

Contents

Foreword	xi
Preface	xiii
1 Energy Markets	1
1.1 The oil market	4
1.1.1 Consumption, production and reserves	4
1.1.2 Crude oil trading	7
1.1.3 Refined oil products	8
1.2 The natural gas market	9
1.2.1 Consumption, production and reserves	10
1.2.2 Natural gas trading	12
1.2.3 Price formulas with oil indexation	14
1.2.4 Liquefied natural gas	15
1.3 The coal market	16
1.3.1 Consumption, production and reserves	17
1.3.2 Coal trading	18
1.3.3 Freight	22
1.3.4 Coal subsidies in Germany: BAFA-indexed prices	23
1.4 The electricity market	23
1.4.1 Consumption and production	23
1.4.2 Electricity trading	27
1.4.3 Products in the electricity markets	28
1.4.4 Energy exchanges	33
1.5 The emissions market	37
1.5.1 Kyoto Protocol	37
1.5.2 EU emissions trading scheme	39
1.5.3 Flexible mechanisms	42

1.5.4	Products and market places	44
1.5.5	Emissions trading in North America	46
2	Energy Derivatives	47
2.1	Forwards, futures and swaps	48
2.1.1	Forward contracts	48
2.1.2	Futures contracts	51
2.1.3	Swaps	52
2.2	“Plain vanilla” options	53
2.2.1	The put–call parity and option strategies	53
2.2.2	Black’s futures price model	55
2.2.3	Option pricing formulas	55
2.2.4	Hedging options: the “Greeks”	57
2.2.5	Implied volatilities and the “volatility smile”	62
2.2.6	Swaptions	64
2.3	American and Asian options	66
2.3.1	American options	66
2.3.2	Asian options	66
2.4	Commodity bonds and loans	69
2.5	Multi-underlying options	69
2.5.1	Basket options	70
2.5.2	Spread options	72
2.5.3	Quanto and composite options	73
2.6	Spot price options	76
2.6.1	Pricing spot price options	77
2.6.2	Caps and floors	78
2.6.3	Swing options	80
2.6.4	Virtual storage	83
3	Commodity Price Models	87
3.1	Forward curves and the market price of risk	88
3.1.1	Investment assets	89
3.1.2	Consumption assets and convenience yield	89
3.1.3	Contango, backwardation and seasonality	91
3.1.4	The market price of risk	91
3.1.5	Derivatives pricing and the risk-neutral measure	92
3.2	Commodity spot price models	95
3.2.1	Geometric Brownian motion	95
3.2.2	The one-factor Schwartz model	100
3.2.3	The Schwartz–Smith model	103
3.3	Stochastic forward curve models	108
3.3.1	One-factor forward curve models	109
3.3.2	A two-factor forward curve model	111
3.3.3	A multi-factor exponential model	112

3.4	Electricity price models	113
3.4.1	The hourly forward curve	114
3.4.2	The SMaPS model	117
3.4.3	Regime-switching model	120
3.5	Multi-commodity models	125
3.5.1	Regression analysis	125
3.5.2	Correlation analysis	128
3.5.3	Cointegration	128
3.5.4	Model building	130
4	Fundamental Market Models	131
4.1	Fundamental price drivers in electricity markets	132
4.1.1	Demand side	132
4.1.2	Supply side	136
4.1.3	Interconnections	143
4.2	Economic power plant dispatch	143
4.2.1	Thermal power plants	145
4.2.2	Hydro power plants	151
4.2.3	Optimisation methods	155
4.3	Methodological approaches	166
4.3.1	Merit order curve	166
4.3.2	Optimisation models	178
4.3.3	System dynamics	184
4.3.4	Game theory	186
4.4	Relevant system information for electricity market modelling	196
4.4.1	Demand side	196
4.4.2	Supply side	197
4.4.3	Transmission system	200
4.4.4	Historical data for backtesting	201
4.4.5	Information sources	201
4.5	Application of electricity market models	202
4.6	Gas market models	204
4.6.1	Demand side	205
4.6.2	Supply side	206
4.6.3	Transport	208
4.6.4	Storage	210
4.6.5	Portfolio optimisation	212
4.6.6	Formulation of the market model	212
4.6.7	Application of gas market models	215
4.7	Market models for oil, coal, and CO ₂ markets	215
5	Electricity Retail Products	217
5.1	Interaction of wholesale and retail markets	217
5.2	Retail products	220
5.2.1	Common full service contracts	220
5.2.2	Indexed contracts	221

5.2.3	Partial delivery contracts	222
5.2.4	Portfolio management	223
5.2.5	Supplementary products	224
5.3	Sourcing	225
5.3.1	Business-to-business (B2B)	226
5.3.2	Business-to-consumer (B2C)	227
5.3.3	Small accounts	227
5.3.4	Municipalities and reseller	228
5.4	Load forecasting	228
5.5	Risk premium	230
5.5.1	Price validity period	231
5.5.2	Balancing power	232
5.5.3	Credit risk	235
5.5.4	Price–volume correlation	235
5.5.5	Strict risk premiums	237
5.5.6	Hourly price profile risk	239
5.5.7	Volume risk	240
5.5.8	Operational risk	240
5.5.9	Risk premium summary	241
6	Risk Management	243
6.1	Market price exposure	243
6.1.1	Delta position	244
6.1.2	Variance minimising hedging	249
6.2	Value-at-Risk and further risk measures	250
6.2.1	Definition of Value-at-Risk	250
6.2.2	Parameters of the Value-at-Risk measure	252
6.2.3	Computation methods	253
6.2.4	Liquidity-adjusted Value-at-Risk	258
6.2.5	Estimating volatilities and correlations	261
6.2.6	Backtesting	263
6.2.7	Further risk measures	264
6.3	Credit risk	265
6.3.1	Legal risk	266
6.3.2	Quantifying credit risk	267
6.3.3	Credit rating	269
	Appendices	275
A	Mathematical background	275
A.1	Econometric methods	275
A.1.1	Linear regression	275
A.1.2	Stationary time series and unit root tests	277
A.1.3	Principal component analysis	279
A.1.4	Kalman filtering method	279
A.1.5	Regime-switching models	281

A.2 Stochastic processes	283
A.2.1 Conditional expectation and martingales	284
A.2.2 Brownian motion	284
A.2.3 Stochastic integration and Itô's lemma	285
A.2.4 The Feynman–Kac theorem	287
A.2.5 Monte Carlo simulation	288
Bibliography	291
Index	295

