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D'Ecclesia, Rita Laura and Gallo, Crescenzo

Dipartimento di Matematica Statistica, Informatica ed Applicazioni  
- Università di Bergamo (Italy)

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# Price-caps and Efficient Pricing for the Electricity Italian Market

Rita L. D'Ecclesia  
Università di Roma "La Sapienza"  
e.mail: ritadec@uniurb.it

Crescenzo Gallo  
Università di Foggia  
e.mail: c.gallo@unifg.it

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## **Abstract**

Deregulation of the electricity generating industry, under way in the United States as well as in Europe, would yield economies to operate in a more competitive environment causing improvement of efficiency and the possibility to develop related financial markets to manage price uncertainty. Electricity spot prices tend to be remarkably volatile as consequence of extreme weather conditions, therefore there seems to be sufficient price uncertainty to warrant the development of derivative markets, however it is important to verify whether the underlying spot market is sufficiently competitive and well functioning to stimulate the development of related financial markets. Analyzing the features and price volatility of European markets which undertook the same process, as well as Norway, Germany and Spain, we formulate a simple model to control the well functioning of energy spot markets in a deregulated context. The model is tested using Norwegian, Deutsch and Spanish spot prices over the last two years in order to assess the correct price formation in competitive operating markets.

**Keywords:** Electricity market, Price limits, Market Power.

# 1 Introduction

Regulatory reform of the electricity sector offers significant benefits in terms of improved efficiency in the production of electricity and in the allocation of resources across the economy:

- lower prices for consumers;
- improved risk allocation;
- stimulus to economic growth and competitiveness.

Competition in electricity market should improve efficiency but at the same time some market behaviour may cause the price of electricity to be higher than the short run marginal cost generation. In addition, power prices tend to be extreme volatile under extreme weather conditions, and in that case prices become disconnected from the cost of production and may be driven very high by squeezes in the market due to generation shortages or transmission disruptions.

Risk sharing instruments, as well as futures and options contracts, allow consumers and producers to hedge their price-risk and represent an essential element of the electricity reorganization process well under way in the United States and most of the European countries and starting now in Italy. Where market for electricity power has been established new financial markets have also been established. Electricity contracts range from long terms (e.g. 20 years) requirement contracts to short term (e.g. one-half hours) supply contracts.

This paper involves an analysis of the feasibility of establishing an electricity futures markets at the same time of the underlying spot market in order to guarantee the development of both markets and to reduce, if not to eliminate, the presence of Market Power. The issue of the presence of Market Power is crucial for the Italian electricity market which has been undertaking the deregulation process since 1996. Government Authorities are progressively privatizing the State owned Italian electricity producer and supplier, ENEL, and the on going process should be ultimated within the year 2002. At present, however, 75% of electricity supply during the peak hours is still provided by Enel causing a major concern on how spot prices behave. The question of whether the underlying new spot-market is sufficiently competitive and well-functioning in order to guarantee the success of a derivative market becomes therefore an issue to analyze.

The goal of this paper is to investigate the possible approaches to assess the well functioning of an electricity spot market in order to verify the correct price formation and the presence of a competitive system. Analyzing the features and price volatility of European markets which undertook the

same process, as well as Norway, Germany and Spain, we show how market data may provide a useful tool to identify the presence of Market Power and recognize a competitive spot market. Competition which is not guaranteed by the presence of a relatively high number of firms: during most of the 1990s, regulatory evaluation of short run horizontal market power focused on concentration measures, such as the Herfindahl-Hirschman index (HHI) that as shown by Borenstein & al (2002) resulted a poor indicator of the potential for market power in the electricity industry since the industry is characterized by highly variable price-inelastic demand, significant short run capacity constraints and extremely costly storage. In such circumstances firms with very small market shares could still exercise significant market power. In this work we argue that competitive behavior may be recognized by a certain behaviour of prices and volatilities in the market. In such a context, we formulate a model to set up price-caps for energy spot prices in order to guarantee the correct price formation and generate success of futures trading. The model is first implemented and tested using Norwegian, Deutsche and Spanish spot prices data over the last two years, under specific assumptions as well as the hypothesis of parametric normal distribution of price changes. Relaxing this assumption will provide a more general framework as it is currently the aim of an in progress research.

## 2 Electricity Spot Market

Electricity spot market has specific features which make this market different from traditional commodity markets and from other energy products. Precisely:

- electricity is a homogenous commodity which implies the delivery of specific amounts of energy units during a certain period of time.- Electricity cannot be stored, therefore, generation and consumption must be perfectly matched at all times.-
- The storage of the commodities which are the raw materials used to produce electricity (mainly fuel and gas) may be performed in order to realize cross market arbitrage.
- Electricity supply is quite flexible for low levels of demand, and very rigid for high levels.

The electricity demand fluctuates in a daily and seasonal pattern and registers a significant lack of elasticity, especially at peak hours, mainly due to production processes and household consumption. Incorrect estimations of consumption or generation mean higher prices for those who have deviated [IAE '99].

Electricity demand is also sensitive to economic cycles in the long term, and shows a high degree of seasonality mainly due to consumption habits and weather conditions. These factors have a direct influence on prices as well.-

From other countries' experiences it can be inferred that electricity prices are very variable (the main reason is that it cannot be stored) and, as a consequence, difficult to forecast. They behave in such a way that they never go beyond a certain floor level and experiment pronounced jumps returning rapidly, afterwards, to the previous levels. This price behavior reflects high and low demand hours and what generating units are at the margin of each of those hours.

Generally speaking, power prices tend to be remarkably volatile under extreme weather conditions. Prices then become disconnected from the cost of production and may show high volatility in presence of generation shortages or transmission disruptions.

Spot price evolution is difficult to model given the presence of spikes, one model that address this issue is the diffusion process (Geman '99) with stochastic volatility

$$\begin{aligned} dS_t &= \mu_1(t, S_t) dt + \sigma(t) S_t dW_t^1 \\ d\Sigma_t &= \mu_2(t, \Sigma_t) dt + y(t, \Sigma_t) dW_t^2 \end{aligned} \tag{1}$$

where  $\Sigma_t = [\sigma(t)]^2$ ,  $W^1(t)$  and  $W^2(t)$  are two Brownian motions, with a correlation coefficient  $\rho(t)$ , and the terms  $\mu_1(t, S_t)$  and  $\mu_2(t, \Sigma_t)$  may account for some mean reversion either in the spot prices or in the spot price volatility. Stochastic volatility is necessary if we want a diffusion representation to be compatible with the extreme spikes as well as the leptokurtosicity displayed by distribution of realized power prices.

The convenience yield is a very relevant factor in electricity consumption, as the demand side does not want to be without a power supply due to the damage it would cause to their industrial activities. The experiences of other electricity futures markets in the world serves, on the one hand, as a reference how to approach the development of this type of contracts and, on the other, as an indicator of the acceptance and consolidation of electricity in the exchange-traded derivatives environm

### 3 Electricity Derivatives

The advantages of having access to a Futures and Options Exchange are very clear as it:

- Provides information on the electricity price term structure to the different periods of time traded, with all that implies for accurate risk management on energy prices.

- Allows the purchase cost or selling price of electricity to be pre-set, or their respective maximum and minimum limits to be established.
- Makes it easier to carry out hedging strategies for risk price management, thus protecting commercial margins against unfavourable price movements.
- Offers the possibility of comparing prices between markets, albeit with those corresponding to other raw materials or with those of the electricity spot market. This allows firms to choose the best price and to carry out arbitrage operations and, therefore, take advantage of opportunities otherwise not on offer.
- Trading in the Exchange gives futures and options the following unique features:
  1. Unlike bilateral and forward contracts, these contracts have no counterparty risk, as the Clearing House insures the financial integrity of each trade by acting as a middle-man between buyers and sellers.
  2. The intense flexibility of futures trading allows traders to adopt or leave a position depending on the moving expectations and interests of the traders. This is due to the fact that these markets offer a deep, liquid environment with plentiful and ready supply and demand. On the contrary, in non-organised markets, obligations have to be completed on the agreed date or dates.
  3. Seeing prices in real time adds transparency to markets and promotes easier decision-making.

### **3.1 European Futures Markets on Electricity**

Reorganization of the electricity sector has been taking place in the last decade in several European countries. The main issue raised by this deregulation is the establishment of spot-markets which allow for efficient pricing in response to the nature of the demand and supply of this commodity. Demand and supply in the electricity market vary stochastically therefore market prices for the producer and the consumer show volatility and contrasts with the certain world of fixed prices and long term contracts which used to dominate the centrally organized electricity sector in these countries.

In this context futures and options contracts which allow consumers and producers to hedge their price risk in the spot market become an additional essential element of the re-organization process.

At present Austria, Belgium, Denmark, Finland, Germany, Norway, Spain, Sweden and the UK have undertaken successfully the deregulation

process. Among these European countries the Scandinavian Pool, United Kingdom, Germany and Spain have contemporarily introduced the futures market.

### **3.2 Norway**

The electricity futures market in Norway is managed by Nord Pool. Since 1996, Nord Pool is the power exchange for both, Norway and Sweden, as the Swedish System Operator acquired 50% of the exchange, becoming the first supranational power exchange in the world. The last countries to fully enter Nord Pool have been Finland and Denmark.

Some relevant facts about the Norwegian market are that it was deregulated in 1989 and that all customers - even the domestic ones - are qualified in terms of being able to choose a supplier. We should also mention the existence of an important OTC market run by a multitude of brokers and power marketers such as the companies Skankraft or Energipartner.

The futures market started its activities in 1993 (as a forwards market until late 1995) with three different contracts: base load, peak load and off-peak load. Only the first one is listed at present as the other two did not gather enough liquidity. Nord Pool's market is based on the trading of months (seasons) which, as maturity approaches, split into groups of weeks (blocks) and, closer to expiration (about a month) split into individual weeks.

Futures contracts are mainly financial contracts so physical delivery is not required in this market.

### **3.3 United Kingdom**

The UK is the European country with longest standing electricity pool (operating since 1990), after its power sector was deregulated in 1989. In the current year the New electricity Trading Arrangement (NETA) was established, NETA is a new wholesale market where electricity is traded forward through bilateral contracts on one or more power exchanges. NETA provides central mechanisms which do two things:

1. Help NGC to ensure that demands meet supply An outstanding fact that should be pointed out is the existence of EFAs (Electricity Forward Agreements), a standardized OTC derivative brokered by GNI, which has been highly traded since 1991. It appears that the UK will soon have exchange traded derivatives on electricity.

The IPE (International Petroleum Exchange) is finalizing a deal with Nord Pool so that members from one exchange can access the other exchange's contracts, placing the IPE in an advantageous position to list electricity futures contracts. The final go ahead will probably be catalyzed

when the power sector adopts the reform proposed by OFFER (the UK power regulator).

### **3.4 The Deursche Market (EEX)**

The objective of European Energy Exchange is to become the leading energy exchange in Central Europe. In future power, gas and other energy sources are to be tradable at EEX. This range is to be completed by services related to the exchange, such as Clearing of transactions outside the exchange (OTC Clearing).

The point of origin is the operation of the German power exchange. Since Summer 2000 the Spot Market with physical fulfilment on the day to follow is established. The Auction Market provides the possibility of placing purchase and sales bids for single hours and bloc bids. The equilibrium price determined on this market is a market price which is defined by way of bilateral auction by suppliers as well as by consumers.

On the market of the Continuous bloc trading purchase and sales bids for blocs on Base Load and Peak Load can be placed.

Second foothold is the Futures Market on which standardized products such as Futures are tradable. On the Futures Market Month, Quarter and Year Futures with Phelix as underlying price are offered. By this combination of Spot and Futures Market a complete risk hedging is possible.

### **3.5 The Spanish Market (OMEL)**

The Electric Sector act and Royal Decree 2019/97, of December 26th, which govern the organisation and regulation of the electric power production market, entrust functions to the Compañía Operadora del Mercado Español de Electricidad, S.A.

The new law was reflected by the Ministry of Industry and Energy and the different power companies, and has been further developed through different Royal Decrees. From the market's organization perspective the decree defined:

- the setting up of a centralized pool where, following an auction-style system, generation units sell and acquisition units purchase electricity daily to be delivered the following day. This is the Day-Ahead Market (art. 6);
- The creation of a new entity, the Market Operator, in charge of the economic side of the market (art. 27).- The possibility of signing bilateral contracts aside of the central market. These contracts may imply physical delivery or simply be contracts for differences (art 19 y 20).- The guaranteed access for all agents to the grid and distribution networks (art. 33);



- The creation of the figure of power marketer (art. 3);
- The setting up of different intradaily markets (closer to real time) where positions can be adjusted and even offset. The market started on 1st January 1998, becoming the first amongst the countries within the European Monetary Union alongside Finland. FC&M started operations on 8th September 1995, becoming the first Commodities Exchange in Spain.

## 4 Efficient Spot Market

One important assumption in this analysis is that there will be an absence of Market power in the coming competitive market for electricity. "...Market power means that a supplier or consumer has the ability independently to influence prices by virtue of size or control over an important aspect of the market, such as access to transmission lines" (Newbery 95) If there is no market power, then economic theory suggests that prices will fall to the marginal costs of production, and the cost of operating the most expensive generating plant in operation at any point in time will set the price for electricity

Under conditions of intense competition, where many producers have access to customers and engage in price cutting strategies to win market share, prices could fall by as much as 24 percent instead of the 8 to 15 percent cited above. However, a price decline of this magnitude will not be achieved unless utilities are able to reduce their costs substantially from current levels and maintain those cost reductions.

The main problem is represented by the fact that at present the Market Power may still be performed by the dominant agent which still detects more than 60% of the total generators.

In such a context what may happen is that the dominant operator may set up prices at a very low level in the off-peak period causing the competitors not to enter the market or gain a steady market quote, on the other hand, since during the peak hours most of the demand has to be satisfied only using the dominant agent who may easily set up a very high price with the aim of covering most of their marginal cost and maximize profit.

The aim of this work is to study a way to avoid the presence of a dominant agent by imposing some trading behavior and/or Market Authority control that may guarantee a correct functioning of the spot market and the correct price formation. A timely monitoring of price dynamics may represent the initial requirement for the creation of an electricity spot and futures market

The idea of imposing a price limit on the daily changes that a single contract price may experience in order to avoid the manipulation of the

dominant agent is not new in the financial markets where price limits are currently set up by the Exchanges or the Authority who regulates the markets.

The idea of imposing a price cap on electricity spot price, at least in the first years of operation, was provided by C. Wolfram (99) who performed an empirical analysis based on UK market data. She derives price-cost markups using direct measures of marginal cost and making some assumptions on the elasticity of the demand function for electricity.

Wolfram model (1999), based on the traditional economic theory, assume that a price mark-up may be set using the marginal cost for generator, this approach may provide succesful techniques in competitive markets or pseudo competitive, where the presence of several operator is fundamental for the electricity distribution. In Italy where, especially during the peak hours, the dominant agent still controls mre than 75% of demand, the collection of marginal costs for each generator may result pretty useless and not real.

#### 4.1 A simple model

As alternative to the approach provided by C. Wolfram we want to develop a market based approach aimed at analyzing the spot price dynamics and identifying some *correct* dynamics using only market data. The idea is to identify a price limit that may represent the price mark-up for the daily trading which should guarantee presence of several different operators.

Simplyfing the assumption of stochastic dynamic and stochastic volatility for the electricity spot price as described by equation (1) and assuming a constant volatility may be observed, we derive the following equation for electricity spot prices

$$dS_t = \mu dt + \sigma dW_t \quad (2)$$

Under this assumption we may assume to estimate the probability distribution,  $f(\Delta S_t)$ , of daily price changes,  $\Delta S_t$ , for each contract, and to set up a maximum price change  $\eta_t$  such that

$$\eta_t = \inf \{ \eta | f(\Delta S_t, \eta) > \beta \} \quad (3)$$

where

$$f(\Delta S_t, \eta) = P \{ S | \Delta S > \eta \} \quad (4)$$

According to the shape of the probability distribution we may set up an upper change limit,  $\eta_u$ , and a lower change limit,  $\eta_l$ , to apply to price increases or price reductions:

$$\begin{aligned} {}_u S_t &= S_{t-1} + \eta_{ut} \\ {}_l S_t &= S_{t-1} + \eta_{lt} \end{aligned} \quad (5)$$

that prices may experience in a trading day. In order to avoid the manipulating behavior of the dominant agent Market Authority may use these price

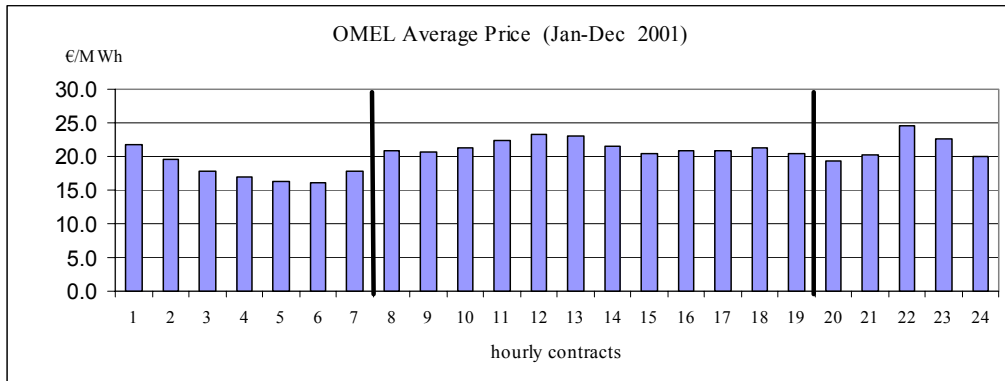


Figure 1: Average Price over the period Jan-Dec. 2001. Spanish Electricity Market

limit to monitor the correct behavior of prices. In order to estimate the current price limit we need to estimate the empirical probability distribution for the observed spot prices.

Assuming a parametric distribution (i.e., Normal, Fisher, Gamma...) may be assumed the change limit  $\eta_t$  may be easily obtained using the appropriate inverse formula for the distribution given by (3).

## 4.2 Validation of the model

Using European spot electricity data for the last two years we analyzed the features and the behaviour of the markets which undertook the deregulation process and to-day provide a very interesting example of well functioning futures+ spot market.

We collected daily prices for the Nordpool, the Spanish and the Deutsche market. For each market we obtained daily prices for each hour contract that is exchanged. We had daily data from January 2001 to December 2001 for each of the 24 contracts available every day. The contracts to exchange electricity from 8:00 p.m. to 7:00 a.m are considered "off peak" contracts while contracts from 8:00 a.m. to 7:00 p.m. refer to *peak* load period.

We analyzed the price dynamic and volatilities for each contract for the three markets, after testing each financial time series for stationarity by the Unit Root test. Spot prices,  $S_t$ , resulted  $I(1)$  while price differences,  $\Delta S_t$ , are stationary so we could analyze the distribution features of price changes.

Average prices and volatilities for the period January- December 2001, for the three markets are described in figures 1-6.

It is interesting to notice how for the Scandinavian market, Nordpool, as well as the Deutsche market, EEX higher average price and corresponding

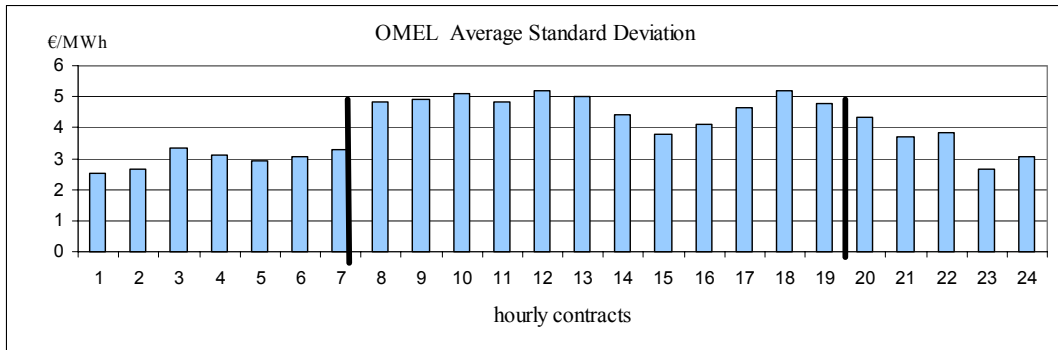


Figure 2: Average Standard Deviation for the period Jan.-Dec. 2001. Spanish Electricity Market

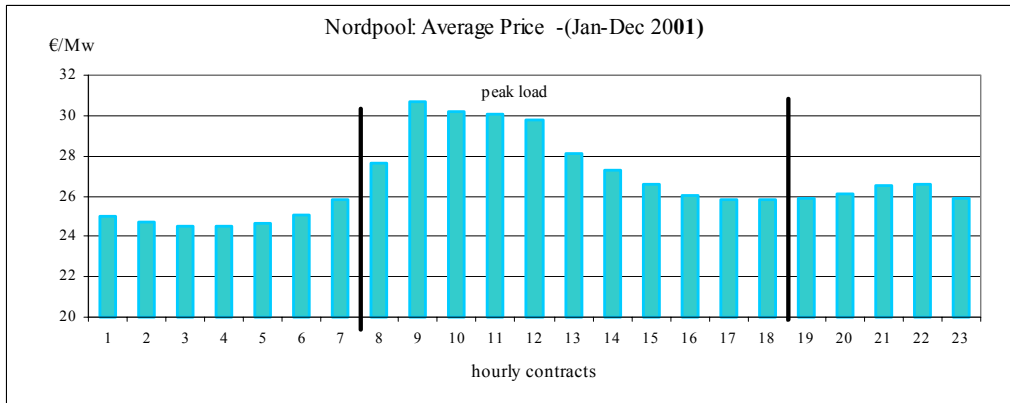


Figure 3: Average Price for the period Jan-Dec 2001 for the Scandinavian Market

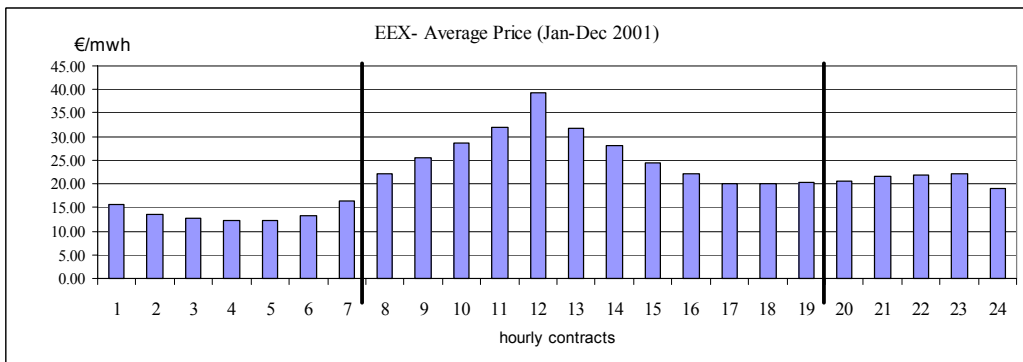


Figure 4: Average Price for the period Jan-Dec 2001 for the Deutsche Market

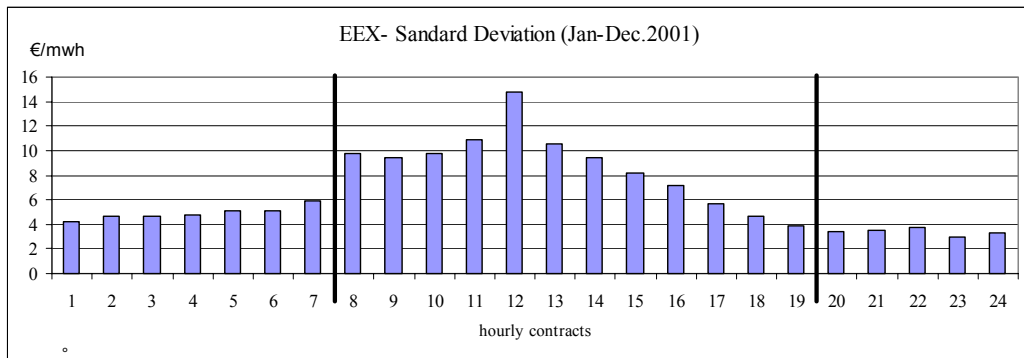


Figure 5: Standard Deviation for the period Jan-Dec 2001, for the Deutsche Market.

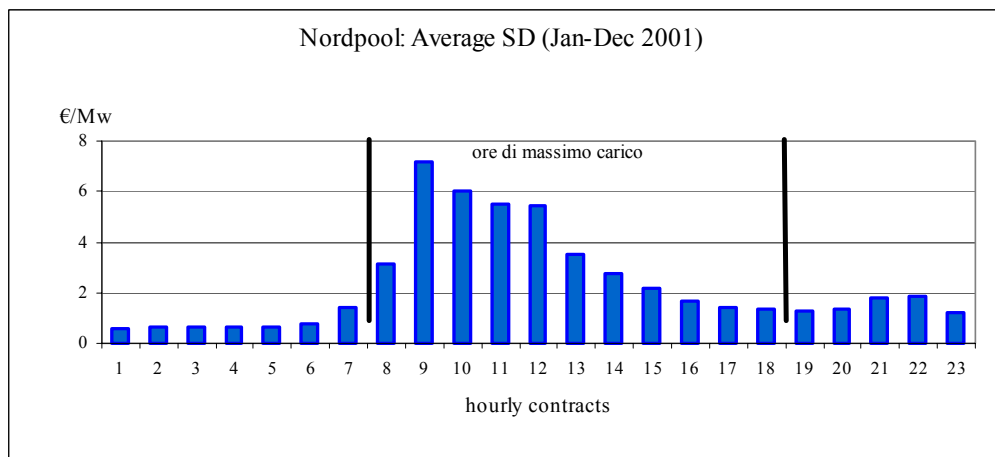


Figure 6: Standard Deviation for the period Jan-Dec 2001, for the Scandinavian Market.

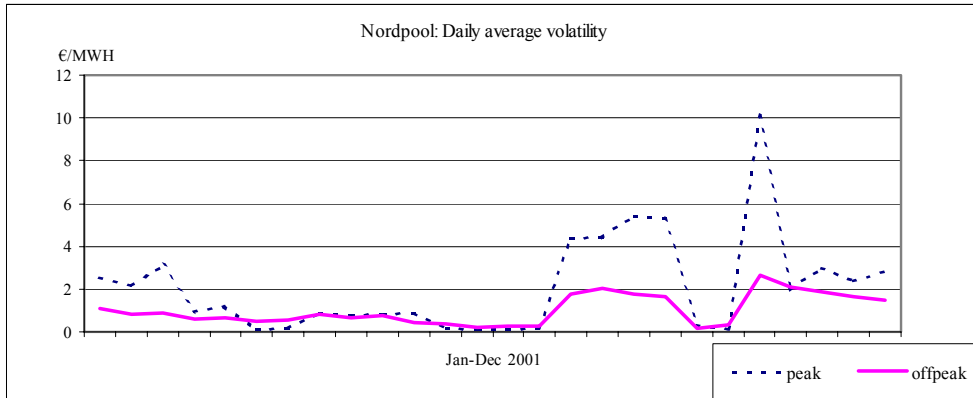


Figure 7: Daily Volatility: Peak hours vs Off peak hours. Scandinavian Market.

higher volatility can be observed during the period of **peak** hours while lower volatility and average price are typical of the **off peak** period. This is to confirm how in markets who have a higher liquidity and competition higher volatility has to be realized during the period of higher requirement, witnessing the presence of a large number of agents who may provide different prices for the consumers or distributors. On the other hand, prices and volatility for the Spanish market, which is well known to operate in a oligopoly context, seem to have a steady average and volatility to confirm the absence of a competitive system.

A different way to look at the volatility performance is to compute the average monthly volatility of prices during peak hours and off-peak hours, as it is shown in Figure 7. The picture describes the price behavior for the Scandinavian market and once more it shows higher average volatility during the peak hours.

The analysis of the price features support our assumption that well functioning of the spot market may be revealed by the price and volatility dynamic so an attempt to capture a correct price limit using price distribution may result a succesful tool.

### 4.3 Price limits estimation

Given the daily price changes for each of the 24 contracts of each electricity market we first analyzed the possibility that a parametric distribution, i.e.a Normal distribution, may succeed in correctly describing the price features of these markets. Disnormality tests for each of the series were run and the results show the presence of symmetric distribution, for some of the contracts we examined, precisely the 9:00 a.m contracts and the 10:a.m. contracts.

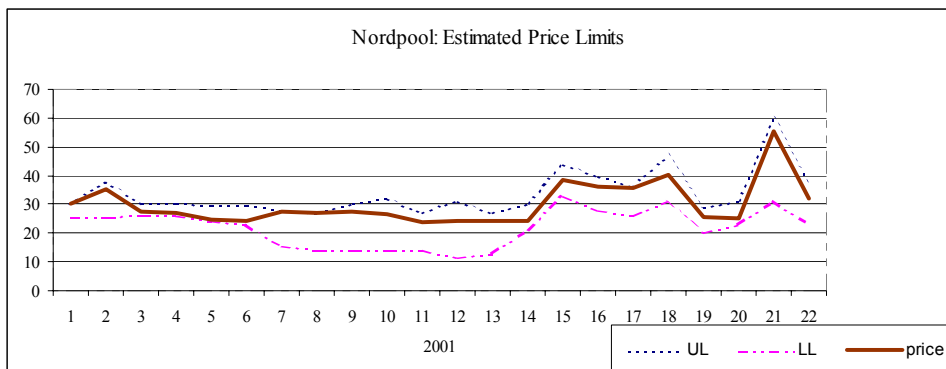


Figure 8: Estimated price limits for the 9:00a.m contract;  $\beta = 0.9$ .

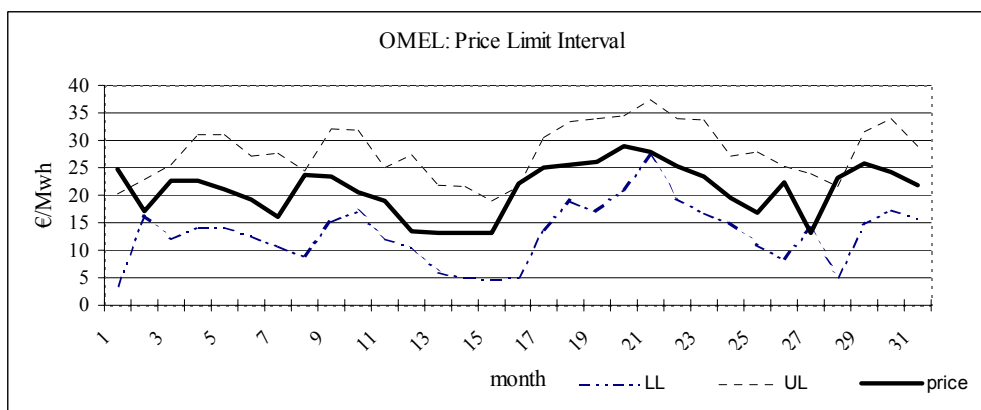


Figure 9: Estimated price limits for the 9:00a.m contract;  $\beta = 0.9$ .

The other contracts show very little symmetry. As far as for the kurtosis index most of the contracts show a value of the index far from the theoretical value of 3 with the exception of the 9:00 a.m. contracts which allow us to accept the Hypothesis of normality only for this contract.

A first attempt to estimate the price limits according to expression (3) using as probability distribution the Normal distribution is performed using the 9:00 a.m contracts data and a confidence level  $\beta = 0.9$ . The band obtained for the three examined markets is shown in Figures 8-11.

It is worth to notice that the assumption of Normality and a confidence level of 90% is not a too restrictive assumption, market price seems to correctly behave within the estimated band and no intervention from the Authority seems to be required for the period we considered.

The results we obtained refer to a very simplified assumption of normal

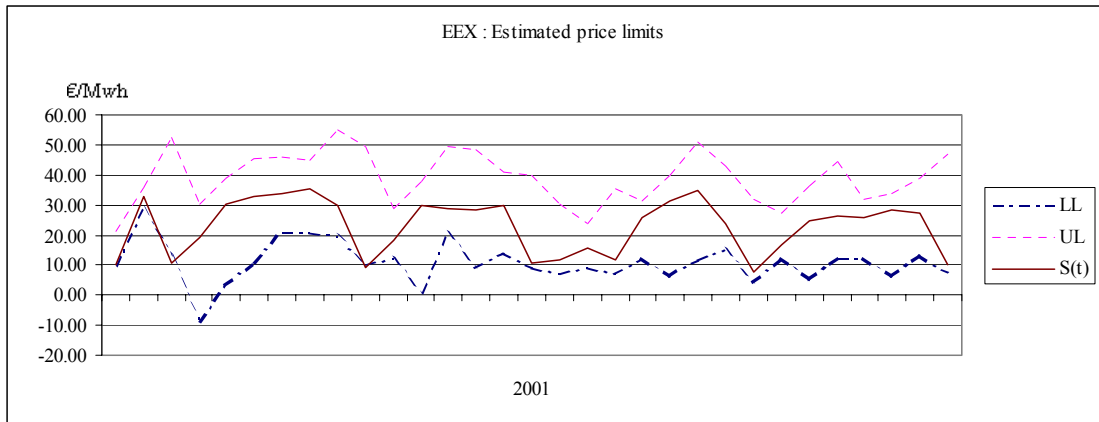


Figure 10: Estimated price limits for the 9:00a.m contract;  $\beta = 0.9$ .

probability distribution of price changes, assumption which does not seem to be confirmed for most of the price series we analyzed, at least according to the current disnormality test. Even under this simplified assumption the estimation of a price changes band where the market price may freely fluctuate and the market Authority may decide to intervene only when the market price exceeds the upper or the lower limit.

An estimation of the empirical probability distribution may provide a correct definition of the band for the market price and may be adopted by Market Authorities to monitor the well functioning of the market in order to avoid manipulation performed by the dominant agent.

The aim of further research is therefore to estimate the probability distribution for the hourly electricity contract of the three European markets who are currently operating in a deregulated context.

## 5 Conclusions

The crucial issue for the development of well functioning derivative markets is represented by the existence of a well regulated and competitive spot market. At present the main electricity Italian producer and distributor, the ENEL, plays the role of dominant agent owning 75% of electricity supply during the peak hours. This may cause excessive price volatility or no volatility at all threatening the success of the spot market as well as of the related derivative market. In this paper we provide a simple model to monitor price dynamic during each day of trading and set up a "price limit" that may represent a useful tool for Market Authority aimed at avoiding manipulation of a dominant agent. The model is tested using market data for three European Electricity spot markets under simplifying assumption concerning



the probability distribution of price changes, i.e. Normal distribution. The results obtained support the assumption that this model may be adopted during the initial operating of the spot market by Regulatory Authority to guarantee a correct functioning of the spot market aimed at stimulating the development of a derivative market.

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