Biofuels, Solar and Wind as Renewable Energy Systems

David Pimentel
Editor

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Benefits and Risks

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Preface

The petroleum age began about 150 years ago. Easily available energy has supported major advances in agriculture, industry, transportation, and indeed many diverse activities valued by humans. Now world petroleum and natural gas supplies have peaked and their supplies will slowly decline over the next 40–50 years until depleted. Although small amounts of petroleum and natural gas will remain underground, it will be energetically and economically impossible to extract. In the United States, coal supplies could be available for as long as 40–50 years, depending on how rapidly coal is utilized as a replacement for petroleum and natural gas.

Having been comfortable with the security provided by fossil energy, especially petroleum and natural gas, we appear to be slow to recognize the energy crisis in the U.S. and world. Serious energy conservation and research on viable renewable energy technologies are needed. Several renewable energy technologies already exist, but sound research is needed to improve their effectiveness and economics. Most of the renewable energy technologies are influenced by geographic location and face problems of intermittent energy supply and storage. Most renewable technologies require extensive land; a few researchers have even suggested that one-half of all land biomass could be harvested in order to supply the U.S. with 30% of its liquid fuel!

Some optimistic investigations of renewable energy have failed to recognize that only 0.1% of the solar energy is captured annually in the U.S. by all the green plants, including agriculture, forestry, and grasslands. Photovoltaics can collect about 200 times more solar energy per year than green plants. The green plants took more than 700 million years to collect and then be stored as the concentrated energy found in petroleum, natural gas, and coal supplies.

This book examines various renewable energy technologies and reports on their potential to supply the United States and other nations with needed energy. Some chapters examine several renewable energy technologies and their potential to replace fossil fuel, while others focus on one specific technology and its potential, as well as its limitations. In this volume, the aim of the contributors is to share their analyses as a basis for more research in renewable energy technologies. Basic to all the renewable energy technologies is that they attempt to minimize damage to the environment that supports all life.

Several of the chapters reflect the current lack of agreement in the field, as pressure mounts to explore and develop potential energy alternatives. The reader will notice considerable variability in the energy inputs and potential energy outputs in some of the studies. This is evidence of the complexity of assessing the large number of energy inputs that go into production of a biofuel crop and the extraction of its useful energy. As research continues, we will discover if current analyses of renewable energy technologies have adequately estimated energy requirements, outputs and environmental consequences. Hopefully, this research will help guide energy policy makers toward the most viable choices and away from energy costly missteps, as we collectively encounter energy descent.

The authors of each of these chapters have done a superb job in presenting the most up to date perspective of various renewable energy technologies in a highly readable fashion.

NY, USA D. Pimentel

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Robert Boddey graduated in 1975 from Leeds University, UK, with a BSc in Agricultural Chemistry. He earned a PhD at the University of the West Indies (Trinidad) in 1980, with a thesis on biological nitrogen fixation (BNF) associated with wetland rice. He then moved to the Soil Microbiology Centre of the Brazilian Corporation for Agricultural Research (Embrapa Agrobiologia) in Seropédica, Rio de Janeiro. There he developed various techniques, including those using the stable isotope 15N, to quantify inputs of BNF to grasses and cereals. His team also works on the impact of BNF on N dynamics in various agroecosystems. Boddey has published almost 100 papers in international journals, and over 60 chapters in books and conference proceedings.

Marcelo E. Dias de Oliveira graduated in 1997 as an Agronomic Engineer at University of São Paulo-Brazil, working as an undergrad student with GIS and Remote Sensing. In 2001 he started his Master's Degree at Washington State University – Richland - USA, concluding his work in 2004. During this time he did research on hazardous materials at the Hanford site, and developed his thesis on energy balance, carbon dioxide emissions and environmental impacts of ethanol production. Currently he works as consultant for an environmental company in Brazil and is about to start his PhD studies.

Jeroen Dooper holds a Bachelor degree in Ecological Material Technology and is currently completing a Master's degree in Sustainable Development, Energy and

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Andrew Ferguson, after National Service flying training in Canada, joined BEA (later British Airways). In the 1960s, he tried to see if it was possible to persuade his flying colleagues that there was an environmental crisis ahead due to growing population. Finding that it was impossible to locate even one person to acquiesce in this proposition, he waited for more propitious times to engage in wider efforts. In the 1990s, he became a member of the Optimum Population Trust (UK), started by the late David Willey, and since 2002 has been editor of the biannual OPT Journal.

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Charles A. Hall is a Systems Ecologist who received his PhD from Howard T. Odum. Dr. Hall is the author of seven books and more than 200 scholarly articles. He is best known for his development of the concept of EROI, or energy return on investment, which is an examination of how organisms, including humans, invest energy into obtaining additional energy to increase biotic or social fitness. He has applied these approaches to fish migrations, carbon balance, tropical land use change and petroleum extraction, in both natural and human-dominated ecosystems. He is developing a new field, biophysical economics, as a supplement or alternative to conventional neoclassical economics.

Edwin Kessler graduated from Columbia College in 1950 and received the Sc.D. in Meteorology from MIT in 1957. From 1954-1961 he specialized in radar meteorology with the Air Force Cambridge Research Laboratories in Massachusetts, and from 1961-1964 he was Director of the Atmospheric Physics Division, Travelers Research Center in Hartford, Connecticut. From 1964 until retirement in 1986, he was Director of the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory in Norman, Oklahoma. In 1989, he received the Cleveland Abbe award of the American Meteorological Society. He has been Chair of Common Cause Oklahoma and is now Vice-Chair. He manages 350 acres of pastures with woodlands and stream in central Oklahoma.

Doug Koplow is the founder of Earth Track in Cambridge, MA (www.earthtrack.net), an organization focused on making the scope and cost of environmentally harmful subsidies more visible. The author of Biofuels - At What Cost? Government support for ethanol and biodiesel in the United States (Global Subsidies Initiative, Geneva: 2006 and 2007), Doug has worked on natural resource subsidy issues for nearly twenty years. He holds an MBA from the Harvard Graduate School of Business Administration and a BA in economics from Wesleyan University.

Claudia Ho Lem is currently a Project Manager for REAP-Canada's International Development and Bioenergy Programs. A rural development specialist with over 10 years of experience in environmental project management, Ms. Ho Lem holds a B.Sc. in Environmental Science specializing in Biology and Chemistry from the University of Calgary. She has worked on bioenergy, climate change and agro-ecological development in China, the Philippines, Cuba, West Africa and Canada, supporting farming communities in increasing their self-sufficiency through participatory assessments, training and research. Her experience has given her an integrated understanding of the social, economic, biological, ecosystem and health impacts of agricultural development.

Kozo Mayumi, a former student of Georgescu-Roegen, has been working in the field of energy analysis, ecological economics and complex hierarchy theory. He is a professor at the University of Tokushima and an editorial board member of Ecological Economics, Organization and Environment, and International Journal of Transdisciplinary Research. He is the author of The Origins of Ecological Economics: The Bioeconomics of Georgescu-Roegen, published by Routledge in 2001, and The Jevons Paradox and The Myth of Resource Efficiency Improvements from Earthscan in 2008. Together with Dr. Mario Giampietro and three other researchers, Mayumi started a biennial international workshop, ("Advances in Energy Studies,") in 1998.

Kenneth Mulder obtained his PhD in Ecological Economics from the Gund Institute for Ecological Economics at the University of Vermont. His research is multidisciplinary, applying systems modeling and analysis to problems in ecology, economics and agriculture. He is particularly interested in the development of meaningful indicators for alternative energy technologies. Dr. Mulder currently manages an integrated student farm at Green Mountain College and teaches in the Environmental Studies Department there.

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David Pimentel is a professor of ecology and agricultural sciences at Cornell University, Ithaca, NY. His PhD is from Cornell University. His research spans the fields of energy, biotechnology, sustainable agriculture, and environmental policy. Pimentel has published more than 600 scientific papers and 25 books. He has served on many national and government committees including the National Academy of Sciences; President's Science Advisory Council; U.S Department of Agriculture and U.S. Department of Energy; Office of Technology Assessment of the U.S. Congress; and the U.S. State Department. In 2008 he received an Honorary Doctorate from the University of Massachusetts for his work in recognizing and publicizing critical trends in interactions between humans and the environment.

Robert Powers is finishing a BS in Environmental Science at the State University of New York College of Environmental Science & Forestry under Dr. Charles Hall. He is interested in the intersection of energy and economic issues, specifically in modeling problems to find innovative solutions. He has also started a Masters in System Dynamics at the University of Bergen (Norway) to further develop his modeling skills.

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