

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