## **2000 ACEEE SUMMER STUDY ON ENERGY EFFICIENCY IN BUILDINGS**

Efficiency Sustainability

**1** Residential Buildings: Technologies, Design, and Performance Analysis

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**3** American Council for an Energy-Efficient Economy

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## American Council for an Energy-Efficient Economy

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# Foreword

Responding to the theme of this Millennium Summer Study—"Efficiency and Sustainability" professionals from around the world discussed the technological basis for and practical methods of implementing efficient and (hopefully) sustainable energy use in buildings. Issues, trends, challenges, and accomplishments were discussed. Each volume in this proceedings focuses on specific issues that encompass global visions for the future and discussion of future trends.

The 2000 Summer Study continued to emphasize new trends in buildings, equipment, markets, and social issues. Topics ranged broadly from the ENERGY STAR® program for new construction to building envelope and system engineering issues. The papers presented reviewed the latest information on utility restructuring and impacts on utility-sponsored programs, as well as global market issues, information technologies, and non-energy benefits. Sustainable development strategies; community-scale initiatives; factors influencing energy consumption and purchase of energy-efficient technologies; and how to design, implement, and evaluate energy programs were just a few of the cutting edge discussions that warm the mind and stir our quest for enlightment.

The subjects of the ten volumes in this proceedings are:

- 1. Residential Buildings: Technologies, Design, and Performance Analysis
- 2. Residential Buildings: Program Design, Implementation, and Evaluation
- 3. Commercial Buildings: Technologies, Design, and Performance Analysis
- 4. Commercial Buildings: Program Design, Implementation, and Evaluation
- 5. Deregulation of the Utility Industry and Role of Energy Service Companies (ESCOs)
- 6. Market Transformation
- 7. Information and Electronic Technologies
- 8. Consumer Behavior and Non-Energy Effects
- 9. Energy and Environmental Policy
- 10. Building Industry Trends

We, the co-chairs, would like to thank the 23 panel leaders who sorted more than 658 abstracts, selecting and nurturing 309 papers through the rigid review and publishing process, and selecting more than 60 talks for the poster sessions. We would also like to thank the many peer reviewers who worked with the panel leaders. Finally, a well-deserved thank you to the staff of ACEEE, in particular Glee Murray and Rebecca Lunetta (who received key assistance from Renee Nida and Julia Harvell) for their support and guidance throughout this process and for making the week a very successful "energy camp."

James McMahon, Lawrence Berkeley National Laboratory Pat Love, Oak Ridge National Laboratory

# Acknowledgments

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# Contents

PANEL 1: INTRODUCTION	1.xi
Updates on Revision to ASHRAE Standard 90.2:	
Including Roof Reflectivity for Residential Buildings	1.1
H. Akbari, Lawrence Berkeley National Laboratory	
S. Konopacki, Lawrence Berkeley National Laboratory	
D. Parker, Florida Solar Energy Center	
Reducing Measurement Uncertainties in Duct Leakage Testing	1.13
John W. Andrews, Brookhaven National Laboratory	
Measured Impact of Advanced Windows on Cooling Energy Use	1.29
Michael T. Anello, Florida Solar Energy Center	
Danny S. Parker, Florida Solar Energy Center	
John R. Sherwin, Florida Solar Energy Center	
Katie Richards, Florida Solar Energy Center	
Factors Influencing Space Heat and Heat Pump Efficiency	
from a Large-Scale Residential Monitoring Study	1.39
Matt Bouchelle, Florida Power Corporation	
Danny S. Parker, Florida Solar Energy Center	
Michael T. Anello, Florida Solar Energy Center	
Katie M. Richardson, Florida Solar Energy Center	
Protocol for Monitoring of Moisture in the Walls of a Home	1.53
Dan Cautley, Cautley Engineering	
Craig Schepp, Energy Center of Wisconsin	
André Desjarlais, Oak Ridge National Laboratory	
Impacts of Shading and Glazing Combinations on Residential Energy Use	
in a Hot Dry Climate	1.63
Sara Farrar, National Renewable Energy Laboratory	
Paul Reeves, Partnership for Resource Conservation	
C. E. Hancock	
Ren Anderson, National Renewable Energy Laboratory	
Performance of Duct Leakage Measurement Techniques in Estimating Duct Efficiency:	
Comparison to Measured Results	1.77
Paul W. Francisco, <i>Ecotope</i> , <i>Inc.</i>	
Larry Palmiter, <i>Ecotope, Inc.</i>	

Effects of Equipment Cycling and Sizing on Seasonal Efficiency	. 1.89
Fredric S. Goldner, Energy Management & Research Associates	
Energy Efficiency and Indoor Air Quality in R-2000 and Conventional New Houses in Canada John Gusdorf, The Buildings Group, Natural Resources Canada Anil Parekh, The Buildings Group, Natural Resources Canada	1.101
Improving DOE-2's RESYS Routine: User Defined Functions to Provide More Accurate Part Load Energy Use and Humidity Predictions Hugh I. Henderson, Jr., <i>CDH Energy Corp.</i> Danny Parker, <i>Florida Solar Energy Center</i> Yu J. Huang, <i>Lawrence Berkeley National Laboratory</i>	1.113
A Case Study of a Successful Innovative Multi-Unit Residential Building Duncan Hill, Canada Mortgage and Housing Corporation David Carruth, Canada Mortgage and Housing Corporation	1.125
Measured Impact of Mechanical Thermostat Replacement Russ Johnson, <i>Northeast Utilities</i> Dinesh Bhagani, <i>Northeast Utilities</i> Steven W. Carlson, <i>CDH Energy Corp</i> .	1.137
<b>Transformers Efficiency: Unwinding the Technical Potential</b> David Korn, <i>The Cadmus Group</i> Adam Hinge, <i>Sustainable Energy Partnerships</i> Fouad Dagher, <i>Nees Companies</i> Charles Partridge, <i>Boston Edison</i>	1.149
Payback Analysis of Design Options for Residential Water HeatersAlex Lekov, Lawrence Berkeley National LaboratoryJim Lutz, Lawrence Berkeley National LaboratoryCamilla Dunham Whitehead, Lawrence Berkeley National LaboratoryJames E. McMahon, Lawrence Berkeley National Laboratory	1.163
Benchmarking Residential Energy Use Michael MacDonald, Oak Ridge National Laboratory Sherry Livengood, Oak Ridge National Laboratory	1.175
Best Practice Upgrades for Energy Efficient New Homes David Meisegeier, ICF Consulting Glenn Chinery, U.S. Environmental Protection Agency Climate Protection Division	1.187
A New Device for Field Measurement of Air Handler Flows Larry Palmiter, <i>Ecotope, Inc.</i> Paul W. Francisco, <i>Ecotope, Inc.</i>	1.197

Towards Zero Energy Demand: Evaluation of Super Efficient Building Technology with Photovoltaic Power for New Residential Housing	1.207
Danny S. Parker, <i>Florida Solar Energy Center</i>	
James P. Dunlop, Florida Solar Energy Center	
Stephen F. Barkaszi, Florida Solar Energy Center	
John R. Sherwin, Florida Solar Energy Center	
Michael T. Anello, Florida Solar Energy Center	
Jeffrey K. Sonne, Florida Solar Energy Center	
Hidden Power Drains: Residential Heating and Cooling Fan Power Demand John Proctor, Proctor Engineering Group, Ltd.	1.225
Danny Parker, Florida Solar Energy Center	
Measure Retention in Residential New Construction	1.235
Valerie Richardson, Pacific Gas and Electric Company	
Lisa A. Skumatz, Skumatz Economic Research Associates, Inc.	
Unvented-Cathedralized Attics: Where We've Been and Where We're Going	1.247
Armin F. Rudd, Building Science Corporation	
Joseph W. Lstiburek, Building Science Corporation	
Kohta Ueno, Building Science Corporation	
A Field Study of Exhaust Only Ventilation System Performance	1 2(1
Andy Shapira Energy Palance Inc.	1.261
And Shapho, Energy butance, Inc.	
Jeremy King, Vermont Energy Investment Corporation	
Stopping Duct Quacks: Longevity of Residential Duct Sealants	1.273
Max Sherman. Lawrence Berkelev National Laboratory	
Iain Walker, Lawrence Berkelev National Laboratory	
Darryl Dickerhoff, Lawrence Berkeley National Laboratory	
An Experimental Investigation of Cooking, Refrigeration and Drying End-uses in 100 Households	1.285
Olivier Sidler, Cabinet SIDLER	
Paul Waide, PW Consulting	
Benoit Lebot, International Energy Agency	
Delivering Tons to the Register: Energy Efficient Design and Operation	
of Residential Cooling Systems	1.295
Jeffrey Siegel, Lawrence Berkeley National Laboratory	
Iain Walker, Lawrence Berkeley National Laboratory	
Max Sherman, Lawrence Berkeley National Laboratory	

Cool Neigborhoods: The Measurement of Small Scale Heat Islands	1.307
Jeffrey K. Sonne, Florida Solar Energy Center	
Robin K. Vieira, Florida Solar Enegy Center	
Non-Compressor Cooling Alternatives for Reducing Residential Peak Load	1.319
David Springer, Davis Energy Group	
George Loisos, Loisos/Ubbelohde Associates	
Leo Rainer, Davis Energy Group	
Understanding Energy End-Use In New Zealand Houses	1.331
Albrecht Stoecklein, Building Research Association of New Zealand	
Andrew Pollard, Building Research Association of New Zealand	
Jeremy Tries, Building Research Association of New Zealand	
Michael Camilleri, Building Research Association of New Zealand	
Nigel Isaacs, Building Research Association of New Zealand	
Gerard Fitzgerald, Fitzgerald Applied Sociology	
Residential Air Infiltration and Ventilation Study in New York State	1.343
Peter Strunk, Synertech Systems Corporation	
Laurence F. Kinney, Synertech Systems Corporations, E Source, Inc.	
Robert M. Carver, New York State Energy Research and Development Authority	
Evaluation of Photovoltaic Power Generation Systems in Residential Homes in Japan:	
A Partnership Program of Utility and Consumers' Cooperative	1.355
Takahiro Tsurusaki, Jyukankyo Research Institute	
Akio Tanaka, Jyukankyo Research Institute	
Hidetoshi Nakagami, Jyukankyo Research Institute	

## PANEL 1: INTRODUCTION

## Residential Buildings: Technologies, Design, and Performance Analysis

anel One covers diverse topics associated with residential buildings: technological improvements to the thermal envelope, ventilation, equipment, thermal distribution systems, and appliances. The eclectic focus of the papers reflect the evolution of current thinking regarding residential energy efficiency at the turn of the century.

### **Energy Distribution Systems**

Energy distribution systems are a natural focus for recent efficiency research given the wide acknowledgment of their shortcomings. Siegel, Walker, and Sherman show the large magnitude of duct losses on peak system performance, while Francisco and Palmiter provide a more refined description of how duct system efficiencies can be measured. Finally, Sherman, Walker, and Dickerhoff evaluate the long-term integrity of duct sealants.

### Advanced Buildings and Integration with Photovoltaic Power

Integrated building design is one of the emerging trends of the last decade of global efficiency research. Points of interest include combining efficiency with solar electric power and addressing health issues. Gusdorf and Parekh show how Canada's flagship efficiency program, R-2000, has evolved to produce greater efficiency savings while addressing the need for improved indoor air quality. In the United States, Parker et al. present results from a side-by-side test of a very efficient Florida home, which produced a 93 percent reduction in daily energy demand and near zero demand during peak hour. In contrast, Tsurusaki, Tanaka, and Nakaami describe an extremely ambitious project in Japan, which has evaluated 132 residential installations with 3 kilowatt photovoltaic systems that produced 40 percent of electric power requirements.

### **Envelope Components**

Building envelope improvements and associated evaluation remain fundamental to improving the energy efficiency of residence buildings. Meisegeier and Chinery provide an assessment of best practice efficiency upgrades for residences around the country from evaluation of a complex set of options. Additionally, Rudd, Lstiburek, and Ueno present important performance data on unvented attics, a controversial method to improve attic thermal performance in appropriate climates. Finally, Hill and Carruth describe a unique project attempting to design a very energy-and resource-efficient building in Canada with some interesting conclusions regarding the post-construction performance.

### **Ventilation Technologies**

Ventilation of our homes in an energy-efficient fashion remains an extremely strenuous challenge for the 21st Century. Shapiro, Cawley, and King provide an enlightening evaluation of exhaust-only ventilation systems in New England. Complementing this work is a detailed study by Strunk, Kinney, and Carver in New York State. Springer, Loisos, and Rainer provide the other side to ventilation: how it can be used to meet cooling loads in the more arid portions of California.

### Advanced Glazing Systems and Shading

Recent improvements to window technology for our homes make very substantial air conditioning energy savings possible. However, shading remains a time-tested method to accomplish the same end. Anello et al. show a measured 15 percent savings in cooling energy from a carefully executed side-by-side test of advanced spectrally selective windows in Central Florida. Farrar et al. describe a series of ingenious measurements of the oft-ignored impacts of shading on window performance and conclude that shading is more important than the glazing itself. Finally, Sonne and Vieira show how neighborhood-level landscape shading can reduce peak summer afternoon temperatures by 3°F or more.

### **Analysis and Simulation**

Our methods of assessment of residential energy efficiency continue to improve. MacDonald and Livengood demonstrate how residential energy consumption can be benchmarked to have a meaningful reference relative to other buildings. From a nuts and bolts perspective, Henderson, Parker, and Huang describe how our most detailed building energy simulations can be improved through enhanced modeling of equipment part-load performance. In contrast, Stoecklein et al. demonstrate an analytical evaluation based on detailed monitoring in many residential buildings in Australia.

### **HVAC System Performance**

The performance of heating and cooling equipment is extremely important to achieving efficiency goals. Bouchelle et al. show how various factors—particularly thermostat setback—can adversely impact air-to-air heat pump performance and seriously degrade its potential efficiency advantages. Against this, Proctor and Parker show how heating, ventilation, and air conditioning system fan energy consumption can significantly impact cooling and heating efficiencies. Goldner describes how part-load impacts and sizing can impact system seasonal efficiency of heating systems in the Northeast.

### **Appliances and Equipment**

Water heating and other appliances are a large total share of residential energy use and ancillary devices such as a thermostat can be important. Johnson, Bhagani, and Carlson show persuasively how the controls for baseboard electric heating systems can make a large difference in the heating efficiency of that system. Lekov et al. present a detailed evaluation of various design options to increase the efficiency of residential water heaters. And finally, Sidler et al. show results from a very interesting study of measured cooking energy end-use in large sample of French homes.

### **Testing and Measurement**

Our ability to gauge efficiency depends largely on our success in accurate measurement. Palmiter and Francisco describe a very promising new device that measures air handler air flow—a chronically difficult, but important measurement. Additionally, Andrews presents a detailed evaluation of the relative accuracy of various duct leakage measurement techniques available to installers or auditors. Finally, Cautley, Schepp, and Desjarlais provide an evaluation of how moisture levels can be measured in residential buildings, along with the specific hazards involved.

### **Technology Transformation**

An important challenge for residential energy efficiency is moving from a new technology to one that succeeds in the marketplace. Akbari, Konopacki, and Parker describe the development of provision within ASHRAE Standard 90.2 for reflective roofing systems, a powerful method to reduce cooling loads in hot climates. Also, getting there and staying there is important. Richardson and Skumatz discuss the success of measure retention in residences. And last, but not least, we have a one-off: a paper on transformer efficiency by Korn et al., which although a commercial building technology, was intriguing enough to the panels leaders to be afforded a place on our roster. Learn something!

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