CONTENTS

INTRODUCTION viii Chapter 1 SUSTAINABILITY AND ENERGY 1 Quality of Life Benefits 7 Finite Fossil Fuel Resources 8 Greenhouse Gases 10 Profits and Savings from Energy Efficiency 11 Site-to-Source Effect 12 New LEED Version 2009 13 Per Capita Energy Consumption Building Energy End-Use Splits, People Use Energy 15 Carbon Footprint 17 **Funding Opportunities** Chapter 2 RADIANT COOLING 21 History 21 Introduction 23 Why Radiant Cooling? 26 **Applications** Radiant Cooling and Historic Preservation Chapter 3 DISPLACEMENT VENTILATION 41 History 41 42 Introduction

Conventional or Mixed-Air Systems

Air Distribution (UFAD) 47

Difference Between Displacement and Underfloor

Applications 48 Large Public Spaces (Cafeterias, Dining Halls, Exhibit Spaces) Chapter 4 CHILLED BEAMS 61 Principle of Operation and Technology 62 Benefits of Chilled Beams 63 Types of Chilled Beams 67 Chilled Beam Applications 72 Chilled Beam Use with Underfloor Air Distribution (UFAD) **Applications** 78 Chapter 5 UNDERFLOOR AIR DISTRIBUTION (UFAD) 83 Validation of UFAD Designs with CFD Analysis Impact on Buildings 95 Chapter 6 DISPLACEMENT INDUCTION UNITS (DIU) 101 Benefits of Displacement Induction Units **History of Induction Units Applications** 107 Chapter 7 HIGH-PERFORMANCE ENVELOPE Engaging and Nonengaging Envelopes High-Performance Envelope Definition 117 Most Common Energy Codes: ANSI and ASHRAE 90.1 Glazing Characteristics How to Exceed the Mandatory Code Performance 128 Chapter 8 THERMAL ENERGY STORAGE Renewable Energy Storage **Conventional Air Conditioning Systems** 153 Nonrenewable Energy Storage 156 Chapter 9 SOLAR ENERGY AND NET-ZERO **BUILDINGS 163** Net-Zero Step 1: Harvesting Solar Energy Solar Energy in Net-Zero Buildings

48

Net-Zero Step 2: Improve Energy Efficiency of the Building and Its Mechanical and Electrical Systems 181

Net-Zero Step 3: Reduce Consumption 183

Chapter 10 GEOTHERMAL SYSTEMS 185
Introduction 185
Geothermal Heat Pumps 190
Types of Heat Pumps 198

Chapter 11 COGENERATION 205

Other Applications of Cogeneration 207

Cogeneration Technologies 211

Micro-Cogeneration or Combined Heat and Power (Micro-CHP) 221

Chapter 12 DATA CENTER SUSTAINABILITY 223
History of Data Centers 224
2011: Top Ten Trends in Data Centers 225
Power Usage Effectiveness (PUE) 226
Technologies That Can Benefit Data
Center Efficiency 230
Office Building Applications 234
Air Management in the Data Center 237