

# The Engineering Guide to LEED-New Construction

Sustainable Construction for Engineers

*Second Edition*

Liv Haselbach

## 新建项目 LEED 工程指南

### 面向工程师的可持续性建造技术



**A GreenSource BOOK 影印版**

# The Engineering Guide to LEED-New Construction

**Sustainable Construction for Engineers**

Second Edition

Liv Haselbach

---

**新建项目 LEED 工程指南**  
**面向工程师的可持续性建造技术**



哈爾濱工業大學出版社  
HARBIN INSTITUTE OF TECHNOLOGY PRESS

# 黑版贸审字08-2014-016号

Liv Haselbach

The Engineering Guide to LEED-New Construction: Sustainable Construction for Engineers ( Second Edition )  
ISBN 978-0-07-174512-3

Copyright © 2010,2008 by McGraw-Hill Education.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including without limitation photocopying, recording, taping, or any database, information or retrieval system, without the prior written permission of the publisher.

This authorized English reprint edition is jointly published by McGraw-Hill Education (Asia) and Harbin Institute of Technology Press Co. Ltd. This edition is authorized for sale in the People's Republic of China only, excluding Hong Kong, Macao SAR and Taiwan.

Copyright © 2014 by McGraw-Hill Education (Asia), a division of McGraw-Hill Education (Singapore) Pte. Ltd. and Harbin Institute of Technology Press Co. Ltd.

版权所有。未经出版人事先书面许可，对本出版物的任何部分不得以任何方式或途径复制或传播，包括但不限于复印、录制、录音，或通过任何数据库、信息或可检索的系统。

本授权英文影印版由麦格劳-希尔（亚洲）教育出版公司和哈尔滨工业大学出版社有限公司合作出版。此版本经授权仅限在中华人民共和国境内（不包括香港特别行政区、澳门特别行政区和台湾地区）销售。

版权 © 2014 由麦格劳-希尔（亚洲）教育出版公司与哈尔滨工业大学出版社有限公司所有。

本书封面贴有 McGraw-Hill Education 公司防伪标签，无标签者不得销售。

## 图书在版编目（CIP）数据

新建项目LEED工程指南：面向工程师的可持续性建造技术 = The engineering guide to LEED-New construction: sustainable construction for engineers ( Second Edition ) : 英文 / (美) 哈泽尔巴赫 (Haselbach, L.) 著. —哈尔滨：哈尔滨工业大学出版社，2014.3

ISBN 978-7-5603-4506-2

I. ①新… II. ①哈… III. ①建筑工程-工程项目管理-指南-英文 IV. ①TU71-62

中国版本图书馆CIP数据核字（2014）第015363号



责任编辑 杨 桦

出版发行 哈尔滨工业大学出版社

社 址 哈尔滨市南岗区复华四道街10号 邮编 150006

传 真 0451-86414749

网 址 <http://hitpress.hit.edu.cn>

印 刷 哈尔滨市石桥印务有限公司

开 本 787mm×960mm 1/16 印张 29

版 次 2014年6月第1版 2014年6月第1次印刷

书 号 ISBN 978-7-5603-4506-2

定 价 138.00元

（如因印刷质量问题影响阅读，我社负责调换）

# **The Engineering Guide to LEED— New Construction**

## **Sustainable Construction for Engineers**

Liv Haselbach

Second Edition



New York Chicago San Francisco  
Lisbon London Madrid Mexico City  
Milan New Delhi San Juan  
Seoul Singapore Sydney Toronto

## McGRAW-HILL'S GREENSOURCE SERIES

---

### **Attmann**

*Green Architecture: Advanced Technologies and Materials*

### **Gevorkian**

*Solar Power in Building Design: The Engineer's Complete Design Resource*  
*Alternative Energy Systems in Building Design*

### **GreenSource: The Magazine of Sustainable Design**

*Emerald Architecture: Case Studies in Green Building*

### **Haselbach**

*The Engineering Guide to LEED—New Construction: Sustainable Construction for Engineers*,  
Second Edition

### **Luckett**

*Green Roof Construction and Maintenance*

### **Melaver and Mueller (eds.)**

*The Green Building Bottom Line: The Real Cost of Sustainable Building*

### **Nichols and Laros**

*Inside the Civano Project: A Case Study of Large-Scale Sustainable Neighborhood Development*

### **Yudelson**

*Green Building Through Integrated Design*  
*Greening Existing Buildings*

### **About GreenSource**

A mainstay in the green building market since 2006, *GreenSource* magazine and GreenSourceMag.com are produced by the editors of McGraw-Hill Construction, in partnership with editors at BuildingGreen, Inc., with support from the United States Green Building Council. *GreenSource* has received numerous awards, including American Business Media's 2008 Neal Award for Best Website and 2007 Neal Award for Best Start-up Publication, and FOLIO magazine's 2007 Ozzie Awards for "Best Design, New Magazine" and "Best Overall Design." Recognized for responding to the needs and demands of the profession, *GreenSource* is a leader in covering noteworthy trends in sustainable design and best practice case studies. Its award-winning content will continue to benefit key specifiers and buyers in the green design and construction industry through the books in the *GreenSource* Series.

### **About McGraw-Hill Construction**

McGraw-Hill Construction, part of The McGraw-Hill Companies (NYSE: MHP), connects people, projects, and products across the design and construction industry. Backed by the power of Dodge, Sweets, *Engineering News-Record (ENR)*, *Architectural Record*, *GreenSource*, *Constructor*, and regional publications, the company provides information, intelligence, tools, applications, and resources to help customers grow their businesses. McGraw-Hill Construction serves more than 1,000,000 customers within the \$4.6 trillion global construction community. For more information, visit [www.construction.com](http://www.construction.com).

**About the Author**

Liv Haselbach is currently a faculty member in the Department of Civil & Environmental Engineering at Washington State University. She is a licensed engineer and a U.S. Green Building Council LEED® accredited professional with 30 years of experience in the field. The author of numerous articles for industry journals, Dr. Haselbach was the founding owner of a civil/environmental engineering firm specializing in land development and regulatory compliance.

---

# Preface

**T**he *Engineering Guide to LEED—New Construction* is intended as a reference or a textbook to aid in the understanding and application of green building design concepts for the engineering and development community. It focuses on the U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design® (LEED) rating system as an example format for sustainable vertical construction and has been updated in this second edition to version 3.0 (LEED 2009) through addenda December 2, 2009.

*Sustainability* has many definitions. The definition that has been generally accepted in the context of human beings building and living in a more “sustainable” world was initially developed at the World Commission on Environment and Development (WCED) in 1987. It is simply this: “Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

*Sustainable Construction* is a subset of sustainability, which focuses more on the built environment, both during the construction phase and during the operational life cycle of the facility. However, both sustainability and sustainable construction are subject to interpretation and are very difficult to define. What may seem sustainable in one culture or per one set of values, may not appear sustainable to another. Likewise, the concepts that may be viewed as more important for sustainability by some people, may not be as important to others.

A very common term used for a major focus area in sustainable construction is *Green Building*. Green Building may not really represent true sustainable construction in some people’s opinion, but it is an attempt to approach sustainability in a format that fits readily into our current culture. It is a movement that tries to put some of the concepts of sustainability into the construction or renovation of our buildings and facilities.

In like manner, even though this book has sustainable construction in its title, it by no means represents a fully comprehensive method to construct sustainably. This book is intended to be an introduction to some of the major concepts that are being accepted in methodologies to introduce sustainability into construction practices in the United States. It specifically covers the concepts that are currently being promoted by a rating system developed by the USGBC. The system is entitled LEED and has grown out of energy-saving efforts in the United States.

This book focuses more on the “Environmental” aspects of LEED. The “Energy” aspects have been fairly well developed and might require another volume or two to adequately explain in greater detail. In addition, this book expands on some of the

environmental issues that are focused on in LEED and gives some direction into means to accomplish the goals, or gives more detailed background information on the environmental systems and impacts that many of the LEED subcategories are based on. In this way, an engineer or other professional may better grasp the intent of the proposed sustainability methods. A better understanding may result in better and more comprehensive, or perhaps alternative designs to obtain the goals. This book is meant to be a guide for all professionals working on sustainable construction in the United States.

The book is divided into three different types of sections. The first section, which consists of Chap. 1, gives an introduction to both sustainable construction and the USGBC LEED—New Construction rating system. The second section, Chaps. 2 through 7, goes into detail on many of the prerequisites and credits used by the USGBC for certification through its version 3 (LEED 2009) rating system for new construction and major renovations. The last section, Chaps. 8, 9, and 10, consists of several distinct parts broadening out from the specific rating system items with emphasis on application to various sectors of particular interest to many groups, management, the military, and low-impact development (LID). Chapter 8 includes the Minimum Program Requirements as specified for a project to be eligible to register for LEED 2009, and gives some overviews of construction management and organization for helping a *green* professional make a sustainable construction project successful particularly if based on the LEED rating system. Chapter 9 gives a view of how the Federal Government and one of its largest departments, the Department of Defense (DoD), have evolved as major contributors to the sustainable development movement in the United States. This chapter starts with a broad overview of how the DoD is involved in the movement and gradually details it down to the example of how the DoD is starting to address the improving of indoor air quality. Chapter 10 gives a broad overview of how this rating system may effectively intersect with another growing movement in the sustainable construction arena in the United States, Low Impact Development (LID), which focuses on the outdoor impacts of construction, particularly with respect to stormwater.

*The Engineering Guide to LEED—New Construction* can be used either as a textbook or a reference book. The exercises in the chapters help to develop sustainable skills and understanding for the students, while also allowing them to research the new principles and guidances that may evolve after publication of the book. I hope that others find as great a satisfaction and enjoyment in becoming more *green* as I have over the past few years.

Liv Haselbach



---

# Acknowledgments

I would like to thank the people who have helped educate me on various aspects of green building, politely listened to me talk excitedly about sustainability, and have helped me research or review some of the specific items in the text over the past few years. Of particular note in this second edition is my youngest daughter Heidi Marie Brakewood who contributed many of the photos, including the cover photo which is of the Shell Woodcreek Office and Multipurpose Building Complex in Houston, TX. Then there is my husband Mike Navarro, who makes my work a pleasure by constantly encouraging me to continue in my efforts to teach and research “sustainability,” even incorporating many of the green concepts in his daily work.

# Contents

Preface .....	xiii
Acknowledgments .....	xv
<b>1 Introduction .....</b>	<b>1</b>
1.1 An Introduction to Sustainable Development .....	1
1.2 Introduction to the USGBC LEED-NC Rating System .....	7
Guidances .....	7
How LEED-NC Is Set Up .....	9
LEED-NC Documents .....	11
Credit Formats .....	11
Registration, Certification, Membership, and Accreditation .....	12
Project Checklist, LEED-Online, and Templates .....	14
What to Do if Things Are Not Clear for Your Project .....	21
1.3 Miscellaneous .....	22
Organizations .....	22
Standard 189 .....	23
The Carbon Commitment .....	23
References .....	24
Exercises .....	27
<b>2 LEED Sustainable Sites .....</b>	<b>29</b>
Land Area Definitions .....	34
Sustainable Sites Prerequisites .....	36
SS Prerequisite 1: <i>Construction Activity Pollution Prevention</i> ...	36
2.1 SS Credit 1: <i>Site Selection</i> .....	38
2.2 SS Credit 2: <i>Development Density and Community     Connectivity</i> .....	40
2.3 SS Credit 3: <i>Brownfield Redevelopment</i> .....	45
2.4 SS Credit Subcategory 4: <i>Alternative Transportation</i> .....	47
SS Credit 4.1: <i>Alternative Transportation—Public Transportation         Access</i> .....	48
SS Credit 4.2: <i>Alternative Transportation—Bicycle Storage and         Changing Rooms</i> .....	51
SS Credit 4.3: <i>Alternative Transportation—Low-Emitting         and Fuel-Efficient Vehicles (LEFEVs) [and also Alternative         Fuel Vehicles (AFVs)]</i> .....	55
SS Credit 4.4: <i>Alternative Transportation—Parking Capacity</i> ...	59
2.5 SS Credit Subcategory 5: <i>Site Development</i> .....	62
SS Credit 5.1: <i>Site Development—Protect or Restore Habitat</i> ...	62
SS Credit 5.2: <i>Site Development—Maximize Open Space</i> .....	66

2.6	SS Credit Subcategory 6: <i>Stormwater Management</i>	70
	SS Credit 6.1: <i>Stormwater Management—Quantity Control</i>	70
	SS Credit 6.2: <i>Stormwater Management—Quality Control</i>	75
2.7	SS Credit Subcategory 7: <i>Heat Island Effect</i>	79
	SS Credit 7.1: <i>Heat Island Effect—Non-Roof</i>	79
	SS Credit 7.2: <i>Heat Island Effect—Roof</i>	83
2.8	SS Credit 8: <i>Light Pollution Reduction</i>	87
2.9	Discussion and Overview	97
	References	98
	Exercises	101
<b>3</b>	<b>LEED Water Efficiency</b>	<b>105</b>
	Water Efficiency Prerequisite	109
	WE Prerequisite 1: <i>Water Use Reduction Required</i>	109
3.1	WE Credit Subcategory 1: <i>Water Efficient Landscaping</i>	109
	WE Credit 1: <i>Water Efficient Landscaping</i>	110
3.2	WE Credit 2: <i>Innovative Wastewater Technologies</i>	116
3.3	WE Credit Subcategory 3: <i>Water Use Reduction</i>	123
	WE Credit 3: <i>Water Use Reduction</i>	124
3.4	Discussion and Overview	131
	References	132
	Exercises	133
<b>4</b>	<b>LEED Energy and Atmosphere</b>	<b>137</b>
	Energy and Atmosphere Prerequisites	142
	EA Prerequisite 1: <i>Fundamental Commissioning of the Building Energy Systems</i>	142
	EA Prerequisite 2: <i>Minimum Energy Performance</i>	145
	EA Prerequisite 3: <i>Fundamental Refrigerant Management</i>	150
4.1	EA Credit 1: <i>Optimize Energy Performance</i>	152
4.2	EA Credit 2: <i>On-Site Renewable Energy</i>	165
4.3	EA Credit 3: <i>Enhanced Commissioning</i>	168
4.4	EA Credit 4: <i>Enhanced Refrigerant Management</i>	170
4.5	EA Credit 5: <i>Measurement and Verification</i>	176
4.6	EA Credit 6: <i>Green Power</i>	178
4.7	Discussion and Overview	182
	References	184
	Exercises	186
<b>5</b>	<b>LEED Materials and Resources</b>	<b>191</b>
	Material and Resources Credit Calculation Summaries	196
	Materials and Resources Prerequisites	198
	MR Prerequisite 1: <i>Storage and Collection of Recyclables</i>	198
5.1	MR Credit Subcategory 1: <i>Building Reuse</i>	203
	MR Credit 1.1: <i>Building Reuse—Maintain Existing Walls, Floors, and Roof (LEED 2009)</i>	203

	MR Credit 1.2: <i>Building Reuse—Maintain Interior Nonstructural Elements (LEED 2009)</i> .....	205
5.2	MR Credit Subcategory 2: <i>Construction Waste Management</i> ....	207
	MR Credit 2: <i>Construction Waste Management—Divert from Disposal (LEED 2009)</i> .....	207
5.3	MR Credit Subcategory 3: <i>Materials Reuse</i> .....	212
	MR Credit 3: <i>Materials Reuse (LEED 2009)</i> .....	212
5.4	MR Credit Subcategory 4: <i>Recycled Content</i> .....	215
	MR Credit 4: <i>Recycled Content (postconsumer + ½ preconsumer)</i> .....	215
5.5	MR Credit Subcategory 5: <i>Regional Materials</i> .....	219
	MR Credit 5: <i>Regional Materials—Extracted, Processed, and Manufactured Regionally</i> .....	219
5.6	MR Credit 6: <i>Rapidly Renewable Materials</i> .....	222
5.7	MR Credit 7: <i>Certified Wood</i> .....	224
5.8	Discussion and Overview .....	226
	References .....	226
	Exercises .....	227
<b>6</b>	<b>LEED Indoor Environmental Quality</b> .....	<b>237</b>
	Indoor Environmental Quality Prerequisites .....	245
	IEQ Prerequisite 1: <i>Minimum IAQ Performance</i> .....	245
	IEQ Prerequisite 2: <i>Environmental Tobacco Smoke (ETS) Control</i> .....	248
6.1	IEQ Credit 1: <i>Outdoor Air Delivery Monitoring</i> .....	251
6.2	IEQ Credit 2: <i>Increased Ventilation</i> .....	254
6.3	IEQ Credit Subcategory 3: <i>Construction IAQ Management Plan</i> ..	257
	IEQ Credit 3.1: <i>Construction IAQ Management Plan—during Construction</i> .....	257
	IEQ Credit 3.2: <i>Construction IAQ Management Plan—before Occupancy</i> .....	260
6.4	IEQ Credit Subcategory 4: <i>Low-Emitting Materials</i> .....	265
	IEQ Credit 4.1: <i>Low-Emitting Materials—Adhesives and Sealants</i> .....	266
	IEQ Credit 4.2: <i>Low-Emitting Materials—Paints and Coatings</i> ...	266
	IEQ Credit 4.3: <i>Low-Emitting Materials—Flooring Systems (Previously Carpet Systems in LEED 2.2)</i> .....	268
	IEQ Credit 4.4: <i>Low-Emitting Materials—Composite Wood and Agrifiber Products</i> .....	270
6.5	IEQ Credit 5: <i>Indoor Chemical and Pollutant Source Control</i> .....	273
6.6	IEQ Credit Subcategory 6: <i>Controllability of Systems</i> .....	276
	IEQ Credit 6.1: <i>Controllability of Systems—Lighting</i> .....	276
	IEQ Credit 6.2: <i>Controllability of Systems—Thermal Comfort</i> .....	277
6.7	IEQ Credit Subcategory 7: <i>Thermal Comfort</i> .....	279
	IEQ Credit 7.1: <i>Thermal Comfort—Design</i> .....	279
	IEQ Credit 7.2: <i>Thermal Comfort—Verification</i> .....	281

6.8	IEQ Credit Subcategory 8: <i>Daylighting and Views</i> .....	282
	IEQ Credit 8.1: <i>Daylighting and Views—</i>	
	<i>Daylight (75% of Spaces)</i> .....	283
	USGBC Rating System (LEED 2009) .....	284
6.9	Discussion and Overview .....	293
	Air Pollution Calculation Conversions and	
	Concentrations .....	294
	References .....	296
	Exercises .....	298
<b>7</b>	<b>LEED Innovation in Design Process and Regional Priorities</b> .....	<b>303</b>
7.1	ID Credit 1: <i>Innovation in Design</i> .....	305
7.2	ID Credit 2: <i>LEED Accredited Professional</i> .....	308
7.3	Regional Priorities .....	308
7.4	Discussion and Overview .....	309
	References .....	310
	Exercises .....	310
<b>8</b>	<b>A Systematic View of Green and Minimum Program</b>	
	<b>Requirements</b> .....	<b>313</b>
	Minimum Program Requirements .....	313
8.1	Green Building from the Project Viewpoint .....	313
	How to Get Started .....	313
	How to Keep Track .....	315
	Project Methods and Scheduling .....	316
	Miscellaneous .....	325
8.2	Summary of Relevant Codes and Credits .....	328
	Summary of Relevant Codes .....	328
	Summary of the Credits .....	334
8.3	Additional Tools and Education .....	334
	Energy Star, BEES, and More .....	334
	Incorporation into CSI Formats .....	336
	Education .....	338
	References .....	338
	Exercises .....	340
<b>9</b>	<b>Department of Defense (DoD) Sustainable Construction</b>	
	<b>and Indoor Air Quality (IAQ)</b> .....	<b>343</b>
9.1	Government Mandates .....	343
9.2	Department of Defense Facilities .....	345
	U.S. Army and the U.S. Army Corps of Engineers .....	345
	Naval Facilities Engineering Command .....	346
	Air Force Center for Environmental Excellence .....	348
9.3	LEED Application Guide for Lodging .....	348
	Sustainable Sites .....	349
	Water Efficiency .....	349
	Energy and Atmosphere .....	350

Materials and Resources .....	350
Indoor Environmental Quality .....	351
Innovation in Design .....	351
9.4 Importance of Indoor Air Quality .....	351
Source Control .....	352
Ventilation .....	353
Air Cleaning .....	353
Future Combined Technologies .....	355
9.5 Summary .....	355
References .....	356
Exercises .....	357
<b>10 Low-Impact Development and Stormwater Issues .....</b>	<b>359</b>
10.1 Nonpoint Source Pollution, BMPs, and LID .....	360
Why BMPs Were Developed: Stormwater Impacts of	
Urbanization .....	363
BMP Terminology .....	364
ESC .....	368
LID .....	369
Green Streets and Urban LID Practices .....	375
10.2 Modeling LID BMPs .....	382
Overall Mass Balances .....	382
Pervious Concrete .....	385
References .....	389
Exercises .....	393
<b>A Notation .....</b>	<b>397</b>
<b>B Definitions .....</b>	<b>417</b>
<b>C Units .....</b>	<b>433</b>
<b>Index .....</b>	<b>435</b>

## Introduction

### 1.1 An Introduction to Sustainable Development

There are many definitions of *sustainability* and *sustainable development*. What is sustainable for one group may not be as sustainable for another. The most accepted worldwide definition of *sustainable development* is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland Commission, 1987). However, in an effort to address some of the sustainability ideals and goals in the United States, a subset of sustainability referred to as *sustainable construction* and its subcomponent called *green building* are emerging. They offer a look at sustainability in terms of a smaller scope, such as typical building or construction in an area of the developed world, and in the shorter term, perhaps the life of a building.

Sustainable construction is any construction, while green building focuses on vertical construction. There is also a movement developing to address horizontal construction (transportation and utility corridors). The horizontal construction program related to roads in the United States is usually referred to as *green highways*, although there are also publications that refer to some of the designs as *sustainable streets*. The Green Highway Partnership is an organization which has the U.S. Environmental Protection Agency (EPA) and the Federal Highway Administration (FHWA) among its partners. This partnership began in the Washington, D.C., area and is expanding nationally. The American Society of Civil Engineers (ASCE) became a leader in this field in 2009 and 2010 with the establishment of committees in both its Transportation and Development Institute (T&DI), and Environmental and Water Resources Institute (EWRI) under the EWRI Low Impact Development (LID) umbrella. The first T&DI/ASCE Green Streets and Highways Conference was scheduled for November 14–17, 2010, in Denver, CO. A Greenroads sustainability performance metric rating system is also being developed at the University of Washington. Another initiative relating mainly to the outdoors and horizontal construction is the Sustainable Sites Initiative (SSI), which is a collaboration between the American Society of Landscape Architects (ASLA), the Lady Bird Johnson Wildflower Center (The Wildflower Center), and the United States Botanic Garden (USBG) among others. More information can be found at their website: <http://www.sustainablesites.org/>.

Sustainable construction is an international concern. Although this book focuses on the process in the United States, great efforts have been made to develop sustainable policies and practices throughout the world. The sustainable practices range from procurement or supply chain practices through wastewater reuse practices in the operational phases. Good solutions and practices for sustainable construction may not

be the same in all areas of the world and for all societies. Therefore, the rating systems developed and the techniques used will differ. Energy efficiency is a high priority in many countries, particularly in countries with cold winters. There has been much publication and research into improving energy efficiencies internationally both for new construction and as retrofits in existing buildings.

By looking at the green building movement in the United States, it is obvious that the green rating system as developed by the U.S. Green Building Council (USGBC) has had wide acceptance to date and is becoming more widespread. This system is referred to as LEED®, which stands for Leadership in Energy and Environmental Design.\* Since LEED grew out of energy program initiatives, it is already developed in focus areas of both architects and mechanical engineers. Sometimes the construction that focuses on energy efficiency and also water efficiency is referred to as *high-performance* building.

Sustainable construction research and applications are still in their infancy. There is a great need for research, education, and case studies from applications to further develop a more sustainable future in development and construction. Even the definitions of what is or what is not sustainable need to be researched and further evaluated. For instance, certain people may believe that keeping as much as possible of the natural environment pristine is one of the most important goals of sustainability, whereas others may believe that an improved food supply for humans is more important. Thus, not only do the principles behind sustainability differ from group to group, or may be in contrast or seemingly incompatible with one another, but also the ranking or value judgments of the importance of various impact factors of sustainability are very difficult to develop and find consensus on.

To facilitate the further development and implementation of the green building system in the United States, engineers and other professionals must be educated in the rating systems used, and in the parameters and principles that have been established in the use of these rating systems. The intention of the author is to develop a text that educators can use to teach engineers and professionals about sustainable development, particularly the LEED system. The emphasis is on the development of skills to facilitate the use of this system, as well as guidance on potential additional research avenues to further improve the green building movement, with stress on environmental aspects, as future developments and needs arise.

The author likes to explain that a sustainable environmental goal will focus on both how construction impacts the environment and how environmental decisions impact development. It is a two-way road, and things must be looked at from both directions. In addition, other impacts in the entire life cycle of the facilities or practices need to be looked at. What may seem like an environmentally sound practice may in fact not turn out quite that way when input into an anthropogenic world. Two examples which follow are the sustainability of stormwater ponds and the use of certain additives in gasoline.

A common form of stormwater management is the use of a retention or a detention pond for storage and possibly infiltration of additional runoff caused by an increase in paved or roofed areas. Therefore in an approved site plan set, a pond may be called for. However, it has been shown that in many cases the specified ponds are not installed, much less maintained to sustain a more manageable stormwater system. Why?

---

\*LEED is a registered trademark of the U.S. Green Building Council.



The reasons are not known, but perhaps the contractor or owner does not understand the environmental impact that the lack of a pond may cause, therefore, installation of one may not seem important.

Then there is the use of MTBE (methyl-tertiary-butyl ether) as an additive in gasoline to improve air quality, which was a common practice in the 1990s. It was considered to be a sound environmental practice with respect to air issues. However, there were some unexpected consequences. Traditionally in the United States, gasoline is made at a refinery, is transported and distributed through a network of petroleum facilities, and ends up at the retail outlet, the gasoline station. Gasoline is usually stored in underground tanks, for many reasons including safety, at this end resale site. Underground tanks are currently fairly well regulated and monitored in the United States, but that was not always the case. In many sites, gasoline has leaked into the ground, and the product sits on or in the groundwater. Most constituents in gasoline are nonpolar organics which do not dissolve readily in polar water, but might prefer to adsorb to organic material in the soil. So even though the groundwater may slowly flow off-site, most of the gasoline contaminants remain closer to the site. However, MTBE is an ether, and ethers are more polar than many gasoline constituents such as benzene. Polar organics tend to be more soluble in water and may have a greater tendency to travel with the groundwater gradient. Therefore, there are many places where some gasoline leakage in the soils at a site did not initially cause an off-site concern until the MTBE was added and moved more rapidly off-site. In this way a practice that is an environmental benefit for one system may not be as sustainable in another.

There are several other green rating systems for vertical construction in the United States, but the LEED system and the alternative Green Globes system are by far the most prominent. Green Globes is distributed by the Green Building Initiative (GBI) in the United States and is based on a system developed in Europe and later also used in Canada. The European version is referred to as the Building Research Establishment's Environmental Assessment Method (BREEAM). Another similar initiative is the California Green Building Standards (CALGreen) Code, which was in draft form in 2010 and scheduled to become effective on January 1, 2011. It has been developed by the California Building Standards Commission. This text is based on the LEED system, but this in no way implies that the other systems are not useful and viable. The LEED rating system was chosen as the focus of this text as it is currently more widespread in the United States. It also does not allow for a self-certification method, which makes it more restrictive and possibly more difficult to complete, but at the same time may also give greater control and consistency to green building.

The text has a heavy focus on some of the civil and environmental aspects of the rating system, since the author is first targeting this engineering community. However, it also addresses in some fashion other issues in the rating system. One of the reasons for its being more all encompassing in the topics reviewed is to educate the civil and environmental engineers about the other credits and criteria so that they can effectively work with other disciplines in a cooperative fashion to better implement sustainable construction practices. Other engineering and nonengineering disciplines have found the text useful, including mechanical engineering, computer science, architecture, and construction management, just to name a few.

There is a need for further involvement from the civil and environmental engineering community in the development of the LEED rating system. The evaluation of best