

FOURTH 4 EDITION

SUSTAINABLE CONSTRUCTION

GREEN BUILDING DESIGN AND DELIVERY

CHARLES J. KIBERT

WILEY

Sustainable Construction

Green Building Design and Delivery

Fourth Edition

Charles J. Kibert

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For Charles, Nicole, and Alina,
and in memory of two friends and sustainability stalwarts,
Ray Anderson and Gisela Bosch

Preface

The significant additions and changes for this fourth edition of *Sustainable Construction: Green Building Design and Delivery* include revisions to the chapters on LEED and Green Globes, both of which have changed significantly over the past few years. LEED version 4 is now the main building assessment product being offered by the US Green Building Council for projects, and this recent addition is covered in detail. Because the US Green Building Council also allows projects to opt for LEED version 3 and familiarity with both systems is needed to allow flexibility for owners and project teams, LEED v3 is also addressed in an appendix. Green Globes has also changed; version 2 of this important rating system is covered in detail. Information about the other major assessment systems, such as Green Star, Comprehensive Assessment System for Building Environmental Efficiency, Building Research Establishment Environmental Assessment Method, and Deutsche Gesellschaft für Nachhaltiges Bauen, has been updated.

In addition to the changes to bring the information about the major building assessment systems up to date, a new chapter on carbon accounting addresses the increasing interest in reducing the carbon footprint of the built environment, from a green building perspective and also to provide clarity about the contribution of buildings to climate change.

A major emerging issue is transparency, and demands for transparency are appearing regarding several performance issues. These include the provision of information about building product ingredients and the risks of these ingredients to human health and ecosystems. Risk-based assessment, Health Product Declarations, and other approaches are emerging to address this demand, and manufacturers are buying into the concept of being more open about the content of their products. In addition, many major cities are requiring transparency regarding the energy performance of buildings. In New York City, for example, building owners are required to provide information about the performance of their buildings on an annual basis. This requirement dovetails with the shift in building assessment system strategies that explicitly provide credit for reporting of both energy and water data. Transparency is described and discussed in several locations in this fourth edition.

One of the new additions is coverage of the rapid growth in the numbers and quality of green skyscrapers around the world. Ken Yeang, the renowned Malaysian architect, first elaborated this concept in his 1996 book, *The Green Skyscraper: The Basis for Designing Sustainable Intensive Buildings*, and in his two other volumes on the subject, *Eco-Skyscrapers* (2007), and *Eco-Skyscrapers, Volume 2* (2011). In this volume, we address skyscrapers two chapters. In Chapter 1, one of the world's premier green skyscrapers, the Pertamina Energy Tower, located in Jakarta, Indonesia, is described in great detail because it represents perhaps the cutting edge of very large building design. This project is especially noteworthy because it is the first net-zero-energy skyscraper and represents the cutting edge of skyscraper performance. Later in the volume, in Chapter 16, two sets of skyscrapers—one group in New York City and the other group selected from green skyscraper projects around the world—are described and compared. I would like to express my gratitude to the group of architects and engineers at Skidmore, Owings & Merrill (SOM), who designed the Pertamina Energy Tower. These include the Gabriele Pascolini, Sergio Sabada, Luke Leung, Scott Duncan, David Kosterno, Stephen Ray, Elyssa Cohen,

and Jonathan Stein. Although extremely busy with their day jobs designing significant skyscraper projects around the world, they gave generously of their time and resources to assist me. I would also like to thank the team at HOK that designed the Lake Nona Research Building for the University of Florida, specifically Van Phrasavath and Mandy Weitknecht. Frank Javaheri, project manager for the University of Florida, was also very helpful in assisting in gaining access to information and documentation.

This fourth edition has significantly more graphics than the third edition of *Sustainable Construction*, and a large number of organizations and companies were kind enough to permit the publication of their content in this edition. Thanks to all the contributors of these invaluable materials.

Thanks to Paul Drougas and Margaret Cummings at John Wiley & Sons for once again guiding me through the initial stages of the publication process and to Mike New at John Wiley & Sons for keeping me on track. This edition would not have been possible without the enormous contributions of Tori Reszetar and Alina Kibert, who were extremely dedicated to helping produce a comprehensive, quality outcome. I owe an enormous debt to both of them for their very hard work and dedication.

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Gainesville, Florida

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Chapter 1

Introduction and Overview

In the short quarter century after the first significant efforts to apply the *sustainability* paradigm to the built environment in the early 1990s, the resulting *sustainable construction* movement has gained significant strength and momentum. In some countries—for example, the United States—there is growing evidence that this responsible and ethical approach is dominating the market for commercial and institutional buildings, including major renovations. Over 69,000 commercial building projects have been registered for third-party green building certification with the US Green Building Council (USGBC), the major American proponent of built environment sustainability, in effect declaring the project team's intention to achieve the status of an officially recognized or certified green building. The tool the USGBC uses for this process is commonly referred to by its acronym, LEED (Leadership in Energy and Environmental Design). Thus far, 27,000 commercial projects have navigated the LEED certification process successfully. Nowhere has the remarkable shift toward sustainable buildings been more evident than in American higher education. Harvard University boasts 93 buildings certified in accordance with the requirements of the USGBC, including several projects with the highest, or platinum, rating and including more than 1.9 million square feet (198,000 square meters [m²]) of labs, dormitories, libraries, classrooms, and offices. An additional 27 projects are registered and pursuing official recognition as green building projects. The sustainable construction movement is now international in scope, with almost 70 national green building councils establishing ambitious performance goals for the built environment in their countries. In addition to promoting green building, these councils develop and supervise building assessment systems that provide ratings for buildings based on a holistic evaluation of their performance against a wide array of environmental, economic, and social requirements. The outcome of applying sustainable construction approaches to creating a responsible built environment is most commonly referred to as *high-performance green buildings*, or simply, *green buildings*.

The Shifting Landscape for Green Buildings

There are many signs that the green building movement is permanently embedded as standard practice for owners, designers, and other stakeholders. Among these are four key indicators that illustrate this shift into the mainstream. First, a survey of design and construction activity by McGraw-Hill Construction (2013) found that, for the first time, the majority of firms engaged in design and construction expected that over 60 percent of their work would be in green building by 2015. South Africa, Singapore, Brazil, European countries, and the United States all report this same result: that green building not only dominates the construction marketplace but also continues to increase in market share. This same report suggests that around the world, the pace of green building is accelerating and becoming a long-term business opportunity for both designers and builders. The green building market is growing worldwide and is

not isolated to one region or culture. According to McGraw-Hill Construction, architects and engineers around the world are bullish on green building. Between 2012 and 2015, the number of designers and building consultants expecting more than 60 percent of their business to be green more than tripled in South Africa; more than doubled in Germany, Norway, and Brazil; and increased between 33 percent and 68 percent in the United States, Singapore, the United Kingdom, and Australia. The reasons for the rapid growth in high-performance green building activity has changed dramatically over time. In 2008, when a similar survey was conducted, most of the respondents felt that the main reason for their involvement was that they were doing the right thing, that they were simply trying to have a positive impact. Fast-forward just six years to 2014, and the reasons had changed significantly. The most cited triggers for green building around the world are client demand, market demand, lower operating costs, and branding/public relations. Green building has become simply a matter of doing good business, and has entered the mainstream in both the public and the private sectors. Although those interviewed indicated that they were still interested in doing the right thing, this reason moved from the top of the list in 2008 to number five in the six-year period between the two surveys.

A second illustration of the green building movement's staying power occurred at the Arab world's first Forum for Sustainable Communities and Green Building held in late 2014. Mustafa Madbouly, Egypt's minister of housing and urban development, told the audience: "Climate change forces upon us all a serious discussion about green building and the promotion of sustainability" (Zayed 2014). According to the United Nations Human Settlement Program (UNHSP), cities in the Arab world need to introduce stronger standards for green building and promote sustainable communities if they are to have this chance of tackling climate change. The UNHSP estimates that 56 percent of the Arab world's population already lives in cities and urban centers. This number quadrupled between 1990 and 2010 and is expected to increase another 75 percent by 2050. In short, applying sustainability principles to the built environment is essential not only for the well-being of the region's population but also for their very survival. According to the World Bank, the unprecedented heat extremes caused by climate change could affect 70 percent to 80 percent of the land area in the Middle East and North Africa.¹ Green building and climate change are now inextricably linked, and the main strategy for addressing climate change must be to change the design and operation of the built environment and infrastructure to reduce carbon emissions dramatically.

Third, in the United States, activity in sustainable construction continues to increase, some of it marking the continued evolution of thinking about how best to achieve high standards of efficiency in the built environment while at the same time promoting human health and protecting ecological systems. The state of Maryland and its largest city, Baltimore, provide a contemporary example of how strategies are being fine-tuned to embed sustainability in the built environment for the long term. In 2007, both Maryland and Baltimore, the 26th most populous city in the United States, adopted the USGBC's LEED rating system, requiring that most new construction be LEED certified. At the time, this move was considered groundbreaking, and it paralleled efforts by many states and municipalities around the country to foster the creation of a much-improved building stock. Baltimore, along with 176 other American jurisdictions, mandated green buildings and supported their implementation with a variety of incentives, including more rapid approval times, decreased permitting fees, and, in some cases, grants and lower taxes. In 2014, in a move that is likely to become more common, both Maryland and Baltimore repealed the laws and ordinances requiring LEED rating certification and instead adopted the International Green Construction Code (IgCC) as a template for their building codes. A construction or building code such as IgCC, in contrast to a voluntary rating system such as LEED, *mandates* green strategies for buildings. This turn of events marks a significant change in both strategy and philosophy because it indicates a shift

from third-party certification systems to mainstreaming green building through the use of standards and building codes enforced by local authorities.

The fourth sign of the shifting landscape for high-performance green building is the fact the major tech giants Apple and Google and a range of other tech companies have announced major projects that indicate their industry is embracing high-performance green building. Apple Campus 2 (see Figure 1.1), scheduled for a late 2016 completion, will house 14,200 employees. In first announcing the new project in 2006, the late Steve Jobs referred to it as “the best office building in the world.” The architects for this cutting-edge facility are Foster + Partners, the renowned British architecture firm whose founder and chairman, Sir Norman Foster, was inspired by a London square surrounded by houses to guide the design concept. As the building evolved, it morphed into a circle surrounded by green space, the inverse of the London square. Located on about 100 acres (40.5 hectares) in Cupertino, California, the 2.8 million-square-foot (260,000 square meters) building is sited in the midst of 7,000 plum, apple, cherry, and apricot trees, a signature feature of the area’s commercial orchards. Only 20 percent of the site was disturbed by construction, resulting in



Figure 1.1 Apple Campus 2 is an NZE building designed to generate all the energy it requires from photovoltaic (PV) panels located on its circular roof. Its many passive design features allow it to take advantage of the favorable local climate such that cooling will be required just 25 percent of the year. (Source: City of Cupertino, September 2013)

abundant green space. Apple's Transportation Demand Management program emphasizes the use of bicycles, shuttles, and buses to move its employees to and from two San Francisco Bay regional public transit networks. The transportation program alternatives for Apple Campus 2 include buffered bike lanes and streets near the campus that are segregated from automobile traffic and also wide enough to permit bicycles to pass each other. Hybrid and electric automobile charging stations serve 300 electric vehicles, and the system can be expanded as needed. The energy strategy for Apple's new office building was shaped around the *net zero energy* (NZE) concept, with extensive focus on passive design to maximize daylighting and natural cooling and ventilation. The result is a building that generates more energy from renewable sources than it consumes. Energy efficiency is important for the net zero strategy, and the lighting and all other energy-consuming systems were selected for minimal energy consumption. The central plant contains fuel cells, chillers, generators, and hot and condenser water storage. A low carbon solar central plant with 8 megawatts (MW) of solar panels is installed on the roof, ensuring the campus runs entirely on renewable energy.

Another tech giant with ambitious high-performance green building plans is Google. Early in 2015, as part of a planned massive expansion, Google announced a radical plan for expansion of its Mountain View, California, headquarters into the so-called Googleplex. The radical design included large tentlike structures with canopies of translucent glass floating above modular buildings that would be reconfigured as the company's projects and priorities change. The area beneath the glass canopy included walking and bicycle paths along meadows and streams that connect to nearby San Francisco Bay. The emerging direction of design by the superstar collaboration between the Danish architect Bjarke Ingels and the London design firm, Heatherwick Studio was an eco-friendly project that would feature radical passive design and integration with nature and local transportation networks. However, in mid-2015, the Mountain View City Council voted to allow Google just one-fourth of its planned expansion, with the remaining site being made available to another tech firm, LinkedIn. In spite of this setback, Google, like many other technology-oriented companies, is committed to greening its buildings and infrastructure. One of its commitments is to investing in renewable energy, and the firm committed \$145 million to finance a SunEdison plant north of Los Angeles. This was one of many renewable projects in which Google has invested a total of over \$1.5 billion as of 2015.

Other tech firms are also leading the way with investments in architecturally significant, high-performance green buildings. Hewlett-Packard hired the renowned architect Frank Gehry to design an expansion of its Menlo Park, California, campus. It is clear that the behavior of these tech firms is part of an emerging pattern among start-up firms, which often begin their lives in college dorm rooms, storage units, garages, and living rooms. They move out of such locations as they mature, renting offices in industrial parks. Then, when they have become supersuccessful and flush with cash, they tend to build iconic monuments. However, in spite of the desire to make a splash by investing in signature headquarters buildings designed by well-known architects, the tech industries have managed to remain eco-conscious and serve as change agents by pushing society toward more sustainable behavior, particularly with respect to the built environment.

These trends, which mark the current state of high-performance green building around the world, indicate a maturing of the movement. The first of these buildings emerged around 1990, and the movement is now being mainstreamed, as evidenced by the incorporation of high performance building rating systems, such as LEED, into standards and codes. Since the inception of its pilot version in 1998, LEED has dealt with building energy performance by specifying improvements beyond the requirements of these standards to earn points toward certification. The main energy standard in the United States is the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1, *Energy Standard for*