

PHYSICS OF SUSTAINABLE ENERGY II: USING ENERGY EFFICIENTLY AND PRODUCING IT RENEWABLY

Berkeley, California, USA 5 – 6 March 2011

EDITORS

David Hafemeister
Daniel Kammen
Barbara G. Levi
Peter Schwartz

AIP
American Institute
of Physics

AIP | CONFERENCE PROCEEDINGS ■ 1401

Hafemeister
Kammen
Levi
Schwartz


PHYSICS OF SUSTAINABLE ENERGY II: USING ENERGY
EFFICIENTLY AND PRODUCING IT RENEWABLY

1401

AIP



ISBN 978-0-7354-0972-9
ISSN 0094-243X



PHYSICS OF SUSTAINABLE
ENERGY II: USING ENERGY
EFFICIENTLY AND PRODUCING
IT RENEWABLY

To learn more about the AIP Conference Proceedings Series,
please visit [**http://proceedings.aip.org**](http://proceedings.aip.org)

PHYSICS OF SUSTAINABLE ENERGY II: USING ENERGY EFFICIENTLY AND PRODUCING IT RENEWABLY

Berkeley, California, USA 5 – 6 March 2011

EDITORS

David Hafemeister

California Polytechnic State University, San Luis Obispo, CA

Daniel Kammen

World Bank, Washington, DC

Barbara G. Levi

Physics Today, Santa Barbara, CA

Peter Schwartz

California Polytechnic State University, San Luis Obispo, CA

SPONSORING ORGANIZATIONS

American Physical Society Forum on Physics and Society

American Association of Physics Teachers

American Physical Society Topical Group on Energy Research and Applications



Melville, New York, 2011

AIP | CONFERENCE PROCEEDINGS ■ 1401

Editors

David Hafemeister
553 Serrano Dr.
San Luis Obispo, CA 93405

E-mail: dhafemei@calpoly.edu

Daniel Kammen
1818 H. St. NW
Washington, DC 20433

E-mail: dkammen@worldbank.org

Barbara G. Levi
1616 LaVista del Oceano
Santa Barbara, CA 93109

E-mail: bglevi@msn.com

Peter Schwartz
Physics Department
California Polytechnic State University
San Luis Obispo, CA 93407

E-mail: pschwart@calpoly.edu

Authorization to photocopy items for internal or personal use, beyond the free copying permitted under the 1978 U.S. Copyright Law (see statement below), is granted by the American Institute of Physics for users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$30.00 per copy is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923, USA: <http://www.copyright.com>. For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Services is: 978-0-7354-0972-9/11/\$30.00

© 2011 American Institute of Physics

No claim is made to original U.S. Government works.

Permission is granted to quote from the AIP Conference Proceedings with the customary acknowledgment of the source. Republication of an article or portions thereof (e.g., extensive excerpts, figures, tables, etc.) in original form or in translation, as well as other types of reuse (e.g., in course packs) require formal permission from AIP and may be subject to fees. As a courtesy, the author of the original proceedings article should be informed of any request for republication/reuse. Permission may be obtained online using RightsLink. Locate the article online at <http://proceedings.aip.org>, then simply click on the RightsLink icon/“Permissions/ Reprints” link found in the article abstract. You may also address requests to: AIP Office of Rights and Permissions, Suite 1N01, 2 Huntington Quadrangle, Melville, NY 11747-4502, USA; Fax: 516-576-2450; Tel.: 516-576-2268; E-mail: rights@aip.org.

L.C. Catalog Card No. 2011938628
ISBN 978-0-7354-0972-9
ISSN 0094-243X
Printed in the United States of America

AIP Conference Proceedings, Volume 1401
**Physics of Sustainable Energy II: Using Energy Efficiently
and Producing it Renewably**

Table of Contents

Preface: Physics of Sustainable Energy II: Using Energy Efficiently and Producing it Renewably David Hafemeister, Daniel Kammen, Barbara G. Levi, and Peter Schwartz	1
SESSION A: POLICIES FOR SUSTAINABLE ENERGY	
California enhances energy efficiency Arthur H. Rosenfeld	7
Defining a standard metric for electricity savings Jonathan Koomey, Hashem Akbari, Carl Blumstein, Marilyn Brown, Richard Brown, Robert Budnitz, Chris Calwell, Sheryl Carter, Ralph Cavanagh, Audrey Chang, David Claridge, Paul Craig, Rick Diamond, Joseph H. Eto, William J. Fisk, William Fulkerson, Ashok Gadgil, Howard Geller, José Goldemberg, Chuck Goldman, David B. Goldstein, Steve Greenberg, David Hafemeister, Jeff Harris, Hal Harvey, Eric Heitz, Eric Hirst, Holmes Hummel, Dan Kammen, Henry Kelly, Skip Laitner, Mark Levine, Amory Lovins, Gil Masters, Pat McAuliffe, James E. McMahon, Alan Meier, Michael Messenger, John Millhone, Evan Mills, Steve Nadel, Bruce Nordman, Lynn Price, Joe Romm, Marc Ross, Michael Rufo, Jayant Sathaye, Lee Schipper, Stephen H. Schneider, Robert H. Socolow, James L. Sweeney, Malcolm Verdict, Alexandra von Meier, Diana Vorsatz, Devra Wang, Carl Weinberg, Richard Wilk, John Wilson, Jane Woodward, and Ernst Worrell	26
Listening to the planet and building a sustainable energy economy Daniel M. Kammen	44
Energy in the developing world Ashok Gadgil, David Fridley, Nina Zheng, Andree Sosler, Thomas Kirchstetter, and Amol Phadke	54
The co-created Guatemalan field school: Carbon reduction with appropriate technology Peter V. Schwartz	75

The nexus of energy and water in the United States Michael E. Webber	84
Energy efficiency: Transportation and buildings Michael S. Lubell and Burton Richter	107
California state policy on sustainable energy Dian M. Grueneich	153

SESSION B: ENVIRONMENTAL EFFECTS OF FOSSIL FUELS

Hidden costs of energy: Unpriced consequences of energy production and use Committee on Health, Environmental and Other External Costs and Benefits of Energy Production and Consumption, National Research Council	165
Studying the causes of recent climate change Benjamin D. Santer	183
Methane: A menace surfaces Katey Walter Anthony	198
Climatic consequences of afforestation Inez Fung and Abigail Swann	211
The thinning of Arctic ice Ronald Kwok and Norbert Untersteiner	220
Infrared radiation and planetary temperature Raymond T. Pierrehumbert	232
Touring the atmosphere aboard the A-Train Tristan S. L'Ecuyer and Jonathan H. Jiang	245

SESSION C: DECARBONIZING TRANSPORTATION

The future of low-carbon transportation fuels Christopher Yang and Sonia Yeh	259
--	-----

Technology status and expected greenhouse gas emissions of battery, plug-in hybrid, and fuel cell electric vehicles Timothy E. Lipman	271
---	-----

SESSION D: ENHANCED EFFICIENCY OF BUILDINGS

Exploring the limits of energy efficiency in office buildings David E. Claridge and Oleksandr Tanskyi	301
Energy simulation tools for buildings: An overview Philip Haves	313
Smart buildings and demand response Sila Kiliccote, Mary Ann Piette, and Girish Ghatikar	328
Appliance standards and advanced technologies Louis-Benoit Desroches	339
Energy on the home front Thomas W. Murphy, Jr.	353

SESSION E: RENEWABLE ENERGY

Renewable electricity in the United States: The National Research Council study and recent trends K. John Holmes and Lawrence T. Papay	369
Integrating renewable electricity on the grid George Crabtree, Jim Misewich, Ron Ambrosio, Kathryn Clay, Paul DeMartini, Revis James, Mark Lauby, Vivek Mohta, John Moura, Peter Sauer, Francis Slakey, Jodi Lieberman, and Humayun Tai	387
Development of non-tracking solar thermal technology Roland Winston, Bruce Johnston, and Kevin Balkowski	406
Potential and innovations in rooftop photovoltaics Ben Bierman	413
Topics in nuclear power Robert J. Budnitz	436

APPENDICES

Energy and environment chronology	
David Hafemeister	447
Energy outlook, 1990–2035	
U. S. Energy Information Administration	455
Energy units	471
WWW energy sites	475
Author bio brief	477
Sustainable energy II participants	483
Author Index	485