EFFECTS OF LIBERALIZATION IN SPANISH ELECTRICITY MARKET: A SIMULATION MODEL

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SUMMARY

The creation of a wholesaler market of electricity generation is settled as the central element of the new liberalized electricity systems. Such market functions, in the majority of the countries, by means of a mechanism of competitive auctions with the consequent seeking of efficiency. However, the international experience has shown that generators can develop a conduct based on strategic behaviour as a consequence of the basic characteristics of the electricity industry. In this sense, the formation of two possible strategies by generator enterprises, whether hiding output whether increasing the selling price of marginal output, were observed in some territories, such as California, United Kingdom or PJM market, The objective of our paper is to analyze the formation of strategies in the Spanish electricity pool by means of the creation of a simulation model. The results show the execution of market power by the principal electricity companies because their production is indispensable, in many time periods, to supply demand. Because of this situation it is indispensable to change the industrial structure which is being actually treated in the Spanish White Book of Electricity.

RÉSUMÉ

La création d'un marché-grossiste de production d'électricité est arrangée comme élément central des nouveaux systèmes libéralisés. Un tel marché fonctionne, dans la plus part des pays, par moyen d'un mécanisme des enchères concurrentielles avec la recherche de l'efficacité. Cependant, l'expérience internationale a prouvé que les générateurs peuvent développer une conduite basée sur le comportement stratégique à la suite de les caractéristiques proares de l'industrie de l'électricité. Dans ce sens, on a observé la formation de deux stratégies possibles par des entreprises génératrices, (si cachant le output, si augmentant le prix de vente du rendement marginal de output), dans quelques territoires, tels que la Californie, le Royaume-Uni ou le marché de PJM. L'objetive de notre papier c'est analyser la formation des stratégies dans le pool espagnole de l'électricité grâce à la création d'un modèle de simulation. Les résultats de lui montrent l'exécution de la puissance du marché par les principales compagnies de

l'électricité parce que leur production est indispensable, en beaucoup de périodes de temps, pour fournir la demande. Avant que cette situation soit indispensable pour changer la structure industrielle qui est traitée réellement dans le Livre Blanc Espagnol de l'électricité.

1. THE CREATION OF THE SPANISH ELECTRICITY MARKET

The production of electricity energy in Spain, before to liberalization, was based on a system of "merit order" which supposed that the regulator determined what installations had to function to supply demand in every time period. Likewise, the retributive system of electricity companies was a regulator mechanism *cost plus* which established the settling of a price which allowed to cover the service cost of the electricity enterprises and a return rate. In this context, electricity enterprises had incentives to secure the electricity supply in all time periods (Calero, 1999). However, Law 54/1997 of Spanish Electricity System establishes the legal base to implant a new electricity system whose central item is the creation of an electricity wholesaler market. The price settled in such a market determines the remuneration of the electricity enterprise.

The definition of the Spanish electricity pool is established in Royal Decree 2019/1997 of 26 December. It considers such a market as the joint of purchase and sale trade transactions of energy related with the electricity energy supply. The electricity market began to function the first of January 1998 where every day is shaped in twenty-four hourly periods. For every one of them, generators determine the amount and price offered for every generation unit. Similarity, the qualified[1] consumers realize their purchase offers determining the required energy amount and the maximum prices that they are ready to pay. In this context, OMEL, this is, the organization which controls the economic management of the system, sorts the sale offers by means of a criterion of upward prices and the purchase offers by means of a criterion of downward prices. The cut point between both curves determines the marginal price, this is, the price which remunerates all dispatched generator units[2].

The last objective of the pool is to introduce competition in the generation activity with the consequent effect over electricity prices. However, this organization of wholesaler electricity markets, based on an auction mechanism, has been object of important criticisms because of the electricity pool prices fixed in some countries has been higher than the expected values (greater than marginal costs of generators) (Wolfram, 1997; Borenstein y Bushnell, 1999; Apt, 2005). The explication of this situation has been based on various factors such as the market structure, a low elasticity of demand or the presence of a residual demand.

So, after liberalization, some countries have continued with a *high concentration in the industrial structure*. In the case of the Spanish electricity system, from a view point of its vertical structure, legislation does not demand a separation of ownership between activities but it only establishes an account separation between competitive and not competitive activities. The situation becomes worse from the view point of horizontal

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[1] All consumers are considered as *qualified* since first of January 2003, this is, they can chose the electricity cenprise that supplies electricity to them and so participate in an active manner in syhe pool.

[2] When the results of the daily market are established, other mechanisms of exchanging function because of the special characteristics of the electricity industry. There is an intra-daily market which realize the necessary adjustments to the daily results in plenty of time and the introduction of competition in the processes of technical operation to maintain the necessary supply between the offer an the demand (complementary services and detour management) (Rodríguez, 2001).

structure due to Law 54/1997 does not pick up this aspect. In this sense, in the year 1996, a process of horizontal concentration is developed which supposed that the two principal generator enterprises –Endesa and Iberdrola- control around 70% of pool with the consequent difficult to increase the competition.

A second problem is derived from the *low elasticity of the demand*. In this sense, after liberalization, the majority of the clients have preferred to continue with tariff. Besides, the distributors, this is, the principal buyers in the pool, realize their purchase offers at a low price with the objective of guaranteeing supply to the end consumers.

Finally, a last problem is the presence of a *positive residual demand* in the Spanish electricity system. In this sense, the generation capacity of Endesa and Iberdrola is indispensable to supply the demand, this is, these electricity companies have a positive residual demand. Therefore, during such hours, such enterprises can fix the price that they wish in the pool and the rest of electricity companies behave as price-acepters.

2. APLICATION OF SYSTEM DYNAMICS IN THE SPANISH ELECTRICITY MARKET

We have chosen System Dynamics as the methodology employed to design Spanish electricity pool because it can proportionate a global comprehension of generation activity in the new market situation. In this sense, the electricity generation system is characterized because all of its components are extremely related, so the use of this kind of simulation seems to be suitable to obtain a global point of view about the new competitive framework (Grobbel, 1999). Moreover, System Dynamics is considered a strategic tool to analyze companies that suffer important changes. This implies high uncertainty and risks as in the case of the electricity industry (Dyner and Larsen, 2001).

Our model has the objective of analyzing the strategies that generator enterprises follow in the settling the pool price, this is, we study if such a market is competitive or if a non-suitable behaviour has been developed. Specifically, we realize a simulation for the years covered between 1999 and 2004. In this sense, we exclude the first year of functioning of the Spanish electricity pool because the strategies developed in it have been more close to a strategy of trial and mistake. Likewise, we only have modeled the daily market because it is representative of the functioning of the pool. So, the daily market develops more than 95% of energy transactions and more than 80% of the economic volume of the transactions (González and Comendador, 2002).

In the simulation model, we analyze the principal companies in generation activity, this is, Endesa, Iberdrola, Unión Fenosa and Hidrocantábrico. We have also considered the sale of the filial Viesgo realized by Endesa to Enel Group in 2001 and the entrance of Gas Natural in the year 2002.

So to determine the strategies of offered prices and amounts realized, we have grouped the generator units in function of the technology that they use because they have the same cost structure with independence of the enterprise that they belong to. With this criterion, our sample is shaped by 125 generator groups: 44 coal plants, 30 fuel-gas generator unit, 27 hydraulic plants, 19 nuclear plants and the last seven are combined cycles.

After the realization of various interviews with experts of the electricity industry, we introduce the policies in our model. With regard to the *offered amount of electricity,* we establish a criterion based on the available capacity of the generator plants in the time period which they present their offers. In this sense, Law 54/1997 establishes the obligation of generators to offer all their available capacity. So to determine such

amount, we have identified the generation capacity of each production technology and we have subtracted the average unavailable by breakdown and maintenance programs published by the System Operator (see diagram 1).

DIAGRAM 1. RELATIONSHIPS BETWEEN THE PRINCIPAL VARIABLES IN THE POLICY OF OFFERED PRICE
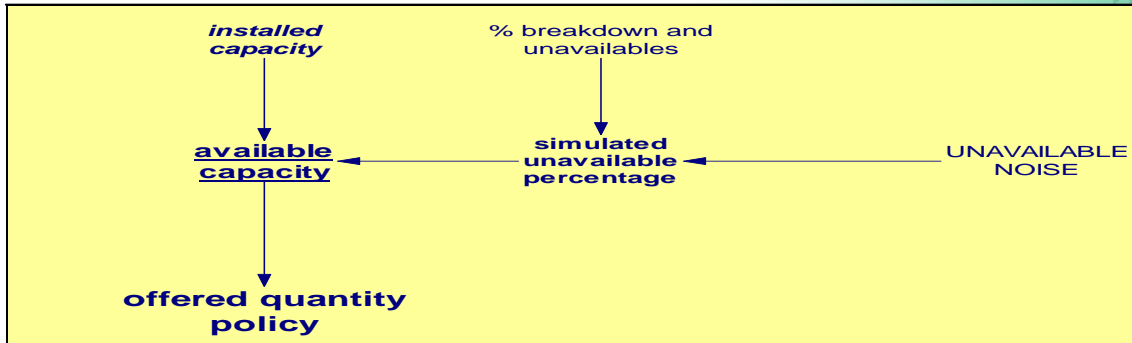
With respect to the *offered price of electricity,* it is established as the variable cost plus an increase of the fix costs which allows to recuperate the investments realized by the electricity enterprises[3]. However, it is necessary to consider the dilemma of the generators in the decision of such increases because if they settle high prices, it could happen that marginal price were lower and so they would not be called to produce (Wolfram, 1997; Wolak y Patrick, 2001, Ferreira *et al*., 2005; O´Neill, *et al.*, 2005). The contribution of the fix costs[4], as we show in the diagram 2, is determined as the control that an electricity company has in the pool. In this sense, when a company controls the offer excess of a market, it controls the price and so it will try to recuperate a larger part of its fixed costs (see diagram 3).

DIAGRAM 3. RELATIONSHIPS BETWEEN THE PRINCIPAL VARIABLES IN THE POLICY OF OFFERED PRICE

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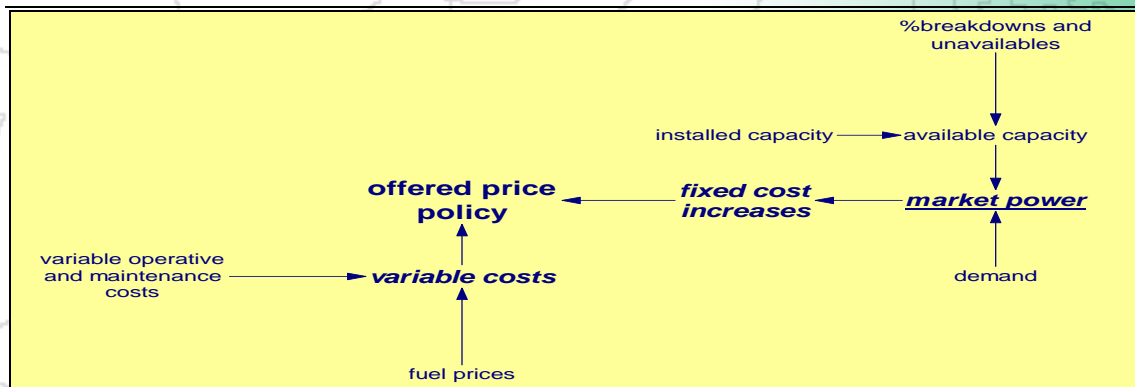
[3] The variable costs of generator plants are shaped by the fuel price and the variable part of the maintenance and operative costs. With respect to the fixed costs, they include the capital cost and the fixed part of the maintenance and operative costs.

[4] The market power is defined as the relationship between the available generation capacity of an electricity enterprise with regard to the available capacity of the industry minus the demand. If such ratio has a value minor to one, it supposes that the enterprise controls the demand of the industry and so it will increase the offered fixed costs in the pool (Grobbel, 2001).

However, it is necessary to consider the evitable cost additionally, this is, the costs that a generator plant will support if it is not called to produce in the pool. This variable is principally integrated by the costs of stating and turning off the generator unit. So, it affects specifically the nuclear plants which have high costs of this type. This situation supposes that nuclear plants realize lower offered prices compared to their variable costs or even with a value zero to secure their functioning.

With regard to demand, we consider it as an exogenous variable because, as we have commented before, it has a low elasticity. Therefore, with the objective of determining the value of demand, we have established twelve behaviour patterns which pick up the seasonality of demand. The initial values those that correspond to 1999 and we establish increases of 4% over them to adjust the real increase for the following years.

3. ANALYSIS OF THE RESULTS IN THE SIMULATION MODEL.

The results[5] show the presence of certain stability in the prices (see graph 1) when the offered prices is the marginal cost, this is the variable cost of the generator group (Rudkevich *et al*., 1998). So, when the demand is low, they have values close to 20 euros/Mwh, settled with coal plants as marginal technology. In the case of high demand, fuel-gas plants or combined cycles of gas are the marginal technologies with prices between 28 Euros/Mwh y 30 Euros/Mwh. Specifically, after year 2002 (period 864), combined gas cycles start to function which allow, in many periods of time, to supply demand and reduce price of fuel-gas plants.

However, such results show lower marginal prices with respect to the real prices of the Spanish wholesaler electricity market whose evolution varies between 20 and 55 euros/Mwh[6] (see graph 2). This difference of results establishes the necessity of including fixed costs in the offered price of the pool.

Therefore, it seems that the most relevant element in the formation of the pool price is the contribution of fixed costs which the generator enterprises include in their offers. The establishment of the limits of the percentages is derived from the own characteristics of the technologies. In this sense, technologies with higher possibility of being marginal will establish higher increases of fixed costs. However, nuclear plants or hydraulic plants without storage capacity will have incentives to realize their offers at low prices because if their offers are not accepted, the first could have functioning problems and the second will los the raw material to the electricity supply.

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[5] Following the paper of Ford (2001), we have chosen to simulate the 24 hours of a typical day of every month. The reason of such a decision is the high number of time periods which woull be generated by the model during the six years of simulation.

[6] In 2001, prices reached a value of 90 euros/Mwh. Nevertheless, this situation was derived from the breakdowns happened simultaneously in many nuclear plants and the low hydraulicity of this period. Therefore, this value is consequence of a series of random factors that are difficult to be repeated in the same way for a same time period.

GRÁPH 1. SIMULATED POOL PRICES (POLICY 1) OF THE SPANISH ELECTRICITY MARKET

PRECIO mercado diario
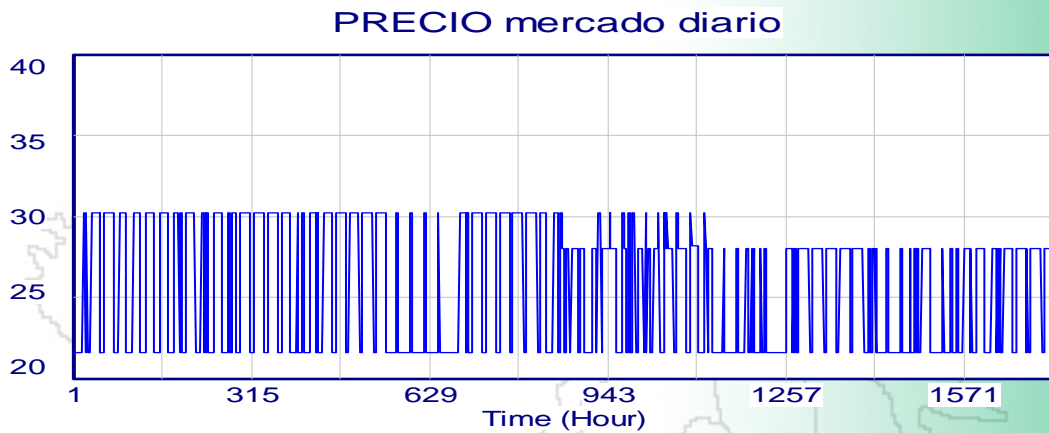
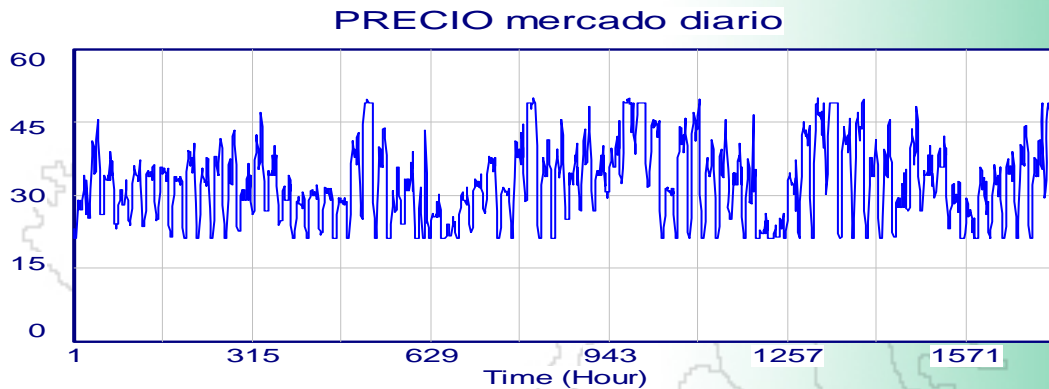PRECIO mercado diario : rldos precios ofertados igual costes marginales

GRAPH 2. SIMULATED POOL PRICES (POLICY 1) VERSUS REAL POOL PRICES OF THE SPANISH ELECTRICITY MARKET
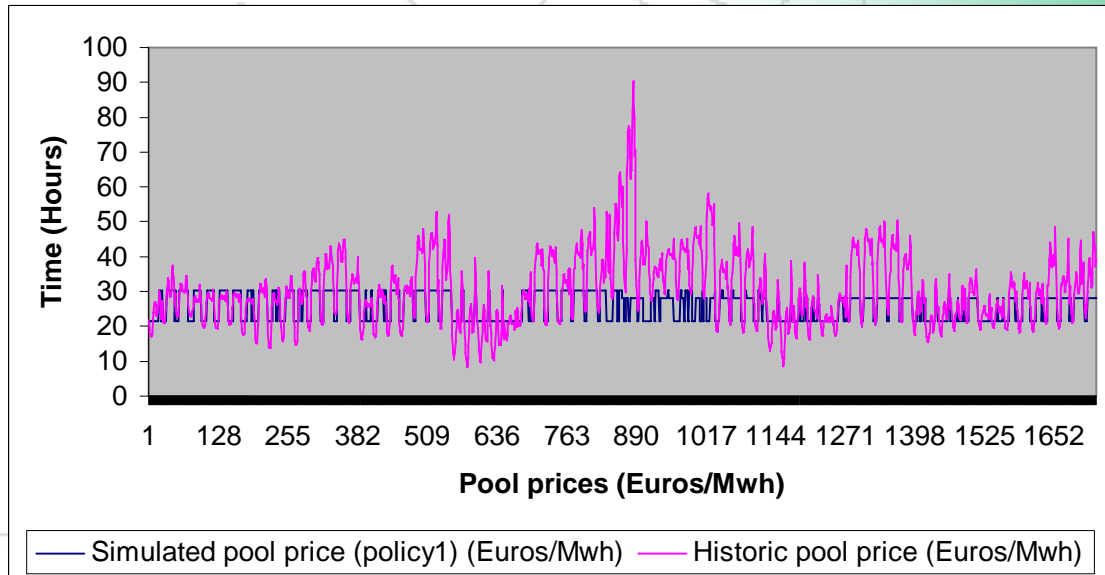
With the objective of determining the specific percentage of increase of fixed costs that will be included in the offered price, we have considered the possible exercise of market power of an electricity enterprise in the pool. In this sense, when the offer of an electricity enterprise is indispensable to supply the demand, the generator groups belonging to such company will offer the superior limit of their technology (whose values were determined before by the characteristics of the technology).

The results of the application of this new policy can be seen in the graph 3 and 4. So, we observe a pattern in which the marginal prices are more similar to the real prices respect to the previous case. In this sense, pool prices are developed between 20 euros/Mwh, marginal cost of coal plants, and 50 euros/Mwh which is higher than marginal cost of any marginal technology.

**GRÁPH 3. SIMULATED POOL PRICES (POLICY 2) OF THE SPANISH ELECTRICITY MARKET**

GRAPH 4. SIMULATED POOL PRICES (POLICY 2) VERSUS REAL POOL PRICES OF THE SPANISH ELECTRICITY MARKET
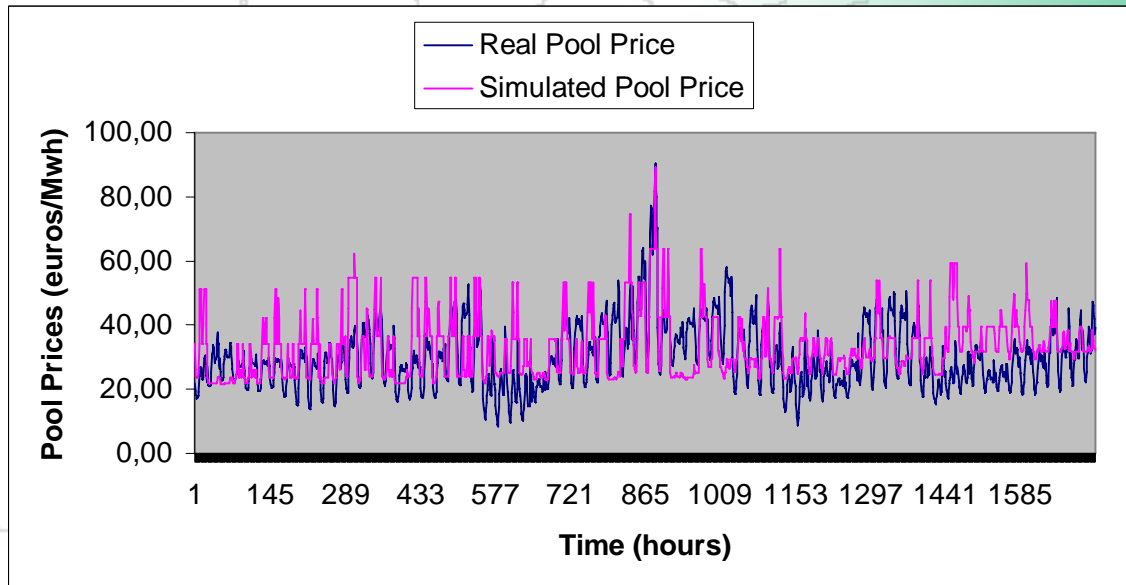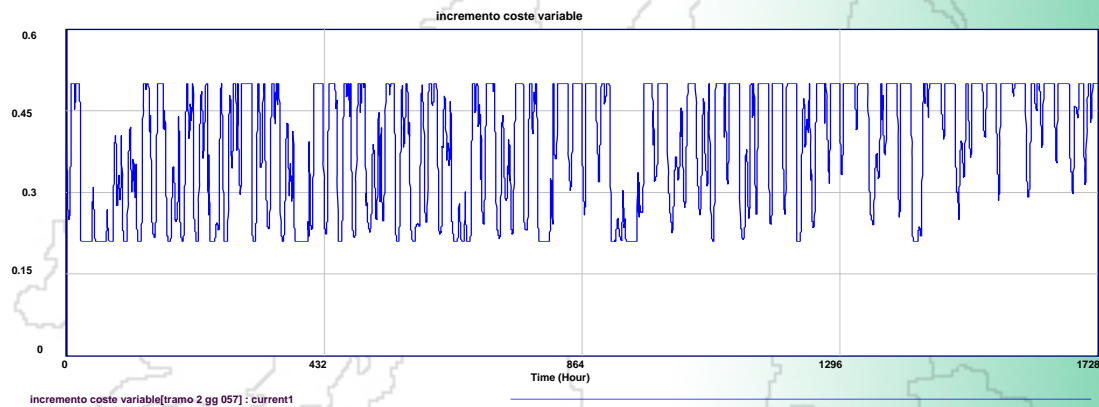

In this sense, coal plants, this is, those plants that have little opportunities of being marginal, hardly increase their offered prices except in periods of scarce offer where such offered prices increase around 3% respect to the marginal cost (see graph 5). However, we observe a totally different behaviour in the case of the fuel-gas plants. So, such plants are characterized because, in the majority of the time periods, they offer increases over the marginal costs in their offered prices except in very punctual moments (when there is shortage of demand). The increases of the fuel-gas plants, as we observe in the graph 6, have values close to 50% of their marginal costs.

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GRÁPH 5. INCREASES OF OFFERED COSTS IN THE COAL PLANTS RESPECT TO THE MARGINAL COSTS
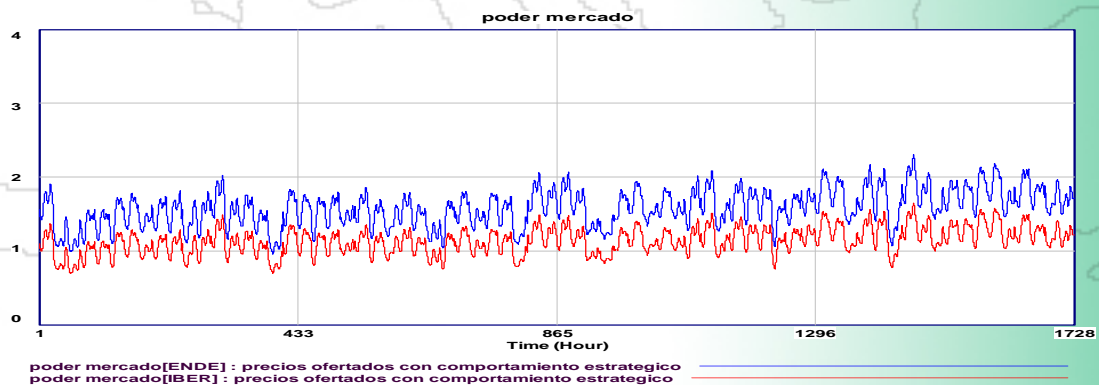
incremento coste variable

incremento coste variable[TRAMO 2 GG 001] : current1
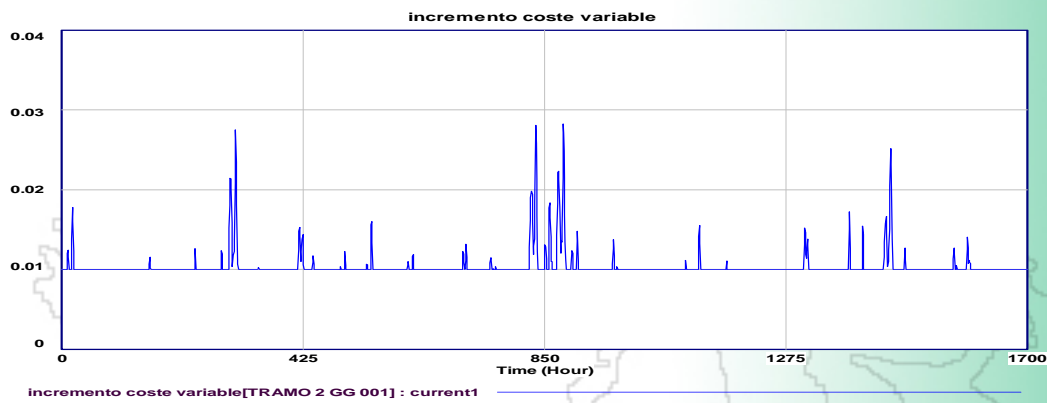
GRÁPH 6. INCREASES OF OFFERED COSTS IN THE FUEL-GAS PLANTS RESPECT TO THE MARGINAL COSTS

incremento coste variable

incremento coste variable[tramo 2 gg 057] : current1

Likewise, the evolution of market power of electricity enterprises (see graph 7) show that Endesa (blue line) and Iberdrola (red line) have always a value higher than one, this is, their production is in all time periods necessary to supply demand. This situation supposes the consequent incentive to increase the offered prices.

GRÁFICO 7. EVOLUTION OF THE MARKET POWER OF THE PRINCIPAL GENERATOR ENTERPRISES

poder mercado

poder mercado[ENDE] : precios ofertados con comportamiento estrategico
poder mercado[IBER] : precios ofertados con comportamiento estrategico

4. CONCLUSIONS

The creation of the Spanish electricity pool has the objective of increasing the efficiency of such an industry. However, a distance between the formal competition defined in the

normative framework and the industrial reality is observed. This favours the realization of strategic offers. In this sense:

➢ The 70% of the transactions are realized by only two enterprises which put in evidence that it functions following the rules of the competitive markets.

➢ New competitors have hardly entered in the electricity industry. So, the great part of the new foreseeable capacity, included the combined cycles of gas, belong to the enterprises established previously in the sector.

In this paper, we develop a simulation model, by means of the using of the System Dynamics, which allows to determine the strategies of generators. So, as to create such a model, we establish the following behaviour guidelines:

➢ Analysis of the generator groups is done with respect to the technology that they use in the production of electricity energy because they present the same cost structure.

➢ The policy of offered amount is realized depending on the available generation capacity.

➢ The policy of offered price is shaped by the variable costs and a contribution of the fixed costs which vary with respect to the market power of the electricity companies.

The results of applying such policies in our simulation model show that the wholesaler electricity market is not a competitive market due to the prices shaped in it are, in many time periods, higher than the marginal cost of the last plant called to produce. The principal reasons are derived from high inelasticity of demand and the high concentration in the Spanish electricity industry.

Therefore, liberalization is not sufficient, by itself, to guarantee efficiency. It is necessary to combine with an industrial reestructuration process which facilities such objective. In this sense, the Spanish White Book of the Electricity is being developed in Spain with the objective of proposing changes in the industry structure which can supposes a higher increase of competition in the industry.

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