

Preface of Volume II

Power systems are undeniably considered as one of the most important infrastructures of a country. Their importance arises from a multitude of reasons of technical, social and economical natures. Technical, as the commodity involved requires continuous balancing and cannot be stored in an efficient way. Social, because power has become an essential commodity to the life of every person in the greatest part of our planet. Economical, as every industry relates not only its operations but also its financial viability in most cases with the availability and the prices of the power.

The reasons mentioned above have made power systems a subject of great interest for the scientific community. Moreover, given the nature and the specificities of the subject, sciences such as mathematics, engineering, economics, law and social sciences have joined forces to propose solutions.

In addition to the specificities and inherent difficulties of the power systems problems, this industry has gone through significant changes. We could refer to these changes from an engineering and economical perspective. In the last 40 years, important advances have been made in the efficiency and emissions of power generation, and in the transmission systems of it along with a series of domains that assist in the operation of these systems. Nevertheless, the engineering perspective changes had a small effect comparing to these that were made in the field of economics where an entire industry shifted from a long-standing monopoly to a competitive deregulated market.

The study of such complex systems can be realized through appropriate modelling and application of advance optimization algorithms that consider simultaneously the technical, economical, financial, legal and social characteristics of the power system considered. The term technical refers to the specificities of each asset that shall be modelled in order for the latter to be adequately represented for the purpose of the problem. Economical characteristics reflect the structure and operation of the market along with the price of power and the sources, conventional or renewable, used to be generated. Economical characteristics are strongly related with the financial objectives of each entity operating a power system, and consist in the adequate description and fulfillment of the financial targets and risk profile. Legal specificities consist in the laws and regulations that are used for the operation of the power system. Social characteristics are described through a series of

parameters that have to be considered in the operation of the power system and reflect the issues related to the population within this system.

The authors of this handbook are from a mathematical and engineering background with an in-depth understanding of economics and financial engineering to apply their knowledge in what is known as modelling and optimization. The focus of this handbook is to propose a selection of articles that outline the modelling and optimization techniques in the field of power systems when applied to solve the large spectrum of problems that arise in the power system industry. The above mentioned spectrum of problems is divided in the following chapters according to its nature: Operation Planning, Expansion Planning, Transmission and Distribution Modelling, Forecasting, Energy Auctions and Markets, and Risk Management.

Operation planning is the process of operating the generation assets under the technical, economical, financial, social and legal criteria that are imposed within a certain area. Operation is divided according to the technical characteristics required and the operation of the markets in real time, short term and medium term. Within these categories the main differences in modelling vary in technical details, time step and time horizon. Nevertheless, in all three categories the objective is the optimal operation, by either minimizing costs or maximizing net profits, while considering the criteria referred above.

Expansion planning is the process of optimizing the evolution and development of a power system within a certain area. The objective is to minimize the costs or maximize the net profit for the sum of building and operation of assets within a system. According to the focus on the problem, an emphasis might be given in the generation or the transmission assets while taking into consideration technical, economical, financial, social and legal criteria. The time-step used can vary between 1 month and 1 quarter, and the time horizon can be up to 25 years.

Transmission modelling is the process of describing adequately the network of a power system to apply certain optimization algorithms. The objective is to define the optimal operation under technical, economical, financial, social and legal criteria. In the last 10 years and because of the increasing importance of natural gas in power generation, electricity and gas networks are modelled jointly.

Forecasting in energy is applied for electricity and fuel price, renewable energy sources availability and weather. Although complex models and algorithms have been developed, forecasting also uses historical measured data, which require important infrastructure. Hence, the measurement of the value of information also enters into the equation where an optimal decision has to be made between the extent of the forecasting and its impact to the optimization result.

The creation of the markets and the competitive environment in power systems have created the energy auctions. The commodity can be power, transmission capacity, balancing services, secondary reserve and other components of the system. The participation of the auction might be cooperative or non-cooperative, where players focus on the maximization of their results. Therefore, the market participant focus on improving their bidding strategies, forecast the behavior of their competitors and measure their influence on the market.

Risk management in the financial field has emerged in the power systems in the last two decades and plays actually an important role. In this field the entities that participate in the market while looking to maximize their net profits are heavily concerned with their exposure to financial risk. The latter is directly related to the operation of the assets and also with a variety of external factors. Hence, risk managers model their portfolios and look to combine optimally the operation of their assets by using the financial instruments that are available in the market.

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