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STUDIES

Issue 2014/07
December 2014

POLICY BRIEF

FLORENCE
SCHOOL OF
REGULATION

Enhancing flexibility and ensuring efficiency and security: Improving the electricity market in Brazil

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Highlights

- Electricity industries have evolved to ensure fair competition, higher efficiency, declining prices and reliability of operation. The Brazilian electricity market is characterised by having around 75% of installed capacity coming from renewables, and has gone through two reforms in recent years. Nowadays, it contains certain particularities that distinguish it from other markets.
- Nevertheless, the conciliation between commercial commitments and the physical dispatch is not smooth. There is a lack of “trading opportunities” to encourage participants to comply with their contracts. Moreover, the Brazilian short-term market acts as a mechanism to settle differences rather than a true market and, neither the short-term price nor the dispatch schedule is determined by the market.
- If a more market-oriented approach is to be adopted, certain dilemmas have to be faced. This brief describes a new market framework, aimed at enhancing flexibility to enable participants to sustain their contracts, while ensuring the efficient use of the energy resources and maintaining the current level of the security of supply.
- In this new market design, two worlds would coexist: the real one, associated with the power system and with physical effects; and the virtual one, related to the settlement system and with commercial effects. By doing so, the ISO can physically operate the power system in an optimised way, and generators can manage their contracts strongly supported by their level of risk perception.



Introduction

Several countries embarked on a path characterised by market liberalisation, in order to implement decentralised and competitive structures. Brazil presents a continental interconnected transmission system with a growing demand and with a total generation installed capacity of around 135 GW (around 70% comes from hydropower plants), and having gone through two large institutional reforms in the last twenty years. The first reform promoted a transition from the vertical integrated utility structure to a market where agents could freely negotiate contracts. Nevertheless, driven by an aggressive energy rationing programme experienced from June 2001 to February 2002, the second reform restored certain fundamentals/ principles and added some new guidelines:

- A. Reintroduction of the long-term centralised planning conducted by the federal government to address the security of supply. Thus, the expansion of the system doesn't rely on a market-based approach;
- B. Implementation of long-term contracts (PPAs) with availability of payment. The goal was to promote the installation of thermal power plants;
- C. Requirement that consumers must be fully supplied by energy and power purchase contracts, and all contracts must be registered with the Brazilian market operator (CCEE). Distribution utilities and free consumers must ensure the compliance of 100% of their consumptions;
- D. Requirement that sellers must have enough capacity when selling energy and power to entirely implement their contracts. In other words, all sold electricity should be 100% physically backed. This "physical coverage for sale" consists of what is known as the "physical guarantee" of the power plants. In the long-term, the physical guarantee represents the amount of electricity that can be continuously produced; and
- E. Creation of two contracting environments: the *ACR* - Regulated Contracting Environment (single buyer model), encompassing around 70% of the market, and the *ACL* - Free Contracting Environment (competition in the retail market), with 30%. In the *ACR*, prices are determined by national public auctions conducted by the government (one of the main targets of this scheme is to provide affordable tariffs to the growing economy) while in the *ACL* prices are freely negotiated.

Despite these changes, the short-term market price is not a result of the market participant's interactions, and the dispatch is performed in a centralised way by the ISO, such that gen-

eration companies are not allowed to decide their own generation in order to comply with their contracts. In addition, the mechanism implemented in order to share the risk of not being dispatched does not allow generators to develop their own strategy according to their risk perception.

In this brief, we discuss the problems and dilemmas that have to be confronted, if a more conventional market-oriented approach is to be adopted in Brazil. Moreover, we propose a market design aimed at enhancing flexibility to enable market participants to maintain their contracts, while still ensuring the efficient use of energy resources and maintaining the current level of the security of supply.

Remarkable features of the Brazilian Electricity Market

Seasonalisation process

After closing a contract and when the power plant becomes available, market participants can perform a seasonal adjustment of the contracted energy and of the physical guarantee, respectively. This process is called "seasonalisation" which, in other words, allows once a year the distribution of the annual energy committed in monthly MWh packages.

ISO dispatch procedure

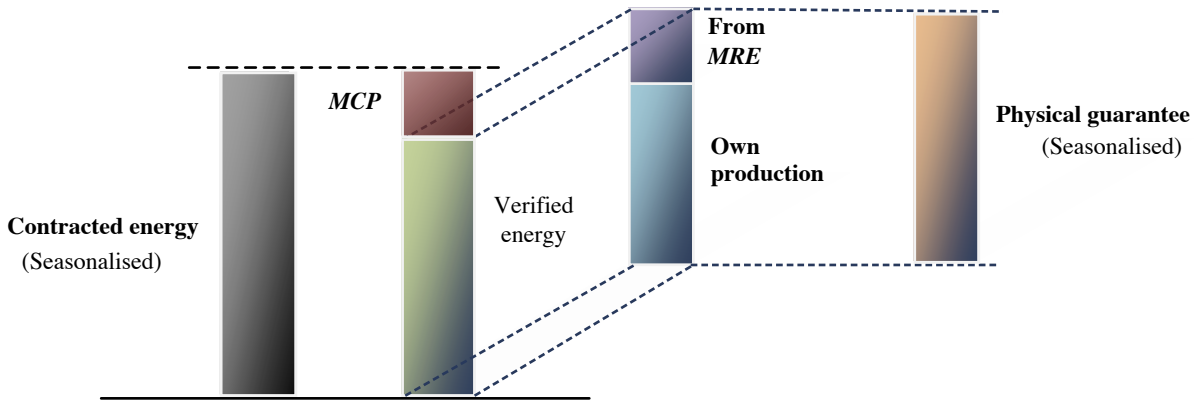
Instead of a market-based approach, the dispatch is defined based on the solution of a minimum operational cost problem that seeks a trade-off between saving water now and using thermal fuel (if the expectation of inflows is low), or using water now and saving thermal fuel (if the expectation of inflows is favourable). The optimal dispatch problem is currently solved through a stochastic dynamic and linear programming software package. The opportunity water value is one of the key elements of this model and it is set to examine, among other issues, the forecasted hydrology and demand. The two main outputs are: the dispatch schedule of the power plants; and the short-term market prices, well-known as *PLD* (Price of the Differences Settlement). Both of them are established weekly for three daily load steps.

Mechanism for Reallocation of Energy

Since the dispatch is performed in a centralised way by the ISO without considering the contracted energy, the Mechanism for Reallocation of Energy (*MRE*) is then activated. The *MRE* is applied to hydros that committed to deliver a certain amount of electricity (MWh) during a specific period, at a pre-defined



Figure 1. Traded energy in MCP: negative exposition



price¹. The goal of this mechanism is to cover the risk of generators having to buy electricity in the short-term market at *PLD* to account for the amount of energy committed in their contracts. Briefly, the *MRE* reallocates energy, transferring the surplus generated from those that produce beyond their physical guarantee to those that produce below.

Short-term market

The short-term market (also called *MCP*) is used to make all settlements. Once all closed contracts have to be recorded in *CCEE*, the *CCEE* measures the amounts that were actually produced / consumed by each agent. After applying the *MRE*, the differences between contracted energy and the verified energy are accounted for, and the exposed positions are valued at the *PLD*. Their own production (power plants just follow the dispatch order of the *ISO*) plus the energy allocated from the *MRE* (which depends on the seasonalised physical guarantee) is equal to the verified energy. Then, the verified energy is compared with the contracted energy, and the resulting difference is settled in the *MCP* at *PLD*. This settlement process, as illustrated in Figure 1, is performed on a monthly basis.

Problems

Problem 1

In this current market design, the conciliation between the commercial commitments of the market participants and the physical dispatch is not easily accomplished. In Brazil there is no balancing market; neither intraday or day-ahead options, nor future markets. Instead, there is an annual “window” in which to monthly distribute the physical guarantee and the

1. The thermal power plants usually sign contracts to receive an availability payment plus an additional remuneration for each MWh effective produced.

contracted energy. The centralised dispatch is carried out by the *ISO* without considering the signed contracts, and generators are not allowed to decide their own generation in order to uphold their contracts. On balance, in day-ahead and intraday markets, players are more active in the definition of the merit order on a day-by-day basis, and so they have more opportunities to cover the positions they committed to, in bilateral contracts.

Problem 2

Unlike other markets, the Brazilian short-term market is not a marketplace where generators are active through a self-dispatch procedure, or where generators influence the dispatch through their bids. Ultimately, this short-term market is not an environment where market participants can engage in short-term trades on their own account, as there is no short-term declaration of intent. Moreover, the price that values these transactions is not a result of the interaction of market participants, but from the application of a chain of software models, that are operated by a third party. So, rather than being a market, the *MCP* is a mechanism to settle differences between the amount of electricity committed by contracts and the amount of electricity that each agent ends up providing / receiving.

Problem 3

The codes associated with the software package used to run the centralised dispatch are under intellectual property rights. Eventual inconsistencies in these algorithms have a huge impact within the entire sector, and the confidence of the market can be affected. Unfortunately, during 2007 and 2011, relevant problems related to inconsistencies in these models were detected and a new version of the software was launched.



Dilemmas

A solution typically adopted in other countries and geographical areas is the employment of a more market-oriented approach. This could enable all generators to submit quantity and price bids in the short-term, which would be used to settle the market positions. Nevertheless, there are some dilemmas that must be faced, especially if considering a power system with a large share of hydros.

Efficiency of energy resources

Putting into perspective the dichotomy between a centralised dispatch (based on hierarchy) and a decentralised one (based on a market approach), it becomes clear how important it is to coordinate the use of water stored in the reservoirs, in order to safeguard the efficiency of using the energy resources, i.e. to take advantage of the all potential energy stored in the cascade.

A decentralised dispatch, e.g. a scheme of bids in a market pool, can essentially be an instantaneous process and the intertemporal features of river chain operations cannot be entirely represented, if a pure single-period market clearing mechanism is adopted. Moreover, the presence of several owners of the hydro cascades, as is the case in Brazil, endorses a market design based on a centralised dispatch.

Security of supply

Concerning the ability of the market to ensure sufficient capacity to meet future demand, it must be noted that generators will only invest in new power plants if they expect to recover their total costs. Thus, considering a Brazilian electricity market entirely reliant upon a short-term market, the following question arises: Will the response of generators regarding the short-term market prices come in the form of new installed capacity?

The Brazilian short-term market has been in existence for about fifteen years. For the time being, the *PLD* has an average value of 37.72 €/MWh², and the successful hydro average price bid that came from public auctions is 38.16 €/MWh³. Nevertheless, it should be noted that Brazil endured two large energy crises (2001-2002 and 2013-2014), that caused the *PLD* to remain at extreme levels for long periods, which were not expected in a country that traditionally produces electricity based on hydro-power.

Regardless, supposing that from now on more thermal stations are included in the dispatch and thus, the *PLD* would be greater, the question is will the *PLD* curve shape be a barrier to new investment? The *PLD* standard deviation of the entire set of data is around 55.36 €/MWh. With an average of 37.72 €/MWh, this standard deviation imposes a huge risk to the health of the business, especially regarding the stability of the cash flow.

Finally, it is recognised that a capacity mechanism is needed in order to provide enough incentives to ensure the security of supply. Nowadays, this concern is addressed via both the contracting scheme where the demand must be fully contracted ex-ante and contracts physically backed, and the ISO dispatch, either through the mechanism of risk aversion in the software package, or through a dispatch according to the merit order authorised by CMSE, the entity that monitors the supply adequacy in the country.

Flexibility to comply with contracts

There is one unique “window” in which to define the physical guarantee that will uphold the contracts. Moreover, generators operate their power plants simply following the rate of production defined by the ISO, and the *MRE* is automatically performed, which imposes a kind of “strait jacket” on the market participants.

Every time that the *PLD* is high, there are more dispatched thermal stations and less hydro stations. Depending on the quantity of the thermal dispatch, hydros can be displaced in such a way that *MRE* will not have extra energy to be shared among its participants. When this occurs, an adjustment factor is applied to withdraw a fraction from the seasonalised physical guarantee of the participants. Extending this reasoning to water scarcity periods, this represents a widespread negative position for hydros. In conclusion, the *MRE* is not able to cover the risk of generators that have to buy electricity in the short-term market to complete the energy committed in their contracts.

Unfortunately, Brazil is currently facing a similar situation. Due to an unusual rainfall cycle that has lasted since 2012, the power system has a widespread water shortage, a large thermal dispatch and sky-rocketing short-term market prices. For this reason, hydros appealed to the Federal Government for financial support. The Federal Government has been arguing that this is a business risk of hydros, and that it does not intend to relieve them. In the long-term, and pragmatically speaking, within this conjuncture the question to be answered is as follows: for how long can this negative exposition be internalised by hydro companies?

2. Values were converted from Brazilian Reals (R\$) to EUR (€) considering the currency exchange rate on September 4th, 2014 (1€ = R\$ 2.8899). Available at: <http://www4.bcb.gov.br/pec/conversao/conversao.asp>.

3. CCEE - Electric Power Commercialization Chamber. Prices. Available at: <http://www.ccee.org.br>.



The proposed market design

The Brazilian market design is lacking a level of flexibility that would allow hydro companies to adequately manage this risk. Focused on improving flexibility for market participants to comply with their contracts, while still ensuring the efficient use of energy resources and maintaining the current level of the security of supply, a new market design was developed, supported by the following proposed virtual reservoir model:

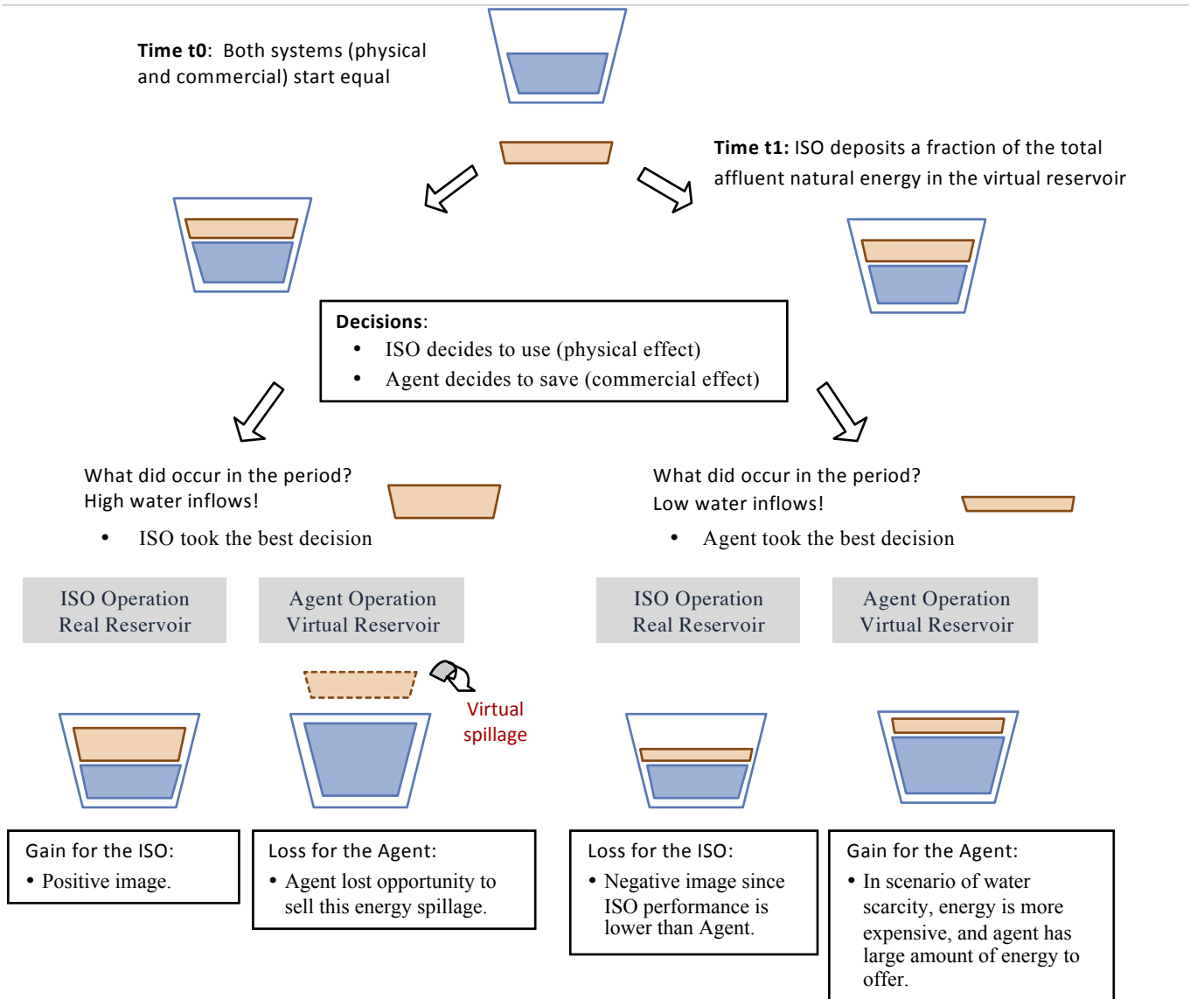
- Each cascade of hydro stations operates as an equivalent reservoir;
- Each agent has a virtual account that represents how much energy is virtually stored in his hydropower plant;

- For each period, each account is fed by a fraction of the total affluent energy of the equivalent reservoir, proportional to the hydro’s physical guarantee.

Then, the following sequence of events should be adopted:

1. The system operator continues his work as it is currently done, and defines the amount of generation for each power plant. So, the efficiency of the use of the energy resources and the security of supply are maintained at the current levels;

Figure 2. Decision making process





2. The “remaining demand” is obtained for each dispatch period. This demand is equal to the total demand minus the total dispatch allocated to the thermal power plants;
3. A hydro short-term market is established based on bids for this remaining demand:
 - a. Regarding the price bid: hydros can bid a price between zero and a regulatory ceiling price defined by the regulatory agency;
 - b. Regarding the quantity bid: each agent can offer any value within the balance of his account;
4. The final short-term market price is calculated as a weighted average considering the hydro short-term market price that comes from the hydro virtual short-term market and the variable cost of the dispatched thermal power plants, and other energy sources.

Through this market design, two worlds would coexist: the real one, associated with the power system considering the physical operation of the system; and the virtual one, related to the settlement system and with commercial purposes. Thus, the ISO will freely operate the physical system, while agents would be responsible for deciding, in commercial terms, how much they want to withdraw from their virtual reservoirs to meet their contracts. To do that, their bids have to be accepted in an auction that will be performed as a day-ahead market. In doing

so, each generator has the opportunity to manage his contracts more efficiently, without affecting the real operation of the physical system.

Furthermore, this model promotes a monitoring of the ISO performance, based on comparisons between his decisions (the physical world) and the market participant decisions (virtual world). To illustrate this issue, Figure 2 presents a scheme regarding the decision-making process in this new market design.

At the end of this process, prices no longer primarily result from a package of computational models that may eventually present problems related to inconsistencies and transparency, but can be obtained through the combination of thermal costs based on the ISO dispatch and short-term market prices arising from the hydro short-term market.

Thereby, this market design maintains the same levels of efficiency and security, while increasing the level of flexibility for agents. This flexibility can be achieved by replacing the *MRE* and the seasonalisation process by virtual reservoir models. As a result, the management of (virtual) reservoirs is the responsibility of each hydro, which could save (virtual) water according to their own risk perceptions and, in doing so, the operation of the physical system is not affected.

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