institutions, constructing a broader definition of institutions while treating actors' preferences as endogenous to institutions, thus institutions influence individuals' identities, preferences and behaviour. A difference that is worth mentioning is that while rational-choice institutionalism treats actors as utility maximizers, given a set of options and opportunities, sociological institutionalism sustains that actors proceed in certain ways asking themselves what the expected behaviour is in a given situation. Thirdly, historical institutionalism takes a mean position, focusing on how institutions matter over time, once they have been established by actors, how institutions escape from actors' control and shape their behaviour, through paths over which the actions unfold (Pierson, 2000).

As part of this discussion, the supranational *institutionalists* give, particularly to the European Commission, a leading role as broker, as well as an 'entrepreneurial' role in policy-making (Borràs, 2007). According to these views, member states do not control the whole scope of the European integration process, and it is the European institutions –such as the

Commission - that fill the void left by member state governments (Pierson, 1998).
It is worth mentioning that, while European integration studies were dominated by international relations scholars before the 1990's, in the early years of that decade participation by political scientists increased significantly, culminating in a milestone settlement by Hix (1994; 1998). This also meant calling for scholars in comparative politics to use their tools and methodology in the study of "European Community policies". Increased interest by political scientists comes mainly because of the intrusion of 'European issues' in national political arenas (Pollack, 2010), thereby increasing the importance of European issues in nation-state arenas and resulting in the increased importance of European institutions.
Taking in account the subject of this chapter, what we will try to pursue is a multi level interpretation of the role of institutions. This may be pertinent since national governments played an important role, but so did European institutions (mainly the EC, and two DG Tren and Competition) as well as some private actors (lobbies and firms mainly). Furthermore, following Hix (2011), we think that the European Union can be studied as a political system even when it is not a state nor an international organization, but a *sui generis* entity with unique policies and architecture. Studying the EU with the tools of the political sciences should help us understand this new entity.
We will centre our analysis on actors' preferences and actions since we assume, following Scharpf (1997), that "social phenomena are to be explained as the outcome of interactions among intentional actors" and that institutions, and their general settings, are the frame in which these interactions occur.
Policy transfer might be seen as the degree of influence that certain actors have on the outcome of a decision-making process, and this is not given in a single way, Bulmer and Padgett (Bulmer 2005) have described three different forms of policy transfer in the EU: *hierarchical*, when there is some kind of coercive form of transfer; the *negotiation transfer* when there is some process of majority or consensus to create new common rules and; *facilitated unilateralism* when member states retain sovereignty but co-operate through EU institutions. The process, which it is our aim to describe, is of the second type, since the whole process has consisted in creating majorities and consensus.
By focusing our analysis on relevant actors, their preferences and strategies, we are hoping to isolate the conditions under which the third package of polices was finally approved, how and to what extent different actors influenced the outcome.

2.2 Objectives

The aim of this project is to throw some light on the bargaining process in the construction of the European electricity market, specially, in the last stage, since from our point of view, relevant changes occurred that made this part of the process an interesting research subject.

The whole package took into account both, electricity and gas markets, not as one but as parallel markets with similar needs for improvement. Even when it was clear that on its way towards liberalization each market had its pace, the policy package under study established similar goals for both markets, relevant actors were also different (concerning gas and electricity markets), but took part in the same process and thus, in this chapter we will look at both markets while dealing with the whole bargaining process.

2.2.1 Question

The main question that has guided our research of this bargaining process, and derives from the previous considerations and background is:

- Under what conditions was the third package of policies approved (Directives of 2009)?

In some way we are looking for the main changes during the 2003-2007 period that made the negotiation of a third package of policies possible. Even when the whole process was pictured in different stages, these were not drawn in detail, since great amounts of diplomacy and bargaining power was needed from the very beginning. Thus, changes in member-states' political arenas, or at European level may have a significant impact on European level policy making.

Even when compliance of all Member States was not yet completed, it was quite clear that, if a better and more profound integration of the energy market was the goal, a decided step forward was also needed. The European Commission was aware of this situation and either a) saw the opportunity due to some new conditions in actors' positions or; b) thought that, even without ideal conditions, this might be its last opportunity to go forward in the process since the Commission forecast a worsening of general conditions to go forward in this process. (One, two or none of these possibilities might be true).

On the one hand, after the approval of the previous package of energy policies (2003 package), there was a considerable enlargement of the EU (the inclusion of Eastern countries), changes in the governments of Member States might have influenced their willingness to go forward in the process, more effective lobbying may have been responsible for a change of opinion in different actors or just a general change of opinion and, consequently, the opinions of relevant actors.

On the other hand, the desire of the Commission officials to improve its leading role in the policy making of the European Union, may be one of the inside forces. Thus, the project of increased liberalization of the energy markets may be seen as a "term project".

Taking in account the above questions and the considerations that follow them, we make two hypotheses that conducted our work:

Hypothesis 1: The Commission's proposal on a third energy package of policies was finally approved since coordination of different actors was more effective than some national states interests.

Hypothesis 2: Relative success of the process might be attributed to the leading role of the European Commission and to its increasing importance in policy making in the European Union.

In order to pursue our goals we will follow a qualitative method describing the scenario and focusing on: a) players involved in the process; b) their strategic alternatives; c) the outcomes associated with strategy combinations and; d) the preferences of the players over these outcomes. To do so, we use mainly second hand sources, such as declarations in reviews, diaries, specialized journals and so on. First hand sources are limited to official documents produced by actors, but in the case of European institutions these documents do not contain opinions of member State representatives, only the conclusions are summarized.

2.3 How are European laws created?

The purpose of this section is to make an introduction to the general process of how decisions are made in the European Union. Since our interest is in secondary European law (primary refers only to Treaties), this is the process we will speak about. Energy issues are among those subjects that must pass through a process of 'co-decision', meaning that the European Parliament together with the Council (the representatives of the governments of the 27 countries) must approve what the European Commission proposes (TFEU: Treaty on the Functioning of The European Union, Art. 294). This process requires a great proportion of approval, since there is a double lock system, first a majority is required in the Council and, second, it is crucial to have the European Parliament's approval.

More precisely, the process of making European laws starts with the 'impact assessment' process, which is a period previous to the drafting of the proposal, consisting in looking for the advantages and disadvantages of what is proposed. The second step is the period of consultations that the Commission opens to know the opinions of interested parties, such as NGOs, local authorities, all kinds of organizations, firms and others; experts' advice is also sought, especially on technical subjects. The main objective of this step is to gather the opinions and needs of all parties involved so as to avoid unnecessary corrections.

After the drafting process come the review and adoption processes, where the European Parliament and the Council review the proposal made by the Commission and suggest amendments. If the Parliament and the Council do not reach agreement, a second reading is proposed after which Parliament and Council can again make more amendments. If both institutions agree, legislation is adopted, but if they do not, a conciliation committee is formed to try find a solution. It is worth looking in detail at the process in the European Parliament, since when the co-decision process is given – as in our case - EP has a blocking right. After the Commission –the only European institution empowered to start legislation - has presented a proposal, a member of European Parliament presents a report (this member is called a Rapporteur), before a committee that votes on it and is entitled to make amendments. The text passes from the committee to the plenary where it is revised, and possibly, approved. It is at this point that the European Parliament takes its position. If the Council and the Parliament reach agreement, the laws come into force after publication.

2.3.1 Background of the process: Previous to the Third Package

In this section we will again come to the core of our subject of study, by drawing an outline of the creation of the Interior Energy Market. The setting up of the interior energy market, is followed by means of the electricity and gas markets, it has been configured in different stages. García Mezquita (2006) describes three different stages between 1988 until 2003, while Eikeland (2008) describes also three stages but over a wider range of years 1988-2007, highlighting the last package of policies. The main objective was to progressively introduce elements of liberalization and competence into the energy activities of the member States.

In 1992, the Commission formalized the regulations by which the interior market would be created, and established a calendar for the three stages of development (García Mezquita 2006), which would be complemented by adding some mechanisms of competence for the electricity activities.
The first stage was articulated by mean of three directives; the first of which made reference to the transparency of prices applied to industrial consumers of electricity and gas; the second and third directives referred to were relative to the transit of electricity and gas (respectively) over the big grids.
On the one hand, the first objective of the first stage was to guarantee the transparency in prices, assuming that such transparency may contribute to suppress some discrimination towards certain consumers, by making it possible for these to opt freely among energy sources and suppliers. The price paid by the industry for the energy consumed is a factor of its competitiveness.
On the other hand, in this first stage another objective was to facilitate the transit of electricity and gas over the big transport grids. The idea was that the increase of exchanges might contribute to the optimum use of the means of production and infrastructures. Later, during the year 2003, these directives, relating to the transit of electricity and gas were abolished and substituted by two regulations for the conditions of access to the European transport grids of electricity and gas.
The second stage was configured with the approval of the Directives of the European Parliament and Council 96/92/CE about the common norms for the interior market of electricity and 98/30/CE about the common norms for the interior market of gas. These measures establish a turning point on regulation, organization and structure of electricity and gas sectors of the European Union.
The Directive 96/92/CE was an important change in reorganizing the European electricity sector, introducing some free market measures in all areas of activity (generation, transport, distribution and commercialization).
Regarding generation, the setting up of new plants was permitted, by opting for two procedures: authorization and licences. In transportation, for the first time the access by third parties to the grid appears, which can be regulated (by a toll) or negotiated (with the system operator); it also contemplates the possibility of establishing the figure of an only buyer. It becomes mandatory to separate the accounts for the firms implicated in more than one activity in the electricity market (legal unbundling). A calendar was also established for the

opening of the electricity market with deferred access depending on the level of consumption.
Member States were free to some extent regarding the appliance of the directive, choosing the best fitted option for the organization and regulation of its electricity systems. It was mandatory to reach the same economic results and a comparable level of openness of the electric markets and a comparable level of access to them (Directive 96/92/CE was later substituted by the 2003/54/CE).
The third stage of the construction of the European energy market, described by Garcia Mezquita started in June 2003, with the approval of the Directives 2003/54/CE and 2003/55/CE about the common norms for the interior market of electricity and natural gas.
In this third stage liberalization is accelerated and harmonizes the process by eliminating some dispositions or options contained in past Directives but not used by any member State; at this stage new measures are also introduced for the improvement of competitiveness in energy markets. The opening of the market for the non-domestic consumers was fixed for no later than 1 July 2004 and for domestic consumer from 1 July 2007.
During the last years of this stage, two regulations were approved, relative to the conditions of access to the European grids of electricity and natural gas, with the objective of easing the free circulation of energy among the member States. Regulations nom. 1228/2003 and 1775/2005 establish, among other issues, principles of harmonization on access tariffs to the grids and about the assignation of interconnection capacity and the management of the congestions in the trans-frontier exchange.

2.3.2 The fourth stage (third package of policies)

The *Third Energy Package* was first proposed by the Commission in January 2007, and from there it started a bargaining process that ended in 2009 with the adoption of a final version of the package. The aim of this third package of policies was to go a step forward in the construction of the European Energy Market by including measures of "ownership unbundling of networks and production assets", while maintaining the "fall-back" option of an Independent System Operator (ISO), in order to avoid decisions on operations, maintenance and development of the network, continuing to be made the responsibility of the vertically integrated owner.
A different group of measures were about harmonization of the level of "powers and independence" of national energy regulators from industry and

government under the premise that what should be promoted first is the internal (European) energy market and not only effective development of national markets.

Another important measure included was to strengthen the EU regulatory function by changing the voluntary co-operation approach, to a binding one. The aim of the Commission was to improve governance required for the harmonization of conditions for a better cross-border trade. Also important was the transparency of information, in order to make it easier for new comers to compete and to avoid price manipulation.

Finally, another group of measures were established to maintain or improve the supply security by highlighting the importance of developing trans-European gas and electricity lines, to improve the monitoring of the supply/demand balance, to set up solidarity mechanisms with import-dependant member states, among others.

2.4 Actors

Regarding the actors, these are basically classified into: a) governments: member states' governments; b) European institutions: EU Parliament, European Commission, European Council; c) Private agents: Firms, groups of firms, lobbies and NGO's, and; d) Non EU actors. All these are treated as "stake-holders" since they all have something to say about the policy-making on the energy market issue. Nonetheless, from the very beginning of the process actors are grouped in a different way; basically in groups "against" and "favourable" to the Commission's proposal, headed by certain countries and backed by firms, groups of firms and lobbies.

2.4.1 Some ideas on actors' positions

As we have already stated before, the process of liberalization of the gas and electricity industries in Europe started in the late 80's of the past century and was drawn in different stages. Before the preparation of the second package of policies (that came into effect in 2003), a benchmarking of the Commission gave the alert about the lack of compliance by governments and about the rush of mergers in the energy industry that threatened to aggravate the problem of concentration and unfair competition (Commission of the European Communities 2001, Eikeland 2008).

A new Commission was appointed in November 2004 and one of the objectives of the its new president, José Manuel Barroso was to re-launch the Lisbon Treaty by taking a more pro-active attitude in what concerned *competition policy* (Kreidman 2009). One of the pillars of this strategy was the internal energy market. To do so, two Directorates-General (DG) started a process of close cooperation, one dedicated to transport and mobility (DG TREN) the other dedicated to competition (DG Competition). These two DGs started a process of benchmarking from which they concluded that it was necessary to go even further forward in the liberalization of the gas and electricity industries in Europe.

After the idea of a new liberalization package became a claim of the council in 2007, both DG started to co-write the proposal. This was surprising for two reasons: first, DGs usually work under the premise that they should not interfere in the other's policy domain (Eikeland, 2008); and second, it seems that participation of DG Competition became capital_in the inclusion and defence of the "ownership unbundling" that was the core of the proposal and the later negotiations.

The first proposal included basically two alternatives for member states' governments, firstly and most importantly "ownership unbundling"; secondly, and as a fall-back alternative the Independent System Operator model (ISO-model), that was more in line with the consensus-seeking procedure preferred by DG Energy.

We can also make a distinction between European level and local actors, where in the first group we find European institutions together with a group of Non-State actors, specially lobbies that act at the European level in order to influence the decision-making process; while, in the second group we find firstly national governments, but also firms that operate mainly under national-state premises and that have special influential power with local politicians (this is specially true when we speak of state-owned firms, like in France, but it is also true when we speak about the firms called "national champions" like E.On in Germany or Gas Natural in Spain, among others). In the following sub-sections we will present actors and their positions in this order, firstly Europeans and secondly, local and member state actors.

2.4.1.1 European Institutions

European Parliament: On 10th July, 2007, the Parliament Plenary Session backed the Commission's proposal, including "ownership unbundling", even when the vote showed a group of parliamentarians not supporting "ownership unbundling" and the split-up of groups along national lines. A notable example of this was the common opinion of the French representatives

(across groups), who voiced strongly against the proposed directive and especially against its supposed effects on the obligations of public services.
European Commission: The Commission's opinion is an abstract of the first version of the proposal that contains the following points: 1) Ownership Unbundling; 2) The fall-back option of the "Independent System Operator"; 3) Harmonization of the level of power of national industry regulators, based on the highest - not the lowest - common denominator; 4) Strengthening of the EU-level regulatory function, higher empowerment of the ERGEG (European regulatory agency); 5) harmonization of the minimum standards of transparency demanded of the TSOs; 6) The Commission's proposal also included measures to strengthen planning and approval of priority trans-European gas and electricity networks (to improve the supply security); 7) Integration of the energy and climate package that settled the 20-20-20 goals. After the first meeting in the spring of 2007 a clause was also included that said that ownership unbundling must also be applied to third country companies, preventing the takeover of vertically integrated companies from outside the EU.

2.4.1.2 Non-State Actors at European Level
"Interest group interaction with EU institutions and national governments has historically played a crucial role in internal energy market policy development" (Eikeland 2008). This has much to do with the "consensus procedure" used in the past policy-making processes in the energy industry and, with the need for expert advice from agents, it gave them particularly good access to the Commission (Lehmann, 2003; Eikeland, 2008).
Lobbies in Brussels may be grouped into supply side organizations and demand side ones; supply-siders have also been classified as *Producer Interests*, which group Businesses, Professions and Labour, while demand-side lobbies (consumers), have also been grouped in a wider class together with Regions, Environmental and Social and Community lobbies, called *Civic Interests* (Lehmann, 2003). In the first group we have:
Eurelectric: represents national electricity associations or leading electricity enterprises in all member countries, other European countries and OECD. Like other supply-side organizations its general position was a "no" to the proposal (Eikeland, 2008), even when they consider that the "liberalization process has brought considerable benefits to the electricity industry" (Euroactive 2008), they call for the full implementation of the liberalization package in all member states and going forward in what concerns guidelines

for congestion management, harmonization on transmission tariffs and a compensation mechanism for TSOs.

ETSO: represents the transmission system operators and, as well as the major part of the supply-side organizations it also said "no" to the proposal for "ownership unbundling", it also "argues for consistent (although not necessarily identical) regulatory principles and practice between member states in order to promote the development of the internal market and economic efficiency". It also encourages the Commission to establish draft guidelines on cross-border trade and congestion management. Continuing with regionalization, as a initial stage of a single energy market, was also proposed by ETSO.

EFET: represents energy traders and they also said "no" to the Commission's proposal.

EREC: is the European Renewable Energy Council and completes the supply-side group, but with a different opinion of its group members. It holds a clear position in favour of "ownership unbundling", since it represented the improvement of conditions for independent producers of renewable energy.

Eurogas: is a trade association representing national gas industry grouping as well as individual companies including France's EDF and GDF, Gas Natural of Spain and RWE Gas Midstream in Germany. It aired its doubts about the Commission's 'ownership unbundling' plans. In a statement, it said that "other feasible solutions may exist" to achieve a more integrated EU gas market, adding that the ISO option is "a possible alternative to be studied".

The organizations that correspond to demand side are:

BusinessEurope: represents many energy-intensive industries that, nevertheless, are some- times also represented by sector specialised organizations. As to what concerns the Commission's proposal, even when they said that it was a very positive step forward, it could not give a totally positive opinion, since BusinessEurope represents not just energy consumers but also some producers.

IFIEC-Europe: represents various national federations of energy-consumer industries and it is co-founder of the Alliance of Energy-Intensive Industries that proposed –together with other seven actions - the "full ownership unbundling".

BEUC: stands for the *"Bureau Européen des Unions de Consummateurs"* and represents national consumer organizations. It was also in favour of the "ownership unbundling".

2.4.1.3 The position of Member State Governments

Member States governments form the European Council, which is a very important piece in the co-decision process. Without a majority of governments in favour of the Commission's proposal, it does not succeed. Even if we give the most important details of the positions, it is important to say that in favour of simplification we will present some grouped countries and opinions [since they also acted in groups to achieve better results]. First we present the groups of countries that were opposed to the proposal, followed by those countries that were in favour of it; some background to member states' opinion is given when considered relevant:

Germany: From the very beginning of the process Germany was one of the leading countries that opposed the ownership unbundling. The economy state secretary Joachim Wuermeling once stated that "Germany is open to the discussion about ownership unbundling and also open to the idea of an independent network operator" (EU Observer, 10.01.2007), but still the German economy minister also said that he had doubts about compatibility of ownership unbundling and the German constitution.

In what concerns the German background: it is worth mentioning the reunification process that started in 1989-1990, their high dependence on coal and their lack of alternative indigenous energy sources (important development of photovoltaic and wind energy). E.ON is German and one of the biggest companies in the EU. In February 2008 E.ON negotiated with the DG Competition to sell its electricity transmission network in order to stop antitrust enquiries that may lead to huge fines (DG Competition 2008).

France: Without any doubt, the French government was, from the very beginning, the one that showed unbending opposition to Commission's proposal and especially to ownership unbundling. Even when the French government showed its preference for the weaker Independent System Operator model, EDF, the largest French electricity firm expressed its opposition to "any kind of unbundling move" (EU Observer, 10.01.2007).

Concerning the French background, French scepticism on this matter can be interpreted due the distance between some liberal governance ideas and state-planned industry policies, which are more to the French taste.

Czech Republic: Czech EP Jan Březina (EPP-ED) pointed out that many countries that joined the EU after 2004 "are dependent on one supplier" and thus unbundling doesn't make sense. The perception of Czech representatives is of great vulnerability in front of other EU risks, and that therefore it is important for them to synchronize their concerns with those of the EU (Mišík

2010). The Czech Republic, together with other new member states (who joined the EU between 2004 -2007), were protagonists of the 2009 gas crisis due the dispute between Russia and the Ukraine over gas prices that lead to the complete cut-off of the Russian gas supply. Even though, the Czech government stated a clear position on the limits they believe that EU energy policy should have; on the one hand the Czechs were against the two types of unbundling detailed in the Commission's proposal and suggested a third one (together with Group 1 that we will describe later), on the other hand the EU decision on member states energy mix was also a matter of dispute, since gas and nuclear energy are, by far, the most important sources in the Czech energy mix.

Slovakia: Was one of the countries that suffered the most severe consequences of the gas supply crisis of 2009, and the only one that blamed the Ukraine solely and directly. One of the consequences of the gas supply crisis was that countries like Slovakia and Czech Republic realized that supply from Russia is not 100% reliable (Mišík, 2010). Slovak representatives shared with the Czechs the position on three types of unbundling (instead of the two suggested by the Commission), and their worry about the EU deciding on the mix of member states. Like the Czech Republic, Slovakia's energy mix is hallmarked by natural gas and nuclear power.

Bulgaria: Together with Slovakia was one of the most affected countries by the gas supply crisis of 2009, since both countries depended exclusively on Russian gas supplies; this dependence on one supplier led the Bulgarian government to adopt a negative position towards ownership unbundling, arguing "negative social consequences" (Tsekova and Rangelova, 2010). It is worth mentioning that Bulgaria is a key piece in two alternative projects: first, the Nabucco pipeline –conducted by the EU- and, second, the South stream project –conducted by Gazprom and the Russian government-; both projects pass through Bulgaria and are seen as competitors. What is clear is that the Nabucco pipeline may help some State Members of the EU to improve their supply security avoiding dependence solely on Russian exports, while on the other hand Gazprom does not want to lose its privileged position.

Baltic Republics: Estonia, Latvia and Lithuania showed, from the very beginning, their opposition to the Commission's proposal with the argument that ownership unbundling may lead to negative social consequences. In what concerns its markets, all three Baltic republics are making efforts in the electricity markets to comply with the EU directives and they have succeeded in different degrees, but what will be a major issue is the gas market, since all three countries depend 100% on the Russian gas supply.

United Kingdom: The UK was one of the most pro-active promoters of the ownership unbundling and the third energy package. This may be so due to the circumstance that liberalization in the UK is not a new matter since, the process of privatization and liberalization started during Margaret Thatcher's government in the late 80's and the early 90's of last century. In July 2010 compliance of UK government with the Third Energy Package was at least 60% (DECC- Department of Energy and Climate Change, 2010).

Nordic States: Denmark, Sweden and Finland were in favour of the Commission's proposal from the very beginning. Firstly, Denmark was one of the first countries – together with the Netherlands and the UK- to show its favourable position. Secondly, in the case of Sweden, it was the Swedish opinion that, complete ownership unbundling should be applied together with the ISO model (Vilkens et al. 2008). Thirdly, Finland was the least enthusiastic of the group, but still supportive of the Commission's proposal. It is worth mentioning that these three countries present different realities in what concerns their electricity and gas markets, on the one hand these three countries together with Norway are part of a single integrated electricity market, but, on the other hand, gas markets are not integrated and depend on different suppliers; while Finland depends a 100% on Russian gas, Denmark and Sweden do not buy any Russian gas at all.

Poland: In 2004 full ownership unbundling was introduced in Polish law, and by the time the Third Energy Package was prepared, production and grid management was already separated in both gas and electricity activities. Still, the same as some other Member States, Poland was not in the group of the most enthusiastic about the Commission's proposal, but it gave its support after the introduction of a special clause that mandated ownership unbundling for third countries from outside the EU. The main concern was that the unilateral split-up of EU companies could weaken the power of negotiation with vertically integrated companies from third countries. It is worth mentioning that Poland has acted in some matters as an informal spokesperson for the Visegrad Four (Poland, Czech R., Slovakia and Hungary), and has attempted to act as a leader of this group (Mišík, 2010).

2.4.1.4 Non-Government Actors at National Level

Private firms stated their position about the third energy package mainly through sector organizations (Euroelectric and Eurogas). However, it would be make matters clearer if we spoke briefly of some relevant firms.

E.On: This German firm is private owned, vertically integrated and one of the biggest companies in the European energy sector. It is worthy of mention not only because of its size but also because 1) it participated in a rush of mergers among European energy firms in the late ninety's and early two-thousand's that was contrary to the European institutions' will and plans since this was seen as an action favouring concentration, against liberalization and increasing competition; 2) It is a vertically integrated firm and before 2008 its idea was to retain the property of its distribution grid, but DG Competition opened diligences in order to sanction the firm for being suspected of abuse of market power. Then E.On negotiated to sell its transmission grid voluntarily if the DG Competition stopped the sanctioning procedure; all this happened while the third energy package was still being negotiated and the result reinforces the Commission's position for ownership unbundling.

EDF and **GDF**: These two French firms are both vertically integrated and both have a large participation by the French government. They were both fiercely opposed to the Commission's plans even after the inclusion of a third option. Liberalizing in France has never been a top priority and compliance with European liberalizing legislation in the energy sector has been slow, with only partial privatization of state owned companies. Furthermore, the opposing views of the European Commission and the firms of the French energy sector can be seen by the facts that 1) while Commission's plans were in the direction of increasing liberalization whereas, GDF was planning to merge with Suez to create one of the largest firms in the continent; 2) GDF was fined (together with E.On) with an historical fine in European energy sector for collusion from 1975 until 2005 (European Commission, IP/09/1099).

2.4.1.5 Outside EU Actors

Russian Gazprom: Gazprom is the Russian government owned Gas Company, and one of the biggest in the world; it supplies Europe with around a quarter of the gas it consumes. Gazprom's (and Russian government interests) were not affected in the first place, but in March 2007 in a Commission meeting a specific clause was adopted specifying that ownership unbundling would also apply for third countries. No country was mentioned, but the clause was soon nicknamed the "the Gazprom-clause". Reaction from the Russian government was clear, accusing the EU of an under-cover expropriation or "appropriation of assets" that would harm the activities of the energy companies. Gazprom has been accused of being an instrument of the Russian government to "regain the geopolitical influence lost after the collapse of the economy and fall of the iron curtain" (Eikeland, 2008), and since early 2007 it has exhibited a very pro-active attitude to defend its interests, not just in what concerns to ownership unbundling, but also in the construction of the South stream project (gas pipe lines from Asia to Centre-Europe). The bitterness of Russia's reaction caused some worries among EU Member States about the supply stability coming from Russia.

4.1.5 Groups

From the very beginning of the process, just after the Commission presented its proposal, two groups were clearly formed focusing on one of the most important parts of the proposal, which was the "ownership unbundling". Germany and France led the first group, and their general position was against ownership unbundling. The second group did not exhibit a clear leader, but it was formed around the active promotion of "ownership unbundling". In the following tables these groups are bunched together with their general opinion and the non-government actors that subscribed to this opinion.

<table>
<tr><td>Group 1</td><td>Germany (leader)</td><td rowspan="9">Group led by France and Germany, its opinion is that enforced unbundling may be unconstitutional and that might have negative social consequences.</td></tr>
<tr><td>France</td><td rowspan="7"></td></tr>
<tr><td>Austria</td></tr>
<tr><td>Bulgaria</td></tr>
<tr><td>Greece</td></tr>
<tr><td>Latvia</td></tr>
<tr><td>Slovakia</td></tr>
<tr><td>Luxemburg</td></tr>
<tr><td colspan="2">Non-State agents: Eurogas, (it should be noted that Gaz de France and EDF (France), RWE (Germany), and Gas Natural (Spain), are part of this organization).</td></tr>
</table>

This group exhibited from the beginning a strong opposition to ownership unbundling, furthermore, the French position was somewhat fierce and together with Germany, they headed the group's position. Between the two groups, this first, may be seen as the more homogeneous one, since seven of the eight countries depend to some extent on Russian gas (with the sole exemption of Luxemburg), and in what concerns electricity markets, the first group countries have chosen looser unbundling options for their electricity transmission systems (legal or independent system management operators; Jamasb and Pollitt, 2005 –For former EU members; Pollitt, 2009 for eastern and south-eastern EU countries). Private agents that form part of this group are mainly gas companies and the organizations that group them; this may be so because gas grids are, to some extent, more strategically significant than electricity grids. With the loosening of the unbundling option this group started to convince themselves that alternatives like the ISO-model – the loosest option- would be possible to adopt or at least the best possibility to comply with the upcoming directives (Schmeltz 2010 for Austria; Lejins 2010 for Latvia). Since there were also different realities and different degrees of liberalization, the mean option, the ITO-model also persuaded some of these countries to support the Commission's proposal (Tsekova 2010 for Bulgaria in the case of electricity markets).

<table>
<tr><td>Group 2</td><td>UK (leader)</td><td rowspan="6">These countries were "active promoters of ownership unbundling" (Euractive, 2008)</td></tr>
<tr><td>Netherlands</td><td rowspan="4"></td></tr>
<tr><td>Denmark</td></tr>
<tr><td>Finland</td></tr>
<tr><td>Sweden</td></tr>
<tr><td colspan="2">Non-State organizations: Cefic, ESTO, Euroelectric, BusinessEurope and EREC also hold this opinion.</td></tr>
</table>

As to what concerns gas markets particularly, it is important to point out the role played by the out-of-EU actors (especially Russia) trying to persuade some EU member states to maintain their negative vote. With the eastern expansion of the EU some important dots of the Gazprom's gas grid lie well within EU borders, and its strategic relevance was highlighted during the Ukraine-Russia gas crisis and during the Georgia-Russia war, but also these facts convinced EU member states to speak "with a single voice in front of third countries" in matters of energy supply, since frequent crises demonstrated that to rely solely on Russian supply is contrary to EU security of supply. Frequent calls for unity caused the European Commission great concern, and the inclusion of this matter in the final agreement must be taken in account.

Former members of the EU and a heterogeneous group of private agents are part of this second group: renewable energy producers (EREC), consumer organizations or trans-sectorial organizations. This group did not exhibit a clear leader, but was definitely supportive of the Commission's proposal. It should also be said that besides Denmark who had opted for the legal unbundling model, the other four State-members of this group were already compliant with total ownership unbundling in electricity markets (Jamasb and Pollitt, 2005). It is also worth mentioning the active involvement of the United Kingdom representatives in the promotion of total ownership unbundling since the UK governments are not usually active in European matters, but it is most important since this country warned about the danger of neglecting the opportunity to increase liberalization in the gas and electricity markets (DECC, 2010).

Apart from the role played by member state governments, we must also mention the role of non-government actors, especially lobbies, looking out for consumers' interests. These interests were differently defended by Cefic (the European Chemical Industry Council) who soon put pressure on the whole process for increasing liberalization and coordination of the actors; while BusinessEurope was more prudent in expounding its opinion, since this lobby represents both consumers and energy producers. Its support of the Commission's proposal definitely helped to reinforce the idea that a true liberalization process was in process.

2.4.2 Second Stage of the process

In June 2008, the second stage of the process started after the EU Council of Ministers and the dissident group (G1) reached a commitment by which a third option is added to the final proposal; this third option consisted in the inclusion of the Independent Transmission Operator model as a means to achieve a sort of ownership unbundling. With this agreement the blocked position was unlocked and the whole package was ready to be approved; the period of compliance of eighteen months started on August 2009.

Under the third option finally approved, energy companies could hold the ownership of the grid, but must create "objective conditions" for the access of third parties to the grid. It is worth mentioning that the final negotiation was conducted under the presidency of the Czech president who was, at that time, president of the Council. It seems strange since the Czech Republic was not particularly enthusiastic about the Commission's proposal, but its energy vulnerability (its dependence on Russian gas), made the Czech government particularly sensitive to the synchronization of European and local concerns in energy matters.
Finally the proposal included three options of unbundling for the member-states: a) Total ownership unbundling (the option preferred by the Commission, consumer associations and only a few countries); b) the Independent System Operator or ISO-model, where vertically integrated firms can maintain the ownership of the grid, but management of the grid must be responsibility of an independent entity and c) the last and loosest version of unbundling, where companies retain ownership of their grids but must permit access to them by third parties. The inclusion of this third model convinced the necessary majority of countries, leaving France alone rejecting any kind of unbundling.

2.5 Summing up and Scenario Analysis (*Constellation)*

In this section we will make the scenario analysis taking into account the actor's capabilities, their strategic options and the related outcomes and payoffs. Actor's capabilities are the resources that allow actors to influence outcomes (Scharpf, 1997), while strategic options are the different possibilities that actors have to pursue their goals, and finally, outcomes and payoffs refer to what actors may gain or lose depending on the strategy selected.

2.5.1 Actor's capabilities

Thus, in what concerns lobbies and private actors it should be said that in the first step of the drafting on any proposal, the Commission gives these agents the opportunity to give their opinion and make specific proposals, giving them privileged access to decision making (Eikeland, 2008). The lobbing activity at the European level has been increased, and specially in the recent years; there are about 2600 interest groups permanently based in Brussels and at least a tenth part of them correspond to national business associations (Lehmann, 2003). However, their capabilities are limited in the European Union decision-making processes, since, even conceding their power of influence they do not have a vote.

Secondly, to sum up member States' capabilities we would like to say that they constitute the European Council, but their power of influence is limited to a blocking majority. The EC have different degrees of agreement required in order to make decisions (either complete consensus or simple majority), this depends on the Treaty that applies to particular subjects. Generally decisions are made by consensus, but sometimes they adopt decisions by qualified majority. One important change that took place with the approval of the Treaty of Lisbon was the increase of areas that needed a qualified majority voting instead of unanimity. In the case of energy markets, decisions must be made with a qualified majority.

Thirdly, the European Parliament's capabilities are higher in co-decision procedures when an absolute majority is needed to pass decisions, and with the same procedure it can reject a proposal in the first reading. If a majority is not reached, a second and a third reading can be forced; powers and capabilities of European Parliament have been constantly increasing with each new treaty (although we will give more details in the section devoted to strategy, it is worth mentioning that MEPs usually vote in alignment with political groups and not national interests).

Fourthly, the Commission is the only European institution empowered to start legislation, and the one that drafts and conducts the whole process, but even so, the President of the Commission does not have a vote, either in the Council or in the Parliament.

And lastly, in what concerns out-of-EU actors, obviously, they do not have any vote or veto power, but they can pressure EU governments to create blocking majorities that favour their interests (in our case we are thinking of the Russian government and the public firm Gazprom).

2.5.2 Strategic options

Continuing with the summing up of the scenario, and as to what concerns strategic options, we would like to start with those of the sceptical member States since they opted for different strategies; Germany, soon assumed that the Commission's proposal might be in conflict with German fundamental legislation, while France refused any kind of unbundling of the grid and Austria, at its time opted for pressure for a third model that had lately become the Independent Transmission (ITO) model, the loosest form of unbundling transmission grids.

Concerning lobbies, with the idea of increasing influence on European policy, firms are grouped in lobbies and lobbies are somehow divided - but not exactly - into supply-side and demand-side lobbies (generally speaking, lobbies that group firms are those of the supply side, while lobbies that defend consumers' interests are in the demand side). In recent years these lobbies have learnt how to coordinate their actions better so as to better defend their interests. This has been the case specially for the demand side lobbies while not so for the supply side ones. Grids are strategically more important for gas companies than for electricity ones. When a first draft of the Commission's proposal was presented the greater part of larger European companies was already compliant with unbundling, and for those that were not (like the case of E.On in Germany) selling their grids to someone else was not a major issue. In these circumstances, some lobbies had problems with establishing a clear position and strategy, as well as organizations like the BusinessEurope group, some energy intensive firms and also some producers, which resulted in a certain blurriness of opinions.

The European Commission had its preferences pretty clear (total ownership unbundling), and an innovative strategic approach (co-drafting of the proposal by both DG Competition and DG TRANS); still, the Commission, through DG Competition did not hesitate to threaten to use its powers of 'punishment' to pressure firms to go forward in ownership unbundling, as was finally the case of E.On, who negotiated the voluntary sale of its transmission grid to avoid sanctions due to market abuse.

The Parliament usually looks out for consumer's interests and because of this it was predictable that it would vote in favour of the proposal (Eikeland, 2008), furthermore, a simulation of voting gave the Commission the hope of a somehow easy support by the parliament. MEPs, as we said before, usually vote according to their political groups instead of voting in accordance with national interests, still, all the French representatives, decided to vote this time against the Commission's proposal, aligning their vote with national interests. Negotiations with some countries led to the inclusion of the third countries clause, in order to calm worries about losing market power in the face of non-EU companies.

The most important non-European actors to participate in the process were undoubtedly Gazprom and the Russian government. Strategy in this case was two-fold, on the one hand pressured directly the Commission, but it also used its relevance as a gas supplier to gain support among European governments. Russia decided to pressure not just through simple gas supply (Slovakia, Czech

Republic, Estonia, Romania, Baltic republics) but also by promising investments with the construction of the South stream pipeline (Romania).

2.5.3 Outcomes and Pay-offs

Finally, in the chapter of Outcomes and Pay offs, we would like to start with those obtained by the Commission, since its proposal was finally approved with relatively small changes i.e. the inclusion of a third option of ownership unbundling; this was the second best possible scenario for the Commission. The European Parliament approved it at the first reading (June 2008) nevertheless, it had to be renegotiated due the inclusion of the third option (March 2009).

Even if the group that opposed the Commission's Proposal was formed by at least eight countries, the inclusion of a third option is attributed to the leadership of two, i.e. France and Germany (Euractive, 05/05/2008 and 07/07/2009), and then, a certain capacity of influence must be attributed to them and the coordination within the first group of countries.

For the supply side organizations the undesired result was to lose ground or competitiveness with regard to non-EU companies, and so they were not obliged to follow the EU directives; this concern was solved with the inclusion of the third countries clause (also nicknamed the Gazprom clause). Due to the lack of compliance by certain companies like E.On in Germany, DG Competition accused this company of market power abuse, but this firm negotiated to sell its transmission grid if the charge was dropped, and so it was.

Russian pressure reached the point that when decisions were made (2009) it was stressed several times that there was a need to speak "with a single voice" concerning European energy supply by third countries (Conclusions European Council, March 2009). Nevertheless, this pressure clarifies Russian fears and also possible EU-member's benefits, since fierce opposition from Russia had helped the contrary effect by unifying the response and giving more credibility to the Commission's arguments.

We would like to end this section speaking about some possible consequences and what key actors forecast.

Compliance with the third energy package is a major worry for the European Commission, given that the results, and relative success, of the negotiations does not constitute the real end of the road. The deadline for transposition of the third energy package ended at mid 2011, but the internal political life of many member states has provoked some delay in at least 20 of the 27 member states.

Apart from the compliance period it is worth to say that the loosest option of the package of policies will be used by at least 8 countries while only five will choose the total unbundling of the grid. What was the "fall-back" option, the Independent System Operator, or ISO-model has become the preferred option of Member States. The multiplication of unbundling models adds some uncertainty and this constitutes a major barrier to investment.

According to some forecasting, natural gas will play a key role in the transformation of the European energy system as the main substitute for coal and oil (European Commission 2011), due to such key role, increasing integration is a major priority as well as the diversification of supply sources of natural gas.

Energy markets move fast; new and existent trends picture new scenarios while new regulations and structures become old in only few years. The increasing demand of energy in Europe and abroad, together with the need of development of different sources and suppliers of energy, will stress the need to go forward in the integration of European energy markets. We may expect a new package of European policies and regulations in this sector, pulled by the needs of European families and firms.

2.6 Conclusions

In the light of the foregoing analysis of the actors, strategies and outcomes, we would like to end this chapter with some statements about our conclusions:

The Outcomes favoured the position of the European Commission: Even when the first plan of the Commission was to include only total ownership unbundling, the further inclusion of alternative models could be seen as a step forward in the liberalization process of the energy markets, which is the final goal. A large group of all member states must make great legislative changes and efforts to comply with the directives that make up the third energy package.

Supply and demand side interests were differently coordinated: The first step of law making in The European Union (i.e. Impact assessment), has favoured the access to the Commission by interest groups, and this has encouraged the creation and growth of lobbies (Eikeland, 2008; Lehmann 2003); nevertheless, these are differently coordinated, sometimes lobbies are too big and with a variety of interests. While increasing liberalization and integration of energy markets are supposed to favour consumer interests, these are most likely to support measures in this direction (this is true not just for consumers lobbies but also for "consumer representatives", i.e. the European Parliament). Supply side interests, on the other hand, remain in the field of some private and public firms who were finally unable to defend their position against the stream.

More intensive activity of lobbies and private organizations gives more support to institutional approaches: Regarding the above statement, we consider that institutional approaches do not deny the importance of national-state governments (Pollack, 2010), but also stress the importance of supranational institutions. Increased lobbying activity towards European institutions (especially in the 'impact assessment' step of the law making process (Lehmann, 2003)), gave us some clues about the increasing importance of European institutions.

Outside-EU opposition, especially by Russia, helped the "in favour" group's interest by clarifying the so far unclear benefits of increased liberalization: The real effects of liberalization on consumers' benefits have not been a subject of discussion in this chapter, nevertheless, doubts on its real impact has always been an obstacle for its promoters; evidence in favour appears to be circumstantial and based on case studies (Pollitt, 2008; Brunekreeft, 2008). Strong opposition by Russia paved the way by making it clear that the Commission's proposal was in the correct direction for the reduction of Gazprom's power in the gas Market. Even if the "in favour" group (G2) was more heterogeneous, coordination was easier since benefits were clearer for these actors, again, not because of incontestable scientific proof, but because of fierce Russian opposition.

Progression of the whole process, one step at the time: a proposal for liberalizing energy services like this, would not be possible in one single stage (it is worth remembering that some countries have already unbundled the ownership of former vertically integrated firms), and this design proved quite positive and constituted an example of how institutions matter, how institutions change over time and how these help to shape actors preferences.

Finally, we would like to end this part of the chapter stating some pros and cons of the liberalization of the European energy market, as an evaluation of the process and a way of seeking a future horizon.

The most important positive consequence of the process of liberalization is the increasing of supply security, since member States and European entities can now better coordinate their response to a possible energy supply crisis. This is particularly important to central European countries and especially in gas supply.

If liberalization reaches an advanced stage, consumers might be able to choose among a wider range of suppliers or retailers, regarding specially two aspects: price per unit supplied and quality of the service.
The increasing competition among suppliers should lead to more efficient production and transport of energy. Especially we must expect a wider range of production methods (a more balanced energy mix) and an increasing participation of renewable energies (e.g. wind and solar energy in the case of electricity). Finally, in what concerns to more efficient transport of energy, we should expect an updating of the transport grids (in the case of electricity) to avoid losses and an increase in the number of interconnections with neighbour markets (in the case of natural gas) in order to be able to improve the quality of supply contracts.
On the other hand, we should also mention some possible negative consequences of the liberalization of the energy markets.
First of all, there are no conclusive proves of the positive effect of liberalization on energy prices. This process has been long and has required big amounts of effort and patience while one of the most desirable effects is just theoretically true. This ambiguity encourages the most sceptical to resist and constitutes a constant obstacle to those who believe, while it maintains the uncertainty about the future configuration of the European energy markets.
Firms in the energy sector seem to have other priorities rather than opening or integrating markets, while some national governments have made of this a major issue; waving alternatively the national flag or their presumed worry for European integration, some politicians at national level have been more an obstacle than facilitators or leaders. Member States governments fear the loss of sovereignty and loss of power of their own regulatory agencies relative to the new European entities.
Apart from national particularities or personal leadership, some major obstacles for liberalization in the energy markets are the natural monopolies that we find in these kinds of commodity markets (i.e. transportation and distribution). The most common answer to such problem has been regulation, but this increases the complexity of markets, building new barriers while trying to demolish the old ones.
And last, the consensus seeking policy during the whole process had the consequence of the inclusion of multiple models while the most desirable outcome was the setting up of a single and more open model, i.e., total ownership unbundling (at least for the European Commission that started and lead the process). While compliance with the multiple model solution should

be easier for Member States, it does not constitute a warranty of liberalization and we must expect a new bargaining process towards liberalization.

We have identified the players involved, their preferences and their strategies, so we have been able to reach some conclusions and to find some proof for the hypotheses set out in the first part of this chapter; still stronger proof may be found through quantification of preferences and outcomes while going ahead with the isolation of players and their alternative strategies.

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Chapter 3

European Electricity Markets: Integration, Liberalization and Electricity Prices

Abstract

In this chapter, we focus on the effect that five factors may exert on electricity prices for mid-size households and mid-size industries. The five factors that we tested are: ownership of the main electricity-producing firm; the balance of each country in terms of primary energy and electricity; the degree of concentration of the electricity markets, and the amount of renewable energies supplied in each country. We conducted a two-panel data analysis: one for industries and one for households. We found that ownership of the main electricity companies might have a direct relationship with the prices paid by final consumers and that final prices might also be related with the primary energy imported by each country.

3.0 Background & Problem Statement,

In the last twenty-four years the European Union has pursued the integration of the internal market of energy, mainly in what concerns to electricity and natural gas. In 1988 the need of integrating the European energy markets was stated for the first time. This was in order to fight against two main questions: price rising without control and increasing the efficiency of energy producing firms while maintaining or improving the security of supply. This is due to two causes: first to the, at the time, still fresh memory of the oil crisis at the beginning of the 1970's decade and to the re-launched process of European integration.

This chapter concludes the a series of three in which first we describe the process of integration of the European energy markets (EEM), then we talk and test for the relevance of a group of factors that are supposed to affect energy prices, and finally, we discuss and test the main factors affecting the efficiency of the electricity producing and distributing firms. In this chapter we will focus in the second part, and we will talk almost exclusively about electric energy prices.

Our main interest is the evolution of prices since the beginning of the process of construction of the internal energy market and the main causes that influence fluctuations. In order to achieve this goal we will use homogeneous data published by Eurostat as well as some self-constructed variables that complete the database.

Part of the state of the art concerning electricity prices has a lot to do with reforms of the energy sector and liberalization of markets that introduce or increase competition in this industry. General microeconomic theory suggest that competition together with the search of maximum profits results in better performance of the actors that produce better (reduce their costs of production -internal) and perform better in markets (sell at lower prices - external).

Everyone interested in the Electricity Supply Industry must be aware of three relevant features that must be taken into account: reform, improvement and regulatory matters. First, there are large sunk costs that limit the possibilities for newcomers; second, companies dedicated to different stages (generation, transport, distribution and retailing) have very different optimal scales and; third, energy cannot be stored at large scale, which obliges to pay constant and accurate attention to the balance between demand and supply of energy in the network.

Reform of the electricity sector has been pretty difficult and a long run goal, designed in different stages. Jamasb and Pollitt (2005) suggest that any reform of the electricity industry may require the "implementation of one or more of the following inter-related steps: sector restructuring, introduction of competition in wholesale generation and retail supply, incentive regulation of transmission and distribution networks, establishing an independent regulator, and privatization" (Jamasb T. , 2002; Joskow P. L., 1998; Newbery, 2002; Jamasb & Pollitt, 2005).

According to Dukert (2009), there are factors on both the supply side and the demand side of energy that affect the slope of the demand and supply curves and thus the point in which they intersect (the price at which electricity is sold and bought). Dukert (2009) identifies four factors affecting electricity prices: a) first, the diverse sources from which it may be produced, coal, oil, wind, etc., have different prices in different places; b) on the demand side, consumers have different needs (i.e. transport, heating, lighting), but not all sources fit well with all needs; c) different kinds of energy can be transformed in other types of energy back and forth (heat in motion, motion in electricity, etc.); and finally d) various sources of energy can often be substituted for one another (i.e. we can use oil, gas, or electricity to move a car).

We focus our attention in a group of factors that may affect electricity prices in a way or another, regardless their status as offer or demand factors.

3.1 Objectives

In this chapter we first talk about the price formation in the European Union, particularly about the wholesale market, that determines the liberalized part of the final prices. We assume that since the single market is not yet completely constructed, we can speak of different energy markets in Europe and thus, speak of different characteristics and different possible developments. The European energy market is actually divided in seven regional markets (see descriptive table in the annex 2).

Second we identify and discuss a group of factors that we think may influence the fluctuation of electricity prices in different European countries. We discuss the way in which we think these different factors or drivers may affect electricity prices according to what the related literature has said about these factors.

Finally, we set a simple model in order to try measurering or quantify somehow the influence of the main factors discussed and test for the impact that these really have on electric energy prices.

3.2 Electricity prices in Europe

One important feature to state clearly is that the process of reform has not yet been completed and then every result should be presented as partial. Some scholars have, for example, tested for convergence of wholesale electricity prices (Zachmann, 2008), but even when some evidence can be find, this is partial and far from theoretical expectations.

It is also worth to mention that the prices have two basic parts, one that is decided by the market, the so called liberalized part of the prices, and another part that is decided by the national governments and the regulators, this part comprises levies and taxes of different nature (e.g. green taxes, consumption taxes and other). We focus in the liberalized part of the prices, since it is the part that can be more directly affected by the reforms in the sector.

Prices of electricity are of capital importance for many reasons, including state level strategic policy, international competitiveness, as electricity prices represent a significant portion of total energy costs for the industrial sector. Electricity is a very particular commodity as it is completely homogeneous (we cannot distinguish electricity provided by different suppliers, this is identical), but differently as other energy commodities (e.g. oil), which are traded in global markets at relatively uniform prices, electricity is traded at very different prices depending on the place where it was produced and consumed. Besides of some general trends that may influence electricity prices, like those pointed by Dukert (2009), (see above), there are also other general factors such like the geopolitical situation, the import diversification, network costs, environmental and protection costs and severe weather conditions (Zachmann & von Hirschhausen, 2008; Alberola, Chevalier, & Chèze, 2008).

Nevertheless, we are interested in more specific factors or drivers of net electricity prices, that is, the part of the prices that is not directly decided by governments and regulators. Some drivers have been proposed in relation to trends in net prices of electricity, such as generation mix, market structure, elasticity of demand and price mechanisms (Lucia & Schwartz, 2002). In relation with these and other factors that have been proposed as being in direct relation with price formation we summarize the following drivers as the most important ones: First, the amount of renewable energies that are part of the energy mix, where two effects have contradictory impact in electricity prices, these are, the merit-order effect and the marginal-cost effect (Munksgaard & Morthorst, 2008); secondly, the ownership of the main electricity supplier has been pointed as a factor of the level of prices, private and public firms may have different interests in charging different prices

(Newberry D. , 2006; Rudnick, Varela, & Hogan, 1997; Florio, 2007); thirdly, market structure and particularly the concentration of the market is also a possible feature that may end up affecting prices (Linden & Peltola-Ojala, 2010) and; finally, the availability of primary sources of electricity and international electricity exchanges (Messner & Schrattenholzer, 2000). In the following section we will extend the discussion on how these factors may affect electricity prices.

3.3 Factors Affecting Electricity Prices

In this section we will describe in detail the relation between the factors or drivers that we propose have an effect on electricity prices as well as some additional references to the literature and how these have been introduced in the discussion.

The first factor of which we are willing to speak about is the share of renewable energy (electricity) produced in a given country i at time t, in our model R_{it}.

The expected effect is that $\Delta R_{it} => \Delta P_{it}$, it increases the prices due to support schemes such as feed-in tariffs (Bryce, 2012). New fixed costs like the already mentioned support schemes and new infrastructures are the most mentioned additional costs of renewable energies, but also higher costs of production compared with coal and natural gas technologies.

Nonetheless, the size of the impact is still a matter of discussion, since while some scholars argue that support schemes lead doubtlessly to price rising in every case (Bryce, 2012), other scholars insist that prove is not conclusive and that price rising is in many cases quite modest (Caperton, 2012). Finally, there is still a group that sustain that if we focus in certain production methods (like wind mills, for instance), we may find that the increasing production of energy may have a reducing effect in wholesale prices (Sáenz de Miera, del Río González , & Vizcaíno, 2008).

On the other hand, some authors speak about the "merit order effect". This effect might appear if the network operator differentiates between generation methods, giving preference to those with lower marginal costs. Concerning renewable energies and specially windmill generators, the price of power is expected to be lower during windy periods than in periods with low wind. This is called the "merit order effect" (Sensfuß, Ragwitz, & Genoese, 2008). The general hypothesis of the merit order-effect is that the increasing production of electricity with low marginal costs, leads to lower prices of energy.

Second, O_{it} is a discrete variable that says if the main energy producer is owned by the government (0), by private agents (2) or just partly owned by one or the other (1). The effect we want to test is that $\Delta O_{it} => \nabla P_{it}$, since private companies may search to operate more efficiently, reducing costs of production and thus final energy prices.
Nonetheless, if these private companies are monopolies, incentives to reduce production costs are less important than the maximization of profits, using monopoly power to make final consumer pay higher prices, then the effect may be described as $\Delta O_{it} => \Delta P_{it}$.
This is one of the most controversial factors treated in this chapter, but still we are looking for stronger evidence about the relationship between ownership and price evolution. Results may depend indirectly on the main reasons for which a country decides to privatize the electric sector; reasons might be various: political –due to decision of local governments-; economical –due to lack of resources by governments that jeopardize investments; worry about high tariffs, managerial failure or global economic crises (Rudnick, Varela, & Hogan, 1997). Ownership shifts might have different outcomes (prices of electricity may rise or fall), depending on the new configuration of the electricity market after the privatization (Newberry D. , 2006), it is far more important the increasing of competition in the new market than the titularity of the companies, say if electricity firms are private or public owned (Domah & Pollitt, 2001).

Based on those arguments we decided to include a concentration/liberalization measure C_{it}, say the share of the biggest power company in retailing electricity market of country *i*. The expected effect must be $\Delta C_{it} => \Delta P_{it}$, the greater the concentration, the higher the prices, or to put it the other way around, the greater the competition is given in a market, the companies approach their final prices to costs of production (or MgC) and the $\nabla C_{it} => \nabla P_{it}$.

In what concerns to this matter, some concentration measures have been suggested in the literature, but also some other ways to account the market power of electricity firms. It is important to point out that due to the nature of this sort of markets, competition and market power might be difficult to measure or pointless to do without a proper background (Linden & Peltola-Ojala, 2010).

Regarding El_{it}, that is the difference of the imports and exports of electricity, if $El_{it} \rightarrow \infty$, then the country *i* exports electricity and if $El_{it} \rightarrow -\infty$, then the country i imports at least some amount of the electricity it consumes; therefore, the expected effect may be $\Delta El_{it} => \nabla P_{it}$, the more self-sufficient a country is, the lower the electricity prices may pay the final consumers of such country.

Finally, in what concerns to En_{it}, that we have identified as the difference between the imports and exports of primary energy, if $En_{it} \rightarrow \infty$, then the country c exports primary energy and if $En_{it} \rightarrow -\infty$, then the country i imports at least some amount of primary energy; the expected effect may be $\Delta El_{it} => \nabla P_{it}$, the more self-sufficient a country is, in what concerns to primary energy, the lower the prices might be to final consumers of such country.

3.4 Methods and Procedures

After the previous discussion of possible interactions of a group of variables, we specify a model with which we measure the impact or interaction between the discussed factors and the final energy prices.

3.4.1 Specification of the model:

The model we propose is a multivariate model, since we propose that the factors we discuss in this chapter not only have an effect in electricity prices, but also might be used to characterize different sorts of markets (as far as there is not an European single market –integration is not complete- we should continue speaking about different markets and their differentiating characteristics). The model we use for the estimations is specified as follows:

$$P_{it} = \alpha_t + \beta_t R_{it} + \gamma_t O_{it} + \delta_t En_{it} + \theta_t El_{it} + \eta_t C_{it} + \varepsilon_t$$

Where P_{it} is the price of electricity in country i at time period *t*; R_{it} is the share of renewable energy produced in country i at time period *t*; O_{it} is a discrete variable that may take the values 0,1,2 and says if the main electricity firm company is public, partly public or private; En_{it} is the difference between the total production and consumption of primary energy; while El_{it} is the total production and consumption of electricity; last we include C_{it} a concentration measure, a proxy, representing the market share of the biggest power company of country i at time period t. Finally, ε_t is the error element, normally distributed and with mean 0.

In this specification it is important to point out that we have included two different variables, for two different phenomena. In the first place, we have included a variable that deals with ownership of the firms, i.e. if the firm is owned by the government, some private agent or both (O_{it}). In second place, we have also included a variable that deals with the degree of liberalization of the electricity market (C_{it}). Even when liberalization and privatisation are used some times as equal terms, from our point of view such concepts are quite different and thus must be treated separately and tested with different variables. (Monopolies can be owned either by the government or by private hands –ownership is not relevant-, while the existence of different companies is an indicator of the degree of openness/liberalization of any market).

3.4.2 Data

For the dependent variable P_{it} we use electricity prices charged to final consumers. We use two different series, and two different sets of data. The first series refers to industrial consumers while the second refers to households. Particularly, the industrial consumers' series is defined as the average national price measured in Euro per kWh and excluding taxes (see annex 1 to see consumption of each series). Similarly, the households' series refers also to midsize households and it's also measured in Euro per kWh. Both industrial and households series are reported by Eurostat. Due to changes in the methodology for the classification of consumers and the break in series that this change produced, we rather prefer to use the midsize series instead of different series for each type of consumer for the regression analysis. We are not using a mean of all prices paid for all kind of consumers, but the price used by the mean sized consumer. We thought that it would be quite more convenient to use two homogeneous and longer series instead of shorter and more heterogeneous ones, since the explicative power of the factors we use might vary over time and thus using longer series might result in more reliable outcomes, the first dataset refers to the years comprised between 2001 to 2010, starting then before the approval of the second package of liberalizing measures and ending three years after the third and last

package of measures. The second set of data refers to prices and is a shorter set, just from 2007 until 2011, but it reports prices charged to different consumers; we thus decided to use this smaller data set to perform a preliminary analysis on prices and talk about some expected results and exploratory analysis.
In what concerns to the series of the dependent variables we constructed our database as follows: For R_{it} we use two different variables for two different specifications of the model; the first one is the share of renewable energies in gross final energy consumption reported by Eurostat. Usually this variable or indicator is used to monitor accomplishment of member states with European directives for renewable energies promotion. In what concerns particularly to electricity from renewable energy sources, it is defined as the ratio between electricity produced from renewable energy sources and gross national electricity consumption. This category comprises: hydropower plants, biomass/waste, wind, solar and geothermal installations. Nevertheless, even when this variable is quite informative it is relative to consumption and thus might hide a season component difficult to extract. For this reason we decided to use also an alternative variable, that is, the supply of renewable energy; this figure comprises the total of hydro, photovoltaic and wind power. The main advantage of this variable, compared to the one previously described is that it is a raw figure, it does not depend on any other variable and accounts for the larger sources of renewable energy, but, on the other hand it does not take into account the whole package of renewable energy and thus might underestimate the amount of renewable energy supplied to the energy system.

For O_{it} we have constructed a discrete variable that takes different values depending on the ownership of the main energy producer in different European countries. It makes sense to take just one (the biggest), since it is an indication of the degree of liberalization of the local market, this is complemented with the concentration measure that we will explain later in this section. Values goes from 0 if the main electricity producer is owned by the government, passing through the 1 if the main electricity producer is partly owned by the government, and finally, it may take the value of 2 if the main energy producer is a private entity. To be qualified as a public entity, governments must hold at least a 34% of the social capital of the main energy producing firm, and the same criteria is used to be qualified as a private entity, at least a 34% of the social capital must be hold by private hands. Almost all countries that had decided to start a process of privatization of their main energy firms have opt for a long run process, and we want to, at least partially, to account for the main changes that this privatization process may cause. Even when we think that a more sensible scale might give us more information, we had to process a good deal of information to construct this variable for a large group of countries and we believe that this is reflected in the results of the empirical exercise. For crosschecking purposes we also used the information on the construction of this variable to make a specification with three dummy variables that took the value 1 if the main energy producer was public, partially public and private and totally private, while taking the value 0 in any other case, respectively for each of the dummy variables.

For En_{it} we have used the difference between the total primary energy produced and the gross primary energy consumed. This variable is self-constructed with two variables from Eurostat; on one hand, total production of primary energy, that refers to, exploitation of natural resources like coal mines, crude oil fields, hydropower plants or fabrication of biofuels (by definition, no electricity or heat production is counted here); on the other hand, gross inland consumption of primary energy, that is, the total amount of primary energy produced in a given territory plus the import of primary energy from other countries; this second variable reflects the energy necessary to satisfy inland consumption within the limits of national territories. Simple as it is, this variable gives us information about the independence of the energy system of a given country. Independence of the energy system, as we stated above, might have direct consequences in the prices paid by final consumers.
For the construction of El_{it}, we have also used the difference between two variables published by Eurostat, total gross electricity generation and final energy consumption of electricity. Total gross electricity generation is defined as the total electricity generated including the consumption of electricity in the plant itself together with auxiliary plants and transformers. Meanwhile, final energy consumption of electricity covers the electricity delivered to the final consumer's door, it includes industry, transport, households and other sectors, regardless the final use of energy. This figure gives us information about self-sufficiency of the electricity markets and how much electricity power might be required to import. While in some regions of Europe in which the integration of markets and electricity grids is a fact, this international exchange might not have a direct effect on prices paid by final consumers, it is not the same for the whole of Europe or for other less integrated markets or poorly connected grids.

Finally, for C_{it} we use a proxy as a concentration measure, that is, the share of the largest generator in electricity market. Like previous variables, this is taken yearly, and the calculation is based in net production, excluding own use for the generating plants. In this data, also from Eurostat, the production of subsidiary companies and/or firms with which the main company has a contracting share is included. We are aware that there are other ways to measure concentration of markets, being the more popular one the Herfindahl-Hirschman Index (HHI), that creates a measure of concentration of the market by summing up the square root of the market share of all participant firms in the market; or variation of this one that only takes in account the square root of the bigger four (quite enough for highly concentrated markets like electricity markets); Nevertheless we discarded this option because: first, we would have to look for and find the market shares of a huge number of firms in different countries and in a sector with very different degrees of transparency; second, after constructing such index we might end up having not much additional information that we already have and not as neat as the simple variable that we already presented. As we see it, the cost-benefit between constructing a HHI, and keeping the concentration measure as we finally decided, clearly favours the second option.

We report different kind of analysis for two different groups of countries. The first and simpler analysis includes the bigger group of countries for which we collected the longer series on prices. The 27 European Union countries plus Norway compose the first group of countries, while the regression analysis only includes 16 countries of the first group. This reduction in the group of countries obeys only to the availability of data and we regret the exclusion of some countries that would be quite interesting to include in the second analysis.

In what concerns to the time horizon for the preliminary analysis we have used series from 1999 until 2011, but regarding the regression analysis we had to cut the series a couple of years since we only had data from 2001 until 2011. Even when for some variables we had data from 1990 (i.e. energy generated from renewable sources), we could not find homogeneous series for all variables. Again we decided to construct the most balanced database even at the expense of some time periods.

Table 1. Countries Included in the Analysis

Country	Preliminary analysis	Regression analysis	Country	Preliminary analysis	Regression analysis
Belgium	X	X	Luxembourg	X	X
Bulgaria	X	-	Hungary	X	X
Czech Republic	X	-	Malta	X	X
Denmark	X	X	Netherlands	X	X
Germany	X	X	Austria	X	-
Estonia	X	-	Poland	X	-
Ireland	X	X	Portugal	X	X
Greece	X	X	Romania	X	-
Spain	X	X	Slovenia	X	X
France	X	X	Slovakia	X	-
Italy	X	-	Finland	X	X
Cyprus	X	-	Sweden	X	X
Latvia	X	-	U. Kingdom	X	X
Lithuania	X	-	Norway	X	-

3.5 Results & Conclusions (and extensions)

In this final section we present the results and conclusions of both analysis done with the data we collected. First we present the results of the preliminary analysis and afterwards the results and observations on the regression analysis. We will close this section stating our conclusions and suggestions for future analysis.

3.5.1 Preliminary analysis of data

What we report in this section is a simple analysis of dispersion of prices; we are interested in knowing about how different markets discriminate between different sorts of consumers. This differentiation of consumers, regarding the quantity of energy purchased can be useful as a first approach to check for the sensibility of markets on prices.

3.5.1.1 Variation within

We can clearly distinguish four groups of countries. In the first place, the countries with a higher variation (distinction) between different sorts of consumers, this group is composed by Ireland and Norway, where the difference between the consumers that pay the lower and the higher prices can be as much as a 11 or 12% respectively. The variation in these two countries is four times the average of the set of countries than in the vast majority of the rest of countries and more than ten times higher than the countries with less variation. In the second place we have a group of countries, in which the variation is a little bit higher than that of the EU as a whole (the mean of the countries studied). This second group of countries is conformed by Czech Republic (7%), Spain (6%) and somehow Portugal (5.5% in average for the whole period). In the third place we have the group of countries for which the variation is a little bit lower than the mean of the whole group; among these we find Germany (4.9%), France (4.6%), Luxemburg (3.9%), The Netherlands (4%), Slovenia, Slovakia, Finland and Sweden (average of 3%). And finally we have the group of countries for which the variation of prices between consumers (distinction between sorts of consumers) is rather low, in this group we may find Denmark, Estonia, Greece, Italy, Cyprus, Latvia, Lithuania, Hungary, Austria, Poland, Romania, The United Kingdom, Montenegro and Croatia, in some of these countries the variation is near to cero.

3.5.1.2 Lower and higher prices

If we focus on prices as reported by Eurostat (euros per KWh), Bulgarian and Estonian households pay the lowest in Europe, together with Latvian, Lithuanian, Romanian and Croatians. In the low middle of the spectrum, we found Greek households, together with French, Hungarians, Polish, Slovenians and Finish households. Meanwhile, in the upper middle of the spectrum of prices of electricity paid by households, we find the Czechs together with Danish, Luxemburgish, Dutch, Austrians, Portuguese, Slovakians and British. Finally, Belgians together with Germans, Spanish, Cypriots, Norwegians, Maltese and Irish pay the highest prices of electricity, where the last two ones pay the highest prices of the spectrum. The proportion is that the lower prices are about a third of the higher prices.

3.5.1.3 Evolution of prices over time (a simple glance).

We are interested in which markets evolve faster, in which direction and if markets are becoming more sensitive regarding quantities demanded by different consumers. Energy prices remained steady during the 1990's for around ten years electricity prices remained in a band of 0.08-0.12 cents of Euro, but in almost all European countries for which we have data the story changes about ten years ago, when electricity prices start to climb.

Nevertheless, it is also important to point out that the story is not the same for all countries. Notably, electricity prices in France have remained almost steady for the last two decades (around 10 cents of Euro), while on the contrary, in Hungary the rising of electricity prices started in the first years of the 90's from 0.03€ to 0.13€, Still, if we focus not just in the direction (rising or constant prices), but also in the rates at which this variation occurs, we find much more diversity.

3.5.2 Regression Analysis

We have run different regression taking electricity prices for households and for electricity prices for the industry. We have used panel data methodologies in order to avoid possible endogeneity problems. We essay alternative methodologies and different specifications and we report the results for these various alternatives.

3.5.2.1 Households Estimation

In table (T.2) we present the results for different models and estimations. It is worth saying that results are not completely conclusive, but yet, some expected results were confirmed. We report in the table three specifications including the share of renewable energies in gross final energy consumption and a fourth one including the supply of renewable energies. We used different methods of estimation that we will comment together with the results.

The first point we would like to comment is that even when some figures are not statistically significant, the sign showed by almost all coefficients are the expected ones and thus is an indication that we are in the correct track after all. Improving the collection of data may give us better results and we will comment this in the last section.

Coefficients for our Ownership variable are always positive stating that an increasing proportion of private stakeholders in the electricity companies is positively correlated with the increasing prices. In two of the four estimations of the model this variable was significant at a 95%. We are pretty sure that a more sensitive variable to changes in proportions of private and public ownership would result in more consistent outcomes.

One of the most robust results is the coefficient of the imported primary energy. In all four specifications this variable shows significant (at the 90% in the first two specifications and at a 95% in the last two). Even when the coefficients are not as big as we would expect, it is important to stress that the import of primary energy has a negative effect in prices from the consumers' point of view. In other words, the more primary energy a country imports, the higher the prices of electricity are

Table 2: Dependent Variable: Price (Midsize Households)

	(1)	(2)	(3)	(4)
Constant	0.09794**	0.1052**	0.09484**	0.09915**
	(0.03204)	(0.01660)	(0.007545)	(0.005198)
	[0.0028]	[0.0000]	[0.0000]	[0.0000]
Ownership	0.005401	0.005555	0.01024**	0.008226**
	(0.007317)	(0.005338)	(0.002289)	(0.002186)
	[0.4618]	[0.2999]	[0.0000]	[0.0003]
En	-3.095e-07*	-2.462e-07*	-1.664e-07**	-1.479e-07**
	(1.575e-07)	(1.274e-07)	(4.827e-08)	(4.531e-08)
	[0.0516]	[0.0555]	[0.0008]	[0.0014]
El	-4.026e-10	-5.570e-08	-3.308e-08**	-1.655e-08
	(1.653e-07)	(4.647e-08)	(1.503e-08)	(1.586e-08)
	[0.9981]	[0.2328]	[0.0295]	[0.2986]
Concentration	-0.0007099**	-0.0004070**	-0.0001054	-0.0001010
	(0.0002100)	(0.0001709)	(7.473e-05)	(6.965e-05)
	[0.0010]	[0.0187]	[0.1608]	[0.1492]
Renewables	0.001525**	0.0007527**	7.131e-05	
	(0.0003886)	(0.0003002)	(0.0001326)	
	[0.0001]	[0.0134]	[0.5916]	
Supply_Renew				-1.977e-06**
				(8.364e-07)
				[0.0195]
n	139	139	139	139

*(Standard Dev.), [p-values], * Significant at 10% level, ** Significant at 5% level.*

Quite a different story emerges from the amount of electricity exchanged between countries. Even when the sign of the coefficients are negative, as we

expected, it is also true that these coefficients were significant only in the third specification of the model. Our guess is that this might be related with the regional integration of electricity grids, and thus with how trans-frontier exchanges are accounted.
Regarding the concentration measure we should also focus in the sign of the coefficients since these are all negative as we expected. The less concentrated a market is, the lower the prices might be. Nevertheless, the coefficients are statistically significant only in two of the four specifications. The variable we have used is a proxy, and more sophisticated measures can be used; however, it gave us fairly good information about how we can continue our research. Measuring the concentration of a market is a matter that is about to be solved, but still, we should recognize certain consistency in the results we obtained.
In what concerns to the renewable energies we expected more conclusive results, but instead we only found that in what concerns to the relation between renewable energies and prices two different trends play important roles. We cannot give conclusive results in favour of the trends we describe at the beginning of this chapter. On one hand the support schemes might be important enough to make prices increase, and thus a positive sign in coefficients, like in the first two specifications of our model (columns one and two), might give some evidence in favour of this hypothesis. But, on the other hand, if we focus in the supply of renewable energies, the story (at least for midsize households) might be different, and the cheaper production costs of certain renewable energies might have the opposite effect. In this second case, the so-called "merit-order" effect might call for our attention.

3.5.2.2 Industry Estimation

We have also calculated some regressions with specific data related to the industrial consumption of electricity and present these results in the following table (T.3). The dependent variable is defined as the average national price measured in Euro per kWh and excluding taxes. We ran two regressions using the share of renewable energies in gross final energy consumption and two different regressions using the supply of renewable energy. Comments about the results follow after the table.
According to these results, ownership of the biggest electricity producer company matters. Nevertheless prove seems stronger than in the case of prices paid by households and it might be so since the process of liberalization and privatization has been introduced before for industrial consumers. Private companies charge higher prices to industrial consumers than public owned

companies. Even when all coefficients are significant, we should note that they are rather small, and thus, some caution is advised for their interpretation. As we said before, a more sensitive variable might give us more robust results.

Table 3. Dependent Variable Price_Ind (Midsize Industries)

	(1)	(2)	(3)	(4)
const	0.07756**	0.07756**	0.06956**	0.06956**
	(0.006193)	(0.006193)	(0.004082)	(0.004082)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Ownership	0.005045**	0.005045**	0.004719**	0.004719**
	(0.001718)	(0.001718)	(0.001595)	(0.001595)
	[0.0039]	[0.0039]	[0.0037]	[0.0037]
En	-1.196e-07**	-1.196e-07**	-8.273e-08*	-8.273e-08*
	(5.181e-08)	(5.181e-08)	(4.790e-08)	(4.790e-08)
	[0.0225]	[0.0225]	[0.0865]	[0.0865]
El	-5.129e-08**	-5.129e-08**	-1.625e-08	-1.625e-08
	(1.576e-08)	(1.576e-08)	(1.619e-08)	(1.619e-08)
	[0.0014]	[0.0014]	[0.3175]	[0.3175]
Concentration	-6.124e-05	-6.124e-05	2.848e-05	2.848e-05
	(5.909e-05)	(5.909e-05)	(5.111e-05)	(5.111e-05)
	[0.3019]	[0.3019]	[0.5783]	[0.5783]
Renewables	-0.0001930*	-0.0001930*		
	(0.0001128)	(0.0001128)		
	[0.0894]	[0.0894]		
Supply_Renew			-3.272e-06**	-3.272e-06**
			(8.285e-07)	(8.285e-07)
			[0.0001]	[0.0001]
n	139	139	139	139

(Standard Dev.), [p-values], * Significant at 10% level, ** Significant at 5% level

Like in the regressions specified for midsize households, results for the En variable are consistent. The more primary energy you must import, the higher the prices the companies must charge to industrial consumers. This is an important result since the price you pay for primary energy goes directly to the marginal cost of the transformed energy you will sell.

On the other hand, we did not find those consistent results concerning the balance on electricity (El variable). Even when the sign of the coefficients are

as expected, in the last two specifications this variable was not significant. Again, it might be so because of regional interconnection of European electricity grids and how trans-frontier exchanges are accounted.
Concentration was not significant in any of the four regressions we report with prices charged to industrial consumers as a dependent variable. We might still blame the data, since we should recognize that this variable loses explanatory power in less concentrated markets. It might be recommendable to include a different index.
Finally, we would like to comment the results for the two variables on renewable energies. All four regressions (with two different variables) give us coefficients with negative signs, and thus at least in the case of industrial consumers we may say that the increasing supply of renewable energies might pull down the final prices of electricity. In this case the "merit order" effect might be stronger than the alternative effect caused by the support schemes. Nevertheless, we cannot speak of definitive evidence in favour or against of any of the competitive hypothesis.

3.5.3 Conclusions

Ownership of the biggest producer of electric power seems to matter. Prices charged by private companies are slightly higher than those charged by public owned companies. Even when we did not expected to find too representative results in this particular matter it gives us important and somehow consistent information. It is not the most relevant issue who owns the biggest electricity company, but how it performs in the market. This is a variable that is closely related with the liberalization of the market, but the information it gives must be taken carefully, since both private and public owned companies might behave as non-competitive actors.
Concentration of the market is quite relevant, but also how we measure the concentration and how this measure interacts with the rest of our model. Unfortunately even when results point in the direction we expected, these were not as consistent as we supposed in the first place. The concentration measure we used loses some power of explanation as the market it describes becomes less concentrated. We should doubtlessly think in alternative measures to improve the explicative power of our model. This constitutes one of the possible extensions of our work, since concentration of electricity markets have changed in the seven regional European markets as a direct consequence of liberalization.

- Available primary energy seems to matter more than we thought in the first place. Relation might not seem direct at first glance, but the origin of electricity as a transformed energy seems to be connected with the abundance or scarcity of primary energy. It may not be just the security of supply but also that the prices paid for the import of primary energy must be added to marginal costs. Countries with a negative balance in the imports and exports of primary energy also report higher prices of electricity.

A different story must be told about the imports and exports of electricity (El variable). Even when the signs of the coefficients were as we expected, these were not always statistically significant. As we already pointed out these might be so because of the regional interconnection of the European electricity grids and with how international exchanges are reported. We can continue suspecting that consumers in those countries with a credit balance in electricity production pay lower prices than consumers in those with debit balance in electricity production. Nonetheless, we did not find the conclusive evidence we expected.

Finally, concerning renewable energies we cannot be categorical about the most important effect. On the one hand, we did find that there is some negative relation (from the consumer point of view), prices seems to rise with the increasing proportion of renewable energies, and thus the effect of public support schemes might be more powerful than other competitive trends. But on the other hand, the "merit order effect" that is, the preference given to some production methods with lower marginal costs, might be helping to turn around the trend. The final word about the effect of renewable energies in electricity prices is still to be written.

We would like to end this section and the chapter proposing possible improvement and extensions: First of all we are convinced that all the work we have done constructing the Ownership variable might result in a more sensitive variable and not just the one with three possible values that we use. Using a variable with wider values might return us more conclusive results.

Working with prices of electricity as a dependent variable has been pretty interesting, but still, the European process towards liberalization of the energy sector started twenty years ago and thus in order to talk about the whole process, it would be also interesting to have a database covering at least from 1990 for the complete set of variables. At some point we had to cut our database in order to keep it balanced, with the less possible missing observations, but again, data can and must be improved.

Still talking about data, we have found also that one of the key concepts of which we talk about can be alternatively described. We are thinking here about concentration measures. From the beginning we were aware of the complexity of these sorts of variables and how many scholars discuss about the different alternative approaches. This is one point in which we would like to improve our results.

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Annex 1. Summary of variables used

Variable	Source	Years Available	Unit	Observation
Prices of electricity charged to Midsized Households	Eurostat	1991-2011	€/KWh	Excluding Taxes 2 500 and 5000 kWh
Prices of electricity charged to midsized Industries	Eurostat	1991-2011	€/KWh	Excluding Taxes 500 and 2000 MWh
Share of Renewable energies in gross final energy consumption	Eurostat	2001-2010	Percentage of total electricity consumption	
Supply of renewable energy	Eurostat	2001-2010	Thousands of TOE (Tonnes of Oil Equivalent)	
Ownership	Different sources	2001-2010	0 if the main electricity producer is public 1 if the main energy producer is partially public and partially private 2 if the main energy producer is private	
Primary Energy	Eurostat	2001-2010	Thousands of TOE (Tonnes of Oil Equivalent)	Difference between the primary energy available produced and consumed
Electricity	Eurostat	2001-2010	GWh Gigawatts hour	Difference between the electricity produced and consumed
Concentration measure	Eurostat	2001-2010	Percentage of the market share of the biggest producer	

Annex 2. Regional Energy Markets in Europe

Regional Market	Countries
Central Western Europe	Austria, Belgium, France, Germany, the Netherlands, Switzerland*.
British Isles	United Kingdom, Ireland.
Northern Europe	(Denmark, Estonia, Finland, Latvia, Lithuania, Norway*, Sweden
Apennine peninsula	Italy
Iberian Peninsula	Spain, Portugal
Central Eastern Europe	Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia
South Eastern Europe	Greece

* Non EU member

Chapter 4

European Energy Market Integration: Efficiency Improvements in Electricity Producing Firms

Abstract
In this chapter we review and use different methods to measure and compare efficiency scores in energy producing plants. In particular we use non-parametric and parametric techniques. We focus our attention in electricity producing power plants in eighteen European countries as well as in thirty energy systems as a whole. This chapter also state some preliminary results like: efficiency has widely improved in the period studied, but these positive results are not homogeneous among energy systems or firms. We present some evidence that the greatest part of the energy improvement is consequence of the technological shift and not necessarily due to alternative factors such as market integration, increasing competition or other firm level decisions.

4.0 Introduction

From the last few decades the energy sector in almost all countries, and particularly in Europe, has experienced a group of reforms; these reforms try to cope with mainly three aspects of the energy producing firms: the security of supply of raw materials, the control of shocks in prices and the efficiency improvements of firms in the energy sector. In this chapter we explore the last one, and particularly if the market integration has had a relevant effect in the efficiency improvement of the energy producing firms and power plants. We review different methods of measurement that have been proposed in the literature, we discuss the differences in the results obtained when applied in different studies and; finally speak about the efficiency improvements that might be directly related to the integration of Energy Markets in Europe or alternative phenomena. While efficiency improvements have been pointed as one of the main objectives in the design, development and deployment of European reforms in this sector, we believe that the greatest part of improvements can be better identified with other causes like technological shift or new energy generation methods. A better identification of factors and their consequences it's crucial to cope better with further reforms and policy design.

Particularly the European Union has started this process of energy markets reform in 1988 with the publication of the "White Book of the European Commission on the Interior Market Construction". The idea of such white book was that any European citizen might buy energy from any European provider, regardless of who owns the transport grid. Nevertheless, it was not until 1992 with the Lisbon treaty that the whole process started with the setting of four basic goals: 1) improve the assurance of supply; 2) achieve lower prices for final consumers; 3) improve environment friendly practices and; 4) improve efficiency of firms through energy savings. From the very beginning the process was designed in different stages with the third one bargained between EU members along the 2007-2009 period; from that point, a period for compliance was also set until 2011 (Eikeland, EU Internal Energy Market Policy: New Dynamics in the Brussels Policy Game, 2008).

As stated above, in this chapter we focus mainly in the fourth of these goals, that is, the efficiency improvement of the energy-producing firms. In order to do so, we propose a two-fold research question: Under what conditions does the efficiency of electricity-producing firms improves? And to which factors we may attribute the greater part of this improvement?

We discuss briefly the methods used to assess efficiency, its advantages and flaws but most importantly, we conduct a two-step empirical analysis, first with a data set at country level and secondly with a different data set at firm level. This way we first look for the most efficient countries within the European countries and afterwards we can also look for the progression of energy producing firms in Europe.

Our general hypothesis is that efficiency has improved greatly in the last fifteen years but that there are important observations to do regarding the main factors of this improvement, we present such concerns in the form of three particular hypotheses: first, in what concerns to overall improvements (at the country level), the improvements are consequence of a more diverse energy mix; second, a big proportion of the inefficiency detected in the less efficient countries is caused by unused but installed capacity and not just by technical inefficiency; and third, in what concerns particularly to energy producing firms, we believe that a greater part of their improvement is due to technological change (use of better technologies) and not just to increasing competence due to energy market integration, either at regional or European level.

4.1 Objectives

For the development of our work we set four objectives clearly differentiated, we first describe the most used measures of efficiency evolution in different companies and energy-producing firms in particular. After we introduce the sort of methods that are currently used to assess efficiency, we secondly discuss some advantages and drawbacks of the different measures and point two of the best ones that we will use in the empirical part of our work.

The third objective of this chapter is to focus in the empirical data that will allow us to compare different methods, rank the different countries and energy-producing firms and assess the more likely cause of energy improvements.

Finally we will contrast our results with the expectations at the beginning of the reform of the energy sector and the electricity-producing firms in particular.

4.2 Single market and efficiency

In economics it is a well-known result that openness and integration of markets can lead to a series of results among which we can find the increasing efficiency of the firms operating in the area to be integrated (countries,

regions, etc.). Efficiency improvements is not the only result, it is clear that there are some more positive results as well as negative ones. In this section of the chapter we will mention all of these but we will extend some more in the efficiency effect.
When the European policy makers thought first about the creation of a single market they were thinking mainly in this tool as a trade enhancer within European Union members, but of course, while constructing this single market they had to assess other positive outcomes and all negative ones. Besides of efficiency improvements, we have also mention gains on trade volume, increasing competition (thanks to what we can expect prices cuttings, technical improvements and efficiency gains), interchange of ideas and production methods, due to increasing commercial exchange, can be also an innovation enhancer, and finally, there can be policy making synergies thanks to sector spill-overs, in what concern to energy policies, such spill-overs can affect environmental policy or higher education.
In what concerns to the negative outcomes that can happen we can point first the trade diversion losses from third parties from the new (more) integrated area as trade increases among partners, third parties may lose terrain. Synchronizing policies with your partners and tight the scope of your possible decisions to those of the group might be seen as sovereign cost and cause controversy within countries. A different kind of costs are those described as subsidiarity costs, that are those created because of the obligation to comply with some policies not well fitted with the local needs (wearing a uniform can be useful, but it does not fit all bodies or situations). Finally there are the costs of the process, while there might be some that are just paid once (new energy lines, costs of adaptation, etc.), there are some others that once are created, must be paid regularly (cost of new authorities, new costs of maintenance, etc.). All these costs and benefit evolve in different ways as integration towards a single market advances, but in the following paragraphs we will focus solely in how efficiency improves and the tools used by European countries to construct the single energy market.
The basic tool-kit of European single market construction might be easily simplified, but it is way more complex than what we describe here. The first kind of tools are those of the construction of any free-trade or custom area, that are the elimination of internal tariffs and imposing tariffs to third parties, of course, depending of the degree of integration tariffs can be blurred or completely eliminated and third parties tariffs can apply to all or a group of country members. The signature and compliance of different European

Treaties is one of the main tools; almost all, if not all, European Union treaties contain some new rules to deepen the integration of European countries, mainly in what concerns to free movement of goods, services and factors of production (capital and labour). Compliance with European treaties and directives often requires mutual recognition of other member states laws and norms, besides of profound coordination and harmonization of rules and institutional structures like unbundling of vertical integrated energy firms or re-structuration of member state energy markets. It is quite common that the EU directives contain some suggestions for adapting member states ways to the best practices, but it is also true that the Nation-State has proven to be way more resilient than what is usually thought.

Since there is a positive and a negative side of the integration of markets, there is a trade-off, then there must be an optimal outcome, where there is no possible improving without getting worst in at least one aspect. While it is good to know that there might be an optimal point and that it is possible to reach it, for our purposes it is first important to asses such optimal point in what concerns to efficiency as well as it is important to know if we are heading to it, that is, if efficiency has been really improving and if such improvement can be attributed to the creation of the European energy single market.

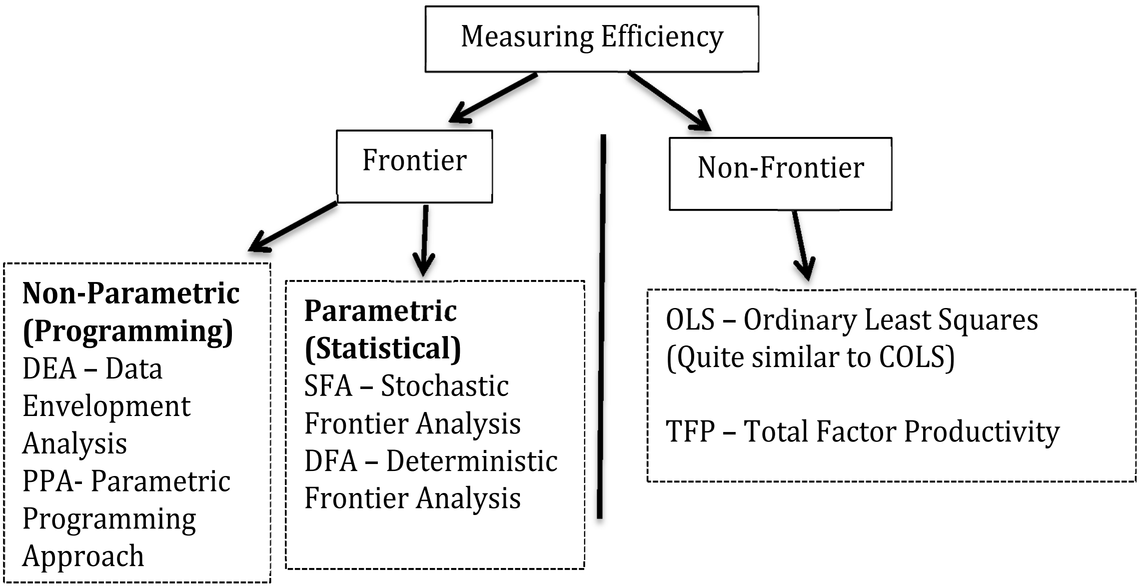
4.3 Methods and Procedures

4.3.1 Overview of current methods

The literature in what concerns to measuring the efficiency of firms is abundant, and it can divided it in two main groups; first the so called non-frontier approach, that basically consist in estimate a cost function without a stochastic component for inefficiency and thus it is assumed that all firms operate in the cost frontier. Once the cost functions have been estimated it is possible to calculate the inefficiency of scale and scope of the companies (Farsi & Filippini, 2009; Jamasb & Pollit, Benchmarking and Regulation: International Electricity Experience, 2001; Jamasb & Pollitt, International Benchmarking and Regulation: an Application to European Electricity Distribution Utilities, 2003). The most common methods of estimation of these cost functions are Ordinary Least Squares or Total Factor Productivity techniques. Both of these techniques use a mean or an average performance of companies to compare all firms and that is why this group is also known as the average performance approach.

The second part of the literature is the Frontier approach, which assumes that the full cost efficiency is limited to those companies that are identified as the best-practice producers (Farsi & Filippini, 2009). It is also assumed that the rest of companies in the sector produce at higher costs and thus the inefficiency is higher than zero. In this case, it is possible to measure not just the scope and scale inefficiency but also the cost inefficiency. In what concerns to the estimation methods, this second group can be also divided in two different categories that are the non-parametric and the parametric methods. In the first one we can find the Data Envelopment Analysis, which is a linear programming method; while in the second category we can find the Deterministic Statistical Frontier Analysis method or the Stochastic Frontier Analysis that both are statistical approaches (Jamasb & Pollitt, International Benchmarking and Regulation: an Application to European Electricity Distribution Utilities, 2003; Pollitt M. G., 1995). In the figure 1 we present a scheme of the literature and below we describe the most relevant ones.
All these methods of measuring efficiency of different firms or DMUs (Decision Making Units) have been developed with a main objective, that is, help regulators to promote efficiency improvement by rewarding good performance relative to some pre-defined benchmark (either a frontier or a mean).

Fig. 1



Source: Own elaboration based in (Farsi & Filippini, 2009)

It is also true that several scholars trying to acknowledge the efficiency of different firms have used all these methods. In particular we would like to call the attention over two particularly relevant studies.
The first one of these studies was conducted by Pollitt (1995), and it analyses the technical productive efficiency of an international sample of electric power plants. The data Pollitt uses in this study is an international sample of power plants (rather than firms) and it uses different methodologies, like Stochastic Frontier Analysis, Data Envelopment Analysis and other, to acknowledge for what is called a "methodological cross-checking". Nonetheless, one of the main objectives of this study is to identify differences in efficiency of public and private owned power plants and this constitutes one of his main results (he actually finds that there are no significant differences in the performance of plants regarding if it's publicly or private owned). Other significant results are the comparison of alternative methods like DEA and Parametric Programming Approach, where the former gives a better approximation of the actual frontier; regarding non programming techniques, the Stochastic Frontier Analysis results more efficient while estimating the frontier function while the DSA Deterministic Statistical Frontier Analysis (DSA) performed worst with Pollitt's sample.
The second one, is that conducted by Førsund and Kittelsen (1998), they use a Malmquist index to study shifts in frontier technology and change in efficiency for Norwegian electricity distribution utilities. They found a positive productivity growth, averaging 2% per year, but also that this change is mainly due to the shift in technology frontier. Even when they offer quite interesting and relevant results, they use data for only few years and they account the increase for distribution firms while we plan to do so for electricity producing plants.

4.3.2 Selected methods

Our toolkit consists of three basic applications; we decided to keep these instead of other available ones because of a number of reasons, among which we might mention simplicity of calculation, alternative experiences of implementation with which we could compare to and finally, our opinion about the flaws of some of those methods. This way, we are sure that we will use the best methods and the best fitted to get the answers we are looking for. In the following sections then we will detail how the methods we selected works, mainly Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) put the focus on the performance of firms and the evolution of the best performers and the firms that follow the lead, whereas we decided to include the Malmquist index in order to asses the factors to which we should attribute the changes in efficiency.

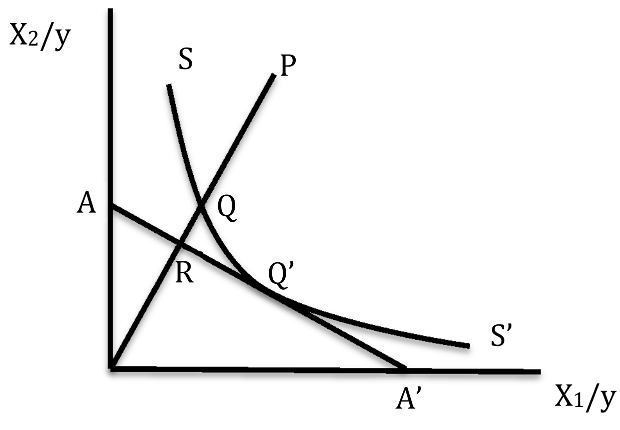
4.3.2.1 DEA - The first of all methods we would like to comment is the Data Envelopment Analysis (DEA). This method was first developed by Farrell (1957) and somehow retaken and further developed by Coelli (2005). With their examples we will illustrate how it functions assuming a set of firms that use two inputs x_1 and x_2, and produce a single output y (we use here the single output example only to simplify the explanation, but one capital feature to select DEA as a methodological approach is that it can be implemented with multiple outputs); we will sustain the assumption of constant returns to scale. The isoquant SS' represents the full efficient firm in figure 2 and knowing this line we can measure the technical efficiency of a given firm. If such firm uses quantities of inputs in the point P, to produce a unit of input, the distance QP can represent the technical inefficiency of that firm, which is the amount by which all inputs could be proportionally reduced without a reduction in output. We can also present that in percentages with the ratio QP/0P, which represents the percentage by which all inputs can be reduced. Finally we can define the Technical Efficiency (TE) of a firm like;

TE=0Q/0P

This measure takes values between zero and one and provides an indicator of the degree of technical inefficiency of the firm. If the firm is efficient it might obtain a value of one and it would be placed in the isoquant, like the point Q.

AE=0R/0Q

Fig. 2



If we know also the input price ratio, here represented by line AA' it is possible to calculate the allocative efficiency (also referred some times as price efficiency). The allocative efficiency (AE) of the firm operating at P is defined to be the ratio

Since the distance RQ might be taken as the reduction in production costs that might occur if production takes place in the in the allocativelly and technically efficient Q', instead of produce at the technically efficient but allocativelly inefficient point Q.

The efficiency measures we have presented so far assume that the production function is known (or the cost function if such approach is preferred), but in practice this is not the case, and thus, the efficient isoquant must be estimated from the available data. Two alternatives have been suggested to calculate the isoquant, either a picewise-linear convex isoquant, or using a Cob-Douglas function fitted to the data.

4.3.2.2 SFA – The second method considered here is the Stochastic Frontier Analysis that is a parametrical method. We prepared this explanation based mainly in Coelli et al. (2005). We might say that one of the most important differences with the previously exposed method is that the envelopment of data is done by choosing an arbitrary function. The most common function used in applications is the Cobb-Douglas of the form:

$$\ln q_i = \mathbf{x_i}'\beta - u_i \qquad\qquad i = 1, \ldots, I$$

where q_i is the output of the firm *i*; $\mathbf{x_i}$ is a K x 1 vector with the logarithm of inputs; β is a vector of unknown parameters and ; u_i is a non-negative random variable associated with technical inefficiency. For the estimation of these parameters different studies have used different methods like linear programming, maximum likelihood, least squares or a variation of this last one, modified least squares.

The problem with the frontiers like the one we have just described is that it does not take in account (like DEA neither) measurement errors or other sources of statistical noise and thus, all deviations of the frontier are assumed to be the result of technical inefficiency unless we introduce some modifications.

We can find in the literature stochastic frontier production functions like the following:

$$\ln q_i = \mathbf{x}_i{}'\beta + v_i - u_i$$

That is, more ore less the same described above but with a symmetric random error v_i, to acknowledge for statistical noise.

In order to illustrate graphically how the stochastic frontier model works, we will use the transformation and simplification by Coelli (2005) in which it is used only one input x_i. The Cobb-Douglas stochastic frontier model takes thus the following form:

$$\ln q_i = \beta_0 + \beta_1 ln\, x_i + v_i + u_i$$

or $$q_i = \exp(\beta_0 + \beta_1 ln\, x_i + v_i + u_i)$$

or $$q_i = \exp(\beta_0 + \beta_1 ln\, x_i) \times \exp(v_i) \times \exp(u_i)$$

where: $\exp(\beta_0 + \beta_1 ln\, x_i)$ is the deterministic component

$\exp(v_i)$ is noise

and $\exp(u_i)$ is the inefficiency

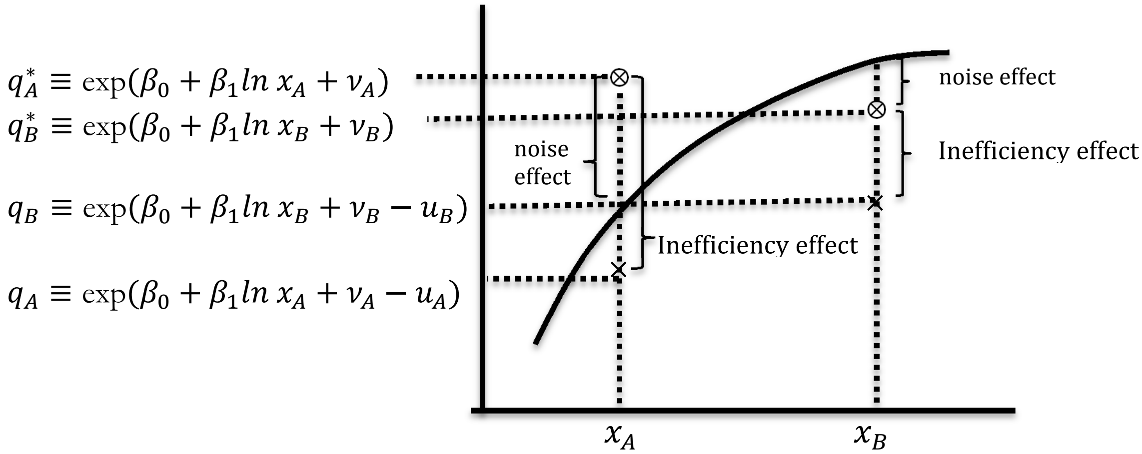
Still following the example by Coelli (2005) we present below a graph where two firms are plotted, A and B, and where diminishing returns of scale are assumed. The horizontal axis corresponds to inputs and the vertical axis measures the outputs. x_A and q_A are the input level and output used and obtained by firm A, and thus x_B and q_B are the input level and the output of firm B. With no inefficiency effect, that is u_A=0 and u_B=0, the frontier outputs for firms A and B respectively will be

$$q_A^* \equiv \exp(\beta_0 + \beta_1 ln\, x_A + \nu_A) \quad \text{and} \quad q_B^* \equiv \exp(\beta_0 + \beta_1 ln\, x_B + \nu_B)$$

Observed values are indicated in the graph below by × while frontier values are indicated by ⊗. Frontier output for firm A lies above the deterministic part of the production frontier only because the noise effect is positive ($\nu_A > 0$), while the frontier output of the for firm B lies below the deterministic part of the frontier because the noise effect is negative ($\nu_B < 0$). In the graph it is also represented that the observed output of firm A lies below the deterministic part of the frontier because noise and inefficiency summed up ($\nu_A - u_A < 0$) are negative.

If we generalize this example to cases with firms using several inputs, observed outputs tend to lie below the deterministic part of the frontier. Indeed they can only lie above the deterministic part of the frontier when noise effect is positive and greater than the inefficiency effect ($q_i^* > \exp(\mathbf{x}_i'\beta)$ if $\epsilon_i \equiv \nu_i - u_i$).

Fig. 3



4.3.2.3 Malmquist Productivity Index – Using this index we can decompose the productivity improvements into technological change and other productivity improvements (Førsund & Kittelsen, 1998)

The Malmquist efficiency index was first defined after Sten Malmquist (1953) and gained a big deal of popularity to measure not just productivity but also how this changes over time. Nonetheless this index has been also criticized and reviewed by many scholars that have shed some light on its drawbacks, specially, in some systematic bias and its dependence on the magnitude of scale economies (Grifell-Tatjé & Lovell, 1995); (Bjurek, 1996); also see (Halkos & Tzeremes, 2006). Still, if we proceed carefully, it is a great tool that may help us to test our main hypothesis; first we calculate productivity development, relative to the best practice production frontier and; secondly we can split into change in efficiency and technical change, acknowledging changes in individual performance relative to the frontier, but also changes in the best practice, that is, the frontier.

As Førsund (1998) and Farrell (1957) defined previously, the production possibility set that faces an operation unit can be expressed as follows:

$$P^t = \{(y, x) | y \text{ can be produced by } x \text{ at time } t\}$$

where $\boldsymbol{y}$ is the vector of *N* outputs and $\boldsymbol{x}$ the vector of *S* inputs, given that we assume a multi-input, multi-output scenario. As with other examples, we also assume here constant returns to scale. The Farrell efficiency measure for an input-output combination (y_t^τ, x_t^τ) for observation *j* at time τ, with technology P^t from the year *t* can be expressed as

$$E_{j\tau}^t = E^t\left(y_j^\tau, x_j^\tau\right) = Min_\theta\left\{\theta | \left(y_j^\tau, \theta x_j^\tau\right) \in P^t\right\}$$

Minimizing θ we minimize the use of output *x* with the available technology *P* at time *t*. When an efficiency score is less than one, the observation is inefficient compared to the technology in period *t*. Since our goal is acknowledge sifts in efficiency over time, we will base our index in binary comparisons for each production unit between two time periods. In this example we denote those time periods with 1 and 2. Expressions involving period 2 observations will be in the numerator and expressions involving period 1 observations will be in the denominator. Thus, the Malmquist productivity index, $M_{j1,2}$, that compares the performance of unit *j* with a frontier technology from period *1* as reference is

$$M_{j1,2} = M\left(y_j^1, x_j^1, y_j^2, x_j^2\right) = \frac{E_{j2}^1}{E_{j1}^1} = \frac{Min_{\theta 2}\left\{\theta_2 | (y_j^2, \theta_2, x_j^2) \in P^1\right\}}{Min_{\theta 1}\left\{\theta_1 | (y_j^1, \theta_1, x_j^1) \in P^1\right\}}, 1,2 \in T$$

T represents the time periods. If $M_{j1,2} > 1$, the observation in period 2 is more productive than the observation in period 1. A change in productivity might be caused by either a change in efficiency or a shift in the frontier production. Färe (1994) showed how these indexes can be decomposed with data for at leas two time periods; the Malmquist productivity index $M_{j1,2}$ can be decomposed into two parts: the catching up $M_{Cj1,2}$, and the pure technology shift, $M_{Fj}^{1,2}$ as follows

$$M_{j1,2} = \frac{E_{j2}^1}{E_{j1}^1} = \frac{E_{j2}^2}{E_{j1}^1} \cdot \frac{E_{j2}^1}{E_{j2}^2} = M_{Cj1,2} \cdot M_{Fj}^{1,2}, 1,2 \in T$$

This way we can know the catching-up effect $M_{Cj1,2}$, that is the relative movement of the observed unit to the frontier. The frontier technology change, on the other hand, it is expressed by the ratio of the efficiency scores for the second period observation relative to the two technologies.

4.4 Our Plan

We split our analysis in two stages clearly differentiated; first we will compare the overall efficiency of a group of countries; this group includes almost all European Union member states and some non EU members like Switzerland, Norway or Turkey, we consider the inclusion of this non EU members might be useful not just as a control group but also for further country grouping. A complete homogeneous change in all countries, including those non-EU members, would give us the idea that the change is due to factors affecting equally those two groups (EU and non-EU members) and not just one of these groups of countries (for our interest it is good to find some evidence that such homogeneous results is due to the technological change to which all countries have access regardless of the membership or association status with the EU). This stage of the analysis consist mainly in conducting a multi-output, multi-input analysis adapting linear programming tools to set a point of comparison for different methods. We use the Data Envelopment Analysis to get a first rank of countries from the more efficient ones and those following the lead. Since the first set of data (at countries level) has a wider range of inputs and outputs this will allow us to assess the energy efficiency improvements. This first stage of analysis give us a first hint of the effects that will also appear in the second stage of analysis, since we aim to asses the main factors and conditions that face electricity producing firms.

In the second part of the analysis, on the other hand, we will use micro-data related to a sample of power plants, to conduct our analysis at power plant level. At this point, we will compare different scores obtained with different methods, like the mentioned Data Envelopment Analysis and Stochastic Frontier Analysis. Our aim at this point of our work is to be also capable to discuss the performance of the most used techniques used to measure efficiency, not just by scholars but also by some regulators. With the micro data we also calculate the Malmquist-Indexes for the 2004-2009 and 2009-2013 pairs of years, this way we will be available to comment not just the evolution of efficiency but we will be also capable to split the results into technical efficiency and improvements due to other factors, that is, the movements of the power plant's scores towards the frontier of production (catch-up effect) and the movement of the same frontier (technology shift).

4.4.1 Data

The data we use as we mentioned above consist basically in two datasets, each for one of the two levels of analysis we are willing to conduct. First dataset refers to countries (energy systems) while the second dataset refers to electricity generation power plants.

The first dataset we will use is a combination of five input variables and five output variables and each of these is observed for sixteen years, from 1995 until 2010; this period of time covers almost all the process of integration of European energy markets, taking in account that the first package of liberalization measures were adopted in 1996. This is a completely balanced dataset as it is needed for conducting DEA and SFA, all series are homogeneous since all of them have been published by Eurostat.

Table 1

Input variables	Output variables
Primary energy consumed*	Solar Photovoltaic Produced
Energy Intensity	Nuclear Power Produced
Nuclear Power Capacity	Hydro Power Produced
Combustible Fuel Capacity	Wind Power Produced
Hydro Power Capacity	Solar Power Consumed
*It accounts for hydro, wind and solar power	

The second dataset we use to do the empirical part of this chapter consist in a sample of 130 power plants in eighteen countries (sixteen EU members and two non-EU countries): Italy, Romania, Bulgaria, Spain, France, Sweden, Czech Republic, Germany, Slovenia, Switzerland, Finland, Croatia, Hungary, Slovakia, Belgium, Norway, Portugal, Estonia. All the current EU members were part of the EU at the starting point of the dataset and thus were compelled to follow the same rules regarding the liberalization of energy markets, and regarding the two non-EU countries we include them for control and comparison purposes. We don't need data for all the industry in all countries, since our main objective is to know if there have been changes in European firms in the last few years and to which particular factors we may attribute those changes. In the case of our second database it has been extracted from the AMADEUS database that publishes the data collected from the financial statements of all European countries, this is the main reason why this second set of data is mainly financial data. In order to have a better understanding of the efficiency improvements, we construct the variable "output" as a proxy of the real output of the firms dividing the total sales by the price of the energies, even when this proxy is just an indicator of the real output it is also measured in kw/h, like the real output.

Table 2

Input variables	**Output variables**
Labour (number of workers)	Operating Income
Total Assets	Yearly Results
Size	Results before Taxes
Cost of materials	Sales
Independence of stakeholders	Output
Labour costs	

Data accuracy is of capital importance in order to minimize further problems; frontier approaches are susceptible to shocks and data errors. This is specially the case when cross sectional data is used and there is no allowance for errors as in DEA (Jamasb & Pollit, 2001), this is the main reason why we prefer to stick with a carefully selected group of variables instead of trying a larger group but with other flaws consequence of the collection or the sources (unbalance of the panel, multiplicity of sources, etc.).

4.5 Results and Conclusions

In this section we present the preliminary results we have so far obtained with the treatment of the first and second dataset, we also speak of some expected results of the first and second stage of the analysis, and we close the section with some concluding remarks, related with what we have found so far.

4.5.1 Results

As a starting point for our analysis we first construct a simple index based in the energy intensity of each of the countries included in our first set of data. The goal is to have a first approximation to the scores we might find in the more sophisticated analysis and, on the other hand, we might also be able to critically overview the standard measures (energy intensity) and other scores like those resulting from the Data Envelopment Analysis and other methods.
If we only take in account the standard measure of efficiency which is energy intensity, we might expect a quite inefficient general environment, and we take these first results as a comparison point to start explaining our first results.

Different countries have faced different resources endowments and may rely solely in a particular source of energy generation, particularly expensive or that account in a high proportion against the energy intensity of those countries; that, for example might be the case of the Czech Republic, Romania, Estonia and Bulgaria, some of the most energy inefficient countries if we only rely on the energy intensity as an indicator. Energy mixes are quite diverse throughout the European continent and it is also the case for general economic performance. The other side of the energy intensity measure is GDP or the size of the economies in the set. Our first results then, the position in the ranking (see Table 3) and the belonging to one group or another might be highly dependent on GDP during the period of study and to the deployment of certain generation methods in further proves we will be able to test these results but so far there seems to be a correlation between GDP growth rates, the size of the economies and energy efficiency improvements. Some countries, because of their climate conditions for example, exhibit higher needs for energy than others, when it is the case that such countries are among the less favored countries in the EU (have small GDP's), their energy intensity is way much higher than others. That affects directly their scores in this first index dependent on the energy intensity indicator.

Table 3

Efficient Group	The follower Group	The non-Efficient	The less Efficient
(0.85-1)	(0.50-0.85)	(0.20-0.49)	(0.07-0,19)
Switzerland	Italy	Malta*	Lithuania
Ireland	Norway	Sweden	Poland
Denmark	United Kingdom	Belgium	Latvia
	Austria	Cyprus	Slovakia
	Spain	Turkey	Czech Republic
	Luxemburg	Finland	Romania
	Germany	Iceland*	Estonia
	Greece	Croatia	Bulgaria
	France	Slovenia	
	Portugal	Hungary	
	Netherlands		

* Missing data may alter the result

We can clearly distinguish four groups of countries regarding the position that each of them occupies in the ranking; in the table below we present the groups regarding the score obtained in our first analysis. These groups have been labeled as Efficient, Follower, non-Efficient and less Efficient. Even when a small GDP can drag you to the bottom of the rank, it is also true that a high GDP level do not grant a good performance in the exercise, since it is also known that with higher GDP's there are also more need for energy, not just because there are more appliances in use but also because consumption of all kind of products is higher and there is more need of energy to produce them.
An additional result that is worth reporting is that there is some convergence in what concerns to efficiency, that is, a group of countries, particularly the less efficient ones move towards the frontier (even when at the end of the analyzed period are still far from the frontier); we must take in account, though, that some countries start from very inefficient scenarios, which might be five times less efficient than the best performers.
A result that we were expecting and that has been partially proved is that energy efficiency has improved in the last fifteen years. This improvement has been of about two or three percent each year, depending of the year but also of the country. We have already talked about the existence of a catch-up effect, and that such effect is stronger in the less efficient countries, then, it is clear that more efficient countries exhibit smaller rates of improvements in their energy efficiency scores. Nonetheless, at the present rates of improvement and "all things been equal" it might take decades to the less efficient countries to catch the more efficient scores. For the full table see the appendix one at the end of the chapter.

4.5.2 DEA by country

When we use more sophisticated techniques to account for the efficiency of the group of countries we have included in our set, a very different reality awakens. The first results that we would like to stress is that countries perform much better than what we expected. There are more countries in the frontier than what we could expect from the first approximation with the energy intensity indicator. Around half of the countries in the set perform fairly well and are in the frontier at least once, even when some of them lose this position at least once. Some countries start a little below the frontier but end up catching it, like Belgium, Hungary, Netherlands, Slovenia or Finland, some others even when they are in the frontier at least once, lose this position in the year 2010, like Austria or the United Kingdom; particularly these two countries lose some ground since it seems that the frontier moves away from them (detailed results are reported in the Annex 2). After comparing all scores and looking for certain correlations, it is also true that the more production methods are used in the different countries, the more likely is that such country will end up been in the frontier and the higher the score in energy intensity the less likely such country will be in the frontier. Both observations might be quite intuitive, the more diverse the country's energy mix is, the more efficient might be and the more inputs it takes to produce an extra unit of GDP the less efficient it is also in overall terms.

What is really interesting about the use of non-parametric techniques such as DEA is that this methodology let us know not just the scores of every country and assess different technologies, that is, the combination of certain inputs to produce one or more outputs, but also how much technology improves.

4.5.2.1 Frontier moves and catch-up effects

Given these results it is also worth to mention the changes in the frontier of production, acknowledged by the Malmquist index calculated and also available at detail in the Annex 2. Between 1995 and 2000 the total productivity increased a 2% in average, but the technical change effect was a little less important than the efficiency change (catch-up effect), 0.9% and 1% respectively. This changes slightly for the rest of the years coupled, where technical change is a little better than the catch-up effect, like in the 2005/2010, when the technical change accounts for a 0.96% and efficiency change for a 0.93.

4.5.3 DEA by production firms

As it was expected, the efficiency scores at the production plant levels are way more diverse that the results at country levels. Only a small portion of the complete set of producing firms (11%) reach and maintain the position in the frontier for the whole period of study. As often happens in these sort of studies, many firms or DMU score differently in every year, even when they maintain a certain level of efficiency. In average, the distance from the typical producing firm to the frontier is of about 30%, but again, some firms are way more inefficient than others. Size of the firm is one of the factors that can be directly correlated with the less efficient scores, that is, the bigger the firm, the less likely that it will get to the production frontier; it is harder for bigger firms to achieve full efficiency. On the other hand, and non-surprisingly, the higher the volume of assets the firm holds, the more likely is for it to reach the production frontier.

Finally, if we account by country of origin of the firms, there are no strong correlation with been a given country and perform better than the rest of countries. It is clear that there are stronger factors, micro factors (like firm size, assets available or cost of factors) rather than national states context or regulation.

4.5.3.1 Frontier moves and catch-up effects in production firms

Since technology is an important factor in production, the use and ageing of certain production method can account relevant changes both in the frontier (how much electricity is produced in the whole sector) and how much can a given firm produce (catch-up effect). In the set of firms we study, it seems that there is a correlation between the source used to produce electricity and the final efficiency score; firms using traditional sources of energy, like coal or other fossil fuel lose ground through time more easily than others.

A very relevant result and that we would like to stress again is that the frontier moves accounting for a higher production of the firms in the sample, the increase is of 12% within 2004 and 2009 (2.4% each year), 12% again between the year 2009 and 2013 (2.4% again). On the other hand, those firms that better improve their scores are those that account for a higher technical change than the rest of the firms in the set; that is, technical change is the more important driver of efficiency improvement at the firm level also.

4.5.3.2 SFA by production firms

Finally, we report some results from the Stochastic Frontier Analysis estimation. First thing that we should say is that this method has an important flow relative to other methods used here and in other related studies, that is, you can only estimate the stochastic frontier using only one output, other multi-output approaches using stochastic frontier methodology are under development and we couldn't warranty the comparability of the results. We decided then to make a second calculation of DEA frontiers taking only one output for seek of comparability.

Scores estimated with the SFA method are consistently lower, as expected, the difference is a full 10% in average. This difference is partially explained by the fact that since SFA estimations also accounts an estimation error while DEA calculation of inefficiency attributes all the distance from the observed inefficient units to pure inefficiency.

When we compare different SFA scores for 2004 and 2009 we can say that productivity has increase, but not for all firms nor in equal quantities.

Somehow the results are equivalent to those of the DEA, but quite different in its size and nature.

4.5.4 Conclusions

Efficiency measures are useful, not just for benchmarking of firms, power plants or countries as part of the energy sector (or any other sector where you want to apply these techniques), but also for policy makers and entrepreneurs. While the second group must be aware of the major causes that deliver results after the energy market reform and the slow pace that some results have been exhibiting, the entrepreneurs can be interested in their position in the market and the factors that might help them to improve their performance relative to their direct competitors.

Even when different regulators use different measures, it is important to know other possibilities and the drawbacks of all of them, in what concern to simplicity, reliability and the information that every technique provides. Sometimes it might be not enough with just a ranking of firms or countries but also to assess the main factors of change, in this respect, the inclusion of the Malmquist index is quite illustrative, but also other techniques that enrich the results.

Asses the different components or factors of the efficiency improvements are also important for further policy deployments and to know better where to put more effort, either in the group of policies that help companies to move towards the frontier of production or in the group of policies that promote technological change and thus an overall improvement in the sector (It is important how we use different scores to different phenomena).

An important and shared drawback of all the measures is the relevance of accurate data. There is an important margin for improvement not just from the development of different methods (parametric and non-parametric) point of view but also from the collection and availability of data, particularly at firm level. Even when there is information available at country level, the availability of information decrease when we look for micro data.

We were able to prove the relevance of the technological progress in the improvement in the volume of output, even if we were expecting higher shares relative to the catch-up effect, if we differentiate by production sources, the effect can be more clearly seen. The increasing participation of renewable sources of energy is a clear improvement in the overall sector, besides of other decisions that firms can make at the micro level, like the amount of labor, the effort they put in sales or the output produced.

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Annex 1. Index of efficiency constructed with energy intensity of each country

GEO/TIME	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Switzerland	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Ireland	0,70	0,75	0,79	0,79	0,82	0,82	0,85	0,86	0,91	0,92	0,94	0,98	0,92	0,91	0,93	0,86
Denmark	0,80	0,74	0,82	0,84	0,88	0,90	0,92	0,91	0,87	0,90	0,92	0,89	0,85	0,92	0,87	0,85
Italy	0,73	0,75	0,76	0,74	0,73	0,71	0,75	0,73	0,70	0,69	0,67	0,69	0,65	0,67	0,69	0,65
Norway	0,75	0,81	0,81	0,79	0,76	0,76	0,78	0,83	0,77	0,80	0,78	0,79	0,74	0,70	0,74	0,61
United Kingdom	0,58	0,58	0,62	0,63	0,64	0,63	0,67	0,68	0,70	0,70	0,69	0,72	0,72	0,73	0,76	0,72
Austria	0,68	0,66	0,68	0,69	0,71	0,71	0,71	0,69	0,66	0,65	0,62	0,65	0,63	0,64	0,67	0,61
Spain	0,60	0,63	0,61	0,60	0,60	0,57	0,60	0,58	0,58	0,56	0,55	0,58	0,54	0,57	0,62	0,58
Luxembourg	0,55	0,55	0,59	0,64	0,65	0,64	0,65	0,62	0,60	0,55	0,55	0,59	0,59	0,61	0,63	0,57
Germany	0,55	0,55	0,56	0,57	0,59	0,57	0,59	0,58	0,58	0,57	0,56	0,58	0,57	0,58	0,59	0,56
Greece	0,54	0,55	0,55	0,53	0,54	0,51	0,54	0,53	0,55	0,55	0,54	0,57	0,54	0,54	0,56	0,54
France	0,55	0,54	0,57	0,56	0,57	0,56	0,58	0,56	0,56	0,55	0,54	0,57	0,54	0,55	0,57	0,53
Portugal	0,56	0,59	0,59	0,57	0,54	0,54	0,57	0,53	0,54	0,52	0,49	0,54	0,49	0,52	0,53	0,52
Netherlands	0,52	0,52	0,56	0,57	0,59	0,57	0,59	0,57	0,56	0,55	0,54	0,58	0,52	0,55	0,56	0,51
Malta	n	n	n	n	n	0,53	0,49	0,52	0,47	0,45	0,43	0,48	0,43	0,46	0,49	0,47
Sweden	0,42	0,42	0,45	0,45	0,48	0,50	0,50	0,48	0,50	0,49	0,50	0,54	0,52	0,53	0,56	0,50
Belgium	0,43	0,42	0,44	0,43	0,44	0,43	0,46	0,47	0,45	0,45	0,45	0,47	0,46	0,45	0,46	0,42
Cyprus	0,46	0,44	0,46	0,46	0,47	0,44	0,48	0,47	0,44	0,47	0,47	0,48	0,44	0,44	0,46	0,45
Turkey	0,39	0,39	0,40	0,40	0,39	0,37	0,40	0,38	0,38	0,40	0,40	0,39	0,35	0,36	0,36	0,34
Finland	0,36	0,35	0,36	0,37	0,38	0,38	0,40	0,37	0,36	0,36	0,39	0,38	0,37	0,39	0,39	0,36
Iceland	0,35	0,35	0,36	0,35	0,32	0,30	0,31	0,30	0,31	0,32	0,32	0,28	n	n	n	n
Croatia	0,33	0,35	0,34	0,34	0,33	0,34	0,36	0,35	0,34	0,35	0,35	0,37	0,34	0,37	0,37	0,35
Slovenia	0,31	0,31	0,31	0,33	0,34	0,34	0,35	0,35	0,35	0,35	0,34	0,37	0,36	0,36	0,37	0,35
Hungary	0,23	0,23	0,24	0,25	0,26	0,26	0,28	0,28	0,28	0,29	0,28	0,30	0,28	0,29	0,29	0,27
Lithuania	0,12	0,12	0,13	0,13	0,16	0,18	0,18	0,17	0,18	0,19	0,21	0,23	0,22	0,23	0,22	0,26
Poland	0,16	0,16	0,18	0,19	0,21	0,21	0,22	0,22	0,22	0,23	0,23	0,23	0,23	0,24	0,26	0,24
Latvia	0,14	0,15	0,17	0,18	0,20	0,21	0,22	0,23	0,23	0,24	0,25	0,27	0,27	0,27	0,24	0,22
Slovakia	0,14	0,15	0,15	0,16	0,16	0,15	0,16	0,16	0,17	0,17	0,18	0,19	0,21	0,22	0,23	0,22
Czech Republic	0,18	0,19	0,18	0,19	0,20	0,19	0,20	0,19	0,19	0,19	0,20	0,21	0,21	0,22	0,23	0,21
Romania	n	0,13	0,13	0,14	0,15	0,15	0,16	0,16	0,16	0,17	0,18	0,19	0,18	0,20	0,22	0,20
Estonia	0,10	0,10	0,11	0,13	0,14	0,15	0,15	0,17	0,16	0,16	0,18	0,20	0,18	0,18	0,17	0,15
Bulgaria	0,07	0,07	0,07	0,08	0,09	0,09	0,09	0,09	0,10	0,10	0,10	0,11	0,11	0,11	0,13	0,12

Annex 2. DEA scores by country and Malmquist indexes for different pairs of years

	Efficiency scores with DEA				1995/2000			2000/2005			2005/2010			1995/2010		
	1995	2000	2005	2010	Tech change	Eff Change	$M_{1995,2000}$	Tech change	Eff Change	$M_{2000,2005}$	Tech Change	Eff Change	$M_{2005,2010}$	Tech Change	Eff Change	$M_{1995,2010}$
Belgium	0,9472	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Bulgaria	1,0000	1,0000	0,8616	0,9960	1,0000	1,0000	1,0000	1,0773	1,1606	1,2504	0,9301	0,8651	0,8046	1,0020	1,0040	1,0060
Czech Republic	0,6170	0,6682	0,7831	0,9149	1,0086	1,0174	1,0262	0,9237	0,8533	0,7882	0,9252	0,8559	0,7919	0,8620	0,7430	0,6405
Denmark	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Germany	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Estonia	0,3752	0,4827	0,9096	1,0000	0,8821	0,7781	0,6864	0,7285	0,5307	0,3866	0,9537	0,9096	0,8675	0,6129	0,3756	0,2302
Ireland	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Greece	0,6653	0,6180	0,5852	0,9066	1,0376	1,0765	1,1170	1,0276	1,0560	1,0852	0,8034	0,6455	0,5186	0,8566	0,7338	0,6286
Spain	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
France	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Croatia	1,0000	1,0000	0,7033	0,9550	1,0000	1,0000	1,0000	1,1924	1,4219	1,6955	0,8582	0,7364	0,6320	1,0233	1,0471	1,0715
Italy	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Cyprus	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Latvia	0,5262	0,9166	1,0000	0,9919	0,7577	0,5741	0,4350	0,9574	0,9166	0,8775	1,0041	1,0082	1,0123	0,7284	0,5305	0,3864
Lithuania	0,2512	0,3943	0,4211	0,5740	0,7982	0,6371	0,5085	0,9677	0,9364	0,9061	0,8565	0,7336	0,6284	0,6615	0,4376	0,2895
Luxembourg	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Hungary	0,7481	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Netherlands	0,7087	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Austria	0,9531	1,0000	1,0000	0,9456	0,9763	0,9531	0,9305	1,0000	1,0000	1,0000	1,0284	1,0575	1,0875	1,0040	1,0079	1,0119
Poland	0,1788	0,2530	0,2587	0,3074	0,8458	0,7154	0,6051	0,9889	0,9780	0,9671	0,9174	0,8416	0,7720	0,7673	0,5888	0,4518
Portugal	0,9362	0,7672	0,6860	1,0000	1,1047	1,2203	1,3480	1,0575	1,1184	1,1827	0,8283	0,6860	0,5682	0,9676	0,9362	0,9058
Romania	1,0000	0,4750	0,8785	0,9741	1,4510	2,1053	3,0546	0,7353	0,5407	0,3976	0,9497	0,9019	0,8565	1,0132	1,0266	1,0401
Slovenia	0,9050	1,0000	1,0000	1,0000	0,9984	0,9968	0,9952	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	0,9984	0,9968	0,9952
Slovakia	0,6613	0,6584	0,4065	0,5338	1,0022	1,0044	1,0066	1,2727	1,6197	2,0613	0,8727	0,7615	0,6645	1,1130	1,2389	1,3789
Finland	0,9249	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Sweden	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
United Kingdom	0,9613	1,0000	1,0000	0,9319	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0359	1,0731	1,1116	1,0359	1,0731	1,1116
Norway	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Switzerland	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Turkey	0,3949	0,5078	0,6553	0,8311	1,0398	1,0811	1,1241	0,8803	0,7749	0,6821	0,8880	0,7885	0,7001	0,8128	0,6606	0,5369

Annex 3. Efficiency scores of the set of firms by years DEA (part 1)

No	Name of the company	e2004	e2009	e2013
1	ELECTRICITE DE FRANCE	0,4886	0,4874	0,5524
2	IBERDROLA GENERACION SAU	1,0000	0,5114	0,6072
3	ENEL ENERGIA S.P.A.	1,0000	1,0000	1,0000
4	ENEL PRODUZIONE S.P.A.	1,0000	0,4887	0,4716
5	ČEZ, A. S.	0,5536	0,5096	0,5116
6	A2A S.P.A.	0,5973	0,4682	0,4262
7	ENDESA GENERACION SA	0,6628	0,6408	0,4687
8	MVV ENERGIE AG	0,5274	0,5862	0,5703
9	HIDROELECTRICA DEL CANTABRICO SA	0,4614	0,4873	0,4715
10	STADTWERKE LEIPZIG GMBH	0,5816	0,5917	1,0000
11	SLOVENSKÉ ELEKTRÁRNE, A.S.	1,0000	0,4838	0,4689
12	STADTWERKE HANNOVER AKTIENGESELLSCHAF	0,6454	0,5632	0,5012
13	MAINOVA AKTIENGESELLSCHAFT	0,5390	0,5125	0,5291
14	REPOWER AG	0,5927	0,5122	0,4716
15	UNION ELECTRICA DE CANARIAS GENERACION S	0,5616	0,6234	0,5751
16	FORTUM POWER AND HEAT OY	1,0000	0,7040	0,9478
17	HIDROCANTABRICO ENERGIA SA	1,0000	1,0000	1,0000
18	COMPAGNIA VALDOSTANA DELLE ACQUE	0,8701	0,7665	0,7254
19	REPOWER ITALIA S.P.A.	1,0000	0,9344	1,0000
20	EON GENERACION SL	0,3264	0,4417	0,5535
21	E.ON KÄRNKRAFT SVERIGE AB	1,0000	1,0000	1,0000
22	AZIENDA ENERGETICA S.P.A. - ETSCHWERKE	1,0000	1,0000	1,0000
23	STADTWERKE KIEL AKTIENGESELLSCHAFT	0,7480	1,0000	0,6544
24	RHÖNENERGIE FULDA GMBH	0,4397	0,5445	0,4921
25	HEP-PROIZVODNJA D.O.O.	0,3395	0,4157	0,4700
26	MVM PAKSI ATOMERŐMŰ ZÁRTKÖ	0,5404	0,9283	1,0000
27	ELECTROCENTRALE BUCURESTI SA	0,7097	0,6254	0,4686
28	OKG AKTIEBOLAG	0,2911	0,3031	0,2690
29	GAS Y ELECTRICIDAD GENERACION SA	0,7270	0,5334	0,3782
30	GROSSKRAFTWERK MANNHEIM AK	0,4098	0,4289	0,2756
31	JÄMTKRAFT AKTIEBOLAG	1,0000	0,4709	0,4118
32	EESTI ENERGIA NARVA ELEKTRIJAAMAD AS	1,0000	1,0000	1,0000
33	GETEC ENERGIE AG	1,0000	0,7966	1,0000
34	SOCIETATEA NATIONALA -NUCLEARELECTRICA-	0,2494	0,3240	0,3628
35	ELIA ASSET	0,4727	0,4285	0,3614
36	TEOLLISUUDEN VOIMA OYJ	0,8013	0,8273	1,0000
37	АЕЦ КОЗЛОДУЙ ЕАД	1,0000	1,0000	1,0000
38	ROSEN - ROSIGNANO ENERGIA SPA	1,0000	1,0000	1,0000
39	MÁTRAI ERŐMŰ ZÁRTKÖRŰEN MŰKÖDŐ RÉSZV	0,8280	0,7111	0,6268
40	KERNKRAFTWERK GÖSGEN-DÄNIKEN AG	1,0000	1,0000	1,0000
41	EWV ENERGIE- UND WASSER-VERSORGUNG GN	0,5965	0,8313	0,8089
42	KERNKRAFTWERK GUNDREMMINGEN GMBH	0,2896	0,8381	1,0000
43	E-CO ENERGI AS	1,0000	1,0000	0,9508
44	ТЕЦ МАРИЦА ИЗТОК 2 ЕАД	0,9081	0,8840	0,8198
45	AGDER ENERGI VANNKRAFT AS	1,0000	0,7739	1,0000
46	ENEL GREEN POWER ESPAÑA S L	0,6270	1,0000	0,3372
47	SWE ENERGIE GMBH	0,5550	0,7554	0,9422
48	LYSE PRODUKSJON AS	0,8748	1,0000	1,0000
49	TERMOELEKTRARNA ŠOŠTANJ D.O.O.	0,7781	0,8358	0,5485
50	BKK PRODUKSJON AS	1,0000	1,0000	1,0000
51	ITAL GREEN ENERGY S.R.L.	1,0000	1,0000	1,0000
52	STADTWERKE TÜBINGEN GMBH	0,4739	0,6420	0,5159
53	КОНТУРГЛОБАЛ МАРИЦА ИЗТОК 3 АД	0,9495	1,0000	1,0000
54	TEJO ENERGIA - PRODUÇÃO E DISTRIBUIÇ	1,0000	1,0000	1,0000
55	JYVÄSKYLÄN ENERGIA OY	0,8088	0,5112	0,6787
56	ZEAG ENERGIE AG	0,9561	0,4855	0,4165
57	INFRASERV GMBH & CO. WIESBADEN KG	0,6645	1,0000	1,0000
58	LAHTI ENERGIA OY	0,5908	1,0000	0,7349
59	STADTWERKE REMSCHEID GESELLSCHAFT MIT I	0,3252	0,5374	0,4694
60	G.O.R.I. S.P.A. - GESTIONE OTTIMALE RISORSE I	1,0000	0,9394	1,0000
61	FMV SA	0,8801	1,0000	0,7341
62	ENERGOTRANS, A.S.	0,8423	1,0000	1,0000
63	UNTERFRÄNKISCHE ÜBERLANDZENTRALE EG	0,5102	0,5296	0,5390
64	KRAFTWERKE OBERHASLI AG	1,0000	0,7120	0,6198
65	ELCOGAS SOCIEDAD ANONIMA	0,4573	0,5723	0,5642

Annex 3. DEA of the set of firms (part 2)

66	FLYENERGIA SOCIETA' PER AZIONI	1,0000	1,0000	1,0000
67	ŠKO-ENERGO, S.R.O.	1,0000	1,0000	0,6678
68	EDISON ENERGIE SPECIALI S.P.A.	1,0000	0,5858	1,0000
69	GEMEINSCHAFTSKRAFTWERK VELTHEIM GESEL	0,6374	0,6296	0,7334
70	SCHLUCHSEEWERK AKTIENGESELLSCHAFT	0,2756	0,5186	0,3769
71	ASTEA S.P.A.	0,6735	0,6267	0,8383
72	HYDRO EXPLOITATION SA	1,0000	1,0000	1,0000
73	GUDBRANDSDAL ENERGI AS	1,0000	0,7194	0,7894
74	OTTANA ENERGIA SOCIETA' PER AZIONI - S.P.A. (	1,0000	0,9615	0,8539
75	ENGADINER KRAFTWERKE AG	1,0000	0,3927	0,5470
76	ITALGEN S.P.A.	1,0000	0,8280	0,8746
77	BIOMASSE ITALIA S.P.A.	0,7092	1,0000	0,7735
78	ČEZ OBNOVITELNÉ ZDROJE, S.R.O.	1,0000	1,0000	1,0000
79	DRAVSKE ELEKTRARNE MARIBOR D.O.O.	1,0000	0,8706	0,7942
80	ELEKTRIZITÄTSWERK ALTDORF AG	0,8500	1,0000	1,0000
81	HÄRJEÅNS KRAFT AKTIEBOLAG	1,0000	0,6933	0,7383
82	TAFJORD KRAFTPRODUKSJON AS	0,7962	1,0000	1,0000
83	ENERGIEVERSORGUNG SYLT GMBH	1,0000	0,7233	0,7627
84	SEA ENERGIA S.P.A.	0,6924	0,7673	0,7878
85	LOMELLINA ENERGIA S.R.L.	0,5846	0,8191	0,9789
86	KEMIJOKI OY	0,3089	0,2888	0,3859
87	PORVOON ENERGIA OY - BORGÅ ENERGI AB	0,5798	0,6437	0,5523
88	ETELÄ-SAVON ENERGIA OY	0,4941	0,5684	0,5540
89	ASM TERNI S.P.A.	0,6419	0,5836	0,7631
90	ONDA COGENERACION SL	0,7935	0,6727	1,0000
91	GREEN GAS DPB, A.S.	0,8257	0,8560	0,9214
92	SOŠKE ELEKTRARNE NOVA GORICA D.O.O.	0,7006	0,3049	0,4215
93	ТОПЛОФИКАЦИЯ ПЛЕВЕН ЕАД	0,7382	0,8668	0,6224
94	ISTAD KRAFT AS	1,0000	0,9705	0,8994
95	ELEKTRIZITÄTSWERK OBWALDEN	0,4820	0,7557	0,6613
96	COGENERACION DEL NOROESTE SL	0,9325	1,0000	1,0000
97	TAMPIERI ENERGIE S.R.L.	0,8277	1,0000	1,0000
98	KANTONALES ELEKTRIZITÄTSWERK NIDWALDEI	0,7355	0,3827	0,5825
99	VULKAN ENERGIEWIRTSCHAFT ODERBRÜCKE G	0,8016	1,0000	0,5485
100	TUSSA ENERGI AS	0,6435	0,6631	0,6203
101	ASPIRAVI	1,0000	1,0000	0,5897
102	SWL ENERGIE AG	0,6257	0,6361	0,9534
103	HAMINAN ENERGIA OY	0,7315	0,6504	0,6401
104	SEL EDISON SPA % SEL EDISON A.G.	1,0000	1,0000	1,0000
105	ТОПЛОФИКАЦИЯ РУСЕ ЕАД	0,4004	0,6590	0,6106
106	VOGHERA ENERGIA S.P.A.	1,0000	0,5406	0,5314
107	TECHNISCHE BETRIEBE GLARUS SÜD	0,9742	1,0000	0,7561
108	SAN MARCO BIOENERGIE S.P.A. IN FORMA ABB	0,7284	1,0000	0,6939
109	VATAJANKOSKEN SÄHKÖ OY	0,4123	0,5053	0,5464
110	BALTEAU IE	1,0000	1,0000	0,9261
111	ТЕЦ СВИЛОЗА АД	1,0000	0,7154	0,7031
112	GKS-GEMEINSCHAFTSKRAFTWERK SCHWEINFU	0,4250	0,8330	0,7386
113	KAINUUN VOIMA OY	0,4396	0,5373	0,6478
114	TARANIS DU ROUVRAY	1,0000	0,8701	0,8635
115	MJÖLBY- SVARTÅDALEN ENERGI AB	0,7797	0,5147	0,4366
116	MASTROPASQUA INTERNATIONAL - S.P.A.	1,0000	1,0000	0,9996
117	PRIMIERO ENERGIA S.P.A.	1,0000	1,0000	1,0000
118	EDA RENOVÁVEIS, S.A.	1,0000	0,7756	1,0000
119	ECOSESTO S.P.A.	0,6648	0,6820	0,5766
120	AKTIEBOLAGET EDSBYNS ELVERK	0,5349	0,7659	0,6908
121	E.T.A. - ENERGIE TECNOLOGIE AMBIENTE SOCIE	0,5515	0,5995	0,3966
122	SOCIETA' ELETTRICA IN MORBEGNO SOCIETA' C(	0,6676	0,6946	0,6402
123	CENTRALA ELECTRICĂ DE TERMOFICARE ARAD S	0,2997	0,6766	0,3202
124	VARESE RISORSE S.P.A.	1,0000	0,9937	0,7288
125	VOSS ENERGI AS	0,6393	0,5074	0,5838
126	GRANADA VAPOR Y ELECTRICIDAD SL	0,6169	0,9889	1,0000
127	AZIENDA SPECIALIZZATA SETTORE MULTISERVIZ	0,4507	0,4594	0,3960
128	LINEA ENERGIA S.P.A.	0,3934	0,6296	0,5712
129	VERSORGUNGSBETRIEBE BORDESHOLM GMBH	1,0000	1,0000	1,0000
130	VEST - ENERGO SA	1,0000	0,7533	1,0000

Annex 4. Production Firms Malmquist indexed 2004-2009, decomposed (part 1)

		2004/2009		
No	Name of the company	Tech change	Eff Change	$M_{2004,2009}$
1	ELECTRICITE DE FRANCE	1,0012	1,0025	1,0037
2	IBERDROLA GENERACION SAU	1,3984	1,9554	2,7344
3	ENEL ENERGIA S.P.A.	1,0000	1,0000	1,0000
4	ENEL PRODUZIONE S.P.A.	1,4305	2,0462	2,9271
5	ČEZ, A. S.	1,0423	1,0863	1,1323
6	A2A S.P.A.	1,1295	1,2757	1,4409
7	ENDESA GENERACION SA	1,0170	1,0343	1,0519
8	MVV ENERGIE AG	0,9485	0,8997	0,8534
9	HIDROELECTRICA DEL CANTABRICO SA	0,9731	0,9468	0,9213
10	STADTWERKE LEIPZIG GMBH	0,9914	0,9829	0,9745
11	SLOVENSKÉ ELEKTRÁRNE, A.S.	1,4377	2,0670	2,9717
12	STADTWERKE HANNOVER AKTIENGESELLSCHAF	1,0705	1,1460	1,2267
13	MAINOVA AKTIENGESELLSCHAFT	1,0255	1,0517	1,0786
14	REPOWER AG	1,0757	1,1572	1,2448
15	UNION ELECTRICA DE CANARIAS GENERACION S	0,9491	0,9009	0,8550
16	FORTUM POWER AND HEAT OY	1,1918	1,4205	1,6929
17	HIDROCANTABRICO ENERGIA SA	1,0000	1,0000	1,0000
18	COMPAGNIA VALDOSTANA DELLE ACQUE	1,0654	1,1352	1,2094
19	REPOWER ITALIA S.P.A.	1,0345	1,0702	1,1071
20	EON GENERACION SL	0,8596	0,7390	0,6352
21	E.ON KÄRNKRAFT SVERIGE AB	1,0000	1,0000	1,0000
22	AZIENDA ENERGETICA S.P.A. - ETSCHWERKE	1,0000	1,0000	1,0000
23	STADTWERKE KIEL AKTIENGESELLSCHAFT	0,8649	0,7480	0,6469
24	RHÖNENERGIE FULDA GMBH	0,8986	0,8075	0,7257
25	HEP-PROIZVODNJA D.O.O.	0,9037	0,8167	0,7381
26	MVM PAKSI ATOMERŐMŰ ZÁRTKÖ	0,7630	0,5821	0,4442
27	ELECTROCENTRALE BUCURESTI SA	1,0653	1,1348	1,2089
28	OKG AKTIEBOLAG	0,9800	0,9604	0,9412
29	GAS Y ELECTRICIDAD GENERACION SA	1,1675	1,3630	1,5912
30	GROSSKRAFTWERK MANNHEIM AK	0,9775	0,9555	0,9340
31	JÄMTKRAFT AKTIEBOLAG	1,4573	2,1236	3,0946
32	EESTI ENERGIA NARVA ELEKTRIJAAMAD AS	1,0000	1,0000	1,0000
33	GETEC ENERGIE AG	1,1204	1,2553	1,4065
34	SOCIETATEA NATIONALA -NUCLEARELECTRICA-	0,8774	0,7698	0,6753
35	ELIA ASSET	1,0503	1,1032	1,1586
36	TEOLLISUUDEN VOIMA OYJ	0,9842	0,9686	0,9532
37	АЕЦ КОЗЛОДУЙ ЕАД	1,0000	1,0000	1,0000
38	ROSEN - ROSIGNANO ENERGIA SPA	1,0000	1,0000	1,0000
39	MÁTRAI ERŐMŰ ZÁRTKÖRŰEN MŰKÖDŐ RÉSZV	1,0791	1,1644	1,2565
40	KERNKRAFTWERK GÖSGEN-DÄNIKEN AG	1,0000	1,0000	1,0000
41	EWV ENERGIE- UND WASSER-VERSORGUNG GN	0,8471	0,7176	0,6078
42	KERNKRAFTWERK GUNDREMMINGEN GMBH	0,5878	0,3455	0,2031
43	E-CO ENERGI AS	1,0000	1,0000	1,0000
44	ТЕЦ МАРИЦА ИЗТОК 2 ЕАД	1,0135	1,0273	1,0412
45	AGDER ENERGI VANNKRAFT AS	1,1367	1,2922	1,4688
46	ENEL GREEN POWER ESPAÑA S L	0,7918	0,6270	0,4965
47	SWE ENERGIE GMBH	0,8572	0,7347	0,6298
48	LYSE PRODUKSJON AS	0,9353	0,8748	0,8182
49	TERMOELEKTRARNA ŠOŠTANJ D.O.O.	0,9649	0,9310	0,8983
50	BKK PRODUKSJON AS	1,0000	1,0000	1,0000
51	ITAL GREEN ENERGY S.R.L.	1,0000	1,0000	1,0000
52	STADTWERKE TÜBINGEN GMBH	0,8592	0,7382	0,6342
53	КОНТУРГЛОБАЛ МАРИЦА ИЗТОК 3 АД	0,9744	0,9495	0,9252
54	TEJO ENERGIA - PRODUÇÃO E DISTRIBUIÇ	1,0000	1,0000	1,0000
55	JYVÄSKYLÄN ENERGIA OY	1,2578	1,5822	1,9901
56	ZEAG ENERGIE AG	1,4033	1,9693	2,7636
57	INFRASERV GMBH & CO. WIESBADEN KG	0,8152	0,6645	0,5417
58	LAHTI ENERGIA OY	0,7686	0,5908	0,4541
59	STADTWERKE REMSCHEID GESELLSCHAFT MIT I	0,7779	0,6051	0,4707
60	G.O.R.I. S.P.A. - GESTIONE OTTIMALE RISORSE I	1,0318	1,0645	1,0983
61	FMV SA	0,9381	0,8801	0,8257
62	ENERGOTRANS, A.S.	0,9178	0,8423	0,7730
63	UNTERFRÄNKISCHE ÜBERLANDZENTRALE EG	0,9815	0,9634	0,9456
64	KRAFTWERKE OBERHASLI AG	1,1851	1,4045	1,6645
65	ELCOGAS SOCIEDAD ANONIMA	0,8939	0,7991	0,7143

Annex 4. Production Firms Malmquist indexed 2004-2009, decomposed (part 2)

66	FLYENERGIA SOCIETA' PER AZIONI	1,0000	1,0000	1,0000
67	ŠKO-ENERGO, S.R.O.	1,0000	1,0000	1,0000
68	EDISON ENERGIE SPECIALI S.P.A.	1,3065	1,7071	2,2304
69	GEMEINSCHAFTSKRAFTWERK VELTHEIM GESEL	1,0062	1,0124	1,0186
70	SCHLUCHSEEWERK AKTIENGESELLSCHAFT	0,7290	0,5314	0,3874
71	ASTEA S.P.A.	1,0367	1,0747	1,1141
72	HYDRO EXPLOITATION SA	1,0000	1,0000	1,0000
73	GUDBRANDSDAL ENERGI AS	1,1790	1,3900	1,6389
74	OTTANA ENERGIA SOCIETA' PER AZIONI- S.P.A. (	1,0198	1,0400	1,0607
75	ENGADINER KRAFTWERKE AG	1,5958	2,5465	4,0636
76	ITALGEN S.P.A.	1,0990	1,2077	1,3273
77	BIOMASSE ITALIA S.P.A.	0,8421	0,7092	0,5972
78	ČEZ OBNOVITELNÉ ZDROJE, S.R.O.	1,0000	1,0000	1,0000
79	DRAVSKE ELEKTRARNE MARIBOR D.O.O.	1,0717	1,1486	1,2310
80	ELEKTRIZITÄTSWERK ALTDORF AG	0,9220	0,8500	0,7837
81	HÄRJEÅNS KRAFT AKTIEBOLAG	1,2010	1,4424	1,7323
82	TAFJORD KRAFTPRODUKSJON AS	0,8923	0,7962	0,7104
83	ENERGIEVERSORGUNG SYLT GMBH	1,1758	1,3826	1,6256
84	SEA ENERGIA S.P.A.	0,9499	0,9024	0,8572
85	LOMELLINA ENERGIA S.R.L.	0,8448	0,7137	0,6030
86	KEMIJOKI OY	1,0342	1,0696	1,1062
87	PORVOON ENERGIA OY - BORGÅ ENERGI AB	0,9491	0,9007	0,8549
88	ETELÄ-SAVON ENERGIA OY	0,9324	0,8693	0,8105
89	ASM TERNI S.P.A.	1,0488	1,0999	1,1535
90	ONDA COGENERACION SL	1,0861	1,1796	1,2811
91	GREEN GAS DPB, A.S.	0,9821	0,9646	0,9474
92	SOŠKE ELEKTRARNE NOVA GORICA D.O.O.	1,5159	2,2978	3,4831
93	ТОПЛОФИКАЦИЯ ПЛЕВЕН ЕАД	0,9228	0,8516	0,7859
94	ISTAD KRAFT AS	1,0151	1,0304	1,0459
95	ELEKTRIZITÄTSWERK OBWALDEN	0,7986	0,6378	0,5094
96	COGENERACION DEL NOROESTE SL	0,9657	0,9325	0,9005
97	TAMPIERI ENERGIE S.R.L.	0,9098	0,8277	0,7530
98	KANTONALES ELEKTRIZITÄTSWERK NIDWALDEI	1,3863	1,9219	2,6643
99	VULKAN ENERGIEWIRTSCHAFT ODERBRÜCKE G	0,8953	0,8016	0,7177
100	TUSSA ENERGI AS	0,9851	0,9704	0,9560
101	ASPIRAVI	1,0000	1,0000	1,0000
102	SWL ENERGIE AG	0,9918	0,9837	0,9756
103	HAMINAN ENERGIA OY	1,0605	1,1247	1,1928
104	SEL EDISON SPA % SEL EDISON A.G.	1,0000	1,0000	1,0000
105	ТОПЛОФИКАЦИЯ РУСЕ ЕАД	0,7795	0,6076	0,4736
106	VOGHERA ENERGIA S.P.A.	1,3601	1,8498	2,5159
107	TECHNISCHE BETRIEBE GLARUS SÜD	0,9870	0,9742	0,9616
108	SAN MARCO BIOENERGIE S.P.A. IN FORMA ABB	0,8535	0,7284	0,6217
109	VATAJANKOSKEN SÄHKÖ OY	0,9033	0,8160	0,7370
110	BALTEAU IE	1,0000	1,0000	1,0000
111	ТЕЦ СВИЛОЗА АД	1,1823	1,3978	1,6526
112	GKS-GEMEINSCHAFTSKRAFTWERK SCHWEINFU	0,7143	0,5102	0,3644
113	KAINUUN VOIMA OY	0,9045	0,8182	0,7401
114	TARANIS DU ROUVRAY	1,0721	1,1493	1,2321
115	MJÖLBY- SVARTÅDALEN ENERGI AB	1,2308	1,5149	1,8645
116	MASTROPASQUA INTERNATIONAL - S.P.A.	1,0000	1,0000	1,0000
117	PRIMIERO ENERGIA S.P.A.	1,0000	1,0000	1,0000
118	EDA RENOVÁVEIS, S.A.	1,1355	1,2893	1,4640
119	ECOSESTO S.P.A.	0,9873	0,9748	0,9624
120	AKTIEBOLAGET EDSBYNS ELVERK	0,8357	0,6984	0,5836
121	E.T.A. - ENERGIE TECNOLOGIE AMBIENTE SOCIE	0,9591	0,9199	0,8823
122	SOCIETA' ELETTRICA IN MORBEGNO SOCIETA' C(	0,9804	0,9611	0,9423
123	CENTRALA ELECTRICĂ DE TERMOFICARE ARAD S	0,6655	0,4430	0,2948
124	VARESE RISORSE S.P.A.	1,0032	1,0063	1,0095
125	VOSS ENERGI AS	1,1225	1,2600	1,4143
126	GRANADA VAPOR Y ELECTRICIDAD SL	0,7898	0,6238	0,4927
127	AZIENDA SPECIALIZZATA SETTORE MULTISERVIZ	0,9905	0,9811	0,9717
128	LINEA ENERGIA S.P.A.	0,7905	0,6248	0,4939
129	VERSORGUNGSBETRIEBE BORDESHOLM GMBH	1,0000	1,0000	1,0000
130	VEST - ENERGO SA	1,1522	1,3275	1,5295

Annex 5. Production Firms Malmquist indexed 2009-2013, decomposed (part 1)

		2009/2013		
No	Name of the company	Tech change	Eff Change	$M_{2009,2013}$
1	ELECTRICITE DE FRANCE	0,9393	0,8823	0,8288
2	IBERDROLA GENERACION SAU	0,9177	0,8422	0,7729
3	ENEL ENERGIA S.P.A.	1,0000	1,0000	1,0000
4	ENEL PRODUZIONE S.P.A.	1,0180	1,0363	1,0549
5	ČEZ, A. S.	0,9980	0,9961	0,9941
6	A2A S.P.A.	1,0481	1,0985	1,1514
7	ENDESA GENERACION SA	1,1693	1,3672	1,5986
8	MVV ENERGIE AG	1,0138	1,0279	1,0421
9	HIDROELECTRICA DEL CANTABRICO SA	1,0166	1,0335	1,0507
10	STADTWERKE LEIPZIG GMBH	0,7692	0,5917	0,4551
11	SLOVENSKÉ ELEKTRÁRNE, A.S.	1,0158	1,0318	1,0480
12	STADTWERKE HANNOVER AKTIENGESELLSCHAF	1,0600	1,1237	1,1912
13	MAINOVA AKTIENGESELLSCHAFT	0,9842	0,9686	0,9533
14	REPOWER AG	1,0422	1,0861	1,1319
15	UNION ELECTRICA DE CANARIAS GENERACION S	1,0411	1,0840	1,1286
16	FORTUM POWER AND HEAT OY	0,8618	0,7428	0,6402
17	HIDROCANTABRICO ENERGIA SA	1,0000	1,0000	1,0000
18	COMPAGNIA VALDOSTANA DELLE ACQUE	1,0279	1,0567	1,0862
19	REPOWER ITALIA S.P.A.	0,9666	0,9344	0,9032
20	EON GENERACION SL	0,8933	0,7980	0,7129
21	E.ON KÄRNKRAFT SVERIGE AB	1,0000	1,0000	1,0000
22	AZIENDA ENERGETICA S.P.A. - ETSCHWERKE	1,0000	1,0000	1,0000
23	STADTWERKE KIEL AKTIENGESELLSCHAFT	1,2362	1,5281	1,8890
24	RHÖNENERGIE FULDA GMBH	1,0519	1,1065	1,1639
25	HEP-PROIZVODNJA D.O.O.	0,9405	0,8845	0,8318
26	MVM PAKSI ATOMERŐMŰ ZÁRTKÖ	0,9635	0,9283	0,8944
27	ELECTROCENTRALE BUCURESTI SA	1,1553	1,3346	1,5418
28	OKG AKTIEBOLAG	1,0615	1,1268	1,1961
29	GAS Y ELECTRICIDAD GENERACION SA	1,1876	1,4104	1,6749
30	GROSSKRAFTWERK MANNHEIM AK	1,2475	1,5562	1,9414
31	JÄMTKRAFT AKTIEBOLAG	1,0694	1,1435	1,2228
32	EESTI ENERGIA NARVA ELEKTRIJAAMAD AS	1,0000	1,0000	1,0000
33	GETEC ENERGIE AG	0,8925	0,7966	0,7110
34	SOCIETATEA NATIONALA -NUCLEARELECTRICA-	0,9450	0,8931	0,8439
35	ELIA ASSET	1,0889	1,1857	1,2911
36	TEOLLISUUDEN VOIMA OYJ	0,9096	0,8273	0,7525
37	АЕЦ КОЗЛОДУЙ ЕАД	1,0000	1,0000	1,0000
38	ROSEN - ROSIGNANO ENERGIA SPA	1,0000	1,0000	1,0000
39	MÁTRAI ERŐMŰ ZÁRTKÖRŰEN MŰKÖDŐ RÉSZV	1,0651	1,1345	1,2084
40	KERNKRAFTWERK GÖSGEN-DÄNIKEN AG	1,0000	1,0000	1,0000
41	EWV ENERGIE- UND WASSER-VERSORGUNG GN	1,0138	1,0277	1,0418
42	KERNKRAFTWERK GUNDREMMINGEN GMBH	0,9155	0,8381	0,7673
43	E-CO ENERGI AS	1,0255	1,0517	1,0786
44	ТЕЦ МАРИЦА ИЗТОК 2 ЕАД	1,0384	1,0783	1,1197
45	AGDER ENERGI VANNKRAFT AS	0,8797	0,7739	0,6808
46	ENEL GREEN POWER ESPAÑA S L	1,7221	2,9656	5,1070
47	SWE ENERGIE GMBH	0,8954	0,8017	0,7179
48	LYSE PRODUKSJON AS	1,0000	1,0000	1,0000
49	TERMOELEKTRARNA ŠOŠTANJ D.O.O.	1,2344	1,5238	1,8810
50	BKK PRODUKSJON AS	1,0000	1,0000	1,0000
51	ITAL GREEN ENERGY S.R.L.	1,0000	1,0000	1,0000
52	STADTWERKE TÜBINGEN GMBH	1,1155	1,2444	1,3882
53	КОНТУРГЛОБАЛ МАРИЦА ИЗТОК 3 АД	1,0000	1,0000	1,0000
54	TEJO ENERGIA - PRODUÇÃO E DISTRIBUIÇ	1,0000	1,0000	1,0000
55	JYVÄSKYLÄN ENERGIA OY	0,8679	0,7532	0,6537
56	ZEAG ENERGIE AG	1,0797	1,1657	1,2585
57	INFRASERV GMBH & CO. WIESBADEN KG	1,0000	1,0000	1,0000
58	LAHTI ENERGIA OY	1,1665	1,3607	1,5873
59	STADTWERKE REMSCHEID GESELLSCHAFT MIT I	1,0700	1,1449	1,2250
60	G.O.R.I. S.P.A. - GESTIONE OTTIMALE RISORSE I	0,9692	0,9394	0,9105
61	FMV SA	1,1671	1,3622	1,5899
62	ENERGOTRANS, A.S.	1,0000	1,0000	1,0000
63	UNTERFRÄNKISCHE ÜBERLANDZENTRALE EG	0,9912	0,9826	0,9740
64	KRAFTWERKE OBERHASLI AG	1,0718	1,1488	1,2312
65	ELCOGAS SOCIEDAD ANONIMA	1,0072	1,0144	1,0216

Annex 5. Production Firms Malmquist indexed 2009-2013, decomposed (part 2)

66	FLYENERGIA SOCIETA' PER AZIONI	1,0000	1,0000	1,0000
67	ŠKO-ENERGO, S.R.O.	1,2237	1,4975	1,8324
68	EDISON ENERGIE SPECIALI S.P.A.	0,7654	0,5858	0,4484
69	GEMEINSCHAFTSKRAFTWERK VELTHEIM GESEL	0,9265	0,8585	0,7954
70	SCHLUCHSEEWERK AKTIENGESELLSCHAFT	1,1730	1,3760	1,6140
71	ASTEA S.P.A.	0,8646	0,7476	0,6464
72	HYDRO EXPLOITATION SA	1,0000	1,0000	1,0000
73	GUDBRANDSDAL ENERGI AS	0,9546	0,9113	0,8700
74	OTTANA ENERGIA SOCIETA' PER AZIONI- S.P.A. (	1,0611	1,1260	1,1949
75	ENGADINER KRAFTWERKE AG	0,8473	0,7179	0,6083
76	ITALGEN S.P.A.	0,9730	0,9467	0,9212
77	BIOMASSE ITALIA S.P.A.	1,1370	1,2928	1,4700
78	ČEZ OBNOVITELNÉ ZDROJE, S.R.O.	1,0000	1,0000	1,0000
79	DRAVSKE ELEKTRARNE MARIBOR D.O.O.	1,0470	1,0962	1,1477
80	ELEKTRIZITÄTSWERK ALTDORF AG	1,0000	1,0000	1,0000
81	HÄRJEÅNS KRAFT AKTIEBOLAG	0,9690	0,9390	0,9100
82	TAFJORD KRAFTPRODUKSJON AS	1,0000	1,0000	1,0000
83	ENERGIEVERSORGUNG SYLT GMBH	0,9738	0,9483	0,9235
84	SEA ENERGIA S.P.A.	0,9869	0,9740	0,9612
85	LOMELLINA ENERGIA S.R.L.	0,9147	0,8368	0,7654
86	KEMIJOKI OY	0,8651	0,7484	0,6474
87	PORVOON ENERGIA OY - BORGÅ ENERGI AB	1,0796	1,1655	1,2582
88	ETELÄ-SAVON ENERGIA OY	1,0129	1,0260	1,0392
89	ASM TERNI S.P.A.	0,8745	0,7648	0,6688
90	ONDA COGENERACION SL	0,8202	0,6727	0,5517
91	GREEN GAS DPB, A.S.	0,9639	0,9290	0,8954
92	SOŠKE ELEKTRARNE NOVA GORICA D.O.O.	0,8505	0,7234	0,6152
93	ТОПЛОФИКАЦИЯ ПЛЕВЕН ЕАД	1,1801	1,3927	1,6435
94	ISTAD KRAFT AS	1,0388	1,0791	1,1209
95	ELEKTRIZITÄTSWERK OBWALDEN	1,0690	1,1427	1,2216
96	COGENERACION DEL NOROESTE SL	1,0000	1,0000	1,0000
97	TAMPIERI ENERGIE S.R.L.	1,0000	1,0000	1,0000
98	KANTONALES ELEKTRIZITÄTSWERK NIDWALDEI	0,8106	0,6570	0,5325
99	VULKAN ENERGIEWIRTSCHAFT ODERBRÜCKE G	1,3502	1,8232	2,4617
100	TUSSA ENERGI AS	1,0339	1,0690	1,1053
101	ASPIRAVI	1,3022	1,6958	2,2083
102	SWL ENERGIE AG	0,8168	0,6672	0,5450
103	HAMINAN ENERGIA OY	1,0080	1,0161	1,0242
104	SEL EDISON SPA % SEL EDISON A.G.	1,0000	1,0000	1,0000
105	ТОПЛОФИКАЦИЯ РУСЕ ЕАД	1,0389	1,0793	1,1212
106	VOGHERA ENERGIA S.P.A.	1,0086	1,0173	1,0261
107	TECHNISCHE BETRIEBE GLARUS SÜD	1,1500	1,3226	1,5210
108	SAN MARCO BIOENERGIE S.P.A. IN FORMA ABB	1,2005	1,4411	1,7300
109	VATAJANKOSKEN SÄHKÖ OY	0,9617	0,9248	0,8893
110	BALTEAU IE	1,0391	1,0798	1,1221
111	ТЕЦ СВИЛОЗА АД	1,0087	1,0175	1,0264
112	GKS-GEMEINSCHAFTSKRAFTWERK SCHWEINFU	1,0620	1,1278	1,1977
113	KAINUUN VOIMA OY	0,9107	0,8294	0,7554
114	TARANIS DU ROUVRAY	1,0038	1,0076	1,0115
115	MJÖLBY- SVARTÅDALEN ENERGI AB	1,0858	1,1789	1,2800
116	MASTROPASQUA INTERNATIONAL - S.P.A.	1,0002	1,0004	1,0006
117	PRIMIERO ENERGIA S.P.A.	1,0000	1,0000	1,0000
118	EDA RENOVÁVEIS, S.A.	0,8807	0,7756	0,6831
119	ECOSESTO S.P.A.	1,0876	1,1828	1,2864
120	AKTIEBOLAGET EDSBYNS ELVERK	1,0530	1,1087	1,1674
121	E.T.A. - ENERGIE TECNOLOGIE AMBIENTE SOCIET	1,2295	1,5116	1,8585
122	SOCIETA' ELETTRICA IN MORBEGNO SOCIETA' C(	1,0416	1,0850	1,1301
123	CENTRALA ELECTRICĂ DE TERMOFICARE ARAD S	1,4536	2,1131	3,0716
124	VARESE RISORSE S.P.A.	1,1677	1,3635	1,5921
125	VOSS ENERGI AS	0,9323	0,8691	0,8103
126	GRANADA VAPOR Y ELECTRICIDAD SL	0,9944	0,9889	0,9834
127	AZIENDA SPECIALIZZATA SETTORE MULTISERVIZ	1,0771	1,1601	1,2495
128	LINEA ENERGIA S.P.A.	1,0499	1,1022	1,1572
129	VERSORGUNGSBETRIEBE BORDESHOLM GMBH	1,0000	1,0000	1,0000
130	VEST - ENERGO SA	0,8679	0,7533	0,6538

Annex 6. Production Firms Malmquist indexed 2004-2013, decomposed (part 1)

		2004/2013		
No	Name of the company	Tech Change	Eff Change	$M_{2004,2013}$
1	ELECTRICITE DE FRANCE	0,9405	0,8845	0,8319
2	IBERDROLA GENERACION SAU	1,2833	1,6469	2,1135
3	ENEL ENERGIA S.P.A.	1,0000	1,0000	1,0000
4	ENEL PRODUZIONE S.P.A.	1,4562	2,1204	3,0877
5	ČEZ, A. S.	1,0402	1,0821	1,1256
6	A2A S.P.A.	1,1838	1,4015	1,6591
7	ENDESA GENERACION SA	1,1892	1,4141	1,6816
8	MVV ENERGIE AG	0,9617	0,9248	0,8893
9	HIDROELECTRICA DEL CANTABRICO SA	0,9892	0,9786	0,9680
10	STADTWERKE LEIPZIG GMBH	0,7626	0,5816	0,4435
11	SLOVENSKÉ ELEKTRÁRNE, A.S.	1,4604	2,1327	3,1144
12	STADTWERKE HANNOVER AKTIENGESELLSCHAF	1,1348	1,2877	1,4613
13	MAINOVA AKTIENGESELLSCHAFT	1,0093	1,0187	1,0282
14	REPOWER AG	1,1211	1,2568	1,4089
15	UNION ELECTRICA DE CANARIAS GENERACION S	0,9882	0,9765	0,9650
16	FORTUM POWER AND HEAT OY	1,0272	1,0551	1,0837
17	HIDROCANTABRICO ENERGIA SA	1,0000	1,0000	1,0000
18	COMPAGNIA VALDOSTANA DELLE ACQUE	1,0952	1,1995	1,3137
19	REPOWER ITALIA S.P.A.	1,0000	1,0000	1,0000
20	EON GENERACION SL	0,7679	0,5897	0,4528
21	E.ON KÄRNKRAFT SVERIGE AB	1,0000	1,0000	1,0000
22	AZIENDA ENERGETICA S.P.A. - ETSCHWERKE	1,0000	1,0000	1,0000
23	STADTWERKE KIEL AKTIENGESELLSCHAFT	1,0691	1,1430	1,2220
24	RHÖNENERGIE FULDA GMBH	0,9453	0,8935	0,8446
25	HEP-PROIZVODNJA D.O.O.	0,8499	0,7223	0,6139
26	MVM PAKSI ATOMERŐMŰ ZÁRTKÖ	0,7351	0,5404	0,3973
27	ELECTROCENTRALE BUCURESTI SA	1,2307	1,5145	1,8638
28	OKG AKTIEBOLAG	1,0403	1,0822	1,1257
29	GAS Y ELECTRICIDAD GENERACION SA	1,3865	1,9223	2,6651
30	GROSSKRAFTWERK MANNHEIM AK	1,2194	1,4869	1,8132
31	JÄMTKRAFT AKTIEBOLAG	1,5583	2,4284	3,7842
32	EESTI ENERGIA NARVA ELEKTRIJAAMAD AS	1,0000	1,0000	1,0000
33	GETEC ENERGIE AG	1,0000	1,0000	1,0000
34	SOCIETATEA NATIONALA -NUCLEARELECTRICA-	0,8291	0,6874	0,5700
35	ELIA ASSET	1,1437	1,3080	1,4959
36	TEOLLISUUDEN VOIMA OYJ	0,8952	0,8013	0,7173
37	АЕЦ КОЗЛОДУЙ ЕАД	1,0000	1,0000	1,0000
38	ROSEN - ROSIGNANO ENERGIA SPA	1,0000	1,0000	1,0000
39	MÁTRAI ERŐMŰ ZÁRTKÖRŰEN MŰKÖDŐ RÉSZV	1,1493	1,3210	1,5183
40	KERNKRAFTWERK GÖSGEN-DÄNIKEN AG	1,0000	1,0000	1,0000
41	EWV ENERGIE- UND WASSER-VERSORGUNG GN	0,8587	0,7374	0,6332
42	KERNKRAFTWERK GUNDREMMINGEN GMBH	0,5381	0,2896	0,1558
43	E-CO ENERGI AS	1,0255	1,0517	1,0786
44	ТЕЦ МАРИЦА ИЗТОК 2 ЕАД	1,0525	1,1077	1,1658
45	AGDER ENERGI VANNKRAFT AS	1,0000	1,0000	1,0000
46	ENEL GREEN POWER ESPAÑA S L	1,3636	1,8594	2,5355
47	SWE ENERGIE GMBH	0,7675	0,5890	0,4521
48	LYSE PRODUKSJON AS	0,9353	0,8748	0,8182
49	TERMOELEKTRARNA ŠOŠTANJ D.O.O.	1,1910	1,4186	1,6896
50	BKK PRODUKSJON AS	1,0000	1,0000	1,0000
51	ITAL GREEN ENERGY S.R.L.	1,0000	1,0000	1,0000
52	STADTWERKE TÜBINGEN GMBH	0,9584	0,9186	0,8804
53	КОНТУРГЛОБАЛ МАРИЦА ИЗТОК 3 АД	0,9744	0,9495	0,9252
54	TEJO ENERGIA - PRODUÇÃO E DISTRIBUIÇ	1,0000	1,0000	1,0000
55	JYVÄSKYLÄN ENERGIA OY	1,0916	1,1917	1,3009
56	ZEAG ENERGIE AG	1,5151	2,2956	3,4780
57	INFRASERV GMBH & CO. WIESBADEN KG	0,8152	0,6645	0,5417
58	LAHTI ENERGIA OY	0,8966	0,8039	0,7208
59	STADTWERKE REMSCHEID GESELLSCHAFT MIT I	0,8323	0,6928	0,5766
60	G.O.R.I. S.P.A. - GESTIONE OTTIMALE RISORSE I	1,0000	1,0000	1,0000
61	FMV SA	1,0949	1,1989	1,3127
62	ENERGOTRANS, A.S.	0,9178	0,8423	0,7730
63	UNTERFRÄNKISCHE ÜBERLANDZENTRALE EG	0,9729	0,9466	0,9209
64	KRAFTWERKE OBERHASLI AG	1,2702	1,6134	2,0494
65	ELCOGAS SOCIEDAD ANONIMA	0,9003	0,8105	0,7297

Annex 6. Production Firms Malmquist indexed 2004-2013, decomposed (part 2)

66	FLYENERGIA SOCIETA' PER AZIONI	1,0000	1,0000	1,0000
67	ŠKO-ENERGO, S.R.O.	1,2237	1,4975	1,8324
68	EDISON ENERGIE SPECIALI S.P.A.	1,0000	1,0000	1,0000
69	GEMEINSCHAFTSKRAFTWERK VELTHEIM GESEL	0,9323	0,8691	0,8102
70	SCHLUCHSEEWERK AKTIENGESELLSCHAFT	0,8551	0,7312	0,6253
71	ASTEA S.P.A.	0,8963	0,8034	0,7201
72	HYDRO EXPLOITATION SA	1,0000	1,0000	1,0000
73	GUDBRANDSDAL ENERGI AS	1,1255	1,2668	1,4258
74	OTTANA ENERGIA SOCIETA' PER AZIONI- S.P.A. (	1,0822	1,1711	1,2673
75	ENGADINER KRAFTWERKE AG	1,3521	1,8282	2,4718
76	ITALGEN S.P.A.	1,0693	1,1434	1,2226
77	BIOMASSE ITALIA S.P.A.	0,9575	0,9169	0,8779
78	ČEZ OBNOVITELNÉ ZDROJE, S.R.O.	1,0000	1,0000	1,0000
79	DRAVSKE ELEKTRARNE MARIBOR D.O.O.	1,1221	1,2591	1,4129
80	ELEKTRIZITÄTSWERK ALTDORF AG	0,9220	0,8500	0,7837
81	HÄRJEÅNS KRAFT AKTIEBOLAG	1,1638	1,3545	1,5763
82	TAFJORD KRAFTPRODUKSJON AS	0,8923	0,7962	0,7104
83	ENERGIEVERSORGUNG SYLT GMBH	1,1450	1,3111	1,5013
84	SEA ENERGIA S.P.A.	0,9375	0,8789	0,8240
85	LOMELLINA ENERGIA S.R.L.	0,7728	0,5972	0,4615
86	KEMIJOKI OY	0,8947	0,8005	0,7162
87	PORVOON ENERGIA OY - BORGÅ ENERGI AB	1,0246	1,0498	1,0756
88	ETELÄ-SAVON ENERGIA OY	0,9444	0,8919	0,8423
89	ASM TERNI S.P.A.	0,9172	0,8412	0,7715
90	ONDA COGENERACION SL	0,8908	0,7935	0,7068
91	GREEN GAS DPB, A.S.	0,9466	0,8961	0,8483
92	SOŠKE ELEKTRARNE NOVA GORICA D.O.O.	1,2892	1,6622	2,1429
93	ТОПЛОФИКАЦИЯ ПЛЕВЕН ЕАД	1,0891	1,1861	1,2917
94	ISTAD KRAFT AS	1,0544	1,1119	1,1724
95	ELEKTRIZITÄTSWERK OBWALDEN	0,8537	0,7289	0,6223
96	COGENERACION DEL NOROESTE SL	0,9657	0,9325	0,9005
97	TAMPIERI ENERGIE S.R.L.	0,9098	0,8277	0,7530
98	KANTONALES ELEKTRIZITÄTSWERK NIDWALDEI	1,1237	1,2627	1,4188
99	VULKAN ENERGIEWIRTSCHAFT ODERBRÜCKE G	1,2089	1,4614	1,7667
100	TUSSA ENERGI AS	1,0185	1,0374	1,0566
101	ASPIRAVI	1,3022	1,6958	2,2083
102	SWL ENERGIE AG	0,8101	0,6563	0,5317
103	HAMINAN ENERGIA OY	1,0690	1,1428	1,2217
104	SEL EDISON SPA % SEL EDISON A.G.	1,0000	1,0000	1,0000
105	ТОПЛОФИКАЦИЯ РУСЕ ЕАД	0,8098	0,6557	0,5310
106	VOGHERA ENERGIA S.P.A.	1,3718	1,8818	2,5815
107	TECHNISCHE BETRIEBE GLARUS SÜD	1,1351	1,2885	1,4625
108	SAN MARCO BIOENERGIE S.P.A. IN FORMA ABB	1,0246	1,0497	1,0755
109	VATAJANKOSKEN SÄHKÖ OY	0,8687	0,7546	0,6555
110	BALTEAU IE	1,0391	1,0798	1,1221
111	ТЕЦ СВИЛОЗА АД	1,1926	1,4223	1,6962
112	GKS-GEMEINSCHAFTSKRAFTWERK SCHWEINFU	0,7586	0,5754	0,4365
113	KAINUUN VOIMA OY	0,8238	0,6786	0,5590
114	TARANIS DU ROUVRAY	1,0761	1,1581	1,2463
115	MJÖLBY- SVARTÅDALEN ENERGI AB	1,3364	1,7858	2,3865
116	MASTROPASQUA INTERNATIONAL - S.P.A.	1,0002	1,0004	1,0006
117	PRIMIERO ENERGIA S.P.A.	1,0000	1,0000	1,0000
118	EDA RENOVÁVEIS, S.A.	1,0000	1,0000	1,0000
119	ECOSESTO S.P.A.	1,0738	1,1530	1,2380
120	AKTIEBOLAGET EDSBYNS ELVERK	0,8800	0,7743	0,6814
121	E.T.A. - ENERGIE TECNOLOGIE AMBIENTE SOCIE	1,1792	1,3906	1,6398
122	SOCIETA' ELETTRICA IN MORBEGNO SOCIETA' C(	1,0212	1,0428	1,0649
123	CENTRALA ELECTRICĂ DE TERMOFICARE ARAD S	0,9675	0,9360	0,9055
124	VARESE RISORSE S.P.A.	1,1714	1,3721	1,6073
125	VOSS ENERGI AS	1,0465	1,0951	1,1459
126	GRANADA VAPOR Y ELECTRICIDAD SL	0,7854	0,6169	0,4845
127	AZIENDA SPECIALIZZATA SETTORE MULTISERVIZ	1,0668	1,1381	1,2142
128	LINEA ENERGIA S.P.A.	0,8299	0,6887	0,5716
129	VERSORGUNGSBETRIEBE BORDESHOLM GMBH	1,0000	1,0000	1,0000
130	VEST - ENERGO SA	1,0000	1,0000	1,0000

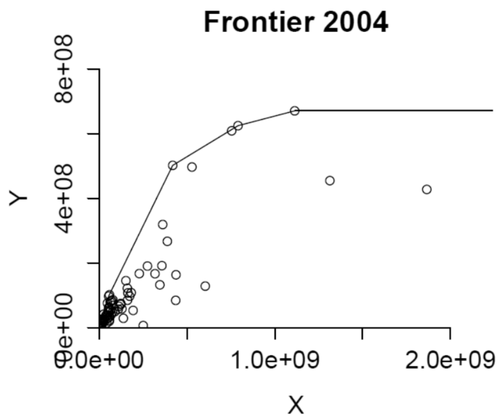
Annex 7. SFA, 2004 and 2009 scores for producing firms (part 1)

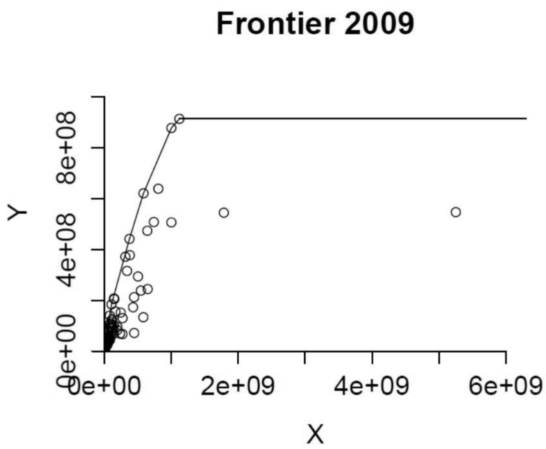
No	Name of the company	sfa2004	sfa2009
1	ELECTRICITE DE FRANCE	0,5219	0,5230
2	IBERDROLA GENERACION SAU	0,5440	0,5084
3	ENEL ENERGIA S.P.A.	0,4799	0,5755
4	ENEL PRODUZIONE S.P.A.	0,5762	0,5506
5	ČEZ, A. S.	0,5733	0,5680
6	A2A S.P.A.	0,4939	0,5395
7	ENDESA GENERACION SA	0,5605	0,5173
8	MVV ENERGIE AG	0,4934	0,5067
9	HIDROELECTRICA DEL CANTABRICO SA	0,5271	0,5079
10	STADTWERKE LEIPZIG GMBH	0,4298	0,5029
11	SLOVENSKÉ ELEKTRÁRNE, A.S.	0,5059	0,4816
12	STADTWERKE HANNOVER AKTIENGESELLSC	0,4843	0,5000
13	MAINOVA AKTIENGESELLSCHAFT	0,4717	0,4659
14	REPOWER AG	0,3709	0,4497
15	UNION ELECTRICA DE CANARIAS GENERACI	0,4522	0,4522
16	FORTUM POWER AND HEAT OY	0,5169	0,4952
17	HIDROCANTABRICO ENERGIA SA	0,3953	0,4461
18	COMPAGNIA VALDOSTANA DELLE ACQUE	0,3888	0,3890
19	REPOWER ITALIA S.P.A.	0,3665	0,3834
20	EON GENERACION SL	0,4107	0,4275
21	E.ON KÄRNKRAFT SVERIGE AB	0,4401	0,3990
22	AZIENDA ENERGETICA S.P.A. - ETSCHWERKE	0,1865	0,1803
23	STADTWERKE KIEL AKTIENGESELLSCHAFT	0,3720	0,2762
24	RHÖNENERGIE FULDA GMBH	0,3247	0,3596
25	HEP-PROIZVODNJA D.O.O.	0,4255	0,4115
26	MVM PAKSI ATOMERŐMŰ ZÁRTKÖ	0,4258	0,3942
27	ELECTROCENTRALE BUCURESTI SA	0,4555	0,4069
28	OKG AKTIEBOLAG	0,4118	0,3625
29	GAS Y ELECTRICIDAD GENERACION SA	0,4207	0,4118
30	GROSSKRAFTWERK MANNHEIM AK	0,3818	0,3612
31	JÄMTKRAFT AKTIEBOLAG	0,3127	0,2979
32	EESTI ENERGIA NARVA ELEKTRIJAAMAD AS	0,4671	0,4751
33	GETEC ENERGIE AG	0,2638	0,3150
34	SOCIETATEA NATIONALA -NUCLEARELECTRI	0,3579	0,3926
35	ELIA ASSET	0,3798	0,3471
36	TEOLLISUUDEN VOIMA OYJ	0,2878	0,2901
37	АЕЦ КОЗЛОДУЙ ЕАД	0,3093	0,3152
38	ROSEN - ROSIGNANO ENERGIA SPA	0,4306	0,4750
39	MÁTRAI ERŐMŰ ZÁRTKÖRŰEN MŰKÖDŐ RÉ	0,3733	0,3544
40	KERNKRAFTWERK GÖSGEN-DÄNIKEN AG	0,3245	0,5096
41	EWV ENERGIE- UND WASSER-VERSORGUNG	0,3412	0,3402
42	KERNKRAFTWERK GUNDREMMINGEN GMB	0,3134	0,3340
43	E-CO ENERGI AS	0,3763	0,3590
44	ТЕЦ МАРИЦА ИЗТОК 2 ЕАД	0,5255	0,4050
45	AGDER ENERGI VANNKRAFT AS	0,3588	0,3717
46	ENEL GREEN POWER ESPAÑA S L	0,2594	0,3192
47	SWE ENERGIE GMBH	0,3151	0,3537
48	LYSE PRODUKSJON AS	0,3542	0,3320
49	TERMOELEKTRARNA ŠOŠTANJ D.O.O.	0,6045	0,4379
50	BKK PRODUKSJON AS	0,3447	0,3466
51	ITAL GREEN ENERGY S.R.L.	0,6184	0,5736
52	STADTWERKE TÜBINGEN GMBH	0,2788	0,2823
53	КОНТУРГЛОБАЛ МАРИЦА ИЗТОК 3 АД	0,6720	0,7261
54	TEJO ENERGIA - PRODUÇÃO E DISTRIBUIÇ	0,5667	0,6029
55	JYVÄSKYLÄN ENERGIA OY	0,6255	0,5947
56	ZEAG ENERGIE AG	0,2729	0,2652
57	INFRASERV GMBH & CO. WIESBADEN KG	0,3071	0,2884
58	LAHTI ENERGIA OY	0,5855	0,5808
59	STADTWERKE REMSCHEID GESELLSCHAFT M	0,3053	0,2811
60	G.O.R.I. S.P.A. - GESTIONE OTTIMALE RISORS	0,6075	0,5849
61	FMV SA	0,6232	0,5907
62	ENERGOTRANS, A.S.	0,3209	0,3023
63	UNTERFRÄNKISCHE ÜBERLANDZENTRALE EG	0,2221	0,2325
64	KRAFTWERKE OBERHASLI AG	0,6040	0,6008
65	ELCOGAS SOCIEDAD ANONIMA	0,3361	0,2843

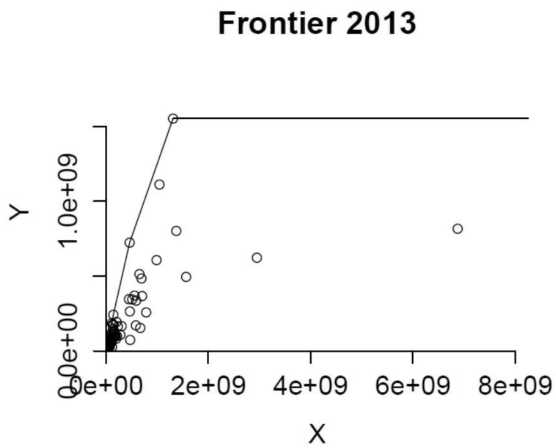
Annex 7. SFA, 2004 and 2009 scores for producing firms (part 2)

66	FLYENERGIA SOCIETA' PER AZIONI	0,5939	0,5720
67	ŠKO-ENERGO, S.R.O.	0,2760	0,2444
68	EDISON ENERGIE SPECIALI S.P.A.	0,5656	0,6639
69	GEMEINSCHAFTSKRAFTWERK VELTHEIM GE	0,3067	0,2717
70	SCHLUCHSEEWERK AKTIENGESELLSCHAFT	0,2522	0,2412
71	ASTEA S.P.A.	0,5985	0,5948
72	HYDRO EXPLOITATION SA	0,5274	0,5174
73	GUDBRANDSDAL ENERGI AS	0,6358	0,6080
74	OTTANA ENERGIA SOCIETA' PER AZIONI- S.P	0,5905	0,5794
75	ENGADINER KRAFTWERKE AG	0,6474	0,6528
76	ITALGEN S.P.A.	0,6357	0,6159
77	BIOMASSE ITALIA S.P.A.	0,6130	0,6212
78	ČEZ OBNOVITELNÉ ZDROJE, S.R.O.	0,0841	0,1423
79	DRAVSKE ELEKTRARNE MARIBOR D.O.O.	0,6541	0,6579
80	ELEKTRIZITÄTSWERK ALTDORF AG	0,6090	0,6158
81	HÄRJEÅNS KRAFT AKTIEBOLAG	0,6630	0,6196
82	TAFJORD KRAFTPRODUKSJON AS	0,6470	0,6586
83	ENERGIEVERSORGUNG SYLT GMBH	0,2079	0,2013
84	SEA ENERGIA S.P.A.	0,6174	0,6141
85	LOMELLINA ENERGIA S.R.L.	0,6410	0,6538
86	KEMIJOKI OY	0,6144	0,6296
87	PORVOON ENERGIA OY - BORGÅ ENERGI AB	0,6297	0,6200
88	ETELÄ-SAVON ENERGIA OY	0,6334	0,6309
89	ASM TERNI S.P.A.	0,5641	0,5943
90	ONDA COGENERACION SL	0,6342	0,6142
91	GREEN GAS DPB, A.S.	0,1970	0,1988
92	SOŠKE ELEKTRARNE NOVA GORICA D.O.O.	0,6386	0,6329
93	ТОПЛОФИКАЦИЯ ПЛЕВЕН ЕАД	0,6394	0,6465
94	ISTAD KRAFT AS	0,6142	0,6077
95	ELEKTRIZITÄTSWERK OBWALDEN	0,6258	0,6183
96	COGENERACION DEL NOROESTE SL	0,6137	0,6042
97	TAMPIERI ENERGIE S.R.L.	0,6238	0,6259
98	KANTONALES ELEKTRIZITÄTSWERK NIDWAL	0,6071	0,5982
99	VULKAN ENERGIEWIRTSCHAFT ODERBRÜCK	0,2438	0,1587
100	TUSSA ENERGI AS	0,6335	0,6281
101	ASPIRAVI	0,5778	0,6060
102	SWL ENERGIE AG	0,6125	0,6014
103	HAMINAN ENERGIA OY	0,6324	0,6189
104	SEL EDISON SPA % SEL EDISON A.G.	0,6272	0,6429
105	ТОПЛОФИКАЦИЯ РУСЕ ЕАД	0,6439	0,6315
106	VOGHERA ENERGIA S.P.A.	0,4318	0,6397
107	TECHNISCHE BETRIEBE GLARUS SÜD	0,5290	0,5177
108	SAN MARCO BIOENERGIE S.P.A. IN FORMA A	0,6219	0,6213
109	VATAJANKOSKEN SÄHKÖ OY	0,6213	0,6152
110	BALTEAU IE	0,6112	0,5933
111	ТЕЦ СВИЛОЗА АД	0,6431	0,6282
112	GKS-GEMEINSCHAFTSKRAFTWERK SCHWEIN	0,1975	0,1684
113	KAINUUN VOIMA OY	0,6373	0,6240
114	TARANIS DU ROUVRAY	0,6765	0,6309
115	MJÖLBY- SVARTÅDALEN ENERGI AB	0,6290	0,6082
116	MASTROPASQUA INTERNATIONAL - S.P.A.	0,6004	0,5933
117	PRIMIERO ENERGIA S.P.A.	0,6163	0,6235
118	EDA RENOVÁVEIS, S.A.	0,5810	0,6044
119	ECOSESTO S.P.A.	0,6226	0,5940
120	AKTIEBOLAGET EDSBYNS ELVERK	0,6113	0,5942
121	E.T.A. - ENERGIE TECNOLOGIE AMBIENTE SO	0,6035	0,5980
122	SOCIETA' ELETTRICA IN MORBEGNO SOCIETA	0,5762	0,6085
123	CENTRALA ELECTRICĂ DE TERMOFICARE AR	0,6185	0,6045
124	VARESE RISORSE S.P.A.	0,5668	0,5833
125	VOSS ENERGI AS	0,6060	0,5531
126	GRANADA VAPOR Y ELECTRICIDAD SL	0,6054	0,5961
127	AZIENDA SPECIALIZZATA SETTORE MULTISE	0,5901	0,5866
128	LINEA ENERGIA S.P.A.	0,6069	0,6021
129	VERSORGUNGSBETRIEBE BORDESHOLM GM	0,1082	0,1098
130	VEST - ENERGO SA	0,5849	0,6048

Annex 8. Different Technologies Plots for producing firms, DEA method.







5. Conclusions

The present dissertation included a mixture of methods available in Economics and the literature of other social sciences. We started out using qualitative tools, but also employed some qualitative ones in order to contribute to affording some empirical proof to the general discussion on factors affecting three main aspects of electricity markets: first, the ongoing reform process in European countries (European Union); second, the effects of prices billed to final consumers, and third, the effect on efficiency improvements or performance in electricity-producing plants.
In the following sections and pages, we will discuss the conclusions that we reached in each chapter, together with including some general discussion in conjunction with the related literature. And finally, we speculate on possible further lines of research and some of the limits that we have faced in working on the present thesis.

5.1 Particular conclusions

In the first chapter, we described the main features of the electricity supply industry. We spoke in depth about the role of electricity as a commodity and the organization of the production, transmission, and retailing of electricity. We touched on how consumption has evolved in the one hundred thirty years of the existence of such an industry, and how the evolution of electricity consumption per capita comprises a suggestive feature of the electricity sector. We strove to stress the sector's complexity, mainly due to the technical difficulties of the whole electricity lifecycle, but also because it is unprofitable and technologically nearly impossible to store electricity in high quantities.
Regarding the relevance of the electricity sector, we stressed the fact that we use increasing amounts of electricity, and the latter is present at practically

every moment of our daily lives. Modern life depends heavily on the reliability of the electricity supply.
When we spoke of energy mixes throughout Europe, we were able to observe the very diverse realities of European countries, some dominated to a great extent by sources such as France and its big share of energy deriving from nuclear power, The Netherlands, dominated by natural gas, or Norway, with crude oil in the driver's seat. On the other hand, we can also find more diverse energy mixes, such as those of the U.K., Spain or, on different scales, Belgium or the Czech Republic.
In the first chapter we also talked about the evolution of consumption of electricity, stressing two basic trends, the increase of the quantity consumed from 1949 to nowadays, mainly due to the, in turn, increasing number of appliances we use; the second trend we stressed is a little more recent, we can see that in the las fifteen years or so the increase in consumption of electricity is less sharp than in the years before, we attribute this fairly new trend to changes in regulations in rich countries, that in turn have been an impact in the technical efficiency of appliances and thus in final consumption of electricity.
We also presented in the first chapter the different models of reforms in the electricity sector that have been used as "template" for recommendations. The two main models of reforms we presented are somehow similar or have common points, both stressing the relevance of reforming the electricity sector in the way that no discriminatory behaviour occurs in third parties accessing the transmission and distribution grids. The model developed by Littlechild is somehow more categorical when he says that any deviation of his model can lead to failure in a correct reform, whereas Jamasb and Pollitt are more flexible in the selection of measures to reform the electricity sector. At this point it is important to mention that not all stages of the lifecycle of electricity are susceptible of haveing a functionally competitive environment; generation and retailing are the stages where this can be achieved.

In the second chapter of this thesis we presented an analysis of the process of approval of the third energy package. We used qualitative tools not often used in economics but well accepted in other social sciences; we strongly believe that the inclusion of this second chapter enriches the analysis and introduces in depth the aspects of the electricity sector analysed in the third and fourth chapters.

We decided to analyse in depth the bargaining and approval of the third energy package since it is one of the more ambitious steps in the construction of the European Energy Market and thus it was expected that its approval will deliver important and expected results. In order to answer the question on which conditions had to concur for the approval of the third energy package we set two different hypotheses to be contrasted: a) first, "the Commission's proposal on a third energy package of policies was finally approved since coordination of different actors was more effective than some national states interests" and; b) second, "relative success of the process might be attributed to the leading role of the European Commission and to its increasing importance in policy making in the European Union".

In the second chapter we clearly identify all players involved in the whole process, in the strategic alternatives of each of them, the outcomes associated with strategy combinations and the preferences of the players over the outcomes. Differently as in the other three chapters we also include in the second one some references to the reform of gas markets, this was so because it was included in the same package of reforms but we focus clearly our attention in electricity markets.

Regarding the particular conclusions of the second chapter, we fund that the outcomes favoured the initial position of the European Commission towards increasing liberalization of the market. A key issue of this package was the unbundling of different activities in the electricity and natural gas sectors and the reached arrangement can be taken as a major success of the European institutions.

Supply and demand interests were differently coordinated and that is a key issue to understand why the final approval of the third energy package can be seen as a success of the demand side forces (with the liberalization process the main gains are for consumers), whereas these improvements may not be clear in what concerns to lower prices of electricity, it is true that service has improved significantly in many European countries; we will talk in the future research section of the thesis about the obstacles to price changes. The design of the liberalization process in different stages constitutes a very relevant feature, since doing the whole pack of reforms in just one time would be impossible to manage.

At the end of the process of approval of the third energy package is possible to see some positive and negative consequences of the liberalization process. Some positive effects or consequences are the increasing security of supply and the possibility of choosing among suppliers (directly related with improvements in consumers' welfare); as an example of how security of supply has improved, we can say that only between 2011 and 2014 the ratio of cross border trade of electricity relative to domestic consumption has increased 3.2%, from 9.9 to 13.1% for the whole EU and 1% for the Iberian peninsula (Portugal and Spain) (European Commission, 2014). On the other hand, since the whole process has not ended yet, it is hard to assess the results of the whole liberalization process, lack of data and partial reforms in some European countries adds up more complexity to the final analysis of the energy sector.

In the third chapter of the present dissertation we focused our attention in the effect that five factors may have in electricity prizes for midsize households and midsize industries. We tested if the ownership of the electricity supply (if the supplier was private or public) might influence the prices paid by final consumers; we also tested if the energy balance in primary energy and electricity was related with the prices; additionally, it was also tested if the degree of concentration of the electricity markets in Europe was also related with the prices paid and; finally, we also tested if the amount of renewable energy had an effect in the final prices paid by consumers. In order to test the relationship between these factors and final prices we conducted an analysis with two different datasets, the first one with data for households and the second one with data for industrial consumers. Besides of the availability of these different data sets, we decided to split our analysis since industrial consumers face a more accelerated liberalization calendar, and we strongly believe that that liberalization process is a more than relevant background issue; effects of the liberalization process are clearer in industrial consumers than in household ones.

Regarding the particular conclusions of the third chapter, in the following paragraphs we will point out what we found.

Ownership of the biggest producer of electric power seems to matter. According with the proves we found and controlling for the concentration of the electricity market, private companies charges on average higher prices, even if the difference is somehow small, it is significant for all the midsize industries estimations. This is a factor closely related with the liberalization process, but we should take this result with care since regardless of the ownership of the company (private or public), companies can behave as non-competitive actors, and thus it should be important for policy makers to accompany reforms in ownership with other reforms, for sure more relevant and complicated than just privatizing public companies.

Market concentration is a very important feature of almost every market, and energy and electricity markets are not the exception. It is also quite relevant how we measure such concentration and that measurement interacts with the rest of our model. Even when the sign of the coefficients were as we expected, these were not significant and we couldn't present conclusive proves on our hypothesis. A more consistent measure of concentration of the market should be used in further research, even when a Herfindahl-Hirschman index for the whole period and the whole set of countries could be hard to construct, it can be a good goal for further improvements.

In what concerns to available primary energy, it is more important than what we thought it would be in the first place. Even when the relation might not seem direct at first glance, the prices of electricity are quite connected with the abundance or scarcity of primary energy. It is not just the relation it has with security of supply, but also with costs of import of certain sources of primary energy (or public support to uncompetitive indigenous sources like Spanish coal), that add up to marginal costs. In summary, countries with negative balance in the imports and exports of primary energy also have a higher probability to end up reporting higher prices of electricity.

On the other hand, a different story must be told about what we expected related with imports and exports of electricity (electricity balances). Signs of the coefficients were as we expected or as our hypotheses predicted, but these were not always statistically significant. Our suspect is that this partial result is due to the fact that regional interconnections of the European electricity grids are still under construction and still should be improved. Still, we can continue sustaining the hypothesis that consumers in those countries with a credit balance in electricity production pay lower prices than consumers in those with debit balance in electricity.

Finally, in what concerns to the share of renewable energies in different countries, there seems to be two different trends. First, there is some negative relationship (from the point of view of consumers), prices are higher where the share of renewable energy is bigger, and this might be related with the effect of public support schemes that overcome other competitive trends. Second, the "merit order effect", that is the preference given to some production methods with lower marginal costs might be compensating the trend.

Prices of electricity are one of the more regulated features of the sector, the taxes and levies, together with regulated trams of prices constitute an important share of the final prices paid by consumers. We worked with the unregulated part of prices, but still the liberalization process has not yet ended and thus we might expect different or more conclusive results in further research on this subject.

In the fourth chapter we described the best methods to acknowledge the improvements of the electricity producing plants (generation of electricity). We find that there are some methods to acknowledge improvements of efficiency that are better than others, and we found that there are some factors (technological change) that are more important than others (e.g. creation of the single market or policy reforms). It is also important to stress that the process is incomplete and thus results like those we present in the following paragraphs can describe more neat trends that we just presented here.

Following the order we used in the chapter, we will first talk about results and conclusions of the first dataset, the one related with countries and later we will talk about the specific results of the dataset related with power-plants.

First, we expected a more diverse panorama in what concern to efficiency scores and such thing was somehow confirmed by our pre-exploratory exercises. Nevertheless, when we applied more sophisticated techniques to account for efficiency we found a less diverse landscape and that countries perform much better than what we expected. Around half of the countries in the set perform fairly well and are in the frontier at least at once in the three analysed periods. One factor that might be correlated with higher efficiency scores are the diversity of sources exploited in the countries, in other words, the more diverse the energy mix, the higher the efficiency score of the country.

We also found some important changes in the frontier of production; between 1995 and 2000 the productivity increased a 2% in yearly average, but the technical change was a little less important than the efficiency or catch-up effect. This changes slightly on the other years coupled, where technical change is somehow more important than the catch-up effect. This is important to stress since it constitutes a proof in favour of our hypothesis stated in this chapter, that technical change is the most important driver of efficiency improvements.

In what concerns to efficiency performance of the electricity producing plants, we found that the scores were more diverse than in the case of the countries' database; only about 11% of the set of producing firms reached and maintain the position in the frontier for the whole period of study. One of the factors that is more clearly correlated with worse efficiency scores is the size of the firm, in other words, the bigger the firm the harder it is for the firm to achieve full efficiency.

Firm size, the available assets or cost factors are some of the relevant factors that help power plants to perform better in the efficiency test, while the country where it is placed the plant does not have any relevance at all with the scores in the test.

In what concerns to the frontier moves and the catch-up effects in power plants, it seems that there is a correlation between the source used to produce electricity and the final efficiency score; firms using traditional sources of energy, like coal or other fossil fuel lose ground through time more easily than others.

Also, a result that we don't want to lose the opportunity to stress is that the frontier moves or technological effect increases about 12% within 2004 and 2009, that is, 2.4% each year; and again 12% between 2009 and 2013. Technical change is the more important driver of efficiency improvement at the firm level, and even more important than at country level.

One of our goals in the fourth chapter was to compare different methods of acknowledging efficiency, and we were able to try a couple of the best ones, but it is clear that the DEA accounts for more advantages than the SFA method. First of all, you can only estimate the stochastic frontier using just one output, while DEA permits the multi-output approach. Even when results are equivalent (when calculating DEA with just one output), SFA results are smaller, as we expected in the first place since SFA also accounts for statistical error and does not attributes all deviation from the frontier to inefficiency.

Acknowledge of efficiency is important not just for power plants but also for firms that own the power plants, for regulators or policy makers. Knowledge about the performance is crucial to take strategic decisions at the firm level, but also to take action in setting or reforming policies at the sector or industry or country level. This importance of measuring performance and benchmarking makes also crucial the decision about how we measure and to understand what are we measuring. In the fourth chapter we made our case for the best available methods available to measure efficiency we provided results of a sample of power plants and identified technological development as the main driver of efficiency improvement.

5.2 Future research and limitations

In this final section we focus our considerations on the subjects we are attracted to and some of the limitations and possible solutions for the obstacles we have faced during the development of the present dissertation.

The electricity sector (and the wider energy sector) is currently under reform, the liberalization process has not yet arrived to the end and of course there are still many changes to do. The sector is complex and vast, acknowledging the results of all the reforms is a promising line for further research in the sector.

There are more drivers on prices that can be tasted in different ways. Nevertheless, one constant struggle that we should face when approaching electricity studies is the quantity and sometimes accessibility of statistical data; when talking about price components it is particularly hard to get beyond the three basic components e.g. cost of energy, network costs and taxes & levies. Once we are working with net prices of energy there are some drivers or factors that can be tasted in different contexts, like R&D effect on prices in the context of liberalized markets as suggested by Markard and Truffer (2006) or the effect of resource scarcity or pricier resources in electricity prices; while on the other hand we can also point out the possibility to approach electricity prices study from the modelling and econometric point of view but with very different kind of data, like spot prices and intraday projections.

We have found that there is a change in efficiency of electricity producing firms, but we haven't found yet prove that this change in efficiency translates directly to lower prices of electricity, as Schumpeterian analysis may suggest. The question that arises with an examination of the evolution of electricity prices is: what is stopping the fall of electricity prices while efficiency of the electricity producing firms is clearly improving? Shouldn't we see a fall in prices in equal or similar proportion? This might constitute a good research question for future works.

While setting the ground for the third chapter we found that there is a fascinating discussion about the best methods and tools to acknowledge efficiency improvements. There are different trade-offs that can lead a particular research to one or the other side. We choose the linear programming tools, but it is also true that using stochastic methods can be also advisable in some cases, but adding complexity to the tools we use (e.g. adding specific production function, include an error term, etc.) does not always pays the price and you may end up with the same information you got with simpler tools. A possible further line of research can be to contribute to such discussion about methods and tools to acknowledge efficiency improvements.

We came to the energy field studies attracted by the concepts of energy transition, that is, the change in extensive use of fossil fuels to renewable energy, this dissertation is only an approximation to "energy and economics" studies and we hope to head towards the energy transition studies again as there is a lot to study as renewable energies gain relevance as part of the wider energy sector. Particularly we think that there is a lot to do about the main factors that may accelerate or hinder such process e.g. economic development, urban realities, or fossil fuels availability and prices.

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