DECISION SUPPORT METHODS IN ENERGY AUCTIONS

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Highlights

- We propose an energy demand forecasting model integrated with ...
- models to
  - simulate and optimize energy purchasing costs and
  - reduce the penalties that the government imposes on the energy retailers.
- We present a resampling scheme to evaluate the PLD (Settlement Price), one of the components of penalties in the electricity market, which is stochastic and heavily influenced by inflows.

The New Electric Sector Regime

- In the new regime, the regulator is in charge of auctioning new and existing projects to supply the whole captive market.
- Distributors are only required to inform their forecasted demands five years ahead. They have to decide:
  - First decision: How much to ask in each individual auction?
  - Second decision: How to access future demand in each of the 60 months ahead?

The New Electric Sector Regime

- These decisions are risky for two main reasons:
  - i) auction prices differ (it has been possible to buy energy for half the price in specific auctions);
  - ii) errors in demand forecasts are punished in an asymmetric fashion.

The New Electric Sector Regime

- The weighted average of the prices paid by the regulator for the total energy bought from various generators will be passed-through to prices.
- Distributors will pay for their energy in proportion to their declared demand in each auction.

The New Electric Sector Regime

- Distributors who demand a relatively high share of their needs in low price auctions will have their profits increased.
- Losses will come to those distributors who concentrate their demand in the high price auctions.
- Distributors are not truly free to allocate their demand amongst auctions because the terms of the contracts being auctioned may be incompatible with theirs needs.

Demand Model

- The structure of the demand model is:

Variable	Coefficient	Standard Error	T Statistic	Significance
Log(C_TOTAL[-1])	0,772	0,077	10,085	100,0%
Log(PIB[-1])	0,367	0,122	3,013	98,9%
Log(PR_ENERGIA)	-0,189	0,053	-3,564	99,6%
Log(PR_GAS)	0,053	0,017	3,111	99,1%
RACION	-0,132	0,022	-6,105	100,0%

- Where:
- C_total[-1] = consumption in the previous month
- PIB[-1] = GDP in the previous month
- PR_ENERGIA = electricity price
- PR_GAS = GLP price
- RACION = dummy variable – rationing period

PLD – Settlement Price Simulation Model

- Hydroelectric energy is generally cheaper but hydro units are not always fully dispatched since low water levels mean a supply risk.
- The ISO ponders the present benefit of cheap water use and the future benefits of high level reservoirs, both measured by their opportunity cost in terms of fuel savings in thermoelectric plants.

PLD – Settlement Price Simulation Model

- NEWAVE is the software used to optimize dispatch between hydro and thermal units.
- It also calculates monthly CMOs – Marginal Costs of Operation, considering hydrological conditions, demand levels, new plants, fuel prices and deficit costs.
- Monthly CMOs are further transformed into weekly CMOs through the use of another optimization software, DECOMP.

PLD – Settlement Price Simulation Model

- PLD – Settlement Prices are CMOs – Marginal Costs of Operation in a limited range.
- Currently in 2007, PLDs are restricted to the interval (R$ 17.59, R$ 534.50).
- Penalties for demand over and underestimation use a yearly PLD which is a weighted average of the monthly PLDs prevailing in the twelve preceding months.

PLD – Settlement Price Simulation Model

- In this paper, we simulate yearly PLDs through the following process:

1. Estimation of monthly seasonal factors
2. Estimation of Southeastern CMOs through NEWAVE for 2007-2011 (we used CCEE's Feb. 2007 "deck"). In this step, 2000 CMO series are generated for each one of the 60 months ahead: Jan/2007, Feb/2007, Mar/2007, ..., Dec/2011.

PLD – Settlement Price Simulation Model

3. Create 2000 realizations of average PLD series through:

$$PLD_i = \frac{w_1 CMOrestr_{1i} + w_2 CMOrestr_{2i} + ... + w_{12} CMOrestr_{12,i}}{12}$$

- Where i = 2007, 2008, ..., 2011, and
  - w_1 is the seasonal factor for January (constant in all years)
  - w_2 is the seasonal February factor (constant in all years)
  - CMOrestr = CMO restricted to the interval (17.59, 534.50), i.e. each monthly CMO subjected to PLD restrictions. For simplicity, this interval was admitted to be the same until 2011.

PLD – Settlement Price Simulation Model

4. The 2000 PLD series of 2007 (and also 2000 of 2008, 2000 of 2009 and so on...) are resampled allowing the PLD to be introduced as a random variable in the model.

- The resampling model described above uses the SAME NEWAVE series throughout the period 2007-2011.

PLD – Settlement Price Simulation Model

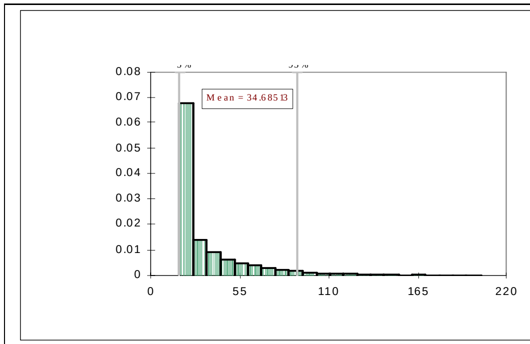
- Thus, if in one simulation the ***k-th* series** is sorted out from the 2000 CMO series, 2007 average PLD will be calculated using this series; the average 2008 PLD is also calculated from the CMOs of this series and so on until 2011.

- This is very important to **preserve the time dependency of CMOs** the PLD NEWAVE simulation scheme.

- **PLDs simulated** for the period 2007-2011 are **highly variable** as the next graphs show.

PLD – Settlement Price Simulation Model

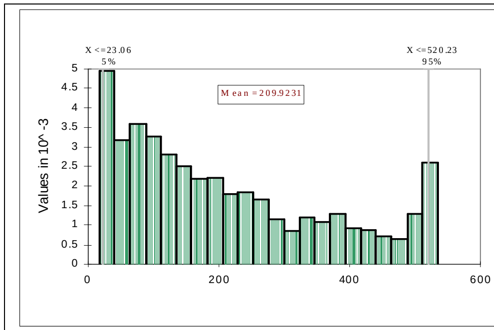
- Simulated PLD – 2007



Statistics	Values
Minimum	17.59
Maximum	203.7
Mean	34.69
Std Dev	27.27
Percentiles	Values
5%	17.59
50%	22.13
75%	40.92
95%	90.11

PLD – Settlement Price Simulation Model

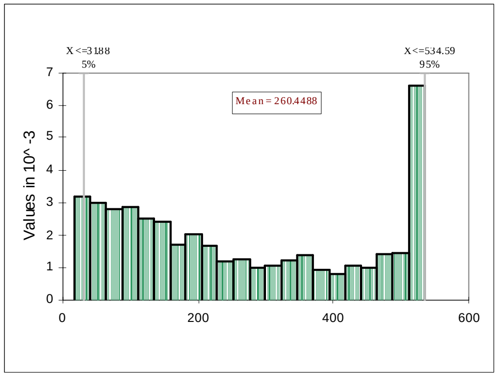
- Simulated PLD – 2009



Statistics	Values
Minimum	17.59
Maximum	534.59
Mean	209.92
Std Dev	155.1
Percentiles	Values
5%	23.06
50%	169.37
75%	318.38
95%	520.23

PLD – Settlement Price Simulation Model

- Simulated PLD – 2011



Statistics	Values
Minimum	17.59
Maximum	534.59
Mean	260.45
Std Dev	176.74
Percentiles	Values
5%	31.88
50%	218.66
75%	437.3
95%	534.59

Simulation Model for Energy Purchases

- The proposed simulation model for the annual cost of energy purchases is a function of 7 factors:
  1. Percentage of the estimated load purchased in a given year;
  2. Load forecast in MWh;
  3. Standard deviation of the load forecast in MWh;
  4. Actual demand in MWh;

Simulation Model for Energy Purchases

5. Reference Value (VR), in R$ per MWh;
6. The distribution company's energy purchasing cost, commonly known as the company's "mix", in R$ per MWh;
7. The average annual settlement price (PLD), in R$ per MWh.

- The simulation model was implemented in Excel using the add-in *@Risk* by *Palisade Corporation.* Some of the inputs of the model are random and others are deterministic.

Simulation Model for Energy Purchases

- The percentage of the estimated load purchased in each year is what we seek to optimize.
- It represents the ideal purchasing amount in each year, so that the total cost in the specified period is minimum.
- In the simulation, this percentage was taken as a Uniform (0.95, 1.10) random variable.
- That is, in each year, some value between 95% and 110% of the forecasted demand can be purchased.

Simulation Model for Energy Purchases

- The **demand forecast** is the value obtained **from the time series model**. It is considered fixed (deterministic) in the simulation model, as well as its standard deviation.
- The **“actual” demand** is a stochastic input. In fact, nothing can be said about it until it is observed (in the future).

Simulation Model for Energy Purchases

- We propose a **left truncated Normal** distribution for this variable, at a point x_0 located below the mean of the original Normal distribution.
- This forces the simulation to produce higher values of the “actual” demand than those that would be observed by simulation from a (non-truncated) Normal.

Simulation Model for Energy Purchases

- Since **penalties are asymmetric** and utilities are more severely penalized for under-purchasing energy, **this procedure** (keeping all other factors constant) **raises the risks of under-purchasing** energy in any given year.
- Here we use as truncation point 95% of the mean of the original Normal distribution.

Simulation Model for Energy Purchases

- The **Reference Value** is deterministic (R$ 84.58/MWh), and fixed by the Brazilian regulator 2007.
- The company´s energy purchasing cost (the “**mix**”) is also taken as deterministic, and set at R$ 86.70/MWh.
- The **average annual PLD** is random and was simulated as previously described.

Simulation Model for Energy Purchases

- **The annual purchasing cost is comprised of four components: one is the energy cost itself, and the other three are direct or indirect penalties.**
- **The penalty due to non recovery of costs while under-purchasing energy is given by:**

$$F_1 = \{PLD - min(PLD, VR)\}.(qsub)$$

qsub = amount underpurchased (gap below 100% of actual demand)

PLD = settlement price

VR = reference value

Simulation Model for Energy Purchases

- **This penalty occurs because the amount of energy necessary to supply the actual load has to be purchased at price PLD.**
- **If the PLD is high, the acquisition cost cannot be passed through to consumers, and the utility should be penalized with this additional cost.**
- **By construction, this penalty (F_1) is always nonnegative and implies an increased cost for the distributor.**

Simulation Model for Energy Purchases

- **The penalty for under-purchasing energy is defined as:**

$$F_2 = max(PLD, VR).(qsub)$$

- **Similarly to F_1, F_2 is also nonnegative and always leads to increased costs to the distributors.**
- **A third penalty occurs when the utility has over-purchased energy above a level considered "acceptable" by the regulator (103% of the actual demand).**

Simulation Model for Energy Purchases

- **This is not a penalty in the literal sense, but an additional cost that cannot be passed to consumer's tariffs.**

$$F_3 = (qover).(MIX - PLD)$$

qover = amount of energy purchased above 103% of the actual demand
MIX = utility's average energy purchasing cost

- **A cost reduction will happen whenever PLD exceeds the company's average purchasing cost.**

Simulation Model for Energy Purchases

- F_3 indicates a clear possibility of profits instead of losses when a utility chooses to over-purchase energy (above the 103% limit).
- Profits will occur in case PLD is high, which happens when energy shortages are foreseen.
- This result may be considered to be rare, since PLD historically remained at very low levels.

Simulation Model for Energy Purchases

- In the scenarios generated from the official data of February 2007, when a shortage is quite probable in the coming years, these profit opportunities arise.
- The total energy purchasing cost is:

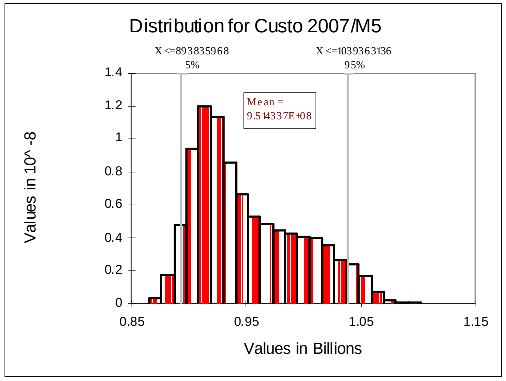
$$C = F_1 + F_2 + F_3 + MIX.q$$

- In the simulation model, the quantity purchased is defined as: $q = p.(D\_Actual)$

- Where p is the percentage of energy purchased, supposed Uniform in the interval (0.95, 1.10) and D_Actual is the “actual” demand, a truncated Normal random variable.

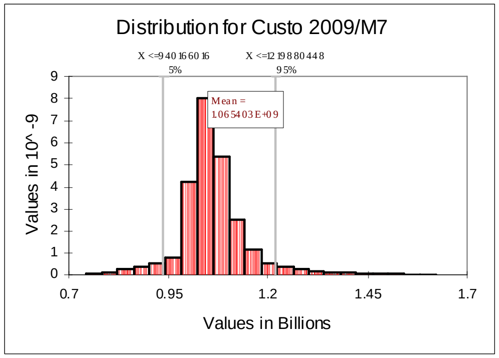
Simulation Model for Energy Purchases

- Total Acquisition Cost – 2007



Simulation Model for Energy Purchases

- Total Acquisition Cost – 2009



Simulation Model for Energy Purchases

- A sensitivity analysis on the inputs reveals that the percentage of the estimated load purchased in 2009 is the most important factor to determine the total cost for that year.
- The higher the amount of energy purchased, the lower the cost.
- This is due to the substantial increase in the Settlement Prices observed in 2009.

Simulation Model for Energy Purchases

- This tends to alter a company's purchasing strategy – when forecasting very high levels for the PLDs, it is cheaper to over-purchase energy than to risk any level of under-contracting.
- The results for 2010 and 2011 are quite similar to those for 2009, but there is an even more marked tendency to cost increases, reflecting higher Settlement Prices.

Simulation Model for Energy Purchases

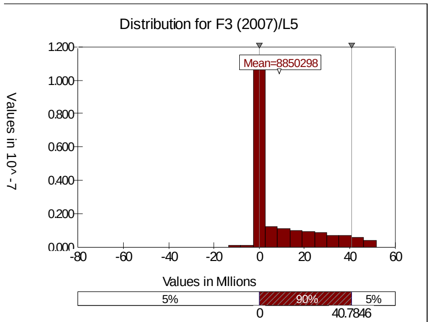
- This sensitivity analysis suggests a possible cost minimization strategy:
  - Keep percentages of energy purchases high in 2010 and 2011 and, to a lesser extent, in 2009.
  - Keep the energy purchase amounts well adjusted in 2007 and 2008 to avoid unnecessary costs.

Simulation Model for Energy Purchases

- One could also examine the penalty costs separately.
- Let F be the total penalty incurred by a distributor, that is, $F= F_1 + F_2 + F_3$.
- Components F_1 and F_2 always represent a loss for the utility, while F_3 may bring profits.

Simulation Model for Energy Purchases

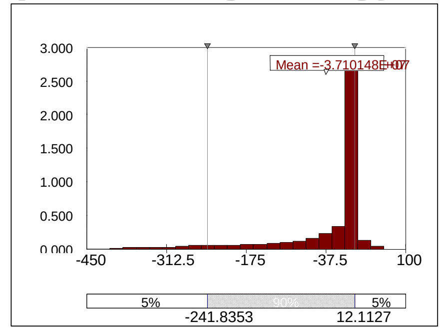
- **Excessive cost due to over-purchasing energy – 2007**



Almost all values represent a penalty, i.e, an added cost (when $F_3 > 0$).

Simulation Model for Energy Purchases

- **Excessive cost due to over-purchasing energy – 2011**



Quite often, the component F_3 represents profit, not penalty. This happens when its value is negative.

Conclusions

- **One might think the new regulatory model practically eliminated distribution companies risk because their responsibilities were considerably reduced.**
- **Now distributors are only required to inform their demand forecasts.**
- **But they are punished in case these forecasts prove wrong.**

Conclusions

- **The new regulatory model tries to encourage a relatively high purchasing level by means of asymetric penalties.**
- **When companies under purchase, correction possibilities are fewer than when the opposite occurs.**

Conclusions

- The sophisticated regulatory model implemented is fragile because:
  - the same acquisition strategy in the auctions may prove profitable or not depending on variables that are not under the control of distribution companies.
  - The Settlement Price - PLD is highly volatile and this increases the possibilities of punishment.