# Contents

Acknowledgments ................................................................. xv
List of Figures ................................................................. xxi
List of Tables ................................................................. xxvi

## Chapter 1
**Introduction to Our Journey** ............................................... 1
Some Scientific Principles ........................................................... 2
Outline of the Book ................................................................. 6

## Chapter 2
**Energy Lessons from the Past and Modeling the Future** ................. 13
Introduction ................................................................. 13
Energy Geological History ...................................................... 13
Natural Gas ................................................................. 18
Unconventional Oil Resources .................................................. 21
Coal Resources ................................................................. 23
Energy's Human History ....................................................... 23
Energy Modeling ................................................................. 27
Summary ................................................................. 39

## Chapter 3
**Perfect Competition and the Coal Industry** ............................ 43
Introduction ................................................................. 43
Perfect Competition ............................................................. 47
Energy Demand and Supply .................................................... 54
Shifts in Supply and Demand .................................................. 59
Demand and Supply Elasticities .............................................. 61
Supply Elasticities ............................................................. 66
Using Elasticities to Forecast Supply ......................................... 67
Price Changes from a Supply Disruption ..................................... 67
Creating Demand and Supply from Elasticities ............................. 68
Summary ............................................................................. 69
Chapter 4

Energy Price Controls, Taxes, Subsidies, and Social Welfare

Introduction .......................................................... 71
Social Welfare .......................................................... 71
Government Price Controls ......................................... 74
Government Taxes and Subsidies .................................. 78
Types of Taxes .......................................................... 79
Modeling Taxes in a Competitive Market ................. 86
Incidence of Tax Depends on Demand and Supply Elasticities ..... 89
Consumer and Producer Surplus Show Deadweight Loss from a Tax .... 90
Energy Subsidies ......................................................... 91
Summary ............................................................... 91

Chapter 5

Natural Monopoly and Electricity Markets ..................... 93
Introduction ........................................................ 93
Electricity Market Evolution ....................................... 96
Modeling Electricity Markets ....................................... 98
Load Cycle .......................................................... 104
Monopoly in a Decreasing Cost Industry ....................... 105
Government Policy for a Natural Monopoly ................. 111
Rate of Return Regulation ....................................... 112
Problems with Rate of Return Regulation ................. 112
Valuing Money across Time .................................... 113
Utility Rate of Return on a Bond or Stock ................. 115
Utility Rate Base .................................................. 117
Utility Cost Allocation .......................................... 120
Peak-Load Pricing ................................................. 120
Summary ........................................................... 122

Chapter 6

Restructuring in the Electricity Sector ......................... 125
Introduction ........................................................ 125
Problems with Regulated and Government-Owned Utilities .......... 125
Models for the Electricity Sector ..................................... 127
Examples of Electricity Restructuring ............................ 128
Evaluation of Early Reforms ..................................... 139
Summary ........................................................... 150

Chapter 7

Monopoly, Dominant Firm, and OPEC ......................... 153
Introduction ........................................................ 153
Monopoly Model ................................................... 155
Monopoly Compared to Competition ........................................... 159
Price Controls in a Monopoly Market .......................................... 160
Antitrust Laws ........................................................................... 162
Brief History of Oil Markets ....................................................... 165
Multiplant Monopoly Model ...................................................... 171
OPEC’s Demand Curve and Marginal Revenue Curve .................. 174
Price Elasticity of Demand for OPEC’s Oil ................................. 178
Non-Profit Maximization Goals for OPEC ................................. 180
Summary .................................................................................. 183

Chapter 8
Market Structure, Transaction Cost Economics, and US Natural Gas Markets ........... 185
Introduction ............................................................................... 185
Natural Gas Consumption and Production Worldwide .................. 186
Natural Gas Conversions ........................................................... 189
Transaction Cost Economics ...................................................... 191
Evolution of the US Natural Gas Industry .................................... 197
Gas Consumers ......................................................................... 202
Gas Transmission ....................................................................... 203
Volatility in the Natural Gas Market .......................................... 205
Contracts .................................................................................. 208
North and South of US Borders ................................................. 212
Summary .................................................................................. 213

Chapter 9
Monopsony: Japan and the Asia-Pacific LNG Market ..................... 217
Introduction ............................................................................... 217
LNG Production and Trade ....................................................... 220
LNG Monopsony on Input Market, Competitor on Output Market .... 225
Monopsony Model Compared to Competitive Model ................... 229
Monopsony Model with Price Discrimination .............................. 229
Monopoly and Bilateral Monopoly ............................................. 230
Bargaining and Negotiation ...................................................... 234
Summary .................................................................................. 234

Chapter 10
Game Theory and the European Natural Gas Market ..................... 237
Introduction ............................................................................... 237
Coal and Oil Consumption ....................................................... 238
Coal and Oil Production ........................................................... 242
Natural Gas Markets ................................................................. 245
Primary Electricity ..................................................................... 256
European Market Structure ...................................................... 258
Cournot Duopoly ....................................................................... 264
Duopoly Compared to Competitive Market ................................................. 267
Monopoly Compared to Competitive and Duopoly Market ...................... 269
Other Game Theory Models: Bertrand and Stackelberg .......................... 270
Limit Pricing Model .................................................................................. 271
Summary ................................................................................................. 272

Chapter 11

Externalities and Energy Pollution .......................................................... 275
Introduction .......................................................................................... 275
Pollution as a Negative Externality ........................................................ 277
Optimal Level of Pollution ..................................................................... 278
Regional Differences in Optimal Pollution Levels ................................. 282
Evolution and International Comparison of Vehicle Emission Standards .... 283
Abatement across Firms ......................................................................... 284
Difficulties Measuring Costs and Benefits of Pollution ......................... 288
Summary ................................................................................................. 289

Chapter 12

Public Goods and Global Climate Change .............................................. 291
Introduction .......................................................................................... 291
Public Goods .......................................................................................... 292
Two Other Abatement Policies ................................................................ 297
Energy Conservation and Its Cost .......................................................... 300
Energy Efficiency Gap and Policy Options .......................................... 303
Government Failure .............................................................................. 307
Global Carbon Policy ............................................................................ 308
Adaptation ............................................................................................. 311
Summary ................................................................................................. 312

Chapter 13

Safety and Security .................................................................................. 315
Introduction .......................................................................................... 315
Market Responses to Uncertainty and Disruption ................................. 321
Governments and Energy Security .......................................................... 325
Energy Accidents .................................................................................... 328
US Government Promotion of Nuclear Power ...................................... 330
Summary ................................................................................................. 333

Chapter 14

Allocating Fossil Fuel Production over Time and Oil Leasing ................. 335
Introduction .......................................................................................... 335
Reserves and Reserves-to-Production Ratios (R/P) ................................. 336
Dynamic Two-Period Competitive Optimization Models without Costs .... 339
Model One (No Costs, No Income Growth) ............................................ 341
Model Two (No Costs, Income Growth) .......................... 346
Model Three (No Costs, No Income Growth, Lower Interest Rate) 347
Model Four (No Costs, No Income Growth, Increased Reserves) 348
Model Five (No Income Growth, with Costs) ..................... 349
Model Six (No Income Growth, No Costs, with Backstop Technology) 352
Dynamic Multi period Models .......................... 354
Dynamic Models with Market Imperfections ..................... 354
Taxing and Bidding Decisions .......................... 357
A Foray into the Real World .......................... 362
Summary .......................................................... 363

Chapter 15
Supply and Costs Curves ............................................. 367
Introduction .......................................................... 367
Nuclear Fuels ..................................................... 371
Hydroelectricity ................................................. 375
Other Renewable Energy Sources .......................... 377
Unit or Levelized Costs of Wind Electricity ..................... 378
Solar Energy ..................................................... 379
Geothermal Energy ............................................. 381
Inground and Aboveground Costs for Gas and Oil ............. 383
Unit Costs with No Decline Rate .......................... 387
Developing Cost Data ......................................... 390
Estimating Total Energy Resources .......................... 390
Summary .......................................................... 393

Chapter 16
Energy Balances and Energy Demand .......................... 397
Introduction .......................................................... 397
Energy Balances ................................................. 398
Household or Consumer Demand .......................... 417
Consumer Demand and a Subsidy .......................... 425
Factor Demand for the Industrial, Commercial, and Electricity Sectors .......................... 426
Econometric Estimates of Energy Demand—Picking the Functions .......................... 429
Summary .......................................................... 433

Chapter 17
Linear Programming, Refining, and Energy Transportation .......................... 437
Introduction .......................................................... 437
Crude Oil Refining ............................................... 438
Gasoline Blending ............................................. 444
Linear Programming to Optimize Refinery Profits ............. 446
Energy Transportation ......................................... 451
Summary .......................................................... 463
Chapter 18
Energy Futures Markets for Managing Risk ........................................... 465
Introduction ......................................................................................... 465
Energy Futures Contracts ..................................................................... 468
Hedging with Energy Futures .............................................................. 473
Arbitrage ............................................................................................ 475
What Determines Energy Future Prices on Commodities? ............... 476
Efficient Market Hypothesis ................................................................. 482
Crack and Spark Spreads .................................................................... 483
Speculation and High Prices ............................................................... 484
Summary ........................................................................................... 488

Chapter 19
Energy Options for Managing Risk .................................................... 491
Introduction ......................................................................................... 491
Pricing Options .................................................................................... 493
Options Quotes ................................................................................... 495
Valuing Options with Replicating Formulas ...................................... 496
Creating Probabilities for a Binomial Lattice Model ......................... 499
Variables that Affect Option Prices .................................................. 505
Option Trading Strategies ................................................................. 505
Energy Swaps .................................................................................... 507
Summary ........................................................................................... 508

Chapter 20
Climbing the Energy/Development Ladder to Sustainability ............. 511
Introduction ......................................................................................... 511
Combustible Biomass and the World's Poor ....................................... 518
Collecting Wood from the Commons ............................................... 526
Energy and Water ............................................................................... 530
Renewable Energy Policies ............................................................... 532
Optimal Timber Rotation ................................................................... 532
Summary ........................................................................................... 536

Chapter 21
Sustainable Wealth in Fossil Fuel–Rich Developing Countries .......... 541
Introduction ......................................................................................... 541
Fossil Future for FR Countries ............................................................ 545
Primary Electricity and Modern Biofuels ........................................... 551
Economic Issues in Fossil Fuel–Rich Countries .................................. 556
Investing Fossil Rents for a Sustainable Future ................................. 570
Summary ........................................................................................... 574
# Chapter 22

**Managing in the Multicultural World of Energy**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>577</td>
</tr>
<tr>
<td>Culture</td>
<td>578</td>
</tr>
<tr>
<td>Time</td>
<td>585</td>
</tr>
<tr>
<td>Universalism and Particularism</td>
<td>585</td>
</tr>
<tr>
<td>Cognitive Styles</td>
<td>588</td>
</tr>
<tr>
<td>Life Values</td>
<td>589</td>
</tr>
<tr>
<td>Business Protocols</td>
<td>589</td>
</tr>
<tr>
<td>Human Dimensions of Managing Technology</td>
<td>596</td>
</tr>
<tr>
<td>Think Like an Economist</td>
<td>598</td>
</tr>
<tr>
<td>Managing on the Margin</td>
<td>598</td>
</tr>
<tr>
<td>Managing across Time</td>
<td>600</td>
</tr>
<tr>
<td>When Markets Fail</td>
<td>601</td>
</tr>
<tr>
<td>Summary</td>
<td>602</td>
</tr>
</tbody>
</table>

**Appendix A**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Conversions</td>
<td>607</td>
</tr>
</tbody>
</table>

**Appendix B**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bibliography</td>
<td>613</td>
</tr>
</tbody>
</table>

**Index**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note:</td>
<td></td>
</tr>
</tbody>
</table>

An online glossary for this text can be found at [http://dahl.mines.edu/glossary.pdf](http://dahl.mines.edu/glossary.pdf).
Energy Lessons from the Past and Modeling the Future

Those who cannot remember the past are condemned to repeat it.

—George Santayana

Introduction

Energy markets continually evolve. How they evolve in the future will be influenced by many of the factors that we will discuss in this book, including energy resources, technology, population growth, demographics, climate change, costs, preferences, government policy, regulation, and risk. In this chapter, we will consider energy in the great historical panorama, which sets the stage for coming chapters. We will also consider models that help us forecast coming events, analyze policies, make business decisions, and simulate interactions between energy and other sectors.

Energy Geological History

Science suggests that the most cataclysmic energy event for the universe was at its beginning, with the big bang and subsequent inflation of the universe some 14 billion years ago (NASA 2013). These and other geological energy milestones are shown in table 2–1.

Although there is not total agreement or understanding of how the universe began, physicists generally believe it to have proceeded as follows. Before the big bang, time, space, matter, and energy did not exist. Then an anomaly caused negative gravity and positive energy to form from nothing. The net energy was zero, but the universe had zero size and infinite temperature. The negative gravity caused an expansion, and the high temperatures caused the formation of a small amount of matter in the form of subatomic particles from energy according to Einstein’s $E = mc^2$. With the expansion, temperatures started to drop.
## Dates | Era or Event
--- | ---
1901 | Using the first rotary drill, Spindletop was discovered in East Texas.
1903 | Wright brothers completed the first airplane flight powered by gasoline engine.
1908 | Anglo Persian struck first oil in Persia.
1911 | US government broke up Standard Oil.
1928 | “Red Line” and “As Is” agreements limited international oil company competition.
1938 | Mexico nationalized its oil industry; oil was discovered in Saudi Arabia and Kuwait.
1948 | Jersey Standard (Exxon), Socony Vacuum (Mobil), California Standard (Chevron), and Texaco formed the Arabian American Oil Company (Aramco).
1951 | Iran nationalized Anglo Persian Oil into the National Iranian Oil Company (NIOC).
1954 | Western companies took over NIOC in Iran after the previous year’s coup.
1959 | Groningen gas field found in the Netherlands.
1960 | OPEC was formed in response to cut in posted prices that reduced their tax revenue.
1968 | Prudhoe Bay oil field was discovered in Alaska.
1969 | Oil was discovered in the North Sea.
1971–79 | Increased government participation and/or nationalizations occurred in OPEC countries (e.g., Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, Iran, and Iraq).
1973 | Arab oil embargo of United States and the Netherlands began as result of Yom Kippur War.
1974 | International Energy Agency (IEA) was formed.
1975 | Brazil implemented an ethanol program designed to eliminate fossil fuels in vehicles.
1979 | Energy crisis resulted from the Iranian Revolution and oil production cuts. Iran renationalized NIOC.
1980 | US domestic oil price controls were lifted.
1984 | OPEC first established production quotas.
1985–86 | Oil price plummeted more than 50% with Saudi Arabian netback pricing and increased production.
1991 | Gulf War ousted Iraq from Kuwait.
1997 | Qatar started exporting from world’s largest LNG facility.
1997–98 | Asian financial crisis caused oil prices to plummet.
1998 | Landlocked Caspian Sea area became exploration hot spot, with export pipelines built in the following decade.
1999–2006 | Oil company acquisitions and mergers: BP/Amoco; Exxon/Mobil; TotalFina/Elf; Repsol/YPF; Norsk Hydro/Saga; Chevron/Texaco; Conoco/Phillips; and Rosneft/Yukos.
2004 | World Bank agreed to new lending rules intended to prevent the funding of corrupt regimes with revenues from oil and natural gas projects.
2005–08 | Shale gas production took off in the United States.
2006 | Russia temporarily cut natural gas supplies to Ukraine over a pricing dispute, which caused continuing security concerns in Western Europe.
Growth rates of coal production have varied over time, as well. They averaged more than 4% per year on a global basis from 1860 to 1913. More than 45% of this output came from a rapidly industrializing United States, with annual average increases of 6.8% during this period. Then with a world war and a world recession, global coal production in 1938 had not regained its prewar level from 1913. World production increased more than fourfold from 1938 to 1990. However, during this time period, it never regained its pre-1913 growth rates except in the 1970s, when the oil crisis and surging oil prices caused industry and electric utilities to switch toward cheaper and politically safer coal. Falling consumption in the 1990s was followed by growth rates after 2000 of 4.7%, rivaling those of the heady years before 1913, when coal was king.

Fossil fuel markets are rarely dull. We can see this from coal prices, which have fluctuated rather dramatically, as shown by US coal prices since 1800 (fig. 3–3).

**Fig. 3–3.** US historical coal prices adjusted for inflation

_Sources_: The price variable is bituminous price deflated by the consumer price index. Price from 1949 to 2012 is from US EIA (n.d.b), which is extrapolated back to 1800 using the price of anthracite coal. Price of anthracite coal from 1800 to 1949 and consumer price index from 1800 to 1913 are from US DOC (1975). Consumer price index from 1913 to 2012 is from the US BLS (n.d.).

The price has been adjusted for inflation to real 2012 dollars. (See [http://dahl.mines.edu/st03/st03.pdf](http://dahl.mines.edu/st03/st03.pdf), question 34, if you want to see how to use a price index to change nominal to real dollars.) It has averaged about $62 per short ton over the past 200 years. (Multiply by 1.1 to convert price to dollars per metric ton.
Subsequent to 1979, US coal mine productivity has shown dramatic improvements, with production per miner-hour increasing. Production increased from 1.9 tons per miner-hour in 1980 to average more than 5.5 tons per miner-hour in the most recent decade (US NMA, n.d.). (For an Excel model that can be used to simulate supply and demand models similar to the one above, as well as other models in this chapter, go to http://dahl.mines.edu/ch03m.xlsx.)

**Demand and Supply Elasticities**

Often we want to measure how responsive quantities demanded and supplied are to prices or other variables, or both, to help design energy plans and policy. For example, if coal demand in Asia is very responsive to income growth and income rises or falls sharply, there will be a large effect on the coal market. If coal demand and supply are very responsive to price, only a small change in price will be needed to bring about equilibrium after demand or supply shocks. Economists use elasticities to provide such a measure of responsiveness. The price elasticity of demand is the percentage change in quantity divided by the percentage change in price:

\[
\epsilon_d = \frac{\% \text{ change quantity}}{\% \text{ change in price}} = \frac{\Delta Q_d}{Q_d} \frac{\Delta P_d}{P_d}
\]  

(3–7)

If the price elasticity is –0.5, and price goes up by 100%, quantity demanded falls by 50%. If the price change is very large, we often get a different elasticity depending on whether the price and quantity in the respective denominators are those before \((P_{d1}, Q_{d1})\) or after \((P_{d2}, Q_{d2})\) the price and quantity changes. So arc elasticities are typically defined using the average of the respective denominators as follows:

\[
\epsilon_d = \frac{\% \text{ change quantity}}{\% \text{ change in price}} = \frac{\Delta Q_d}{(Q_{d1} + Q_{d2})/2} \frac{\Delta P_d}{(P_{d1} + P_{d2})/2} = \frac{(Q_{d2} - Q_{d1})}{(Q_{d1} + Q_{d2})/2} \frac{(P_{d2} - P_{d1})}{(P_{d1} + P_{d2})/2}
\]  

(3–8)

It is often convenient to rewrite equation (3–7) as follows:

\[
\epsilon_d = \frac{\Delta Q_d}{\Delta P_d} \frac{P_d}{Q_d}
\]
### New Mexico

<table>
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<tr>
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<tr>
<td>Surface Coal</td>
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<tr>
<td>Underground Coal</td>
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<tr>
<td>Severance Tax—Coal</td>
<td>3.50%</td>
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### West Virginia

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<tr>
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<tr>
<td>Severance Tax—Coal</td>
<td>5.00%</td>
</tr>
<tr>
<td>37–45 in. Seam Thickness</td>
<td>2.00%</td>
</tr>
<tr>
<td>Less than 37 in. Seam Thickness</td>
<td>1.00%</td>
</tr>
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</table>

**Sources:** Kent and Eastham (2011); Temte (2010); New Mexico Taxation and Revenue Department (2013); Alaska Department of Revenue Tax Division (2013).

**Note:** See the Alaskan government tax return forms for more information on how the mining license tax varies with mining net incomes. The % symbol refers to an ad valorem tax. See individual state government tax forms for the most complete and updated severance tax information.