# *A DECISION-MAKING MODEL ON HEDGE TRANSACTIONS IN ELECTRICAL ENERGY COMMERCIALIZATION*


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## Overview

In the 1990s, a broad process of restructuring of the electricity sector worldwide introduced competitive electricity markets for the first time (Joskow, 2006). In Brazil, this process began with the implementation of the Restructuring Project of the Brazilian Electricity Sector (*Reestruturação do Setor Elétrico Brasileiro* – RE-SEB Project), which was coordinated by the Ministry of Mines and Energy (MME). From this project, a free energy market formed by generators, marketers and energy-free consumers was established. After this, the Free Contracting Environment was established, where these agents would freely negotiate bilateral contracts for the purchase and sale of energy, in accordance with current rules and regulations (CCEE, 2021).

Due to the high volatility of electricity spot price, agents typically seek to mitigate the exposure to this price risk by negotiating forward contracts (Luz, Gomes, & Brandão, 2012; Matsumoto & Yamada, 2021). On the other hand, in some countries the restructuring of the market led to the creation of broader free markets and even energy exchanges, where a variety of energy derivatives are negotiated for hedging purposes.

Agents of the electricity sector, such as generators, traders and consumers, may often find themselves in a short position in the market. This may occur due to a power generation deficit due to low levels of Natural Energy Inflow (*Energia Natural Afluente* - ENA) or the reduction in reservoir levels in periods of drought, in the case of a hydroelectric generator; to uncertainty in wind speed in the case of a wind power generator; for speculative reasons in the case of a trader; or due to delays in the startup of a new power plant. In this case, these agents are obligated to resort to energy purchases in the spot market to fulfill their sales contract commitments, which exposes them price risk.

One alternative open to these agents is to hedge this risk by entering into bilateral contracts in which the exposed agent can contract part or all of their position at a pre-set price. If the hedge is only partial, the non-hedged balance must be settled at the spot price at maturity, which is known as the Price Differences Settlement (*Preço de Liquidação das Diferenças* - PLD), which exposes the agent to the risk of energy price variation. On the other hand, a full hedge eliminates the risk, but also eliminates any possibility of gains in case of a fall in the spot market prices.

In this article we analyze the decision making on the hedge operation, aiming to maximize the agent's profits subject to a certain level of risk protection. For this, we assume that the agent has a risk aversion level that can be measured through $\alpha$ percentiles of *VaR*. Thus, the contribution of this study is to develop a decision support tool for agents that are in a short position in the electricity market, considering their willingness to pay the risk premium and the cost of this transaction.

## Methods

To achieve this objective, we adopted the preference function proposed by Luz (2016), which allows modeling the variation of the risk aversion level of an agent considering different preference bands. This preference function is defined in equation (1):

$$ECP\_G = E\left[U\left(X\right)\right] = \lambda_0 E\left[X\right] + \sum_{n=1}^{N} \lambda_n CVaR_{\alpha_n} \tag{1}$$

where *X* is the financial position presented in equation (2), $\alpha$ is the level of confidence, $\lambda_i \geq 0$ is the measure of investor risk aversion and $\sum_i \lambda_i = 1,\ i \in [0, N]$.

$$X = \sum_{t=1}^{\tau} \left(-\left(1-\delta\right) \times PLD - \left(\delta \times \pi\right) + \sigma\right) \times \left(\upsilon \times \eta\right) \tag{2}$$

where $\delta$ represents the percentage of the purchase decision of the hedge transaction; PLD is the spot price; $\pi$ is the market price; $\sigma$ is the sale price (R$/MWh); $\upsilon$ is the uncontracted amount (MW); and $\eta$ is the number of hours in month *t*.

From the utility function developed by Luz (2016), we can define the Certainty Equivalent ($\varphi$) and the Risk Premium ($\gamma$), which are presented, respectively, in equations (3) and (4):

$$\varphi = U^{-1}\left(E\left[U\left(X\right)\right]\right) = U^{-1}(\lambda_0 E\left[X\right] + \sum_{n=1}^{N} \lambda_n CVaR_{\alpha_n}) \tag{3}$$

$$\gamma = E\left[X\right] - \varphi \tag{4}$$

To parametrize the *ECP_G* function, we use the AHP method, since it is based on the decomposition and synthesis of the peer-to-peer relationships between the criteria, where it is sought to prioritize the alternatives through a single measure of performance (Saaty, 1991). The main positive aspects of the AHP method are: flexibility, simplicity, easy intuition for the decision maker, hierarchization of the criteria according to their assigned attributes (Ishizaka & Labib, 2011; Macharis, Springael, De Brucker, & Verbeke, 2004; Ramanathan, 2001).

The methodology for applying the AHP recommends the identification of the problem, the definition of its objectives, the existing alternatives, the decision-making criteria and the selection of the decision makers. After this step, it is suggested that the decision-makers ponder the importance of each of the criteria in relation to another, forming a matrix of judgments. Finally, the normalization of the judgments must be performed, thus obtaining a matrix of weights attributed to the parity comparisons and to each of the criteria defined in the first step.

## Results

To verify the validity of our model, we apply it on a numerical example that considers that the hedge decision is made on a quarterly basis. Besides, we use historical data from the electricity sector, two levels of CVaR ($\alpha_1$ = 30% and $\alpha_2$ = 5% ) and the following measures of risk aversion ($\lambda_0$ = 57%, $\lambda_1$ = 20% and $\lambda_2$ = 24%), which were determined by the AHP method. The results indicate that our model allows the electricity sector agent, who is in a short position, to make an optimal decision on hedge transactions.

## Conclusions

The proposed model serves as a decision support tool for agents that are in a short position in the electricity market. Although the model is robust, its main limitation derives from the parametrization of the preference function. In this study, we used the AHP method because it is a mechanism that has been widely discussed in the literature. Future studies could discuss the parameterization of this preference function.

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