

Electricity Market Design in Brazil: An Assessment of the 2004 Reform

Joisa Dutra
Centre for Regulation, FGV, Rio de Janeiro, Brazil
E-mail: joisa@fgv.br

Flavio M. Menezes
School of Economics, The University of Queensland, Brisbane, Australia
E-mail: f.menezes@uq.edu.au

1. INTRODUCTION

Following the electricity industry reforms happening elsewhere in Latin America and the world (Joskow, 2008), Brazil's first attempt at reform occurred in the 1990s. It aimed to foster investment in the sector through the privatisation of government-owned companies and the unbundling of distribution, generation and transmission, allowing large consumers entry into production and trading. An independent regulatory body was also established.

The 1993 reform, however, was not enough to ensure investment in new generation capacity. The lack of investment coupled with a severe drought led to electricity rationing in 2001-2002 and the search for a new model for the sector. The new model, which was introduced in 2004, established two separate environments in which electricity is traded. In the regulated contracting environment (RCE), distribution companies are required to contract electricity supply, through government-organised auctions, to meet the estimated demand for five-years ahead. In the free contracting environment (FCE) large consumers negotiate directly with generators or retailers.

In the RCE, the government holds annual auctions where existing generators sell their production forward (A-1 auctions¹) as well as auctions of long-term contracts (PPAs) that will finance the construction of new power plants. The market design evolved to accommodate competitive bidding for new large hydro dams and to procure intermittent renewables and reserves.

It is well understood that the 2004 reforms facilitated the expansion of the system. However, several features of the model, including the ability of distributors to simply pass through their energy acquisition costs to consumers, resulted in higher prices and limited attempts to improve energy efficiency.² Further changes followed in 2012 whereby the government offered the incumbent generation and transmission concessionaries the possibility of extending their concession contracts.

¹ A-X refers to the start of the supply of electricity. Thus, an A-1 contract auctioned in 2015 refers to a contract where supply starts in 2016.

² While the presence of subsidies makes it difficult to calculate final electricity prices, Dutra, Landau and Sampaio (2013) present evidence that electricity prices increased considerably above inflation in the last ten years.

These contracts would have expired in the period 2015-2017 but under the proposed extension the concessionaries would only be able to cover O&M costs and forego any contribution to covering fixed costs. Under the extension, the Federal Treasury would absorb some of the financial obligations that had been imposed on the concessionaries.³

In a previous article, Dutra and Menezes (2005) assessed the market design introduced by the 2004 reforms. Ten years have elapsed since the 2004 reform, and it is thus appropriate to reassess the market mechanisms by examining their actual performance rather than their design. This is the aim of this paper.

The focus is on the performance of the market mechanisms in balancing short-run and long-run objectives such as ensuring security of supply, fair prices for consumers and an appropriate rate of return to attract required investment. This evaluation is timely as the Brazilian electricity sector is at a crossroads. The government has been unable to secure sufficient long-term contracts to ensure future reliability of supply. Distribution companies, which are highly leveraged, face challenging financial pressures. The recent experience with the tenders for new electricity transmission lines, characterized by a lack of competition, and the delays in the completion of current projects, place further stress on the system and undermine attempts to diversify the fuel matrix away from hydro and towards other renewables such as wind and solar.⁴ In addition, the market design flaws that we identify below, if not addressed, have the potential to further undermine the security of supply especially in the face of the ongoing unfavourable hydrological conditions.

The assessment of the performance of the electricity auctions in Brazil is based on the economic literature on auctions and market design more broadly.⁵ In particular, our analysis focuses on three criteria. First, the ability of the existing market mechanisms to induce investment in new capacity (dynamic efficiency). Second, whether prices are consistent with allocative efficiency. Finally, whether the distribution companies are able to fulfil their regulatory obligations to contract their future loads.

Our key conclusion is that the electricity sector in Brazil is plagued by missing competitive markets (e.g., to incentivise demand response and to reduce losses in the networks), limited transparency and too much reliance on centralised planning, poor auction design (e.g., low ceiling prices) and inappropriate regulatory oversight. A failure to address these issues will likely lead to even higher prices and less reliable supply.

³ These financial obligations represent up to a third of the final prices faced by end users. The programs included universal services obligations (Light for Everybody), non-conventional renewables (PROINFA), and subsidies to fossil fuel generation in the region not connected to the national grid (Fossil Fuel Account, CCC).

⁴ TCU, the judicial body that oversees government spending, reports that delays in the connection of 48 wind power plants to the transmission network has cost consumers nearly R\$ 1 billion. The total installed capacity for these power plants is 1,262 MW. (TCU Award no. 1616/2014.)

⁵ For an introduction to market design, see, for example, Cramton (2010)(<http://www.cramton.umd.edu/papers2010-2014/cramton-market-design.pdf>) and Menezes (2013). (http://www.uq.edu.au/rsmg/WP/Australian_Public_Policy/WPP13_4.pdf)

2. MARKET DESIGN IN THE ELECTRICITY SECTOR

Many markets, particularly in Latin America, continue to fail to ensure that generation capacity meets demand growth. Before we explore in greater detail the performance of the Brazilian market design, it is relevant to ask what market design should accomplish.

Reliability is one of the objectives of market design. Battle and Pérez-Arriaga (2008) argue that there are three dimensions to the reliability of electricity systems: security, firmness and adequacy. Security refers to the ability of the existing generation capacity to respond to demand in the very short run. Firmness is related to the efficiency of the operational scheduling of installed capacity (for example, maintenance management, fuel supply contracts, reservoir management, and start-ups). It is a short to medium term consideration. Adequacy refers to the existence of sufficient capacity to meet both existing and future demand and, therefore, is a medium to long-term concept.

Different market designs entail different levels of reliability. A particularly important distinction is between energy-only markets and designs that include additional economic signals in the form of payments associated with the availability of capacity.

The premise behind energy-only markets is that the revenue obtained by generators, either through the sale of electricity in the wholesale market or through the sale of hedging contracts, is sufficient to cover the efficient costs of generating electricity and provide incentives for the timely expansion of capacity. The nature of energy-only markets is such that a significant share of total revenue is generated during peak periods. In the (energy-only) Australian electricity market, for example, 20 percent of total revenue is generated in 2 percent of the time. This feature of energy-only markets has implications for reliability.

In energy-only markets, the presence of price spikes raises issues associated with security and firmness of supply. The adequacy of supply rests on the ability of generators to recover sufficient revenue during price spikes. This is particularly important given that, in practice, energy-only markets are subject to a cap (usually but not always set at the value of lost load (VoLL)), which may restrict the ability of wholesale prices to provide efficient signals for the expansion of capacity. This phenomenon is known as the Missing Money Problem (MMP) (Hogan, 2005).

Market designs that involve payments associated with the availability of capacity can be thought of as providing a solution to the MMP. For example, ancillary services such as black start capability, regulation services and voltage support can be procured by the system operator to improve reliability and to ensure that a generator's total revenue meets efficient long run costs. Hogan (2005) argues that the introduction of such markets represents a more cost effective solution to ensuring reliability than the costs associated with energy and operating reserves under an energy-only market design.⁶ In the same vein, Joskow (2008) also suggests that capacity markets ought to complement energy markets

⁶ Joskow (2008) also canvasses a range of options that could mitigate the MMP in the context of energy-only markets. These include increases in price caps on energy and operating reserves during scarcity conditions; requirements for automatic increases in price caps when the System Operator take "out of market" actions to deal with operating reserves deficiencies; increases in real time Demand Response resources; and increases in the number of operating reserve products sold in the wholesale electricity markets.

and that forward energy contracts alone do not suffice to solve the MMP. Capacity markets, however, can lead to excessive capacity being build. (Silva, 2012).

Having discussed the trade-offs involved in energy-only versus capacity markets, we now discuss how the Brazilian electricity market design fits within this framework. As described above, the electricity auctions in Brazil were designed with the explicit aim to ensure enough (efficient) investment in new generation. By selling forward-contracts to supply electricity to distributors, generators (existing and future) face less revenue risk⁷ and are also incentivised to produce at the least cost possible. This suggests that the Brazilian market design is akin to a capacity market rather than an energy-only market.⁸ The next section describes the Brazilian market design in more detail and assesses its performance to date.

3. TRADING MECHANISMS UNDER THE 2004 MODEL

As described above, the 2004 reform established two environments in which electricity was traded. Under the RCE, distribution companies were required to purchase forward supply contracts for the next five years through either an auction for electricity generated by existing plants (A-1 auctions, ranging from 3 to 15 years of supply) or auctions for future capacity through PPAs (‘new electricity auctions’ or NEA) yet to be built.⁹

The regulatory framework embeds different mechanisms for the auctioning of new electricity. The first mechanism allocates contracts to deliver electricity five-years and three years ahead (defined as A-5 and A-3 auctions, respectively). Such auctions are used to allocate electricity from multiple power plants to be built. Another mechanism allocates contracts related to specific large new power plants. Under the Structural Project Auctions (SPA), particular projects, deemed as strategic, are selected by an energy policy committee (CNPE) based on characteristics such as size (large installed capacity) and location. So far only large hydro power plants have been designated as strategic. Under the SPA, each new project is sold in an A-X auction, where X is larger than 5 given the long lags required to complete major projects.¹⁰

The RCE allocation mechanisms are complemented by ‘adjustment auctions’, where distributors can either buy (or sell) contracts to meet additional demand (or excess supply) as the system demand conditions become clear and the date of delivery approaches.

⁷ Auction prices are indexed by the consumer price index and, therefore, some price risk still exists to the extent that the increase in the costs of supply over time deviates from the CPI.

⁸ More specifically, hydro generators earn a fixed revenue associated with a contracted amount of energy and thermal generators are granted a fixed revenue to become available to dispatch electricity to meet the demand from distributors. Distributors bear the variable costs to meet the difference between the contracted amount and the actual system demand. See, also, Silva (2012).

⁹ Assessing the efficiency of such arrangements is always difficult due a myriad of prevailing distortions. For example, winners of the PPA auction had access to subsidised lines of credit from the Brazilian Development Bank (BNDES).

¹⁰ The first SPA was held in 2007 to trade electric energy from the Santo Antonio power plant. In 2008 and 2009 the Jirau and Belo Monte PP were also framed as strategic. These power plants share some common features. They are all located in the Amazon region and the commissioning takes several years coherent with the installation schedule of the turbine-generation sets.

Additional mechanisms have been designed and launched specifically to procure electricity generated by renewable sources. These auctions are discussed next.

Under the 2004 model, investments in renewables were initially secured through a pre-reform program, PROINFA (Incentive Program for Alternative Sources), with feed-in-tariffs (FIT) rather than through an auction. It is well accepted that PROINFA led to prices that were too high and considerable delays in the commissioning of the new power plants (Maurer and Barroso, 2011). The perceived failure of PROINFA resulted in the establishment of trading mechanisms for renewables with new wind, small hydro and biomass power plants procured through the Alternative Resources Auctions (June of 2007 and August of 2010) and through the Reserve Auctions targeting wind generation (2008- 2011 and 2013). It is worth noting that renewables power plants have also been contracted in the new energy auctions. Below we will compare the prices achieved under the different mechanisms.

Reserve energy auctions (REA) were introduced in 2009 and joined the myriad of different types of auctions to procure electricity. REA were explicitly designed as capacity auctions; the winner of the auction is required to remain available to dispatch electricity from its plant and it is unable to fulfil its contract by purchasing electricity from another supplier. REA have resulted in the procurement of new generation capacity in biomass, wind and small-hydro power. As we argue below, the evolution of the 2004 model resulted in a complex system of procurement where specific auctions are used to achieve particular goals leading to conflicting price signals.

The original market design was not a single buyer model; while the government procures energy on behalf of the distributors, each generator/seller that wins an auction signs a bilateral contract with each of the distributors for an amount that is proportional to its declared (forecasted) demand. Initially, the Chamber for Electric Energy Trading (CCEE)'s role was simply to organize the financial settlement of the contracts between generators and distributors in the RCE, and of the contracts between large buyers, generators and traders under the FCE.

As yet another example of the ad-hoc nature of the evolution of electricity reform in Brazil, the role of the CCEE has changed substantively from its initial conception. In the aftermath of the 2012 changes, distributors' revenues were not sufficient to cover the extra (variable) costs associated with the dispatch from thermal power plants. Rather than approving an increase in tariffs to pass through these extra costs, the Federal government continued with its policy of mandated reductions in tariffs, and instead required CCEE to act as a financial intermediary borrowing from a pool of commercial banks on behalf of distributors. As a result, some of the market risk was transferred to CCEE.

In addition to the distinction between existing and new energy auctions, the 2004 reform also established two types of contractual arrangements. Energy (quantity) contracts are standard financial forward contracts. The revenue earned by the generator/seller is the product of the amount of energy contracted (MWh) by the winning bid (R\$/MWh). This amount is adjusted annually by the CPI inflation. Differences between the amount contracted in the auction and the energy produced are

settled at the spot price.¹¹ In contrast, availability contracts are energy call options that grant the successful bidder a fixed revenue payable in 12 monthly instalments in addition to a variable amount if the power plant is dispatched (that is, whenever the spot price exceeds the energy strike price). The variable portion of the revenue is also determined in the auction with fuel costs being ultimately covered by the distribution companies.

Generally speaking, energy quantity contracts are used for the allocation of energy from hydro power plants and availability contracts are used to allocate energy from thermal, wind and (more recently) solar power plants. For each auction, the government defines how much of the electricity being procured is to be supplied by different fuel sources and the type of contracts (quantity versus availability) per fuel source.¹² The Energy Research Company (EPE), a government agency that releases annual 10-year plans for the expansion of the system, undertakes auction scheduling. The auctions are then held to match the planned energy mix from the different fuel sources. However the actual contracting may be significantly different from the planned mix.

As explained above, the NEA awards both quantity and availability contracts. Bids for wind, solar and different thermoelectric technologies in these auctions are compared through a score function (ICB, standing for cost-benefit index). The ICB expression weighs the fixed revenue bid with a variable cost component that is associated with the variable costs incurred in case the power plant is dispatched.¹³ The ICB then can be seen as an expected price for MWh to be generated by power plants that are competing for availability contracts. This expectation takes into account a probability of dispatch.

Note that the distributors reimburse the operation cost associated with availability contracts when the power plant runs according to the parameters defined at the time of the auction. These costs are passed through to consumer rates. In the availability contracts the variable revenue consists of a fuel and a non-fuel component. While the non-fuel components of the operating costs are adjusted according to the CPI, the fuel component is indexed to a basket of fuels' prices. To complicate things further, these indexation clauses differ between auctions according to the perception of the risk borne by the contracting parties at each particular auction.

As described, under the current regulatory framework generation investments that are key to ensure reliability of supply are mainly incentivized through the PPA auctions. Winners of contracts to supply the pool of distributors were also granted access to earmarked funds from BNDES. However, despite the availability of subsidised grants, the disincentives embedded in the regulatory framework, along with repeated, arbitrary government interventions, resulted in capacity expanding at a slower pace than demand.

¹¹ The short-run price in the Brazilian model is referred to as the Imbalances Settlement Price (PLD). It is a shadow price calculated weekly through optimization models that take into account the marginal operation costs of the various plants and their availability. It varies according to a region.

¹² There seems to be no rationale to inform these choices. (Maurer and Barroso, 2011).

¹³ This function is calculated by the government based on alternative dispatch scenarios. The variable cost parameters are calculated by EPE and made public for each power plant in advance of the auction. Arguably some of the parameters set by the government in these calculations have biased the process in favor of oil and diesel thermal power plants (Maurer and Barroso, 2011).

Free consumers trade electricity in OTC markets. The resulting contracts are usually not accepted as collaterals due to the shorter duration coupled with several other regulations that prioritize contracting in the regulated market. As a consequence electricity consumption in the free market exhibits a stable participation of 25%¹⁴ of the total sales.

4. A REVIEW OF AUCTION RESULTS

In this section we assess the Brazilian electricity model by comparing the results of the auctions with the explicit goals stated in the current legal and regulatory framework. A key piece of legislation is Statue 10848/04, which mandates that auction results should pursue both static and dynamic efficiency. That is, it requires electricity prices to be set in a way that simultaneously protects consumers from monopolistic prices and ensures that investors receive an appropriate rate of return. These twin goals are prevalent in regulatory frameworks around the world.

An important benchmark to assess the efficiency of prices is the long-run marginal cost (LRMC); the unitised cost that includes both operating costs such as fuel and the costs of expanding capacity. In competitive markets, we do not expect prices to deviate significantly from the LRMC. Indeed, prices that are substantially and consistently higher than the LRMC are usually consistent with the exercise of market power.

Pereira (2013) estimates the LRMC for Brazil:

Table 1. LRMC Estimates (R\$/MWh)

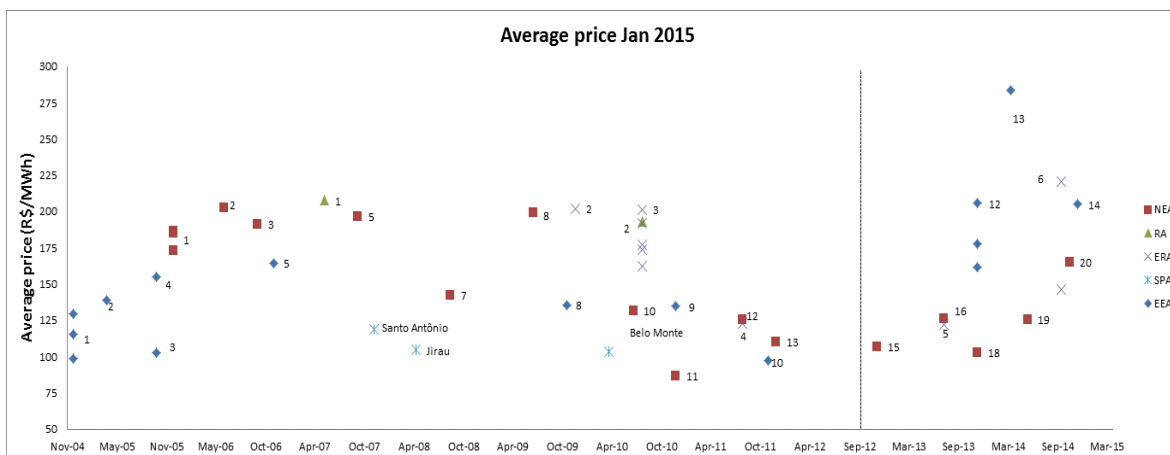
Year	CME
2015	120
2020	180
2025	200
2030	240

Source: Pereira (2013)

These estimates of LRMC can now be compared with the auction prices for new capacity. Figure 1 and Table 2 present auction prices for quantity contracts. The comparison between auction prices and estimates of LRMC is striking and reveals a pattern of prices in excess of LRMC.

¹⁴ The regulated consumers represent 75% of the electricity consumption. The great majority is not metered through hourly meters and there is no access to any usage information besides the monthly bill. Data captured from CCEE website (available at www.ccee.org.br).

Figure 1. Contracting in the Regulated Environment – Quantity Contracts



Source: Data from the Chamber of Electricity Trading – CCEE.

Note: There is an upward trend in process after the 2012 reform that marks the beginning of a stage of higher regulatory risk.

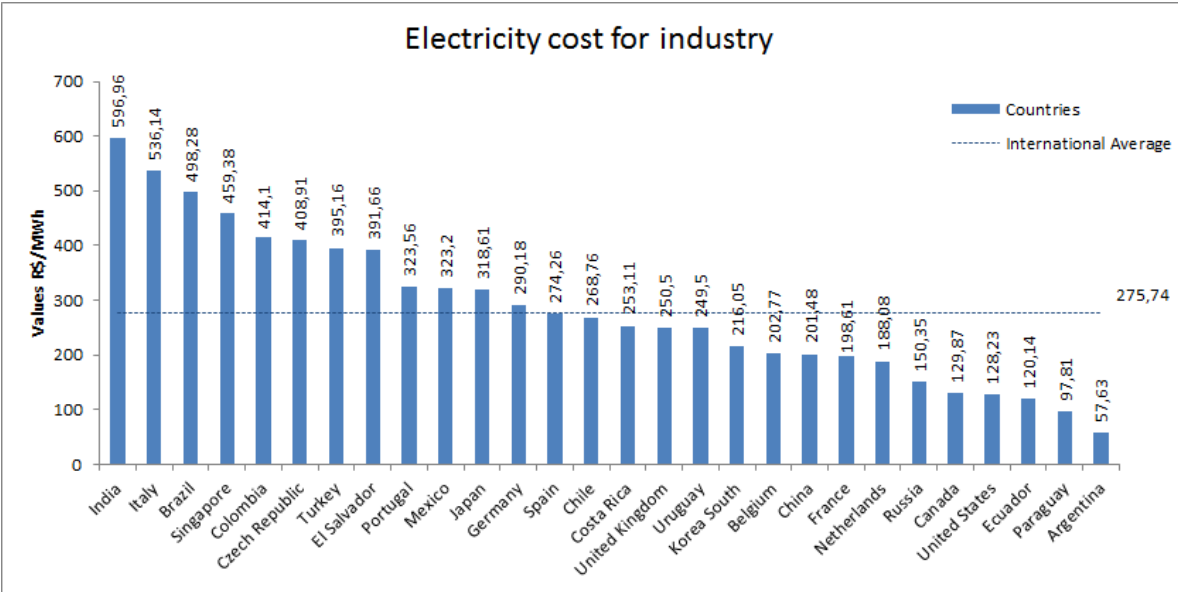
Table 2. Contracting Prices in the Energy Auctions

Energy Auction	Average price jan 2015 (BR\$/MWh)					
	Nº	EEA	NEA	ERA	RA	SPA
1		98,54	173,38		207,85	
		115,36	185,26			
		129,29	186,49			
2		138,72	202,40	202,04	193,43	
				201,45		
				191,81		
3		102,98	191,48	177,25		
				162,27		
				173,78		
4		155,26		122,66		
5		164,62	196,51	121,80		
				145,94		
6				221,03		
7			142,18			
8		135,54	199,00			
9		135,04				
10		97,08	131,43			
11			86,57			
		206,20				
12		177,96	125,63			
		161,58				
13		283,62	110,13			
14		205,08				
15			106,63			
16			126,30			
17						
18			102,77			
19			125,64			
20			165,18			
Santo Antônio						118,67
Jirau						104,38
Belo Monte						103,46

Source: Chamber of Electricity Trading (CCEE).

Additional, indirect, evidence that Brazilian electricity prices are too high by international standards is presented in Figure 2, which depicts the costs (wholesale generation, distribution and transmission costs) faced by industry across different countries (Dutra, et al., 2012).

Figure 2. Electricity Cost for the Industrial Consumers



Source: FIRJAN- Federação das Indústrias do Estado do Rio de Janeiro.

In well-designed markets, we would also expect the prices of similar objects to fetch similar prices. For example, we would not expect auction prices for existing energy for delivery in 2017 to be substantially different from auction prices for new energy to be supplied from 2017. As shown in Figure 1, however, not only are the EEA prices higher than the NEA prices for the same delivery date, but the most recent EEA auctions also failed to attract enough bids to fulfil the forecasted demand from distributors (Table 3). This is evidence of an excessively low ceiling price. As a result, distributors had to settle their (unfulfilled) contractual positions at the much higher short-run price.

So far this section has provided evidence that NEA auction prices are substantially higher than LRMC estimates and are also high by international standards. It has also shown that auction prices failed another efficiency test: similar objects fetch different prices at the auctions. Finally, we have also indicated that the recent EEA prices have failed to attract enough supply, possibly as a result of ceiling prices that are too low.

There are also non-auction related developments that have impacted negatively on the sector. In particular, there have been substantial delays and cost overruns mostly associated with increasing environmental constraints that were not anticipated at the time of the auction. As of October 2014 approximately 30% of the contracted new supply was behind schedule.¹⁵

¹⁵ The Ministry of Mines and Energy predicted, based on auction results, an additional capacity of 7,673 MW for 2013. Instead, the actual new capacity added up to only 5,888 MW.

Table 3. Existing Energy Auctions fail to attract enough supply

Existing Energy Auctions (A-1)	11º EEA	12º EEA	13º EEA
Date of the Auction	Jun-2013	Dec-2013	Apr-2014
Ceiling Price per MW (R\$)	171.80	192.00	271.00
Maximum Price at the Spot Market	780.03	780.03	822.83
Average Spot Price at the Auction Date	206.83	291.33	757.67
Distributors' Aggregate Demand	3,372.91	6,391.00	3,565.00
Electricity Contracted	0	2,571.49	2,046.00
Non-contracted Demand	3,372.91	3,819.51	1,519.00

Source: TCU.

In addition, there are also delays in the completion of new transmission lines.¹⁶ These delays have implications for generation companies, as there are several examples of new power plants that cannot be dispatched due to delays in their connection to the grid, leading to higher electricity prices. Next we review and assess the key characteristics of transmission auctions with a view to better understanding how they contribute to the overall efficiency of the electricity market design.

Transmission Auctions

Brazil has a large-scale electricity system with over 130 GW of installed capacity interconnected by a vast transmission grid that spans the country's vast territory. More than 80% of the electricity is generated from hydro resources, several of them located far from the main load centres. This transmission grid allows the transport of large amounts of energy over long distances.

The expansion of the transmission system follows a deterministic planning process developed by EPE¹⁷ with input from the Independent System Operator (ONS). Once the future transmission requirements are known, the federal regulatory agency (ANEEL) holds auctions to select concessionaries to Build-Operate-and-Own (BOO) these facilities.¹⁸ The winner of the auction is the bidder who bids the lowest annual revenue for a 30-year concession term.

The auctions were initially successful in attracting new entrants to the sector, reducing expansion costs and ensuring that projects were completed on time. Carlos and Dutra (2009) show that there

¹⁶ According to TCU estimates, the inability to timely connect new generation capacity to the grid coupled with delays in generation and transmission entailed a cost of R\$ 8 billion from 2009 to 2013. Similar delays have also been observed in the context of NEA from 2005. As of 2013, NEA delays affected 79% of the (large) hydro, 75% of the thermal, 88% of the wind and 62% of the small hydro power plants. [Also, 83% of the transmission lines and 63% of the contracted substations exhibited delays (TCU TC 029.387/2013-2.).]

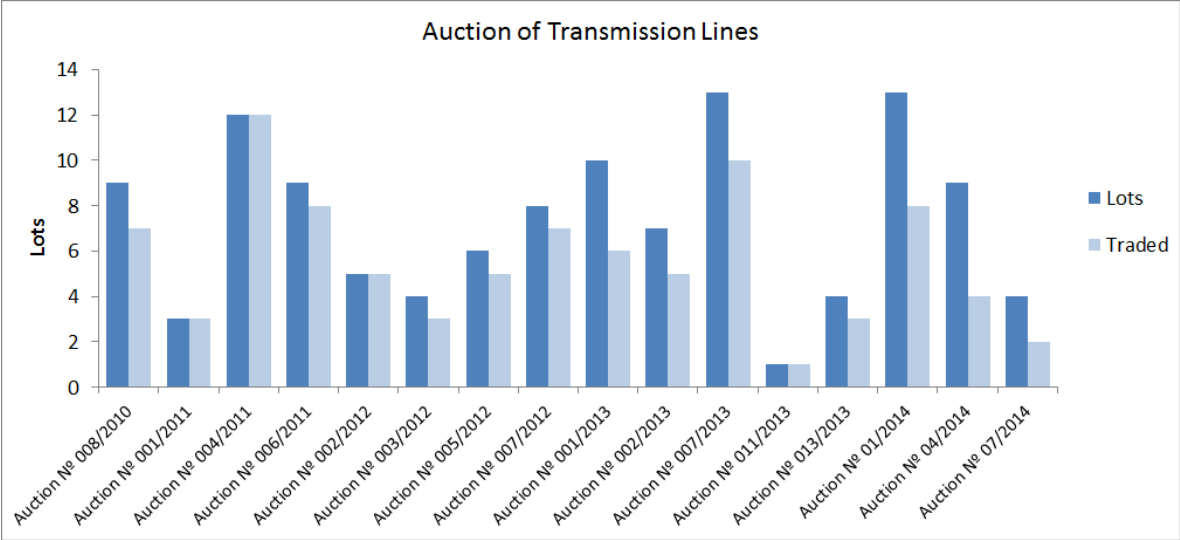
¹⁷ The Brazilian government-created Energy Research Company, *Empresa de Pesquisa Energética* ("EPE"). The EPE is a state-owned company responsible for conducting strategic research on the energy industry, including with respect to electric energy, oil, gas, coal and renewable energy sources.

¹⁸ Transmission charges are collected from generators and consumers through (fixed) access charges. However, generators will have likely passed through to consumers their share of (expected) transmission costs through their bids in the auction. Consumers also bear congestion costs.

was a significant increase in the number of bidders from 2003 onwards, leading to lower transmission costs. Auction outcomes are also impacted by the location of the projects. Bidders who own nearby existing transmission facilities tend to bid lower in the auction reflecting lower overall costs due to economies of scope.

While initially successful in attracting new players and investment to the industry, transmission auctions have been negatively impacted by the global financial crisis. Further, in 2012 a major reform took place that contributed to further reduction of competition in the auction. Under this policy, the government established very stringent conditions to renew several generation and transmission concessions expiring from 2015 to 2017 to force companies to renegotiate existing contracts to reduce prices substantially. This has increased regulatory risk, forcing asset stranding, and reducing participation in future auctions¹⁹ (Figure 4).

Figure 4. Competition in Electricity Transmission Auctions



Source: Data from the Federal Electricity Regulator – ANEEL.

The more recent trend in auction outcomes is of great concern as the last three auctions were unsuccessful in allocating all new transmission projects and some of the project only attracted one competitor (Table 4). In our assessment, such auction outcomes may be a result of ceiling revenue that are too low as it does not take into account the significant increase in regulatory risk.

¹⁹ Marques (2014) estimates a negative impact of this policy on the investments of the electricity companies in the generation segment compatible with a structural break in the pattern of investments in the sector. Also, this policy has had a negative and significant impact into the generation companies’ stock prices leading also a reduction in the system expansion.

Table 4. Competition in Recent Transmission Auctions

Date	Number of Items Offered	Successfully Allocated	No Competition
May 09, 2014	13	8	5
Nov 18, 2014	9	4	5
Jan 01, 2015	4	2	2

Source of the data: BM&FBOVESPA Stock Exchange.²⁰

5. CAN THE MODEL BE ‘FIXED’?

This section discusses some of the key challenges that need to be addressed to restore incentives and promote efficiency in the Brazilian electricity sector. Continuing with the ad-hoc, Band-Aid approach that has characterised government policy for the sector over the last two decades - where each perceived problem is addressed by an ad-hoc measure, distorting incentives and price signals – will undoubtedly result in reliability issues especially in the context of more frequent droughts as a result of climate change.

In particular, this section addresses five key issues: (i) the impact of the reduced role of large hydro power plants in the energy matrix as new large projects are increasingly scarce; (ii) the increasing participation of intermittent renewables in the energy matrix; (iii) the increasing role to be played by thermal generation (and the availability of natural gas) to ensure reliability; (iv) the establishment of new market mechanisms to procure demand response, ancillary services and energy efficiency; and (v) greater emphasis on auction design including an appropriate selection of ceiling prices and an auction format that will lead to similar objects fetching similar prices.

5.1) Structural Changes in the Energy Matrix

Traditionally, hydropower has played a dominant role in the development of the Brazilian electricity generation sector, accounting for over 75% of the installed capacity, and relying on a small number of very large hydroelectric dams.²¹ The dominance of large hydro, however, is fading rapidly for a number of reasons. Increasing environmental constraints are restricting new hydro dams to run-of-river. As a consequence, the multi-year regularisation capacity of the system is decreasing, which makes the whole system more vulnerable to climatic events such as droughts, impacting adversely on reliability.²²

In addition, the increasing participation of intermittent renewables in the electricity mix also leads to greater concerns about reliability.²³ As intermittent renewables are not dispatchable in the traditional

²⁰ Data available at: <http://www.bmfbovespa.com.br/consulta-leiloes/ResumoAcompanhamentoLeilao.aspx?idioma=pt-br>.

²¹ Data from the Ministry of Mines and Energy, 2012.

²² While the hydro installed capacity is estimated to increase by 40% from 2013 to 2022, the multi-year storage capacity in the hydro reservoirs is expected to increase by 2% (Estimates according to the EPE 10-year Plan 2022).

²³ Intermittent Renewable resources are expected to account for 21% of the generation installed capacity by 2022 (EPE 10-Year Plan 2022).

sense, system operators are required to make additional arrangements to continuously balance supply and demand.²⁴

A careful evaluation of costs and benefits of the different generation technologies will likely point to the need to increase the participation of natural gas in the electric energy matrix in Brazil. Natural gas fired power plants can be ramped up and down quickly, and can provide a cost effective way to complement intermittent renewable resources. However, for gas to play a bigger role in electricity generation, it is necessary that the market for gas itself becomes more efficient.

Unfortunately the gas market in Brazil is characterised by high prices, and deficient transmission and reticulation networks. This is the consequence mostly of the institutional design of the markets, where the Brazilian Oil Company (Petrobras) plays a dominant role in all segments (exploration, production, transmission and distribution). That is, the gas market in Brazil is essentially at the same stage of many markets around the world before the microeconomic reforms of the 1990s that introduced unbundling and non-discriminatory access to networks.

Indeed, under the current regulatory (the 2009 Natural Gas Act), there is no requirement that a vertically integrated producer/distributor provides access to third parties. The combination of vertical integration between production and distribution of gas, and the fact that Petrobras is a bidder in the NEA, means that it is difficult for prospective new investors in gas power generation to secure the long-term supply contracts that would allow them to bid in the NEA (Figure 5). This arrangement is detrimental to the development of competition²⁵ and has led to the increase in penetration of oil generators, which now represent 10% of the installed capacity in the power sector in Brazil.

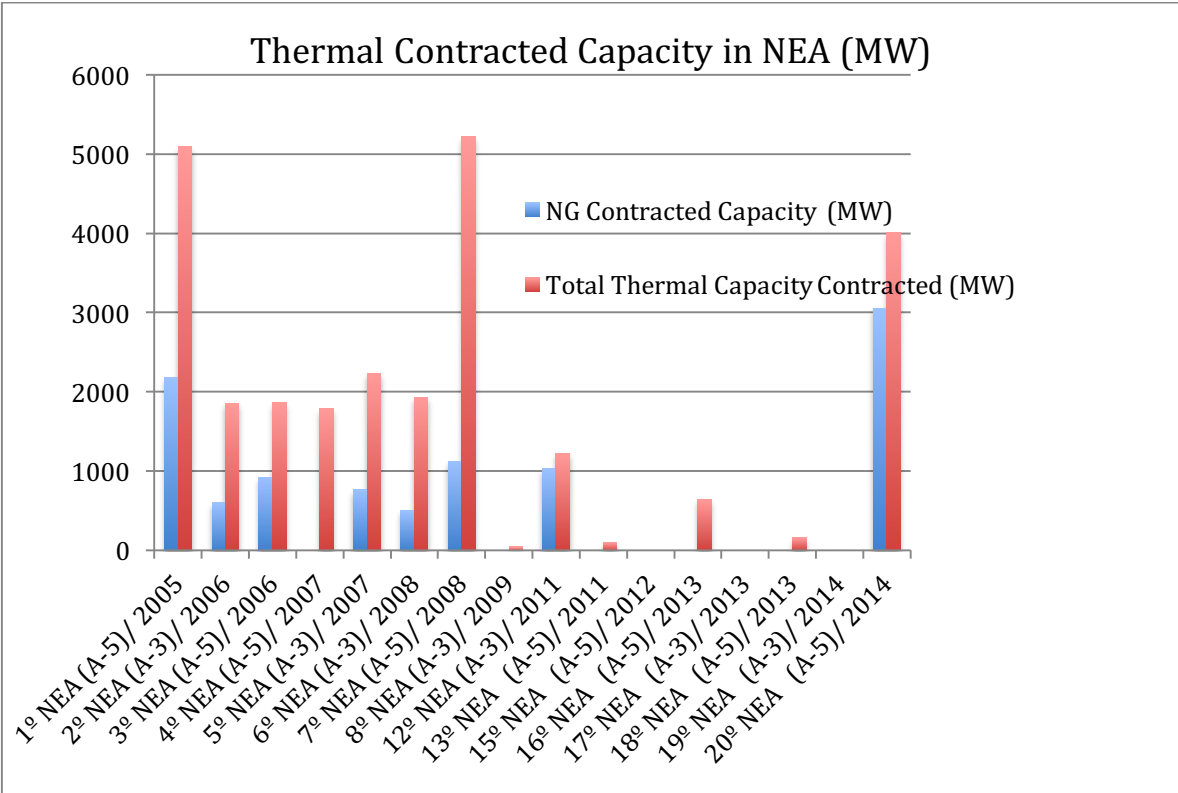
5.2) *Creating New Markets*

The 2001-2002 electricity rationing program provided some powerful lessons in the effectiveness of demand reduction. The program involved a number of market mechanisms, including straight out trading for large consumers and a system of penalties and rewards for households and small consumers that exceeded or did not meet their monthly quota (calculated as 80 percent of their average consumption from the previous 3 years). While the program lasted less than two years, as it was suspended when the drought ended, it had a long term-impact. Costa (2013), for example, estimates that the program led to a persistent and significant reduction in electricity consumption by 14% at the end of ten years.

²⁴ Joskow (2011) argues that the design of competitive procurement systems should allow a proper assessment (and pricing) of the economic value of these technologies increasing transparency.

²⁵ The participation of Petrobras in the NEA creates both the opportunity and the incentives for anticompetitive behaviour. This can be seen when Petrobras participated for the first time as the sole owner of a thermal power plant in an A-3 auction in August 2011. This follows as participants in the auction had to demonstrate their ability to secure long-term take-or-pay contracts for the supply of gas in the event they won the auction. Indeed, the winners of the auction were the only two vertically integrated companies, MPX and Petrobras.

Figure 5. Thermal Power Plants Contracted in NEA



Despite the overwhelming evidence of the success of demand-side programs, the 2004 reform focused exclusively on supply-side measures and ignored the positive outcomes associated with demand-side programs. This focus on the supply-side persists even today as the sector struggles financially as a result of the 2012 reforms that aimed at reducing electricity prices through forced changes in the long-term contracts.

This failure to promote demand-side programs is in striking contrast with the international experience, where the introduction of such programs as distributed generation, demand response and energy efficiency is common place. These programs have proven very effective in increasing competition (for example, through distributed generation) and promoting efficient outcomes by providing better price signals and better utilization of existing capacity. In other countries, the promotion of these programs has included the introduction of market mechanisms to better manage network congestion and to price transmission rights, ancillary services and demand response.²⁶

Ironically, demand side programs have been by and large ignored when they would be most helpful as Brazil has been facing unfavorable hydrological conditions since the end of 2012. As a consequence, thermal power plants have been running on a permanent basis at an average short-run price (PLD) of approximately R\$700.00/MWh in 2014. Figure 6 plots demand in the unregulated environment. The figure also plots the PLD for the Southeast region of the country, the main load

²⁶ See, for example, D. Laloux and M. Rivier (2013).

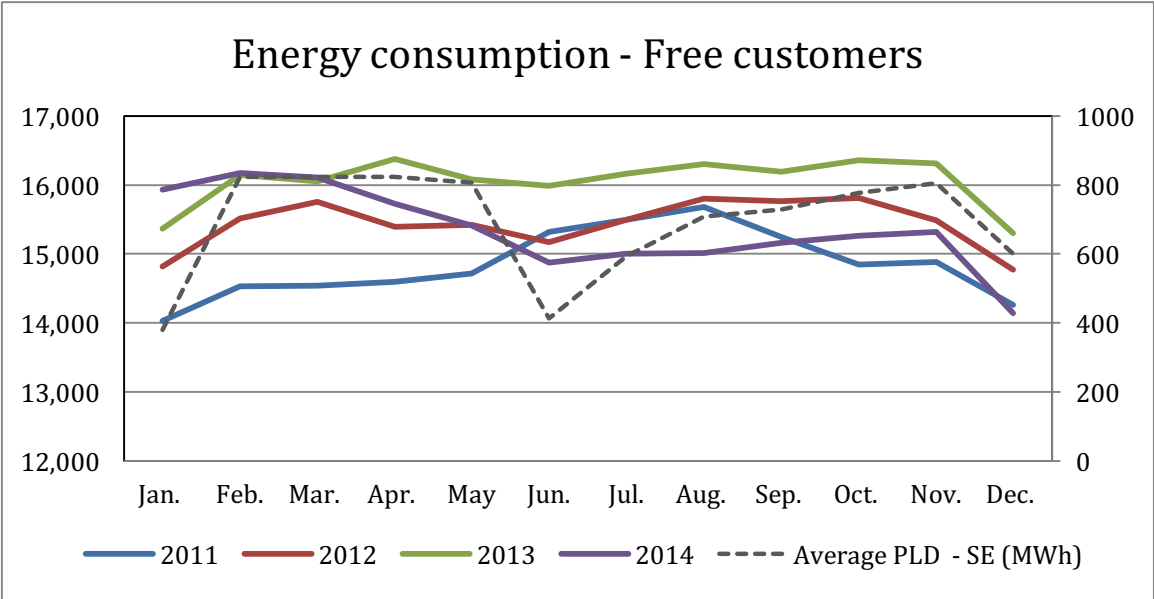
center. Note that PLD does not track demand perfectly because it is not a price; instead PLD is the outcome of a constrained maximization problem that aims to capture the lowest marginal cost of satisfying demand.

To make things worse, a recent government decision²⁷ allows the costs of distributed generation from fossil fuels to be passed-through to consumers as congestion charges. While these high short-run prices have led large consumers to change demand behavior, the lack of regulated price changes means that households and small consumers, who pay a regulated price, have not changed their behavior. This can be seen in Figure 7, which exhibits the electricity demand from captive consumers in 2011 in the Southeast region of the country.

5.3) Improving Auction Design

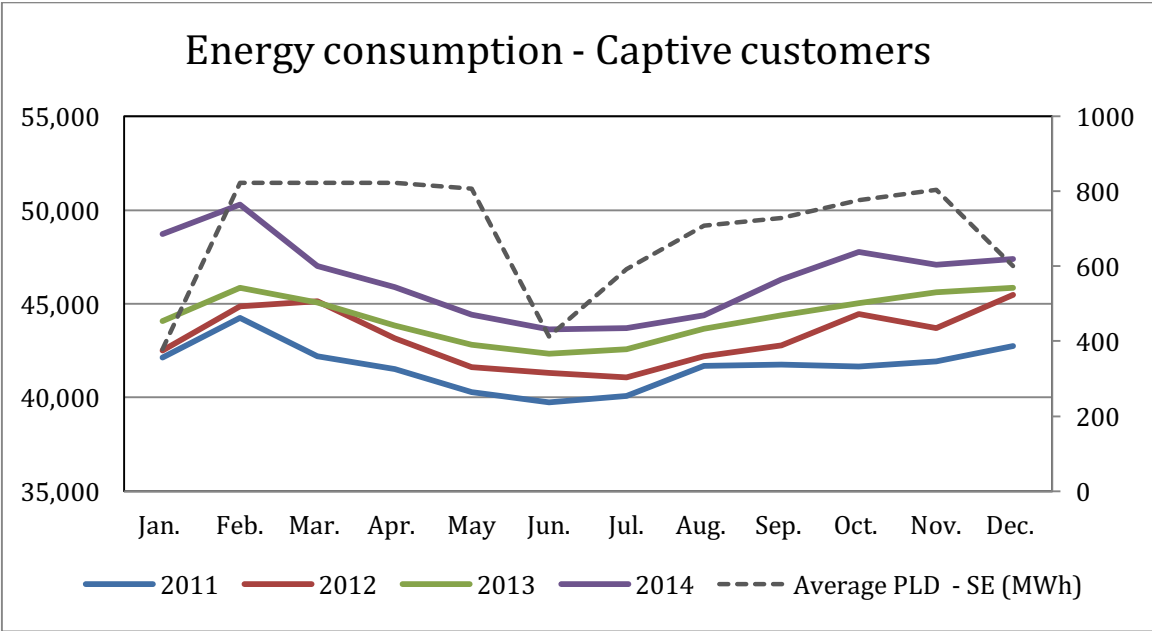
The auction results presented in section IV provide strong evidence for the need to fine tune the auction design. In particular, there is a strong need for a more systematic, principled-based approach to be used to set ceiling prices. In addition, a more strategic approach to auction scheduling should also be pursued. This would allow the government to maximise participation. Pre-qualification requirements ought to be tightened as well. The recent experience is consistent with excessive delays in the completion of projects.

Figure 6– Demand Response at the Wholesale Market



²⁷ According to Ordinance 44/2015 from the Ministry of Mines and Energy, Brazil.

Figure 7 – Electric Energy Consumption in the Regulated Market



Source of the data: CCEE.

Finally, the evidence provided in Figure 2 suggests that similar objects fetch different prices at the auctions. In contrast, efficient auctions will tend to set similar prices for similar objects.

6. CONCLUDING REMARKS

This paper describes the evolution of the Brazilian electricity market design since the 2004 reform. The original aim of the reform was to ensure reliability of supply, achieving both dynamic and static efficiency. The picture that emerges shows policies that have been implemented to address specific concerns without due consideration to the impact on incentives to invest and to pursue productive and allocative efficiencies. Rules were changed to reduce electricity prices, not to reflect lower costs, but rather to control inflation. Auctions were designed that clearly favoured the participation of vertically integrated companies, including the giant Government-owned Petrobras. This hazardous process is likely to come to a head as the unfavourable hydrological conditions place additional stress in the system.

We have also provided a shopping list of concerns that ought to be addressed to place the sector on a more sustainable path. This includes a greater role for demand side programs, new markets to complement existing markets, improved auction design and a complete rethink of the gas market to introduce competition at all levels of the production and distribution chain.

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