A PROPOSAL OF REFORMULATION OF HYDROPOWER SALES CONTRACTS IN THE BRAZILIAN ELECTRICITY SECTOR

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Overview

Hydropower generation accounts for approximately 65% of the total electricity consumption in Brazil, with the remaining provided by wind farms, biomass and thermal power plants (ANEEL, 2015). Hydropower has many advantages: is a non polluting renewable source of energy that contributes to the reduction of greenhouse gas emissions, has a negligible cost of fuel as it uses the natural water affluences of rivers and is an environmentally sustainable source of energy. On the other hand, construction of these plants typically involve high construction costs and hydropower is highly dependent on rainfall and reservoir levels which are seasonal and uncertain (Moreira et al., 2004).

Since 2013 Brazil has been undergoing a crisis in the electricity sector due to a severe drought. Under Brazil´s centralized dispatch mode of operation, in order to cope with this the National Systems Operator (ONS) has taken unusual steps to preserve water for future use which resulted in a significant reduction of hydroelectric production. As these generators have energy sales contract by quantity, in order to meet their obligations they were forced to purchase their energy deficit in the pool, which caused significant financial losses due to high market prices, and as of December 2015, the aggregate financial losses of these firms reached the mark of 10 Billion US dollars.

While the hydro generators agree to bear part of the hydrological risk, they argued that some of the decisions of the ONS such as dispatching high cost thermal units out of the order of merit and not declaring an energy rationing, aggravated an already difficult financial situation by further reducing hydropower production, and thus, they could not be solely held responsible for these losses. This problem escalated in the second half of the year 2015, when the Electric Energy Trading Chamber was forced to paralyze the financial accounts settlements for a few months while a solution was negotiated between the agents. While this solution solves the short-term financial problem, it does not change the structure of the system that allows this problem to develop, and meanwhile, consumers had the tariff adjusted upwards several times during 2015.

Hydropower generation is a risky venture due to the uncertainty over expected rainfall and reservoir levels. Thus, to ensure a minimum level of production, each plant has a physical guarantee, which establishes the maximum production of energy that can be maintained continuously by hydroelectric power plants over the years, assuming a (5 %) risk of failure to meet this load. Thus, the power sales contracts can only be made up to the limit of physical guarantee of plants. In Brazil, all physical guarantee of hydroelectric is contracted per quantity, i.e., they are committed to deliver a fixed amount of energy at a fixed price.

Despite the physical guarantee contracted, hydroelectric power plants are subject to the centralized dispatch by the National Systems Operator (ONS) and, therefore, have no control over the generation level, regardless their energy sales commitments. The ONS determines the dispatch order and quantity of generation of each power plants in the country. The plants are dispatched in order to minimize operating costs, keeping in view the reservoir water storage, the prices offered by thermal plants and operational constraints. Thus, in a long dry period, the hydro generators have their production reduced not only by natural reasons, but also because of the ONS decision, which may choose to use other sources of generation (thermal power plants) to save water for future uses. In addition, ONS can reduce hydropower generation, e.g., by reducing river flows and increasing renewable energy auctions, such as wind, solar and biomass. As the hydroelectric power plants are fully committed to the limit of their physical guarantee, all these externalities have a negative financial impact to these companies.

Hydroelectric power plants are required to comply with all sales contract celebrated, therefore, any reduction in production must be compensated in the spot market. As the spot price has an inverse relationship with hydropower production, the losses of these plants can be significant when production falls short. Moreover, as these plants are the main sources of energy generation of the country, these losses affect the entire electricity system and the national economy.

In this paper we analyze the Brazilian electricity sector crisis and propose a solution to this problem. We develop a methodology for reformulation of the energy sales contracts on regulated electricity market, where part of the hydropower production, currently traded in contracts by amount, would be negotiated as availability, i.e., the available energy only would be dispatched if the spot price is less than the cost of thermal plants fuel. We use a risk management technique to study the effects of the reformulation of these contracts to generators and consumers. The real options approach is also used to price the switch option between the available power from hydroelectric energy and the thermal power.

Method

We use the model adopted by the Electric Energy Trading Chamber (CCEE) for accounting of power consumer and hydropower costs shown in Eqs. 1 to 6. Following that, we model the contractual switch option in Eq. 7 and apply the real options approach to assess the impact of reformulation of the hydropower sales contracts in the total system cost.

$$C_{cons} = C_{hid} + C_q + C_{ter} + RES_{ccee} \quad (1)$$

$$C_{hid} = EC_{hid} \cdot PC_{hid} \quad (2)$$

$$C_q = EC_q \cdot PC_q \quad (3)$$

$$C_{ter} = EC_{ter} \cdot PC_{ter} + \begin{cases} if & PLD < CVU_1^{ter}, \quad 0 \\ if & PLD > CVU_1^{ter}, \quad \left[\sum_{j=1}^{J} (CI_j^{ter} \cdot CVU_1^{ter}) \right] \end{cases} \quad (4)$$

$$RES_{ccee} = (EC_{hid} + EC_q + G_{ter} - C) \cdot PLD \quad (5)$$

$$RES_{hid} = (GSF - 1) \cdot GF_{hid} \cdot PLD \quad (6)$$

The power generation in Brazil is usually considered to have a high level of sustainability because of its large share of hydropower (Moreira et al., 2015), but energy sales are only a fraction of the installed capacity of these plants. The hydroelectric power generators can only negotiate up to their physical guarantee, which is a ballast that guarantees a minimum generation even in periods of severe drought. If the generation exceeds the physical guarantee, there is surplus of energy and the generators receive for this over production; otherwise, the generators must buy power on the spot market to fulfill their contracts. Therefore, the total system cost depends on the magnitude of the dispatch of hydro and thermal plants, which provide the ONS with an option to switch operation modes. This option exercised whenever the electricity spot price is higher than the fuel price of thermal plants; otherwise, ONS can choose to dispatch hydropower instead of thermal plants. The option exercise follows the logic of equation (7), and is characterized as a bundle of European options.

$$switch = \begin{cases} PLD < CVU_1, \quad GDisp_{hid} > 0 \quad and \quad G_{ter} = 0 \\ PLD \geq CVU_1, \quad GDisp_{hid}^{*} > 0 \quad and \quad G_{ter} = \sum_{j=1}^{J} G_j^{ter} \quad and \quad GDisp_{hid}^{*} < GDisp_{hid} \end{cases} \quad (7)$$

Results

Our results suggest that a contract reformulation can be beneficial for both hydropower generators and consumers by mitigating the hydrological and operational risk of hydro generators. Consequently, the cost of capital falls due the greater stability of future cash flow, which contributes to the decrease in the price and tariffs for consumers.

Conclusions

This paper sheds light on an important problem that the Brazilian electricity sector is currently facing and that has being little discussed outside government agencies and suggests alternatives for public policies in this sector. The model uses the real options approach and Monte Carlos simulation techniques to determine the results. The results indicate that there are energy contract arrangements other than the ones currently adopted that may be more efficient for both energy generators and consumers. Finally, the model provides an innovative and unique long-term structural solution specifically designed for the hydro dependent Brazilian electricity system.