
B. K. HODGE

**Alternative
Energy
Systems AND
Applications**

Contents

1	Energy in the United States	1
1.1	Energy and Power	1
1.2	Energy Usage and Standard of Living	1
1.3	A Historical Perspective of Energy Usage in the United States	3
1.4	United States Energy Usage in 2007	6
1.5	Worldwide Energy Use	12
1.6	Efficiencies	13
1.7	Closure	15
	Review Questions	15
	References	15
2	Fundamentals of Turbomachinery	16
2.1	Definition of a Turbomachine	16
2.2	Turbomachine Classifications	16
2.3	Turbomachine Analysis	17
2.4	Example Problems	22
2.5	Closure	27
	Review Questions	27
	Exercises	28
	References	29
3	Hydropower	30
3.1	Introduction	30
3.2	Examples of Hydroelectric Dams	31
3.3	Hydraulic Analysis	33
3.4	Turbine Specific Speed Considerations	38
3.5	Energy Transfer in Turbines	43
3.6	Closure	52
	Review Questions	52
	Exercises	53
	References	55

4 Wind Energy 56

- 4.1 Introduction 56
- 4.2 Fundamental Concepts 59
- 4.3 Wind Energy Resources 66
- 4.4 Wind Turbine Operation 73
- 4.5 Commercial Wind Turbine Examples 80
- 4.6 Closure 84
- Review Questions 85
- Exercises 85
- References 87

5 Combustion Turbines 88

- 5.1 Introduction 88
- 5.2 The Combustion Turbine 88
- 5.3 The Air-Standard Brayton Cycle 91
- 5.4 Actual Gas Turbine Cycle Analysis 92
- 5.5 Combustion Turbine Cycle Variations 102
- 5.6 Examples of Commercially Available Combustion Turbines 104
- 5.7 Closure 111
- Review Questions 111
- Exercises 112
- References 113
- Websites 113

6 Solar Energy Fundamentals 114

- 6.1 Introduction 114
- 6.2 Radiation Heat Transfer Review 114
- 6.3 Sun Path Description and Calculation 129
- 6.4 Sun Path Development Using Mathcad 134
- 6.5 The Solar Energy Database 141
- 6.6 Closure 144
- Review Questions 144
- Exercises 145
- References 148

7 Active Solar Thermal Applications 149

- 7.1 Introduction 149
- 7.2 Flat-Plate Collector Fundamentals 153

7.3	Solar Collector and Weather Data	159
7.4	The f -Chart Method	167
7.5	Other Solar Thermal Systems	174
7.6	Closure	175
	Review Questions	176
	Exercises	176
	References	178
	Appendix A	179

8 Passive Solar Energy 191

8.1	Fundamental Concepts of Passive Solar Energy	191
8.2	Quantifying Passive Solar Features	197
8.3	The First-Level Method or Rules of Thumb	200
8.4	The Second-Level Method (LCR Method)	202
8.5	Daylighting	203
8.6	Passive Solar Software	205
8.7	Closure	206
	Review Questions	207
	Exercises	207
	References	208
	Appendix A	209

9 Photovoltaic Systems 225

9.1	Introduction	225
9.2	Photovoltaic Cell Fundamentals	226
9.3	Photovoltaic Components	233
9.4	Photovoltaic Systems	241
9.5	Closure	246
	Review Questions	247
	Exercises	247
	References	248

10 Fuel Cells 249

10.1	Introduction	249
10.2	Fuel Cell Fundamentals	249
10.3	Fuel Cell Thermodynamics Fundamentals	252
10.4	Fuel Cell Types	258

10.5	Fuel Cell Availability	264
10.6	Closure	266
	Review Questions	267
	Exercises	267
	References	268
11	Combined Heat and Power (CHP) Systems	269
11.1	Introduction	269
11.2	CHP System Fundamentals	272
11.3	CHP System Economics and Operation	277
11.4	Economic Assessment of CHP Suitability	283
11.5	CHP System Example	288
11.6	Closure	292
	Review Questions	293
	Exercises	293
	References	295
12	Biomass	296
12.1	Introduction	296
12.2	Biomass Availability	298
12.3	Biomass Fundamentals	300
12.4	Biomass Characteristics	302
12.5	Biomass Based Fuels and Products	304
12.6	Municipal Solid Waste (MSW)	319
12.7	Closure	326
	Review Questions	327
	Exercises	328
	References	328
	Websites	329
13	Geothermal Energy	330
13.1	Introduction	330
13.2	Geothermal Resources	332
13.3	Geothermal Energy Systems	335
13.4	Geothermal Examples	348
13.5	Ground-Source Heat Pumps	350
13.6	Closure	355

Review Questions **355**

Exercises **356**

References **356**

Websites **357**

14 Ocean Energy 358

14.1 Introduction **358**

14.2 Ocean Thermal Energy Conversion (OTEC) **358**

14.3 Tidal Energy **370**

14.4 Wave Energy **376**

14.5 Closure **380**

Review Questions **380**

Exercises **381**

References **381**

Websites **382**

15 Nuclear Energy 383

15.1 Introduction **383**

15.2 Fundamentals of Nuclear Energy **384**

15.3 Nuclear Power **390**

15.4 Fusion Power **404**

15.5 Closure **410**

Review Questions **410**

Exercises **411**

References **411**

Websites **412**