Preface

The increasing search for the efficiency, the computational continuous improvement and the development of new effective mathematical methods are three impelling forces for the utilization of optimization in electric power systems. Nowadays, it is unlikely to find an electric company that does not use optimization methods. This kind of processes is utilized in both planning and operation calculations for the generation, transmission and distribution areas of power systems. Electrical engineers face these new operational methods, in some cases without the adequate preparation. This book aims to include some of the present and foreseen applications of the optimization in electric power systems, explained by main experts in the field. Furthermore, this book may serve as state-of-the-art for undergraduate and graduate students worldwide.

Optimization is the systemized search for the best action. Probably, the first non-linear formulations for optimization applications in electric power systems were presented in the sixties, included in the works of Carpentier (CARPENTIER, J.; 1962. Contribuition à l'étude du dispatching économique, *Bulletin de la Société Française des Electriciens*, ser.8, vol.3, pp. 431-447) and Dommel and Tinney (DOMMEL, H.W.; TINNEY, W.; 1968. Optimal Power Flow Solutions, *IEEE Transactions on Power Apparatus and Systems*, Piscataway, NJ, USA , PAS 87, n. 10, Oct.). However, the difficulties associated with formulate and solve real problems in the industry delayed the diffusion of the optimization in electric companies. In the last two decades, the maturity of mathematical programming (in particular, the development of Interior Point methods) and the amazing increase in the computational capacities allowed the solution of real large-size power system problems. In addition, an emphasis in the market environment gives prominence to the pursuit for improved results in the electric industry.

It is a fact that the implementation of optimization tools in the electric industry leads to the rationalization of use of resources, decreasing the operational costs. However, the representation of a real electric problem through optimization techniques is frequently not a simple task. Optimization requires a mathematical representation of the physical problem and objectives. Due to the complexity of the electric systems, approximated models of the reality can be used. These models condition the performance of the applications and the accuracy of the results. As a greater part of the optimization tools in the electric industry is customized, the electrical engineers must know what and how can be made by using optimization. In the proposed book, the up-to-date solutions are shown, explained by principal researchers and developers. Techniques, know-how and examples of application are included, showing some advantages of the optimization in the operation and planning of electric power systems.

This book is intended for a wide audience, including researchers and practitioners. Electrical engineers in the industry can use it to understand implemented optimization tools, to know practical solutions applied in other places and, possibly, to evaluate their available operational tools. As educational tool, it can be used in undergraduate courses of Optimization, Electric Power Systems, Economy of the Energy, Technology of the Energy, Electric Power Markets and others. Likewise, this book can integrate the basis of the graduate course of Optimization in Electric Power Systems.

In Chapter 1, Eduardo Caro, Antonio J. Conejo and Roberto Mínguez analyse an optimization method to solve the state estimation problem. The traditional solution method for the state estimation problem is compared with the mathematical programming approach, using illustrative examples. The optimization method presents significant advantages, as result of the treatment of inequality constraints, post-solution sensitivity analyses and decomposition for several independently operated regions.

In Chapter 2, Antônio J. Simões Costa, Roberto S. Salgado and Paulo Hass consider other optimization approach for the power system state estimation problem, using Trust Region estimators. Two innovative alternatives are analysed in the chapter, showing improved convergence characteristics when contrasted with the traditional formulation. Test systems of small and large size are used to reveal the benefits of the optimization method.

With an extended performance in the industry, Narayan S. Rau offers in Chapter 3 a specialist vision of the application of optimization in the new deregulated environment. Starting from an incisive visualization of the actual situation, Dr. Rau proposes challenges and questions that must be solved in the next future for the players of the electric power system. Reactive power influence in the locational marginal prices, proper market signals, the cost of CO_2 emissions and others issues are stood out by the author.

Armando M. Leite da Silva, Cleber E. Sacramento, Luiz A. da Fonseca Manso, Leandro S. Rezende, Leonidas C. de Resende and Warlley S. Sale consider in Chapter 4 the application of three metaheuristic-based methodologies (Evolution Strategies, Tabu Search and Ant Colony algorithms) to the transmission expansion planning problem. This problem aims to determinate the reinforcements required by a power system, to adequately operate in the future. This is a complex and CPU-time consuming problem, if the minimum cost for the reinforcements and satisfactory security conditions are requested. The three methods are fully explained, with illustrative examples and applications to a real sub-transmission network.

In chapter 5, João A. Peças Lopes and André Madureira study the feasibility and the technical advantages of exploiting reactive power generation capability of distributed generation and microgeneration in the operation of distribution power systems. For this objective, a hierarchical voltage with three levels is considered. The results, obtained in two large-scale distribution systems, show the efficiency of the application.

Worldwide, and especially in Europe and USA, wind power has largely incremented in the last decades in electric power systems. Wind power has advantages with regard to other energy sources, as reduction of CO_2 emissions, local availability, use of an unexploited resource, and others. However, large penetration of wind power in the power system can produce some difficulties in the operation, due to the particular characteristics of the primary energy and the special features of the wind farms. In chapter 6, Jorge Martínez Crespo, Hortensia Amarís, Jorge L. Angarita, Julio Usaola García and I summarize different practical tools for the effective integration of large amounts of wind energy in power systems. Procedures to bid the energy in the electric market, cooperation among wind farms and hydro plants or water pump stations, delegated dispatches of renewable producers and voltage stability enhancement in grids with wind farms are considered in this chapter. The text includes complete optimization formulations, application examples and results obtained from test and real networks.

In Chapter 7, Markus Pahlow, Corinna Möhrlen and Jess U. Jørgensen analyse the use of ensemble prediction systems for wind power forecasting. The economic value of wind power is related to the predictability of the resource. The effective participation of the wind power producers in the market depends on the capacity to obtain a good prevision of the wind power production. In the text, the effect of the wind power forecast in different optimization scenarios is presented. The results are obtained from real electric systems.

In Chapter 8, Alberto Berizzi, Cristian Bovo, Maurizio Delfanti and Marco Merlo study the problem of the optimal reactive power flow. Different objective functions are analysed, including minimization of real power losses, minimization of reactive power produced, maximization of the distance to the voltage collapse and others. Multiobjective approaches are also considered by using Pareto sets. The features of all the methods and the procedures presented are shown by numerical tests and examples in a real large-scale system.

Gabriel Olguin and Tuan A. Le deal in Chapter 9 with the optimal placement of equipments. Two examples are considered in this area of power system planning: optimal location of voltage sags monitors and optimal position of flexible alternating current transmission systems (FACTS) devices. Voltage sags (short duration reductions in rms voltage) must be monitored in power systems. FACTS can be very profitable to manage transmission congestions. However, the determination of the best arrangement of these power systems equipments can be complex and computationally demanding. In the text, optimization alternatives for this calculation are analysed, showing results in test and real systems.

Finally, in Chapter 10 Carlos F. Moyano and I review applications of non linear optimization in power system stability. In the last decade, there has been an increasing interest of research to deal with stability problems using optimization algorithms. Two main directions can be recognized: the utilization of static analysis to estimate stability margins and, most recently, the inclusion of transient stability constraints into the optimization problems. Formulations and results for different approaches in these two research lines are presented in the text, including solution algorithms.

The 10 chapters of the book aim to take in consideration the wide spectrum of applications of the optimization in the modern power systems. I am grateful to the authors for adapting to the pressing editorial schedule and the requirements of the book.

This work can not be performed without the support and love of my dear wife Marcela and the tenderness of my daughters Fabiana and Lorena. Thank you.

Edgardo D. Castronuovo
The Editor