

Contents

Preface and Acknowledgments	ix
1 Energy and Society	1
Flows, Stores, and Controls	4
Concepts and Measures	8
Complexities and Caveats	17
2 Energy in Prehistory	21
Foraging Societies	28
Origins of Agriculture	41
3 Traditional Farming	49
Commonalities and Peculiarities	52
Field Work	53
The Dominance of Grains	57
Cropping Cycles	62
Routes to Intensification	65
Draft Animals	66
Irrigation	76
Fertilization	82
Crop Diversity	85
Persistence and Innovation	87
Ancient Egypt	88
China	90
Mesoamerican Cultures	97
Europe	99
North America	106

The Limits of Traditional Farming	110
Achievements	111
Nutrition	118
Limits	120
4 Preindustrial Prime Movers and Fuels	127
Prime Movers	130
Animate Power	132
Water Power	146
Wind Power	157
Biomass Fuels	163
Wood and Charcoal	164
Crop Residues and Dung	169
Household Needs	171
Food Preparation	172
Heat and Light	174
Transportation and Construction	177
Moving on Land	178
Oared Ships and Sail Ships	187
Buildings and Structures	197
Metallurgy	207
Nonferrous Metals	208
Iron and Steel	211
Warfare	217
Animate Energies	217
Explosives and Guns	222
5 Fossil Fuels, Primary Electricity, and Renewables	225
The Great Transition	228
The Beginnings and Diffusion of Coal Extraction	229
From Charcoal to Coke	234
Steam Engines	235
Oil and Internal Combustion Engines	245
Electricity	254
Technical Innovations	267
Coals	271
Hydrocarbons	274
Electricity	281
Renewable Energies	284
Prime Movers in Transportation	289

6 Fossil-Fueled Civilization	295
Unprecedented Power and Its Uses	296
Energy in Agriculture	306
Industrialization	313
Transportation	324
Information and Communication	333
Economic Growth	344
Consequences and Concerns	351
Urbanization	352
Quality of Life	355
Political Implications	364
Weapons and Wars	368
Environmental Changes	381
7 Energy in World History	385
Grand Patterns of Energy Use	385
Energy Eras and Transitions	387
Long-Term Trends and Falling Costs	397
What Has Not Changed?	407
Between Determinism and Choice	417
Imperatives of Energy Needs and Uses	418
The Importance of Controls	425
The Limits of Energy Explanations	430
Addenda	443
Basic Measures	443
Scientific Units and Their Multiples and Submultiples	445
Chronology of Energy-Related Developments	446
Power in History	456
Bibliographical Notes	459
References	463
Name Index	531
Subject Index	535