Preface

Large-scale wind power integrated into power system brings about a great challenge to traditional power flow analysis and economic dispatch decision. This book mainly focuses on these topics to address uncertainties. Based on interval mathematics, the wind power uncertainties are modeled as interval numbers, which facilitates the modeling of wind power. Furthermore, this book studies the mathematical modeling and methods to interval power flow, interval economic dispatch, and interval robust economic dispatch.

In Chap. 1, literature review of related works is presented, and their contributions to the book are summarized.

In Chap. 2, as the basis of this book, mathematical theories of interval calculation and optimal planning are introduced, including definition of interval number, the method for the linear equations with right-hand interval, interval optimal solution, and self-adaptive two-stage robust interval optimization.

Chapter 3 investigates the interval power flow with uncertain wind power, including DC interval flow, AC interval flow, and distribution system interval flow, in which a preprocessing iteration and parallel calculation are adopted to prevent over conservativeness; the DC power flow is taken as an example to discuss power flow calculation with constraints and dynamic interval power flow model.

In Chap. 4, the traditional economic dispatch is expanded to interval economic dispatch in which interval of wind power output is considered; in fact, interval optimization can be seen as the sensitive analysis of the traditional economic dispatch, because it provides a reference for system dispatchers about the influence of wind power uncertainty on the result of economic dispatch; interval optimization is also different from sensitive analysis because interval optimization can consider parameters that change over a wide interval while sensitive analysis usually focuses on the parameters changing within a tight range; it is worth noticing that there might be no feasible solution under the wind power uncertainty, so a minimal wind curtailment and soft transmission constraints are adopted to guarantee feasibility.

In Chap. 5, the robust optimization strategy is adopted to search for the optimal solution. The result from Chap. 3 is usually more suitable for evaluation rather than dispatching order. Dispatching order should be a concrete number instead of an interval number, while robust optimization can provide a concrete dispatching order that satisfy security constraints in uncertain scenarios. Two types of interval robust optimization models are discussed in this chapter: One is the self-adaptive interval robust optimization that can guarantee power balance by the introduction of AGC participation factor. It is shown that this participation factor has some effect on the conservativeness of the robust optimization. If the participation factor can be regulated real time in real-time energy market (within 5 min), then the conservativeness of the robust optimization can be reduced; the second type is to perform economic dispatch under wind power uncertainty considering topology reconfiguration, which is a long-term problem in comparison with the first type, which is a real-time problem. From the perspective of mathematical modeling, two-stage robust economic dispatch is a tri-level optimization model, which can be turned into a mixed-integer optimization problem by Benders decomposition, and the optimal result can be achieved by column constraint generation that introduces cutting planes; while the self-adaptive interval robust optimization model is a bi-level problem, which can be turned to a convex second-order model by adding dummy variables; the most significant problem in the robust optimization is to reduce the conservativeness, and in this book, the concept of robust cost is introduced to reach the balance between security and economy. Finally, some practical problems in power system modeling are discussed, and their mathematical models and algorithms are provided.

In Chap. 6, improved online large-scale economic dispatch problems are studied. It is not hard to understand that real power system has a quite large scale; therefore, the dispatching problem under multiple time periods can be very complex. Such optimization problem is mostly expected to be fast ;and efficiently solved for real-time market regulation and for intraday dispatching in a rolling horizon. To do so, two perspectives are provided to improve online economic dispatching: First is to reduce redundant security constraints through offline simulation to simplify the model, and second is to use parallel optimization approaches to increase computation speed.

Chapter 7 summarizes the works and proposes future research direction.

The draft of this book is the Ph.D. dissertation of Tsinghua University. Due to our limited knowledge, this book might contain mistakes and typos. Please feel free to e-mail us whenever you find any problems within this book. We are more than happy to revise this book on your notice.

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