

Optimization of Electricity Markets Participation with Simulated Annealing

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Abstract The electricity markets environment has changed completely with the introduction of renewable energy sources in the energy distribution systems. With such alterations, preventing the system from collapsing required the development of tools to avoid system failure. In this new market environment competitiveness increases, new and different power producers have emerged, each of them with different characteristics, although some are shared for all of them, such as the unpredictability. In order to battle the unpredictability, the power supplies of this nature are supported by techniques of artificial intelligence that enables them crucial information for participation in the energy markets. In electricity markets any player aims to get the best profit, but is necessary have knowledge of the future with a degree of confidence leading to possible build successful actions. With optimization techniques based on artificial intelligence it is possible to achieve results in considerable time so that producers are able to optimize their profits from the sale of Electricity. Nowadays, there are many optimization problems where there are no that cannot be solved with exact methods, or where deterministic methods are computationally too complex to implement. Heuristic optimization methods have, thus, become a promising solution. In this paper, a simulated annealing based approach is used to solve the portfolio optimization problem for multiple electricity markets participation. A case study based on real electricity markets data is presented, and the results using the proposed approach are compared to those achieved by a previous implementation using particle swarm optimization.

Keywords Artificial intelligence · Electricity markets · Portfolio optimization · Simulated annealing

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1 Introduction

The electric sector has undergone several changes, which caused an increase in competitiveness. These changes are due to the new imposed rules and to the physical limitations, which led to emergence of financial issues [1], [2]. Electricity market participants, mainly sellers and buyers have the need for effective methods that support their actions; the system itself also requires methods to assure the functioning of markets [3]. One of the main causes for the changes in electricity markets is the massive integration of renewable energy sources, which has very particular characteristics: intermittence in the production and distributed nature. In this context we can highlight mainly wind power and solar energy. These hold a great influence on how the management of the electricity network is made and but also in how electricity is traded.

One of the most accepted solutions to deal with the introduction of distributed renewable energy sources is the emergence of the concept of Smart Grid [4], which in recent times has evolved from a concept to a visible reality. Smart Grid are small sub-systems capable of maintaining operating independently of each other and together form a working system. The implementation of Smart Grids has been increasing worldwide, as result from the large distributed generation incorporated in the network [5]. With all these changes market, participants are concerned with the forecasting of the behavior of markets, as this knowledge can anticipate and enable them achieving the best results from trading.

Multi-agent simulators have emerged as suitable tools to support players' decision in energy markets. Multi-agent simulation allows modeling different entities, such as independent agents, with specific objectives and characteristics. It also facilitates the expansion of the used models and the integration of new models. MASCEM (Multi-Agent Simulator of Competitive Electricity Markets) [6] is an agent base simulator of electricity markets, which is integrated with AiD-EM (Adaptive Learning Strategic Bidding System), a decision support system that aims at providing market players with appropriate suggestions on what actions should be performed in every time and in different negotiating contexts [7].

Despite all the advances in the electricity markets field, the ability to learn to adapt to new situations and make the best possible outcomes for electricity market players are still far from being achieved. A less explored area is the option of multiple markets participation, which can be optimized to give players greater profitability in their market operations. This work proposes a portfolio optimization model for multiple markets participation. This model offers the possibility to buy and sell electricity in the same period in different markets. A Simulated Annealing approach is proposed to solve the optimization problem, and the achieved results are compared to those using a previous implementation with Particle Swarm Optimization [8].

After this introductory section, section 2 presents the mathematical formulation of the portfolio optimization problem, and section 3 describes the proposed Simulated Annealing approach. Section 4 presents the achieved results using real