

Preface

Energy is of fundamental importance in the modern society. From 2010 the Wolfgang Pauli Institute (WPI) in Vienna has organized a special thematic program called “Financial engineering for energy asset management and hedging in commodity markets (ENERGY-10)”, which has had its focus on risk management in the energy sector. This volume collects contributions from some of the active participants in this thematic program, showing the research frontiers of this exciting branch of financial mathematics and stochastics.

To give some perspective, the “thematic programs” were launched by Norbert Mauser, the Director of WPI. Norbert invited one of us (Peter) to submit a proposal for such a thematic program in 2009. Peter invited Fred and Valery to join him as co-organizers of the special program, which kicked-off in January 2010. The program has since then organized two conferences on energy finance (one in 2011 and one in 2012) as well as several mini-workshops held by leading experts in their respective specialized fields.

The thematic programs are special in that registration is free, participants thereby obtaining access to talks from leading experts who also give presentations in expensive executive conferences, with triple-digit registration fees. The atmosphere is very friendly and congenial. Many new collaborations and friendships are born in such an atmosphere, and this was indeed very much the spirit in which the *thematic programs* were launched by Norbert, whom we thank for giving us the opportunity to organize this highly successful initiative.

In this volume we have collected contributions from researchers who have given mini-courses or have presented talks at the first conference organized in the program taking place at the WPI in July 2011. Some chapters serve as lecture notes to mini-workshops, while other chapters reflect presentations from the conference. The conference was co-sponsored by the Centre of Mathematics for Applications at the University of Oslo and by VERBUND Trading, along with the generous support of WPI.

We would like to mention that a new thematic program called “Mathematical finance: Applications to energy markets, risk management and pricing of derivatives (FINANCE-12)” started in 2012 and is organized by us together with Almut Veraart at Imperial College.

We wish to thank Hannah Bracken, Catriona Byrne, Brian Foster and Nicholas Philipson for giving us the opportunity to publish this volume at Springer Verlag. Furthermore, we are grateful for all the technical support and assistance from the Springer group in New York. Fred Espen Benth greatly acknowledges the financial support from the project “EMMOS” (Energy Markets: Modelling, Optimization and Simulation) funded by the Norwegian Research Council under the Evita program. He also thanks his wife Jūratė and daughter Julia for all the love and fun. Valery A. Kholodnyi thanks his wife Larisa and his sons Nikita and Ilya for their love, patience and care. Peter Laurence thanks his wife Magdalena for her sweet companionship and support.

We have separated the proceedings into three main parts: surveys, energy spot modelling and pricing of derivatives. Part I consists of four chapters:

- *René Aïd* presents an in-depth and extensive survey on optimal investments in electricity generation. The chapter provides the reader with an overview on the existing literature on investment decisions in the context of power production. This chapter serves as lecture notes from the two-day mini-workshop given by René Aïd at the WPI in January 2012.
- The very first mini-workshop in this thematic program was given at WPI by *René Carmona* in January 2010. In the chapter written together with *Michael Coulon*, structural models in energy markets are presented. The authors provide a well-written and entertaining survey on commodity markets and the challenges in modelling prices in these. Structural stochastic models are introduced and analysed, and details on analytic forward pricing are presented.
- In energy markets the price dynamics is typically of a non-Gaussian nature, and valuation of derivatives calls for methods going beyond the Black and Scholes formula. In January 2012 Ernst Eberlein presented a mini-course on Fourier-based methods for pricing options in markets where the price dynamics is driven by jump processes. This theory is extensively developed in traditional financial markets as fixed income and credit. The chapter by *Ernst Eberlein* serves as the lecture notes from his mini-workshop on the topic and provides the reader with an extensive introduction and analysis of these methods, full of details and examples written in an engaging way. This theory is highly applicable for energy markets.
- A typical feature of energy markets is the abundance of exotic derivatives much more sophisticated in their specifications than more traditional derivatives found in other markets. Many of these energy derivatives go under the umbrella of so-called swing options. *Jukka Lempa* presents a survey on the various mathematical approaches to study the problem of pricing and optimal execution of such options. It involves various techniques collected from stochastic control theory, presented in a highly accessible way by the author.

The second part of this volume consists of three chapters on the basic but challenging problem of energy spot price modelling:

- *Joanna Janczura and Rafal Weron* present a general class of Markov-regime-switching model for electricity prices and discuss the problem of inference. An extensive empirical study is presented for spot prices collected at two electricity exchanges.
- *Almut and Luitgard Veraart* propose a new class of models for the dynamics of hourly spot prices of electricity. The so-called Lévy semistationary models are extended to a multivariate setting, and an extensive empirical study is performed.
- *Valery A. Kholodnyi* presents and further extends the class of his non-Markovian spot price processes to allow for both positive and negative prices, as well as spikes in both the upward and downward directions. The forward price dynamics is analysed within this class of models as well. This chapter serves also as lecture notes for parts of the two-day mini-workshop given by the author at the WPI in October 2011.

The last part of this volume contains four chapters on problems related to energy derivatives.

- *Álvaro Cartea and Pablo Villaplana* provide a detailed analysis on the main determinants of the risk premium and the forward price evolution in electricity markets. As the classical spot-forward relationship breaks down in electricity markets due to non-storability, these are fundamental issues in derivative pricing in power markets. The authors base their analysis on data from European power markets.
- *Thilo Meyer-Brandis and Michael Morgan* propose a bivariate spot model for electricity and gas using dynamic Lévy copulas to capture the dependency structure. They have spark spread option pricing in mind and derive analytic pricing expressions based on Fourier transform methods, as described by Ernst Eberlein in Chap. 3. Data from the UK is used in an empirical case study.
- *Peter Laurence, Ricardo Pignol and Esteban Tabak* present a novel approach to density estimation taking constraints into account. The method is generally applicable to a huge variety of problems in science, but here examples from recovering the density from spread option prices are considered.

- *Fred Espen Benth, Richard Biegler-König and Rüdiger Kiesel* analyse the influence of forward-looking information in electricity markets on call and put options on forward contracts. The mathematical analysis is based on the theory for enlargement of filtrations, and stylized examples are given to illustrate the findings.

We hope that the reader will enjoy the various chapters as much as we have enjoyed listening to, discussing with and reading the contributions from the authors.

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