A decision support system for generation expansion planning in competitive electricity markets

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Abstract

This paper describes an approach to address the generation expansion-planning problem in order to help generation companies to decide whether to invest on new assets. This approach was developed in the scope of the implementation of electricity markets that eliminated the traditional centralized planning and lead to the creation of several generation companies competing for the delivery of power. As a result, this activity is more risky than in the past and so it is important to develop decision support tools to help generation companies to adequately analyse the available investment options in view of the possible behavior of other competitors. The developed model aims at maximizing the expected revenues of a generation company while ensuring the safe operation of the power system and incorporating uncertainties related with price volatility, with the reliability of generation units, with the demand evolution and with investment and operation costs. These uncertainties are modeled by pdf functions and the solution approach is based on Genetic Algorithms. Finally, the paper includes a Case Study to illustrate the application and interest of the developed approach.

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1. Introduction

Generation expansion planning (GEP) has historically addressed the problem of identifying the most adequate technology, expansion size, sitting, and timing for the construction of new plant capacity considering economic criteria while ensuring that the installed capacity adequately met the expected demand growth. However, the development of market mechanisms in the electricity sector altered the traditional GEP assumptions, models, and solution approaches. In fact, the traditional utility practice typically involved the solution of centralized planning problems to identify cost-minimizing plans for the utility. Under competition, multiple agents individually prepare their investment plans in order to maximize their profits. The development of market mechanisms also contributed to anticipate other changes as shortening planning horizons due to the elimination of traditional guaranteed return on investment as well as the advent of strategic interaction and gaming among companies involved in the generation activity [1]. This means that competition is determining that agents face higher risks, that they try to obtain faster returns and that the individual decisions of particular agents will mutually affect the profits and decisions of other players.

Because power plants need a long time to be built and they will be amortized over several years, investment decisions are based on expectations on future profits. Unfortunately, forecasting these profits is a difficult task since they are highly uncertain, volatile and dependent on a large number of risky factors. This implies that this type of problems certainly has to address and inherently incorporate uncertainty modeling and that risk concepts also play a crucial role. These long-term uncertainties can influence the profitability of a project, either directly as an uncertain cost element or indirectly through the market price of electricity, or in both ways.

In the new formulation of the GEP to be used in restructured electricity markets, the objective of each company is to maximize its total expected profit over a planning horizon, while contributing to guaranty the safe operation of the power system through the competition between generation agents. The new formulation has to incorporate the volatility of market prices for electricity and fuels, load growth, the expected revenues based on the predicted market price, construction costs, and operation and maintenance costs. Due to their own nature, some sources of uncertainty determining future operation such as the forecasted market price of electricity, load growth rates, fuel costs and equipment availability have to be taken into consideration explicitly in the generation planning model.