

Contents

Preface

xv

1. Fundamentals of Energy Science and Technology 1

- 1.1 Introduction 1
- 1.2 Energy Sectors 2
- 1.3 Oil Crisis of 1973 2
- 1.4 Classification of Energy Resources 3
- 1.5 Consumption Trend of Primary Energy Resources 4
- 1.6 Importance of Non-conventional Energy Sources 5
- 1.7 Energy Chain 6
- 1.8 Common Forms of Energy 7
- 1.9 Advantages and Disadvantages of Conventional Energy Sources 7
- 1.10 Salient Features of Non-conventional Energy Sources 8
- 1.11 Environmental Aspects of Energy 9
- 1.12 Energy Densities (Heating Values) of Various Fuels 13
- 1.13 World Energy Status 14
- 1.14 Energy Scenario in India 17
- Review Questions 24*

2. Energy Conservation 25

- 2.1 Introduction 25
- 2.2 Salient Features of 'Energy Conservation Act' 27
- 2.3 Various Aspects of Energy Conservation 28
- 2.4 Principles of Energy Conservation 29
- 2.5 General Electrical ECOs (Energy Conservation Opportunities) 31
- 2.6 Cogeneration 32

2.7	Combined Cycle (Binary Cycle) Plants	34
	<i>Review Questions</i>	37
3.	Energy Storage	39
<hr/>		
3.1	Introduction	39
3.2	Necessity of Energy Storage	39
3.3	Energy Storage Methods	40
	<i>Review Questions</i>	57
4.	Solar Energy—Basics	58
<hr/>		
4.1	Introduction	58
4.2	The Sun	59
4.3	The Earth	59
4.4	Sun, Earth Radiation Spectrums	60
4.5	Extraterrestrial and Terrestrial Radiations	61
4.6	Depletion of Solar Radiation	63
4.7	Solar Time	66
4.8	Basic Sun-Earth Angles	66
4.9	Solar Day Length	70
4.10	Estimation of Intensity of Terrestrial Radiation	72
4.11	Solar Radiation on Inclined Plane Surface	73
4.12	Solar Radiation Data	75
4.13	Estimation of Monthly Average, Daily Total Radiation on Horizontal Surface	76
4.14	Estimation of Monthly Average, Daily Diffuse Radiation on Horizontal Surface	77
4.15	Monthly Average, Daily Global Radiation on Tilted Surface	77
4.16	Measurements of Solar Radiation Data	78
	<i>Review Questions</i>	80
	<i>Problems</i>	81
5.	Solar Thermal Systems	82
<hr/>		
5.1	Introduction	82
5.2	Solar Collectors	82
5.3	Solar Water Heater	90
5.4	Solar Passive Space Heating and Cooling Systems	91
5.5	Solar Industrial Heating Systems	95
5.6	Solar Refrigeration and Air-conditioning Systems	96

- 5.7 Solar Cookers 100
- 5.8 Solar Furnaces 103
- 5.9 Solar Greenhouse 105
- 5.10 Solar Desalination 109
- 5.11 Solar Thermo-Mechanical Systems 111
- Review Questions 116*

6. Solar Photovoltaic Systems 117

- 6.1 Introduction 117
- 6.2 Solar Cell Fundamentals 118
- 6.3 Solar Cell Characteristics 125
- 6.4 Solar Cell Classification 131
- 6.5 Solar Cell, Module, Panel and Array Construction 136
- 6.6 Maximizing the Solar PV Output and Load Matching 141
- 6.7 Maximum Power Point Tracker (MPPT) 142
- 6.8 Balance of System Components 144
- 6.9 Solar PV Systems 144
- 6.10 Solar PV Applications 147
- Review Questions 151*

7. Wind Energy 152

- 7.1 Introduction 152
- 7.2 Origin of Winds 154
- 7.3 Nature of Winds 156
- 7.4 Wind Turbine Siting 160
- 7.5 Major Applications of Wind Power 161
- 7.6 Basics of Fluid Mechanics 162
- 7.7 Wind Turbine Aerodynamics 166
- 7.8 Wind Turbine Types and Their Construction 173
- 7.9 Wind Energy Conversion Systems (WECS) 185
- 7.10 Wind-Diesel Hybrid System 189
- 7.11 Effects of Wind Speed and Grid Condition (System Integration) 191
- 7.12 Environmental Aspects 191
- 7.13 Wind Energy Programme in India 193
- Review Questions 195*
- Problems 196*

8.	Biomass Energy	197
8.1	Introduction	197
8.2	Photosynthesis Process	198
8.3	Biofuels	199
8.4	Biomass Resources	201
8.5	Biomass Conversion Technologies	204
8.6	Urban Waste to Energy Conversion	206
8.7	Biomass Gasification	208
8.8	Biomass to Ethanol Production	210
8.9	Biogas Production from Waste Biomass	214
8.10	Biomass Energy Programme in India	225
	<i>Review Questions</i>	230
9.	Geothermal Energy	232
9.1	Introduction	232
9.2	Applications	233
9.3	Origin and Distribution of Geothermal Energy	235
9.4	Types of Geothermal Resources	238
9.5	Exploration and Development of Geothermal Resources	245
9.6	Environmental Consideration	246
9.7	Geothermal Energy in India	247
	<i>Review Questions</i>	249
10.	Ocean Energy	250
10.1	Introduction	250
10.2	Tidal Energy	250
10.3	Wave Energy	260
10.4	Ocean Thermal Energy	270
	<i>Review Questions</i>	276
11.	Emerging Technologies	277
11.1	Introduction	277
11.2	Fuel Cell	277
11.3	Hydrogen Energy	293
11.4	Small Hydro Resources	303
	<i>Review Questions</i>	311

12.	Miscellaneous Non-conventional Technologies	312
12.1	Introduction	312
12.2	Magnetohydrodynamic (MHD) Power Conversion	312
12.3	Thermoelectric Power Conversion	320
12.4	Thermionic Power Conversion	324
	<i>Review Questions</i>	327
	<i>Appendix A</i>	328
	<i>Appendix B</i>	329
	<i>Bibliography</i>	330
	<i>Index</i>	333