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The stochastic effects on the Brazilian Electrical Sector

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ABSTRACT

The size and characteristics of the Brazilian Electrical Sector (BES) are unique. The system includes a large-scale hydrothermal power system with many hydroelectric plants and multiple owners. Due to the historical harnessing of natural resources, the National Interconnected System (NIS) was developed outside of the economic scale of the BES. The central components of the NIS enable energy generated in any part of Brazil to be consumed in distant regions, considering certain technical configurations. This interconnection results in a large-scale complex system and is controlled by robust computational models, used to support the planning and operation of the NIS. This study presents a different vision of the SEB, demonstrating the intrinsic relationship between hydrological stochasticity and the activities executed by the system, which is an important sector of the infrastructure in Brazil. The simulation of energy scenarios is crucial to the optimal manner to operate the sector and to supporting decisions about whether expansion is necessary, thus, avoiding unnecessary costs and/or losses. These scenarios are an imposing factor in the determination of the spot cost of electrical energy, given that the simulated quantities of water in the reservoirs are one of the determinants for the short-term energy price.

1. Introduction

The Brazilian Electrical Sector (BES), which is the ninth largest electrical sector in the world in terms of energy generation, produces approximately 470 TW h (OECD, 2012). In 2011, the generation, distribution and transmission sectors experienced billings of approximately US$6 billion. Electricity reaches over 99% of Brazilian homes.

Due to the historical harnessing of natural resources for energy generation, the National Interconnected System (NIS) was developed outside of the economic scale of the BES. The central components of the NIS enable energy generated in any part of Brazil to be consumed by consumers in far away, considering certain technical configurations. This interconnection between regions produces an enhanced utilisation of resources, which results in a large-scale complex system that is controlled by robust computational models that are used to support the NIS' planning and operation.

The unification of a nationally interconnected system requires billions of dollars from investments (public and private) and the market structure (monopolies and oligopolies) for hydraulic generation, distribution and transmission. As a result, several problems and challenges emerge that require decisions on different time scales.

These problems involve decisions that are directly related to the three functions of the BES: (i) expansion planning, (ii) operational planning and programming and (iii) determination of energy spot price. These functions are executed by different agencies: the Energy Research Company (EPE), the National Electrical System Operator (ONS) and the Board of Electrical Energy Commercialisation (CCEE).

The following questions emerge in this environment: should an investment be made to increase the capacity of the system or would it be better to wait for a time of greater expansion in economic activity? How much thermal and hydroelectric energy should be generated to meet current demand? When is the right time to conserve water and use fossil fuels? What is the required spot price of energy to finance all production factors and ensure that the affordability tariff is paid?

Responses to these questions, which pertain to the daily activities of the BES, are not trivial and require extensive planning and synchronised management. Stochasticity exists in the following three functions of the BES.

In addition to the introduction, this article is organised as follows: Section 2 contains the history of models adopted by the BES. Section 3 describes the sector from the perspective of the new model by identifying relationships between the three supporting functions and hydrological

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stochasticity. Section 4 includes final considerations and relevant contributions.

2. BES historical description

The origin of the electrical energy supply crisis in Brazil is related to four main causes: (a) exhaustion of the state-owned market model of finance and structure, which is responsible for the expansion of the sector since the 1960s, (b) failures in planning the transition from the state-owned model to the private model, (c) contractual and regulatory problems and (d) the lack of coordination between governmental agencies (Pires et al., 2002).

The collapse of the state-owned model can be attributed to two main reasons: the fiscal crisis of the state, which caused the end of the investment capacity of the union at the required levels for expansion of the system (the companies were predominantly state-owned), and an inadequate regulatory regime, which did not promote efficiency and low generation costs as the tariffs were regulated in the generation, distribution and transmission segments.

Other factors also contributed to the fiscal crisis of the state, which began in the 1980s and reduced the quantity of union resources for investments. First, the marginal cost of expansion of the sector increased as new hydroelectric basins were situated further from the consumption centres. For this reason, additional resources had to be invested to produce an equivalent generation capacity.

Second, the actual values of tariffs, whose price levels did not reflect increased sector costs, deteriorated. In addition to their stability throughout Brazil, the tariffs were used as an inflationary control tool. This process culminated in the decapitalisation and subsequent default of several sector agents. Last, with the consolidation of the democracy and the advent of monetary stability, social demands imposed the need for the government to develop better criteria for the application of union resources (Pires et al., 2002).

Based on these reasons, investments in the state-owned companies were not sufficient for satisfying the intensifying demand in Brazil. Thus, a large number of BES expansion projects were halted and/or did not adhere to previously established schedules, which worsened the financial situation of the sector due to increased costs caused by expanded project timelines.

From the regulatory point of view, the lack of stimuli to seek productive efficiency prevented companies from establishing incentives to reduce costs. According to Schaeffer et al.(2003), the tariffs were equalised throughout Brazil in the 1970s to stimulate energy development in certain regions by requiring that surplus and deficit companies compensate each other through transfers, gains and losses from their individual efforts. In 1993, at the beginning of the privatisation process, the tariffs were fixed by the electrical distributing utilities to justify the need for companies to establish appropriate tariffs for their markets and to achieve satisfactory levels of profitability. See more about tariff policy of the Brazilian electric power sector in Santos et al. (2013).

Regarding the failures in the transition from the state-owned model to the private model and contrary to what was expected, private companies did not invest in the expansion of generating facilities at the beginning of the privatisations in 1995. According to Fernandes et al.(2005), the most important effect of these privatisations was a rapid return to tariff levels (which had been obsolete until then) to increase the attractiveness of private companies. On February 13, 1995, the privatisation and reformation process of the sector began with Law No. 8987, which is named the "Law of Concessions". According to Pêgo and Campos Neto(2008), in addition to creating conditions for greater participation of private capital, the new law introduced competition in the construction of new projects through regulation of the concessions bidding system for utilities that were previously exclusive to state and federal utilities.

In 1996, the BES Restructuring Project was initiated. The primary objectives of the project are summarised as follows: (i) the need to implement the vertical disintegration of electrical energy companies, that is, to divide them into segments of generation, transmission and distribution; (ii) to incentivise competition in the generation and commercialisation segments and (iii) to regulate the distribution and transmission sectors of electrical energy, which were considered natural monopolies under state regulation (CCEE, 2012).

The need for the creation of a new regulatory and inspection agency for all sector relationships was identified (Brazilian Electricity Regulatory Agency — ANEEL). The agency, which began to operate in August 1998, was expected to control the operation of the electrical system, from one operator to the national electrical system, in an integrated manner (ONS) and in an environment for buying and selling electrical energy (Wholesale Electricity Market — MAE); the MAE commenced in 2000 with many restrictions.

The authors Goldemberg and Prado (2003), highlight that the failure of the electrical sector reform (free market model) was attributed not only to the lack of external resources or the political resistance encountered by the government but also to failures in strategic management, coordination and planning of the electrical system, which was induced by the adoption of a reform that was grounded in the experiences of other countries and inappropriate for Brazil and its predominantly hydroelectric system.

In 2001, due to failures of the reform and a lack of sustainability of the model and water problems (shortage of rainfall), the electrical sector experienced a significant supply crisis that culminated in a national electrical energy rationing plan, which affected all categories of consumers. As the crisis was insufficiently addressed by the government, measurement of the immediate results consisted of the controlling of consumption. The government concentrated on thermoelectric power plant construction projects and reinforced the budget for investments in state-owned companies.

In 2003, the financial and distribution problems worsened, which caused the government to implement a programme to organise resources for the distribution utilities via the Brazilian Development Bank (BNDES). In addition to measures of short-term emergencies, a new institutional model (new model) was elaborated for the energy sector to correct the failures that caused the crisis and to focus on tariff affordability, universality of access and the resumption of energy planning (Table 1).

The new model defined the creation of an entity that is responsible for long-term energy sector planning, the EPE; an institution assigned to permanently evaluate the safety of the electrical energy supply; the Electrical Sector Monitoring Committee (CMSE); and one to give continuity to activities related to the commercialisation of electric energy in the interconnected system: the Chamber of Commercialisation of Electric Energy (CCEE).

Regarding the commercialisation of energy, two environments were instituted for the negotiation of energy trade contract: the Regulated Contracting Environment (ACR), in which the agents of generation and distribution of energy participate, and the Free Contracting Environment (ACL), in which the exporting agents of generation, commercialisation, importation and free consumers of energy participate (CCEE, 2012).

The new electrical sector model provided a set of measures to be observed by the agents, such as the requirement to contract all demand by the distributors and free consumers, a new methodology for the calculation of backing[1] for the sale of generation and the contracting of hydroelectric and thermoelectric power plants for better equilibrium between the backing and the cost of supply, as well as permanent monitoring of the continuity and security of supply to detect conjunctural imbalances between supply and consumption (CCEE, 2012).

In terms of tariff affordability, the model established the purchase of electrical energy through auctions by the distributors in the regulated environment. It is considered the lowest cost criterion with the

[1] Decree no. 5163/2004 establishes that selling agents must guarantee the backing of power and energy that is sold to 100% of their contracts. This guarantee must be proportioned per generating enterprise or by third parties through energy or power contracts.