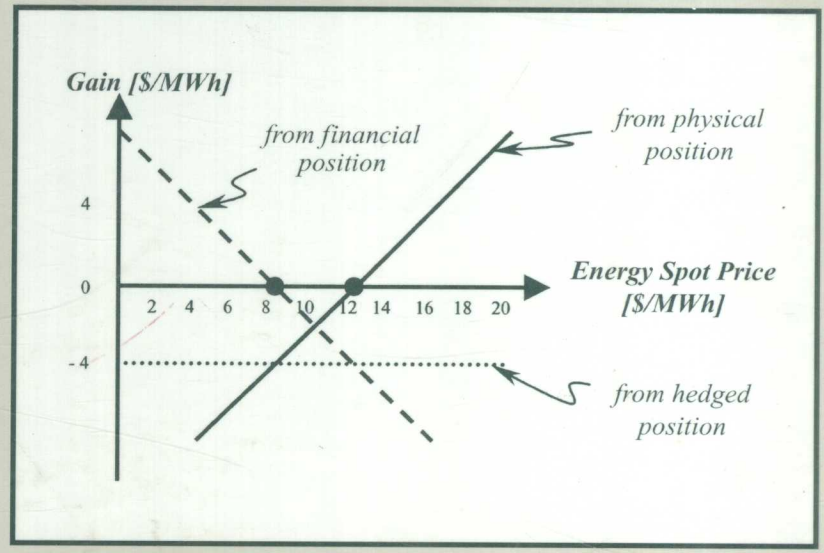
Restructured Electrical Power Systems

Operation, Trading, and Volatility



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Restructured Electrical Power Systems

POWER ENGINEERING

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ADDITIONAL VOLUMES IN PREPARATION

SERIES INTRODUCTION

Power engineering is the oldest and most traditional of the various areas within electrical engineering, yet no other facet of modern technology is currently undergoing a more dramatic revolution in both technology and industry structure. Worldwide, deregulation, privatization and restructuring have transformed the business and operating context within which the electric power industry must operate. While these government and societally mandated rules have in no way changed the basic physical laws that define how electricity behaves, they have dramatically changed the way that the electric industry must function to attain its business and customer-service goals.

The sheer number and scale of these changes have made it a challenge for anyone involved – utility executive, regulator, utility planner, system operator or electricity trader – to grasp firmly how the modern electric industry operates. Thus, this newest addition to Marcel Dekker's Power Engineering Series, *Restructured Electrical Power Systems: Operation, Trading and Volatility*, is particularly appropriate. Professors Shahidehpour and Alomoush have created a comprehensive yet accessible reference that covers both the framework within which modern electric production, transportation and trading systems operate, and the intricacies of the analytical, engineering, and business operations that must function within that framework.

Modern power industry operation is particularly difficult to understand because of the dichotomy between electricity's business and physical manifestations. From the business perspective, electric power is a fungible commodity, something that can be traded much like oil, wheat, or coffee, and for which futures markets and hedging systems can and do exist. But in its physical manifestation, electricity is quite unlike all other traded commodities. Perhaps the fundamental difference is that it cannot be stored to any significant degree. This greatly affects how it must be managed as a business asset, and greatly constrains how its present and future market prices do or don't interact, as compared to other commodities. In large part due to its "storage-less" nature,

electricity can be transported only in a real-time basis, and in a manner heavily constrained by myriad physical laws that are complicated in their interactions but nearly instantaneous in their impact. This means that transportation and delivery more totally define product quality than in other industries, and also means that in a practical sense electricity is not entirely fungible in many situations.

The net effect of all of these differences is that modern electricity trading and wholesale transportation systems are quite different from anything seen previously, either in the electric industry or in any other industry. For this reason, this volume is all the more remarkable, both for the clarity of its presentation and for the comprehensive way in which the authors explain how every facet of the industry interacts with and impacts the whole. Professors Shahidehpour and Alomoush have created an excellent reference for the experienced power engineer or executive who needs a solid background on modern wholesale power exchange and grid operation. In addition, their book is also a very good tutorial for the student who desires to learn the intricacies behind what is literally the fastest moving commodity being traded anywhere in the world.

Like all the books in Marcel Dekker's Power Engineering Series *Elements of Restructured Electrical Power Systems* provides modern power technology in a context of proven, practical application; useful as a reference book as well as for self-study and advanced classroom use. The series covers the entire field of power engineering, in all of its specialties and subgenres, and aims at providing practicing power engineers with the knowledge and techniques they need to meet the electric industry's challenges in the 21st century.

H. Lee Willis

PREFACE

The electric power industry is in the midst of a major restructuring process in which electricity would be traded as a commodity. Electricity is a $200 billion per year market, which makes it the largest commodity market in the United States. This book discusses topics that are the critical ingredients in understanding electric power industry restructuring. The California energy shortages and rolling blackouts in 2000-2001 have further reinforced the need for a book on this subject which would help the reader understand the transition from the electricity of the past to the electricity of the future.

For many decades, electric utilities monopolized the way they generated, transmitted, controlled, and distributed electricity to customers in their service territories. In that monopoly, each utility managed the three main components of electric power systems, i.e., generation, transmission and distribution. In the restructured system, the main tasks of these three components remain the same as before; however, to comply with FERC Orders, new types of unbundling, coordination and rules are established to guarantee competition and non-discriminatory open access to all users in the interconnection.[1]

The United States restructured its electric power markets the last few years of the twentieth century in order to foster the competition. Reform has focused on transforming the wholesale market for electricity into a competitive market at the national level, and importance has been placed on providing a competitive retail market at the state level.

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[1] Interconnection in the United States refers to any one of the three large transmission systems. The Eastern Interconnection covers most of the area east of the Rocky Mountains in the United States and Canada. The Western Interconnection covers an area that is mostly west of the Rocky Mountains in the United States and Canada, as well as a small portion of Mexico. ERCOT Interconnection covers much of Texas.

Ultimately, small customers such as households will be able to select their energy providers in much the same way that they now choose a long-distance telephone carrier.

In response to the electric industry restructuring, new phenomena, new circumstances, new risks, and new tools have emerged. Some of these new topics have risen for the lack of experience with newborn issues, while others have embarked as a necessity for the proposed structures. Although the new electric power structure requires new tools and approaches for decision-making and improving the efficiency of the power network, it is evident that applying theorems and models of other commodities to electricity markets could frequently mislead market participants in the restructured electricity industry. In this market, energy trading tools would help buyers and sellers sign up freely for a range of energy resources, various types of electricity products and different energy alternatives in geographical regions, while they take into consideration special circumstances of energy markets that differ from other commodity practices.

The primary objectives of this book are to present a background on electricity restructuring, to provide insight on new trends in power systems operation and control, and to highlight advanced topics in electricity markets. These topics are covered in various chapters by illustrative examples and graphical representations that will help readers acquire ample knowledge on the respective subjects. This book is suitable for readers from different disciplines, including college students and instructors, electricity traders, hedgers, regulators, vendors, manufacturers, consulting companies, electric utilities, and researchers. Readers will find answers to several questions including: Why is a restructuring necessary? What are the components of restructuring? How is the new structure different from the old monopoly? What are the outcomes of restructuring? How is the restructuring implemented? What are the new trends in restructuring? What are the new tools in restructuring? How are interchange transactions analyzed and approved? How is an optimal decision made in the energy market? How would the communication links work in the restructured electric power industry? What are the characteristics of energy markets in the United States and across the globe?

OUTLINE OF THE BOOK

Chapter 1 provides an introduction to the electric utility industry and its functions. This chapter is a general review of restructuring for power engineers and includes introductory information for non-electrical engineering majors with an interest in utility restructuring. The chapter reviews key issues in restructuring and different restructuring models including stranded costs, market operations, transmission pricing, congestion management, PoolCo model, bilateral contracts and the hybrid model.

Chapter 2 provides a discussion on major U.S. market models, Independent System Operators (ISOs) in the United States and major ISO functions as related to the FERC Order 888. These models include California, Pennsylvania–New Jersey–Maryland (PJM) interconnection, New York Power Pool (NYPP), Electric Reliability Council of Texas (ERCOT), New England ISO and Midwest ISO. The chapter discusses some of the shortcomings and advantages of these models, presents comparisons among models, and reviews topics such as horizontal and vertical market power, stranded costs, tics, market clearing prices, Contracts for Differences and transmission pricing.

Chapter 3 introduces the Open Access Same-Time Information System (OASIS), presents a comprehensive review of OASIS, discusses the FERC Order No. 889 and elaborates on exploring OASIS as an electronic information system. OASIS allows users to instantly receive data on the current transmission network operating status, capacity of a transmission provider (transmission availability), request of transmission services, available transmission capability, and transmission pricing. This chapter discusses requirements of transmission providers, types of information on OASIS such as the availability of transmission services, hourly transfer capacities between control areas, hourly firm and non-firm power scheduled at various points, current outages information, load flow data, current requests for transmission service, and secondary information regarding capacity rights that customers wish to resell. In addition, the chapter discusses how the information is posted on OASIS, what are the required interfaces for this posting, which part of

information is secure and which part is public, how OASIS enables any transmission customer to communicate through requests to buy and responses to sell available transmission capabilities, and how utilities use OASIS to share operating data regarding transmission availability, generation capability, system loads, interchange, area-control error, frequency and operating reserves. The chapter will also discuss whether or not OASIS has a data link to other systems.

Chapter 4 presents the tagging system and discusses the major contributions of the NERC's Policy 3. The chapter illustrates the Constrained Path Method (CPM) and shows the philosophy behind the transition from the old tagging system to the new system and functional requirements of a software used by market participants to meet the minimum NERC Policy 3 requirements. In addition, the chapter shows procedures for canceling and curtailing interchange transactions. It explains how tags are created and submitted, and types of information contained in the tag. The functional specifications are presented that explain obligations and duties of all parties to an interchange transaction, required data to represent a transaction and specific mechanisms for exchanging the data electronically. The chapter helps readers understand the three main services in electronic tagging–Tag Agent Service, Tag Authority Service, and Tag Approval Service–and their interdependency. It explains how tags are initiated, authorized and approved. In addition, the chapter illustrates some of the tagging concepts using graphical representation and provides examples that help readers grasp the entire picture of interchange transactions. Finally, the chapter elaborates on implementation, curtailment, and cancellation of interchange transactions.

Chapter 5 presents various characteristics of electric energy trading and focuses on key issues of trading systems. A description of successful trading tools is presented and qualifying factors of a successful trading system are addressed. The chapter concentrates on main derivative instruments such as futures, forwards and options. Different categories of traders, trading hubs, price volatility and green power trading are discussed. Electricity contract specifications of the New York Mercantile Exchange (NYMEX) and Chicago Board of Trade (CBOT) are presented and the presentations are supported by pertinent examples for energy trading.

Chapter 6 provides more information on possible hedging mechanisms in the restructured electric power industry. It presents basics of hedging tools in electricity markets, new derivatives that are created especially for electricity markets, types of risks, and motivations that lead to more risks in electricity markets. In addition, the Midwest crisis that happened in June 1998 – the unforgettable mark in the U.S. electric industries – is presented to show why hedging strategies are important in electricity markets. It gives a detailed overview of sources that lead different market players to suffer from financial price risk, gives an overview of how players of energy markets may use electricity financial derivatives to hedge different risks, and shows shortcomings in the electricity derivatives pricing model. The chapter also discusses major challenges to electricity derivatives, which include implementing reliable forward curves, inadequacy of existing price indices, basis risk, and inadequacy of traditional pricing models. Forward price curves and counterparty risk are presented, followed by a discussion on how California deals with counterparty risk. Also illustrated in the chapter is how the Greeks are used to analyze exposures of a portfolio or a position. The chapter presents a discussion on hedging tools for weather-related risks, and shows numerous examples for using different hedging tools such as swap transaction, caps, floors, swaption, swing contracts, and weather-related derivatives. Many examples are presented regarding these issues.

Chapter 7 discusses electricity pricing and its impact on electricity market operations. The chapter presents electricity price volatility and means of measuring volatility in electricity market prices. Various indexes and price hubs in the United States are introduced and a case study for California is presented. The chapter discusses basic risks in electricity pricing and presents different models for pricing. The construction of forward curves for long-term pricing is discussed and a detailed discussion for short-term electricity pricing is presented. The chapter compares the characteristics of electricity price forecasting with those of load forecasting in power systems. The application of artificial neural networks in short-term electricity pricing is discussed and practical case studies are presented.

Chapter 8 presents issues related to RTO. In order to promote efficiency in wholesale electricity markets and to guarantee that electricity

consumers pay the lowest price possible for reliable service, the FERC recently has improved its regulations by proposing the formation of RTOs. In addition to improving grid reliability and correcting the non-discriminatory practices, FERC's objective is to improve market performance, and to create light-handed regulations. The chapter will familiarize readers with RTOs and will discuss issues on mimimum characteristics and minimum functions of an RTO. The sources of engineering and economic inefficiencies, which are present in the operation, planning and expansion of regional transmission grids include: difficulty in calculating ATC values, parallel path flows, limited scope of available information and the use of non-market approaches to managing transmission congestion, planning and investing in new transmission facilities, pancaking of transmission access charges, absence of clear transmission rights, absence of secondary markets in transmission service, and possible disincentives created by the level and structure of transmission rates.

Chapter 9 presents a review of certain electric utility markets outside the United States. Although the number of case studies is limited, it provides an interesting perspective for challenges faced by electricity restructuring across the globe. Among the models discussed in this chapter are the Nordic Power Exchange, Australia National Electricity Market, restructuring of electricity in Canada and electricity industry models in England and Wales. In each case, the chapter reviews the specific characteristics of the case and provides a comparison with the restructuring models in the United States. The chapter provides several numerical examples to help readers examine the model more thoroughly.

Appendices Appendix A provides readers with a comprehensive glossary of terms and definitions for restructured electric power systems. The glossary includes definitions of terms in generation, transmission, distribution, trading, risk management, hedging strategies, interchange transactions (tagging), ancillary services, OASIS, entities of restructuring, and many others. Appendix B represents a sample of electricity contract specifications. Part B1 of this appendix discusses NYMEX and Part B2 is on Palo Verde and California/Oregon Border (COB) futures and options contract specifications. Parts B3-B6 cover CBOT electricity market specifications.

In addition, various definitions and pertinent discussions are provided as footnotes throughout the book, to help readers relate to the subject more closely. The brackets within the text refer to references provided at the end of the book.

Mohammad Shahidehpour
Muwaffaq Alomoush

CONTENTS