

Contents

PART I. THE APPROACHING ENERGY DISASTER

Chapter 1. What Is Energy?	3
Energy Is That Which Makes Things Go	3
Classification of Energy	3
Potential Energy	4
Turning Potential Energy to Useful Energy	6
Kinetic Energy	6
Potential Energy in Fuels	7
How the Energy Got Inside the Fossil Fuels	9
A Nasty Realization	9
The Conversion of the Various Forms of Energy to Forms Which Can Be Used by People	10
The Vital Importance of Having a Good Transducer (Converter)	10
Efficiency of Energy Conversion	11
The Predominance of Cost	11
The Importance of Compromise	12
The Importance of the Time Left	12
 Chapter 2. What Part Does Energy Play in Our Lives?	 13
Introduction	13
Energy Determines the Kind of Lives We Lead	13
The Standard of Living	14
Income, The Standard of Living, and Energy Per Person	15
Energy, Comfort, and Efficiency	15
The Divisions of Energy Use	15
Household Energy	17
Transportation Energy	17
Industrial and Commercial Energy	19
One (Avoidable) Negative Aspect of a High-Energy Life: Pollution	20
Another Negative Aspect of the Present Energy System: The Coming Exhaustion of Our Present Sources	22
 Chapter 3. How Do We Get Our Energy Right Now?	 25
Introduction	25
A Summary of Our Present Energy Sources	25
Making Electricity	26
Fossil Fuels	29
How We Get Our Energy in Industry	34
Problems of the Near Energy Future	36
How Energy Is Transported Now	37
Our Finite Energy Sources	38

Chapter 4. Shall We Run Out of Energy in Our Time?	39
Present Fuels Are Limited	39
How Do We Estimate the Fossil Fuels Left?	39
The French Farmer	40
Resources Exhaust Suddenly	41
The Date of the Maximum Production Rate—The Effective End	42
When Will The Maximum Production Rate Be Reached?	43
The Effect on the Exhaustion Date of Rising Living Standards and Population Growth ...	45
How the Rate of Production of a Resource Will Vary with Time	45
The Critical Year of the Maximum	46
The Effect of Change in Price of a Resource on Its Use Rate	47
How an Estimate of 1500 Years of Coal Can Be Revised to Less than 30 Years	48
When Shall We Run Out of Oil and Natural Gas?	49
Running Out of Coal, Too	50
More Pollution?	51
What Would Happen If We Stopped the Growth of Our Economies?	51
Is Conservation the Answer?	52
Shall We Run Out of Fossil Fuels in Our Time?	53

Chapter 5. How Long Does It Take to Develop and Build Up a New Technology?	55
Introduction	55
Stages in Developing a New Technology	56
The First Stage—Dreams	56
The Second Stage—Fundamental Research	57
The Third Stage—Developmental Research	57
The Fourth Stage—Commercialization	57
The Cost of the Various Stages of Developing Technology	58
Historical Guidelines Tell Us How Long Technologies Take to Develop	59
It is Likely to Take 25–50 Years (1–2 Generations) to Develop New Energy Sources	59
Monetary Aspects of Building a New System	60
A Near Thing?	60

PART II. ALTERNATIVES: WHAT COULD REPLACE OUR EXHAUSTING FUELS?

Chapter 6. The Dream of Cheap, Clean Atomic Energy	69
The Beginning of the Dream	69
The Dream Continues	70
A Quantitative Comparison	71
The Dream Fades?	71
Types of Atomic Reactors	72
The Fission Reactor	72
Uranium—The Active and the Stable Forms	73
How Fission Reactors Work	73
The Difficulty with Nonbreeder Fission Reactors: Exhaustion	75
Will the Breeder Reactor Save the Situation?	77
The Drawbacks of Breeder Reactors	79

Chapter 7. Fission Reactors—What Can Go Wrong	81
Introduction	81
Fission Reactor Accidents—A Few Close Calls	81
What Can Go Wrong?	81
The Brown Ferry Mishap—Human Error in Action	83
Three Mile Island—“But No One Was Killed”	84
Biological Hazards of Nuclear Radiation—“Where Does It Hurt?”	84
What Increases in Background Radiation Are Expected if	
We Switch to Atomic Power?	85
Cancer-Causing Cell Damage by Radioactive Substances	85
The Dose Rate Affects the Extent of Biological Damage	87
Dumping Radioactive Garbage in Whose Backyard?	89
Chapter 8. Dreaming About the Future:	
Abundant Clean Energy from Atomic Fusion	91
Fusion?	91
Fusion: Another Atomic Alternative	91
The Advantages of Fusion as an Energy Source	92
The Diluteness of Deuterium	92
Is the Fusion Concept Utopian?	92
Atomic Fission and Atomic Fusion	93
But Shall We Actually Be Able to Attain the Fusion Process?	94
Difficulties in Realizing a Controlled Atomic Fusion Process	95
Plasmas	96
The Difficulty of Containing a Plasma in a Bottle Is That It Escapes	96
Another Possible Method of Getting Energy from Fusion	99
What Has Been the Progress of the Laser Method for Fusion?	101
Time	104
Is Fusion the Best Energy-Producing Prospect of Them All?	104
Fusion Compared with Other Abundant Clean Energy Sources	105
Chapter 9. The Most Available Energy Source: The Sun	107
Energy from the Sun	107
The Sun’s Expected Life	107
How Much of the Solar Energy Radiated from the Sun Reaches the Earth?	109
Solar Energy Reaching the Earth	110
Solar Energy per Person	111
How Much Energy Does the Average Person Consume?	112
Trying to Allow for the Future: How Much Energy Will Be Needed	
by the Years 2000 and 2050?	113
Solar Energy is Dilute	114
How Much of the Earth’s Surface Can Be Used for Solar Collectors?	114
What Will Be the Efficiency of Collection of Solar Energy?	115
Will the Amount of Solar Energy Which We Could Collect Be Enough to	
Supply Our Total Energy Needs?	116
Shall We Need More Energy than We Have Calculated Above in the Further Future?	117
To What Medium Shall We Convert Solar Energy for Use?	117
How Will We Get Solar Energy from the Places Where It Is Easily Available	
to Where It Is Needed?	119

How Much Time Will Be Needed to Make the Solar Collectors?	120
If Solar Energy Is Readily Available, Why Wasn't Its Collection Developed Many Years Ago?	123
The Strange Situation of Countries with Solar Energy That Do Not Collect the Solar Energy	123
Chapter 10. Converting Solar Energy to Useful Fuel	125
Introduction	125
The Solar Spectrum	125
The Photovoltaic Method of Converting the Sun's Energy to Usable Energy on Earth	127
Is the Photovoltaic Method of Collecting Solar Energy Too Expensive?	129
Thin Film Photovoltaics	131
Photovoltaic Collectors in Orbit	132
The Mirror Concentrator Method	134
Ocean Thermal Energy Collectors (OTEC)	135
To What Extent Have the Methods Described in this Chapter Actually Been Built and Used?	137
Chapter 11. Household Energy from the Sun	141
Introduction	141
The Production of Hot Water	143
Space Heating of Houses	143
Space Cooling	146
Household Electricity	148
What Do We Do When the Sun Goes Down?	149
Will Solar Energy for Households Be Commercially Available Before Oil Runs Out?	151
Chapter 12. Transport and Industry Run On Electricity and Hydrogen ...	153
Introduction	153
Running Cars in the Post-Fossil-Fuel World	154
Could We Run Cars on Batteries, Charged by Electricity?	156
Cars Run on Batteries Which Work with Lead Electrodes	156
The Sodium-Sulfur Battery	157
A Source of Energy to Charge Batteries for Electric Cars	158
Hydrogen-Driven Cars	159
Hydrogen-Driven Planes	160
Fuel Cells: How to Get Back Electricity from Hydrogen Derived from the Energy of Solar Radiation	161
The Poor Efficiency of Ordinary Engines	163
The Better Efficiency of Electrochemical Engines	164
Running Industry on Hydrogen	164
Foods from Hydrogen	165
Metallurgy	167
Chapter 13. Tides, Geothermal Heat, and the Big Winds	169
The Big Winds: How They Could Be Used to Give Hydrogen Fuel and Electrical Energy for Cities	169
Could Wind Be a Reliable Source of Energy on a Large Scale?	169
Could Wind Generators Produce Household Electricity?	170

More Wind Energy Estimates 171

The Big Winds 171

Winds at Sea Are Stronger 174

How Would Wind Energy Be Stored on a Massive Scale? 174

Would Massive Wind Power Be a Practical Proposition? 177

It Is Always the Cost that Counts 181

Energy from the Tides? 181

Energy Beneath Our Feet 185

How Hot Rock Geothermal Energy Might Become Practical 187

Difficulties in the Attainment of Hot Rock Geothermal Energy 187

Low-Grade Geothermal Energy 190

Summary of the Prospects of Geothermal Energy 190

Chapter 14. Energy Storage and Transmission 193

Energy Carriers: A Choice Among Three 193

Sources and Media 194

What Are the Possible Media (Carriers of Energy)? 194

Pros and Cons of the Various Media 195

Transmitting Energy Over Long Distances 196

Why Long Distance Electric Transmission Is Not Acceptable 197

Hydrogen Could Help Reduce the Cost of Sending Energy Over Long Distances 198

Very Long-Distance Transmission of Energy 198

PART III. THE HYDROGEN ECONOMY

Chapter 15. Methods of Mass-Producing Hydrogen 205

Introduction 205

The Cyclical Chemical Method for Producing Hydrogen 205

Disadvantages of the Cyclical Thermal Method 207

The Electrochemical Method of Obtaining Hydrogen 208

Getting the Energy Back from Gaseous Hydrogen at the User Terminal 211

What of Homes and the Electricity We Now Use in Them? 212

The Advantages of Using Fuel Cells 213

Chapter 16. The Storage of Abundant Clean Energy 215

Introduction 215

Methods of Storing Energy 216

Storage of Energy in the Form of Heat 217

Storing Energy in Its Electrical Form 218

The Pros and Cons of Heat and Electrochemical Storage 218

Storing Gaseous Energy Underground 219

What Methods Will Be Most Used in Our Time for Energy Storage? 219

Chapter 17. Beyond the Hydrogen Economy: Some Futuristic Ideas 223

Concepts for the Next Few Hundred Years 223

Concepts of the Next Few Thousand Years 223

PART IV. EXTRASCIENTIFIC CONSIDERATIONS

Chapter 18. The Politics of Survival	233
Introduction	233
The Direction of Major Research Funding Depends upon Politicians	234
What Does Survival Mean?	235
The Idea of Vested Capital	236
The Tobacconist	236
The Politician's Dilemma	237
Economies Cannot Expand Forever—When Will Growth Stop?	238
Energy Disaster?—People, Politics, Government Funds, and Research	239
 Chapter 19. Answers	 241
 <i>Glossary</i>	 243
<i>Index</i>	253

