

RENEWABLE ENERGY: TRENDS AND PROSPECTS

Table of Contents

Preface	V
Acknowledgement	X
Part One: Renewable Energy Resources, Technological Development, and Utilization	
Chapter 1: RENEWABLE ENERGY'S PLACE IN THE GLOBAL ENERGY MARKET <i>E. Willard Miller, Department of Geography, The Pennsylvania State University, University Park, PA</i>	
Chapter 2: BIOENERGY FROM BIOMASS: RENEWABLE ENERGY FROM TREES AND ORGANIC WASTE: A GLOBAL PERSPECTIVE <i>Lyndhurst Collins, Department of Geography, University of Edinburgh, Edinburgh, EH8 9XP, Scotland</i>	19
Chapter 3: SOLAR DRYING SYSTEMS FOR AGRICULTURAL PRODUCE <i>M.Y.H. Othman, K. Sopian, B. Yatim, and W.R.W. Daud, Solar Energy Research Group, University of Kebangsaan Malaysia, Selangor, Malaysia</i>	49
Chapter 4: PERSPECTIVES OF CROP RESIDUE AS A RENEWABLE ENERGY SOURCE <i>Apurba Sarkar, PDCSR, Modipuram, Meerut, U.P., India</i>	61
Chapter 5: RENEWABLE ENERGY RESOURCES FROM THE OCEANS <i>B. Bhattacharya, Department of Metallurgical Engineering, Jadavpur University, Calcutta 700 032, India and S.K. Sarkar, Department of Marine Science, University of Calcutta, Calcutta 700 019, India</i>	75

Chapter 6: OCEAN ENERGY CONVERSION – A REALITY <i>Anupam Sarkar, National Institute of Oceanography, Dona Paula, Goa - 403004, India</i>	34
Chapter 7: OCEAN POWER FROM WAVE TO WIRE <i>Richard Curran, School of Aeronautical Engineering, The Queen's University of Belfast, David Keir Building, Belfast, Northern Ireland, United Kingdom, BT9 5AG ...</i>	108
Chapter 8: THE U.S. HYDROELECTRIC POWER INDUSTRY: TRENDS AND PERSPECTIVES <i>Dmitry Mesyanzhinov and David Dismukes, Center for Energy Studies, Louisiana State University, Baton Rouge, LA</i>	133
Chapter 9: WIND POWER IN VIEW <i>Martin J. Pasqualetti, Department of Geography, Arizona State University, Tempe, AZ</i>	147
Chapter 10: MODELLING AND MEASUREMENTS OF COASTAL WIND SPEEDS <i>R.J. Barthelmie, Riso National Laboratory, Denmark and Atmospheric Science Program, Department of Geography, Indiana University, Bloomington, IN</i>	161
Chapter 11: INTEGRATION OF PHOTOVOLTAIC CELLS INTO THE GLOBAL ENERGY SYSTEM <i>Bent Sorensen, Roskilde University, Roskilde, Denmark</i>	76
Chapter 12: SOLAR PHOTOVOLTAIC ELECTRICITY: STATUS AND PROSPECTS FOR COST REDUCTION <i>A.K. Barua and Dabajyoti Das, Department of Solar Energy, Indian Association for the Cultivation of Science, Calcutta, 700 032, India</i>	199
Chapter 13: APPLICATIONS OF SOLAR THERMAL ENERGY <i>Jonathan J. Miles, College of Integrated Science and Technology, James Madison University, Harrisonburg, VA and Charles E. Iskander Yousif, Institute for Energy Technology, University of Malta, Roman Port Street, Marsaxlokk, ZTN 09, Malta .</i>	215
Chapter 14: GROUND-SOURCE HEAT PUMPS <i>Gary Phetteplace, US Army Cold Regions Research and Engineering Laboratory, 72 Lyme Rd., Hanover, NH</i>	231

Chapter 15: GEOTHERMAL ENERGY RESOURCES <i>Phillip M. Wright, Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID, and Assad I. Panah, Department of Geology and Environmental Science, University of Pittsburgh at Bradford, Bradford PA</i>	245
Chapter 16: GEOTHERMAL ENERGY FOR HEATING AND ELECTRICAL GENERATION <i>P.M. Wright, Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID, John W. Lund, Geo-Heat Center, Oregon Institute of Technology, Klamath Falls, OR and Assad I. Panah, Department of Geology and Environmental Science, University of Pittsburgh at Bradford, Bradford PA</i> . . .	271
Chapter 17: HYDROGEN POWER IN SPACE VEHICLES <i>Bryan Palaszewski, NASA John H. Glenn Research Center, Cleveland, OH</i>	298
Part Two: Sustainable Environment	
Chapter 18: HYDROELECTRIC POWER PRODUCTION: REALIZING THE BENEFITS BY RESOLVING ENVIRONMENTAL ISSUES <i>Glenn F. Cada, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN</i>	313
Chapter 19: SUSTAINABLE WIND POWERED GENERATION <i>Alfred B.O. Soboyejo, Ohio State University, Columbus, OH</i>	326
Chapter 20: IMPACTS OF RENEWABLE ENERGY DEVELOPMENTS ON REGIONAL ECOLOGY <i>Fred J. Brenner, Kimberly D. Kosick, and Corrie A. Gardner, Biology Department, Grove City College, Grove City, PA</i>	349
Chapter 21: REEVALUATING LATENT ETHANOL PRODUCTION <i>Brooks C. Pearson, Geosciences Department, State University of West Georgia, Carrollton, GA, and Sara C. Pryor, Atmospheric Science Program, Geography, Indiana University, Bloomington, IN</i>	365
Chapter 22: RENEWABLE ENERGY AND CLIMATE CHANGE <i>Dwayne S. Breger, Department of Civil and Environmental Engineering, Lafayette College, Easton, PA</i>	376

Chapter 23: SUSTAINABLE AGROECOSYSTEMS: PRODUCTIVITY, ENVIRONMENTAL QUALITY, AND RENEWABLE ENERGY <i>Fred J. Brenner, Shawn T. Robinson, and Joy H. Yates, Biology Department, Grove City College, Grove City, PA</i>	392
Chapter 24: POWER FOR THE PEOPLE: A COMPARISON OF THE U.S. AND GERMAN COMMITMENTS TO RENEWABLE ENERGY <i>Michael K. Heiman, Dickinson College, Carlisle, PA</i>	403
Part Three: Policies and Regulations	
Chapter 25: RENEWABLE ELECTRIC GENERATION IN COMPETITIVE MARKETS <i>Marwan Masri, Sulayman Al-Qudsi, and Michael C. Moore, California Energy Commission, Energy Technology Development, Sacramento, CA</i>	412
Chapter 26: THE IMPACT OF CLEAN ENERGY POLICIES ON RENEWABLE ENERGY TECHNOLOGIES <i>Marilyn A. Brown, Oak Ridge National Laboratory, Oak Ridge, TN and Walter Short, National Renewable Energy Laboratory, Golden, CO</i>	426
Chapter 27: RENEWABLE ENERGY: A CARTOGRAPHIC OVERVIEW OF STATE PROGRAMS AND REGULATORY POLICIES <i>Mark Monmonier, Department of Geography, Maxwell School of Citizenship and Public Affairs, Syracuse University, Syracuse, NY, and George A. Schnell, Department of Geography, State University of New York at New Paltz, New Paltz, NY</i>	451
Chapter 28: RENEWABLE ENERGY POLICY, PUBLIC/PRIVATE PARTNERSHIPS, AND PROMISE <i>Nancy M. Waters, Department of Biology, Lafayette College, Easton, PA</i>	460
Chapter 29: THE INTEGRATED SCIENCE AND TECHNOLOGY PROGRAM: OFFERING A NEW PARADIGM FOR TEACHING ENERGY CONCEPTS AND TECHNOLOGIES <i>Jonathan J. Miles, College of Integrated Science and Technology, James Madison University, Harrisonburg, VA, and Charles E. Iskander Yousif, Institute for Energy Technology,</i>	

<i>University of Malta, Marasaxlokk, ZTN 09, Malta .</i>	472
Chapter 30: UNITED STATES' RENEWABLE ENERGY LAWS AND REGULATIONS	
<i>E. Willard Miller, Department of Geography, The Pennsylvania State University, University Park PA</i>	484
Chapter 31: RENEWABLE ENERGY: TRENDS AND PROSPECTS IN NEPAL	
<i>P.K. Jha, S.K. Ghimire, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal, and P. Lacoul, Biology Department, Kathmandu University, Dhulikhel, Nepal</i>	497
Subject Index	521

ACKNOWLEDGEMENT

The publication of this book was aided by contributions from the
E. Willard and Ruby S. Miller
 book publication fund and the
Charles B. Reif
 book publication fund.

Chapter One

RENEWABLE ENERGY'S PLACE IN THE GLOBAL ENERGY MARKET

E. WILLARD MILLER

Department of Geography
 The Pennsylvania State University
 University Park, PA 16802

INTRODUCTION

The modern world economy is based on the availability of vast supplies of fossil fuels— coal, petroleum, and natural gas. The Industrial Revolution was, thus, primarily an Energy Revolution. The demands for energy continue to rise. During the 20th century, the global energy output has risen from a total of 911 million tons of coal equivalent in 1900 to 9,647 million tons of coal equivalent in 1997 (Table 1). The vast deposits of coal and petroleum are not evenly distributed. Asia is the largest producer of energy with an output of 4 million tons of coal equivalent or about 35 percent of the total. Africa and South America have only 5.8 and 5.2 percent, respectively, of the world's total (Table 2).

There has been not only an increase in output level but significant changes in the importance of each fuel in supplying the world's energy needs. In 1900 coal provided 5.5 percent of the total commercial energy and biomass materials 42 percent. Particularly significant in the 20th century has been the rise of petroleum and most recently natural gas. Coal and biomass materials have declined to 22 and 19 percent, respectively, while petroleum now supplies 30 percent and natural gas 23 percent of the total. Nuclear, once thought of as a potential source of energy, provides only about 6 percent of the world's annual energy production. At the present time, as demand for energy rises, particularly in the Third World countries that are poor in fossil fuels, renewable energy resources are receiving attention. Although the renewable energy resources - solar, wind, geothermal and hydropower - provide less than two percent of the present world's energy needs,