

Table of Contents

Acknowledgements	vi
Preface	xiv
Chapter 1 - Introduction	1
Introduction	1
1.1 Renewable Energy <i>Eco-nomics</i>	6
1.2 What Is Energy?	9
1.3 Energy, Pollution and Climate Change	19
Chapter 2 – Energy Efficiency	21
2.1 New Home-Design Considerations	22
2.2 Updating an Older Home	31
2.3 Appliance Selection	48
2.4 Energy-Efficient Lighting	54
2.5 Water Supply and Energy Conservation	59
2.6 Phantom Loads	69
2.7 Eco-nomic Ideas for Renters and Homeowners Alike	71
Chapter 3 - A Renewable Energy Primer	75
3.1 Summarizing the Case for Energy Efficiency	75
3.2 Generating Thermal Energy	77
3.3 Electrical Energy Generation Overview	79
Payments – Net Metering Programs	79
Payments – Feed-in Tariffs	80
Rebates and Incentives	82
3.4 Electrical Generation Technology	82
Digging Deeper into the Details	87
The Changing Seasons	88
Hybrids (Winter Season)	90
Hybrids (Summer Season)	92
Another Look at Phantom Loads	93
Phantom Load Management	93
Metering and Such	94
Is it Economical?	94
Selecting a Dealer	95
Chapter 4 – A Showcase of Renewably-Energy-Powered Homes	99
Introduction	99
4.1 The Kemp Off-Grid Camper	105
Seasonal and weekend off-grid solar system	
4.2 The Beevor Family Cottage	111
Seasonal and Weekend Solar System	

4.3	Fairmont Hotels' "Kenauk Cabins" A Luxury Resort Company Goes Off-Grid	113
4.4	The Houston/Lebfevere Earth Ship 3 An Affordable Entry into Solar-Powered Energy Independence	117
4.5	Anderson-Von Mertens Home Off-Grid in New Hampshire	123
4.6	The Kemps' Zero-Carbon Home Sustainable Off-Grid Living	129
4.7	The Miller-Cameron Home Upgrading an Urban Century Home	143
4.8	Surya House The Dunkley-Fisher Natural Living Home	149
4.9	Earth Energy Case Study The Goodman-Leblanc Home	153
Chapter 5 - Heating and Cooling with Renewable Energy		161
5.1	Passive Solar Heating	163
5.2	Active Solar Air Heating	166
5.3	Solar Water Heating	169
5.4	Solar Pool Heating (see also Chapter 14)	191
5.5	Active Solar Space Heating	195
5.6	Heating with Renewable Fuels	201
5.7	Space Cooling Systems	227
5.8	Earth Energy with Geexchange	230
Chapter 6 - Photovoltaic Electricity Generation		237
	What is Watt?	237
	PV Cell Construction	238
	PV Output Rating Caution	239
	PV Module Lifespan	240
	PV Module Maintenance	240
	PV Module Installation Checklist	240
Chapter 7 – Electricity from the Wind		251
	Home-Sized Wind Turbines	252
	Wind Turbine Ratings	253
	Rating Jargon	255
	Wind Resources in Your Area	255
	Wind Mapping	257
	Site Wind Measurement Study	259
	Locating a Wind Turbine	260
	The Urban Wind Turbine a.k.a. <i>The Urbine</i>	260
	A Proper Location	262
	Getting Started: A Word About Safety	263

Tower Foundations and Anchors	266
Self-Supporting Towers	266
Guy Wire Supported Towers	266
Anchors	267
Guy Wires	268
Electrical Supply Leads	269
Erection of the Tower with a Crane	270
Pre-lift Check List	270
The Lift	270
Hinged Tower Lifting	271
Final Assembly	277
Vertical Axis Wind Turbines	279
Recycling a Classic Jake: A Homeowner's Story by Josée Guénette	281
Chapter 8 - Micro Hydro Electricity Production	283
Understanding the Technology	283
What Is a Good Site?	286
Water Head Level	287
Flow at the Turbine Intake	287
Zero Head Sites with Good Flow	288
Penstock Design Issues	289
Additional Pipeline Construction Details	289
Electrical Energy Transmission Distance	290
Site Selection Summary	291
Connecting the Micro Hydro Parts	291
Tantalus View Retreat- A Mountain Homestead	295
Chapter 9 - Battery Selection	299
Why Use Batteries?	299
What About Fuel Cells?	299
Battery Selection	300
How Batteries Work	300
Depth of Discharge	301
Operating Temperature	303
Battery Sizing	304
Hydrogen Gas Production	306
Safe Installation of Batteries	307
Battery and Energy Metering	308
Summary	310

Chapter 10 - DC Voltage Regulation	311
Series Controller	311
Maximum Power Point Tracking	313
Diversion Charge Controller	315
Voltage Regulator Selection	316
Charging Strategy (all controller configurations)	316
Nighttime	317
Sunrise – Bulk Charge	317
Absorption or Tapering Charge	317
Float Stage	318
Equalization Mode	319
Diversion Loads	320
Extra Features	322
Chapter 11 - DC to AC Conversion Using Inverters	323
Inverter AC Waveforms	324
Grid-Interconnection Operation (grid-dependent or batteryless mode)	326
Grid-Interconnection with Battery Backup (grid-interactive mode)	327
Batteryless Grid-Tie Inverters	328
Off-Grid Inverters (including grid-interconnected systems with battery backup)	329
Inverter Ratings	329
Sine Wave Versus Modified Square Wave Inverter Models	329
Output Voltage	330
Inverter Continuous Capacity	330
Inverter Surge Capacity	331
Inverter Temperature Derating	331
Battery Charging Features	331
DC to DC Voltage Converters	332
Summary	332
Chapter 12 – Fossil-Fueled Backup Power Sources	333
Generator Types	334
Generator Rating	334
Voltage Selection	337
Fuel Type and Economy	338
Generator Noise and Heat	339
Generator Operation	339
Other Considerations	340
Further Notes on Biodiesel Fuel	340
Renewable Energy Generators	341
Combined Heat and Power Generation	341

Chapter 13 - Putting It All Together Safely	343
A Word or Two about Safety	343
Electrical Codes and Regulatory Issues	343
What Goes Where?	346
Direct Current (DC) Wiring Overview	347
AC/DC Disconnection and Over-Current Protection	348
Battery Cables	351
Wiring Color Codes	351
System Grounding	351
Lightning Protection	353
Interconnecting the Parts	353
PV Array	353
Wind and Hydro Turbine Connection	355
Renewable Source to Battery Feed Cable	356
Over-Current Protection and Disconnect Devices	356
Battery Wiring	357
Battery Voltage Regulation	359
Series Regulator	359
Shunt or Diversion Regulator	360
The Inverter	361
DC Input Connection	361
AC Output Connection	361
The Generator	362
Energy Meters	362
Chapter 14 – Pools, Hot Tubs, and Saunas Powered by Sol	365
Swimming Pools and Hot Tubs (Spas)	365
Saunas (and Steam Rooms)	366
14.1 Conventional Swimming Pools Off-Grid	367
14.2 An Alternative Way Forward: the Eco-Pool Concept	371
Overview	371
Eco-Pool Construction	373
14.3 Hot Tubs and Solar Power: A Marriage Made in Heaven	387
Wood-Heated Hot Tubs	388
Solar-Heated Hot Tubs	389
Chapter 15 – Communications Beyond the “End of the Line”	393
Cellular Phone Service	393
Whole Home (Fixed) Cell Service	395
Point-to-Point Phone Service Extender	396
High-Frequency Phone Service Extender Systems	400
Fixed-Point Broadband CDMA (Digital) Wireless Service (provided by the phone company)	400
Radiotelephone Service	400
Satellite Phone Service	400

Wide-Area Wireless High-Speed Internet Service	401
Satellite Internet Service	402
Voice Over Internet Protocol (VoIP) Service	402
Conclusion	406
Chapter 16 – Biofuels	407
Zero-Carbon Liquid Fuels	407
An Introduction to Biofuels	407
Ethanol from Food – A Non-Starter	407
Cellulosic Ethanol – The Better Choice	410
The Downside of Ethanol	411
Biodiesel as a Source of Green Fuel	411
Biodiesel in the Transportation Sector	414
Biodiesel Composition	414
The Pros of Biodiesel	417
Blending	417
Biodiesel Concentration	418
Biodegradability and Nontoxicity	418
High Cetane Value	418
High Lubricity	418
Low Emissions	419
Renewability	419
Low Sulfur	419
The Cons of Biodiesel	420
Oxidation and Bacteriological Stability	420
Nitrogen Oxide Emissions	420
Cold Flow Issues	421
OEM Warranty Issues	422
The Diesel Engine	423
Engine Technology Overview	424
Fuel Injection Systems	427
Basic Fuel Injection	427
Common Rail Direct Injection	428
The Biodiesel Production Process	429
Small-Scale Biodiesel Production System	431
The WVO Receiver/Dryer	435
The Biodiesel Reaction Tank	436
Sodium Methoxide System	437
Biodiesel Washing System	439
Biodiesel Drying and Final Filtration	441
Fuel Dispensing and Storage	442
The Fuel Dispensing Unit	442
Cold Weather Issues	443
Blending Biodiesel with Petrodiesel	444
Summary	445

Chapter 17 - Living with Renewable Energy	447
Solar Thermal Systems	447
Solar Electric Systems	447
Getting Started	447
Up and Running	450
What Else?	451
 Chapter 18 - Conclusion	 453
 Appendices	
1 Cross Reference Chart of Various Fuel Energy Ratings	455
2 Typical Power and Electrical Ratings of Appliances and Tools	456
3 Resource Guide	458
4 Magnetic Declination Map for North America	464
5 North America Sun Hours per Day (Worst Month)	465
6 North America Sun Hours per Day (Best Month)	466
7 Electrical Energy Consumption Work Sheet	467
8 North America Average Annual Wind Speed	468
* Wind Map Link for the United States	
* Wind Map Link for Canada	
9a Polyethylene SDR Pipe Friction Losses	469
9b PVC Class 160 Pipe Friction Losses	470
10 Voltage, Current and Distance charts for 12, 24, and 48 Volt Generation Systems	471
11 Wire Sizes versus Current Carrying Capacity	472
12 A Few Words on Toilets, Greywater, and Waste Management	473
13 Wind Turbine Comparison Guide	480
 Index	 485