Preface

Since the early 1990s, the markets for electricity and related products have been liberalized worldwide. It all started off with the Nordic market Nord-Pool and the England & Wales market at around 1992, and over the last two decades trade in electricity and related products on all continents in the world has been liberalized. In 1999 the Chicago Mercantile Exchange organized a market for temperature derivatives that has gained momentum in recent years. Exchange-based markets for gas have emerged and are now actively traded at the New York Mercantile Exchange and the Intercontinental Exchange in London. As these markets mature, energy becomes increasingly more important asset class of investments, not only attracting the traditional actors in the markets, but also speculators like investment banks, hedge funds and pension funds.

The basic products in the electricity, gas and temperature markets are spot, futures and forward contracts and options written on these. With organized markets comes the need to have consistent stochastic models describing the price evolution of the products. Such models must reflect the stylised facts of the commodity prices we observe at the exchanges, but also lend themselves to analytical treatment like pricing of derivatives. Energy-related spot prices have several typical characteristics, with the most prominent being mean reversion towards a seasonally varying mean level, and frequently occurring spikes resulting from an imbalance between supply and demand. Electricity spot prices may, for instance, increase with several 100% over very short time intervals, before they come back to their normal levels. Such price volatilities are hardly found in any other markets than energy. Further, since the energy commodities are driven by the balance between demand and production, the prices tend to mean-revert. A natural class of stochastic models to describe such dynamics is

the Ornstein-Uhlenbeck processes. We use these mean-reverting stochastic processes as our modelling tool throughout the book.

Contrary to more classical commodity markets like agriculture and metals, energy-related futures contracts deliver the underlying spot over a contracted period. The derivation of futures prices from spot is not straightforward, and depends on the choice of risk-neutral probability and the type of model. The delivery of the spot over a period creates technical problems when calculating the futures prices based on exponential spot models, while arithmetic models on the other hand are feasible for analytical pricing. The Heath-Jarrow-Morton approach suggests a direct modelling of the futures prices. However, again the existence of a delivery period creates problems since it turns out to be hard to propose arbitrage-free models which at the same time are tractable from statistical and theoretical points of view. All these challenges defend a study of energy markets on its own.

The background for writing this book is twofold. Over the recent years, we have worked on electricity and temperature modelling, and wanted to collect our results together in a consistent and general way. On the other hand, we also wished to provide a rigorous introduction to stochastic modelling of the energy markets. One of our goals is to present a mathematically sound foundation for the relevant models to energy-related products, being useful in both theory and practise.

In many practical examples we test our models on data collected from electricity, gas and temperature markets. However, there are many challenges related to the fitting of the relevant stochastic models in the energy markets, and it is outside the scope of this book to provide a detailed treatment of all the various estimation techniques and issues. The focus is on presenting a consistent and complete theoretical framework for energy market models with applications to derivatives pricing.

Acknowledgements: Many colleagues and friends have helped us out in the process of writing this book. One may say that "no one mentioned, no one forgotten". However, we feel that some persons have made a significant contribution to the contents, and it would be unfair not to thank them explicitly. Apart from being an enthusiastic source of information on the market, Fridthjof Ollmar has been the co-author on a scientific paper with us (resulting in Ch. 7) and provided electricity data (through Agder Energy). A crucial input from him has been the creation of a computer program for which smoothed forward curves can be constructed from observed electricity futures prices. This has been invaluable for a big part of

the empirical work done for the electricity markets. Our supportive friend and colleague Alvaro Cartea has read parts of the manuscript and correcting some errors. He has provided us with data (through Oxford Economic Research Associates, Oxera) and shared his insight into the theoretical and practical aspects of electricity and gas markets.

Through their scientific collaboration, many colleagues have contributed (directly or indirectly) to the contents of the book. We are grateful to Roar Aadland, Kęstutis Dučinskas, Dennis Frestad, Petter E. Furrebøe, Pål Nikolai Henriksen, Paulius Jalinskas, Jan Kallsen, Paul C. Kettler, Rüdiger Kiesel, Rodwell Kufakunesu, Thilo Meyer-Brandis, Andrea Roncoroni, Sigbjørn Sødal and Valeri Zakamouline for all the fun in working together with you on problems related to the energy markets, as well as your friendship and support.

Stochastic models for energy markets are not very relevant if you do not have access to data to support (or dismiss) your theories. Data has been provided to us through several sources (some already mentioned). We greatly acknowledge the provision of gas and electricity data from Andre Damslora at PointCarbon, and Håvard Hvarnes and Bjarte Lima at Elkem. Temperature data was kindly made available to us by SMHI, the Swedish Meteorological Institute.

Finally, we thank our respective institutions for their support in this book project, and all our friends and colleagues there for creating such a great research environment and for all the every-day fun. We also feel indebted to the editor Ole E. Barndorff-Nielsen, who enthusiastically encouraged us to publish the book in this series. The staff at World Scientific is thanked for efficient handling.

Fred Espen Benth, Jūratė Šaltytė Benth and Steen Koekebakker
Oslo and Kristiansand, December 2007