

CONTENTS

Introduction	xiii
1 Energy overview	1
1.1 The evolution of power demand	1
1.2 Characteristics of power consumption and prospects for the future	7
1.3 Power resources and their distribution: the dominant role of solar energy	9
1.4 Electricity	14
1.4.1 Conversion processes	14
1.4.2 Cost aspects of conventional electricity	20
1.4.3 Heating and cooling with heat pumps	22
1.4.4 Other consumption patterns	23
1.5 The energies of the future: environmental and economic aspects	24
1.5.1 The need for a long-term energy strategy	24
1.5.2 Qualitative review of conventional power sources	26
1.5.2.1 Prospects of petroleum	26
1.5.2.2 Natural gas	27
1.5.2.3 Shale oil	27
1.5.2.4 Coal	27
1.5.2.5 Natural gas and petroleum from coal	29
1.5.2.6 Energy from nuclear reactors	29
1.5.2.7 Geothermal energy	31
1.5.3 The threat of thermal pollution	32
2 Solar energy conversion	35
2.1 Solar radiation available on the earth's surface	35
2.1.1 Gross intensity and spectral response in space and on the ground	35
2.1.2 Measuring devices currently in use	39
2.1.3 Present measuring practice and future needs	44

2.2	Indirect solar energy: water, wind, photosynthesis	52
2.3	Direct solar energy	67
2.3.1	General problems related to large-scale conversion of solar radiation	67
2.3.1.1	Area and siting problems for the large-scale use of solar energy	67
2.3.1.2	Environmental impact of solar energy utilization	69
2.3.1.3	Prospects of solar energy in some broad demand areas	71
2.3.2	Physical principles of the conversion of solar radiation into heat	73
2.3.3	Solar heat applications	83
2.3.3.1	Solar water heating	84
2.3.3.2	Solar heating of swimming pools	85
2.3.3.3	Solar dryers	85
2.3.3.4	Solar cooking	88
2.3.3.5	Space heating	88
2.3.3.6	Air conditioning and cooling	99
2.3.3.7	Desalination of water	107
3	Solar electricity	115
3.1	Overview of potential conversion processes for solar electricity generation	115
3.2	Thermodynamic conversion	117
3.2.1	General considerations	117
3.2.1.1	The thermodynamic conversion process	117
3.2.1.2	Overview of solar collector families	117
3.2.1.3	Orientation of solar collectors following the sun's movement	120
3.2.1.4	Concentration rate of focusing collectors: physical limits	133
3.2.2	The flat-plate collector type generator	136
3.2.3	The linear-focus type generator	144
3.2.3.1	An historical retrospect	144
3.2.3.2	Design considerations for parabolic troughs	146
3.2.3.3	The faceted mirror-strip collector	149
3.2.3.4	Linear focus-type power plants	152
3.2.4	The central receiver solar power plant	157
3.2.4.1	Tower power plant	157
3.2.4.2	Paraboloidal dish array plant	174
3.2.5	Comparative summary of solar collectors associated with thermo-dynamic converters	177
3.2.6	The ocean thermal energy conversion plant	177
3.3	Photovoltaic conversion	179
3.3.1	The solar cell	179
3.3.1.1	Introduction	179
3.3.1.2	The conventional silicon solar cell	180
3.3.1.3	The cadmium sulphide solar cell	189
3.3.1.4	The gallium arsenide solar cell	190
3.3.1.5	History of the photovoltaic effect	191
3.3.2	The photovoltaic generator	195
3.3.2.1	The solar panel	195
3.3.2.2	The storage battery	199

3.3.2.3 Solar panels under focusing sunlight	200
3.3.2.4 Present state of photovoltaic power generation	209
3.3.3 Prospects of photovoltaic power generation	214
3.3.3.1 The economy of scale	214
3.3.3.2 New technological approaches: the thin solar cell	217
4 Prospects of solar power for large-scale electricity production	224
4.1 The land demand for large-scale solar electricity generation	224
4.2 Implementation and siting of solar power generators	225
4.3 Independent solar generator systems to complement central power plants	228
4.4 Large-scale electricity storage	236
4.5 Load capacity prospects of solar power plants	240
4.6 Design and performance considerations of photovoltaic power plants	245
4.7 Cost estimates of an operational photovoltaic power plant	247
5 Outlook	250
Appendix 1	
Fundamentals of direct solar energy conversion by means of solar cells	252
1. The photovoltaic effect	252
1.1 Physical aspects of the conversion effect	252
1.2 Comparative analysis of solar cells	273
2. Basic characteristics of present solar cells	275
Appendix 2	
Survey and comparison of small-scale independent power plants	279
Appendix 3	
Conversion factors	282
References	285
Index	287