Rutgers Center for GREENBUILDING

2012-2013 Annual Report

Letter from the Directors

Dear Advisors, Funders, Supporters, and Friends:

Welcome to the Rutgers Center for Green Building Annual Report for 2012-2013. Since our formation in 2006, the Center has made great strides in accomplishing its core mission – the promotion of green building and sustainable community – through contributions in research, education and training, and partnerships with industry, government and not-for-profit organizations. In this we are particularly grateful to you, our advisors and supporters, and to our many collaborators within the University community. Not least of all, we would like to express our gratitude to the Center's core faculty, staff, student researchers and interns without whom none of our work would be possible.

The following pages showcase some of our recent projects. Highlights include the completion of two major projects: a 3-year HUD-funded initiative on realizing synergies in affordable housing, green building and healthy and active lifestyles and a 5-year NSF-funded project on self-sufficient urban buildings and simulation-based studies. In 2012 and 2013, we additionally advanced our field research and simulation modeling work through an on-going U.S. Department of Energy grant, the Energy Efficient Buildings Hub, and wrapped up energy modeling and other activities associated with a PSE&G Technology Demonstration Grant.

Present and future research directions continue to embrace usability as a performance measure – from both individual and organizational perspectives, and the intersection of affordable housing, green building and public health. Within these pursuits, we increasingly succeed in introducing "big data" into our analyses, so as to elevate what might otherwise remain as case study data to a more generalizable level. Similarly, in 2013 we turned our attention to the task of developing energy management guidelines for large organizations and owners of building portfolios that incorporate "lessons learned" about both technology deployments and peoples' satisfaction and reactions to them.

This list of activities and research interests is by no means comprehensive and, as has been our habit, we will continue to solicit ideas for what is needed from you. On behalf of the Rutgers Center for Green Building, we wish you all the best for a healthy and happy 2014.

Sincerely yours,

Clinton J. Andrews

Director, Faculty Advisor

Jennifer Senick

Executive Director

The Rutgers Center for Green Building promotes green building and sustainable community through research, education, and training, and partnerships with industry, government, and not-for-profit organizations.

The Rutgers Center for Green Building at the Edward J. Bloustein School of Planning and Public Policy forms a common umbrella for existing and proposed initiatives being carried out at the Bloustein School, the School of Environmental and Biological Sciences (formerly Cook College), the School of Engineering and other Rutgers units that are integral to developing and implementing innovative green building and sustainable community strategies. The Center conducts applied research utilizing prospective and existing projects, works with industry and government to promote green building and sustainability concepts, and develops undergraduate, graduate and professional education programs. Initial funding was provided by the Rutgers University Academic Excellence Fund and subsequently by strategic partners and clients and through various grants. The Rutgers Center for Green Building seeks to establish itself as the pre-eminent interdisciplinary center for green building excellence in the Northeast, while serving as a single accessible locus for fostering collaboration among green building practitioners and policymakers.

2012 - 2013 Staff

Directors

Jennifer Senick
MA, PhD Candidate
Executive Director
Advisor to US Green Building Council NJ Chapter; Editorial Board, Brownfield Renewal; Co-Chair, EDRA Network, Sustainable Planning, Design and Behavior Network; Lead, Codes and Standards subtask, US DOE Energy Efficient Buildings Hub Project

Clinton J. Andrews
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American Collegiate Schools of Planning, Board of Directors, 2008–13; International Society for Industrial Ecology, Board of Directors, 2010-2012; Institute of Electrical and Electronics Engineers (IEEE), Chair, Ethics and Member Conduct Committee, 2012; New Jersey Department of Environmental Protection. Member, Science Advisory Board, 2010-2012

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Pallavi Shinde *BArch, MIP, MLA, MCRP*

2012-2013 Highlights

The year 2012-2013 saw the completion of two multi-year federal grants.

HUD: Green and Active Living Design

The Center has recently completed a three-year community based collaborative research study supported by the HUD's (US Housing & Urban Development) Office of Healthy Homes and Lead Hazard Control. This longitudinal quasi-experimental research evaluated opportunities to improve building operations, design, and occupant behaviors

toward better indoor air quality and occupant health outcomes for lowest income vulnerable residents of the South Bronx.

Data collected in the HUD study also have supported the objectives of an NSF (National Science Foundation) Self-Sufficient Urban Buildings study. Data on apartment level energy and water use were collected on two green but socially and economically different buildings in New York City to contribute to a better understanding of the effect of human activities on building performance.

A follow on project that started in the Fall of 2013, also funded by HUD, focuses on the development of new cost-effective methods for pest infiltration and other types of building damage along with rapid BIM models.

Please refer to page 6 for more information on work carried out under this project.

NSF: Self-Sufficient Urban Buildings

The "Self-Sufficient Urban Green Buildings" project, funded by the National Science Foundation (NSF), explored both technological and human factors that impact green building performance.

This project combined field- and simulation-based studies to investigate the potential for achieving sustainable design in the provision and use of energy and water systems in urban buildings. A specific focus of this work was an examination of the scientific, engineering, and human factors affecting potential self-sufficiency of urban buildings and the development of associated agent-based models.

The Center has conducted research for this project in a high-end residential green building in Lower Manhattan with approximately 292 apartments, ranging in size from studios to 3-bedrooms, as well as an Energy Star certified residential building in the South Bronx with approximately 127 apartments, ranging in size from 1-bedroom to 3-bedrooms.

In 2013, we entered the data analysis stage of the project, analyzing survey results from each building along with rich and complex field

data collected from a subset of apartments in each building, including water consumption, occupancy patterns, air quality and electricity consumption. Researchers on the project team are currently using statistical analysis and other quantitative and qualitative techniques to pull key patterns and findings from the data, with the goal of better understanding both building performance and occupant behavior, as well as important connections between the two.

Please refer to page 6 for more information on work carried out under this project.

Keynote Project

US DOE: Energy Efficient Buildings Hub (EEB HUB)

Established by the Department on Energy in 2011, this 5-year initiative has the objective of reducing energy use in existing commercial buildings by 30 % or more.

In partnership with many other organizations including Penn State, the University of Pennsylvania, Carnegie Mellon University, NJIT, UTRC, ASHRAE, Bayer Material Science, and the University of Maryland, the Center has leadership responsibility on multiple subtasks of the project and is conducting multi-disciplinary research in the areas of occupant-behavior and human-machine interface (HMI); building modeling and simulation of occupant behavior; and codes and standards.

While most of our work involves field studies and data collection from a variety of sources, our occupant behavior activities in particular engage building occupants through online

surveys, focus groups, and one-on-one interviews as well as observing operating conditions of existing buildings that have been retrofit with energy efficient technology.

Similarly, our HMI work looks to facilities operators and managers to help define their needs and provide feedback on improving energy efficiency through more user friendly building management system (BMS) design. Building simulation modeling is able to incorporate our field data to calibrate the models for more accurate estimates of occupant activities in the design of energy efficient buildings.

Finally, partnering with members of public and private sectors, our codes and standards efforts are working to define criteria for best practices applications, and to identify challenges for implementing standards through a range of building types. Through our collective tasks we anticipate producing methods and applications guidelines for scaling up design and standards throughout the market.

Please refer to pages 5 and 6 for more information on work carried out under this project.

Methods & Tools

Life Cycle Cost (LCC) Analysis

The Rutgers Center for Green Building produces models and analyses on the net benefits associated with green building, and disseminates this information to green building stakeholders.

Most recently, the Center created a comprehensive life cycle cost tool to analyze energy life cycle performance in a sample of pilot homes, as part of the NJ Climate Choice Home (NJCCH) Pilot Project. Methods included homeowner interviews/surveys in order to gather information on occupancy patterns, behaviors, and other factors affecting energy consumption.

To help the New Jersey Association of Realtors (NJAR) and the real estate industry understand the net economic benefits of green home building, the Center also completed a detailed analysis of the upfront costs, operating savings, payback period, and appraisal and valuation benefits for these green

features. The research looked at the costs and benefits of purchasing a green home on a life cycle basis, from upfront costs through expected resale value.

Life Cycle Assessment (LCA)

The Center performed life cycle assessments of a typical LEED single family home in New Jersey, and a typical Minergie-P single family home in Chur, Switzerland, to assess the effect of rating systems and construction practices on the buildings' environmental impacts.

Previously, the Center was retained by the New Jersey Meadowlands Commission (NJMC) to perform a Life Cycle Costing and an Environmental Life Cycle Assessment of the Observatory & Classroom building in Lyndhurst, NJ. The Center completed an environmental life cycle analysis of construction materials and post-occupancy metabolic inputs to the building. This report reviewed the cumulative impacts of the building, from resource collection through decommissioning.

Post Occupancy Evaluation

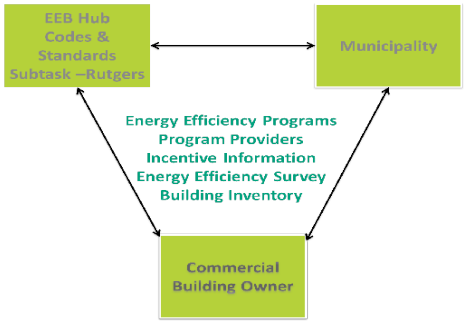
Claims that green buildings can achieve cost-effectiveness, improve occupant health and lower environmental impacts are driving the green building movement. The Rutgers Center for Green Building has developed tools and is conducting research to help document the performance and benefits of green buildings, help demonstrate the market value of such projects, and provide an empirical basis to direct future green building investments.

Policy Research

US DOE Energy Efficient Buildings Hub: Codes and Standards Subtask

The Department of Energy (DOE), the American Planning Association and many others routinely provide robust best practices for implementing energy efficiency measures in the context of building codes, and to a lesser extent, zoning and planning codes and standards. In combination, these approaches can yield energy savings of greater than 30%, although several implementation challenges exist. These include regionally or locally specific barriers -- e.g., resistance to the adoption of current building codes, slippage in building codes enforcement, ordinances that discourage green roofs by including them in the rooftop area limit for rooftop appurtenances, conflicts between historical preservation (and/or zoning) standards and energy efficiency measures. Other local or regional factors that affect the policy environment for AERs and which may be altered through regional policy include the availability of rebates or other incentives for energy efficiency, the structure of utilities and their relationship to building code, and provisions in contracting/procurement law.

The Codes and Standards team is working to identify barriers to AERs and provide strategic guidance on how to overcome them while also demonstrating a subset of these strategies through direct market engagement with building owners. Specific topic areas engaged by the Codes and Standards team include the following: code adoption, code slippage and compliance, performance (outcome) based codes, planning codes/standards that impede or promote AERs, conflicts/synergies in historical preservation standards and AERs, historical/structural divisions in utility mandates and codes, and legal/contractual structures.



PSE&G: Energy Technology Demonstration Grant Program

In 2010, Rutgers, The State University of New Jersey and the New Jersey Institute of Technology (NJIT) partnered to compete as Team New Jersey in the U.S. Department of Energy Solar Decathlon 2011 competition. Team New Jersey was one of 20 collegiate teams, selected from an international pool of 45 applicants, challenged to design, build, and operate solar-powered houses that are affordable, energy-efficient, and attractive. A PSEG Technology Demonstration Grant helped support the construction of Team New Jersey's ENJOY demonstration house.

In the period following the competition, team members, including the Center, continue to assess the commercial potential of specific innovations inspired by the competition experience, including barriers to greater penetration of energy efficient wall assemblies in the U.S. residential market, the focus of a White Paper.

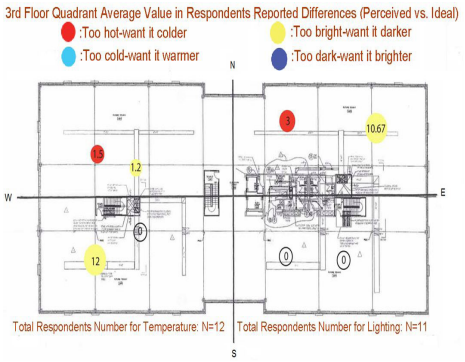
Furthermore, the Center has also been involved in the creation of a concept-level plan for the reconstruction of the ENJOY Solar Decathlon home on the New Brunswick campus of Rutgers University. The building would be utilized as a "Green Building Lab", acting as a "living lab", which would allow for the interchangeability of various building features and systems for the study of building energy efficiency and occupant satisfaction. In addition, other opportunities for the creation of living labs at Rutgers were proposed, including research space in the Civic Square Building, as an "Intelligent Workplace Lab."

Behavioral Research

As an interdisciplinary research center we have the advantage of drawing from a rich source of tools and methods by which to identify and collect a wide variety of data to improve understanding and design for human relationships in the built environment. Our methods are typically grounded in theory-driven quasi-experimental, case study, longitudinal, or cross-sectional post-occupancy evaluation research designs with quantitative and/ or qualitative data. Depending on the capabilities of the buildings and the participants we design reserach protocol as is appropriate for the study site and the occupants as well as for the objectives of the research.

HUD: Green and Active Living Design

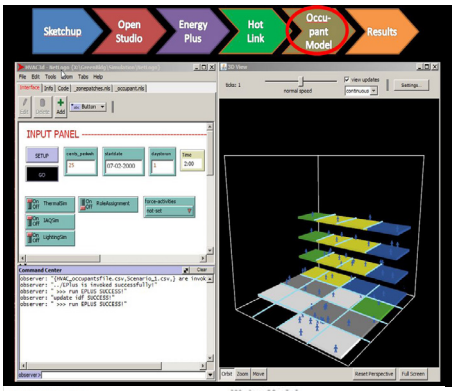
For example, our evaluation of green affordable housing supported by the US Housing and Urban Development agency incorporated a longitudinal and quasi-experimental collaborative research design. Meetings with our partner community organization, focus groups, and the formation of a Residents Advisory Committee were key to helping us develop an interview protocol with appropriate recruitment and intervention strategies.



Forty participants were offered "props" or supplies as well as best practices guides for improving health promoting behaviors, indoor air quality, and energy efficiency in their apartments. Indoor air quality testing conducted in conjunction with Rutgers School of Environmental and Biological Studies indicated that participants who used the alternative low- or no-toxin cleaning strategies significantly improved the readings of indoor particulate matter and some volatile organic compounds (VOC's). Participants also demonstrated increasing interest in the vegetable roof garden as well as using a supplied reusable water bottle for increasing water consumption.

USGBC

In contrast, our USGBC evaluations of LEED (Leadership in Energy and Environmental Design) commercial office buildings relied on a cross-sectional research design



wherein walk-through observations and interviews with building occupants were supplemented with online surveys to describe their satisfaction and experiences with their workplace. Building data were collected to help focus on how well the building meets its energy performance goals as well as the role of human agency in mediating these outcomes. The field data on occupant behavior in conjunction with building performance metrics have been subsequently included in the ongoing advancement of the Center's agent based modeling framework. Building simulation modeling incorporates occupant-building interaction parameters to help inform policy and design for improved building performance in terms of energy and resource consumption as well as occupant satisfaction and well-being.

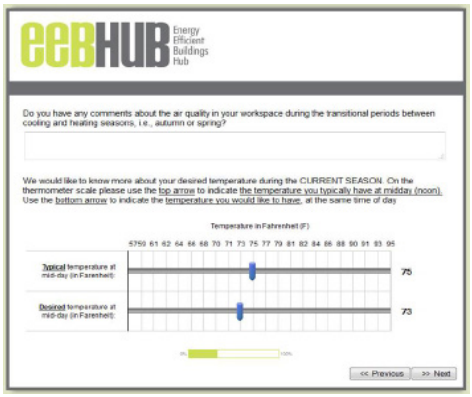
NSF: Self Sufficient Urban Buildings

One important component of the NSF project is its focus on human behavioral factors. This component of the project aims to use results from both qualitative and quantitative data collection methods in order to better understand how human behavior has impacted the performance of each building, and how researchers can better predict and understand consumption behavior among residents. Surveys and interviews conducted consisted of a range of questions regarding energy and water use at home, opinions about the building and apartment unit, and values and attitudes regarding energy and environmental conservation.

In the current data analysis phase, researchers on the project team are analyzing residents' stated values, norms, attitudes and intentions regarding their consumption at home and related conservation behaviors, and attempting to connect these responses to both self-reported and observed consumption data. In addition, we are attempting to connect these psychological constructs along a causal chain outlined in well-known behavioral frameworks in order to better understand the predictive power of these theories. This component of the project ultimately attempts to use these results to investigate important human factors such as the distinction between reasoned and habitual behaviors, the impact of habits on behavioral outcomes, drivers and motivations of both consumption and conservation choices, and patterns of decision-making among residents.

Energy Efficient Buildings Hub (EEB HUB)

The EEB Hub guides the focus of our Department of Energy (DOE) – supported behavioral research. There are numerous objectives and opportunities to develop occupant-behavior related data as it is affected by



and affects building design and performance. Our research design is again primarily post-occupancy evaluation that implements a walk-through observation and interview protocol with online survey measurements. In some cases the design is longitudinal which is fitted with baseline and follow-up measurements of participant experiences. Intermittent daily surveys aim to measure background participant well-being and productivity during days when power is reduced, i.e., load shedding is implemented, to compare with typical, non-reduction days as control days. Although early in our research on the effects of load shedding on participants' behavior and satisfaction, the behavioral research in this area promises to inform policy on the potential advantages and limitations of reducing energy at graduated levels in multi-tenanted buildings.

The State of the Center

Recent Publications

Wener, R.E., McCunn. L., and Senick J.A., "Post Occupancy Evaluation". In Methods in Environment Behavior Research. John Wiley and Sons. (Forthcoming)

Mosteiro Romero, M., Krogmann, U., Wallbaum, H., Ostermeyer, Y., Senick, J.A., Andrews, C.J. "Relative Importance of Electricity Sources and Construction Practices in Residential Buildings: A Swiss-U.S. Comparison of Energy Related Life-Cycle Impacts". Energy and Buildings. 2013.

Andrews C.J. "Empowering Sustainable Consumption'. IEEE Technology and Society Magazine. 2013

Zhang, H., Putra, H.C., Andrews, C.J,. "Modeling Real Estate Market Responses to Climate Change in The Coastal Zone", The Computational Social Science Society of the Americas, 2013.

Senick, J.A., Souder, J. "Combining Community Resiliency and Energy Efficiency Retrofits: the Rutgers Center for Green Building with the Energy Efficient Buildings Hub (EEB Hub)". Brownfield Renewal Magazine, April 2013.

Linkola, Lilli, Clinton J. Andrews, and Thorsten Schuetze. An Agent Based Model of Household Water Use. Water 2013, 5. 1082-1100. Published 17 July 2013.

The Rutgers Center for Green Building. New Jersey Green Building Manual Best Practice Guidelines for Residential and Commercial Buildings. New Jersey Department of Environmental Protection. 2012.

Andrews, C.J. "Planning". Encyclopedia of Environmental Science and Engineering, Sixth Edition, Volume 2. Edward N. Ziegler, editor. CRC Press. 2012. Chapter 64:1005-1007.

Andrews, C.J., Friis, R.H. "Green Living: Reducing the Individual's Carbon Footprint". In The Praeger Handbook of Environmental Health, Volume I: Foundations of the Field. Robert H. Friis, editor. Praeger. 2012. Chapter 23: 455-473.

Andrews, C.J., Senick, J.A. and Wener, R.E. "Incorporating Occupant Perceptions and Behavior into BIM". In Enhancing Building Performance. S. Mallory-Hill, W. Preiser and C. Watson. Oxford, UK, Blackwell Publishing Ltd. 2012. Chapter 20: 234-246.

Andrews, C.J., Senick, J.A., Wener, R.E., Sorensen Allacci, M. "Investigating Building Performance Through Simulation of Occupant Behavior". In Greenbuild 2012, International Conference. November 14-16, 2012. San Francisco, CA. 2012. Research Track Session: 16-22.

Andrews, C.J., Yi, D., Krogmann, U., Senick, J., Wener, R. "Designing Buildings for Real Occupants: An Agent-Based Approach, " IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, 2011.

Recent Reports

Andrews, C.J., Mainelis, G., Wener, R., Sorensen Allacci, M., Plotnik, D., Senick, J., Feygina, I., Autote, O., Ramkumar, S., Pryce, T., Marathe, R. and Ding, J. "Expanding the Definition of Green: Impacts of Green and Active Living Design on Health in Low Income Housing: Added Value of Behavioral Interventions as part of an Integrated Service Delivery Model". Prepared by Rutgers Center for Green Building & Associates for U.S Department of Housing and Urban Development. 2013.

Senick, J.A., M. Sorensen Allacci, R.E. Wener, C.J. Andrews, D. Plotnik, P. Shinde, and S. Malenchak. 2013. Post-Retrofit Assessment of Lighting & HVAC Conditions in Three Tenanted Buildings- Liberty – PECO Smart Grid Investment Grant Program. Prepared by the Center for Green Building at Rutgers University for the Energy Efficient Buildings Hub, Philadelphia, PA. 2013.

Senick, J.A., R.E. Wener, I. Feygina, M. Sorensen Allacci, and C.J. Andrews. 2013. Occupant Behavior in Response to Energy-Saving Retrofits and Operations. Prepared by the Center for Green Building at Rutgers University for the Energy Efficient Buildings Hub, Philadelphia, PA. 2103.

"Combining Community Resiliency and Energy Efficiency Retrofits: The Rutgers Center for Green Building with the Energy Efficient Buildings Hub (EEB Hub)". Prepared by Jennifer Souder, Researcher, Rutgers Center for Green Building and Jennifer Senick, Executive Director, Rutgers Center for Green Building and Editorial Board Member, Brownfield Renewal, for the Energy Efficient Buildings Hub, Philadelphia, PA. 2013.

"Deep Energy Retrofit Modeling and Cost Effectiveness Study: A Technical Policy Brief". Prepared by the Rutgers Center for Green Building at Rutgers University* for the Energy Efficient Buildings Hub, Philadelphia, PA. 2013.

Senick J., Souder J., Shinde P. and Plotnik P."Township of West Windsor Building Inventory and Energy Efficiency Targeted Marketing Approach for Building Owners'. Prepared by the Rutgers Center for Green Building at Rutgers University for the Energy Efficient Buildings Hub, Philadelphia, PA. 2013.

"Municipal Guidance for Promoting Energy Efficiency in the Private Sector". Prepared by the Center for Green Building at Rutgers University for the Energy Efficient Buildings Hub, Philadelphia, PA. 2013.

Rutgers Center for Green Building, Vermont Energy Investment Corporation, New Jersey Institute of Technology's Center for Building Knowledge and MaGrann and Associates. "Climate Choice Homes Research & Development Project". 2013

Andrews, C.J., H. Chandra Putra, and C. Brennan. "Simulation Modeling of Occupant Behavior in Commercial Buildings". Prepared by the Center for Green Building at Rutgers University for the Energy Efficient Buildings Hub, Philadelphia

The Rutgers Center for Green Building. "Investigating Opportunities for Improving Building Performance Through Simulation of Occupant and Operator Behavior". Prepared by the Center for Green Building at Rutgers University for the US Green Building Council. 2012.

The Rutgers Center for Green Building. "Costs and Benefits of Residential Energy Efficiency Investments". Prepared by the Center for Green Building at Rutgers University for the New Jersey Association of REALTORS Governmental Reserach Foundation. 2011

Recent Models

Land Use Change Model: How will communities in the coastal zone adapt to climate change? Funder: National Science Foundation 2010 – 2013

HVAC Model: How do building occupants interact with heating, ventilating, and air conditioning (HVAC) systems in pursuit of thermal comfort and good indoor air quality? Funders: National Science Foundation 2007 – 2013, U.S. Green Building Council 2008-2011.

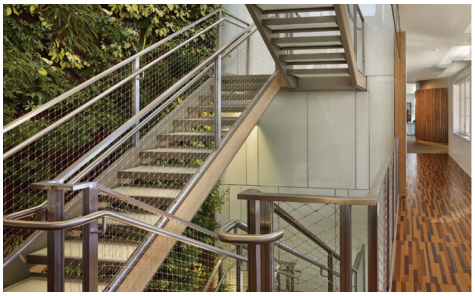
Water Model: How do building occupants use water? Funders: National Science Foundation 2007 – 2013, U.S. Green Building Council 2008-2011.

Lighting Model: How do building occupants interact with lighting and daylighting systems? Funders: National Science Foundation 2007 – 2013, U.S. Green Building Council 2008-2011.







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