"COMPUTER-BASED SIMULATION OF AUCTIONS OF OPTION CONTRACTS AND OF FUTURES CONTRACTS IN THE COLOMBIAN WHOLESALE ELECTRICITY MARKET"

Final Report – Chapter 4

Prepared for:

Comisión de Regulación de Energía y Gas (CREG)

The World Bank

M0608-P 336/01

March, 2003

Buenos Aires
Av. Leandro N. Alem 584, Piso 11
(C1001AAN) - Buenos Aires
Argentina

Madrid
C/ Orense 34, 8º
28020 – Madrid
España

Montevideo
Soriano 903, Ap. 501
C.P. (11100) – Montevideo
Uruguay

INDEX

1. INTRODUCTION 3
2. MARKET SIMULATION 3
   - *2.1. Additional Hypothesis* *3*
3. RESULTS OF THE FUTURES AND OPTIONS MARKET SIMULATION 4
   - *3.1. Conceptual Analysis of the FOM* *4*
4. RESULTS OF THE FOM SIMULATION 6
5. DEFINITION OF STRIKE PRICES AND CHARACTERISTICS OF THE OPTIONS 12
6. DOWNSIDE RISK 14
7. THE CXC VS. THE OPTIONS MARKET 16
8. SIMULATION OF TRADING ACTIVITIES 23
9. CONCLUSIONS 24
10. APPENDIX VI 26

1. INTRODUCTION

This chapter refers to tasks 3.4 and 3.5 of the Terms of Reference which included both the Market Simulation of Option Contracts on Firm Energy and the Simulation of Futures Contracts Market. As mentioned in Report No. 2, some reorganization of the tasks included in the Terms of Reference was made to consider the following facts and features of the options and market simulations:

- It is not convenient to simulate the options and futures markets separately. If prices of financial instruments in these markets are not consistent, arbitrages will force consistency. Therefore tasks 3.4 and 3.5 of the Terms of Reference were worked jointly, and results and conclusions drawn for both markets.
- The simulation of markets with financial instruments' different duration is not relevant. All the information can be obtained with semester or annual simulations that can be extended to longer periods of time.
- In any case it is essential to characterize the risk aversion of market participants since that is precisely what is exhibited when trading in options and futures markets.
- For the characterization of market participants' risk aversion it is necessary to estimate their utility function and statistical distribution of revenues and costs. As there is no information available on such issues, it was necessary to estimate this information, based on international experiences.
- Estimating the effect of the existence of an options and futures market on new investments in generation required an special effort. One of the main objectives of these markets is to reduce risk for investors. Therefore, chapter five of this report addresses this issue.
- We received some CREG requests to develop specific subjects, also included in this report.

To organize the market, we consider necessary to explain several questions and doubts about its functioning. All the concerns about operation of the market were analyzed and specific recommendations issued to surmount such concerns.

2. MARKET SIMULATION

2.1. *Additional Hypothesis*

In Report No. 2 the formulation of the model for simulating the futures and options market (FOM) was presented as well as some application examples.

For this Final Report, the formulation of the model was improved, and some comprehensive series of simulations were completed. Under the hypothesis suggested, specific data were obtained regarding how the model would perform in this market.

To simulate the performance of the FOM, we considered necessary to take into account a larger number of participants. With this objective in mind, the following hypotheses were devised:

- The sellers are all the power generation units that operate in the wholesale market, presenting bids individually, each one with a particular risk profile,
- The buyers are the "last resort suppliers" (LRS) and traders who buy energy in the wholesale market to supply deregulated users, interested in hedging risks.
- Some typical demand profiles were considered for the buyers. Based on these demand profiles, the costs associated to the operation in the spot market for purchases and non hedged sales were estimated.

Appendix VI shows some figures with data corresponding to the power generation units which were used in the simulation. Also shown are the load profiles taken for each type of load. It was assumed that the LRS buy financial options for hedging separately from their base load, off-peak load and peak load.

Value estimations for options for participants without risk aversion were carried out for performance variables in 1 year, 2 year and 5 year periods. For each one of these performance periods we simulated the operation of the FOM. Different alternatives of risk tolerance were then analyzed for market participants and also of spot price uncertainty projections . The results of these simulations are presented below.

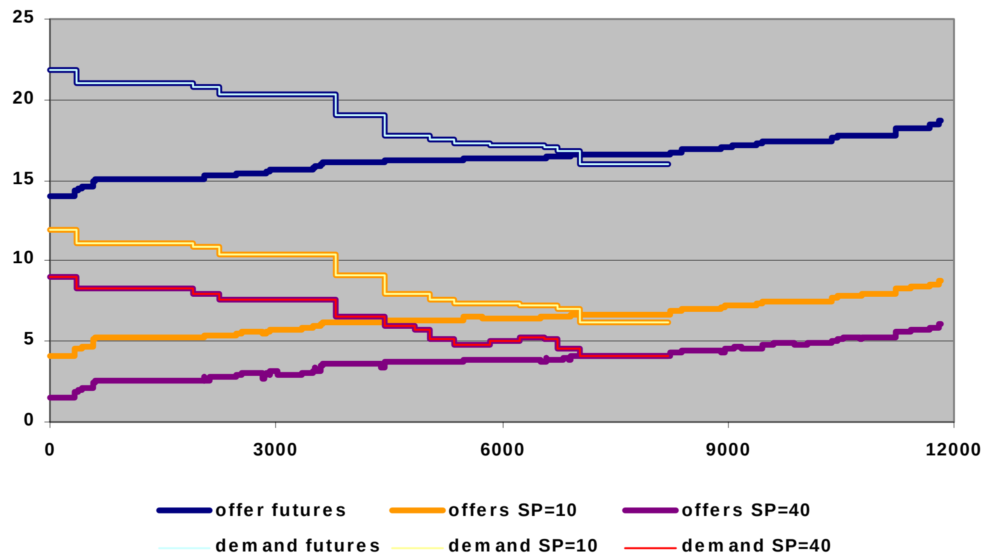
3. RESULTS OF THE FUTURES AND OPTIONS MARKET SIMULATION

▪ *3.1. Conceptual Analysis of the FOM*

Before presenting the results of the FOM performance simulation, it is important to analyze how the market clearing is produced. Graph 4.1 shows the curves and prices of accumulated bids of sellers and buyers for the futures and options. To simplify, it is generally considered that futures are equivalent to options with strike price equal to zero.

Results are presented for market participants' risk tolerances in ranges from 100-2000.

Graph 4.1 Supply and demand for different strike prices

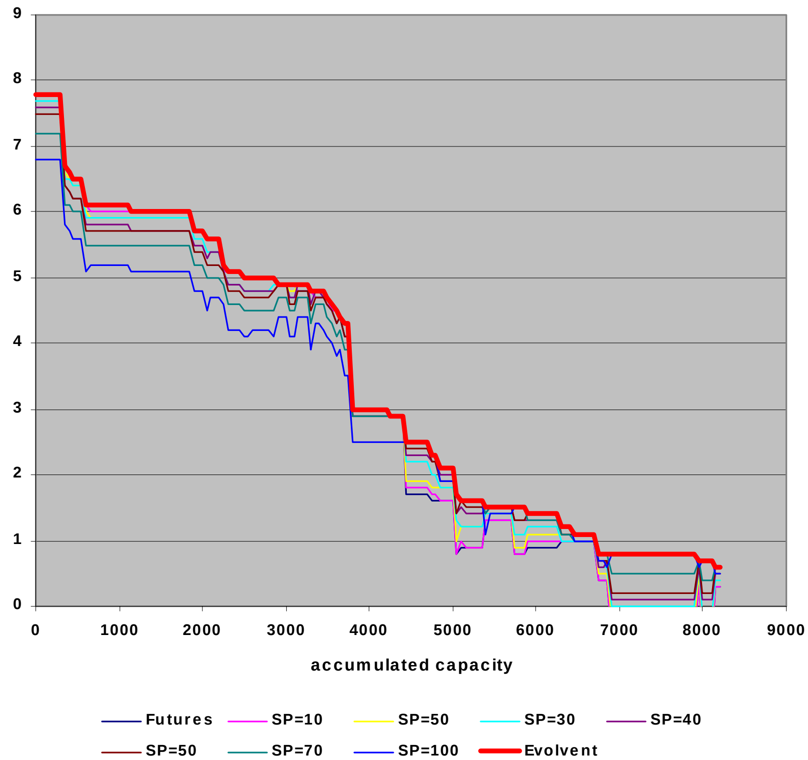


If the option types were the only product available for trading, the intersection of the supply and demand curves would provide the clearing price. But having several products with a simultaneous clearing, the amount of options for each strike price that is sold depends on its contribution to the maximization of the social welfare.

In order to understand how the market would operate, we prepared, graph 4.2 following the next steps:

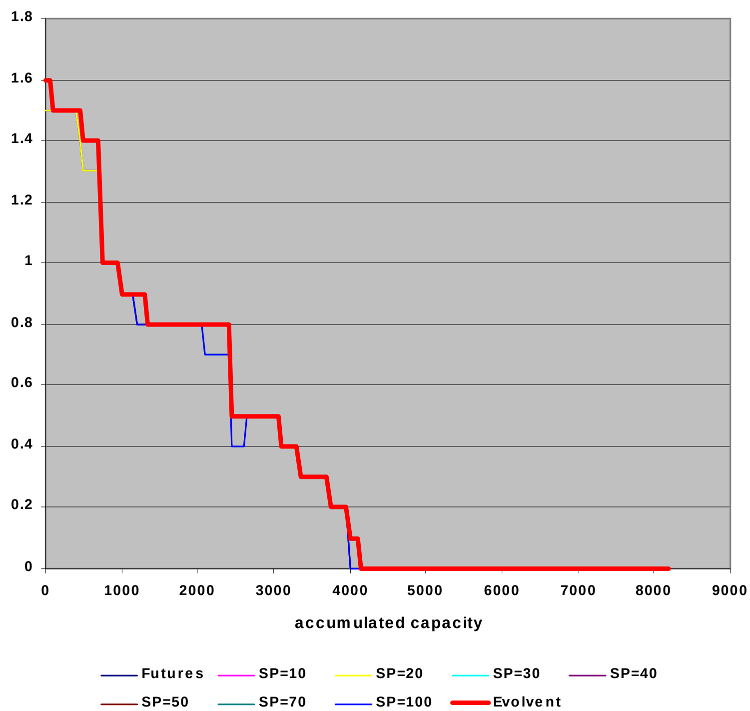
- For each type of option (strike price), we prepared a curve that represents the difference between the price offered by each demand side participant, and the bid of each generator.
- The differences were then ordered from greater to lower values.
- We then took the highest value every 10 MW of demand, and assuming that the difference remains constant within that interval, we built the curve.
- Once these curves were prepared for all the options, we built the envelop of all the curves.
- The social welfare function or gross benefit is equal to the integral between the supply and demand functions. Thus, the envelop represents the maximum welfare that is achievable in function of the capacity traded.

Graph 4.2 Accumulated social welfare for each option strike price



It is interesting to compare this Graph with a similar one, but with much greater risk tolerances (in the range 20,000 – 200,000) that is, to say for the case that all market participants are hardly compelled to pay in order to obtain a reduction in the volatility of their revenues-costs.

Graph 3.3 Accumulated social with high risk tolerance



Compared to the previous Graph, two significant changes may be observed,:

- The social welfare (understood as the integral between the supply and demand functions) decreases more than ten times. This happens given that if there is a great risk tolerance of most of the market participants, they will not be interested in obtaining risk hedging. They will not care whether to operate in the spot market or to buy options, as long as their revenues-expenses are the same.
- The social welfare is nearly the same for all the option alternatives. This is related to the lack of interest in obtaining risk hedging. Only those participants with higher risk tolerances would be interested in participating in these markets. It should be highlighted that the model generates clearing prices with no possibility for arbitrage. In a real market it seems probable that the participants will have possibility for arbitrage or of making a good use of information asymmetries that will lead them to participate of operations, OTC generally speaking.

4. RESULTS OF THE FOM SIMULATION

As a first step, we carried out an analysis of the influence of the risk tolerance of the market participants on the quantity of transactions in the market and on the clearing price. Therefore, a series of simulations with different risk tolerances and uncertainties in the projection of prices in the spot market were executed.

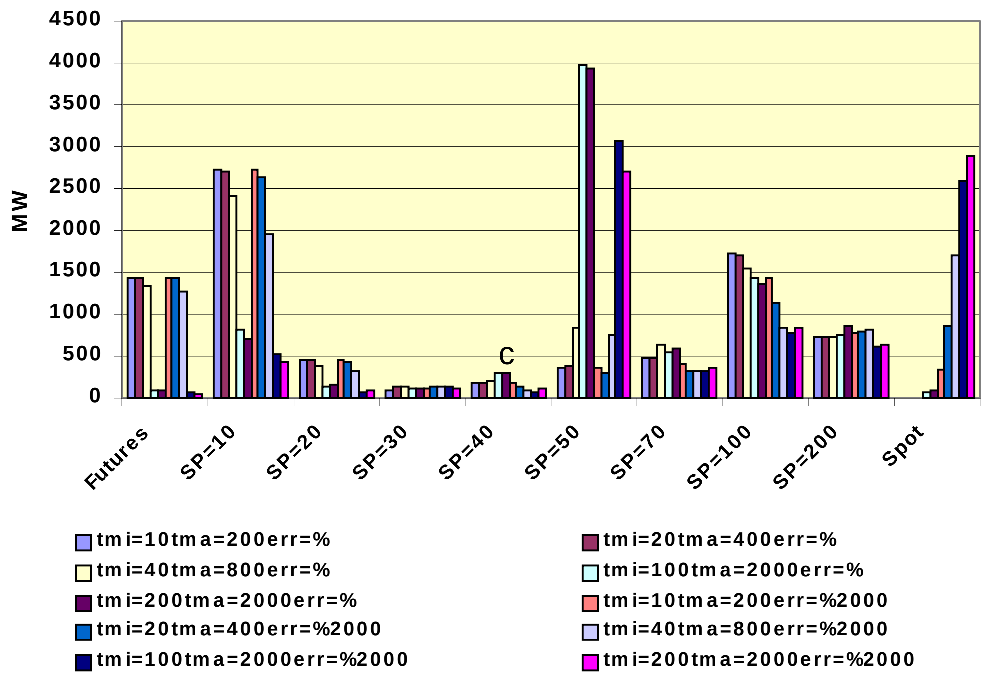
For each range of risk tolerance values (tmin, tmax) and standard deviation of the price estimation of the spot market (DSP), there were 40 randomly generated series of risk tolerance values tk in the range tmin < t < tmax for each participant. The following were the different alternatives analyzed:

Alternative	tmin – tmax	DSP (%)
1	10 – 200	0.
2	20 – 400	0.
3	40 – 800	0.
4	100 – 2,000	0.
5	200 – 2,000	0.
6	10 – 200	20.
7	20 – 400	20.
8	40 – 800	20.
9	100 – 2,000	20.
10	200 – 2,000	20.

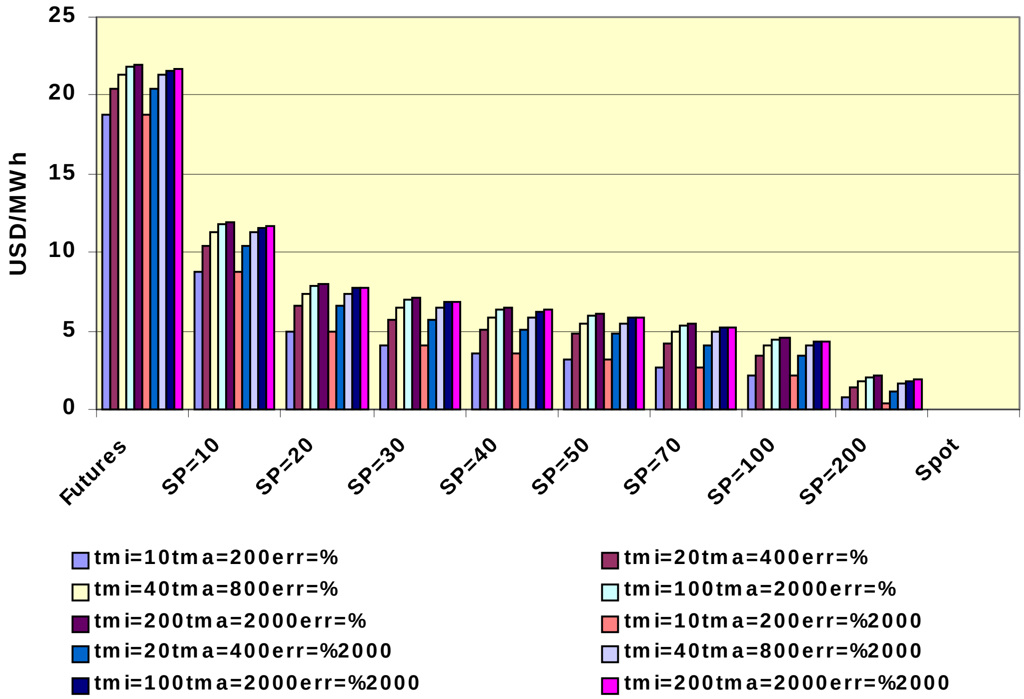
A brief summary of the results obtained is shown below.

Graphs 4.4. and 4.5 show the results for the case of options with a performance period of 5 years, which were calculated between January 2004 and December 2008.

Graph 4.4 Quantities traded – performance period 5 years



Graph 4.5 Market clearing prices performance period 5 years



Some trends that match expectations can be proved:

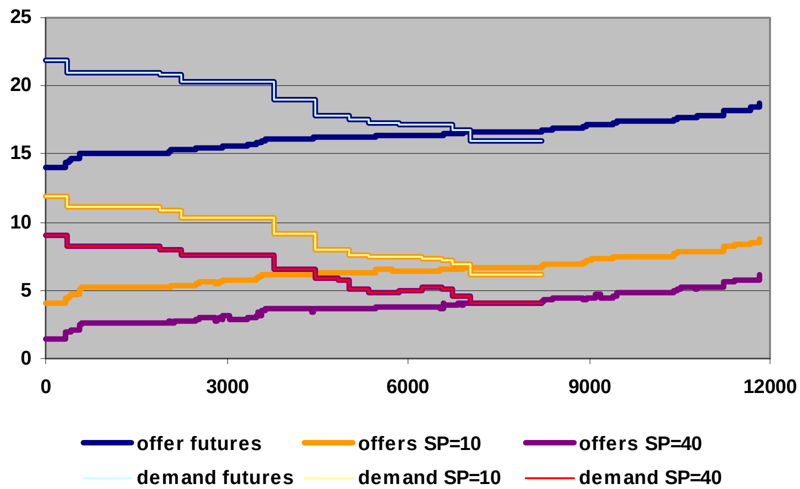
- As the risk tolerance of participants decreases, an increase is observed in the trend to hedge risks with a larger number of operations in the markets of futures and options with low strike price.
- A significant concentration of transactions with futures and options with strike price 10 USD/MWh, for low risk tolerances (with average t in the range 50-200), can be observed, while for the risk tolerances in the range 200-2000, the greater number of operations is for options with strike price of 50 USD/MWh.
- Regarding the impact of uncertainty in the spot price projection, results show that neither clearing prices nor quantities traded are significantly influenced
- A decreasing trend can be observed in the clearing prices when the risk tolerance is reduced. Such common feature will be analyzed further on, since originally it was not expected that the clearing prices would result meaningfully different to the options price for participants with no risk aversion.

When analyzing the buyers' volatility , we can observe that in the cases of demand with a significant participation of energy purchases in peak hours, i.e. profiles 2, 3, 4, 5, 7, 8, 9 (see illustration I.2 of the Appendix VI of this chapter) the volatility decreases as options with greater strike price are considered. The reason for this decrease is because this type of consumers take a seller position through a very significant period of time. Thus, when their sales exceed their purchases, the fact of taking a position in options increase (rather than decrease) the volatility of their spot market transactions.

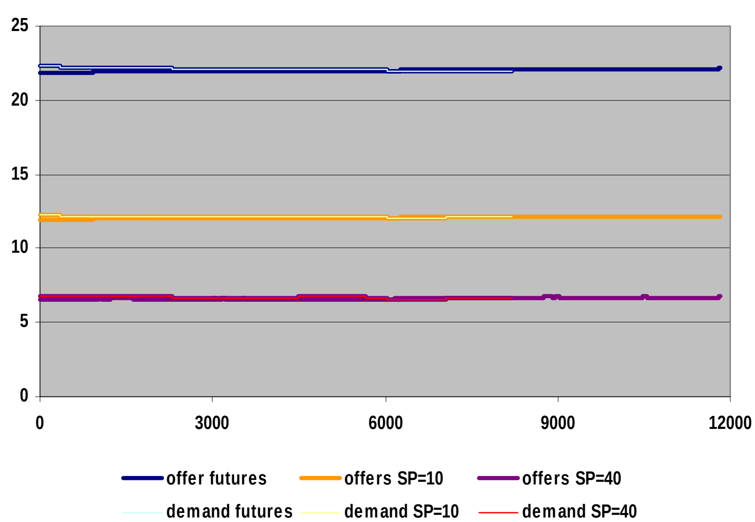
Therefore, when this type of consumers have a low risk tolerance it is necessary to reward them if they are to buy options. This explains why in those alternatives with low risk tolerance the clearing price decreases as the mentioned tolerance declines. Mathematically, this happens because the volatility for a specific strike price is greater than for an exclusive operation in the spot market. Hence, to accept the purchase of options, this type of consumers should be offered a lower price than that corresponding to the operation in the spot market.

In the following graphs we present the curves of bids for those cases of low risk tolerance (10-200) and high risk tolerance (1000-2000). The different shape of the demand curves can be observed. While for high risk tolerances the curves are practically horizontal and the clearing price is the equivalent to the spot price, for low risk tolerances a fall of the bids below the spot price is observed. This drop is associated to those consumer participants who are still in a selling position and whose volatility increases when buying options.

Graph 4.6 Offers and bid curves for participants low risk tolerance

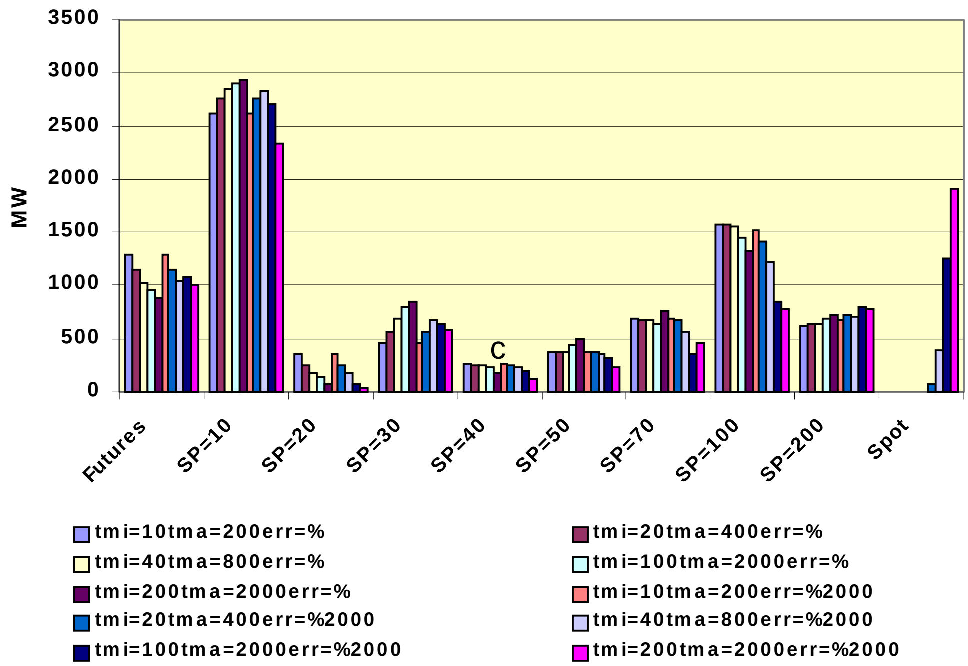


Graph 4.7 Offers and bid curves for participants with high risk tolerance

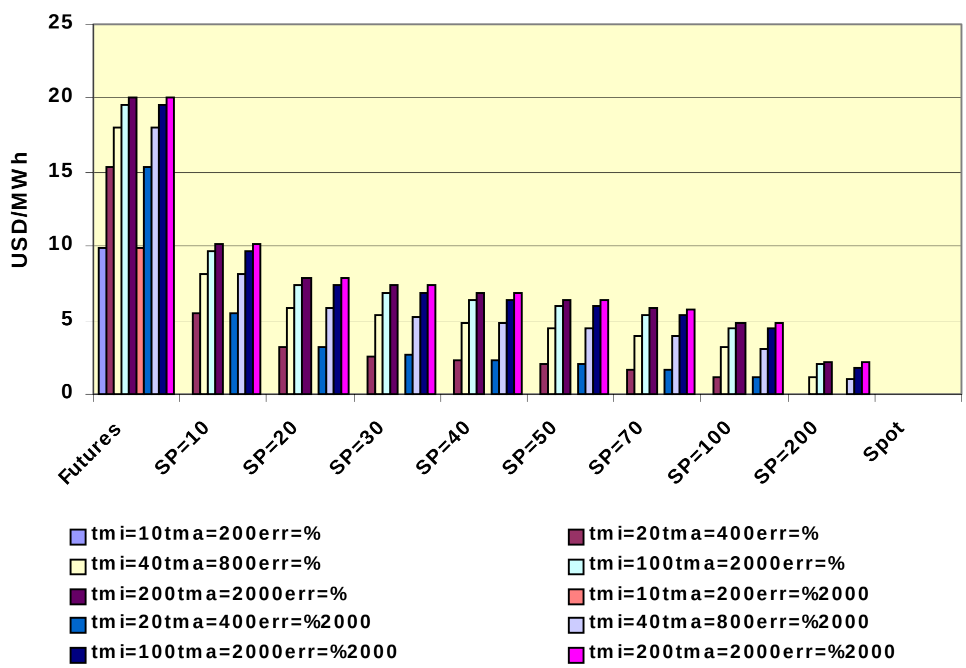


The next graphs present the results of the simulation for options with shorter performance periods (1 and 2 years).

Graph 4.8 Quantities traded – performance period 2 years



Graph 4.9 Market clearing prices – performance period 2 years



The graphs for performance period of 2 years, show a deviation towards a greater participation in options with strike price of 10 USD/MWh, mainly due to a demand with high load factor. This deviation is also observed for a strike price of 100 USD/MWh, considering peak demand. Generally, the options with strike price 10 USD/MWh are sold by the hydroelectric generators and the base thermal plants with lower variable costs. However and since there is also a significant influence of the risk tolerances, this rule does not apply strictly.

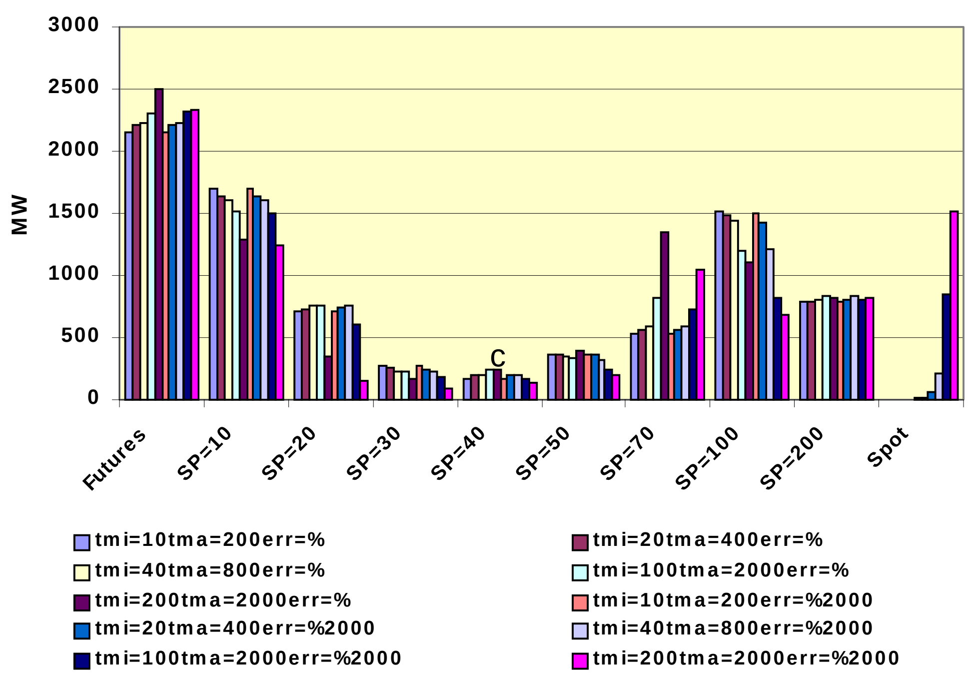
It is worth mentioning that transaction volatility is greater with performance periods of 2 years than with 5 year periods. For instance, for spot transactions, volatility increases from 9 USD/MWh to 17 USD/MWh. This makes sense given that under longer performance periods it is more likely that the water availability comes closer to the average values reducing volatility.

With regard to the clearing prices, these are lower for the cases with less risk tolerance. The influence of uncertainty in spot prices forecast on clearing prices is not relevant.

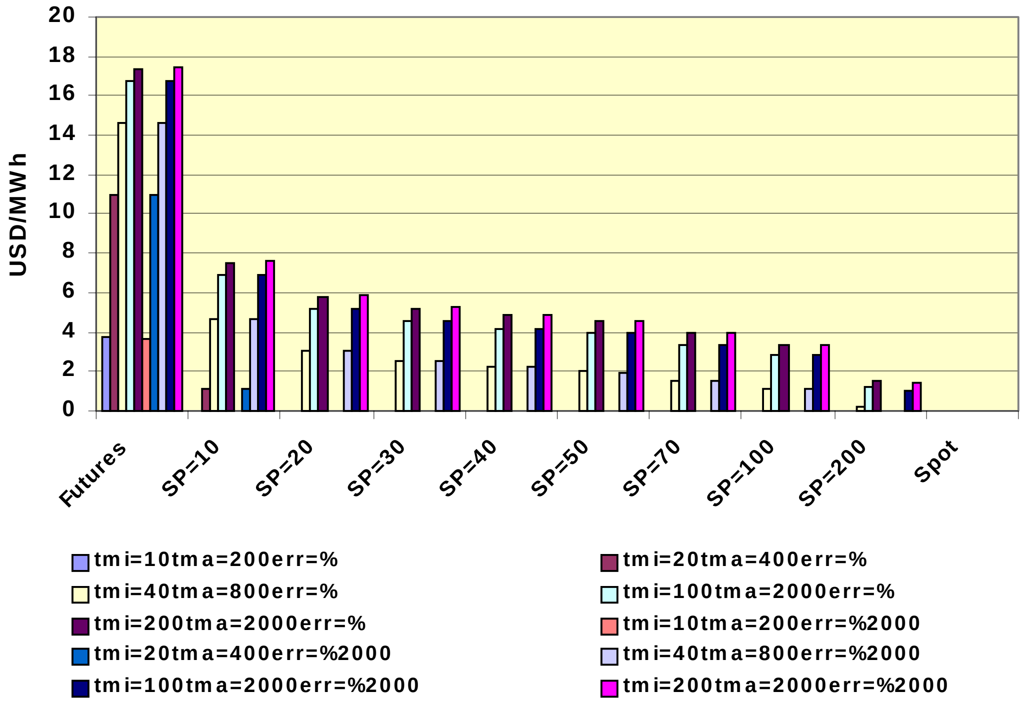
The next two graphs found below are for performance periods of one year. The trends are similar to those that were observed for the performance periods of 2 and 5 years

With regard to the clearing prices, the decrease of prices of options with low strike price is too high. Probably the reason is that volatilities are about 90%, it is, very close to the spot price. Thus, the utility function becomes very low or even negative. The conclusion is that the adopted utility function does not have a suitable behavior when volatilities are too high.

Graph 4.10 Quantities traded – performance period 1 year



Graph 4.11 Market clearing prices – performance period 1 year



5. DEFINITION OF STRIKE PRICES AND CHARACTERISTICS OF THE OPTIONS

The simulation model is useful for defining some of the characteristics of the options. Though it is possible to simulate a wide range of strike prices, it is not convenient to operate a market with too many strike prices since it reduces the liquidity of the market.

Given that some market participants may have demand with a low load factor, the analyzed base options may not be convenient for them. For that reason, the use of base and peak options was studied. Peak options can be exercised from Monday to Friday during the 10 hours with the highest demand.

The criteria used to compare different alternatives is the social welfare . In this case, we refer to social welfare as the increase in the level of utility that the market participants obtain when hedging their risks by buying options. Although absolute values of the social welfare are not relevant, it is possible to compare relative values to assess the convenience of some possible alternative.

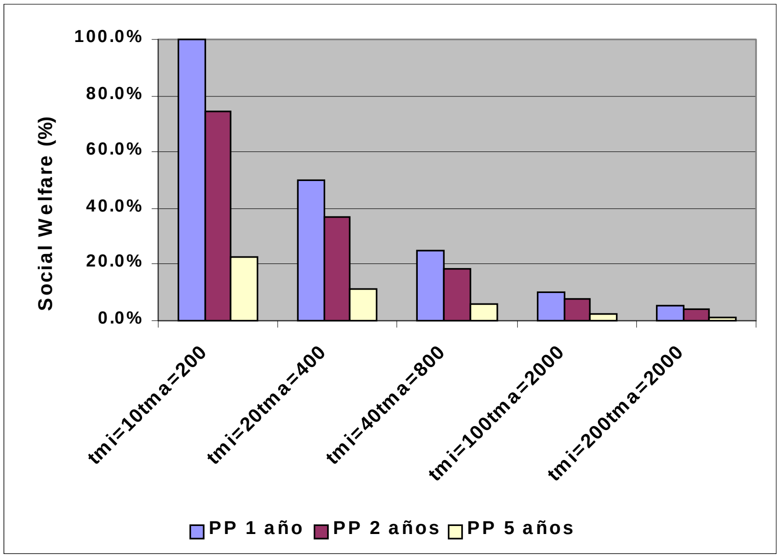
After simulating a wide range of alternatives, we found that it is possible to get a maximum value of social welfare in a market with the following financial products:

- Futures for base load
- Futures for peak load (10 hours from Monday to Friday)
- Options for base load with strike prices 10, 30 and 70 USD/MWh
- Options for peak load with strike prices 10, 30 and 70 USD/MWh

Given the high volatility exhibited by spot prices, it seems convenient to make options available with short performance periods such as 6 months, 1 year and 2 years and besides the 5 year options recommended by TERA.

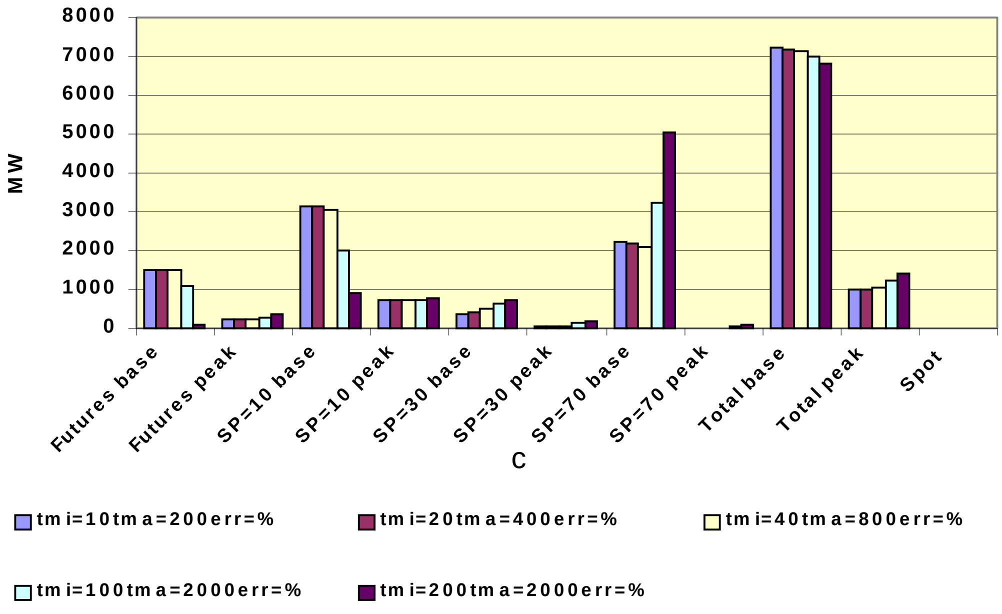
Graph 4.12 shows the social welfare (relative values, using the maximum as 100%) for options with 1 , 2 and 5 year performance periods. In order to compare the social welfare for different performance periods, all the values are referred to an average hour of the period.

Graph 4.12 Relative social welfare for different performance periods (PP)

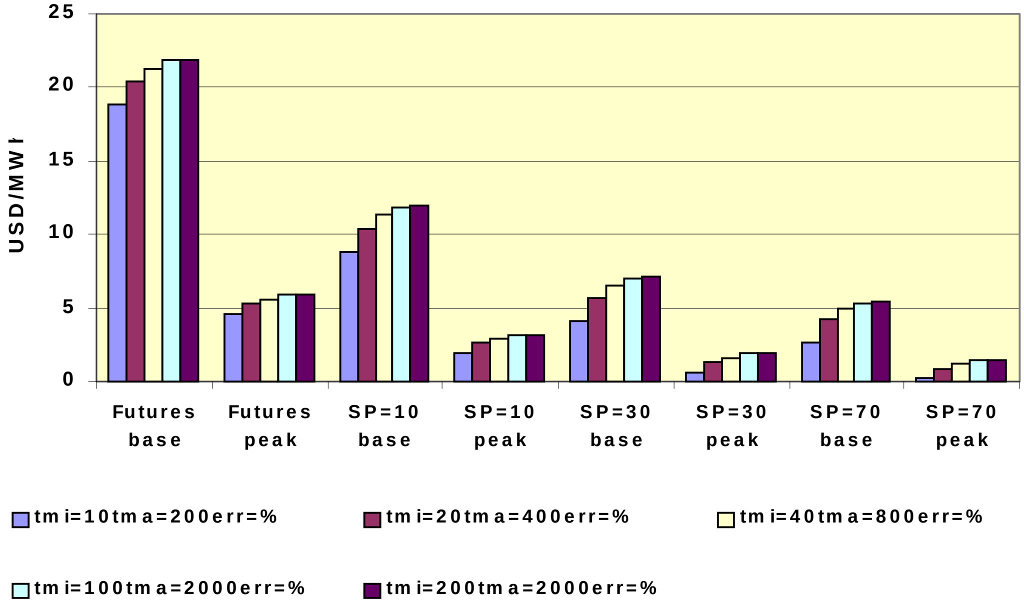


Graph 4.13 and 4.14 show the prices and quantities traded for the proposed alternative:

Graph 4.13 Quantities traded – performance period 5 years



Graph 4.14 Market Clearing Prices – performance period 5 years



Some characteristics of this alternative are:

- 100% of the load is hedged with some type of option
- Peak loads are hedged mainly with peak options and futures
- Base load is hedged with base futures and options with strike price 10 USD/MWh

6. DOWNSIDE RISK

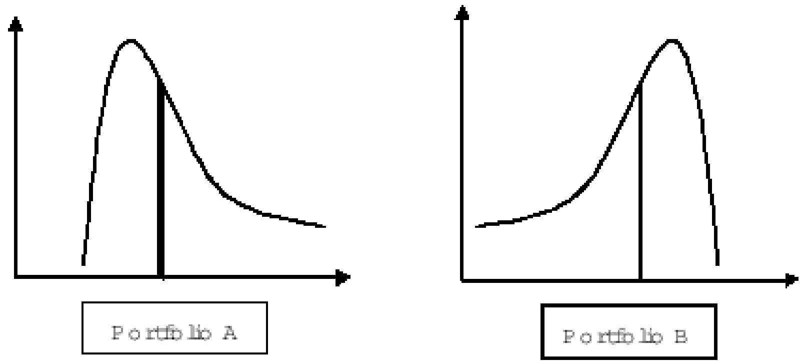
Downside risk is one of the approaches mentioned in chapter 3 to illustrate the gain vs. the risk trade-off.

Downside risk penalizes returns (or revenues) below a given value (reference return) specified by the investor. This type of approach is relevant because with it investors may neutralize lower returns without giving away high possible returns.

Graph 4.15 in the next page shows the return distribution of two different portfolios. The mean and standard deviation of both distributions are the same, however, portfolio A is more attractive because it has a higher probability of greater returns. In other words, the downside risk of portfolio B is higher.

In the case of the FOM, the downside approach was simulated to take into consideration that market participants may consider more risky scenarios where they have to make payments, as opposed to those where they raise revenues. Therefore, a downside risk function was used to estimate volatilities, assuming that utility for market participants associated to revenues is c times the utility for payments, where c is a constant value between 0 and 1.

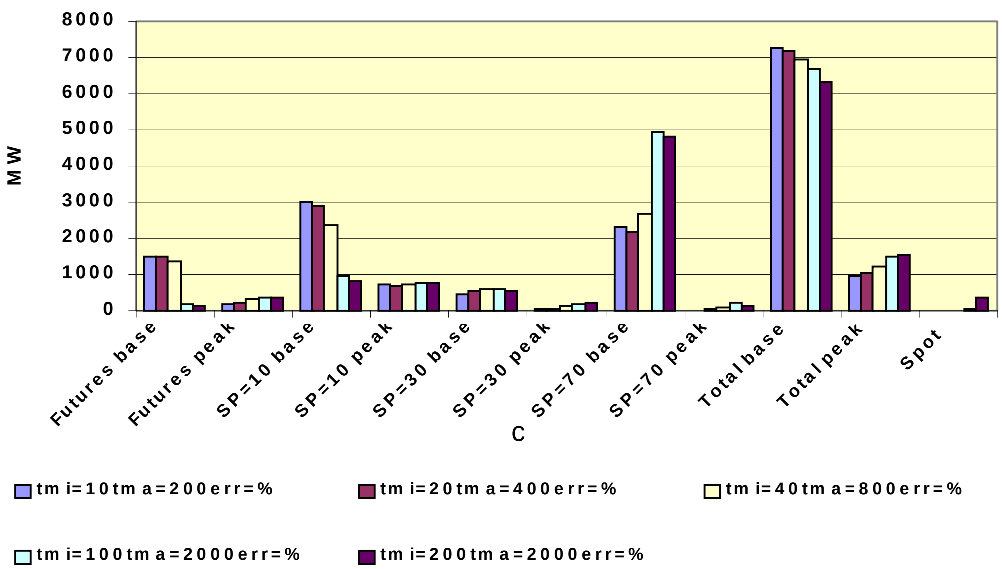
Graph 4.15 Downside risk



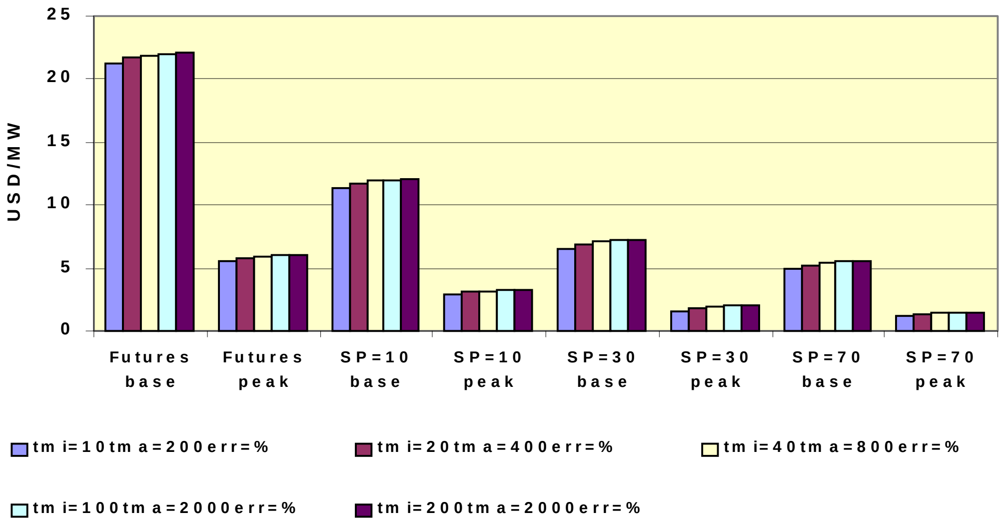
Some market simulations were performed using the downside approach. The value of c was defined as 0.5. The results of the simulations are not strictly comparable with cases where c=1. It is remarkable to observe how the differences in clearing prices become narrower when the risk (measured as the standard deviation of sells and buys in the spot market) of consumers with low load factor is reduced.

Graphs 4.16 and 4.17 show the results of the market simulations performed under this approach.

Graph 4.16 Quantities traded – performance period 5 years – downside risk



Graph 4.17 Market Clearing Prices – performance period 5 years



7. THE CxC VS. THE OPTIONS MARKET

We considered convenient to make a quantitative comparison of the effectiveness of the options market against the current CxC method. As that comparison is not simple, it was necessary to pose some assumptions in order for revenues and volatilities computed for both methods to be consistent.

The assumptions posed were:

- The comparison is made for a period when long run marginal costs are the same. This means that spot price in the CxC alternative is about 8 USD/MWh lower than the same price in the case of the alternative with the FOM.

  The comparison was performed for the following thermal plants:

	CV	Potencia	CxC Medio
	USD/MWh	MW	MW
TERMICA 1	35.2	63.0	31.7
TERMICA 2	13.5	150.0	140.5
TERMICA 3	16.0	231.0	112.1
TERMICA 4	10.1	150.0	129.9
TERMICA 5	4.8	150.0	100.0
TERMICA 6	46.1	14.0	5.0
TERMICA 7	9.9	750.0	577.5

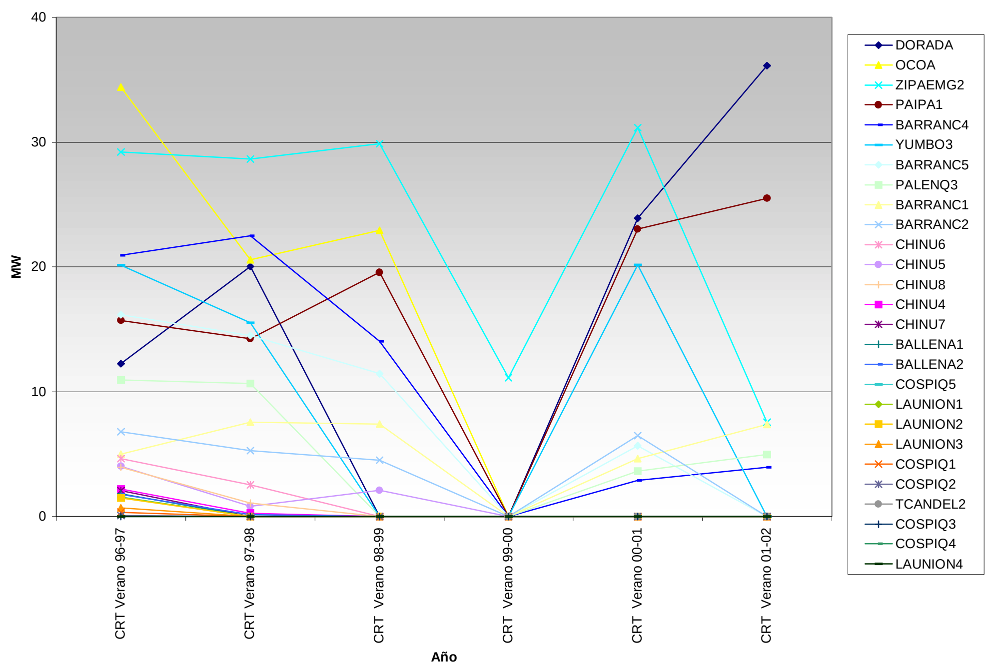
- The CxC payoffs perceived by such plants was obtained from historical records. We assumed that the average MW paid will remain constant, as well as the volatilities of such payoffs.
- In order to consider the uncertainty in the risk tolerance, the following simulations were considered:

- Tested plants low t = 50, market high 100 < t < 2000
- Tested plants high t = 1000, market high 100 < t < 2000
- Tested plants low t = 50, market low 10 < t < 200
- Tested plants high t = 50, market low 10 < t < 200

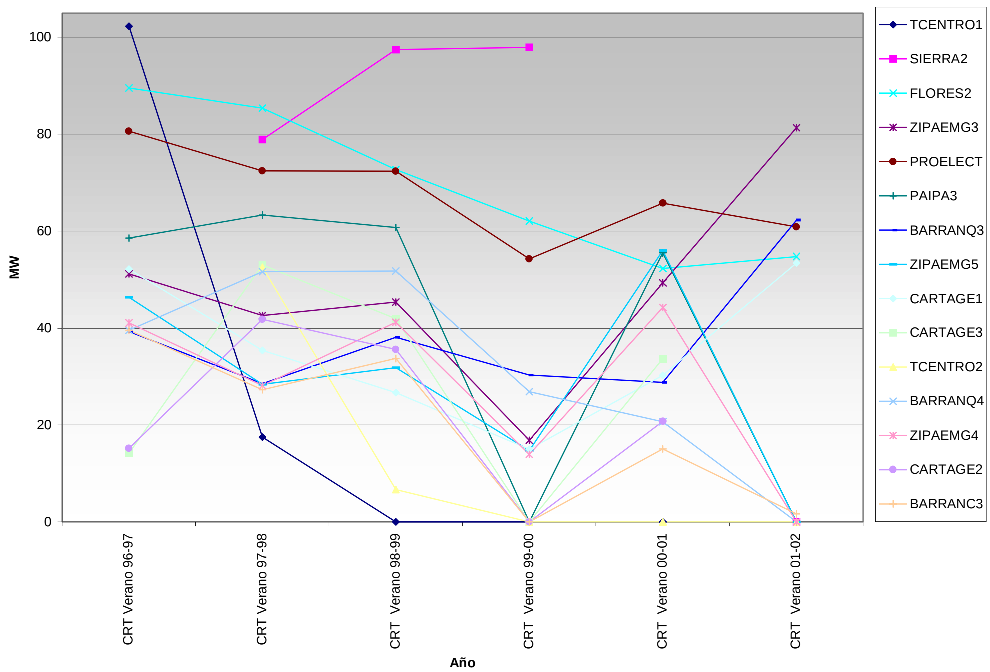
- With these alternatives of risk tolerance it is possible to analyze how the market of options is effective for hedging the risk of market players with different risk profiles.
- The comparison was performed by computing the net revenues (gross revenues minus variable costs) of the plants tested, the volatility of their revenues and the utility associated to their risk tolerance

Graphs 4.18 and 4.19 show the CxC of the thermal plants. It is possible to confirm that the volatility of CxC is important.

Graphs 4.18 MW paid 1996-2001

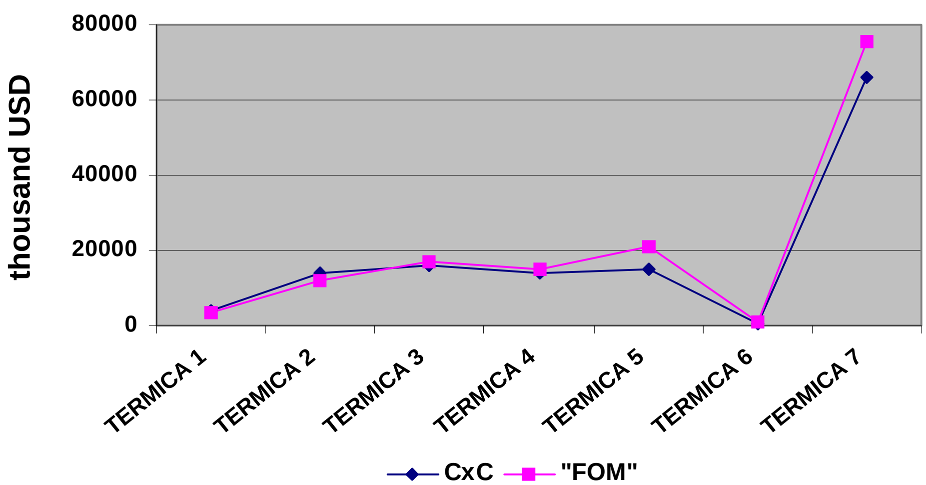


The volatility of revenues of the selected plants was computed considering the uncertainty of capacity payments, spot prices and dispatch of each plant.

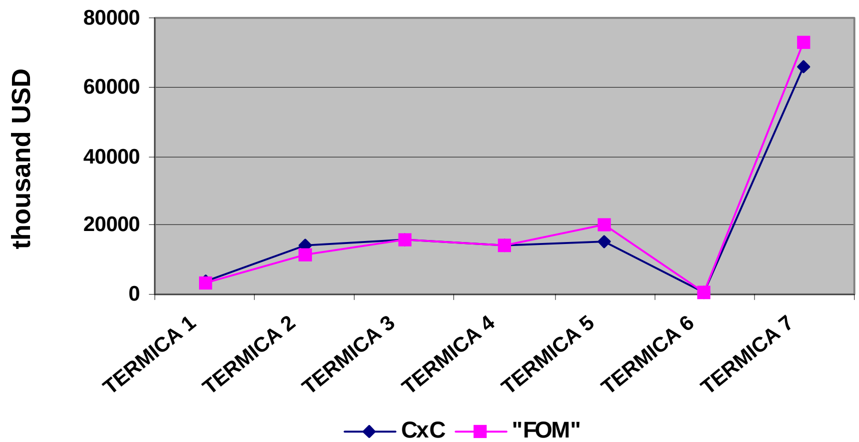


The following Graphs show the revenues for each selected plant for both the present CxC method, and also assuming the existence of the FOM. Revenues are presented for the four combinations of risk tolerance of the market and the selected plants.

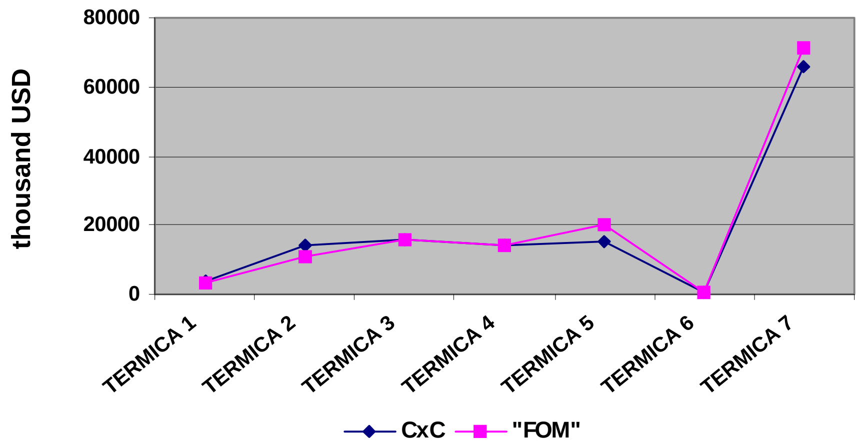
Graph 4.19 Revenues of selected plants tplants= 1000, 10 < tmarket < 200



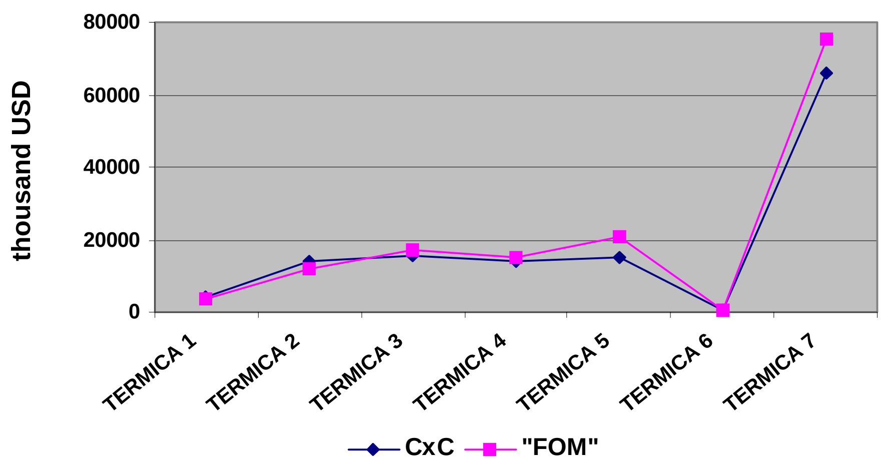
Graph 4.20 Revenues of selected plants tplants= 1000, 100 < tmarket < 2000



Graph 4.21 Revenues of selected plants tplants= 50 , 10 < tmarket < 200



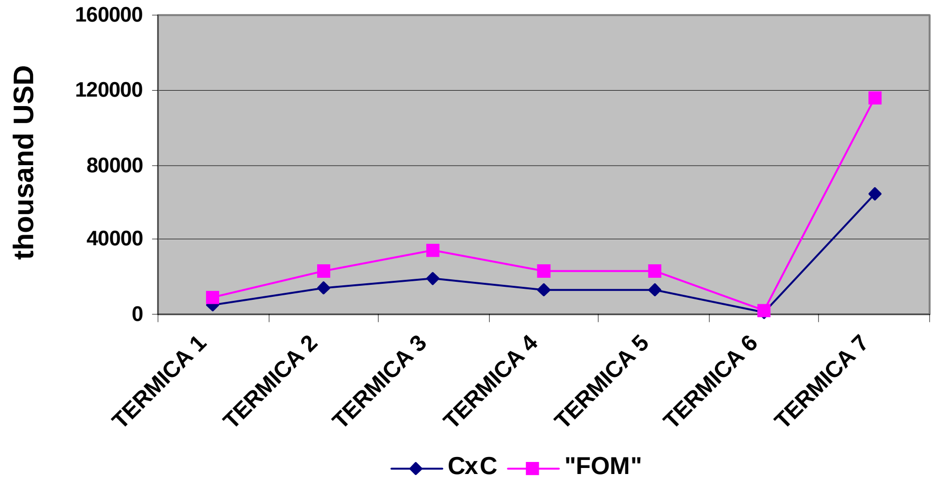
Graph 4.22 Revenues of selected plants tplants= 50 , 100 < tmarket < 2000



The results show that the revenues of the plants are roughly the same in the CxC alternative and in the FOM. However, this is not necessarily true for all the plants, because there is some excesses of capacity that is not paid in either method.

The following graphs show the volatilities of the revenues of the selected plants. It is important to consider that as energy spot prices are lower in the case with CxC, volatilities turn lower.

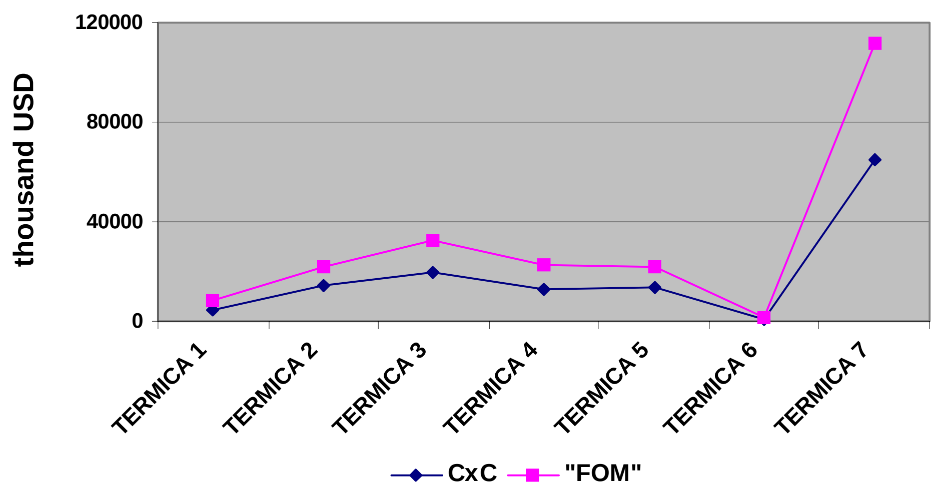
Graph 4.23 Volatility of revenues of selected plants tplants= 1000, 10<tmarket < 200



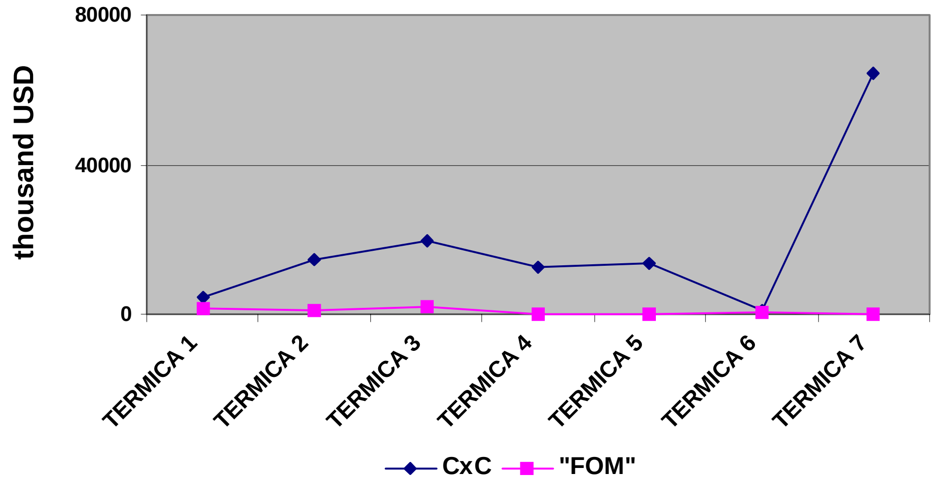
In this case, with market participants with low risk tolerance and the selected plants with high risk tolerance, the results show that the volatilities of revenues of such plants are higher in the FOM alternative. Nevertheless, results show that the selected plants sell all the energy that they produce in the spot market, which means that they have not looked for risk hedging.

The absolute volatility of the spot market is higher than the alternative with the FOM, because the price is also greater than in the CxC case. Relative volatility (mean/standard deviation of prices) is lower in the FOM case.

Graph 4.24 Volatility of revenues of selected plants tplants=1000,100<tmarket < 2000

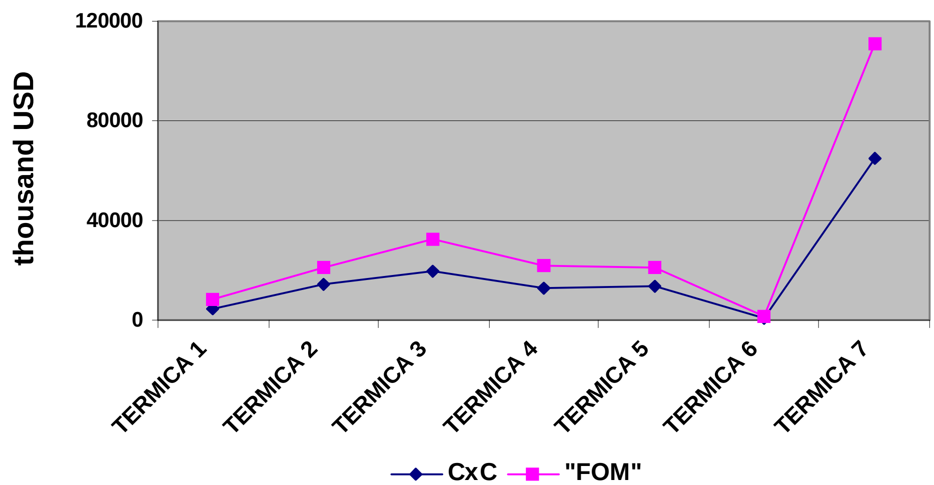


Graph 4.25 Volatility of revenues of selected plants tplants=50, 100<tmarket < 2000



Under this case, where the selected plants have low risk tolerance and the market has high tolerance, the selected plants look for risk hedging, buying options (SP=10 USD/MWh) for their total installed capacity. Therefore, the effect of reduction of volatility is significant.

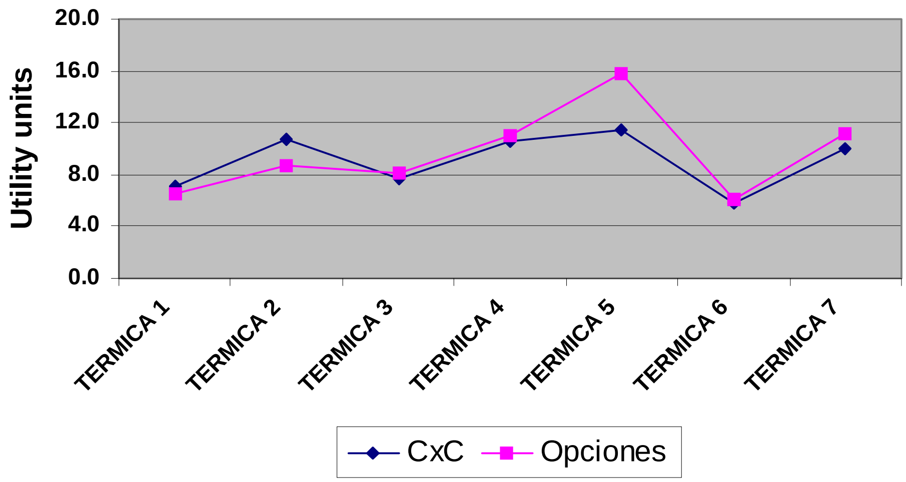
Graph 4.26 Volatility of revenues of selected plants tplants=50, 10<tmarket < 200



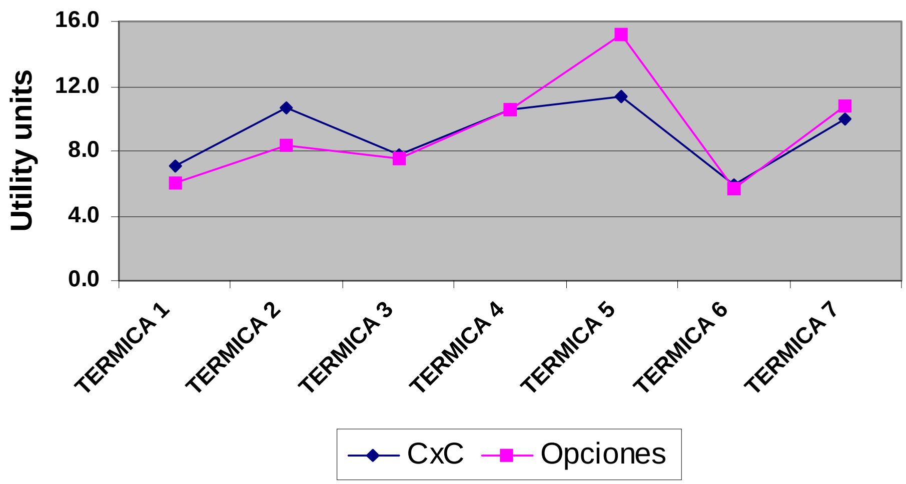
Although there is an important reduction in the volatility of revenues of the selected plants in relation with cases 1 and 2, the absolute value remains high due to competition with other market players for buying options.

Finally, the following graphs illustrate the utilities of the selected plants (computed as proposed in chapter 3 utility =mean – variance/tplant).

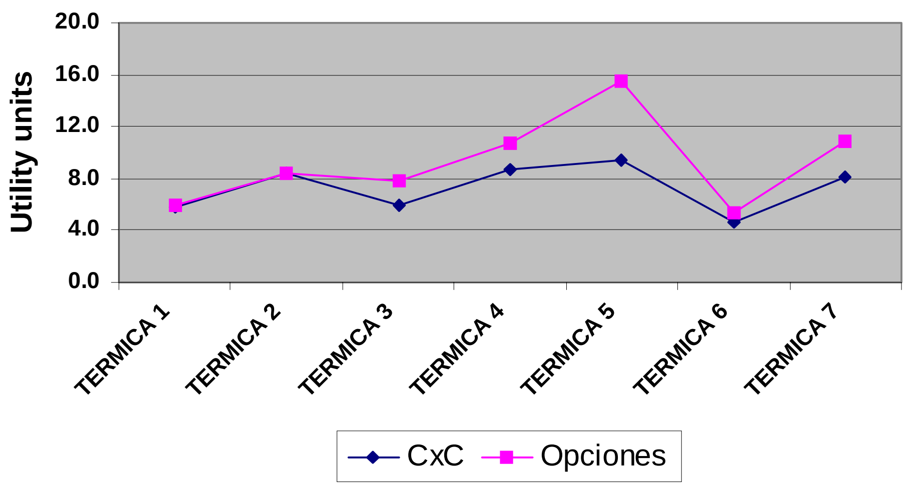
Graph 4.27 Utility of selected plants tplants= 1000, 10<tmarket < 200



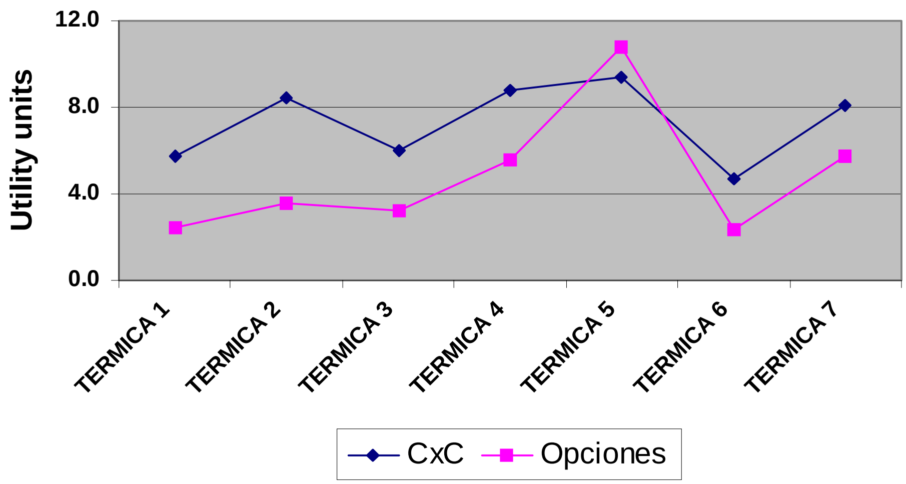
Graph 4.28 Utility of selected plants tplants= 1000, 100<tmarket < 2000



Graph 4.29 Utility of selected plants tplants= 50, 100<tmarket < 2000



Graph 4.30 Utility of selected plants tplants= 50, 10<tmarket < 200



8. SIMULATION OF TRADING ACTIVITIES

The simulation process, as described above, only considers selling and buying of options, but not trading activities.

If variables are allowed to achieve negative values, it becomes possible to consider the case when generators or demand side players buy options for reselling to other participants, either the same type of options, or another. This possibility means that market participants are allowed to trade, to sell-buy options for their own risk hedging.

If it is accepted that variables can take negative values, it is also possible to accept that some market participants do not have their own generation or demand. This is will be the case of "pure traders".

We assumed that only "pure traders" operate in the market, and that they have infinite risk tolerance. These assumptions are convenient for simplifying the analysis, but the model is prepared to process results without such assumptions.

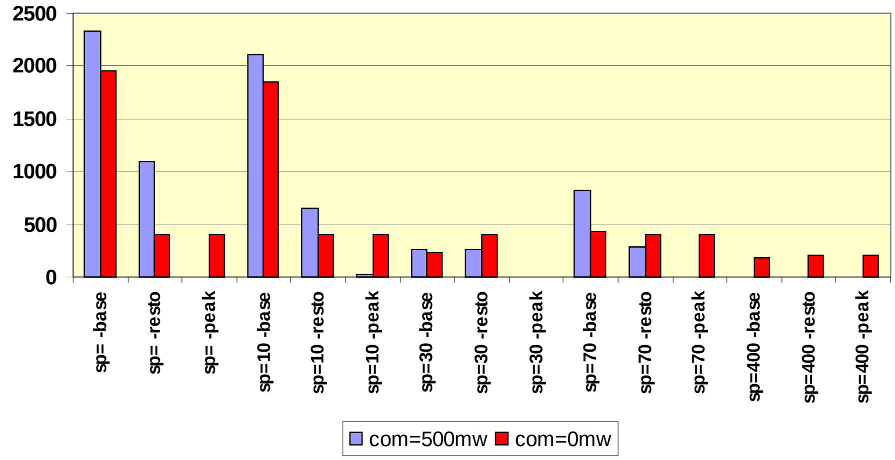
The maximum amount of capacity that a trader can commercialize is bounded, in order to consider its financial capability and to limit the credit risk in the market.

The results of an example are presented below. Two scenarios were considered:

- A first scenario without trading, and
- A second in which we assumed that three traders operate in the market, each with a limit of 133 MW in the capacity that it is allowed to trade. This means that the three cannot commercialize more than 500 MW.

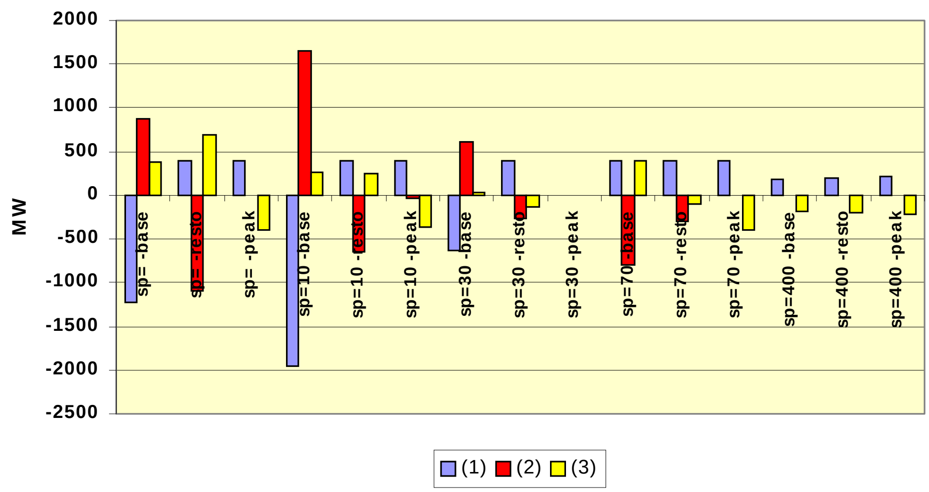
Graph 4.31 shows the results of the total capacity traded for two scenarios. The X axis shows different types of options, characterized by the strike prices (0 us$/MWh, 10 us$/MWh, 30 us$/MWh, 70 us$/MWh, spot), and the blocks of hours when the option is effective (peak, shoulder, base). The Y axis shows the MW traded for each type of option. Social welfare increases by 5% when trading is allowed.

Graph 4.31 Effect of trading on purchases of demand side participants



The graph 4.32 shows how the differences in MW traded are originated when traders are considered. This graph shows: (1) the capacity sold (+) or bought (-) by traders, (2) the difference in the capacity sold by generation side participants, and (3) the difference between the capacity bought by demand side participants with and without traders.

Graph 4.32 MW traded



This graph shows that traders buy capacity in options in the base markets, and can sell that capacity in the shoulder and peak markets, where market participants (mainly demand side) are exposed to higher risks.

9. CONCLUSIONS

The simulations carried out show reasonable results on the behavior/performance of the agents and of the clearing prices.

The simulations confirm the trend to greater hedging levels for participants with less risk tolerances. Consumers with low load factors increase their risk exposure by taking hedges with options since they must often sale excesses in the spot market during off peak hours. This problem can be solved by designing options exclusively for peak hours.

It seems convenient to have options for different performance periods. It is clear that utility increases when the participants, depending on their risk tolerances, can have access to different types of hedging instruments.

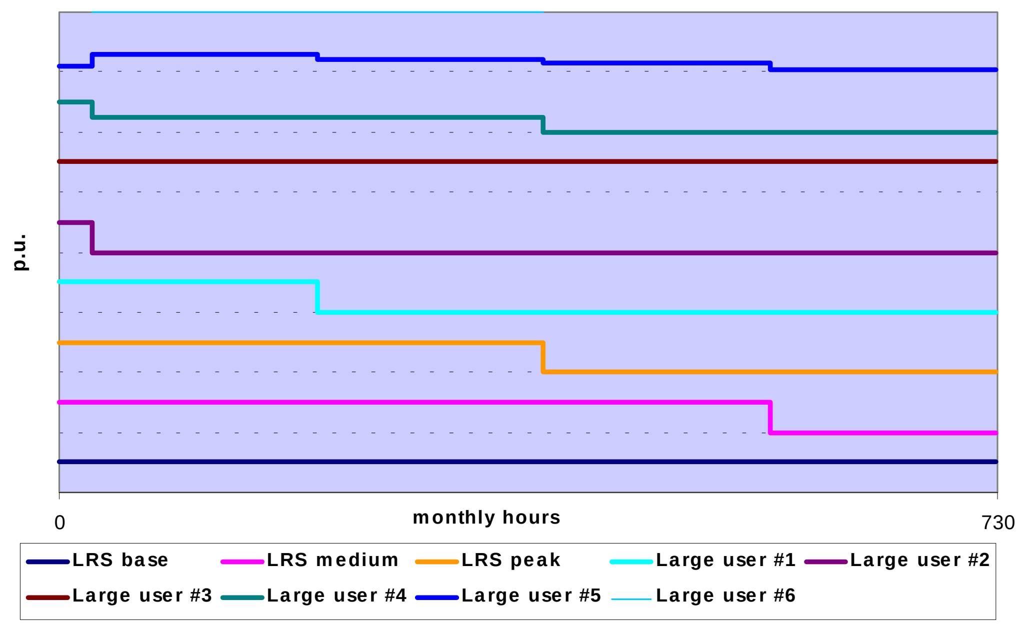
Appendix VI
Information on Market Participants

10. APPENDIX VI

I.1 Buyers

Graph I.1 shows the typical load curves for every type of buyer. The curves are presented as a load duration curve, for a month of 730 hours, for 1 MW of load.

Graph I.1 – Typical load curves

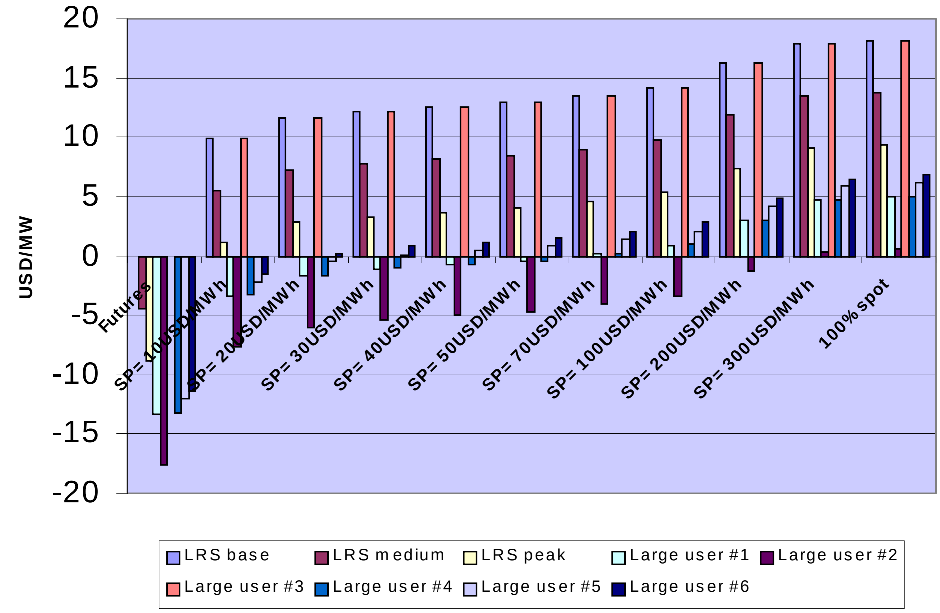


Sellers (generators)

The following graph shows the balance of operation in the spot market for every type of buyer. The balance are the costs – incomes of a market participant that buys an option with strike price SPi, and buys – sells the difference between its actual load and the energy obtained exercising the option, at the current spot price. For instance considering a Large user with load profile type 2, if he exercises an option because the whole month the spot price is above the exercise price SPi, he will use the energy for his own consumption in peak hours, but he will sell energy during off-peak hours, obtaining an income equal to the difference between the spot price and SPi. Load curves were assigned to LRSs and large users assuring that the total demand remains equal to forecasted values.

Please note that buys – sells are expressed in USD/MW, what means that the graph shows the balance for each MW of load hedged with an option. For obtaining costs per MWh it is necessary to divide the USD/MW by the load factor.

Graph I.2 – Expected balance of sells - buys in the spot market

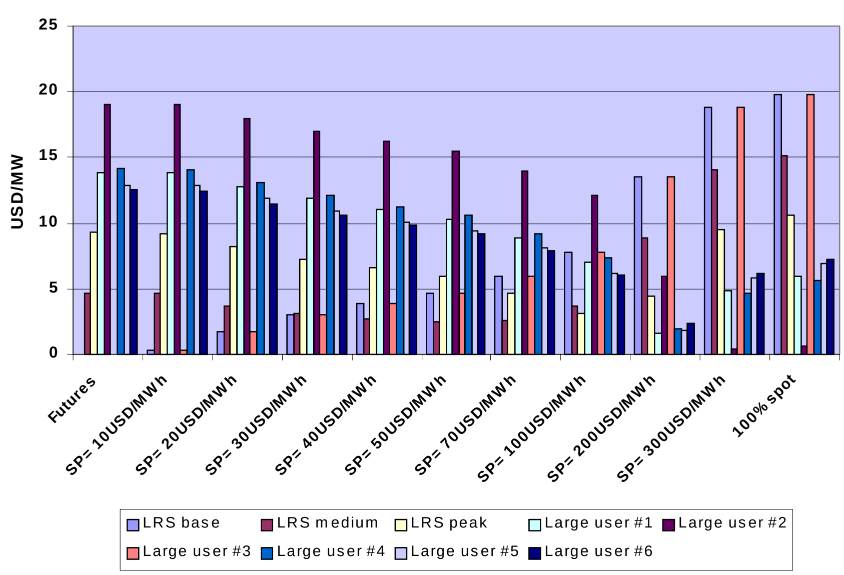


In the graph above negative values mean sells in the spot market, and positive values mean the cost of buying energy. All the values are expected values, taken on all the scenarios and hydrologies (states of the world) and assuming that every scenario has the same probability of occurrence.

Values shown in the last graph correspond to options with performance period since January 2004 to December 2005.

The next graph shows the volatility of the balance of each type of load in the spot market. In this case we assumed that for the utility of the participants a positive or negative value has the same effect.

Graph I.3 – Volatilities of sells – buys in the spot market



II.1 Generators

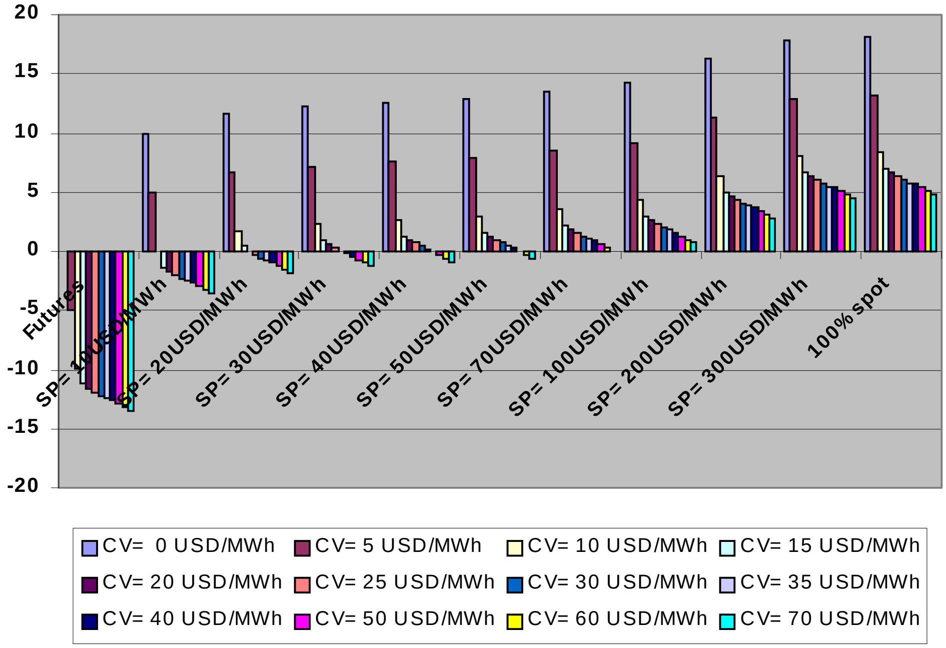
The next table shows the information used for estimating the balance of buys – sells of thermal generators in the spot market.

CODE	CAPACITY MW	CV USD/MWh	CODE	CAPACITY MW	CV USD/MWh
BARRA1	11	32.03	PAIPA1	28	27.82
BARRA2	12	32.24	PAIPA2	68	27.37
BARRA3	54	33.52	PAIPA3	68	27.19
BARRA4	30	34.52	PAIPA4	150	4.83
BARRA5	20	34.41	PALEN3	14	46.06
BARRQ3	63	34.91	PROEL1	42	11.61
BARRQ4	63	35.22	PROEL2	42	11.61
CADAF1	36	17.67	TASAJ1	155	5.01
CANDE1	150	13.53	TEBSAB	750	9.9
CANDE2	250	13.98	TERMOO	279	12.91
CARTA1	65	36.99	TERMO1	51	40.11
CARTA2	44	39.92	TERMOA	448	11.89
CARTA3	70	37.53	TERMO2	201	36.88
COROZ1	54	56.38	YUMBO3	29	14.25
EMCALI	231	16.04	ZIPAE2	34	5.09
FLORE1	150	10.12	ZIPAE3	62	4.78
FLORE2	99	35.94	ZIPAE4	62	4.75
FLORE3	149	34.98	ZIPAE5	63	4.54
GUAJI1	151	34.87	COGINA	9	0.09
GUAJI2	151	34.68	AUTOPI	39	0.07
MERILA	154	37.87	COGPRA	4	0.03

Balances for thermal plants operation and the corresponding volatilities depend on variable costs for each unit. Formulae defined in Chapter 3, APPENDIX V were used for estimation. The following graphs show income-operation cost values in the spot market that are produced when these units sell options with different strike prices.

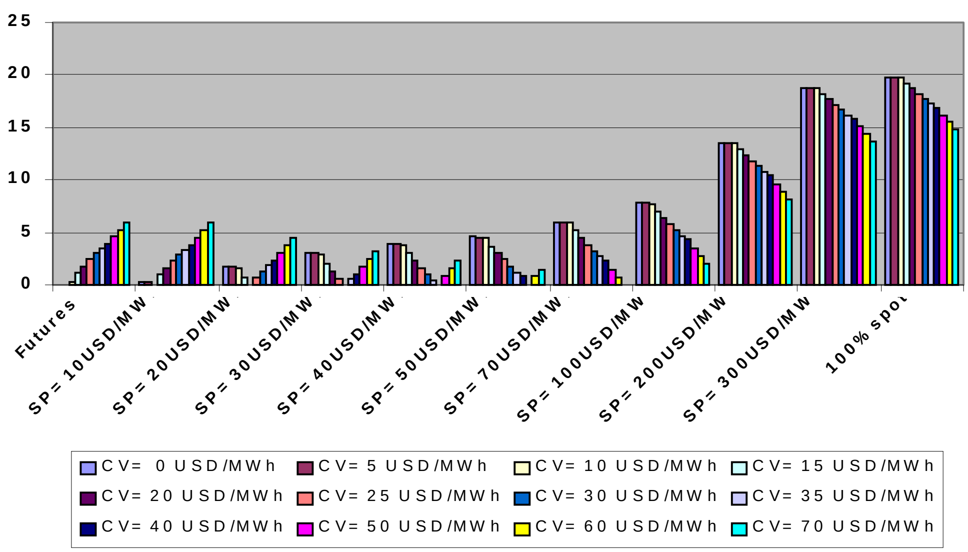
Values shown correspond to the mathematic expected value estimated for all scenarios introduced and for all hydrology series. Performance period beginning January 2004 and ends on December 2005.

Graph I.4 – Expected balance of sells - buys in the spot market of thermal generators



The following graph shows estimated values for thermal generators' income-sells volatility.

Graph I.5 – Volatilities of sells – buys in the spot market of thermal generators

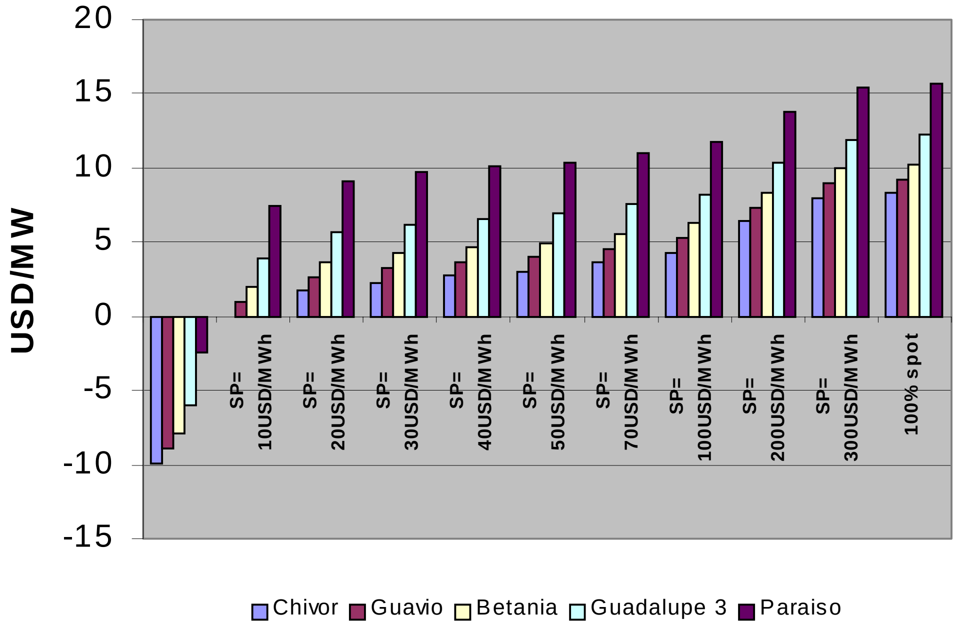


Hydro Generators

Each hydro generator has its own balance in the spot market which depends on its operation. Balance of operation of every hydroelectric plant was estimated using the formulae presented in APPENDIX V of the Chapter 3.

The following graph shows the balances in the spot market and volatilities for some selected hydroelectric plants.

Graph I.6 – Expected balance of sells - buys in the spot market of hydro generators



Graph I.6 – Volatilities of sells – buys in the spot market for hydro generators