21, rue d'Artois, F-75008 PARIS
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Aligning Regulatory Incentives and Price Signals in the Brazilian Wholesale and Retail Electricity Markets

X. VIEIRA[1]
Positiva
Brazil

R. HOCHSTETLER
Inst. Acende Brasil
Brazil

J. C. MELLO
Thymos
Brazil

L. A. BARROSO
PSR
Brazil

SUMMARY

Managing electricity supply and demand for electricity in Brazil is particularly challenging because of the great variability of supply and demand. The variability of supply is due to the stochastic nature of renewable power sources that account for most of Brazil's generation capacity, while the variability of demand is due to the changing structure of its economy and to macroeconomic instability. This high variability of supply and demand requires careful risk management.

The introduction of an electricity market can help deal with this volatility by increasing consumer awareness and responsiveness to aggregate supply and demand dynamics. The market also fosters the development of hedging instruments that help stabilize market financial flows, induce better market monitoring, and adoption of prudent practices.

For the market to work properly, however, it is essential that the market pricing accurately reflect supply and demand conditions, and that the market structure, and supporting regulation, provide proper incentives to both wholesale and retail market participants – both of which have been an ongoing challenge in Brazil.

Pricing of electricity is particularly complex in Brazil because a large share of the generation is derived from renewables that have negligible marginal costs. This means that much of the time wholesale spot market prices are determined by the opportunity costs of these renewable power plants, based on expectations of future supply and demand conditions. Brazil has developed sophisticated tools to aid in the determination of proper pricing, but further improvements are needed. The development of financial instruments has been a key milestone in the evolution of the Brazilian electricity market, but refinements are needed to promote better alignment of the physical and financial markets.

Brazil's current market structure and regulation has evolved over time in response to various needs and concerns, which are not always entirely aligned. This has resulted in the creation of two different Contracting Environments in Brazil, each designed to meet specific needs of different sets of market players, but that have also introduced market distortions.

In the coming years, Brazil should further improve the price-setting mechanism, and adopt additional regulatory reforms to promote market integration, increase market liquidity and flexibility, and improve price responsiveness of all market participants.

KEYWORDS
MARKET DESIGN / ELECTRICITY PRICING / RETAIL MARKET / TARIFF DESIGN

[1] E-mail: xisto.vieira@epositiva.com.br.

1 INTRODUCTION

The key to successful markets is good price responsiveness. Electricity market reforms have gone a long way in developing wholesale markets, which have been quite successful in fostering competition and price responsiveness from the supply side of the industry (i.e. generation), but have not advanced price responsiveness on the demand side of the industry (i.e. retail customers) to the same extent.

The difficulty in developing price responsiveness on the demand side arises primarily from the lack of retail consumer awareness and interest in electricity price variations. For the most part, electricity is an intermediary input used to provide final goods and services demanded by the consumer. Thus, consumers are usually not aware of their electricity consumption patterns. Furthermore, electricity only accounts for a small fraction of total costs of most of the goods and services they consume, which makes electricity prices of little concern in individual consumption decisions. Most customers only react to medium to long-term price variations, as they perceive how aggregate electricity costs affect their overall budget. Electricity tariff regulation also plays a role in dampening demandside price responsiveness due to rigid rate structure, cross-subsides and long regulatory lags, which weaken the direct link between costs and rate recovery. All these factors contribute to dampen customer response to electricity price variations [1].

Demand-side response from the retail market is crucial, however, to obtain fully functioning markets. High supply-side price responsiveness may assure minimization of generation costs to meet aggregate demand, but it does not enable efficient management demand-side factors, such as individual consumer's aversion to risk, value of loss of load, valuation of service quality, and pricing policy.

Looking ahead one can foresee great potential of increasing demand-side price responsiveness by adoption of new tariff structures, of *smart grid* technologies and of distributed generation [2]. While most consumers are not willing or able to adjust their electricity consumption pattern based on real-time electricity prices, many are likely to adopt programmable appliances or to contract remote energy management services to adjust their electricity consumption patterns in response to real-time electricity prices. Batteries and electric vehicles could also play a major role in the coming years providing arbitrage between peak and off peak prices if technological innovations are able to bring costs down to a competitive level.

Furthermore, in the coming years more and more consumers will become *prosumers* (**pro**ducers + con**sumers**), installing micro generators at their homes and workplaces, which may increase consumers' long-term price responsiveness by lowering consumers' reservation price. The increasing share of *prosumer*s will most likely require more supply-side price responsiveness in the wholesale market, however, because most micro generation is derived from intermittent sources, whose production is not responsive to prices and tend to increase the volatility of net demand required by the retail market.

Another, more fundamental issue, that must be considered is regarding the appropriateness of prices provided by the market. Do wholesale and retail prices provide the correct incentives to the market participants? What can be done to improve price signals to promote optimal operation and to foster optimal investment in generation expansion?

In this paper we look at these issues based on the experience in the Brazilian electricity industry. We seek to identify how to improve wholesale and retail market pricing, presenting key challenges faced in the context of the Brazilian electricity power industry, explaining how the electricity market has been structured and regulated to deal with these challenges, describing recent developments regarding these issues, and evaluating how they will probably be dealt with in the future.

2 CONTEXT

2.1 Brazil's Supply Dynamics

Brazil's power supply is predominantly from hydroelectric plants with complementation from thermal power plants and a growing fringe of intermittent renewable generation (primarily wind power and biomass thermal generation from sugarcane bagasse). The hydroelectric plants are spread out in

diverse geographic regions, which implies that significant synergies can be obtained from centralized coordination. Hydroelectric reservoir capacity is quite significant – most hydro plants have multi-year storage capacity – which has so far been sufficient to smooth out the hydroelectric production variability throughout the year. This implies that optimal hydroelectric dispatch decisions involve a complex optimization problem to determine the opportunity cost of hydro inflows in multi-year horizon, which is handled in Brazil by complex models based on dynamic programming technics.

Furthermore, hydro inflows are highly irregular, which makes system adequacy and reliability planning a difficult task. Unlike thermal power dominated systems, in which the system capacity limits are tested on a regular basis – daily or at least on a yearly seasonal basis – severe droughts may not occur for decades and then ensue two to three years of severe shortages. The bar graph in Figure 1 shows the annual hydro inflows and the horizontal line indicates the level production that is deemed secure, according to the "Physical Guarantee" (*GF – Garantia Física*) certification described in section 3.2. This irregularity makes risk management a particularly challenging.

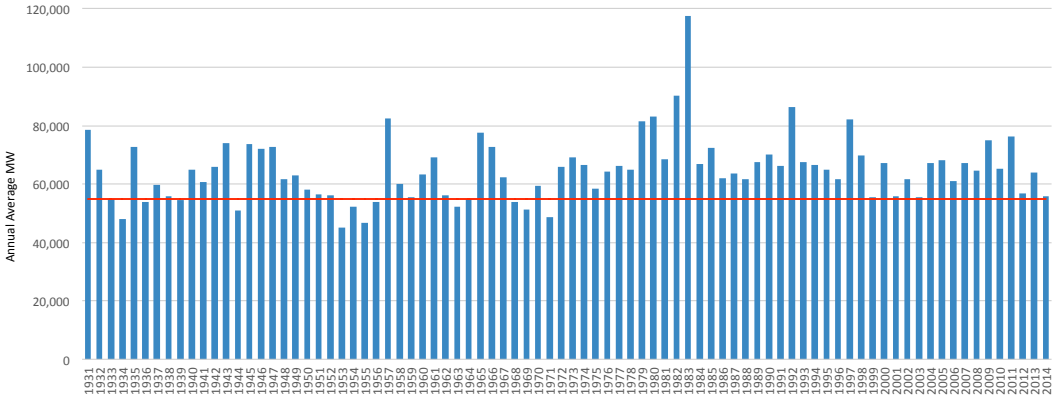

Figure 1: Annual Hydro Inflows and *GF* of Hydro Plants (*ONS* and *Aneel*)

Finally, the Brazilian power mix is changing rapidly. Most of the new supply of energy in the wholesale market is derived from intermittent sources, particularly wind farms and hydroelectric plants with little or no reservoir storage capacity to regularize production. As the power mix changes, the wholesale spot market pricing will need to provide more detailed short-term pricing to accommodate the increased supply and demand variability.

2.2 Demand Dynamics

The challenges arising from the demand side of the industry are also complex. Brazil is an emerging market, thus long-term electricity demand continues to grow at a fast pace due to increasing energy intensity, as consumer incomes rise, and due to the expansion of electricity-intensive industries. Although there is a clear long-term demand growth trend, in any given year, demand behavior may vary substantially due to macroeconomic instability, such as sudden changes in GNP growth rates and large exchange rate fluctuations.

Given theses characteristics, ensuring system adequacy in Brazil typically requires continued expansion of total supply capacity, although occasionally there are setbacks that can significantly lower total demand.

Another overriding concern in Brazil has been the impact of electricity tariff rates for particular customer classes or uses (such as poor households, irrigation, public lighting, rural electrification and regional development), which has given rise to the establishment of substantial cross-subsidies in the electricity rate structure.

3 KEY ASPECTS OF THE CURRENT MARKET DESIGN AND REGULATION

The approach chosen to deal with these challenges in Brazil is based on three major pillars: (i) centralized and cost-based price-setting mechanism for the spot market, (ii) certification of the amount

of energy that can be reliably provided by each power plant coupled to bilateral contracting requirements and (iii) forward energy contracting to meet demand of the regulated customers' load.

3.1 Spot Market Price-Setting Mechanism

Determining the marginal cost of hydroelectric plants is complicated, since most of the cost is not given by their tangible production costs (such as fuel costs for thermal power plants), but rather by the intertemporal opportunity costs of hydro inflows stored in their reservoirs. The opportunity costs of the stored water is based on: (i) expected hydro inflow behavior, (ii) expected dispatch behavior of the other generators, (iii) marginal costs of the system's thermal power plants and (iv) cost of deficits to consumers.

The determination of these opportunity costs is complicated not only because they involve dynamic optimization with stochastic hydro inflows, but also because of the interdependency between generators' operation policy decisions.

Given these difficulties, Brazil has opted to attribute central dispatch authority to the System Operator and rigid pricing-setting mechanism for the spot market. The price-setting mechanism consists of a computer program, which uses a Stochastic Dual Dynamic Programming Model to determine the marginal costs of hydroelectric plants, based on official input data, such as hydro inflow patterns, demand growth projections, the dates when new power plants will be ready to operate, administratively-set marginal costs of thermal power plants, cost of deficit and discount rate [3, 4]. The system spot price is a byproduct of the dispatch model (more specifically, the Lagrange multiplier associated to the load supply constraint), which means it is not based on the willingness of the producers (and consumers) to sell and buy energy but on technical parameters. Prices are calculated *ex ante*, on a weekly basis and for three load blocks ("heavy", "medium" and "light") and for four zones.

While the pricing-setting mechanism ensures coherent dynamic optimization of the hydro resources from a systemic viewpoint, its shortcomings are becoming ever more apparent over time. Methodological issues with respect to the most effective modeling approach (system representation, optimization techniques, simplifications…) are an on-going debate. The determination of the appropriate inputs for the model is also controversial [5, 6]. Even improvements in the price-setting mechanism that are consensus amongst specialists are slow to be incorporated. These issues beg the question to what point the current price-setting mechanism is providing appropriate price signals. Nevertheless, much of the problem could be resolved with improvements in the employed system model and in the input data determination process, as shown by the experience of other countries that apply the same price-setting mechanism – Chile, Peru, Mexico, Central America.

Another important aspect regarding spot market pricing is the changing nature of supply and demand volatility. In the past, daily demand fluctuations could easily be met by generation from hydroelectric plants, with little impact on short-term marginal costs. This explains why Brazil's current wholesale spot market pricing only sets three prices – "heavy", "medium" and "light" load – that are revised weekly. As the share of intermittent generation increases, however, the supply of flexible generation will become increasingly scarce, increasing short-term marginal cost variability, which will require increased spot market price granularity.

3.2 Physical Guarantee Certification Coupled to Bilateral Contracting Requirements

Each generator in Brazil is attributed a "Physical Guarantee" Certificate ("*Garantia Física*"), which is a energy version for a capacity credit of a power plant. It is calculated by the same dispatch models that are used to operate the system and based on the amount of energy that can be reliably produced from each generating plant, weighted by the time value of electricity when it is supplied, considering: (i) historic hydro inflow patterns, (ii) marginal costs of thermal power plants, (iii) the "cost of deficit" (i.e. value of lost load) and (iv) established reliability requirements.

Generators are only allowed to sell energy in bilateral contracts up to the amount established of Physical Guarantee Certificates to ensure long-term adequacy of supply.

Given the reliability requirements, in most years energy production from hydroelectric plants surpasses their Physical Guarantee, depressing spot market prices. On the other hand, when the system

faces a sporadic dry spell, spot market prices may reach – and remain at – the spot market ceiling for many months or even years, causing great financial distress to market participants that happen to be exposed to the spot market at that point. This irregular price pattern makes coordination of investment via spot market particularly difficult.

In an effort to ensure supply adequacy and financial stability of the electricity market, all members of the wholesale market are required to purchase 100% of their forecasted demand bilateral contracts. But the contracts must have a physical backing, given by a Physical Guarantee. In such a framework, contracts between suppliers and consumers are actually hedge instruments by which the parties establish financial obligations to settle the differences between the contractual strike price and current spot market price, but with a physical coverage obligation [7, 8].

While the determination of the Physical Guarantee Certificates greatly simplifies hedging by means of bilateral contracting, it is far from a perfect solution. The determination of the Physical Guarantee of each power plant and subsequent revisions is not trivial.

3.3 Forward Energy Contracting Auctions for Regulated Customers

Bilateral contracting occurs in two "environments" in Brazil: (i) the Free Contracting Environment (*ACL - Ambiente de Contratação Livre*) and (ii) the Regulated Contracting Environment (*ACR - Ambiente de Contratação Regulada*).

The Free Contracting Environment is deregulated. Generators, retailers and "Free Customers" are free to negotiate bilateral contracts terms, conditions and prices, the only requirement being that contracted amounts must be registered monthly in the Wholesale Market (*CCEE - Câmara de Comercialização de Energia)* prior to the settlement date. Customers with demand of at least 3 MW are eligible to become "free customers". Customers with a demand between 0,5 MW and 3,0 MW may freely negotiate bilateral contracts only from "incentivized generators", which are renewables except large hydroelectric plants (small hydroelectric, wind, solar, biomass and qualified cogeneration).

The Regulated Contracting Environment consists of the bilateral contracting between generators and distributors to meet the demand of customers served under regulated tariffs. In this environment all bilateral contracts are procured by means of forward energy auctions organized by the government. Distributors are annually required to inform forecasted demand growth for the coming years, which is met by the "New Energy Auctions". These auctions are held three or five years ahead of the starting date of the contractual period, thus providing purchase power agreements to the auction winners that greatly facilitate project financing of new power plants. Contracting to meet demand from expiring contracts is procured by means of "Existing Energy Auctions" held a few weeks prior to starting date of the contractual period [9, 10].

The regulatory requirements imposed on each Contracting Environment seek to adjust to their respective needs. Long-term forward are seen as essential to hedge energy contracting costs of retail customers that are unresponsive to short-term swings in the Wholesale Spot Market Prices, while they are not required from Free Customers that are considered capable of monitoring and responding to Wholesale Spot Market Prices. The contracting restrictions placed on distribution companies also seek to prevent possible distortions due to "self-dealing" in energy procurement between distribution companies and affiliated generation companies.

Roughly 70% of the energy is currently contracted in the Regulated Environment and 30% in the Free Environment. The migration from one environment to the other is a customer's decision. Given current eligibility requirements, the Free Contracting Environment could meet up to 46% of total demand.

The coexistence of these two "parallel markets" (Contracting Environments) provides an interesting impetus to the Brazilian power industry. Although transactions between the two contracting environments are very limited, they complement each other in important ways. On the one hand, the structured long-term contracting in the energy auctions of the regulated environment promotes investment in power plants, which helps ensure long-term supply adequacy. On the other hand, the nimbleness of the free environment helps promote more rapid adjustment to current conditions.

Conversely, one could point out their respective weaknesses: the lack of the short-term price-responsiveness of the Regulated Contracting Environment and the lack incentives for long-term commitments in the Free Contracting Environment [11].

4 RECENT DEVELOPMENTS

4.1 Retail Tariff Design Innovations

Since most of the retail market is serviced by distribution companies, under regulated tariffs, a large part of the lack of price responsiveness of demand can be attributed to tariff rate regulation. Electricity tariffs are only adjusted once a year. The array of tariff rate structures offered is very limited and most often outdated or inappropriate to local dynamics of the particular distribution concession area.

Aware of these limitations, regulatory authorities have revised the standard rate structure to provide better price signals and incentives to retail customers. Two major changes were introduced:

- the introduction of the "White Tariff", a new tariff schedule that residential customers may choose to adopt; and
- the substitution of seasonal pricing by the "Flag Regime".

An adequate rate structure must convey useful price signals to customers. This may vary from customer to customer. Some customers may only be able (or interested) in reacting to monthly-average electricity price variations, while others may be able (or willing) to modify their consumption behavior over the course of the day and week if more detailed price information is given. The best way to meet the needs of different customers is to provide a menu of rate structures (contracts) from which they may choose to meet their needs.

Aneel, the Brazilian electricity regulator, has taken a step in this direction by expanding the menu of rate schedules offered to retail customers. The most noteworthy change in the recent revision was the new rate structure offered to residential customers – the "White Tariff" (*Tarifa Branca*), which is a time-of-use tariff scheme. Previously Brazilian residential customers were offered only a flat rate per kilowatt-hour consumed during the month. Now residential customers may opt for the White Tariff, which consists of a rate structure that provides three time-of-day prices: "peak", "intermediate" and "off-peak". The daily price variation in this case is not due to varying energy production costs, but rather mitigate network congestion on the distribution grid. Daily consumption patterns are fairly predictable and consistent over the course of the year, which enables the adoption of different pricing for fixed time-intervals. However, network congestion occurs at different periods of the day in distribution companies. For example, in hotter and wealthier regions peak consumption occurs in the afternoons when air conditioning demand is at its peak, while in other regions it is in the early evening when demand from lighting and electric showers are at their peak. This implies that the White Tariff rate structure must be custom designed for each distribution company.

The most difficult aspect in implementing the new menu of contracts is to determine the combination of prices for the different rate schedules in a way that maintains the distribution companies' revenues constant. Given the lack of information on residential customers' price responsiveness it is hard to estimate how many are likely to opt for the new tariff rate and to what extent they will change their consumption pattern to take advantage of the new rate structure.

The time-of-use rate structure (such as the White Tariff) works well for cost variations that occur on a regular basis, but it is not helpful to deal with irregular price variations. The generation costs in Brazil tend to be relatively stable over the course of the day because most of Brazil's electricity is derived from hydroelectric plants that can adjust their production to meet daily load fluctuations. Hydroelectric reservoir capacity is sufficient to smooth out hydroelectric supply over the course of the year, given sufficient hydro inflows during the rainy season, so prices do not regularly vary over the seasons either. In dry years, or when rainfalls fail to arrive in the beginning of the rainy season, however, electricity generation costs raise dramatically, giving raise to very irregular price behavior [12].

In order to provide price signals to Brazilian retail customers that reflect current generation costs on a timely basis, the new rate structure introduced the "Flag Regime". At the end of each month the

regulator announces (also informed on customers' monthly bills) the "flag" that will be in place in the coming month: "red" when wholesale prices are high, "yellow" when wholesale prices are in an intermediate range, and "green" when prices are normal (low). The "red" and "yellow" flags mean there will be an additional surcharge on the electricity price. This solution provides the flexibility to adjust to current wholesale prices on a timely and simple way that allows customers to react to current conditions [13].

The difficulty in adopting the Flag Regime is that wholesale prices do not affect all retail customers in the same way. The distribution companies' costs of acquisition of electricity price depend on their respective portfolio of contracts. To deal with these differences the revenues obtained from the surcharges are pooled and split between the distribution companies in proportion to their additional costs electricity acquisition costs. The fund is managed by the Wholesale Market Operator (*CCEE - Câmara de Comercialização de Energia Elétrica*).

The new rate structure adopted in Brazil has some limitations and drawbacks, but demonstrates a conscientious effort to provide simple and pertinent price signals that reflect system costs, enabling a better alignment of wholesale and retail pricing [14, 15].

4.2 Alteration of the Wholesale Spot Market Price Limits

The Brazilian Wholesale Spot Market has both a price floor and a price ceiling. In 2014, due to severe drought and delay in the entry of some large power plants that were scheduled to enter in operation, suffered a supply shortage, which made spot market prices raise and remain at or near the market price ceiling, at that time set as 822 BRL/MWh. The situation occurred at a time when most distribution companies were not fully hedged to spot market prices, because of insufficient contracting in the forward energy auctions. Although distribution companies signaled the need for more energy, the government administered forward energy auctions were not able to meet all the demand for various reasons (auction delayed, price ceiling too low to attract suppliers, incompatible contract horizons…). Likewise, many hydroelectric generators also were put under financial distress because their energy production was insufficient to cover their bilateral contract financial commitments.

If the crisis were not thwarted, widespread bankruptcy among generators and distribution companies could occur. In order to limit the financial impacts of the ensuing crisis, the regulatory authority lowered the spot market price ceiling by roughly 50%, to 388 BRL/MWh. At the same time the price floor was raised, to ensure that the expected average future price remain unaltered [16].

Perhaps one of the reasons why regulatory authorities opted to mitigate the impacts of the crisis by changing the spot market price ceiling and floor was the recognition that both generators and distributors did not have full autonomy to manage the risk and, therefore, could not be held responsible for the economic consequences of the crisis. Generators could not determine how their power plants were dispatched and distribution companies could not fully control the level of contracting in the forward energy auctions.

Although the change minimized the immediate crisis, it substantially dampened spot market pricing signals and incentives for long-term price hedging. Current (2016) figures for the spot price cap and floor are, respectively, 422 and 30 BRL/MWh. These values are revised annually.

4.3 Introduction of Net Billing

Aneel recently required all distribution companies to offer standardized net billing contracts to any retail customer that desires to install distributed generation. The net billing contract allows consumers to inject surplus electricity production from their own generation into the distribution network, valued at current electricity retail price. This amount is then deducted from the bill from net consumption in other periods.

While the prime objective of the initiative is to promote the introduction of distributed generation, particularly of renewable energy, such as photovoltaic cells, the policy also has the potential of impacting retail long-term price responsiveness by lowering customers' reservation price (price at which they choose not to purchase electricity from the distribution company) [17].

Depending on the technology employed, net billing may increase consumer's short-term price responsiveness by incenting *prosumers* to adjust self production as a function of retail market prices.

Most often, however, micro generation is derived from intermittent sources, whose production is unresponsive to market prices. Thus micro generation will most likely increase the need for supply-side price responsiveness, more so than it will boost demand-side price responsiveness. This would increase the need for flexible power plants with high ramp rates (generators that can quickly change the level of output), which may increase wholesale generation costs.

5 FUTURE OUTLOOK

Over the years various electricity reforms have been adopted to better address the specific needs of the Brazilian electric industry. The reoccurrence of crises caused by irregular hydro inflow fluctuations, unexpected changes in demand growth and other factors, demonstrate that the current market design and regulation is still not sufficiently robust to handle the previously mentioned challenges.

Further reforms are necessary to provide more flexibility, more financial robustness and better market monitoring and preventive action to deter the occurrence of future crises. The key to achieving these goals is to improve market signals and market responsiveness both on the wholesale and retail markets. Looking ahead, we foresee three major initiatives to achieve these goals: (i) the improvement of the spot market price-setting mechanism, (ii) the introduction of full retail competition, and (iii) the requirement that all load be fully hedged many years ahead.

5.1 Improve the Spot Market Price-Setting Mechanism

In hindsight, it is clear that the market pricing has not been very successful in averting crises. Improvements are need both in mathematical modelling and in the process of forecasting crucial variables and determining key parameters that serve as inputs in the mathematical model.

Although the mathematical model employed in the current price-setting mechanism of the wholesale spot market has been gradually improved, there is a clear understanding that there is still much space for improvement.

Regardless of the price-setting mechanism adopted, an important aspect that should be evaluated is how to foster the continuous improvement of the price-setting mechanism and of the determination of the inputs of the model.

Given the model's limitations, especially regarding system supply security, the Brazilian System Operator (*ONS - Operador Nacional do Sistema*) has been given authority to dispatch thermal power plants, whose variable costs are above the current marginal cost calculated by the mathematical model, whenever risks that the mathematical model has failed to properly incorporate are identified. These so-called "out of merit dispatches" have been an important source of learning that has contributed to improvements in the model. For example, in January 2016, there were weeks with spot price at the floor (30 BRL/MWh) but with all thermal plants being dispatched "out of merit" for security reasons.

5.2 Introduce Full Retail Competition

One way to improve the management of the large supply shocks associated to renewable generation – particular hydroelectric generation in Brazil's case – is to increase demand-side price responsiveness. The advent of smart grid technologies and the increasing participation of *prosumers* can substantially increase the potential for demand-side responsiveness. To foster the adoption of these technologies and stimulate active engagement on the part of consumers significant innovations are needed on the retail side of the market. More detailed metering, investments in new equipment, and new tariff rate structures will be necessary. Changes on the retail side will also require more flexibility for contracting energy in the wholesale market. The most effective way to vitalize the retail segment of the industry, promoting innovation and experimentation is to open the market to competition.

This regulation is extremely rigid for distribution companies trading in Regulated Contracting Environment (*ACR*), where retail tariffs are fully regulated by *Aneel*, and forward, long-term contracting for up to 30 years is required. In turn, in Free Contracting Environment (*ACL*) there is

more freedom and a variation of contractual terms and pricing standards offered to meet customers' needs. The *ACL* pricing is much more dynamic, dealing with market conditions in much more agile way than the *ACR*, where regulatory solutions must be obtained to deal with the unexpected problems.

The adoption of full retail competition, therefore, needs to find a way to deal with the legacy of long-term contracts already established in *ACR*.

As robust competition is obtained in the retail market, electricity rate regulation may become less stringent providing more liberty to distribution companies to introduce new tariff rate structures, provide new types of services and more autonomy to contract energy in the wholesale market on behalf of their customers, providing a better alignment of rights and responsibilities of market agents.

The liberalization of the retail segment would also enable the unification of the two contracting environments in Brazil, improving the liquidity and efficiency of the contract market. A pre-requisite for the full retail liberalization, however, is the need to adopt universal policies that ensure long-term system adequacy, which brings us to the final initiative: the requirement that all consumers be fully hedged.

5.3 Require Long-Term Forward Hedging of All Load

The current hedging requirement used in Brazil that all consumers be fully contracted prior to spot market clearing is not very effective because contracts can be of very short duration and because wholesale market clearing only occurs monthly, many days after delivery. To ensure that all consumers are fully hedged, far in advance, a centralized mechanism should be implemented and equally applied to all consumers. This hedging requirement will improve market liquidity and security benefiting all market participants.

The specific form of hedging could take on many different forms. The hedging instrument could take the form of long-term bilateral contracts, forward reliability options, capacity contracts, among others. The hedge instruments could be backed by generation capacity or could be exclusively of financial nature. One way to implement the long-term forward hedging would be to have the government or the regulatory agency procure the required hedge on behalf of all consumers and have its costs covered by a fee charged levied on all customers. The most important factor is that the hedging requirement be universally applied to all load, defined on a centralized basis, that the supply of hedging instruments be regulated so as to ensure they are sufficiently robust to withstand periods of market stress and that they be of long-term nature so as to help coordinate the expansion of the market. The application of a uniform requirement for all consumers would also contribute to more balanced and equitable market participation.

6 CONCLUSION

In this paper we have shown the challenges faced in Brazil both in the development of price-setting mechanism for the wholesale spot market and in the alignment of incentives for wholesale and retail market participants.

We have traced some of the most significant developments in Brazilian electricity market over the past decades. While all changes helped solve specific problems identified at the time, they have also given rise to new challenges that remain to be addressed.

In the coming years the Brazilian electricity industry must further advance in the development of its electricity markets. Improvements in the price-setting mechanism are needed, particularly with respect to evaluation of key parameters and forecasted that are used as inputs in the current mathematical model employed to determine Wholesale Spot Market prices. The market structure and regulation must also be improved to provide better alignment between financial and physical markets.

Regulatory reforms are needed to provide more flexibility for distribution companies to meet the needs of their customers, to enable the emergence of new financial products in the Wholesale Market and of new tariff structures to retail customers.

Efforts are needed to integrate markets, increasing liquidity, innovation and competition. Barriers limiting customer choice should gradually be reduced, enabling better alignment of wholesale and retail market dynamics.

These changes will further strengthen the Brazilian electricity market by improving the electricity industry's robustness. The sustainability of the power market depends on its ability to meet the real market requirements, and every effort should be made to align regulatory incentives and prices in order to ensure its adhesion to the system's physical reality. Thus, the ultimate goal for all key stakeholders of the industry – independent power producers, consumers, distributors, and traders, as well as *Aneel* (the regulator) and related public authorities – should be to achieve proper functioning liberalized markets.

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