

100%

RENEWABLE

ENERGY AUTONOMY IN ACTION

Edited by Peter Droege



30806147

100% Renewable

Energy Autonomy in Action

Edited by
Peter Droege



earthscan

publishing for a sustainable future

London • Sterling, VA

First published by Earthscan in the UK and USA in 2009

Editorial © Peter Droege, 2009

Chapters 1–17 © authors as listed on pages vii–viii, 2009

All rights reserved

ISBN: 978-1-84407-718-2

Typeset by FiSH Books

Cover design by Rogue 4 Design (concept by Anis Radzi)

For a full list of publications please contact:

Earthscan

Dunstan House

14a St Cross St

London, EC1N 8XA, UK

Tel: +44 (0)20 7841 1930

Fax: +44 (0)20 7242 1474

Email: earthinfo@earthscan.co.uk

Web: www.earthscan.co.uk

22883 Quicksilver Drive, Sterling, VA 20166-2012, USA

Earthscan publishes in association with the International
Institute for Environment and Development

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data

100 per cent renewable : energy autonomy in action / edited by Peter Droege.

p. cm.

Includes bibliographical references and index.

ISBN 978-1-84407-718-2 (hardback)

1. Renewable energy sources. I. Droege, Peter. II. Title: One hundred per cent renewable.

TJ808.A15 2009

333.79'4—dc22

2009018125

At Earthscan we strive to minimize our environmental impacts and carbon footprint through reducing waste, recycling and offsetting our CO₂ emissions, including those created through publication of this book. For more details of our environmental policy, see www.earthscan.co.uk.

This book was printed in the UK by

CPI Antony Rowe.

The paper used is FSC certified.



Mixed Sources
Product group from well-managed
forests and other controlled sources
www.fsc.org Cert no. SGS-COC-2953
© 1996 Forest Stewardship Council

Today I challenge our nation to commit to producing 100 per cent of our electricity from renewable energy and truly clean carbon-free sources within ten years. This goal is achievable, affordable and transformative.

*Al Gore, Constitution Hall, Washington DC,
17 July 2008*

This is absolutely nothing to do with emissions trading, this is about getting on and doing it. You cannot tackle climate change by trading, you have to actually do things.

*Allan Jones, London Climate Agency, about his work for
Woking Borough Council, on Australia's ABC Radio National,
26 July 2008*

We will harness the sun and the winds and the soil to fuel our cars and run our factories.

*President Barack Hussein Obama, inauguration speech,
20 January 2009*

Our survival will very much depend on how well we were able to draw down CO₂ to 280 parts per million.

*Hans-Josef Schellnhuber, Potsdam Institute for Climate Impacts
Research in Germany, quoted by Gaia Vince in the
New Scientist,
25 February 2009*

List of Contributors

Brian W. Bush

Brian W. Bush is a Principal Strategic Analyst at the National Renewable Energy Laboratory in Golden, Colorado. His areas of expertise include energy and infrastructure modelling, simulation and analysis, high-performance computing, software architecture, design, implementation and testing, discrete-event and continuous simulation, statistical analysis, and geographic information systems. He holds a PhD in physics from Yale University and a BS in physics from the California Institute of Technology. His prior work experience was as a technical Staff Member at the Los Alamos National Laboratory.

Ted Caplow

Formerly a clean energy consultant for Capital-E, LLC, Dr Caplow worked on energy efficiency and carbon offset credits for a range of clients including the California Energy Commission and the US Department of Energy. His expertise also includes water contaminant dynamics, and he has published articles on this topic in the *Journal of Environmental Engineering, Environmental Science & Technology* and *Estuaries*. Founder and Technical Director of BrightFarm Systems, Dr Caplow developed the master plan for the Science Barge, a prototype sustainable urban CEA facility. His subsequent design work on rooftop and facade-mounted agriculture has been published in *Science, Sustain, Urban Land* and *Good*. Dr Caplow holds a BA from Harvard University, an MSc in Mechanical Engineering from Princeton University, and a PhD in Environmental Engineering from Columbia University, where he has taught a class on green buildings.

Nancy Carlisle

Nancy is the Manager of the Integrated Applications Group in Deployment and Industrial Programs at the National Renewable Energy Laboratory (NREL) in Golden, Colorado and a licensed architect in the state of Colorado, USA. At NREL, she led the effort to develop a 25-year master site plan for future build-out of the NREL sustainable campus. She led the effort to get NREL's Science and Technology facility certified as LEED Platinum, the first federal building receiving this designation. She is currently on the project team overseeing the design of a 740-person 'zero-energy' office building for the NREL campus. She has served as the NREL lead for the DOE Federal Energy Management Program for a number of years, working with federal agencies to meet their federal goals for renewable energy use at their sites. She has managed a strategic initiative for NREL on the topic of renewable energy

communities. She has worked at NREL for over 25 years, in research, analysis, design and outreach activities that promote the design of sustainable low energy buildings. She is a LEED accredited professional and recognized as a Fellow in the American Solar Energy Society. She holds a Masters degree in Architecture, a Masters degree in Urban Planning and a Bachelors degree in Economics with a concentration in Environmental Studies.

Peter Droege

Peter Droege is Chair of the World Council for Renewable Energy for Asia Pacific, Professor of Sustainable Development at the University Hochschule Liechtenstein and Conjoint Professor at Australia's University of Newcastle. He serves on a number of international panels, including the Expert Commission, Cities and Climate Change of the World Future Council and the Steering Committee of the Urban Climate Change Research Network. As principal at Epolis.com.au, the Sydney-based environmental design firm, Peter Droege has been an executive adviser to numerous government, state, local government and private corporate institutions on renewable and sustainable urban development strategies. His academic background includes the Technical University of Munich and Massachusetts Institute of Technology, and professorial positions at Tokyo University and the University of Sydney. Droege has authored *The Renewable City: A Comprehensive Guide to an Urban Revolution* (Wiley) and edited *Intelligent Environments and Urban Energy Transition: From Fossil Fuels to Renewable Power* (both Elsevier).

Hans-Josef Fell

Mr Fell has been a member of the German Bundestag since 1998 and is spokesman for the Alliance 90/The Greens parliamentary group on energy and technology, and also the spokesman for Technology Assessment. Hans-Josef Fell was the author of the proposal of the German renewable energy act (EEG). He also initiated new research programmes for renewable energies. Fell serves as Deputy Spokesman of the Bavarian Solar Initiatives; Vice-President of Eurosolar; member of the World Council for Renewable Energy (WCRE); Initiator of the influential Energy Watch Group. Awards include: Eurosolar German Solar Prize 1994; prize of the German section of the International Solar Energy Society (DGS) in 2000; Energy Globe Award in 2000; Nuclear-Free Future Award in 2001; German Solar Industry Prize in 2002; first German Geothermal Award in 2002; German Biogas Prize in 2003.

Dieter D. Genske

Dr Dieter D. Genske studied Civil Engineering and Geology in Germany and the US and started working on environmental problems, as Humboldt-research fellow in Kyoto, Japan. At Deutsche Montan Technologie (DMT) he became involved in large urban remediation projects, including the International Building Exhibition IBA Emscherpark. In 1994, he was appointed Professor of Engineering Geology at Delft University of Technology and three years later

Professor of Environmental Engineering at the Swiss Federal Institute of Technology in Lausanne, where he founded the Laboratory of Ecotechnics, the first of its kind in Switzerland. He chaired this research laboratory until the end of 2000. He has conducted a number of development projects in low-income countries. Presently, he teaches at Nordhausen University (Germany) and is chairing the Anthroposphere Dynamics Group at the Institute of Environmental Decision, ETH-Zurich.

Cord Hoppenbrock

Cord Hoppenbrock, Dipl.-Geogr., majored in Economic Geography, at the University of Osnabrück, with a minor in Business Studies and Ecology. He gathered work experience at the Institute of Ecological Economy Research and the Institute for Energy and Environmental Research in Heidelberg. Since October 2007 he has been a research assistant and PhD student at the University of Kassel and at deENet, deENet.org.

David Jacobs

David Jacobs is researcher and PhD candidate at the Environmental Policy Research Centre in Berlin (FFU). His research focuses on support mechanisms for renewable electricity. Previously, he gained work experience in the German Bundestag and large European utilities. He also worked on projects for several research institutes, the German Wind Energy Association and the World Future Council. David Jacobs is a frequent speaker at international conferences. He has an academic background in International Business and Cultural Studies.

Walter James

Wal James is a mechanical engineer, graduated from the University of Santiago, Chile, and is a member of the Institution of Engineers Australia. His research and development experience is manifest in his role as Associate Researcher at Curtin and Murdoch Universities in Perth, Western Australia, investigating renewable energies and their connection with plug-in hybrid electric vehicles. He has been a Board Member of the Cooperative Research Centre for Renewable Energy Australia, Projects Manager Murdoch University Energy Research Institute, and Projects Manager Solar Energy Research Institute of Western Australia. His industry experience is extensive: Wal James was founding director of Advanced Energy Systems, and served as chief executive officer of Energy Efficient Co., Singer Controls and RCA Arica, Chile.

Lioba Kucharczak

Lioba Kucharczak Dipl.-Ing. agr. studied agricultural sciences with a specialization in Environmental Management and Development of Rural Areas. Since January 2008 she has been part of the project team 'Sustainable 100% renewable energy regions in Germany' at deENet.org and a PhD student at the Department of Grassland Science and Renewable Plant Resources at the University of Kassel.

Stefan Lechtenböhmer

Stefan Lechtenböhmer Dr rer. pol. is Co-Director of the Research Group Future Energy and Mobility Structures of the Wuppertal Institute for Climate Environment Energy, Germany. He is responsible for the applied research in national and international sustainable energy and climate scenario analysis. He has conducted numerous studies on energy and emission scenario analysis and pathways to a low-carbon society. A particular focus of his work is the design and evaluation of energy efficiency policies and measures. His further research topics comprise greenhouse gas emission inventories and projections, sustainable urban infrastructures, and greenhouse gas emissions from the natural gas lifecycle. He acquired his PhD in Energy and Environmental Management at the International Institute for Management at the University of Flensburg. He holds a university degree (diploma) in Geography, Economy and Political Sciences from the University of Münster and is a member of the UNFCCC Roster of Experts for Greenhouse Gas-Inventories, Policies & Measures, Greenhouse Gas-Projections.

Harry Lehmann

Dr Harry Lehmann works for the German Federal Environment Agency as Head of Division I: Environmental Planning and Sustainable Strategies. From 1983 to 1991 he served as Head of the Consultancy 'UHL Data' – Systemanalyse und Simulation im Bereich Energie- und Umwelttechnik. Until 2000 Lehmann was with the Wuppertal Institute for Climate, Environment and Energy, and until 2006, he was Vice President of Eurosolar. Between 2000 and 2002 he was appointed Member of the Enquete Commission 'Sustainable energy supply under the boundaries of globalization and liberalization' of the German parliament. A founding member of the World Council for Renewable Energy he served as Solutions and Innovations Unit Director for Greenpeace International. Also in the early 2000s he headed the Institute for Sustainable Solutions and Innovations in Aachen. Since 2004 Dr Lehmann has been General Director at the Federal Environment Agency of Germany and President of the Factor 10 Club.

Miguel Mendonça

Miguel Mendonça is Research Manager for the World Future Council. His background is in horticulture, geography, history, journalism, social science and environmental ethics. He is a researcher, writer and advocate, focusing on renewable energy. He has worked on four continents, campaigning, coalition-building and speaking, and is a member of the steering committee of the Alliance for Renewable Energy, promoting feed-in tariffs in North America. He writes books, articles, papers, comment pieces and reviews on sustainability issues, is author of *Feed-in Tariffs: Accelerating the Deployment of Renewable Energy* and is co-writing a new book on decarbonizing the global economy, entitled *A Renewable World – Policies, Practices, Technologies*.

Peter Moser

Dr Peter Moser was project manager at the Centre for Environmental Research, Leipzig (1998–2003) and at the University of Kassel (2003–2007). Since 2007 he has served as project manager at the deENet (deENet.org), especially on the research project ‘Sustainable 100% renewable energy regions in Germany’.

Peter Newman

Peter Newman is the Professor of Sustainability at Curtin University and has recently been appointed to the Board of Infrastructure Australia that is funding infrastructure for the long-term sustainability of Australian cities. In 2001–2003 Peter directed the production of Western Australia’s Sustainability Strategy in the Department of the Premier and Cabinet. It was the first state sustainability strategy in the world. In 2004–2005 he was a Sustainability Commissioner in Sydney advising the government on planning issues. In 2006–2007 he was a Fulbright Senior Scholar at the University of Virginia Charlottesville where he completed two new books: *Resilient Cities: Responding to Peak Oil and Climate Change* and *Cities as Sustainable Ecosystems*. In Perth, Peter is best known for his work in saving, reviving and extending the city’s rail system. Peter invented the term ‘automobile dependence’ to describe how we have created cities where we have to drive everywhere. For 30 years, since he attended Stanford University during the first oil crisis, he has been warning cities about preparing for peak oil. Peter’s book with Jeff Kenworthy, *Sustainability and Cities: Overcoming Automobile Dependence*, was launched in the White House in 1999. He was a Councillor in the City of Fremantle from 1976–1980, where he still lives.

Stefan Peter

Dipl. Ing. Stefan Peter studied Energy and Environmental Technologies, with a special emphasis on renewable energies, at the Fachhochschule Aachen, Germany. The focus of his later work has been on energy efficiency, renewable energy support measures, the possible contribution of renewable energies to energy supply and the integration of renewables into existing energy supply systems. He has authored studies for government departments and independent renewable energy organizations. As one of the main contributors to the ‘Energy Rich Japan’ study he is familiar with energy system simulation and design and scenario development.

Robyn Polan

Robyn studies Sustainable Development at the University of New South Wales. Born and raised in Toronto, Ontario, she received a Bachelor of Science at Dalhousie University in Halifax, Nova Scotia. Robyn contributed research to Chapters 6, 11 and 13 in this book.

Lars Porsche

Since 2002, Lars Porsche has worked for the Federal Office for Building and

Regional Planning (BBR) in Bonn, Germany. He has been in charge of the European Spatial Planning Observation Network EPSON, Contact Point Germany. Since 2007 he has been responsible for the domain Energy and Spatial Planning.

Josep Puig i Boix

Josep Puig is a consultant on energy and the environment. He works as specialist on renewable energy and the Spanish energy market with Ecofys. Also he teaches a course on Energy and Society in Environmental Science Studies at the Autonomous University of Barcelona. He has worked on renewable energy since 1981 in the University, with private companies and as a local politician. He is an energy engineer with a PhD and a Masters in Environmental Engineering. He has published many articles and books on energy and environment. He is vice-president of Eurosolar.

Viraj Puri

Viraj Puri is the Founder and Managing Director of Gotham Greens. Gotham Greens is creating New York City's first commercial-scale hydroponic farm. While a Project Manager for BrightFarm Systems, a New York-based environmental engineering and design firm, Mr Puri managed various urban agriculture projects. He has managed renewable energy and energy efficiency projects at the SECMOL Alternative Institute in Ladakh, India and at the Mount Mulanje Conservation Trust in Malawi, focusing on green building, passive solar design, solar photovoltaics and fuel-efficient cookstoves. He has delivered presentations on urban CEA at varied academic and private sector settings including Wageningen University, The Netherlands, Berlin Technical University and Ecocity World Summit 2008, San Francisco. He holds a BA from Colgate University and is a LEED-accredited professional

Anis Radzi

Anis Radzi graduated from the University of Sydney with a Bachelors degree in Architecture, *summa cum laude*, and a Masters in Urban Design. After practising architecture for six years she turned her attention to researching ways in which the built environment can become self-sustaining in energy terms, giving special focus to renewable energy integration in bioclimatic architecture and sustainable urban design strategies. Anis presently is on a doctorate-candidature track and involved in urban design teaching at bachelor and master levels.

Ariane Ruff

Ariane studied Geography at Potsdam University in Germany. From 2000 until 2003, she taught at the University of Erfurt, Germany. Since 2003, she has conducted a research project focusing on sustainable land management at Nordhausen University of Applied Sciences.

Hermann Scheer

Hermann Scheer studied Economics, Sociology, Political Science and Public Law between 1967 and 1972 at the University of Heidelberg and the Free University of Berlin. He received his PhD in Economic and Social Science in 1972. Dr Scheer was first elected member of the German parliament in 1980, and has been re-elected eight times since. From 1983 Hermann Scheer has been delegated by the German parliament to the Parliamentary Assembly of the Council of Europe, and served as Chairman of the Committee on Agriculture between 1994 and 1997. Dr Scheer has chaired as well as initiated numerous international research and development conferences. His work is dedicated to a broad shift in the energy basis of modern civilization from fossil and nuclear resources to renewable energies. He has demonstrated both the necessity and feasibility of this transition in his five books: *The Stored Sun* (1987), *The Solar Age* (1989), *Solar Strategy* (1993), *The Solar Economy* (1999) and *Climate Change. From the Fossil to the Solar Culture* (2002). In addition, Dr Scheer has also authored more than 1000 articles.

Matthias Schuler

Matthias Schuler is one of the managing directors of TRANSSOLAR Energietechnik in Stuttgart. Born in 1958, he was educated as a mechanical engineer at University Stuttgart. In 1992 he founded the company TRANSSOLAR Climate Engineering. TRANSSOLAR'S focus is on new energy saving and comfort optimizing strategies by an integral approach in building design. Today – with 40 employees in Stuttgart, Munich and New York – Matthias Schuler works on national and international projects with architects such as Kazuyo Sejima, Frank O. Gehry, Steven Holl, Jean Nouvel and Helmut Jahn. Since 2001, he has been teaching as a visiting professor at the Graduate School of Design, Harvard University, and he became Adjunct Professor for Environmental Technologies in 2008.

Michael Stöhr

Michael Stöhr, Physicist, born 1964, received his PhD in fundamental research on silicon at the European High Magnetic Field Facility in Grenoble, France. From 1992 to 2000, he worked as scientific collaborator on renewable energies at WIP, Munich. Since 2000, he has been a senior consultant at BAUM. Consult, Munich, where he coordinates international research projects on renewable energies. For the guidebook *On the Way to the 100% Region*, co-authored with his colleagues M. Tischer, M. Lurz and L. Karg from BAUM Consult GmbH, Munich, he has been awarded the German Solar Prize in 2006 in the media category.

The Stöhr family was Germany's Energy Saving Champion in 2006 in the category of tenants for having completely switched to fully renewable energy supply in its daily life. From 2004 to date, Michael Stöhr has been a member of the supervisory board of WOGENO München e.G., a co-operative for participatory, social and ecological dwelling in Munich, and has been involved

in the planning and realization of the low-energy building where his family lives. In Munich's Messestadt-Riem quarter he has implemented two participatory PV plants.

Martin Vosseler

Dr Vosseler is an environmental activist who, as a physician, is motivated by his deep commitment to the health and well-being of people everywhere. Born in Basel in 1948, he studied and practised medicine in Basel (1982–1995) and worked as Research Fellow at the Division of Primary Care and Family Medicine of Harvard Medical School. Dr Vosseler is initiator and co-founder of PSR/IPPNW Switzerland (1981, Physicians for Social Responsibility, Swiss chapter of the International Physicians for the Prevention of Nuclear War, receiving the Nobel Peace Prize in 1985): www.ippnw.ch; Physicians Action 'Air is Life' (1985): www.aefu.ch; SUNswitzerland (1997); International Energy Forum sun21 (1997): www.sun21.ch; and is a co-founder of Ecocity Basel (1986). He is the co-founder of Transatlantic21, 2006, with a Guinness Book of Records entry in 2007. Long distance walks are 1999 Konstanz, Germany to Santiago de Compostela, Spain; 2003 Basel to Bethlehem; and SUNwalk 2008: Los Angeles to Boston, USA. Martin Vosseler lives in Elm/Gl, Switzerland.

Andrew Went

Andrew received an Honours degree in Nanotechnology from Curtin University. He also has a graduate certificate in Sustainability Studies from Curtin University Sustainability Policy Institute (CUSP). He is now pursuing a PhD into the technologies required for V2G to become a reality.

List of Acronyms and Abbreviations

| | |
|-----------------|--|
| AC | alternating current |
| ADFEC | Abu Dhabi Future Energy Company |
| BBR | German Federal Agency for Construction and Spatial Planning (Bundesamt für Bauwesen und Raumordnung) |
| BBSR | German Federal Institute for Building, City and Spatial Research (Bundesinstitut für Bau-, Stadt- und Raumforschung) |
| BedZed | Beddington Zero Emissions Development |
| BEV | battery electric vehicle |
| BMELV | German Ministry of Food Agriculture and Consumer Protection |
| BMU | Germany's Federal Ministry for Environment, Nature Conservation and Nuclear Safety |
| BTU | British thermal unit |
| °C | degrees Celsius |
| CATE | Cooperative for Technological and Energy Autonomy |
| CCP | Cities for Climate Protection |
| CCS | carbon capture and storage |
| CDTI | Centro para el Desarrollo Tecnológico e Industrial |
| CEA | controlled environment agriculture |
| CENER | National Renewables Centre |
| CENIFER | Integrated National Center for Training in Renewables |
| CEOE | Confederación Española de Organizaciones Empresariales |
| CF | capacity factor |
| CHP | combined heat and power |
| CNG | compressed natural gas |
| CO ₂ | carbon dioxide |
| COP | Conference of the Parties |
| CSA | community-supported agriculture |
| CSP | concentrating solar power |
| CSR | corporate social responsibility |
| CTE | Spanish Building Technical Code |
| DC | direct current |
| deENET GmbH | Competence Network for Decentralized Energy Technologies |
| DG TREN | Directorate-General for Energy and Transport |
| DH | district heating |

| | |
|---------|---|
| DLR | German Aerospace Center |
| DSF | double skin facade |
| DSR | demand side response |
| DTI | Department of Trade and Industry |
| EEE | European Centre for Renewable Energy |
| EEG | Renewable Energy Act (Erneuerbare-Energien-Gesetz) |
| EHN | Corporación Energía Hidroeléctrica de Navarra |
| EMAS | Eco-Management and Audit Scheme |
| ESCO | environmental service company |
| ET | emissions trading |
| EU | European Union |
| EURATOM | European Atomic Energy Community |
| EWEA | European Wind Energy Association |
| EWG | Energy Watch Group |
| ExWoSt | Experimental Housing and Urban Development |
| FCAS | frequency control ancillary services |
| FEE | Force Énergétique par les Enfants |
| FiT | feed-in tariff |
| FNR | German Agency of Renewable Resources |
| GDP | gross domestic product |
| GW | gigawatt |
| HCT | hydrothermal carbon technology |
| HEV | hybrid electric vehicle |
| HVAC | heating, ventilation and air-conditioning |
| IAEA | International Atomic Energy Agency |
| ICE | internal combustion engine |
| ICLEI | International Council on Local Environmental Initiative |
| ICV | internal combustion vehicle |
| IDAE | Spanish Energy Agency |
| IEA | International Energy Agency |
| IECP | Integrated Energy and Climate Programme |
| IFC | International Finance Corporation |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPNW | International Physicians for the Prevention of Nuclear War |
| IRENA | International Renewable Energy Agency |
| ITC | Technical Institute of the Canary Islands |
| IZNE | Interdisciplinary Centre for Sustainable Development |
| Kg | kilogram |
| km | kilometre |
| kt | kiloton |
| kV | kilovolt |
| kWh | kilowatt hour |
| LPG | liquefied petroleum gas |
| LTi | Long-Term Integration of Renewable Energies into the European Energy System |

| | |
|-----------------|---|
| mb/d | million barrels per day |
| MDG | Millennium Development Goal |
| mtoe | million ton oil equivalent |
| MW | megawatt |
| NATTA | Network for Alternative Technology and Technology Assessment |
| NEM | National Energy Market |
| NEV | neighbourhood electric vehicle |
| NGO | non-government organization |
| NO _x | nitrogen oxide |
| NREL | National Renewable Energy Laboratory |
| OEM | original equipment manufactured |
| OPEC | Organization of Petroleum Exporting Countries |
| PER | Plan de Energia Renovable |
| PG&E | Pacific Gas & Electric |
| PHEV | plug-in hybrid electric vehicle |
| PIOH | Island Planning Regulations |
| PJ | petajoule |
| ppm | parts per million |
| PV | photovoltaics |
| R&D | research and development |
| REC | renewable energy certificate |
| REDP | Renewable Energy Development Project |
| SAFA | Finnish Association of Architects |
| SEEG | South Styria Cooperative for Energy and Protein Production |
| SEU | Sustainable Energy Utility |
| SMUD | Sacramento Municipal Utility District |
| SO ₂ | sulphur dioxide |
| SWF | Shaanxi Provincial Women's Federation |
| TARA | Tecnologías Alternativas Radicales y Autogestionadas |
| Tekes | National Technology Agency of Finland |
| TOU | time-of-use |
| TRANS-CSP | Trans-Mediterranean Interconnection for Concentrating Solar Power |
| TW | terawatt |
| UBA | German Federal Environment Agency |
| ULP | unleaded petrol |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNISEO | United Nations International Sustainable Energy Association |

| | |
|---------|--|
| UNSEGED | United Nations Solar Energy Group on Environment and Development |
| UNU-GTP | United Nations University Geothermal Training Program |
| US | United States of America |
| V2G | vehicle to grid |
| VAT | value added tax |
| VIG | vertically integrated greenhouse |
| WEO | World Energy Outlook |
| WTW | well to wheel |
| WWF | World Wide Fund for Nature |
| ZEB | zero-energy building |
| ZED | zero-energy district |

Contents

| | |
|--|-------------|
| <i>List of figures, tables and boxes</i> | <i>ix</i> |
| <i>List of contributors</i> | <i>xiv</i> |
| <i>List of acronyms and abbreviations</i> | <i>xxii</i> |
| | |
| 1 100% Renewable Energy: The Essential Target | 1 |
| Peter Droege | |
| 2 Institutions for a 100% Renewable World | 49 |
| Hermann Scheer | |
| 3 The Renewable Imperative: Providing Climate Protection and Energy Security | 57 |
| Hans-Josef Fell | |
| 4 100% is Possible Now | 71 |
| Harry Lehmann and Stefan Peter | |
| 5 Paths to a Fossil CO₂-free Munich | 87 |
| Stefan Lechtenböhrer | |
| 6 100% Renewable Champions: International Case Studies | 93 |
| Anis Radzi | |
| 7 Feed-in Tariffs: The Policy Path to 100% | 167 |
| Miguel Mendonça and David Jacobs | |
| 8 How to Achieve Renewable Energy Regions and Advance Sustainable Development: Integrated Models and Processes in Germany | 173 |
| Peter Moser, Lioba Kucharczak and Cord Hoppenbrock | |
| 9 Renewable Regions: Life After Fossil Fuel in Spain | 187 |
| Josep Puig i Boix | |
| 10 100% Renewable Transport | 205 |
| Andrew Went, Peter Newman and Wal James | |
| 11 Better Place | 225 |
| Peter Droege | |
| 12 How to Grow Food in the 100% Renewable City: Building-Integrated Agriculture | 229 |
| Viraj Puri and Ted Caplow | |