
Preface

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This edited volume comprises research and review chapters primarily resulting from the recent U.S.-China Workshop on Analytics for Building-Scale Sustainable Ecosystems, sponsored by the U.S. National Science Foundation (NSF), and held in Tsinghua University, Beijing, China, June 12–13, 2012. A group of researchers from both the United States and China academic institutions present in this volume their views of bottlenecks in engineering, software, and social sciences, forming a nexus of critical issues impeding wider application of net zero energy building technology in the context of defining building-scale sustainable ecosystems. The focus of these investigations is the fundamentals of sciences that lead to a robust, significant improvement toward modeling and predicting building performance indices such as energy usage with user integration and sustainability. Achievements and challenges in research and development initiatives and best practices from the United States and China provide a foundation for such development of analytics and possibility of benchmarking and comparability. The edited volume divides the topics in the following main parts.

PART ONE: OVERALL PROSPECTS

The book starts with Chapter 1 to address the challenges in U.S.-China research collaboration. With the initial successful launch of U.S.-China Clean Energy Research Center (CERC) initiative, the United States and China were able to exchange experts who would share their understanding of efficient building technologies. The chapter covers discussions about the opportunities for researchers from two countries to understand the significant differences in building energy utilization and the needs to explore the reasons behind the differences. By focusing on the difference and investigating the comparative reasons, it allows the research communities to invest their time and efforts effectively to arrive at the solutions that could minimize the uncertainties in predicting building energy consumptions, including such factors as building occupant behaviors.

Chapter 2 presents a detailed review of international research on zero-energy building design and technologies from outside of China. It points out the rapid progress primarily in the developed countries where the zero-energy building concept is being aggressively pursued.

Chapter 3 discusses a special aspect of the societal impact of sustainable buildings and its ecosystems for aging populations. It presents a few key factors through examples that the human demands for life experience directly impact the definition of what is sustainable. Because of the unique life experiences of this segment of the population, one cannot think of sustainability, or building ecosystems, in terms of only lowering an elder's footprint.

PART TWO: DATA COLLECTION, COMPARISON, AND ANALYSIS

This part contains three chapters. Chapter 4 discusses the role of life cycle assessment in sustainable building ecosystems and building energy comparison between China and the United States. It has been widely recognized that life cycle assessment arises as a promising method that supports the investigation of the relationship between built environments and ecosystems, even though limitations of this method are well known and documented. This is because life cycle assessment can reveal material and energy flows throughout the material realm and human societies, as well as model the environmental consequences of such flows throughout the life cycle stages of materials, products, or buildings. The chapter discusses in detail the energy and environmental challenges in both countries and evolving views of the relationship between built environments and ecosystems.

Chapter 5 covers one of the challenges facing comprehensive modeling for building energy assessment and evaluation of its sustainability, i.e., the interoperable modeling techniques. It discusses the research progress and methodologies to streamline the integration of parametric modeling, building information modeling (BIM), and building energy modeling. As sustainable building design becomes more of the norm than a luxury, the streamlined modeling process will provide prototypes and specifications for the development of design and simulation software tools.

Chapter 6 presents the research progress toward system integration for interoperable data models of building-scale ecosystems. It offers some emerging concepts on addressing the issues of mismatching between the building delivery process, which is commonly executed as a discrete and sequential set of activities, and sustainable building design analysis and evaluation tools, which employ modern advances in communication and dissemination technologies. The ability to assess the impact of building design on energy and environmental sustainability requires relatively easy exchange of data information among tools used, for example, in dynamic life-cycle information modeling (DLIM) infrastructure and many certification and standard development processes.

PART THREE: HUMAN BEHAVIORS

Chapter 7 addresses several concepts toward understanding human behaviors in general that could potentially impact the design and adoption of building-scale sustainable ecosystems. It outlines some of the relevant cognitive biases and plausible incentives that might prove to be beneficial in helping architects and engineers to nudge building occupants toward behavior that maximizes the potential of buildings for their long-term

efficiency, usability, and sustainability. In addition, a few cases studied in China are presented to illustrate some of the current phenomenological methodologies in analyzing the human behavior factors that could account for differences in building energy consumption between the United States and China.

Chapter 8 focuses on developing occupancy influence parameters in commercial buildings. It illustrates how energy modeling and simulation of human behavior in buildings can be done using the current state-of-the-art tools and methods. The results help improve building energy simulation tools and building design and occupancy-focused interventions, and encourage the adoption of occupancy-focused interventions in energy policies and governmental initiatives.

Chapter 9 outlines the methodology that could be used to investigate a broader impact of human behaviors from building-scale to community-scale applications. The author proposes the theoretical foundations for the application of computational tools and methods to support sustainable design, and outlines four research directions that are believed to require substantial advances to further the goals for understanding the design and behavior of sustainable building-scale ecosystems.

PART FOUR: GREEN BUILDINGS AND INNOVATIVE BUILDING DESIGN AND TECHNOLOGY

Five chapters in this part present topics ranging from emerging practices of green building design and construction to example technologies used or proposed for the sustainable building ecosystems. Chapter 10 covers a comprehensive review of the sustainable construction concept that emerged since early 1990 in the United States and around the world. It outlines the emergence of building assessment systems such as BREEAM, LEED, Green Star, and DGNB, and the latest sustainable construction movement such as the net zero strategy or concept. It also covers the emergence of carbon accounting and environmental product declarations (EPDs) as significant and important shifts in the direction of the evolution of sustainable construction.

Chapter 11 covers the progresses in the European Union and the United States toward the net zero energy buildings targets. Through three different successfully implemented and benchmarked case studies of NET-ZEB and Plus-Energy building occupancy types, the analysis provides insights on how buildings should be better designed, built, and measured with resource footprinting on a common metric scale. The chapter points out that the importance of legislative and curricular efforts that must be based on actual, yearly, measured building energy performance balance, carbon intensity, and an integrated building life cycle analysis, rather than on modeled assumptions from somewhat exceptional national “demo buildings.”

Chapter 12 outlines a study on green air-conditioners using a refrigerant of low global warming potential (GWP). It focuses on the motivation of reducing the impact of refrigerants on the environment and therefore the development of prototype systems that can utilize alternative refrigerants, which include *hydrocarbon refrigerants*, *two-phase carbon dioxide*, ammonia, and naturally existing gases.

Chapter 13 includes the investigation of building supervisory control systems and the system model that is established to capture the dynamics of the building system. It demonstrates that the research on optimization algorithms of the control systems could contribute to the better utilization of energy in sustainable buildings.

Chapter 14 summarizes several recent works in Chinese building technology research including optimization of air-source heat pumps, seasonal cooling energy storage systems, hybrid ground source heat pumps, integrated building design based on minimizing thermal discomfort, innovative building automation systems, and indirect evaporative cooling technology. Some of the technologies could be deployed outside of China.

The additional materials presented in the workshop are included in the Appendix part of the book. It contains seven presentations from researchers at the Building Energy Center from Tsinghua University, China. It covers some of the current ongoing research topics in Tsinghua, including building energy monitoring systems and analysis, energy consumption patterns in the United States, occupant behavior in buildings, thermal discomfort analysis, sustainable residential buildings in rural areas, green building standards development, and the introduction of IEA ECBCS–Annex 59, an international collaborative effort on energy efficient cooling and heating methods.

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