Preface

A Smart Grid is a massively distributed and hierarchical electrical generation, consumption, and distribution system that is instrumented with sensors and utilizes many types of devices and controls. At a fundamental level, an electrical grid exists to provide the means of generating and routing power to meet consumption demands. The intent of a Smart Grid is to use technological advances in communication networks, sensing, and controls to manage the grid safely, reliably, and efficiently. Linear programming is a type of mathematical model that can explicitly produce solutions that optimize allocations of resources in the presence of constraints on their availability in time and place and on supporting infrastructure. Linear programming is also highly scalable to practical problems that are large and complex. Thus, this book concerns the use of Linear Programming models for resource-allocation problems that arise in Smart grid applications. The intended audience are members of the scientific community who work in energy-related fields, computer scientists, and engineering students. The book also serves as a reference book for anyone interested in the area of operations research for utility or other domains of interest.

In recent years, advances in computing and communication have resulted in large-scale, distributed environments. Environments that are capable of storing large volumes of data and, often, have multiple compute nodes. However, the inherent heterogeneity of the data components, the dynamic nature of distributed systems, the need for information synchronization and data fusion over a network, and the security and access-control issues make the problem of resource management and monitoring a tremendous challenge in the context of a Smart grid. Unfortunately, the concept of cloud computing and the deployment of distributed algorithms have been overlooked in the electric grid sector. In particular, centralized methods for managing resources and data may not be sufficient to monitor a complex electric grid. Most of the electric-grid management, including generation, transmission, and distribution, is, by and large, at a centralized control. In this book, we present a distributed algorithm for resource management which builds on the traditional simplex algorithm that is utilized to solve large-scale, linear optimization problems. The distributed algorithm is exact, meaning that its results are identical if it is run in a centralized setting.

More specifically, the authors discuss a distributed decision model, where a large-scale electric grid is decomposed into multiple submodels that can support the resource assignment, communication, computation, and control functions that are necessary to provide robustness and to prevent incidents such as cascading blackouts. The book's key contribution is to design, develop, and test a resource-allocation process through a decomposition principle in a smart grid. We have implemented and tested the Dantzig–Wolfe decomposition process with standard IEEE 14-bus and 30-bus systems. The book details how to formulate, implement, and test such an Linear Programming (LP)-based design in order to study the dynamic behavior and the impact of an electrical network while considering network's failure and repair rates. The Dantzig–Wolfe approach's computational benefits for finding an optimal solution and its applicability to IEEE bus systems are presented.

The last two chapters are dedicated to PMU placement problems and renewable energy allocation using the linear programming formulation. We hope you find this text useful to build research models using linear programming.

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