

Water, Energy, and Environment – A Primer

Allan R. Hoffman



Contents

Preface	xi
Acknowledgements	xv
Acronyms	xvii
Epigraph	xxi

Chapter 1

Water and its global context	1
1.1 Earth's Water Resources	1
1.2 Saline Water and Desalination Processes	2
1.3 Energy Requirements and Costs of Desalination	5
1.4 Demand for Freshwater	6
1.5 Implications of Limited Access to Freshwater	9
1.6 Actions to Increase Access to Freshwater	10
1.7 Gender Equity Issues	11

Chapter 2

Energy and its global context	13
2.1 Energy's Role in Society	13

2.2	Energy Realities	14
2.3	What is Energy?	15
2.4	Energy Trends	16
2.4.1	Important questions	18
2.4.2	How is energy used?	18
2.4.3	Electrification	21

Chapter 3

Exploring the linkage between water

and energy	23	
3.1	Indirect Linkages	24
3.2	The Policy Linkage	25
3.3	The Conundrum	25
3.4	Addressing the Conundrum	26
3.5	The Need for Partnership	27

Chapter 4

Energy production and its consequences for

water and the environment	29	
4.1	Impacts	29
4.2	More on Climate Change	32
4.3	Environment and Religion	33
4.3.1	The theocentric worldview	33
4.3.2	The anthropocentric worldview	34
4.3.3	Other worldviews	34

Chapter 5

Energy options	37	
5.1	Fossil Fuels	37
5.2	Nuclear Energy	38
5.3	Geothermal Energy	38
5.4	The Sun	38
5.5	Energy Efficiency	39
5.5.1	Energy demand	40

Contents	vii
----------	------------

5.5.2 Implementation	41
5.5.3 Saving energy	42
5.5.4 Accelerating implementation	43
5.5.5 Energy star	44
5.5.6 The lighting revolution	45
5.5.7 Energy efficiency in buildings	48
5.5.7.1 Zero energy buildings	48
5.5.7.2 Electrochromic windows	52
5.6 Energy Efficiency in Industry	54
5.7 Energy Efficiency in Transportation	56

Chapter 6

Fossil fuels	61
6.1 Coal	62
6.1.1 Carbon capture and sequestration	63
6.1.2 A conundrum	65
6.2 Petroleum	68
6.2.1 Oil spills	68
6.2.2 Peak oil	72
6.3 Natural Gas	76
6.3.1 Methane hydrates	77
6.3.2 Fracking	80

Chapter 7

Nuclear power	85
7.1 Nuclear Fission	85
7.1.1 Fission fundamentals	85
7.1.2 Introduction to nuclear issues	87
7.1.3 Issues	89
7.2 Nuclear Fusion	91
7.2.1 Fusion fundamentals	91
7.2.2 Numbers	93
7.2.3 Barriers to fusion	94
7.2.4 Pros and cons	95
7.2.5 Thoughts	95

Chapter 8

Renewable energy	97
8.1 The Sun's Energy Source and Radiation	
Spectrum	98
8.2 Direct Solar Energy	102
8.2.1 Photovoltaics	102
8.2.2 Concentrating solar power (CSP)	108
8.2.2.1 Power tower	109
8.2.2.2 Linear concentrator	110
8.2.2.3 Dish engine	111
8.2.2.4 CSTP history	112
8.2.2.5 Advantages and disadvantages	112
8.2.2.6 Thermal storage	113
8.2.2.7 Current status	114
8.2.2.8 Concentrating photovoltaics (CPV)	115
8.3 Solar Power Satellite (SPS) System	116
8.4 Hydropower and Wind Energy	119
8.4.1 Hydropower	119
8.4.2 Wind energy	121
8.4.2.1 Onshore wind	121
8.4.2.2 History	124
8.4.2.3 An onshore limitation	124
8.4.2.4 Offshore wind	125
8.5 Biomass Energy	129
8.5.1 Sources of biomass	129
8.5.2 Wood	129
8.5.3 Biofuels	130
8.5.4 Algae	131
8.5.5 Biochar	132
8.5.6 The future	132
8.6 Geothermal Energy	134
8.6.1 Sources of geothermal energy	134
8.6.2 Manifestations of geothermal energy	135
8.6.3 Uses of geothermal energy	135
8.6.3.1 Geothermal power generation	136
8.6.3.2 Ground-source heat pumps	138
8.6.4 An unusual source of geothermal energy	140

	Contents	ix
8.7 Ocean Energy	142	
8.7.1 Wave energy	142	
8.7.1.1 Wave energy conversion devices	142	
8.7.1.2 Potential and pros and cons	143	
8.7.2 Ocean current energy	144	
8.7.3 Tidal energy	146	
8.7.3.1 Barrage	146	
8.7.3.2 History	147	
8.7.3.3 Environmental impacts	147	
8.7.4 Ocean thermal energy conversion (OTEC) ..	147	
8.7.4.1 Barriers	148	
8.7.4.2 OTEC technologies	148	
8.7.4.3 Other cold water applications	149	
8.7.4.4 OTEC R&D	149	

Chapter 9

Energy storage	151
9.1 Storage and Grids	151
9.2 Types of Storage	152
9.2.1 Traditional and advanced batteries	153
9.2.1.1 Lead–acid	153
9.2.1.2 Sodium sulfur	153
9.2.1.3 Nickel–cadmium	154
9.2.1.4 Lithium-ion	154
9.2.1.5 Supercapacitors	155
9.2.2 Flow batteries	156
9.2.3 Flywheels	157
9.2.4 Superconducting magnetic energy storage (SMES)	158
9.2.5 Compressed air energy storage (CAES)	159
9.2.6 Pumped storage	160
9.2.7 Thermal storage	161
9.3 Applications	161
9.4 Costs	162
9.5 Fundamental Change	163

Chapter 10

<i>Policy considerations</i>	165
10.1 Important Questions	166
10.1.1 Is there a physical basis for understanding global warming and climate change?	166
10.1.2 Is there documented evidence for global warming and climate change?	168
10.1.3 Can global warming and climate change be attributed to human activities, and what are those activities?	170
10.1.4 What are the potential short- and long-term impacts of global warming and climate change with respect to water supply, environment, and health? What is the anticipated time scale for these impacts?	172
10.1.5 What can be done to mitigate the onset and potential impacts of global warming and climate change?	179
<i>References</i>	183
<i>Index</i>	189