Risk Management in Energy Production and Trading

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Preface

Electricity production, delivery and trading developed from simple supply chains with one producer with one delivery network to several customers in the beginning of the 20th century to a very complex system of interconnected producers, huge transportation networks managed by independent system operators and exchange markets on which spot products as well as futures are traded. By complexity, such modern systems are subject to many different risks, such as technical risk in production, transportation and delivery, operational risk for the system operators as well as markets risks for traders and political and other long term risks in strategical management.

This book attempts to give an overview over these types of risk and many of its chapters describe how modern risk management methods may be applied. All management decision have to be made in situations, where not all relevant data are precisely known. Therefore *decision making under uncertainty* is the methodological background and many papers of this book use multistage stochastic optimization as a basic tool for analysis.

The book is divided into four parts. Part I is devoted to energy markets. in particular electricity markets. Chapter 1 by P. Gross, R. Kovacevic and G. Pflug gives a first, nontechnical, overview of energy markets and their main properties. Both physical and financial products are discussed. R. D'Ecclesia gives an introduction to basic price models for energy commodity prices in chapter 2. In the following chapter 3, F. Paraschiv reviews modeling approaches for electricity price processes and also applies extreme value theory to the tails of the price changes.

In energy risk management it is important to keep in mind the whole production, storing and distribution process with all related economic and physical, restrictions. This makes a big different to purely financial markets. Part II therefore deals with optimal decisions in managing energy systems. Because the resulting optimization problems are typically difficult to deal with, algorithms are an important issue. In chapter 4, M. Densing gives a review of hydropower dispatch models and discusses two models for pumped storage plants and related case studies in deep detail. A. Philpott, A. Dallagi and E. Gallet then discuss two classes of algorithms in chapter 5: cutting plane algorithms and approximative dynamic programming. These algo-

rithms are again applied to hydroelectric generation planning. M. Gendreau widens the scope and analyzes combined hydro-thermal production in Chapter 6. As concerns algorithms, this chapter discusses decomposition techniques for multistage stochastic programs. A. Eichhorn then extends the spectrum of production sources in chapter 7 and includes renewables, as well as dedicated energy storages. In the following chapter 8 by A. S. Werner, A. Pichler, K. T. Midthun, L. Hellemo and A. Tomasgard the focus changes to stochastic investment and operational optimization models for natural gas transport systems. Convenient risk measures and a new tree structure for modeling the related stochastic processes are discussed in detail. Decision making in the operation of electricity networks is treated in Chapter 9 by A. Grothey, W. Bukhsh, K. I. M. McKinnon and P. A. Trodden, who consider good islanding decisions in unstable network situations. The issue of natural gas transmission and distribution is again widened by J. P. Luna, C. Sagastizabal and M. Solodov in chapter 10. They take into account market equilibria for profit maximizing agents both in deterministic and stochastic settings. In particular the impact of market power on equilibrium prices is analyzed. Investment in the extension of energy production systems is discussed in Chapter 11 by M. T. Vespucci.

While many chapters deal with renewable energy up to some extent, the three following chapters, are completely devoted to this important issue. In chapter 12, D. Wozabal, C. Graf and D. Hirschmann give an overview of renewable energy and analyze its impact on power markets. In particular the impacts of technological development, wind and solar output, and subsidies for renewable energies are considered. In the following chapter 13, A. Nordveit, K. T. Watle and S. E. Fleten use a copula based Monte Carlo model for hedging the risk of renewable energy sources by forward and futures contracts. Finally, L. Baringo and A. J. Conejo analyze investments in highly stochastic sources of power production, e.g. wind production in chapter 14. A multi-stage stochastic complementarity model is used to determine the optimal investment capacity.

Part III is devoted to pricing: R. Kovacevic and G. Pflug describe several pricing principles and especially the pricing of electricity swing options (Chapter 15) in a unified framework. The pricing of derivatives with volume control is treated in a classical financial setup by F. Espen-Benth and M. Erikson in Chapter 16.

The final part IV widens the scope of risks to long term and political risks. V. Krey and K. Riahi study energy systems under aspects of climate change in Chapter 17, while P. Burgherr, S. Hirschberg and M. Spada deal with operational risks such as catastrophic risks, in particular risks from terrorist attacks in the final Chapter 18.

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