Chapter 7
Competition and power exchanges

It has been shown that the individual behavior of players on power exchanges is not directly observable in the previous chapter, however it is possible to look at the result of this behavior for competition. In this chapter we start with the traditional approach for analyzing competition, i.e. analysis of market structure. Two types of market structure are analyzed: market structure in generation and level of interconnection, and market structure on power exchanges. This analysis highlights the low level of interconnection between countries with respect to national demand and important differences between the “physical” market structure, generators, and the “commercial” market structure, participants on the exchanges. Finally competition on power exchanges is estimated via an analysis of prices and volumes developments on different exchanges.

7-1 Defining competition

7-1-1 Origins and general definition of competition

The Oxford English Dictionary defines competition as *"the action of endeavoring to gain what another endeavors to gain at the same time"*. While Adam Smith is often presented as the founder of the concept of competition (Clark, 1961), the exact origin of this concept can be traced back to earlier work. A decade before the publication of the *Wealth of Nations* authors like Hume and Turgot were already using the concept of competition. According to McNulty (1967) the work of Sir James Steuart should be considered to be the first complete work on competition while the analysis of Adam Smith "only" represents a fundamental step:

"Probably the most complete pre-Smith analysis of competition was that of Sir James Steuart, who stressed that competition might exist among either buyers or sellers (Steuart, 1767).[…]. Rather than considering Adam Smith as the progenitor of a concept whose refinement came at the hands of a group of successors, it is more accurate, as far as the history of competition is concerned, to think of Smith's work as marking the end of one era and the beginning of an other." (McNulty, 1967)

According to Smith competition is the vital mechanism, the invisible hand, which control the pursuit of each individuals self-interest (Smith, 1776). Hence competition is a process of responding to a new force and a method of reaching a new equilibrium (Stigler, 1957).

"The strict meaning of competition seems to be the racing of one person against another, with special reference to bidding for the sale or purchase of anything. […]In modern economic theory, a market is said to be competitive, when the number of firms selling a homogeneous commodity is so large, and each firm's market share is so small, that no individual firm finds itself able to influence

appreciably the commodity price by varying the quantity of output it sells“ (Marshall, 1890).

In this chapter we first present issues relating to the analysis of competition in electricity markets with respect to previous work and the peculiarities of these markets. We use a traditional approach to analyze competition; i.e. we analyze market structures. Two types of market structure are analyzed: market structure in generation and level of interconnection, market structure on power exchanges. Such an analysis shows the low level of interconnection between countries with respect to national demand and important differences between the “physical” market structure, generators, and the “commercial” market structure, participants on the exchanges. Finally competition on power exchanges is estimated with an empirical analysis of prices and volumes developments on different power exchanges.

7-1-2 Analyzing competition in European electricity markets

The analysis of competition in electricity markets in general, i.e. not only power exchanges, is confronted with many difficulties. While all electrons are the same, electricity must be distinguished by time and place. A MWh on a summer weekend night cannot be substituted with a MWh at noon on a winter weekday. Moreover due to possible transmission constraints, it is not always possible to substitute electricity at one location with electricity at another location. The key characteristic of electricity is that electricity cannot be stored and supply and demand must be balanced in real time (Stoft, 2002). Another aspect is related to the market structure of the electricity industry which has been historically organized through vertically integrated monopolies. From a technical point of view, electricity generation is a complicated production process, non-convex costs, operating constraints etc, that creates inter-temporal links in production costs (Bushnell and Savaria, 2002). Finally due to market/marketplace design and regulatory frameworks a method used to analyze competition in one country might be totally non-relevant for another country.

Analyses made in the US have shown that the electricity industry also presents some advantages for the analyst, compared to other industries, which can be used for competition analysis[1]. For instance, production capacities are well defined and to a large extent these data are publicly available. Hence, good estimates of data necessary to estimate short run marginal costs for each production unit are available. These are primarily data concerning the efficiency levels of generation units, and start up costs. Furthermore, total demand on the grid can be measured with great accuracy. Such accessibility of data allows the construction of competitive price benchmarks (Borenstein *et al*, 1999). These benchmark prices can be defined as the price that would result if all firms acted as price-taking firms, i.e. no exercise of market power (Newbery, 1995). Comparing realized prices with a competitive benchmark is a widely accepted and interesting method for estimating the level of competition (Joskow and Kahn, 2001), the open question is: Do economists have the ability to calculate accurately this competitive benchmark? For instance, the complexities of the production process and the role of market design create significant uncertainties about the accuracy of benchmark measures (Harvey and Hogan, 2002).

In continental Europe analysis of competition in the electricity industry has been little used. The first obvious reason is the very recent opening to competition of the industry compared to the US. It is quite premature, if not impossible, to assess the level of competition over a very short period. Second, due to the different levels (and delays) in implementation of the EU Directive between countries, most studies that have been done have been mainly national. For these reasons, most of the analysis done so far has focused on the creation of a single electricity market and on the creation of market mechanisms. Hence there is very little literature on analysis of competition in Europe, and none about competition on power exchanges, because obviously, analyzing competition make little sense in the absence of a market. Instead, most studies have focused

[1] See chapter 4, section 4-4-3

on the implementation of the EU Directive 96/92 into national law rather than on the level of competition[2].

7-1-3 Estimating competition in electricity power exchanges: market structure and prices analysis

Traditional analyses of competition are based mainly on the structure-conduct-performance paradigm (Bain, 1951; 1956). According to this approach, it is the structure of the market that determines its performance, via the conduct of its participants. In line with this paradigm the degree of concentration in a market has long been considered to be one of its major structural characteristics and analysis of market structure then becomes a key indicator of the level of competition. While it is now recognized at both a theoretical and an empirical level that the SCP approach is overly simplistic (Farrell and Shapiro, 1990), in practice, national competition authorities, the US Federal Energy Regulatory Commission, and the European Commission's DGIV put a lot of emphasis on the analysis of market structure and concentration ratios (Hoehn *et al*, 1999)[3].

For the purpose of this work we will use concentration measures as a starting point for the analysis. In this chapter we will consider market structure from a national level point of view, because European power exchanges are marketplaces which provides national prices index, however, so that we can take into account potential competition from neighboring countries we will also consider interconnector capacities. The first traditional approach for analyzing competition consists of calculating the level of concentration based on installed capacity of generators per country. Since delivery areas of power exchanges are defined nationally, such measure gives an interesting proxy of the conditions underlying the functioning of each exchange (section 7-2). Although taking into account the most important part of the market structure, this measure overlooks

[2] See chapter 10

[3] This might be partly due to, one ,from a practical point of view, the fact that these measures are relatively easy to collect and two, from a theoretical point of view, the fact that research in economic theory has until now failed to provide any other robust alternative approach

a part of the market structure with respect to power exchanges because it does not account for interconnections; for this reason, other indicators will be discussed. The nature and number of competitors on power exchanges and other relevant indicators will also be analyzed (section 7-3). We end this chapter with a first attempt to estimate the level of competition on power exchanges based on direct price analysis (section 7-4). Analysis of power exchange's prices together with the respective quantities sold, and market structure can provide a significant amount of information on the level of competition.

7-2 Competitors in generation and interconnections

7-2-1 Introduction

As a starting point for the analysis, in this section we focus on the two fundamental underlying elements of any electricity market which influence the development of competition in general, and the functioning of electricity power exchanges in particular, i.e. the level of concentration in generation and the level of interconnection capacity. In terms of generation structure, European countries can be divided into three distinct categories of markets: a single dominant player, a few dominant players, and no dominant player. For the purpose of this work we focus on countries where power exchanges have started to operate and were fully operational for the year 2002. Powernext, the French power exchange falls in the first category. The Dutch and German power exchanges fall in the second category. Finally the Nordic countries' exchange and the British exchange fall in the last category. As a starting point, table 7-1 gives a general overview of the market structure of major European electricity markets regardless to interconnection using the Hirschman-Herfindahl index (HHI)[4]. We will go into the details of the five markets analyzed in the following sections where in addition to market structure in generation we will also consider the role of interconnectors[5].

[4] The HHI is an index of market concentration. It sums the square of the market shares of individual participants and gives then, a first approximation for the distribution of the shares throughout the market. The HHI index ranges between 1 for an atomistic market and 10.000 for a pure monopoly.

[5] It is worth noting that in this chapter we do not take into account joint ownership which is a factor that can influence market power. Moreover, the elasticity of the residual demand curve, i.e. the elasticity of the market demand curve minus the supply of all the other firms, is ignored. However using it represents

Table 7-1: Generation market structure in Europe

Country	Players	% installed capacity	HHI
Germany			
	RWE	28	
	E.on	22	
	Vattenfall	15	
	EnBW	4	**1509**
	others	31	
Austria			
	Vorbund	48	
	EVN	8	
	Wlemstrom	7	**2417**
	others	37	
Belgium			
	Electrabel	86	**7396**
	others	14	
Spain			
	Endesa	44	
	Iberdrola	31	
	Union Fenosa	12	
	Electra de Viesgo	5	
	Hidrocantabrico	4	**3082**
	others	4	
France			
	EDF	88	
	CNR	3	
	SNET	2	**7757**
	others	7	
Italy			
	Enel	65	
	Edison	8	
	Eni	1	**4290**
	others	26	
Nordic Countries			
	Vattenfall (Sweden)	16	
	Fortum (Finland)	12	
	Stakraft (Norway)	10	
	Sydkraft (Sweden)	7	
	Birka energi (Sweden)	5	
	Energi E2 (Denmark)	4	
	UPM-Kymmene (Finland)	5	**600**
	others	38	
Netherlands			
	EPZ	20	
	Electrabel	23	
	Reliant	17	
	E.on	9	**1299**
	others	31	
UK			
	British Energy	15	
	Innogy	10	
	*Powergen**	14	
	Scottisch Power	6	
	London electricity	6	
	Scottish & Southern	4	**609**
	others	45	

**include former asset TXU (2908)*

Source: Companies annual reports (2001)

another method to estimate potential market power. In particular, un-concentrated market by the HHI measure can offer considerable opportunities for market power if the elasticity of the residual demand

7-2-2 A market with a single dominant player: Powernext

The hub of delivery of the French power exchange is characterized by the domination of Electricité De France (EDF) and a low level of competition from abroad. EDF owns about 90% of installed generation capacity, and in 2000 EDF covered about 97% of French consumption. An important feature of EDF generation capacity is the large share held by nuclear technology which represent about 55% of French installed capacity[6]. On the French territory, the two main rivals of EDF are Compagnie National du Rhone (CNR) and Société Nationale d'Electricité Thermique (SNET) which own respectively 4% and 2% of installed capacity. The level of competition between these three players is quite difficult to assess. On one hand in 2000, EDF held 19% SNET and 16,7% of CNR which reinforce the position of EDF in France. On the other, due to the strategic position of these two companies, foreign companies have expressed an interest for CNR and SNET. Endesa acquired a 30% stake in SNET in 2000 while in 2001, CNR set up a joint venture with Electrabel for power sales. However, due to the overwhelming position of EDF in terms of generation, the roles of CNR and SNET on the wholesale market are rather limited.

In addition to CNR and SNET, an important source of wholesale power that is available in France is related to the "virtual capacity" auctioned by EDF. The European Commission has approved the acquisition by EDF of a stake in EnBW on the condition that EDF make 6.000 MW of its generation capacity available to competitors for a five year period[7]. While the power plants are still owned and run by EDF, this allows some new entrants to secure generation capacity within France. Such an initiative, while improving the competitive structure of the French market a little has been criticized for not being the same as asset divestiture (Finon, 2002).

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curve is low. See chapter 10 for more on that.

[6] RTE (2002)

[7] European Commission Decision of 7 February 2001, Case COMP/M.1853 - EDF/EnBW) Official Journal L 059 , 28/02/2002 P. 0001 – 0017

Finally due to the market structure of the French market one may expect a main source of competition to come from neighboring countries (CRE, 2000; 2001). This was recognized by the French Regulator in its annual report "*in the next few years competition with EDF will result more from the action of foreign operators than from the presence of important producers installed in the national territory*"[8]. The French network is interconnected with the UK (2000 MW), Italy-Switzerland (5400 MW), Germany-Belgium (2100 MW) and Spain (1100 MW)[9]. The aggregated available interconnector capacity can only cover less than 10% of national consumption[10], however due the low production costs of nuclear power plants, France, through EDF, is the largest European exporter with a total volume of 72.6 TWh in 2001. In contrast imports were quite modest in comparison to a volume of 4.2 TWh, showing that competition from abroad is relatively limited.

Table 7-2: Installed generation and interconnection in France (2002)

Player/interconnection	Installed capacity/ available interconnection	%
EDF	102810	80,87%
CNR	2937	2,31%
SNET	2600	2,05%
Total main generators	***108347***	***85,23%***
Others generators	7780	6,12%
From Spain	1000	0,79%
From Italy	1800	1,42%
From Switzerland	4100	3,23%
From Germany / Belgium	2100	1,65%
From UK	2000	1,57%
Total interconnection	***11000***	***8,65%***
Total	127127	100%

In conclusion, from a production point of view the dominance of EDF and the low volumes of import, despite the level of interconnection (8.65%), represent two strong limitations for the development of trading on the French power exchange.

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8 Commission de Régulation de l'Electricité, *Annual report 2000*

9 UCTE, *European Interconnection: State of the Art 2002*, the figures mentioned are available capacity opposed to technical installed capacity (see chapter 9 for more on this)

10 ETSO. *Indicative values for net transfer capacities (NTC) in Europe*, available at http://www.etso-net.org/media/download/

A summary of the underlying conditions of functioning of the French power exchange is given in table 7-2 above.

7-2-3 Markets with a few dominant players: APX and LPX-EEX

The Dutch and German markets are characterized by the existence of a few dominant players and important cross-border flows. In this section we identify the main electricity producers for these two markets and the level of interconnector capacity. Obviously such market structures are intrinsically more favorable for the development of competition than the French structure, and in turn, for the development of electricity trading and liquidity on the APX and LPX-EEX power exchanges.

Table 7-3: Installed generation and interconnection in the Netherlands (2002)

Player/interconnection	Installed capacity/ available interconnection	%
EPZ	4086	17,34%
Electrabel	4647	19,72%
Reliant	3476	14,75%
E.on	1770	7,51%
Total main generators	***13979***	***59,31%***
Others	5991	25,42%
From Belgium	1312	5,57%
From Germany	2288	9,71%
Total interconnection	***3600***	***15,27%***
Total	23570	100%

In the Netherlands, four players own 61% of the installed capacity (Electrabel, 23%; EPZ, 20%; Reliant, 17%; E.on11%)[11] while decentralized production, led by cogeneration plants, represents the rest of installed capacity. In Germany, four players represent a significant part of the market with 68% of installed capacity (RWE, 28%; E.on, 22%; Enbw/EDF, 4%; Vattenfall, 15%)[12].

[11] *Dutch wholesale power market review*, Elan Energy Consulting, May 2002
[12] *European power trading 2002*, Prospex research Ltd., June 2002

In both countries cross-border trade is significant. In the Netherlands interconnector capacity represents a share of 18% of the total national installed capacity[13]. Such a level of interconnection makes the Netherlands one of the most well connected countries in continental Europe alongside Austria (22%) and Belgium (18%)[14]. Germany is the largest trading partner. In 2001, 16.8TWh were imported from Germany for 0.4 TWh exported[15]. Transactions with Belgium are usually more balanced with 4.5 TWh of imports for 3.6 TWh of exports.

Table 7-4: Installed generation and interconnection in Germany (2002)

Player/interconnection	Installed capacity/ available interconnection	%
RWE	32187	25,17%
E.on	24881	19,46%
*Vattenfall**	14209	11,11%
EnBW	10768	8,42%
Total main generators	***82045***	***64,16%***
Others	37380	29,23%
From Denmark	1200	0,94%
From Sweden	460	0,36%
From France	2350	1,84%
From Austria	1850	1,45%
From Switzerland	1450	1,13%
From Netherlands	1150	0,90%
Total interconnection	***8460***	***6,62%***
Total	127885	100%

**=VEAG (7479)+HEW (3727)+BEWAG (3003)*

Due to its central position, the German market is interconnected with nine countries. However the total share of available interconnector capacity related to the national installed capacity is approximately 10%[16] which limits the level of potential competition from abroad. Some major patterns for the use of the interconnectors can be identified. One, due to large the hydro system in Austria and Switzerland, cross-border trade with Germany is related to seasonal hydro

[13] *Electricity liberalization indicators in Europe*, A report to the European commission DG Tren, October 2001,p 144
[14] Ibid.
[15] TenneT, *Annual Report 2001*
[16] Including Poland, and Czech Republic

conditions. Two, large imports are related to large excess in France's nuclear power. Three, in contrast Germany exports large volumes to the Netherlands (see above), where, due to the production park structures, mainly conventional thermal units, prices are traditionally higher. The underlying conditions of the functioning of the Dutch and German power exchanges are summarized in tables 7-3 and 7-4 above.

7-2-4 Market with no dominant player: UKPX and Nord pool

The United Kingdom and the Nordic region, Norway, Sweden, Finland and Denmark, share two characteristics: the level of consumption, respectively 344 TWh and 359 TWh for 2001, and a low level of concentration in generation compared to other countries. In the UK, the three biggest utilities own only 39% of the installed generation capacity (British Energy, 15%; Powergen, 14%; Innogy, 10%). In the Nordic Region the three largest power producers own 38% of the total installed capacity (Vattenfall, 16%; Fortum, 12%; Statkraft, 10%)[17].

Cross-border trading is strongly limited for the UK. The level of interconnection of the UK market with foreign countries is the lowest in Europe with a share of 3% related to national installed capacity. The main connection is a subsea link with France (2000 MW). The UK is also connected with the Republic of Ireland by a 600 MW interconnector. Like Germany the UK imports traditionally cheap electricity from France. However following the introduction of NETA and an important drop in price in 2001, UK imports dropped during period of high prices in Continental Europe.

[17] *European power trading 2002*, Prospex research Ltd, June 2002

Table 7-5: Installed generation and interconnection in the UK (2002)

Player/interconnection	Installed capacity/ available interconnection	%
British Energy	11533	14,21%
Innogy	7731	9,53%
Powergen	10744	13,24%
Scottisch Power	4790	5,90%
London electricity	4803	5,92%
Scottish & Southern	3832	4,72%
Total main generators	***43433***	***53,53%***
Others	35536	43,80%
From France	2000	2,46%
From Ireland	170	0,21%
Total interconnection	***2170***	***2,67%***
Total	81139	100%

**include former asset TXU (2908)*

In contrast, within the Nord pool area, the level of interconnection represents at least 20% of each national installed capacity which allows substantial competition between the four countries[18] but is rather limited with others countries (table 7-5). In 2001 the level of cross-border trade in the Nordic countries reached 14% of regional consumption[19]. Norway and Sweden, with large hydro capacity, are substantial exporters when hydro conditions are good. Finland is a regular importer from others Nordic countries and Russia. Denmark, which mainly uses thermal technology, exports when hydro conditions are poor in neighboring countries and imports when hydro conditions are good. Moreover, in addition Nordic countries are also connected to countries outside the Nordic area. Finland is connected to Russia (1160MW), Denmark is connected to Germany (1950 MW), Norway to Russia (50 MW), Sweden to Germany (600 MW) and Poland (600 MW)[20]. Such a high level of interconnection between the countries of the Nordic Area and between the Nordic Countries and neighboring countries represents a favorable factor for the development of competition since it increases the number of competitors.

[18] Nordel, *Annual Report 2001*
[19] Ibid.
[20] Ibid.

Table 7-6: Installed generation and interconnection in the Nordic area (2002)

Player/interconnection	Installed capacity/ available interconnection	%
Vattenfall (Sweden)	13680	16,12%
Fortum (Finland)	10163	11,98%
Stakraft (Norway)	8815	10,39%
Sydkraft (Sweden)	5900	6,95%
Birka energi (Sweden)	4250	5,01%
Energi E2 (Denmark)	3740	4,41%
UPM-Kymmene (Finland)	4231	4,99%
Total main generators	***50779***	***59,84%***
Others	32769	38,62%
From Germany (Denmark)	940	1,11%
From Germany (Sweden)	370	0,44%
Total interconnection	***1310***	***1,54%***
Total	84858	100%

In both countries, the low level of concentration represents an attractive starting situation for the development of a power exchange and trading in general. However the Nordic area possesses an additional advantage compare to the UK, this is related to the high level of interconnection. In the UK, interconnections with foreign countries are almost insignificant. The underlying conditions of functioning of the Nordic and British power exchanges are summarized in tables 7-5 and 7-6.

7-2-5 Conclusion

Market concentration in generation represents a first useful indicator that cannot be ignored for analyzing competition[21]. Even if this indicator is particularly simplistic it can be used as a starting point for the analysis. For this purpose, comparison and combination of this measure with others indicators is a practical approach. In this section we have combined the traditional national market concentration approach with an analysis of the level of interconnector capacity. This approach allows us to take into account potential competition from abroad which, in some cases might play an important role, figures 7-1 and 7-2 show the

[21] See chapter 10 for discussion of the shortcomings of market concentration analysis

market share of the two largest generators for each power exchange with respect to interconnector capacity.

Figure 7-1: Market share of the two largest generators and interconnection (%)

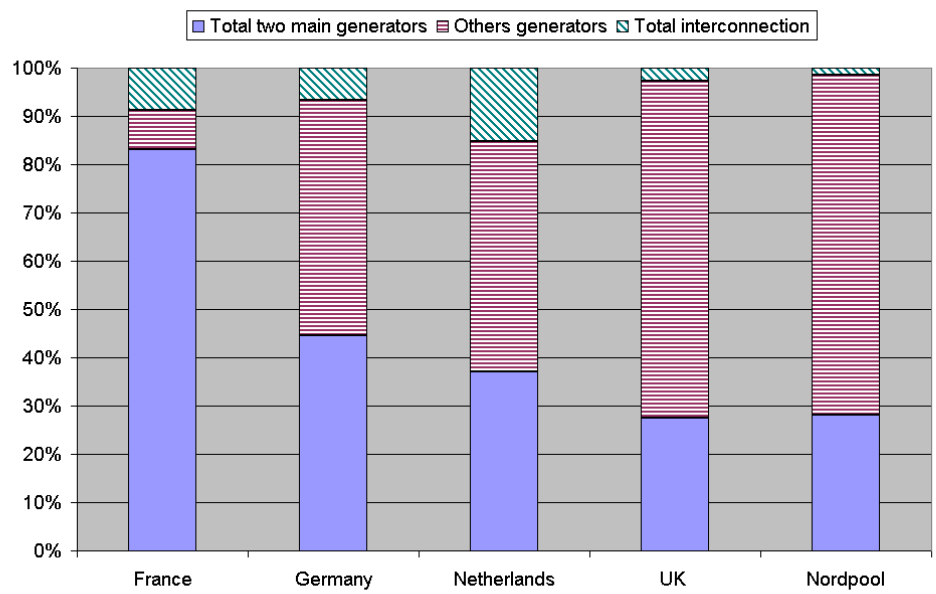
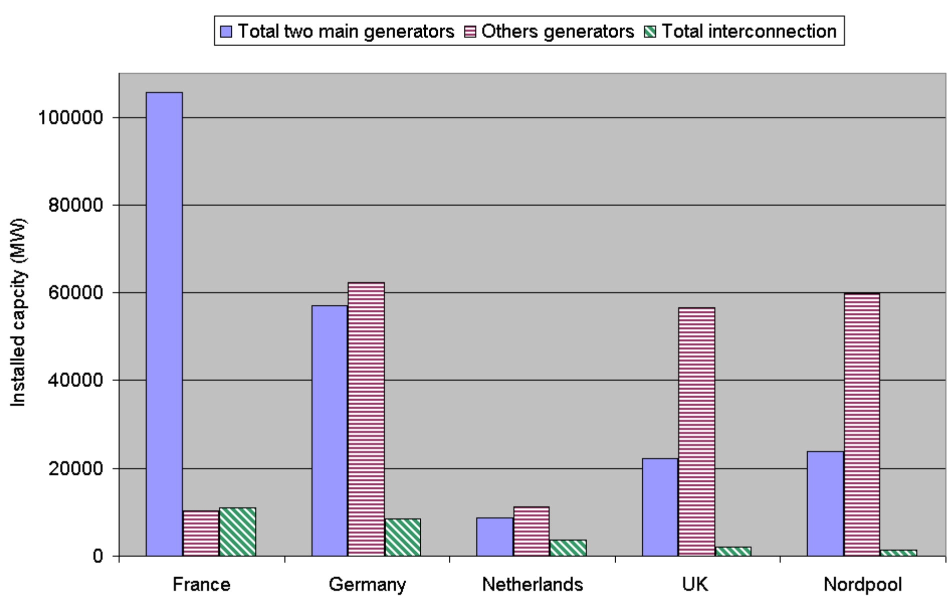


Figure 7-2: Market share of the two largest generators and interconnection (MW)



The concentration of supply and/or the low level of interconnection capacity is a common characteristic of many European national electricity markets. In such a context, competition may fail to develop and market prices may stay above competitive level (Olsen and Skytte, 2000). In December 2001, the European Commission recognized the importance of this issue in its report *"First report on the implementation of the internal electricity and gas market"* (EC, 2001a), however no solutions were put forward.

7-3 Competitors on power exchanges

7-3-1 Introduction

The previous section has showed that the number of electricity producers in many countries is relatively low. However, competition on power exchange is not limited to energy producers. Other players such as energy traders, large industrial consumers and distribution companies play an important role on power exchanges[22]. A good analysis of the role of players on power exchanges would consist of looking at the trading pattern of each participant, however, since information on trade per participants is confidential, and therefore not available, in this section we consider the number and nature of participants on different exchanges.

7-3-2 Number and nature of competitors

The total number of players on each power exchange with respect to their original country are identified in table 7-7, while table 7-6 shows the repartition of player with respect to their nature, i.e. producer, distributor, trader etc. Before going into the details of the analysis it is worth noting that, from a practical point of view, such analysis is confronted with three main difficulties. Power exchanges provide a list of their participants on their websites, but they do not differentiate between *registered members* and *active members*. Indeed, some players are members of power exchanges but participate in little, or not, to trading. Powernext is an exception, in its activity assessment 2001-2002[23], the French power exchange differentiated between the two categories: the exchange has approved 32 members but only 25 are active members. This gap is due to companies that have joined the exchange but have not started to trade. Such

[22] See chapter 6

information is not available for the other exchanges. Table 7-7 only considers registered members.

The second difficulty is related to the *identifying the company behind the participant name*. Indeed, on most exchanges a number of different daughters companies are represented from the same Mother Company. For instance, Fortum Direct Ltd. and Fortum Energy Plus, Scottish power (UK) plc and Scottish power trading energy trading Ltd. are all members of UKPX. Enel Produzione SpA and Enel Trade S.p.A , BP Energie (Deutschland) GmbH and BP Gas Marketing Limited are all registered on LPX-EEX. Finally Electrabel NV and Electrabel Nederland NV are registered as two different members on APX. Such multiplication of subsidiary companies is a real challenge for those trying to identify players. The question is whether two subsidiaries which belong to the same Mother Company can actually be considered to be competitors.

Finally, *defining the activity* of each player, as presented in table 7-6, is sometime ambiguous. Indeed, electricity players are rarely limited to only one activity. For instance all major producers in Europe have developed a “sales departments”, in charge of selling the production of their assets, and a trading department which carries out all kinds of arbitrage, like a pure trader[24]. In order to take into account this aspect, the nature of a player is defined with respect to its main activity in the country considered. Hence, E.on is considered to be a producer on LPX but a trader on Powernext since E.on has production capacity in Germany but not in France. For the same reason, Electrabel is considered to be a producer on APX but a trader on UKPX.

The number of players on the exchanges considered range from 35 for Powernext to 111 for LPX[25] at the end of the year 2002. The average number of participant is thus 61 which represents a large difference with the number of producer in each countries. With the exception of France, a minimum of 50% of

[23] Powernext, *Activity Assessment 2001-2002*

[24] i.e. without physical assets

the players are national players; on the APX 50% of the participants are "national" players, 54% on LPX, 63% on UKPX and 90% on Nord pool. Since power exchanges are markets for physical delivery such a feature is not surprising. The limited presence of French participants on Powernext has two reasons. One, EDF is not only the main producer it is also the main distribution company with a market share in distribution comparable to its market share in production. Two, for French players, the law governing energy trading is ambiguous and it restricts "pure trading" to 20% of production[26]. The remaining players on the different power exchanges are international traders coming from others neighboring countries.

The nature of players on power exchanges also presents interesting information with respect to the nature of competition. As can be seen in table 7-6, in the majority of cases traders represent the largest share of participants. These traders can be separated into two categories. The first one consists of pure traders without any physical assets based on the model of (now defunct) Enron. The second category is composed of the trading department of the large producers such as E.on, RWE, EDF, Endesa or Enel which do not have assets in the hub of delivery of the exchanges under consideration.

[25] For Nordpool (91), only players active on the spot market (Elspot) are considered

[26] Décret 2000-1069 du 30 octobre 2000 relatif à l'activité d'achat pour revente aux clients éligibles.

Table 7-7: Total number of players on European power exchanges and nationality (2002)

	APX		EEX-LPX		Powernext		UKPX		Nord pool	
	Number	%	Number	%	Number	%	Number	%	Number	%
Denmark			4	*4%*					7	***8%***
Finland	1	*3%*					2	*4%*	17	***19%***
Germany	3	*9%*	60	***54%***	7	*28%*	1	*2%*	2	*2%*
UK	3	*9%*	13	*12%*	5	*20%*	29	***63%***	4	*4%*
Norway	2	*6%*	1	*1%*	1	*4%*	1	*2%*	37	***41%***
Sweden	1	*3%*					1	*2%*	21	***23%***
Switzerland		*0%*	12	*11%*	4	*16%*			1	*1%*
Netherlands	16	***50%***	5	*5%*					2	*2%*
Belgium	1	*3%*	1	*1%*	1	*4%*				
United States	2	*6%*					2	*4%*		
France	2	*6%*	1	*1%*	1	***4%***	3	*7%*		
Spain	1	*3%*	3	*3%*	2	*8%*				
Austria			7	*6%*	1	*4%*				
Italy			3	*3%*	3	*12%*	1	*2%*		
Scotland							6	*13%*		
Luxembourg			1	*1%*						
Total	32	*100%*	111	*100%*	25	*100%*	46	*100%*	91	*100%*

Source: UKPX-Powernext-LPX-APX-Nord pool, 2002 (hereafter Power exchanges, 2002)

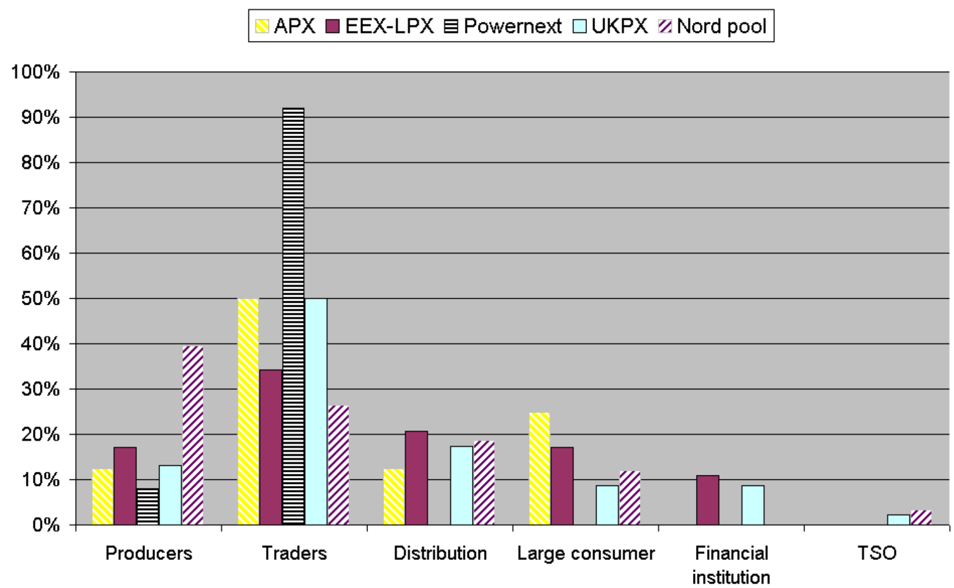
The percentage of producers is logically related to the market structure in generation. On Nord pool 40% of the participants are generators, only 8% on Powernext. On APX, EEX-LPX and UKPX the share of producers is comparable with values between 13% and 17%. Interestingly, financial institutions such as Goldman Sachs International, Credit Suisse First Boston or Deutsche Bank are members of power exchanges. However, it is unlikely that these players participate in physical spot trading, it is more likely that these players are members to monitor closely developments in electricity trading with intention of offering their expertise when financial trading, based on the power exchange price, takes off. Finally, in the UK and in the Nordic Region Transmission System Operators are members of the exchange which shows that TSO may use the power exchange for their own needs.

Table 7-8: Nature of players on European power exchanges (2002)

	APX	EEX-LPX	Powernext	UKPX	Nord pool
Producers	13%	17%	8%	13%	40%
Traders	50%	34%	92%	50%	26%
Distribution	13%	21%	0%	17%	19%
Large consumer	25%	17%	0%	9%	12%
Financial institution	0%	11%	0%	9%	0%
TSO	0%	0%	0%	2%	3%
Total	100%	100%	100%	100%	100%

Source: Power exchanges, 2002

Figure 7-3: Nature of player on European power exchanges (2002)



Source: Power exchanges, 2002

7-3-3 International players

Beside the number of player on each exchange, it is also interesting to identify players that are active on many exchanges. Indeed such players are naturally in the best position to identify market inefficiency and exploit market gaps. Players which are members of at least three of the five exchanges considered are given in Table 7-9. This table identifies 22 players that were registered on a minimum of three exchanges in 2002.

Table 7-9: Players members of three exchanges and more (2002)

	Main trading office	APX	EEX-LPX	Powernext	UKPX	Nord pool	Total
Electrabel	Belgium	X	X	X	X	X	5
Fortum	Finland	X	X		X	X	4
TotalFinaElf	France	X	X	X	X	X	5
E.on	Germany	X	X	X		X	4
EnBW	Germany	X	X	X			3
RWE	Germany	X	X	X	X		4
Enel	Italy		X	X		X	3
Nuon	Netherlands	X	X			X	3
Norsk Hydro	Norway	X	X	X		X	4
Statkraft	Norway	X	X	X		X	4
Endesa	Spain	X	X	X			3
Vattenfall	Sweden	X			X	X	3
Atel	Switzerland	X	X	X			3
Cargill	Switzerland		X	X		X	3
Aquila	UK	X	X	X	X	X	5
Duke Energy	UK		X	X	X	X	4
Dynegy	UK	X	X		X	X	4
EDF	UK	X	X	X	X	X	5
El Paso	UK	X	X		X	X	4
Entergy	UK	X	X		X		3
PowerGen	UK	X			X	X	3
TXU	UK	X	X	X	X	X	5
Total		**19**	**20**	**15**	**13**	**17**	**84**

Source: Power exchanges, 2002

Table 7-9 shows clearly that all the major producers are present on most exchanges and do not limit themselves to their national historical market. In some cases, geographic proximity remains a relevant criterion. For instance E.on and EnBw (Germany) are not present in the UK nor is Endesa. However such consideration tend to be increasingly less relevant. Indeed, most players are present on most exchanges. Besides the producers, the others international players are pure electricity traders such as TXU or Dynegy mainly based in the UK. The first open question concerns the traders' level of activity on the different exchanges, i.e. large market share or just registered member. Secondly when a non-asset based trader sells on a power exchange electricity that was bought from a generator on the bilateral market, can it be said to be competing with generators.

Moreover, it is worth noting that table 7-9 relates to data for 2002, following the collapse of Enron, a large number of pure trader (non-asset based) players have left the European market. This is the case for TXU, Entergy, El Paso, Dynegy, Duke energy, and Aquila. Hence, recent developments have led to a decrease in the importance of this type of player (Newbery *et al*, 2003).

7-4 Prices and volumes analysis

7-4-1 Introduction

Comparison of electricity prices is a classical approach that can be used for analyzing the level of competition in electricity markets. However in Europe most analysis have used retails prices to different user groups collected by Eurostat (EC, 2001a; 2002) rather than wholesale prices prevailing on power exchanges. Furthermore when power exchange prices have been used the analysis has only considered one or two markets (Lange *et al*, 2002; Galli and Armstrong, 2002).

In this section we estimate the level of competition on power exchanges based on direct price analysis. Analysis of power exchange prices together with the respective quantities sold can provide a significant amount of information on the level of competition. We compare price and volume evolution for the year 2002 which was the first full year of operation on the French and British power exchanges. The existence of exchanges in five majors EU electricity markets in 2002 (Netherlands, United Kingdom, France, Germany and Nordic countries) allows us to carry out such analysis for the first time.

We identify several distinguishing features of prices and volumes on these different exchanges in the following sections. Because demand differs widely between days (weekdays/weekend) and hours (peak/off-peak) and since electricity is a non-storable good, prices and volumes vary over time, and this involves an important level of volatility. In this chapter we analyze this volatility with respect to the temporal properties of electricity prices, and the variation of volumes traded on the different exchanges while the relationships between exchanges are analyzed in the following chapter. We first present the different data used for the analysis, then, the question of prices differences and volatility is addressed. The temporal properties of electricity prices are analyzed, finally, relationships between prices and volumes are presented.

7-4-2 Data

The data used in this study consists of hourly prices and volumes taken from five power exchanges (APX, LPX, Powernext, Nord pool[27], and UKPX) for year 2002. The locations, the power exchanges analyzed, the nature of the data and the sources used in the analysis are given in table 7-10.

Table 7-10: Data collected

Location	Source	data	Website
UK			
	UKPX	Half hourly price/volume	www.ukpx.co.uk
France			
	Powernext	Hourly price/volume	www.powernext.fr
Germany			
	LPX	Hourly price/volume	www.lpx.de
Netherlands			
	APX	Hourly price/volume	www.apx.nl
Nordic countries			
	Nordpool	Hourly price	www.nordpool.no

Source: Power exchanges, 2002

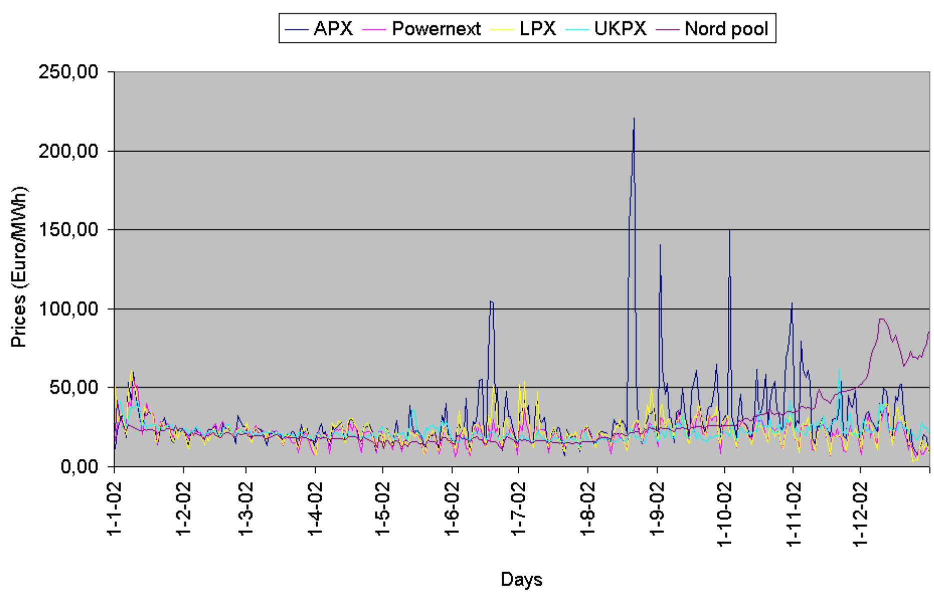
The time series contain hourly electricity prices traded on a day-ahead basis for delivery on the any of the 8760 hours of the year 2002. Daily prices were calculated using a simple arithmetic average. Where necessary, prices were converted to Euros using an average exchange rate prevailing for the period studied.

[27] Volumes for Nord pool were not collected since this exchange defines different hubs, due to market splitting, (See chapter 9) and thus it make little sense to aggregate those volumes

7-4-2 Price differences and volatility

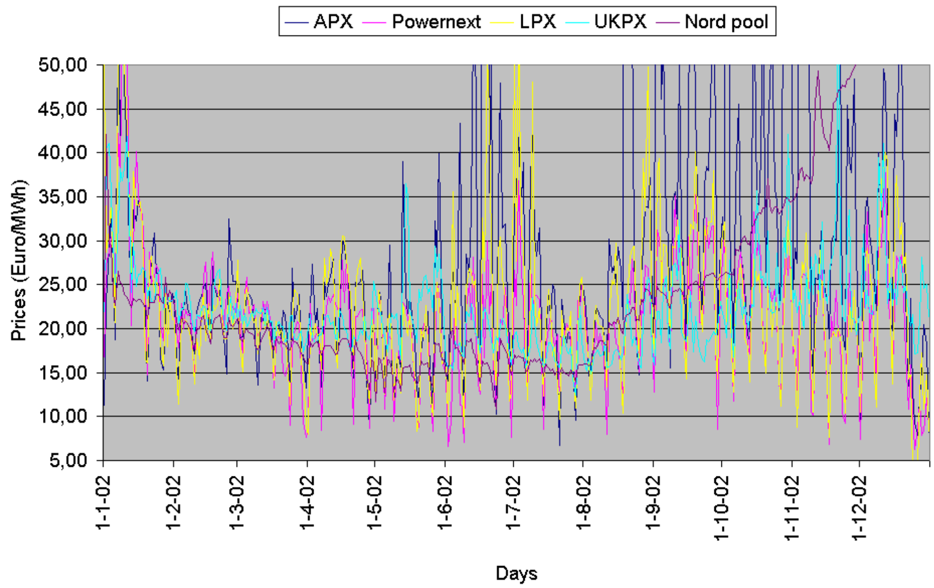
As for any other commodity, electricity is subject to the law of supply and demand, i.e. when demand increases prices tend to go up. Since electricity cannot be stored, no substitutes exists and demand varies widely over time, electricity prices are extremely volatile (table 7-11). The daily average prices on the five power exchanges are showed in figures 7-4a, and 7-4b. The annual daily average price and standard deviation of prices four the five power exchanges[28] are given in table 7-12. Several interesting facts emerge from these figures. One, as found in previous studies on the behavior of electricity spot prices (Wolak, 1997; Knittel and Roberts, 2001), one of the most striking features of these prices is their tremendous volatility across days within the week. Two, as can been seen, day-ahead prices may vary widely between the different geographic locations. These price differences between countries and the volatility of prices have different causes.

Figure 7-4a: Daily average prices (2002)



Source: Power exchanges, 2002

Figure 7-4b: Daily average prices (2002)



Source: Power exchanges, 2002

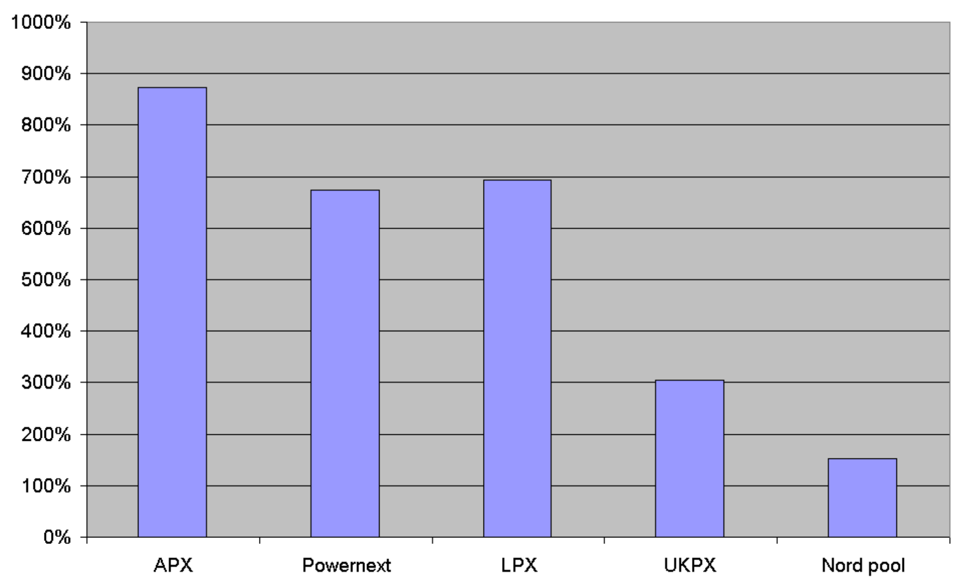
The first reason for price differences is related to generation technologies, i.e. nuclear, hydro, coal, gas etc. The nature of generation technologies is the most important variable with respect to differences in marginal costs. For instance, gas fired generation represent over 50% of Dutch installed capacity, but just 15% in Germany and 1% in France. In France, generation is largely dominated by nuclear plants while in Germany coal and nuclear plants represent the two major technologies used. Prices in France are the lowest despite the dominance of one player. This is mainly due to the generation structure which is essentially based on nuclear technology. Prices on the APX are on average 40% higher than prices on Powernext (table 7-12). The nature of technology has an impact on variable cost, e.g. gas power plants have high variable costs and low fixed costs while nuclear plant have low variable costs and high fixed costs. Thus the differences in fuel prices between countries represent an important reason for price differences.

[28] Four locations within Nord pool are presented

The structure of demand and transmission constraints also plays an important role. The proportion of residential and commercial consumers with respect to the proportion of industrial consumers can also explain higher or lower variations between peak and off-peak demand. In the absence of transmission constraints simple arbitrage would tend to cause electricity prices to converge[29].

Figures 7-4a and 7-4b also indicate that price volatility on most exchanges is high and that price spikes occurred regularly throughout 2002, in figure 7-5 volatility is measured by the annualized standard deviation of daily changes in baseload prices relative to average baseload prices.

Figure 7-5: comparative daily volatility



Source: Power exchanges, 2002

Volatility in electricity power exchanges is especially high for APX, Powernext and LPX (above 600%) and less important for UKPX (300%) and Nord pool (150%). APX has seen repeated price spikes that have not been equaled on any other exchange, most of the others markets also experienced important spikes to

[29] See chapter 8 and 9 for more on this.

lesser extent. Several reasons for “normal” [30] volatility (and price spikes) can be identified:

- Unexpected plant outages
- Unexpected decreases in available interconnection capacity
- Low elasticity of demand
- Unusual high/low temperatures
- Poor hydro conditions
- Volatility of fuel prices
- Market manipulation/market power

Table 7-11: Summary statistic power exchanges (2002)

	Mean	Median	Maximum	Minimum	Std. Dev.
APX BASE	34,60	27,98	220,85	7,84	24,24
POWERNEXT BASE	23,49	22,83	55,85	6,24	6,30
LPX BASE	25,26	23,94	61,00	3,47	8,06
UKPX BASE	23,05	21,72	61,77	15,17	5,73
DK BASE	27,38	24,44	88,47	9,06	11,32
SWEDEN BASE	28,36	23,06	93,32	11,48	16,42
NORDPOOL BASE	27,38	20,85	93,43	11,75	16,96
NORWAY BASE	26,91	20,50	94,17	12,26	17,31

Source: Power exchanges, 2002

The annual daily average price and standard deviation of prices for the five power exchanges are given in table 7-11, four locations within Nord pool are presented. In Nord pool hydro conditions are the primary price driver. The end of 2002 was marked by an important increase in prices due to poor hydro conditions which dropped reservoir levels to their lowest point in 10 years[31]. In addition to a lack of precipitation in 2002 that pushed Norwegian and Swedish reservoir levels well below their seasonal norms, a number of plant outage compounded the situation[32] resulting in dramatic price increases, above 50 Euro/MWh in December. Unseasonably cold weather was an important factor of

[30] By opposition with abuse of market power as a reason for volatility and for price spikes
[31] Heren Report, *European Electricity Markets*, December 2002

price increase across northwest Europe in the end of 2002. Price spikes in June on the APX, average daily price over 100 Euro/MWh on June 19th, have been caused by a combination of line congestion, high temperatures, plant outages, cooling water problems and congestion on the border between France and Belgium[33]. Price spikes over 40 Euro/MWh in Germany were attributed to unplanned nuclear plant outages[34]. On Powernext the main reason for price spikes in January and December, above 40 and 30 Euro/MWh respectively, was a spell of extremely cold weather in Europe.

Others external factors can also have an impact on electricity spot price. For instance, the fall of Enron in December 2001 was presented as an important reason for the high volatility of electricity prices at the beginning of 2002. Similar, concerns over the credit-worthiness of some other US players and the withdrawal of some of them were cited has a contributive factor to some prices spikes. Workers strikes, bank holidays, and things such as national football games can also represent possible explanations for temporary price spikes. Nevertheless, the most important part of volatility is directly related to seasonality. These aspects are discussed in the following sections.

7-4-3 Temporal properties: weekends/weekdays

Light is shed on the importance of temporal properties with respect to weekdays and weekends in figures 7-6a 7-6b and 7-7. To facilitate readability a constant term was applied to the different series on figure 7-6a compared to figure 7-4a while only weekdays are considered in figure 7-6b. The annual daily average price during weeks, weekdays and weekends and standard deviation of prices for the five power exchanges are presented in figure 7-7.

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[32] Heren Report, *European Electricity Markets*, November 2002
[33] Platts *European Power Daily*, June 2002; Heren Report, *European Electricity Markets*, June 2002
[34] Heren Report, *European Electricity Markets*, July 2002

As presented in the previous section, price volatility on most exchanges is high. However, an important part of the volatility suggested is simply related to changes in demand. Prices on three exchanges, Powernext, LPX and APX, present important seasonality features implying that cyclical factors play an important role in price variations. An important factor is related to the difference in demand between weekends and weekdays. These differences in demand are due to the fact that load levels are lower during weekends than during the week. In order to isolate this pattern, in figure 7-6b only weekdays are taken into account and thus clearly shows this seasonal effect when compared to figure 7-6a. Hence, weekend prices are significantly lower, on average, than prices for the rest of the week (figure 7-7). The prices analyzed for the five power exchanges differed on average by 35% between weekdays and weekends.

Figure 7-6a: Seasonality of daily average prices

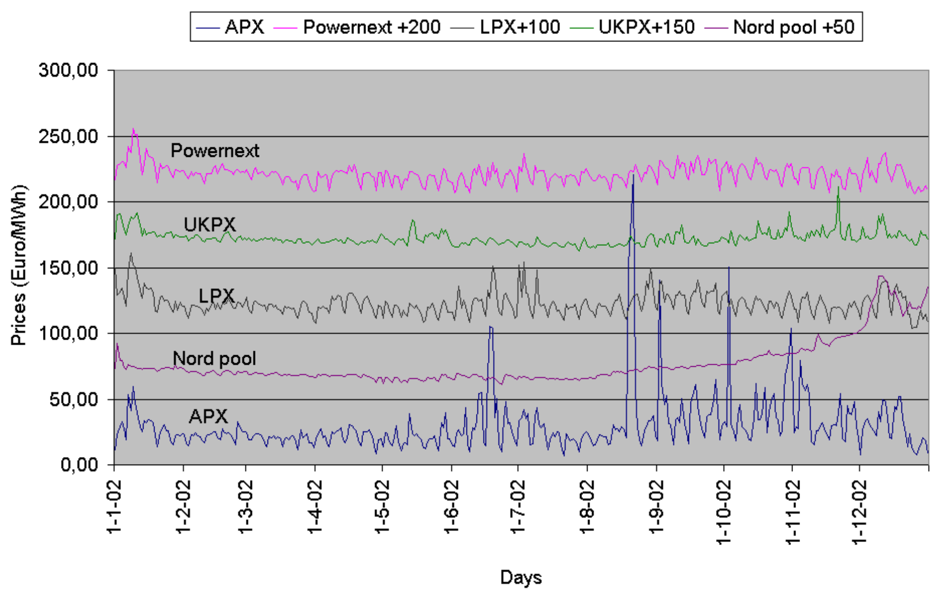
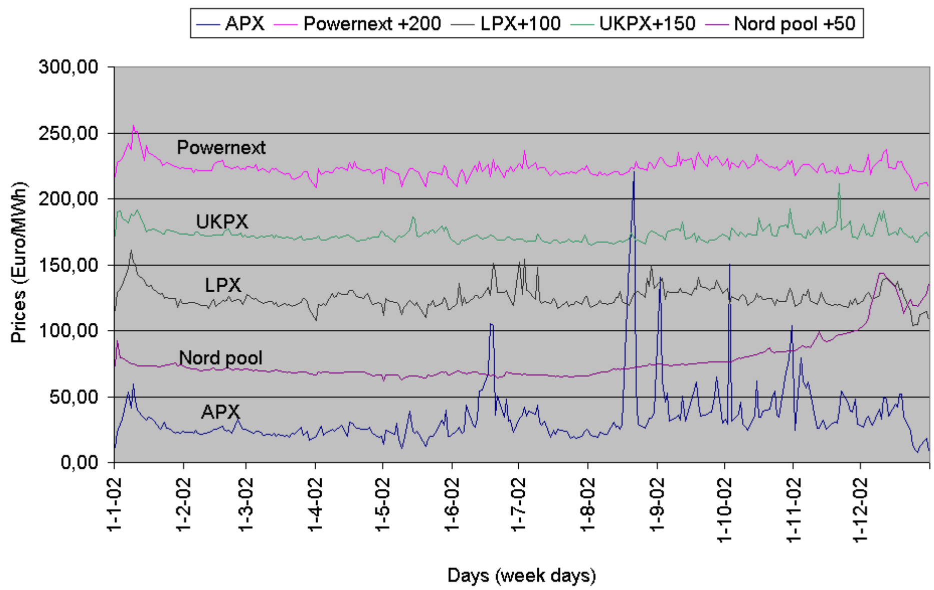


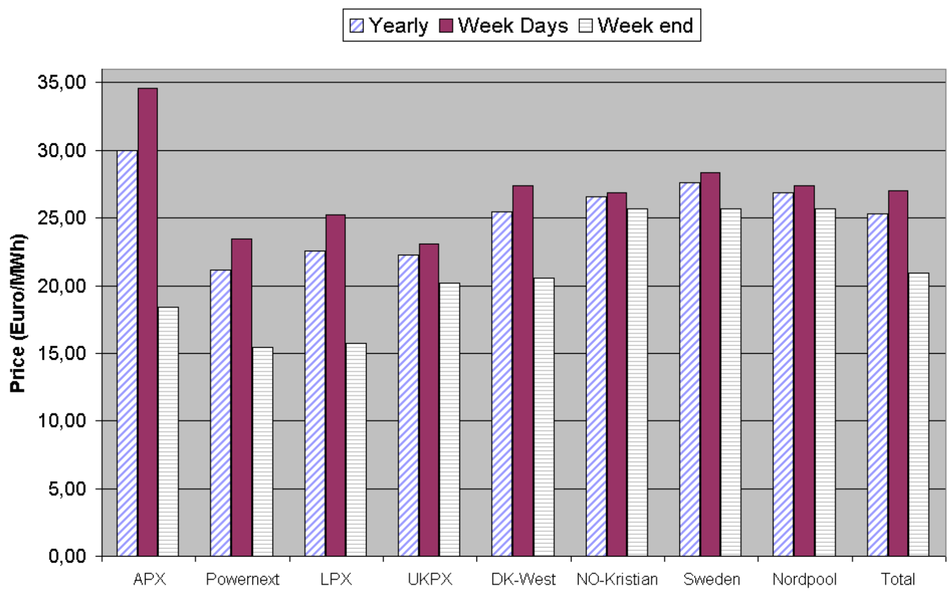
Figure 7-6b: Daily average prices weekdays



Source: Power exchanges, 2002

Average daily electricity prices measured in Euro per megawatt hour for the all week, weekdays and weekends are presented in figure 7-7. From figure 7-6 it can be seen that such price differences vary significantly between the exchanges. The price difference between weekdays and weekends is extremely high for APX (prices during weekends are 50% lower than during weekdays). On Powernext and LPX this difference is approximately 35%. In the UK this difference is lower (12%). Finally, within the Nord pool area this pattern is present to different extents. Norway has the lowest difference (less than 5%) while Denmark has the largest (24%). In Norway, prices are relatively stable over time because electricity is largely used for residential space heating which does not vary between weekdays and weekends. In contrast in the Netherlands industrial and commercial consumers represent a larger part of the demand compared to residential consumers, typically industrial and commercial demand drops during weekends while residential demand is more stable. Such variations shows that prices on power exchanges follow the pattern of demand with respect to weekday and weekend consumption but that some national peculiarities remains.

Figure 7-7: Averages prices 2002

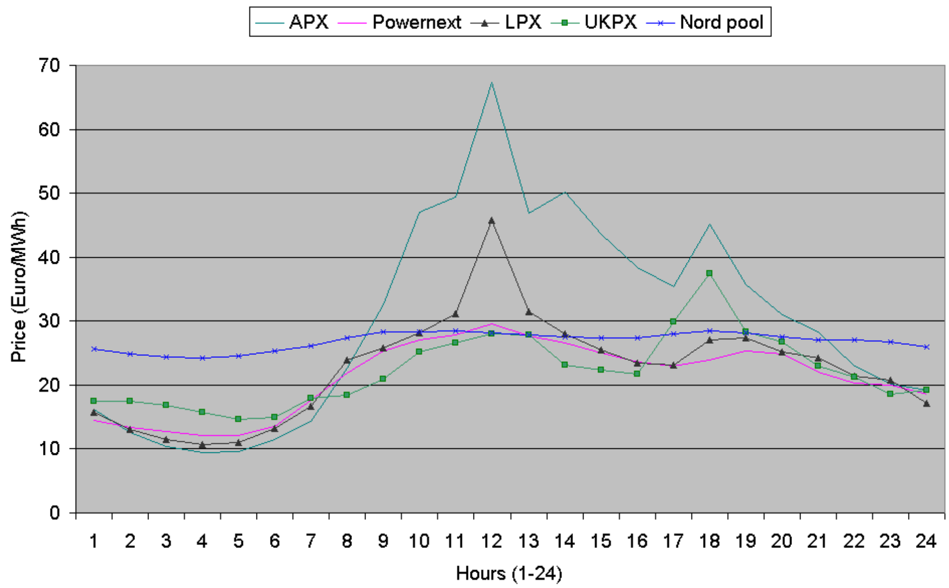


Source: Power exchanges, 2002

7-4-4 Temporal properties: peak/off peak

During the day, since demand varies sharply, prices vary sharply from hour to hour within the day. Hence, there is a marked difference between off-peak and peak hours. Annual average of hourly prices for each hour of the day are plotted in figure 7-7. This figure highlights the correlation between the price traded on the exchange and the structure of electricity consumption and important seasonal components can be identified from this figure. As expected, price begins to increase early in the morning, as the populace wakes up and work activity begins. Hence, prices are especially low during nights and increase regularly from 5.00 until 12.00 which is consistent with the daily variations in electricity consumption. Prices begin to fall at the end of workdays following the decrease in demand.

Figure 7-7: Average prices per hour



Source: Power exchanges, 2002

However the scope of such price variations differs between the different locations. On Nord pool, prices are relatively stable over the day while on APX, LPX and UKPX prices give rise to daily spikes. For instance, a characteristic spike at 11.00 (hour 12) on APX and LPX can be identified as well as a second spike at 18.00 on APX and UKPX when residential demand increase and working activity remains high. It highlights the close correlation between the price traded on the exchange and the structure of electricity consumption during the day. In conclusion just as with the weekdays/weekend variation in demand, the seasonality of prices on power exchanges follows the patterns of demand, but again some national peculiarities exist.

7-4-5 Volumes developments

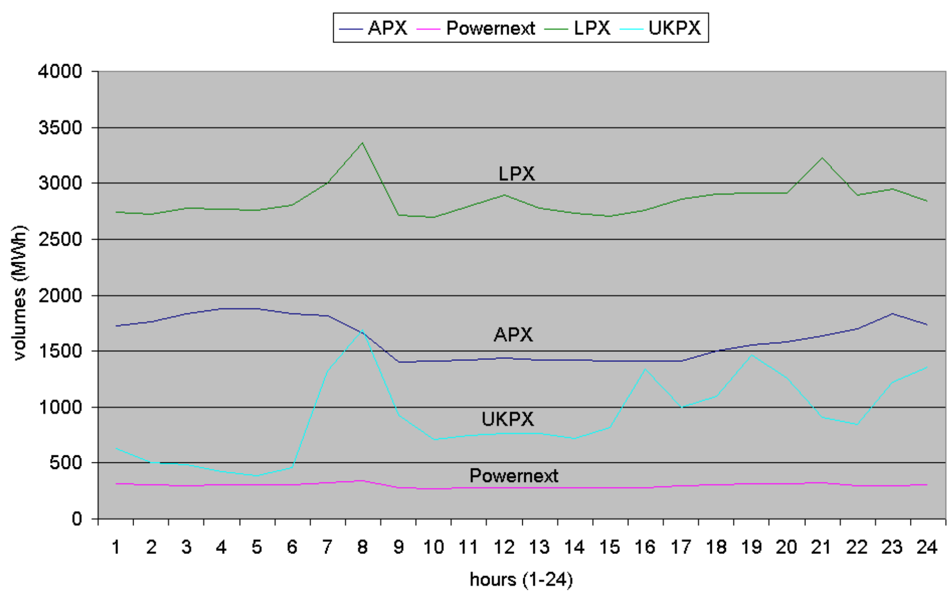
In mandatory pool models the development of volume is meaningless, i.e. all electricity transactions go through the pool and thus volumes traded on the pool are proportional to the size of the market. However, power exchanges are optional day-ahead markets in competition with OTC markets. The issue of volume traded is fundamental for exchanges since it indicates the representativeness of the power exchanges with respect to the rest of the market. A classical way to look at the importance of power exchanges with respect to the global wholesale market is to calculate the percentage of volume traded on the exchanges compared to total electricity consumption (table 7-14). These figures show important differences ranging from 0.7% (France) to 29.7% (Nordic countries) between the five exchanges considered.

Table 7-14: “Market shares” of power exchanges

Country	Consumption (2000, TWh)	Exchange (% of consumption)
Germany	502	4.7%
France	409	0.7%
Scandinavia	368	29.7%
UK	310	1.4%
Netherlands	101	12.8%

Source: Claxton (2003)

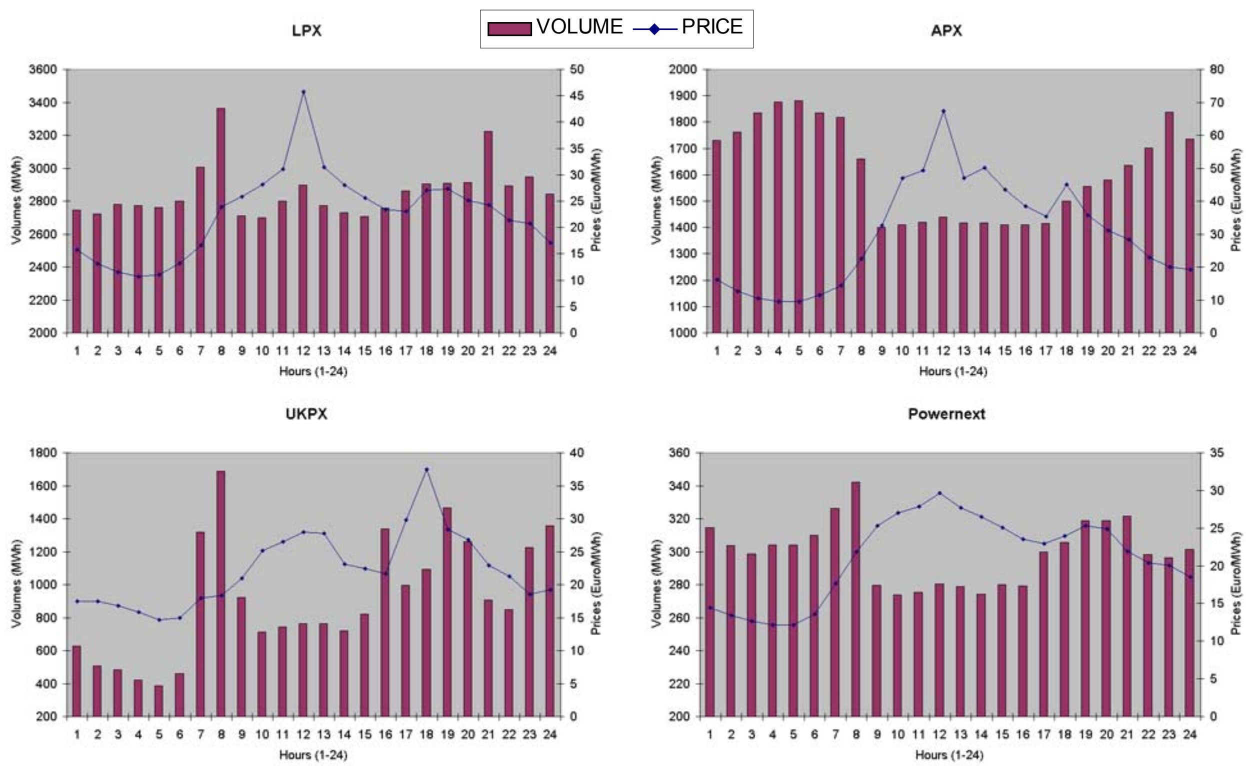
Figure 7-8: Average volume per hour



Source: Power exchanges, 2002

The focus in figures 7-8 and 7-9 is on volume traded on the different APX, LPX, UKPX and Powernext. Average hourly volumes are plotted in figure 7-8 while the relationship between prices and volumes for each exchange is presented in figure 7-9. As already presented on table 7-14, one of the most striking feature is the large difference between volumes traded on each exchange. While Germany and France are comparable countries in terms of electricity consumption, volumes on LPX are almost ten times higher than on Powernext. Similarly, while the UK market is about four times larger than the Dutch market, volumes on the APX are about two times larger than on the UKPX.

Figure 7-9: prices VS volumes



Source: Power exchanges, 2002

There are many alternative explanations for these differences, some of them can be directly related to the market structures presented in the previous section of this chapter. For instance, one, the low volumes on Powernext are mainly due to a lack of competitors in France compared to Germany. Two, the nature of generation technologies used can also explain such differences. The dominance of large inflexible power plants, nuclear, is ill suited for spot trading compared to small flexible units, combined cycles. Three, market/marketplace design can also influence the level of volume traded. This is obviously the case in the Netherlands where all day-ahead imports have to go through the APX[35].

Comparing price evolution and volumes provides interesting information on the functioning of these markets, averages prices and volumes per hour for the four exchanges are plotted in figure 7-9[36]. An interesting conclusion that can be drawn from this figure is that volumes traded on power exchanges are negatively correlated to demand. Indeed volumes traded during peak hours are generally lower than volumes traded during off-peak hours. This is especially striking for Powernext and APX and to less extent for UKPX. Hence volumes are inversely proportional to prices. In others words, while the level of demand, and thus of prices, is the highest during the afternoon, the level of traded volumes is paradoxically low compared to volume traded during the night. This illustrates the scarcity of supply during these hours and is due to the fact that power exchanges are voluntary market, i.e. a large part of peak consumption is covered by bilateral contracts.

On three exchanges (UKPX, LPX, Powernext) large volumes are traded just before the start of the peak period (hour 7 and 8) and suddenly drop for the following hours. This phenomenon can be explained by the fact that during this period many power stations are ramping up for peak hours. Thus their output is progressively increasing. Generators in this period sell their power on the exchange because it is difficult for them to contract on the bilateral market for variable quantities and over short period of time, i.e. 1 or 2 hours. In the following hours volumes decrease on the exchange because the generators have sold their output on the bilateral market. In conclusion, the design of current wholesale electricity markets appears to exacerbate the volatility of prices during peak hours on power exchanges due to the voluntary characteristic of power exchanges.

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[35] See chapter 5, section 5-5-3

[36] Note that for the sake of readability the scales (prices and volumes) are different

7-5 Conclusion

The classical approaches of competition analysis based on market structure are a necessary starting point at a conceptual level. They are adequate for estimating the underlying conditions of functioning of these marketplaces but are not entirely satisfactory for electricity power exchanges; levels of interconnections were taken into account to improve these indicators. This analysis has showed that market structure and level of interconnection differ widely between the five countries analyzed. Moreover, competition on a power exchange is not limited to energy producers and cross border trades, other players such as energy traders, large industrial consumers and distribution companies play an important role on power exchanges.

A comparison of electricity prices was used to analyze the level of competition in electricity power exchanges. As in others studies of deregulated markets, we found strong deterministic cycles including, intraday and day of week effects. In general several similarities have been shown between price developments on the different power exchanges studied especially with respect to the variations of demand over time. However, some differences between countries remain such as the volumes traded on these markets.