Chapter 6
An Application of Alpha-Stable Distributions for the Economic Analysis of Unit Commitment

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ABSTRACT

In power systems, we still lack the existence of standardized test systems that can be used to benchmark the performance and solution quality of proposed optimization techniques. It is therefore necessary to develop new methods for design of test cases for economic analysis in power systems. We compared two methods to generate test systems: time series and a method for simulating stable random variables that can be used to multiperiod unit commitment based on the use of Chambers-Mallows-Stuck. Hence, after comparing both methods, we describe the method for simulating stable random variables in the generation of test systems for economic analysis in power systems. A study focused on generating test electrical systems through fat tail model for unit commitment problem in electrical power systems is presented. Usually, the instances of test systems in Unit Commitment are generated using normal distribution, but in this work, simulations data are based on alpha-stable distribution. Numerical results illustrate the applicability of the proposed method.

1. INTRODUCTION

The optimization problems for electrical power systems have been studied for more than five decades. A definition of Economic Dispatch is the operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities.

In the typical Unit Commitment (Wood & Wollenberg, 1996) the problem consists as determining the mix of generators and their estimated output level to meet the expected demand of electricity over a

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given time horizon (a day or a week), while satisfying the load demand, spinning reserve requirement and transmission network constraints. An electric network consists of many generation nodes with various generating capacities and cost functions, lines of transmission and nodes of power demand (Vasant et al. 2012).

The application of optimization models for electrical power systems is marked by constant development for new algorithms like exact methods, metaheuristics and hybrid strategies (Vasant, 2013). However, to benchmark the performance and solution quality for any solution technique, it is necessary to have variety of electrical test systems (Vasant, 2014).

Nowadays, we still lack the existence of standardized test systems that can be used to benchmark the performance and solution quality of proposed techniques. Many papers consider different test systems, which make it very difficult to perform a proper comparison between methods that have been proposed (Diniz, 2010).

In Zhang and Schaffner (2010), they refer that the existing IEEE test systems developed are mainly used for reliability, power flows and stability analysis but not for economic analysis. Short time ago, some panels focused on the development of standard test systems of transmission and distribution systems for economic analysis has emerged. In 2007 the IEEE Working group (WG) on Test Systems for Economic Analysis was created, sponsored by IEEE System Economics subcommittee.

Finding an appropriate method for generating test cases of a specific electricity network is not an easy task. In this sense, this paper compares two methods to generate test systems: time series models and a method for simulating stable random variables that can be used to multiperiod unit commitment based on the use of Chambers-Mallows-Stuck algorithm.

There are some methods to find the best estimation of load forecasting. The main methods include time series such as exponential smoothing or Autoregressive Integrated Moving Average models (ARIMA). However, the electricity demand pattern becomes more complex to forecast because it has a particular behavior.

Lévy and Aleksander Khintchine (1924) first developed the stable distributions theory in the 20's of last century. Since then, this distribution has been applied in different areas of knowledge, such as economics, physics, engineering and hydrology. The reason is that some phenomena of nature, like electrical demand, cannot be described assuming Normal distribution as they present observations with extreme values, which characterizes the instability of the series and denotes the presence of heavy tails, an effect known as impulsivity.

Usually electrical demand presents a greater degree of impulsivity that the Normal distribution cannot describe due to the presence of peaks in the series during the hours of the day and seasons of high-energy demand.

For this, we propose use Chambers-Mallows and Stuck algorithm for simulating alpha stable random variables characterizing demand patterns of real electrical systems. The use of Chambers-Mallows-Stuck method for simulating stable random variables provides a new way to generate test systems widely used in power systems research. By modeling the demand through the use of alpha stable distribution can catch the real behavior of the electrical demand and build possible extreme scenarios, each scenario corresponds to a price-elastic demand curve. The simulations are based on real observations of demand for different reliability test systems. Electrical network data are taken from the 24 (Charman et al. 1979) and 118 bus IEEE test systems (Christie, 1993), and a portion of electric energy system of Mainland Spain (Alguacil & Conejo, 2000). Cost functions of the thermal plants data are taken from the literature.