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Brazil's Electricity Market Design: An Assessment

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Brazil's Electricity Market Design: An Assessment

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Resumo

Este artigo examina o desenho de mercado do setor elétrico brasileiro tendo em vista as suas características e a crise energética de 2001. As características do sistema elétrico brasileiro impõem vários desafios para a implementação de um mercado competitivo: a dupla natureza da provisão de energia elétrica; a possibilidade do exercício de poder de mercado "alavancado"; e sinergias decorrentes da diversidade hidrológica, da administração de reservatórios na mesma bacia hidrográfica e da coordenação hidrotérmica. A crise energética de 2001 decorreu principalmente de problemas de implementação, mas também demonstrou uma debilidade do desenho de mercado em vigor. O referido desenho de mercado é avaliado e são apresentadas sugestões para aprimorá-lo.

Abstract

This paper examines Brazil's electricity market design in light of its characteristics and the crisis experienced in 2001. Brazil's electric system entails a number of challenges for the implementation of a competitive market: the double nature of electricity provision; the possibility of exercising "leveraged" market power; and synergies due to the hydrological diversity, intra-reservoir management and hydrothermal coordination. The 2001 electricity crisis was due primarily to implementation problems, but it also demonstrated a weakness of the current market design. The current market design is evaluated and improvements are suggested.

Key words: Market design, electricity industry, hydrothermal coordination, antitrust policy.

JEL Classification: D40, K23, L50, L94.

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1 Introduction

In 2001 Brazil's electricity industry experienced a major crisis. Due to a supply shortage, a 20% rationing program was imposed on approximately three-quarters of Brazil's integrated system load. Unclear delineation of responsibilities led to major lawsuits bringing the market into complete disarray. To many analysts, the crisis was evidence that Brazil's market design was fundamentally flawed.

In this paper we assess Brazil's electricity market design. Our assessment begins by examining the industry's physical and technological characteristics to identify the main challenges the market design must address to obtain efficiency. We also examine the 2001 Electricity Crisis to examine the institutional challenges of the industry. Given these criteria we assess Brazil's current market design and present suggestions on how to improve it.

In the next section, the main characteristics of Brazil's electric system are presented. In section 3 we present some of the basic characteristics of Brazil's current electricity market design. The main causes of the 2001 electricity crisis are identified in section 4. We identify the main requirements that the market design must satisfy, and present suggestions of how to improve Brazil's market design in section 5.

2 Market Characteristics

The provision of electricity is a **double-natured service**: it presents characteristics of both private and public goods. The provision of electricity can be categorized as a private good because it is both excludable and rival. The provision of electricity is a rival good in the sense that the electricity consumed by one customer cannot be consumed by another customer; and it is excludable in the sense that the consumption of electricity of each customer can be metered and billed, and that non-paying customers can have their electricity supply cut off.

On the other hand, the provision of electricity presents characteristics of a public good. An important aspect of the provision of electricity to the consumer is its reliability and quality. In integrated systems,[3] the reliability and quality of the provision of electricity does not depend on the individual power suppliers but on how the system as a whole is operated. This occurs because the electricity is a non-storable good transported by transmission and distribution networks. This implies that instant market clearing is required to maintain the supply and demand constantly in balance and that all suppliers must synchronize and regulate their generators to maintain the frequency and amplitude of the alternating current stable. Furthermore, the dispatching of individual power plants must be adjusted to contingencies of the transmission and distribution networks and of each of the power plants. Thus the reliability and quality of the provision of electricity is a non-rival and non-excludable good.

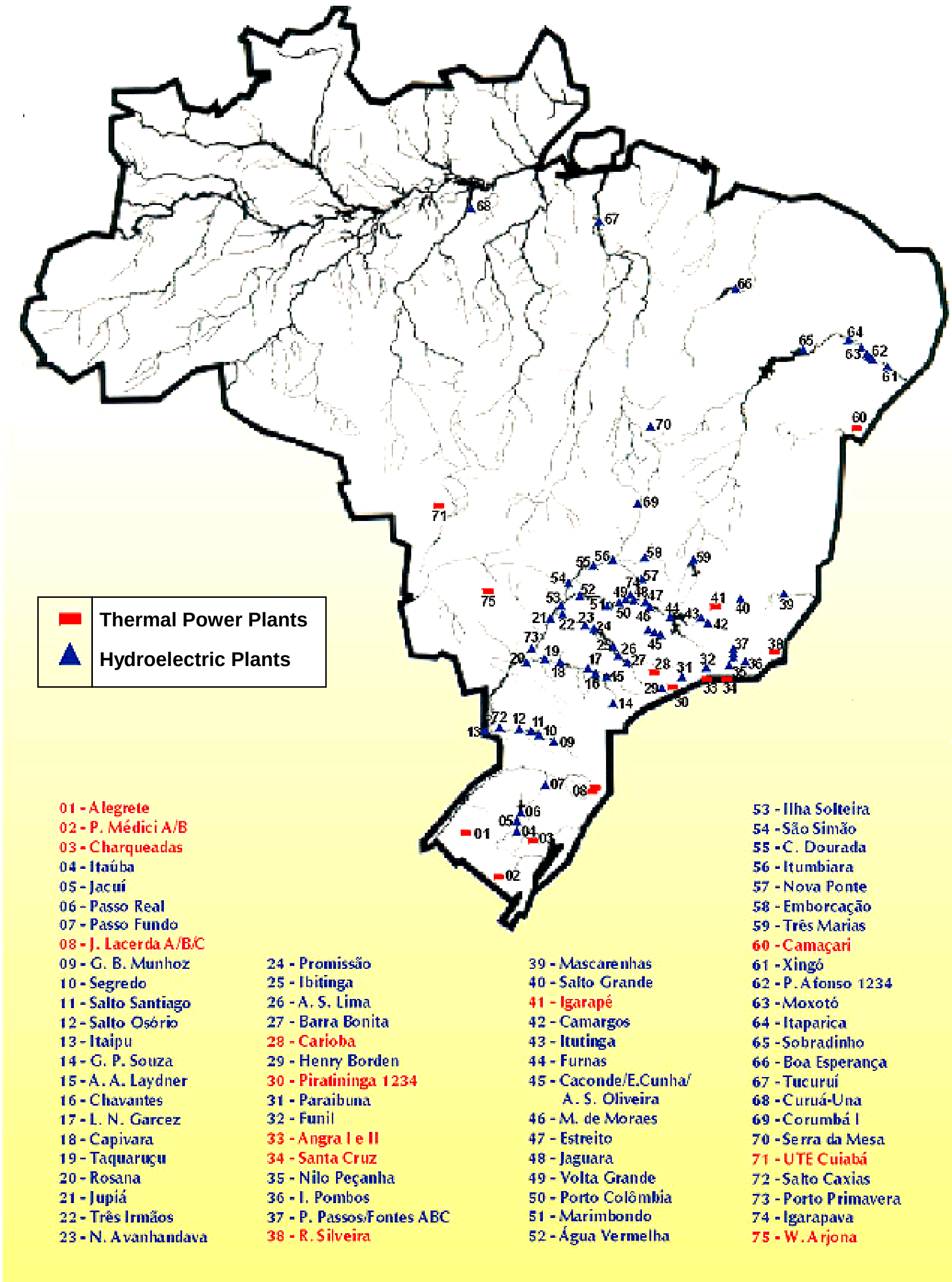
The double nature of the provision of electricity presents an important implication for market design: to allow the market coordination of the private good component of electricity provision, an institutional infrastructure is required to provide the public good component.

[3] Integrated systems refer to electric systems with interconnected transmission or distribution networks, through which electricity can flow freely from one system to the other.

Market power is another concern that must receive special attention due to the double-nature of the provision of electricity. Electricity suppliers may be able to leverage their market power by exploiting the public good component of provision of electricity. Electricity suppliers may force other generating plants to operate out of “merit order” (least-cost basis) due to system constraints. These constraints may be due to limitations of the transmission or distribution networks or due to system reliability requirements.

Another form of market power abuse that can arise in electric systems is a type of gaming by multi-unit generating firms. Electric systems are usually composed of several different generation technologies. These different technologies are adopted to supply different components of the demand cycle. Because of the various cost structures of these different technologies, multi-unit generating firms can often manipulate market prices by withhold one or more of its units to increase revenues paid to its remaining power plants. This is another form of exercising market power that is unique to the electricity industry. The possibility of **leveraged market power** makes the electricity industry particularly susceptible to anticompetitive behavior. Thus the market design must give more weight to antitrust concerns.

In addition to the general concerns associated with electricity provision, the market design for Brazil’s electric system must consider some of its particularities. We point out three particularities that give rise to synergies, which need to be considered to optimize system operation.



Source: Operador Nacional do Sistema

Figure 1: Map of Brazil's Power Plants

Almost all of Brazil's generation currently originates from hydroelectric plants. These hydroelectric plants are spread out in various water basins located hundreds and even thousand kilometers apart from one another (see figure 1). These water basins present diverse hydrological conditions. Often when one water basin experiences adverse hydrological conditions (drought) the other experiences favorable hydrological conditions (floods). In other words, the hydrological conditions among basins are not highly correlated. This diversity of hydrological conditions implies that the aggregate amount of energy the system can consistently supply is higher when the plants are operated in a coordinated manner than when each hydro plant is operated individually without considering the conditions of the system. This is the source of the first type of synergy of the Brazilian electric system, which we refer to as **hydrological diversity**. This implies that coordinated planning and operation of the hydroelectric plants results in a more reliable electricity generation than when each hydroelectric plant acts individually.

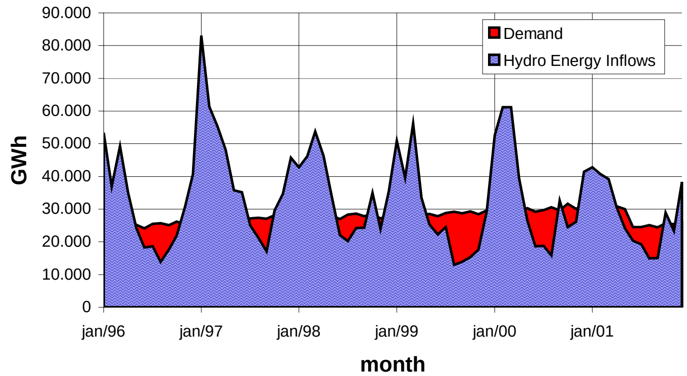
Many of the hydroelectric plants are located on the same river basin. Thus the operation of the reservoirs of hydroelectric plants upstream affect the operation of those downstream. Most of Brazil's hydroelectric plants present relatively low head (low height) and large reservoirs. In this context the level of water stored in the reservoir of the hydroelectric plant affects the head significantly, increasing (or decreasing) the amount of electricity generated per unit of water discharged through the turbines. Generally the optimal way to manage the hydroelectric reservoirs is to prioritize the filling of the downstream reservoirs. This implies that coordinated operation of the hydroelectric plants on the same river basin leads to a greater efficiency level than when each plant is operated individually. This is the second type of synergy, which we refer to as **intra-basin reservoir management.**

The participation of thermal power generation is expected to grow significantly in the coming years. This growth is due to:

- the increased scarcity of potential sites for new hydroelectric plants near the load centers,
- the increased efficiency of natural gas power plants,
- the installation of a major gas pipelines linking large gas reserves to the major load centers.

The increased participation of thermal plants in Brazil's electric system will enable the hydroelectric plants to explore hydro inflows more intensively. Due to the conjunction of limited storage capacity of the reservoirs and the stochastic behavior of the hydro inflows, not all the hydro energy inflows[4] can be exploited (some of it is spilled over). Figure 2 shows the hydro energy inflows of the Brazilian electric system and total load. If all the hydro energy inflows could be stored, the hydroelectric plants would be able to supply the entire market and still have much energy to spare. Yet, because of spillage, a great deal of energy is lost.

[4] Hydro energy inflows refer to the natural river flows (expressed in units of electricity, GWh) that reach each hydroelectric plant, without the regularizing effect of the reservoirs. Hydro energy inflows are the total amount of energy that could be generated from the volume of water reaching each hydroelectric.



Data Source: Operador Nacional do Sistema

Figure 2: Hydro Energy Inflows and Electricity Demand

In the current situation of almost total reliance on hydroelectric generation, hydroelectric plants must be dispatched relatively sparingly to maintain the reservoirs levels high, in order to withstand adverse hydrological conditions that may occur in the future. As the participation of thermal plants increase, hydroelectric plants may be dispatched more liberally because the drop in hydro generating capacity in adverse hydrological conditions can be made up by more generation from the thermal power plants. In this way the amount of "wasted" hydro energy inflows can be minimized. From the perspective of the thermal power plants, the benefits of coordination with hydroelectric are derived from the substitution of low-operating-cost hydroelectric generation for their own generation, during periods of favorable hydrological conditions. The gains obtained from coordinating the operation of hydroelectric and thermal power plants is called **hydrothermal coordination**, and is our third source of synergy.

3 Market Design: how it is meant to work

Brazil's electricity reform sought to promote competition in the generation and retailing segments of the electricity industry. The key elements introduced to achieve this objective were the creation of a spot market, managed by an independent system operator, and of open access legislation to the transmission and distribution networks.

The spot market was designed to provide price signals to the market participants and to give the system operator the flexibility to optimize operation and to ensure system reliability. Thermal plants present price bids at which they are willing to operate.[5] Hydroelectric plants' bids are determined by a computer algorithms administered by the system operator based on the intertemporal opportunity cost of water. The spot market operates as a tight pool, determining the dispatch of all power plants. Although the physical operation of the system is determined in the spot market, most of the financial

[5] The spot market accepts energy-only bids; there are no capacity payments. Capacity payments may be introduced to decrease the spot market price volatility, as discussed by Comitê de Revitalização (2002).

transactions are settled previously through bilateral contracts between generation firms and **free customers**[6] or retail firms.

The retail firms and free customers are expected to secure their own electricity supply through bilateral contracts. Electricity consumed, not covered by bilateral contracts are settled at the current spot market price. When there is insufficient power to supply all demand the price is capped at the cost of deficit, established by the regulatory agency. In order to limit the exposure of captive customers to the volatile spot market prices, retailers are required to contract at least 85% of their captive customers' load.[7] Although bilateral contracts are strictly financial agreements (not affecting the physical operation of the system), only bilateral contracts offered by power plants can be presented to satisfy the minimum contract requirement. Power plants may not offer bilateral contracts in excess of their generating capacity. In the case of hydroelectric plants, the amount that may be offered in bilateral contracts, referred to as **assured energy**,[8] is based on its expected generating capacity which can consistently be supplied with a 95% confidence level, given historic hydro inflows and the hydroelectric plant efficiency. This requirement is intended to drive system expansion to meet expanding demand.

The amount of electricity a particular hydroelectric plant can generate in a given year depends on hydrological conditions, which can vary significantly. To minimize the hydrological risks of the individual hydroelectric plants, their generation is pooled and deviations from the aggregate assured energy level are allocated proportionally among all hydroelectric plants. This pooling mechanism is referred to as the **Energy Reallocation Mechanism**.

4 The 2001 Electricity Crisis: what went wrong?

In 2001 Brazil experienced its largest energy shortage in history. After much discussion the government created a new administrative body, the *Câmara de Gestão da Crise de Energia Elétrica*, to manage the crisis. A mandatory rationing program was introduced: a 20% cut in of the load of the previous year in the Northeast and Southeast/Central West Markets. The electricity industry entered a state of disorder with customers and power suppliers alike threatening lawsuits adding up to billions of dollars and with no financial transactions clearing in the bulk electricity market. The regulatory agency was forced to intervene in the wholesale market. Was this evidence that the electricity market was fundamentally flawed or can the fault be attributed to some other factor(s)? To answer this question we examine the key determinants of the crisis.

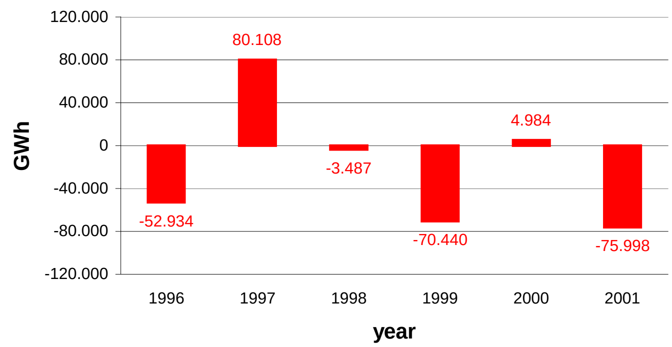
[6] Free customers refer to those customers who spontaneously choose their retailer or choose to purchase their electricity directly in the wholesale market. Customers who have not opted for a particular retailer are named **captive customers**.

[7] This minimum contract requirement is expected to be increased, possibly to 95% and to be extended to free customers also (previously it was only required for the load of captive customers). Comitê de Revitalização (2002).

[8] The assured energy of each plant is determined by the regulatory agency.

4.1 Adverse hydrological conditions

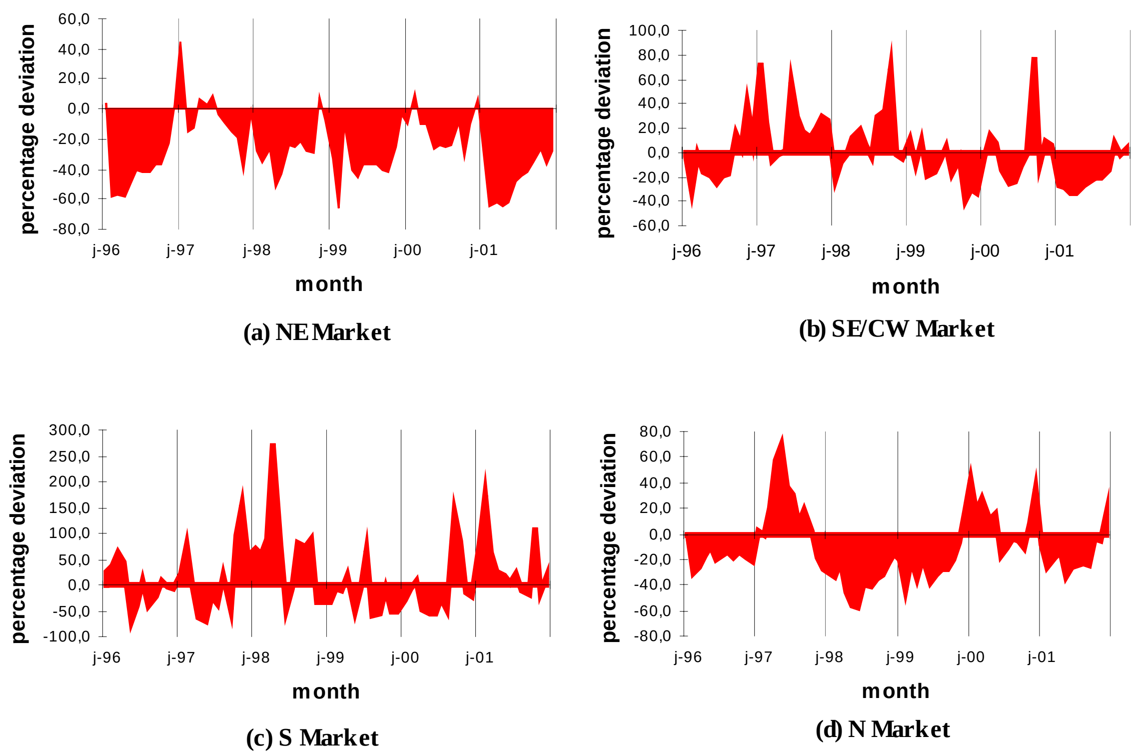
The aggregate hydro energy inflow between 1996 and 2001 was below the long-term average, but only by 4.8%. Although the aggregate hydro energy inflow was near the long-term average, two of the last three years were particularly dry, as shown in figure 3.



Data Source: Operador Nacional do Sistema

Figure 3: Aggregate Hydro Energy Inflow Deviation From Long-Term Average

One gets a better idea of the situation when one examines the hydrological conditions in each market. Due to transmission constraints, the hydrological conditions between markets cannot be totally socialized because the transfer of energy between markets is limited.

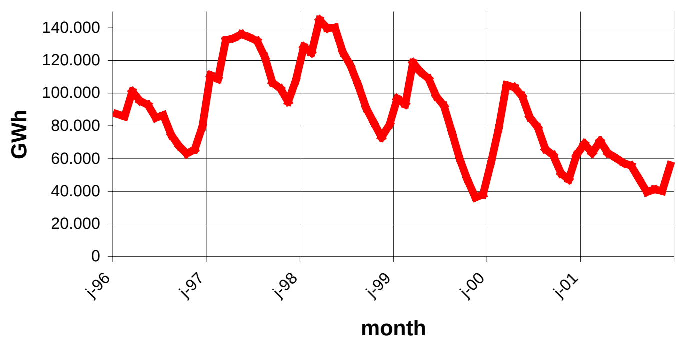


Data Source: Operador Nacional do Sistema

Figure 4: Deviation from Long-Term Average of Hydro Energy Inflows

The hydroelectric plants of the Northeastern Market (NE Market) suffered the worse hydrological conditions. Hydroelectric plants of the Northern Market (N Maket) and the Southeastern/Central-West Market (SE-CW Market) also suffered below average hydro energy inflows, while those in the Southern Market (S Market) experienced above average hydro energy inflows.

Deviations from the long-term average are not unusual, however, and the electric system is designed to withstand all but the most unlikely deviations from the long-term average. Evaluating the system's performance by its own planning criteria, the rationing cannot be justified by the adverse hydrological conditions. While the long-term average hydro energy inflow is 414 TWh per year, the assured energy, that is the amount of energy that system planners expect the hydroelectric plants to consistently supply, is no more than 60.7% of this value, or 251 TWh per year.[9] Yet total hydroelectric generation was consistently higher than this over the entire period between the years 1996 and 2000: 294, 311, 323, 325 and 335 terawatt-hours (TWh), respectively.



Data Source: Operador Nacional do Sistema

Figure 5: Aggregate Hydro Stored Energy

Thus according to this criteria, the 2001 rationing was due to an over reliance on the existing hydroelectric plants to supply the ever-growing demand. The effect of this over-reliance on existing hydroelectric plants was a progressive fall of the system's stored energy supply, as shown in figure 5.

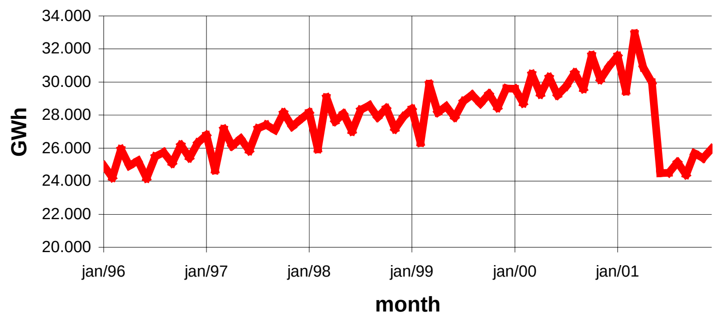
4.2 Inadequate generation expansion

The over reliance on existing hydroelectric generation was due primarily to the lack of investment in new power plants. There are a number of reasons for the inadequate generation expansion.

Although Brazil's electricity demand has grown at a fast pace (electricity consumption growth has outpaced the growth in the gross domestic product), it has not deviated significantly from its historic trend. As can be seen in figure 6, the only significant deviation from its historical trend was the fall in demand due to very

9 The amount of assured energy for each hydroelectric plant was approved by the regulatory agency, ANEEL, in Resolution No. 232 of 1999.

successful energy rationing program. Thus, the crisis cannot be attributed to unexpected demand growth.



Data Source: Operador Nacional do Sistema

Figure 6: Electricity Demand

The main reason for the under investment in new generation is market uncertainties. Considering investors' choices from a real options perspective, one recognizes that the payoff of delaying investments has been higher than that of the remaining alternatives (i.e. immediate investment or permanently abandoning the investment opportunities) because of three major market uncertainties. These uncertainties originate primarily from ambivalent political, institutional and regulatory policies.

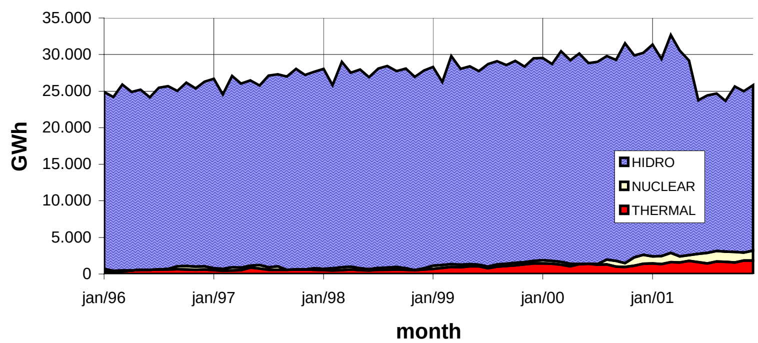
The postponement of announced privatizations of the state generating companies is the first source of uncertainty that has hindered investment in generation. Major investors planning to enter the Brazilian market see privatization as a major starting point to determine their entrance strategies in the country. Depending on the assets they may come to purchase in the privatization process, different investment portfolios may be of interest due to synergies among the assets.

The second source of uncertainties arises from the nonfunctioning wholesale market. Brazil's reform sought to create a market in a consensual way with ample participation of the market agents. Unfortunately, the wholesale market experienced governance problems. The wholesale market assembly, in charge of elaborating and approving the market rules, was halted by gridlock due to opposing interests of the market participants. The functioning of the wholesale market was also impaired by the absence of dispute resolution procedures.

The third source of uncertainties has been the incompatibilities between the gas supply pricing and regulation and the electricity pass through regulation. Brazil's natural gas prices are indexed to a basket of prices of several petroleum products in the international market. The implication of the indexing of domestic natural gas prices is severe volatility due to fluctuating oil prices and exchange rate. On the other hand the electricity regulatory agency has not permitted regulated retailers to pass through these costs to the captive customers (which includes most of the load). Only in the beginning of 2001 did the regulatory agency allow the natural gas prices to be passed through to captive customers on a yearly basis. Yet, in the previous years, that had been one of the major obstacles for investors in natural-gas-fired power plants. Another incompatibility was the contractual terms by which the natural gas supplies were offered. They required that power plants sign take-or-pay provisions, which hinder the hydrothermal coordination. This clause was finally relaxed in 2001, when the take-or-pay provision was limited to only 75% of the contracted amount.

4.3 Inappropriate spot market price signaling

The intertemporal opportunity cost of water depends on a number of variables that are difficult to determine in a decentralized market economy. One of these is the probability of energy shortages in the future. This depends on three factors: hydrological forecasts, load growth projections and expected generation expansion. All of these involve a degree of uncertainty, specially the expected generation expansion, which does not present a predictable trend. When a planned power plant construction is postponed, as has frequently occurred in Brazil (most recently this has been the case of most thermal power plants), the intertemporal opportunity cost of water results in inappropriate dispatching of the system's power plants. This was one of the causes of Brazil's 2001 electricity crisis. In previous years, in spite of low storage levels in the system's reservoirs, the opportunity costs of water calculated by the computer algorithm remained relatively low due to the expectation of new power plants to come on line, which decreased the probability of future energy shortages. The low opportunity costs of water led the system operator to utilize hydroelectric plants more intensively than it should have. Figure 7 shows the progression of electricity production by source. One can observe that thermal power generation was low until 1999. If they had been dispatched more intensively in the previous years, the reservoir levels would have been in better conditions to deal with the adverse hydrological conditions of the following years.



Data Source: Operador Nacional do Sistema

Figure 7: Electricity Production

Unlike the causes for the crisis presented previously, this problem was not due to exogenous causes, like hydrological conditions, or to flawed implementation of the market design, like the postponed privatizations, non-functioning wholesale market and natural gas contractual incompatibilities. The inappropriate price signaling of the spot market is due to fundamental input variables, used in the intertemporal optimization process, which require business judgment calls. These are challenges that the system operator will always face and be second-guessed by market participants.

4.4 Contract misspecification and unprepared rationing procedures

The root cause of the 2001 electricity crisis was the energy shortage. Although the energy shortage was severe, it did not necessarily have to result in a crisis. Brazil has suffered energy shortages previously and successfully implemented rationing programs. The electricity reform envisioned the need of establishing rationing procedures. Unfortunately, the rationing procedures were not sufficiently delineated and the institutions poorly prepared to manage the rationing program. In addition, power supply contracts between the generators and retailers did not properly delineate responsibilities in case a rationing program was to be adopted. As a result the implementation of the rationing program was delayed –requiring even more austere cutbacks in electricity consumption– and the rationing program gave rise to a multitude of lawsuits. The crisis was finally resolved in a collective settlement in which the legal liabilities were to be partially recovered by a surcharge to be charged from customers over the following years and federal loans to provide immediate financial relief to the industry.

5 An Assessment of Brazil's Market Design

Brazil's current market design is a good compromise in the attempt to create an environment open to private investment while safeguarding from market power abuse, maintaining system security and full exploitation of the efficiency gains arising from the synergies of the Brazilian electric system.

The causes of the Brazilian 2001 electricity crisis were primarily related to implementation failures. Brazil's market design is not fundamentally flawed and should be adequate once it is fully implemented and some adjustments made.

While Brazil's market design is workable, it does present a major weakness that will be a constant source of friction. The current market design allows private ownership of hydroelectric power plants, but does not give the owner any autonomy over operation. Unlike the thermal power plants the hydroelectric plants are not allowed to bid their energy in the spot market, rather a computer algorithm managed by the system operator determines the opportunity cost of water. Likewise, the assured energy is determined by the regulatory agency, which restricts the amount of contracting the hydroelectric plant owners are allowed to take on. This breach between ownership and operation of the hydroelectric plants will be a constant source of tension in the Brazilian electricity industry. The performance of hydroelectric plant owners will depend only of their financial and commercial efforts and their ability to influence administrative decisions, optimization procedures and through lawsuits. As pointed out in section 4.3, the operation of the system unavoidably involves some business judgment calls. Under the current market design, the system operator makes these decisions. These judgment calls are always subject to controversy and will undoubtedly be contested.

Another drawback of the current market design is that it does not require long-term supply commitments. This has two effects: it penalizes the end-user in periods of adverse hydrological conditions through rationing programs and it favors hydroelectric plants at the expense of thermal plants. Although rationing programs decrease the overall cost of provision of electricity, the 2001 electricity crisis demonstrates that the tolerance to rationing programs is decreasing, suggesting that system reliability should be increased to assure adequacy even in periods of adverse hydrological conditions. This arrangement also deters investments in thermal power plants because the residual demand (demand not supplied by hydroelectric plants) varies considerably from year to year.

In order to improve the incentive scheme of the market, we suggest that hydroelectric plant owners be given operational autonomy together with firm supply commitments. Integrating ownership and operational autonomy of hydroelectric plants would improve incentives, which could lead to dynamic efficiencies due to improved optimization procedures, more resilient market forecasts, quicker adaptation to changing market conditions, etc.

These changes would require even more from the market design because the market would not only be used to promote the expansion of the system but also for operation of the system. The market design would have to contend with three major challenges: coordinating the operation of different firms and technologies to exploit the synergies of the system, maintaining reliability and quality of service, and minimizing the potential of market power abuse. This would require significant market structuring. The key elements the market design must implement to achieve efficiency:

- require power suppliers to pre-commit far in advance the amount they will supply, this would induce hydroelectric plant owners to commit based on their long-term expected hydro inflows rather than current hydro conditions which can be very volatile;
- have transactions centralized in market to exploit system synergies;
- allow and promote demand-side participation;
- develop a secondary market to allow firms to adjust in order to optimize the operation given current conditions;
- foster contestability by allowing consumers to provide the level of commitment necessary to foster new investment.

In the remaining portion of this paper we present a suggestion of how this market design could take form. Several markets would be required: a centralized **forward market** to promote the intertemporal optimization in the decentralized decision-making setting and minimize the potential of market power abuse; a centralized **secondary market** for the energy certificates issued in the forward market to provide the operational flexibility to allow the exploitation of the system's synergies; long term **bilateral contracts** offered by new suppliers (or from incumbents' new power plants) to increase contestability; **call options** to provide a financial alternative to the forward market and bilateral contracting; and **adequacy of supply demonstrations** to assure adequate supply.

5.1 The forward and secondary markets

A key element for proper operation and expansion of the system is that the management of the water reservoirs. Given that most of Brazil's generation originates from hydroelectric plants, it is crucial that hydroelectric generation be operated in a sustained manner. If hydroelectric generation is not regularized the market will be unstable and less reliable. The increased instability and lower reliability will lead to higher operating costs and a distorted configuration (distorted investment). Thus the market design must induce hydroelectric plants to commit to a sustainable generation level. This can be obtained by centralizing most of the market transactions in a single forward market for energy supply and by penalizing power suppliers who fail to honor their commitments in the forward market.

The forward market would be structured as an auction. Every three years, a single auction would be held to determine the supply over the next three-year period. Power suppliers would determine how much they would be willing to supply at the current price while retailers and free customers would determine how much they would be willing to purchase at the current price. Only power suppliers (i.e. owners of power plants) would be allowed to sell power in the forward market. Incumbent power plants would only be allowed to sell energy through the forward and spot markets.

Two types of energy would be offered in the forward market: flexible energy and non-flexible energy. Both forms would be auctioned simultaneously in blocks of 8.76 GWh/year, for example. Each block of non-flexible energy would entail a capacity of 1 MW, while each block of flexible energy would entail a capacity of 10 MW allowing the customer to concentrate generation in periods of peak demand. Given that customers fluctuating demand, flexible energy will be more valued. The amount of each type of energy offered by the power plants will depend on their cost structure and technological constraints. Hydroelectric plants generally have low start-up costs and turbine capacity in excess of their energy capacity (water supply), thus having a cost advantage in the supply of flexible energy. Likewise combustion gas turbines have low start-up costs and low fixed costs (sunk costs) giving them an advantage in the supply of flexible energy. Nuclear plants, combined-cycle gas turbines plants and coal-power plants, on the other hand, are generally more economical in the provision of non-flexible energy. The difference in price in the two types of energy will provide the market incentives for investments to expand capacity to supply peak demand and for customers to lower consumption during peak demand.

Power suppliers would have strong incentives to supply most of their energy in the forward market, otherwise they would risk inducing the entry of new power plants and loosing their market share. This would be the only way to assure future demand for incumbent power plants. Entrants, on the other hand, would be allowed to close long term bilateral contracts with retailers and free customers which would allow entry with no risk of retaliation by incumbents (given the bilateral contract is of long duration). This should increase the level of contestability of the market. The duration of bilateral contracts would be limited to a set number of years, after which they would be considered an incumbent power plant and would be allowed to sell energy exclusively through the forward and short-term energy markets.

After the forward market auction is completed power suppliers would be free to trade the forward energy supply certificates amongst themselves. Thus if hydrological conditions turned out to be negative, the hydroelectric plant owners would attempt to sell their forward energy supply certificates to thermal power plant owners or hydroelectric plants that experienced more favorable hydrological conditions. Conversely, if hydrological conditions turned out to be above average they would attempt to buy additional forward energy supply certificates from other power suppliers.

In the year prior to the delivery, the proprietor of the forward energy supply certificates would stipulate how the flexible energy is to be allocated over the year, days of the week and hours of the day. At this point power suppliers with hydroelectric plants in the same river basin would have an incentive to trade forward energy supply certificates in order to maximize production.[10] The secondary market would thus allow the exploitation of all three sources of synergies mentioned in section 1.

5.2 The spot market

The role of the spot market would be to function as a residual market to deal with deviations from expected load variations and supply contingencies and to assure reliability. The spot market would continue to be operated by the independent system operator, but dispatch would be based on the pre-established commitments determined by the power supply certificates and bilateral contracts. Only the differences between the contracted amounts and actual load or changes in dispatch to deal with system contingencies would be met by dispatch based on power supply bids (and demand side bids, if any).

5.3 Adequacy of supply demonstrations

Periodically, retailers and free customers would be required to demonstrate their ability to supply their load. The regulatory agency would monitor the agents. Adequacy of supply demonstrations would be required on a tri-annual and yearly basis. Retailers and free customers would be required to hold forward energy purchase certificates, bilateral contracts, call options and uncommitted power plants owned by the retailer or free customer sufficient to cover 120% of their current load. A certain percentage of this total, say 85% of load, would have to be backed by real assets (forward energy purchase certificates, bilateral contracts or self-owned power plants). This requirement is aimed at assuring adequate supply. This requirement would ensure liquidity in the forward market and would provide early market signals of the need for expansion investors.

5.4 Call options

The physical markets would be supplemented by call options. Other financial derivatives may arise spontaneously, but a call options market is explicitly included because it plays a key role in the market design. Any qualified agent (must present financial guarantees to assure solvency) would be allowed to offer call options. The option would allow the buyer to purchase a specified amount of energy in the spot market over a specified period at the strike price. This financial instrument is important to provide a steady cash flow for flexible thermal power plants (i.e. power plants projected to substitute hydroelectric supply during periods of adverse hydrological conditions), to maintain the market solvent during periods of tight supply conditions, and to provide early price signals of possible future energy shortages.

The possibility of procuring supply from the spot market hedged by financial derivatives such as call options would introduce agents of the financial sector in the

[10] Market power problems may hamper this process. This aspect would need to be carefully examined before adoption of this proposal, and if adopted, market behavior should be carefully monitored.

electricity industry. These agents would play an important role in monitoring current and forecasting future market conditions.

5.5 Challenges of the proposed market design

This market design involves a number of new challenges. The risk of market power abuse increases as power suppliers our given more operational autonomy. This market design relies heavily on the effectiveness of the forward market auctions to promote competition amongst the incumbent power suppliers. The market design should be relatively robust, however, for if power suppliers were able to successfully colluded to elevate prices of the forward market auctions, their market power would be limited by the fact that power retailers could procure energy supply from new sources through bilateral contracts or the spot market hedged with call options. Nevertheless, we would advise that the state-owned power-supply firms be split to decrease market concentration.

The decentralized decision-making process under this market design would probably result in some losses due to incomplete exploitation of the system's synergies. On the other hand, this market design would allow firms to take on full control their assets subject to system constraints. This integration of ownership and operational autonomy would provide a better incentive scheme that could lead to significant dynamic efficiencies, such as improvements in hydrological forecasting, optimization algorithms, adaptation to new system conditions, maintenance of system equipment and reservoirs. These dynamic efficiencies should be sufficient to compensate any losses due to reduced coordination under the decentralized decision-making process.

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