Supply Security in the Brazilian Electricity Sector

By Luciano Losekann and Adilson de Oliveira*

Background

Security of supply in electricity systems is an important topic in electricity sector reform. Around the world, different mechanisms are employed to perform this task in a competitive environment (Turvey, 2003; Joskow, 2006; Cramton e Stoft, 2006).

According to Joskow (2006) this is a complex task due to the unusual characteristics of electricity supply and demand. The author argues that usual approaches to remunerate generating capacity are not efficient and don't create enough revenues to stimulate new investments. Due to institutional restraints, the energy price in scarcity moments doesn't reach the level that fully covers the power plants capital cost. Joskow calls it the "missing money" problem, and considers it the main deterrent to investments in generating capacity in the U.S.

Joskow (2006) focuses on the U.S. electricity sector, where supply security results from an excess of generating capacity during peak demand (or a reserve margin). In electricity systems based on hydropower, as Brazil, supply security has other determinants.

First, hydropower production depends on water inflow, which can be highly volatile. It adds uncertainty to the supply security problem, an aspect that is not emphasized by Joskow (2006). Second, water stored in reservoirs can be transformed into electricity almost instantaneously. So, it is easier to provide a real time balance and, depending on the amount of energy that can be stored in the reservoirs, security of supply can be determined by reservoirs levels.

The particular features of the supply security problem have implications for electricity sector reform and a similar "missing money" problem exists in Brazil. This article analyzes the results of energy auctions, the main instrument to promote investments in generating capacity in the new institutional model of the Brazilian electricity sector.

The Brazilian Electric System

The predominance of hydropower is the main feature of the Brazilian electric system. Hydropower plants amount to almost 80% of the installed capacity (101 GW). As many hydro plants share the same river basin most of the decisions are interdependent. The Brazilian hydro plants count on reservoirs with large storage capacity that operate in a pluriannual scheme[1]. In the whole set of reservoirs it is possible to store an amount of energy equivalent to half of the annual electricity consumption of Brazil.

Another consequence of a predominantly hydroelectric system is that the average cost rises through time (marginal cost in the long-term is higher than average cost), as the most attractive hydroelectrics are used first. Another point is that the hydroelectric plants have a functional life that is longer than the amortization period and today the capital costs of a large portion of the hydro plants have been amortized and their operation costs are low. Meanwhile the new plants that are starting to work have to cover investment and operational costs that are higher (especially the thermoelectric ones). These characteristics make the coordination of the Brazilian electric system very unique and raise restrictions to the process of reform.

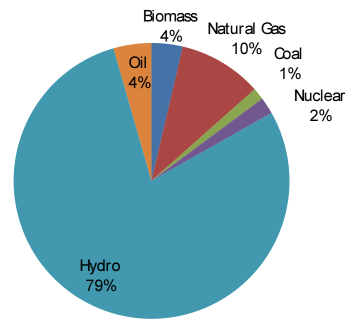

Figure 1
Brazil Installed Capacity
(Dec. 2006)

Note: Hydro includes the Paraguayan capacity of the bi-national hydro plant, Itaipu, that is oriented to Brazil (5.6 GW). The Brazilian electricity system also comprises 0.2 GW of wind power. It refers to the Brazilian interconnected system, which embraces 98% of total capacity.
Source: EPE

The First Reform and the Rationing

Until the 1990s, the electricity sector in Brazil was based on state ownership. The 1990s reform meant to broaden private participation in the Brazilian electricity sector and to introduce incentives to efficiency, mainly through liberalization of electricity generation. Following the international experience with electric sector reform, an independent regulatory agency was established (Aneel), an independent operator of the system (ONS) and a wholesale energy market (MAE).

The liberalization of power generation in Brazil tends to increase prices as they align with the long run marginal cost, which is higher than the average cost (reference to tariffs in the cost of service regulation). In order to avoid a sudden rise of prices the government opted for a steady and slow transition to a competitive energy market. The prices were kept regulated until 2003 and were supposed to be gradually liberalized (25% a year) until 2006.

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See footnotes at end of text.

Even before the transition to the competitive model was completed, Brazil faced a major crisis in electricity supply. Since the late 1990s the level of storage in the hydro-electric reservoirs has progressively diminished (Figure 2). In the beginning of the dry period of 2001 (May), the Southeast and Northeast reservoirs operated with only one third of their full capacities, an amount that is not sufficient to meet the demand until the start of the next rain season[2]. In May 2001, in order to avoid the complete depletion of the reservoirs[3], which would possibly happen in August in the Southeast (red line on Figure 2), the government made rationing mandatory at a rate of 20%[4] of electricity consumption in the sub-systems of the Southeast/Mid-West and Northeast.

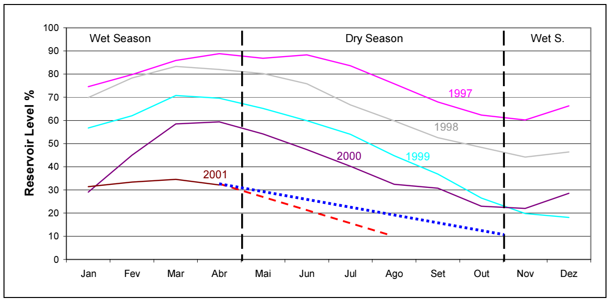

Figure 2
Reservoirs Depletion and Estimated Rationing Impact Reservoir level in SE/MW sub-system (%) - 1997- April 2001

Note: The red dashed line represents estimated evolution if the rationing measures were not adopted. The blue dotted line represents the evolution intended by the rationing measures, even with poor hydrology.
Source: Author / ONS data

The reservoirs' depletion was the result of the imbalance between supply and demand. Installed capacity has expanded at a slower pace than that of the demand, since the late 1980s[5]. Those who lead the reform expected the natural gas thermo-power plants to dominate the generation expansion. The thermoelectric expansion had two advantages in providing energy security: it would make the Brazilian electricity system less dependant on hydrology and it would correct the imbalance between supply and demand in a shorter time than hydropower. However, the thermoelectric plants represented a small part of the generating capacity expansion in the second half of the 1990s (Figure 3).

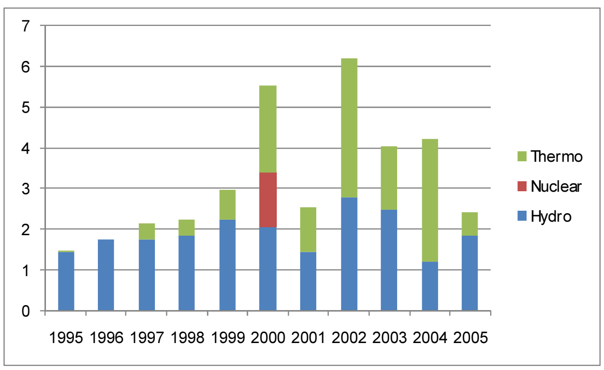

Figure 3
Generating Capacity Expansion 1995 – 2005 – GW

Source: EPE

This was a result of a deficient integration between the electricity and natural gas industries, the latter is still evolving in Brazil. The Brazilian electric system operation is based on the principle of using thermoelectric plants only during low hydrology periods. When a series of high hydrology periods happens, a thermoelectric plant can spend years without dispatching, resulting in negative cash flow and blocking gas industry development. On the other hand, gaps in the regulation of the gas industry, mainly those related to prices, raise uncertainty around the thermoelectric projects. The program created by the government to stimulate investments in thermoelectric plants (Priority Thermo-electricity Program, PPT in Portuguese) could not cope with this scenario. When the power plants included in the program came on line, it was too late to avoid power rationing.

Rationing lasted until May 2002. The consumption of electricity was drastically reduced, resulting in major economic consequences. The estimated social cost of the rationing was close to 3% of the GDP (Sauer et al., 2003).

The Second Reform of the Brazilian Electricity Sector

The second reform aimed at avoiding a new supply crisis with a concurrent rise of electricity prices. In 2004, the new regulatory framework re-established the planning role of the State and drastically altered the wholesale market.

The Energy Research Company (EPE, in Portuguese) was created to assist the Energy Minister in sector planning, playing an important role at the expansion auctions. It was decreed that all energy trade must be carried out by long-term contracts. The only function of the short-term market (Chamber of Electric Energy Trade – CCEE) is to correct imbalances. Agents that are systematically exposed to this market (contract less than necessary) are subject to penalties.

Two trade environments were created in the wholesale market: regulated contracting environment (ACR) and free contracting environment (ACL). At the ACR, distribution companies buy energy in public auctions. They submit demand projections in a five-year horizon to EPE. Based on those projections, EPE sets the total market that will be offered in the auctions. In these auctions, generators compete making bids ($/MWh and $/MW) to satisfy the distribution market. The winners then sign contracts with all the distribution companies that were part of the auction. Then the energy from each generator is divided among the distributors in the proportion that their market represent in the total amount negotiated. The energy sell price is defined by the bids of generation companies (pay as bid) and the purchase price, paid by the distributors, is unique and corresponds to the average of the sell price.

The model distinguishes the energy coming from already existing plants (“old energy”) from the energy coming from the new ones (“new energy”), both being negotiated in the ACR in different ways. The old energy was intended to respond to the existing market. In the auctions of “old energy” eight-year contracts were negotiated.

The “new energy” is aimed at the expansion of the distribution market. The “new energy” auctions are done with a view of three to five years ahead and they define the generating capacity expansion in Brazil. 15 to 30 years contracts are negotiated in the auctions.

At the ACL, large consumers[6] are free to choose their suppliers outside the centralized auctions. The energy is negotiated through bilateral contracts with generators and traders.

Auctions

Since late 2004, there have been five auctions of old energy. They negotiated contracts that start from 2005 to 2009 (Table 1).

Since December 2005, five new energy auctions have been carried out. Hydro and thermo power plants did not get the same treatment. Whereas the hydropower plants competed with prices for the generated energy, the thermoelectric plants made bids for the generating capacity[8]. The operational cost of thermoelectric plants that won the auctions will be passed to the final consumer.

In December 2007, an auction was carried out specifically to license a large hydropower plant. The Santo Antonio hydropower plant will be located in the Amazonian Forest with 3,150 MW of installed capacity. The project was the subject of a long debate and it was approved by the environment agency (IBAMA) after some adjustments to mitigate its impact on a very senstive environmental spot.

Results Evaluation

The new energy auctions are the touchstone of the new model of the Brazilian electricity sector. Concerning the energy tariff, the low prices in the old energy auctions made it possible for the energy buy price (average price) at the ACR to be maintained at a low level in coming years. Even though the prices have risen substantially throughout the auctions (7% yearly), the expected values in the next five years are considerably lower than long-term marginal cost (prices obtained in new energy auctions).

Figure 5 shows the generating mix resulting from the new energy auctions, including Santo Antônio’s auction. They resulted in 12.4 GW of new generation capacity. Hydropower plants represent 55% of the total. However, only 0.6 GW will start operation before 2011[9]. Until 2010, the expansion is concentrated in oil fuelled power plants (63%).

The second reform did not address the deficient integration between natural gas and electricity industries. It may have severe consequences on electricity supply security in Brazil, as those of the 2001-2002 power crises. Even though the capacity payment

	Starting Year	**Contracts Length**	**Price (US$/ MWh)[7]**	**Quantity (MWmed*)**
1st auction	2005	8	26.75	9,054
	2006	8	31.32	6,782
	2007	8	35.09	1,172
2nd auction **	2008	8	38.67	1,325
3rd auction	2006	3	29.28	102
4th auction	2009	8	44.15	1,166
5th auction	2007	8	48.71	204

* 1 MW average = 8,760 MWh/year
** It was offered contracts starting in 2009 but no dealer was interested.
Source: CCEE

Table 1
Old Energy Auction Results

		Starting Year	Contract Length Years	Average Price (US$/MWh)*	Quantity (MWavg**)
1st Auction					
(A – 5)	Hydro	2008	30	49.74	71
	Thermo	2008	15	61.52	561
	Hydro	2009	30	53.15	46
	Thermo	2009	15	60.12	855
	Hydro	2010	30	53.51	889
	Thermo	2010	15	56.66	862
2nd Auction					
(A – 3)	Hydro	2009	30	58.96	1,028
	Thermo	2009	15	61.58	654
3rd Auction					
(A – 5)	Hydro	2011	30	56.22	569
	Thermo	2011	15	63.93	535
4th Auction					
(A – 3)	Thermo	2010	15	62.64	1,304
5th Auction					
(A – 5)	Hydro	2012	30	60.07	715
	Thermo	2012	15	59.71	1,597
Sto. Antônio		Hydro	2013	30	36.68

Notes: * The average price of the thermopower plants is calculated on the basis of the dispatch and fuel prices expectations made by EPE.
** 1 MW average = 8,760 MWh/year
Source: CCEE

Table 2
New Energy Auction Results

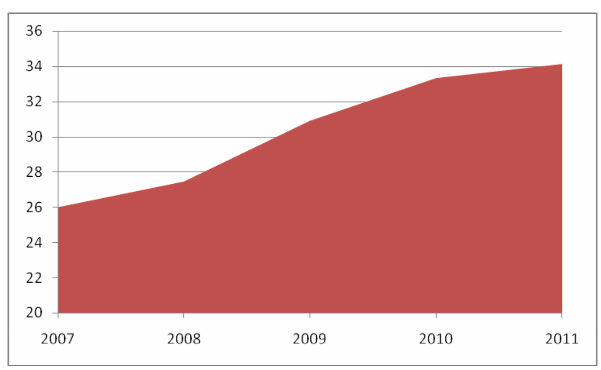

Figure 4
ACR Expected Prices (US$/MWh)

Source: Estimated by the author

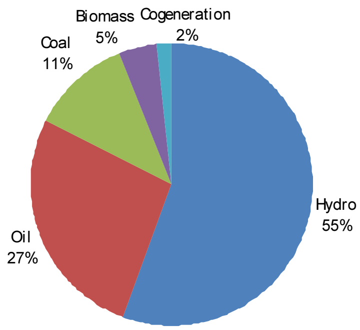

Figure 5
Structure of Generating Capacity Expansion

could stimulate investment in thermoelectric plants, it does not assure sufficient remuneration to the natural gas infrastructure.

Indeed, the very low rate of dispatch of gas power plants after the rationing led Petrobras, the company which controls the natural gas industry, to orient the fuel to other markets (industry and transport, mainly). Today, only 30% of existing natural gas capacity has sufficient fuel to operate.

The oil fuelled power plants that dominated the new energy auctions are not adequate to solve the energy security problem in Brazil. As thermoelectric plants are dispatched intensely during adverse hydrology periods, their high operational cost would mandate an unbearable bill. Considering the plants selected in the auctions, we estimate that the yearly cost can reach US$ 2 billion resulting in a 10% increase in energy tariffs. And, as the recent ONS report indicates, it could be insufficient to avoid a new rationing. In 2009, the risk of an energy deficit is near to 10% in the Northeast region, where the Brazilian electricity system is more fragile (ONS, 2007).

So, a better integration of electricity and natural gas industries is needed to provide energy security in Brazil. It involves a redefinition of the role of thermoelectric plants, which must be dispatched on a regular basis to afford an attractive remuneration to natural gas infrastructure. Using the terms of Joskow (2006) and Cramton and Stoft (2006), it would be the way to solve the "missing money" problem in Brazil.

Footnotes

[1] Water can be stored to respond to demands of over a year ahead.

[2] Specialists point out that reservoirs should retain at least half of their capacity filled up in the beginning of the dry period.

[3] For technical reasons, reservoirs can't operate with less than 10% of their capacity.

[4] This percentage would be enough to ensure that the reservoir reaches the end of the dry period on the level that allows the plant to operate (blue spotted line on Figure 3).

[5] This was one of the reasons of the first reform. A crisis did not occur before because investments were intense in early 1980s resulting in over-capacity in that time.

[6] Demand greater than 3 MW.

[7] All the currency conversions are made using the exchange rate 1 US$ = R$ 2.15, which corresponds to the average exchange rate in 2006.

[8] The bids related to the producers' fixed income. To order offers EPE calculated the dispatch that would be expected from the central.

[9] The government decided to auction only the hydropower sites that already have environmental licenses to operate so as to reduce investors' risk. However, the government faced many difficulties when licensing the centrals and it took longer than anticipated.

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